



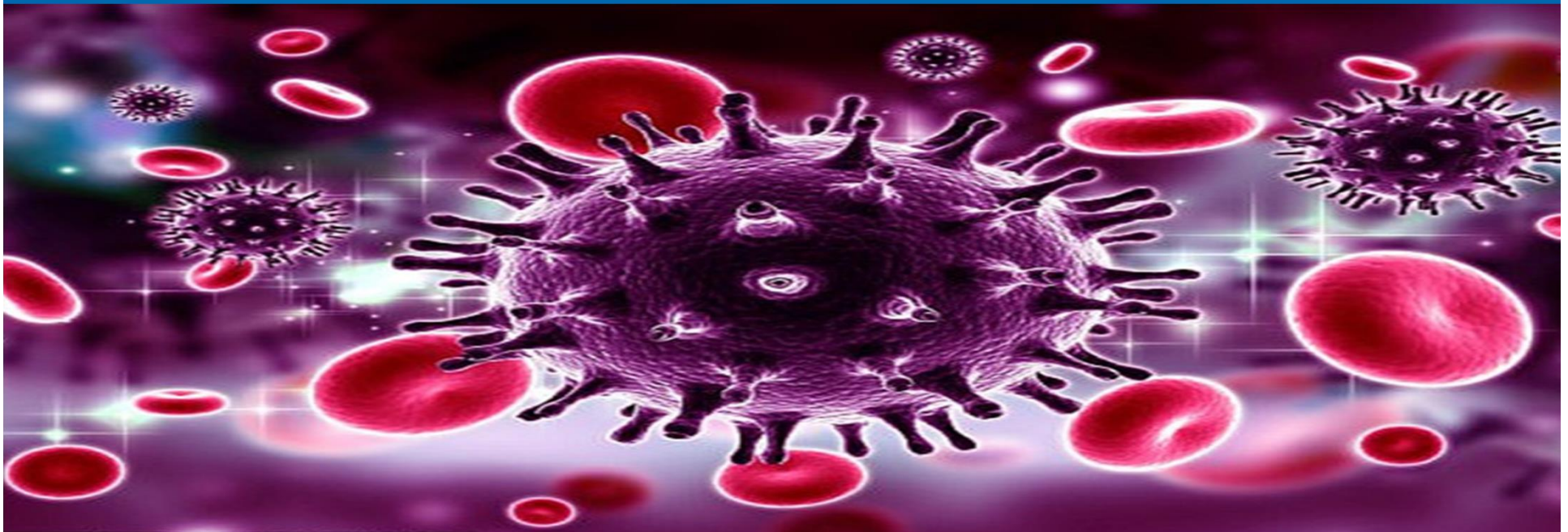
# Viruses

Curriculum: Phase 1/ Semester2/ TOB / Session 8

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# Reference

- ▶ Werren Levinson. edition . Review of Medical Microbiology and Immunology.  
13 edition.
- ▶ Jawetz, Melnick, & Adelberg's. Medical Microbiology, 27 edition

## Objectives of the lecture

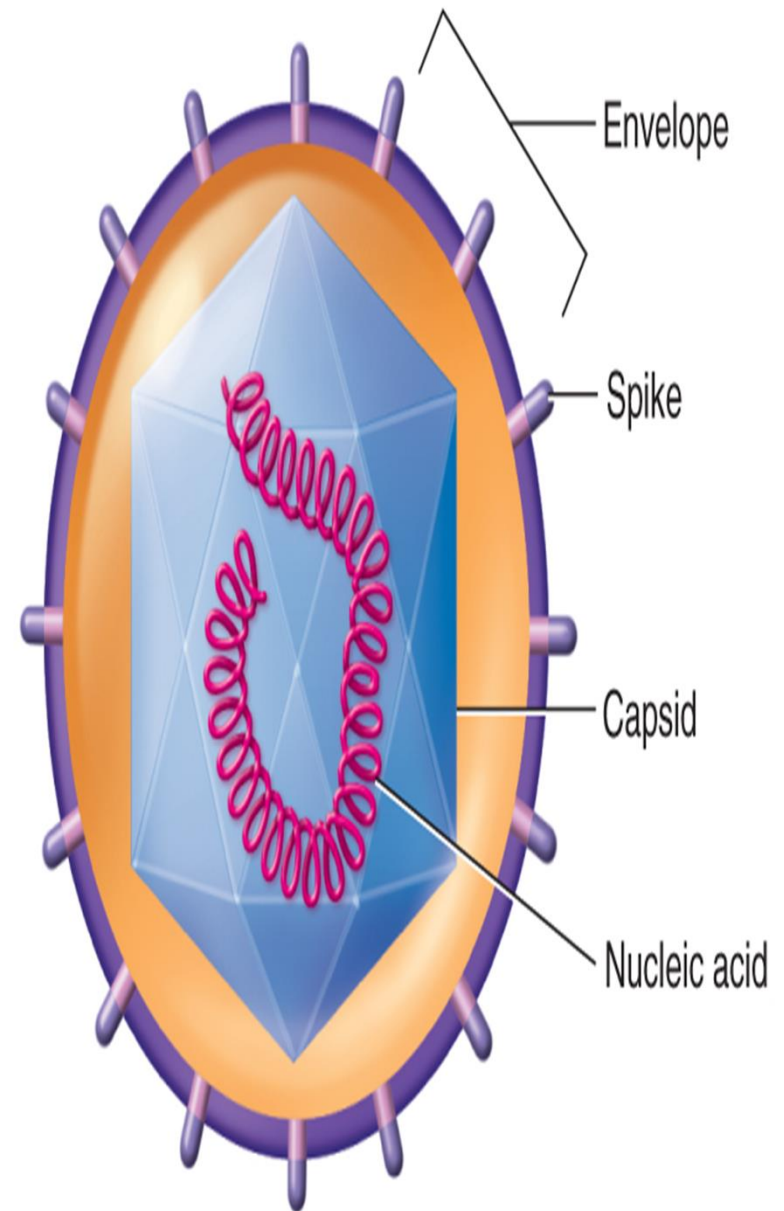
- ▶ understand the important chemical substances that make the architecture of any virus. Their arrangement, shape, importance and their role in viral pathogenicity and immunogenicity.
- ▶ Explain the general significance of genome composition, envelope and replication strategy for the classification and detection of viruses.
- ▶ the different habitats that may be occupied by microbes.
  - o the terms, reservoir, source and mode of transmission in the context of infection.
- ▶ Compare and contrast the key properties of Bacteria and Viruses as distinct from Eukaryotic cells.
- ▶ Understanding the terms, Carriage, Normal flora (microbiota) and Commensal
- ▶ What is infection?
  - o What causes infection?
  - o Why do particular individuals get particular infections?
  - o What influences the outcome of infection?
- ▶ Explain the terms Pathogen and Non-pathogen
- ▶ Explain the significance of acid fast stains for the classification and detection of bacteria.

➤ **Virus**: is infectious particle containing one type of nucleic acid either DNA or RNA , but never both. and surrounded by protein coat. The viral particle has ability to replicate only in living host cell, known as obligate intracellular parasites. and cause disease.

➤ The term virus, which come from the Latin word for poison.

➤ Because the viruses pass through bacterial filters, therefore the viruses were known as (filterable viruses)..

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(b) Enveloped Virus



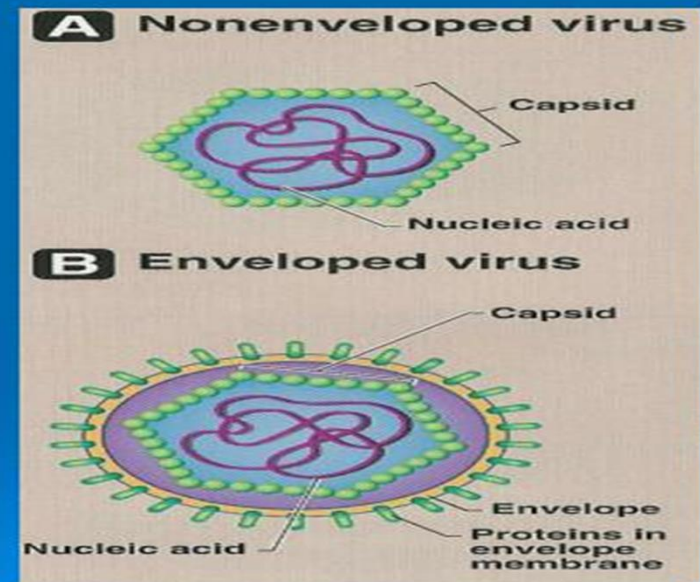
- ▶ Viruses are not considered as cell because they do not have a cellular composition and inert metabolically. They lack cellular organelles such as: nucleus, cytoplasm, mitochondria, ribosome, Golgi apparatus, and endoplasmic reticulum.
- ▶ Viruses can not seen by light microscope( therefore the viruses termed as submicroscopic agents), but they can seen by electronic microscope

## **Viral Structure**

***1- Viral genome***

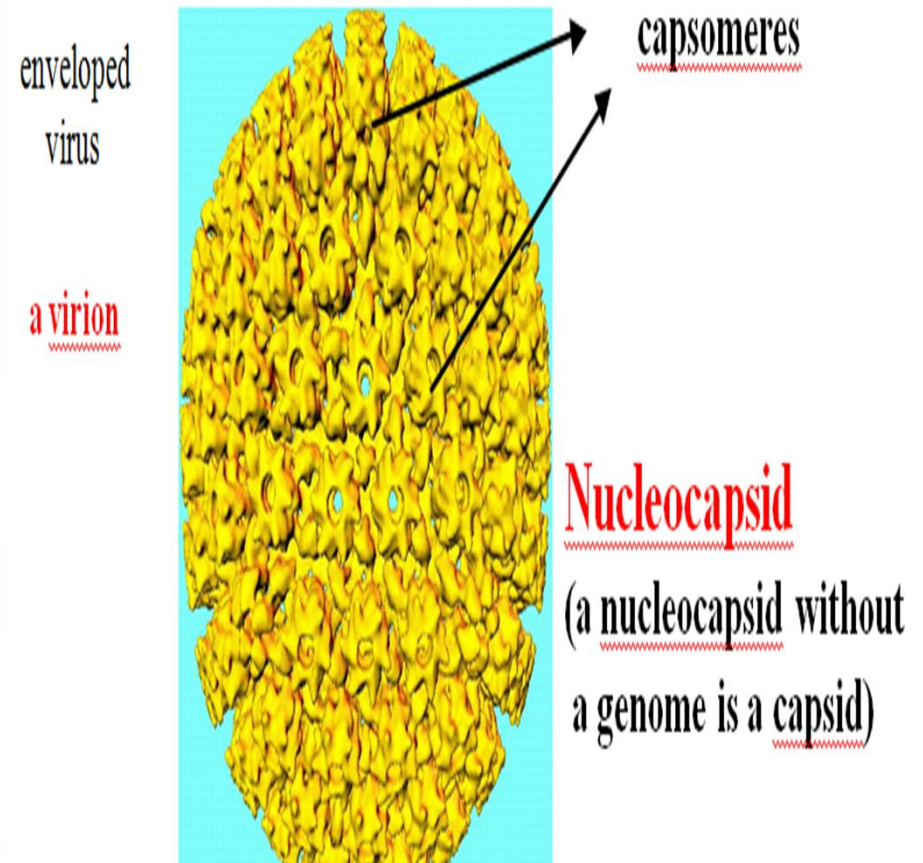
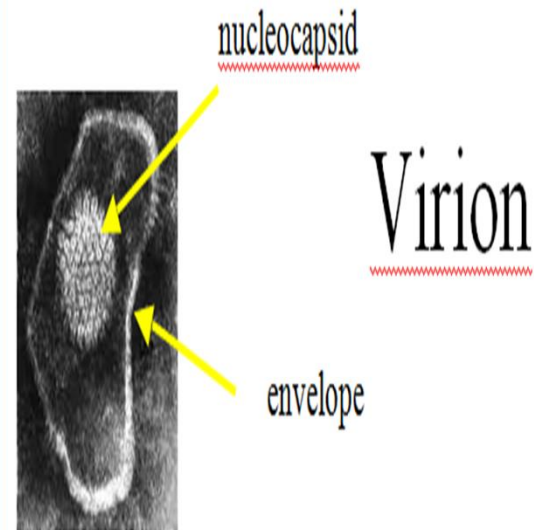
***2- Capsid***

***3- Envelope***



## The capsid have important functions:

- ▶ The capsid gives shape of virus.
- ▶ Protect viral genetic materials from external harmful effects ( such as nuclease enzymes) .
- ▶ Mediated attachment of viruses to specific receptor on surface of host cells and facilitate transfer of viral nucleic acid from one host to another.
- ▶ Act as antigen that induce neutralizing antibodies and activate cytotoxic T-cell to kill virus-infected cells.

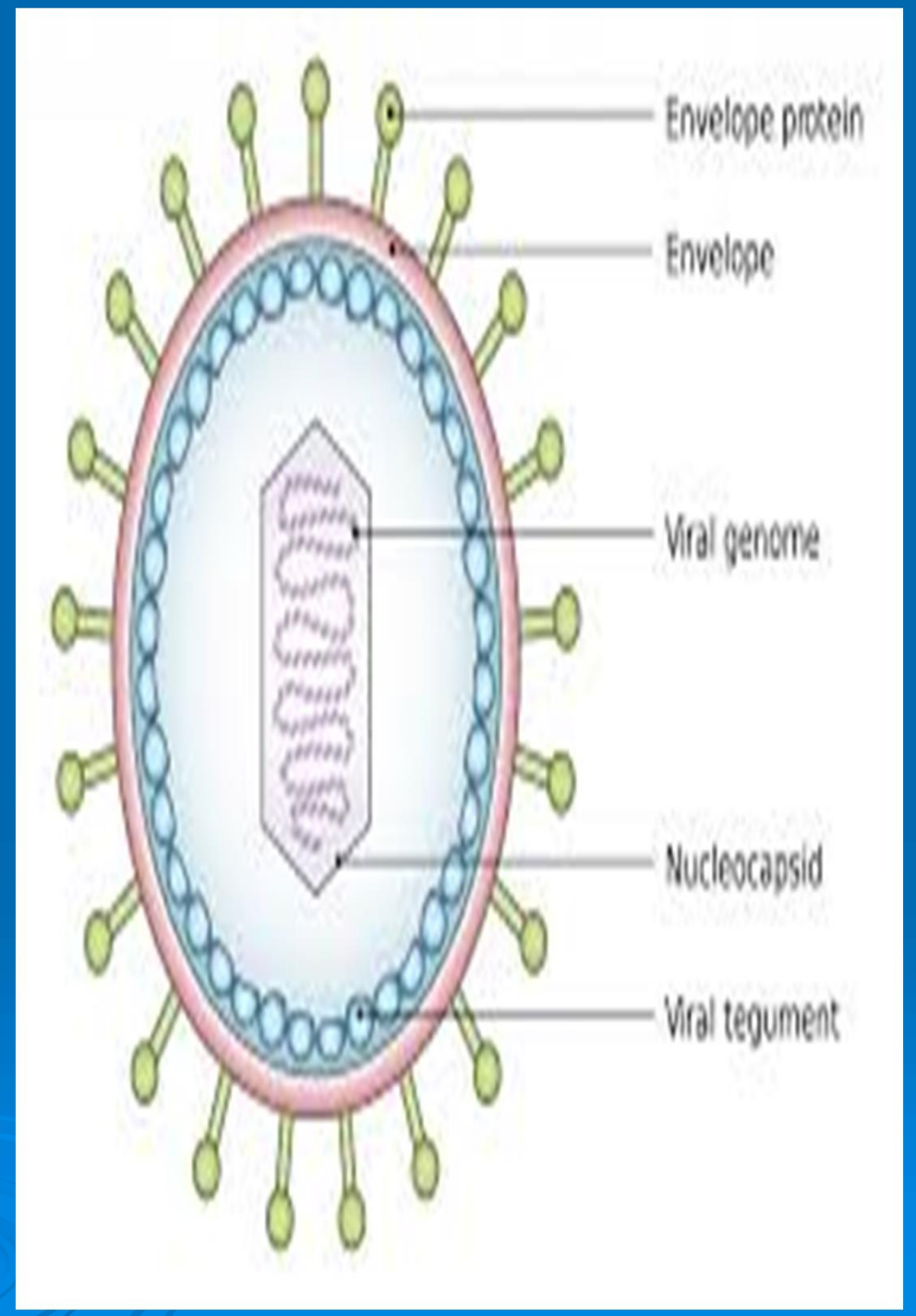


# Envelope:

outer lipid layer is derived from host cell membranes

- The envelope may be covered with projecting **spikes**(glycoprotein).
- The projections may act as viral antigens or may have role in attachment of virus to cellular receptors.

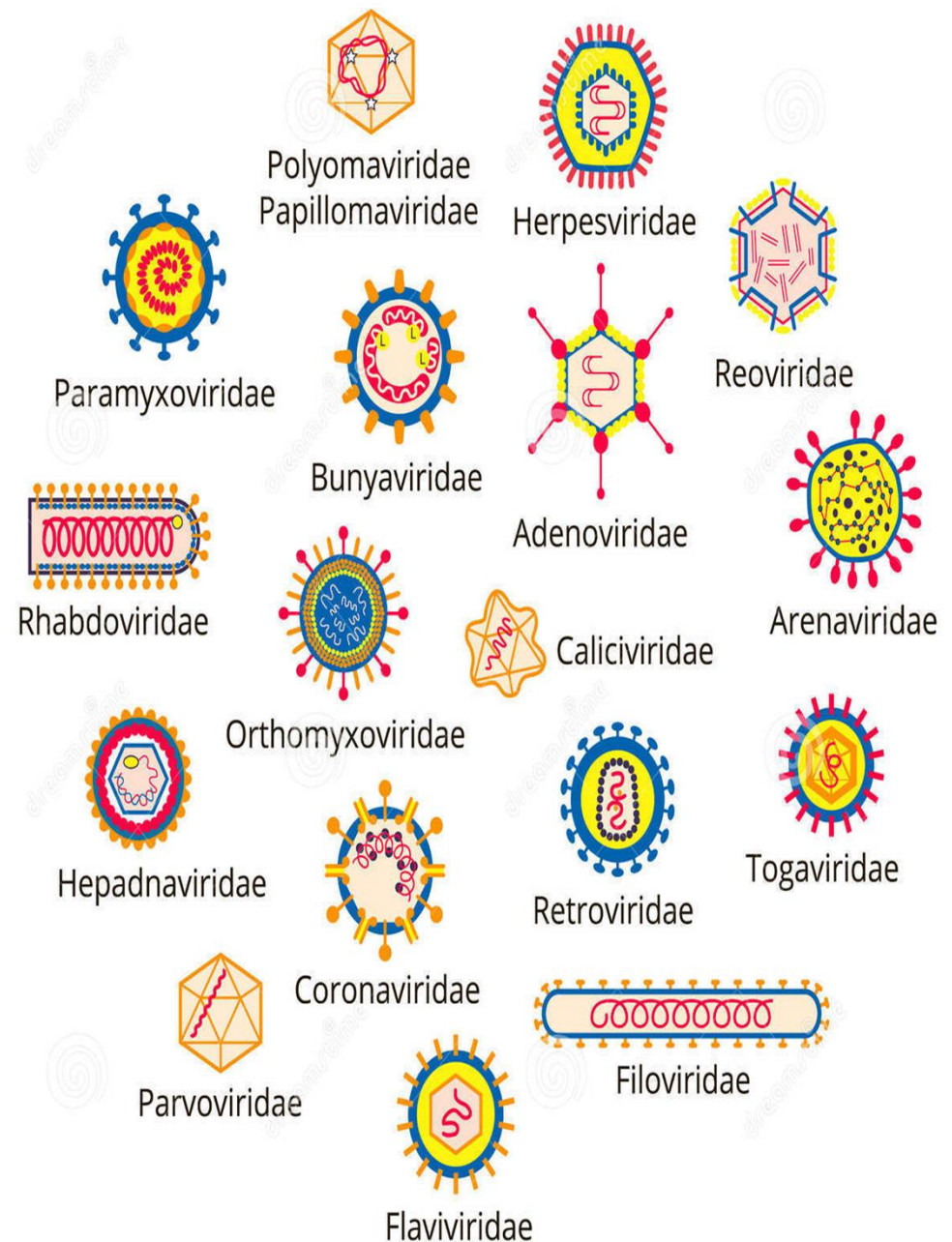
Proteins in the viral envelope mediate fusion of the virus envelope with host cell membrane during the entry of the virus into the host cell





# Shape and size of viruses

- The shapes of viruses may be sphere, rods, bullets, or brick.
- Viruses are very small and have vary widely range in size, ranged from 20- 300nm in diameter. The smallest virus is polio virus has a diameter about 20nm. The largest are poxvirus (300nm).
- The smallest bacteria, *Mycoplasma*, has diameter 0.2μm(200nm).

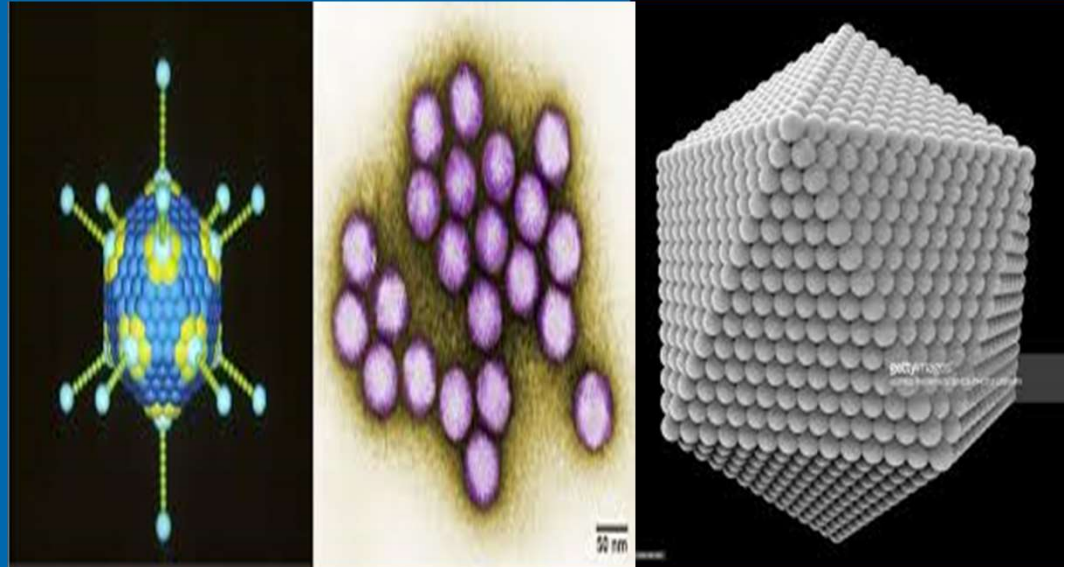




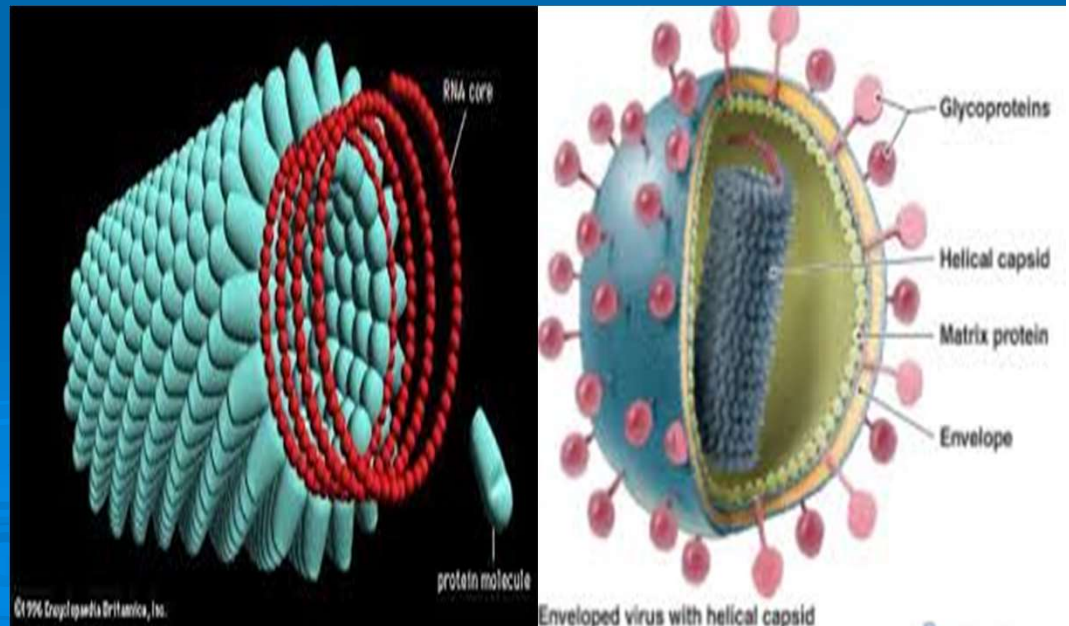
# Symmetry types of virus particles

**Icosahedral symmetry:** cubic multiple faces (polyhedron), in which the capsomeres are arranged in a pattern consisting of 20 triangular faces.

Most DNA viruses are icosahedral



**Helical symmetry:** In which the capsomeres are arranged in a spiral form around nucleic acid that appears rod-shape (tubular shape). Most RNA viruses are helical.



# Classification and nomenclature of viruses

## ➤ viral genome properties

- Type of nucleic acid (may be DNA or RNA).
- Molecular weight of nucleic acid.
- Number of strands (whether single strand or double strand) of nucleic acid.
- Nucleic acid form (may be linear or circular).
- Number and size of nucleic acid segments.
- Manner of replication

## ➤ Capsid properties including

- Shape and size of viral particle.
- Number of capsomeres in capsid.
- Type of symmetry of nucleoprotein.
- Presence or absence of envelope.
- Presence or absence of spikes

# Classification and nomenclature of viruses

## Biological properties including

- Susceptibility to physical and chemical agents , especially ether and detergents , and stability to pH and temperature.
- Host specificity (natural host range).
- Mode of viral transmission.
- Organ specificity(tissue tropism) and pathogenicity .

## Names of viruses are derived from:

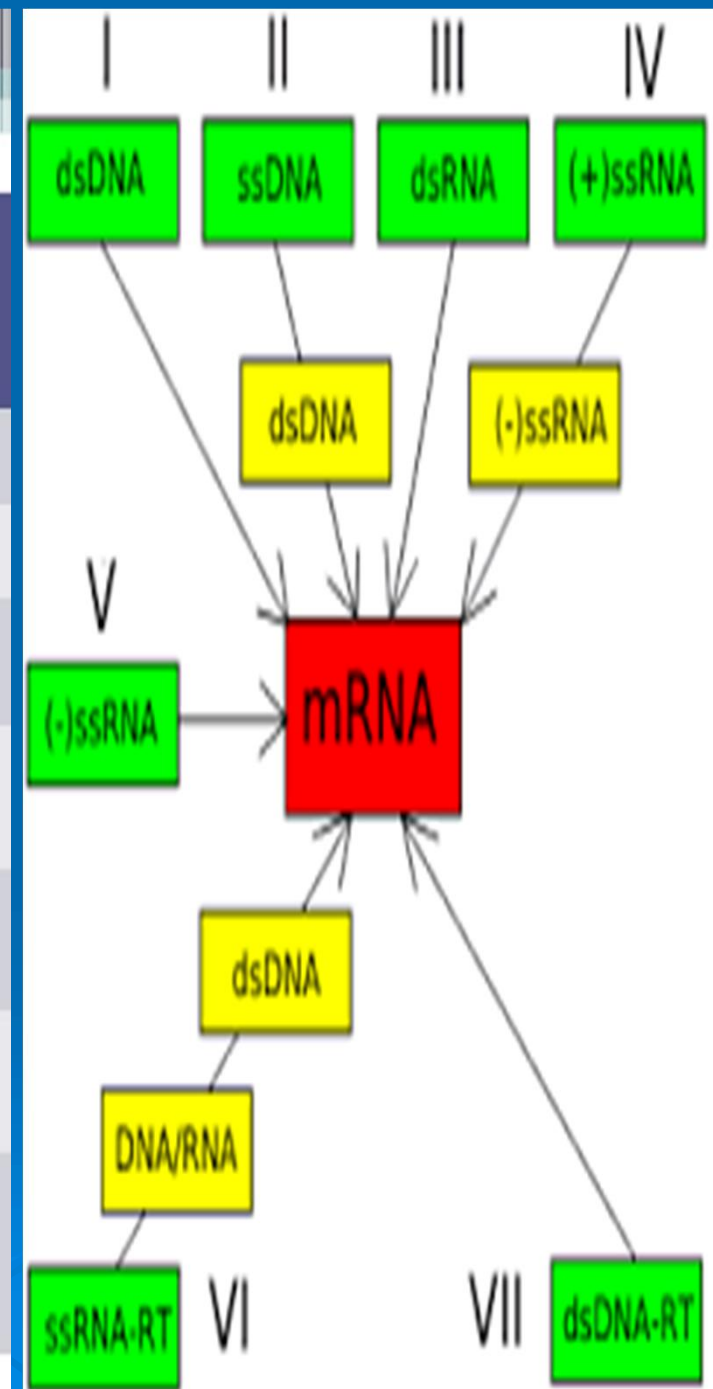
- The name of disease caused by virus(eg:Influenza virus, Hepatitis virus).
- The locality where the virus was first isolated (such as ; West Nile virus).
- The name of scientists responsible for isolating virus(such as; Epstein-Barr virus)

Unique epidemiological characteristics of virus (such as; Arboviruses, these are arthropod-borne viruses).



# 7 class of Baltimore classification

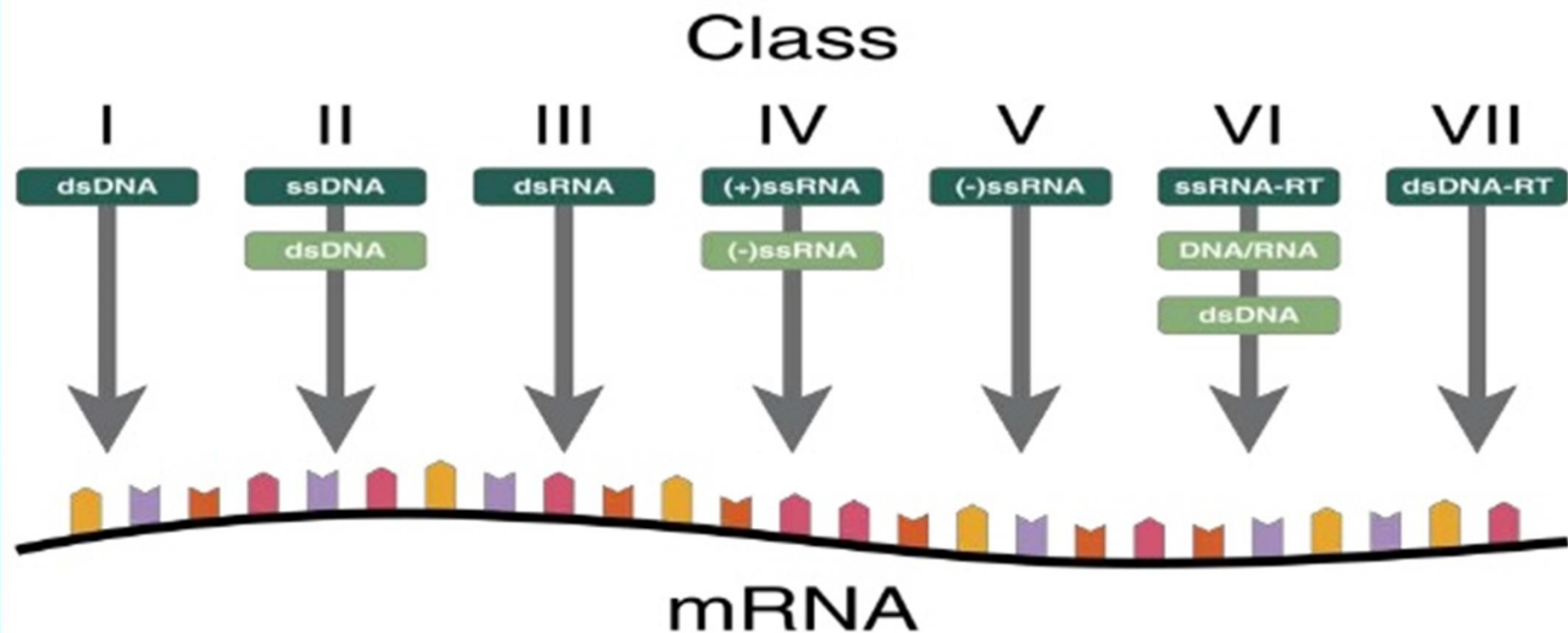
Class	Description of genome and replication strategy	Example of bacterial virus	Example of animal virus
I	Double stranded DNA genome	Lamda, T4	Herpesvirus, poxvirus
II	Single stranded DNA genome	ØX174	Chicken anemia virus
III	Double stranded RNA genome	Ø6	Reovirus
IV	Single stranded RNA genome plus sense	MS2	Poliovirus
V	Single stranded RNA genome minus sense		Influenza virus, Rabies virus
VI	Single stranded RNA genome that replicated with DNA intermediate		Retrovirus
VII	Double stranded DNA genome that replicates with RNA intermediate		Hepatitis B virus





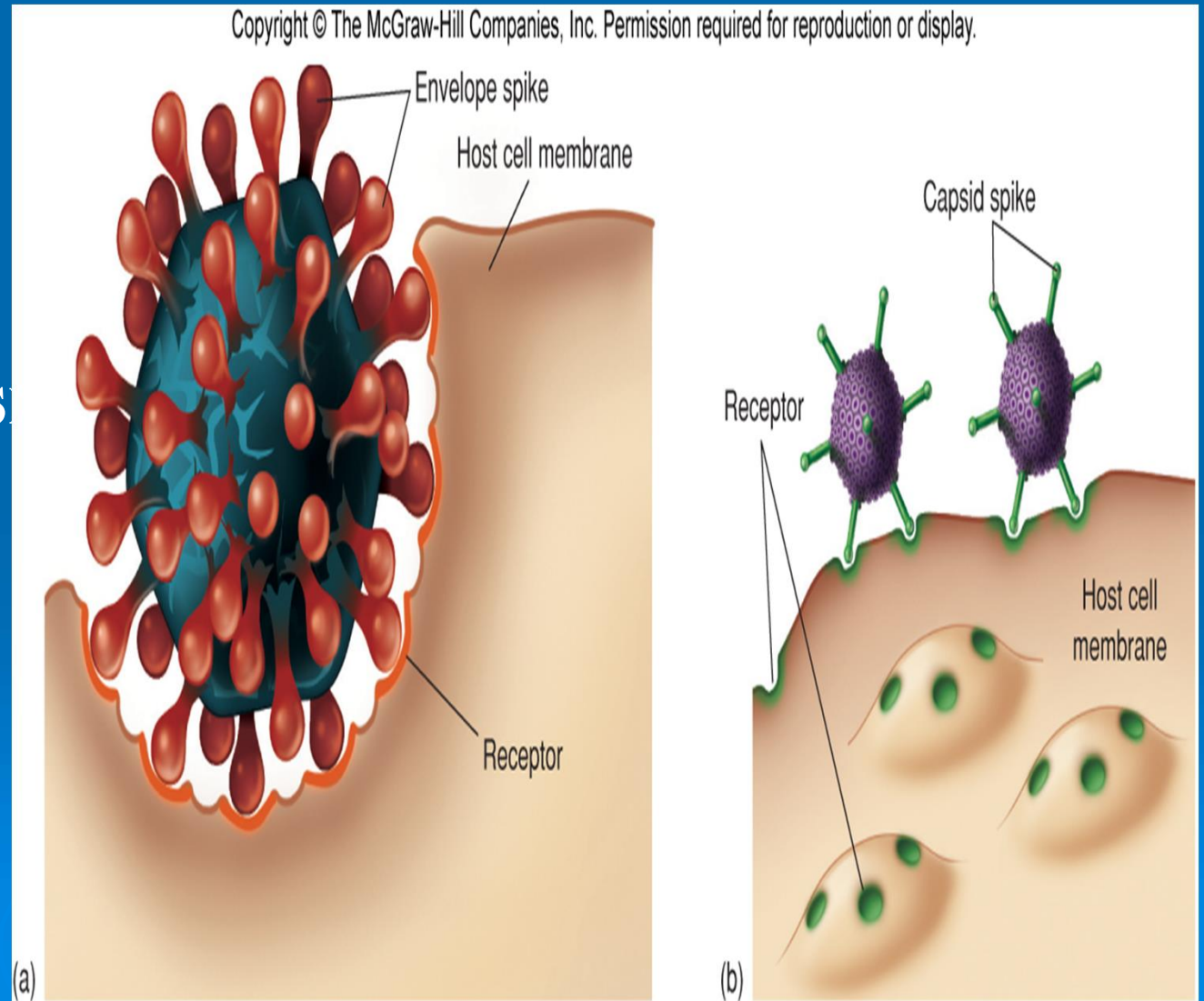
# Baltimore classification

- The Baltimore classification, developed by David Baltimore, is a virus classification system that groups viruses into families, depending on their type of genome



# viral replication

- Adsorption
- Penetration
- Uncoating
- Gene expression
- Biosynthesis
- Release



- ▶ If the virus successfully replicates in the host cell, the infection is productive and the host cell is said to be permissive for the virus.
- ▶ If the cell lacks something required for viral replication, the infection is non-productive and the host cell is considered to be non-permissive for the virus.

# VIRUS LIFECYCLE

## Stage 1

Once the virus particle reaches a vulnerable host cell, it attaches using surface proteins

## Stage 2

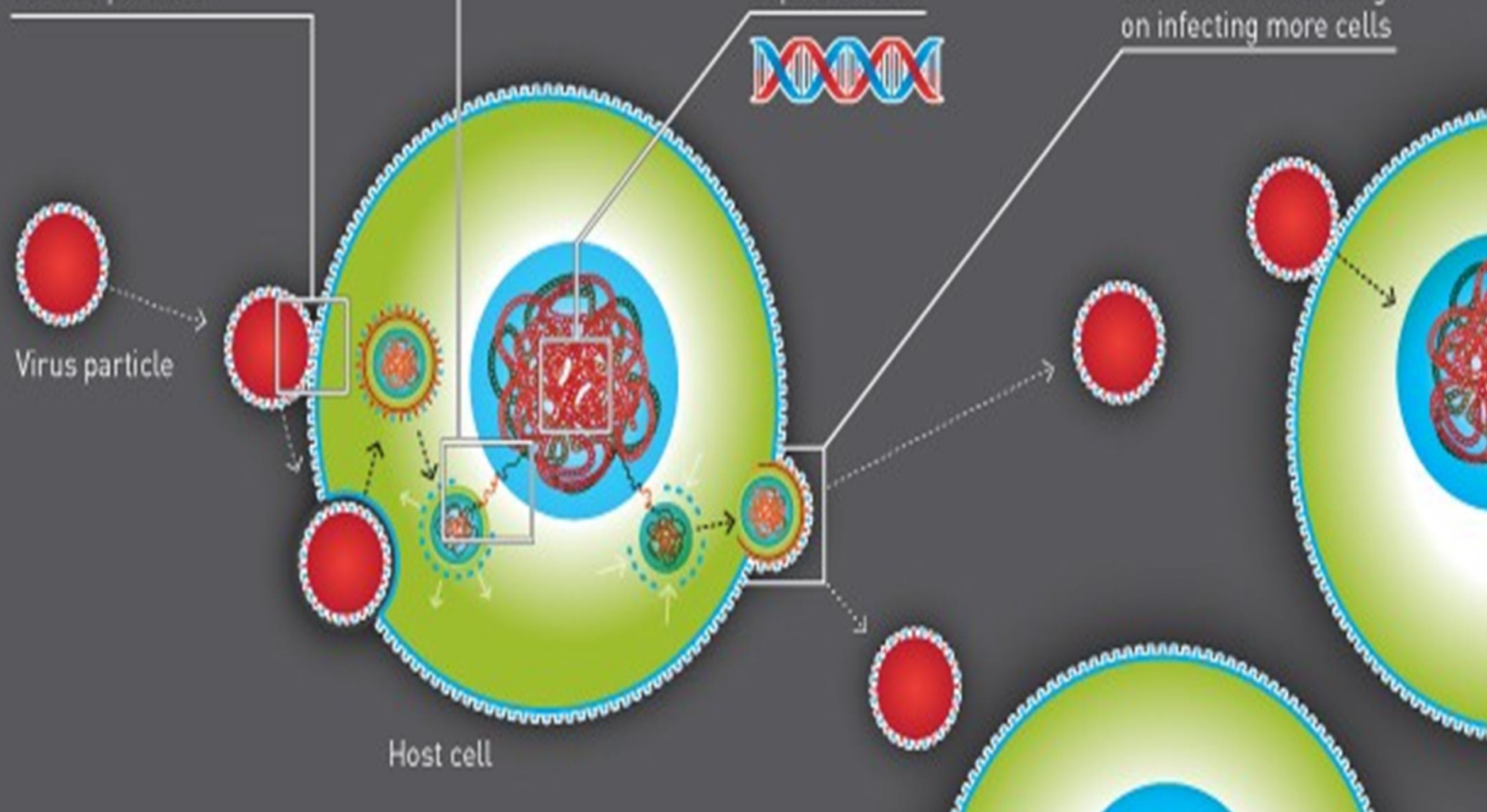
Then the virus' genetic material (DNA or RNA) goes inside the host cell

## Stage 3

The virus DNA or RNA 'takes over' the host cell machinery, making lots of copies of itself

## Stage 4

After the virus has replicated, the new virus particles break off from the host cell and can go on infecting more cells

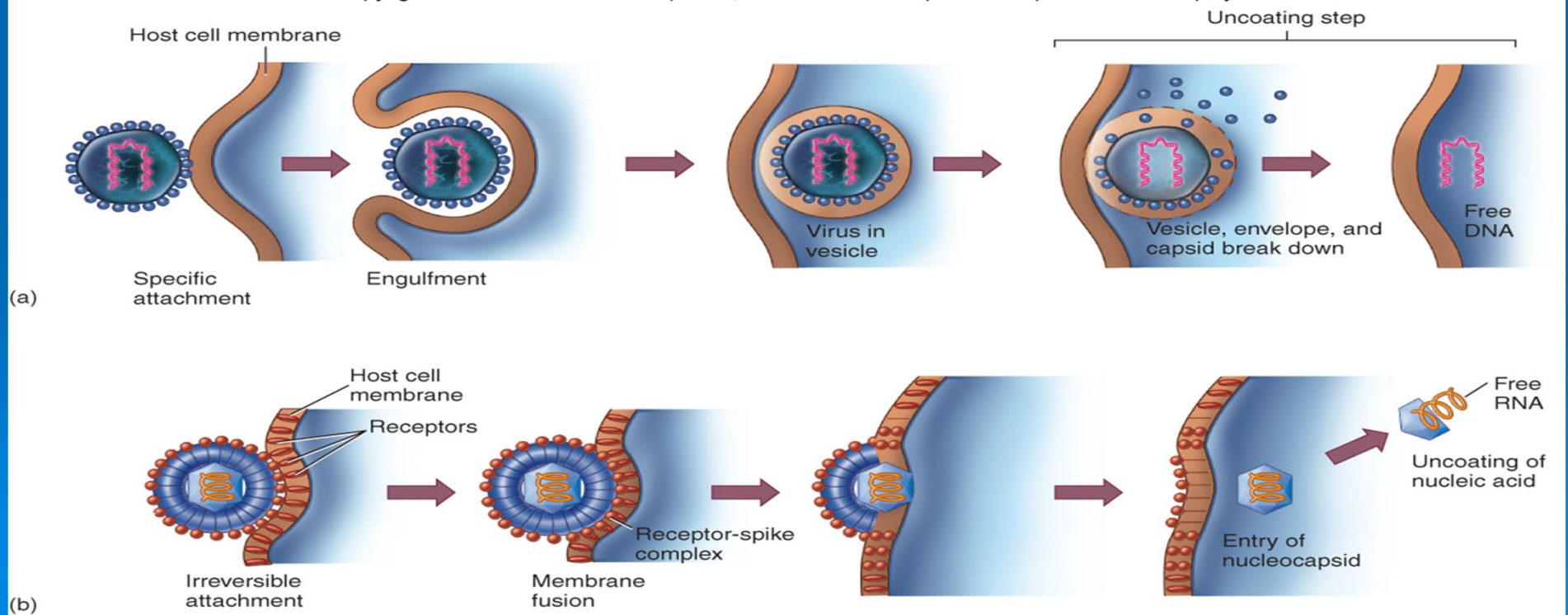




# Penetration

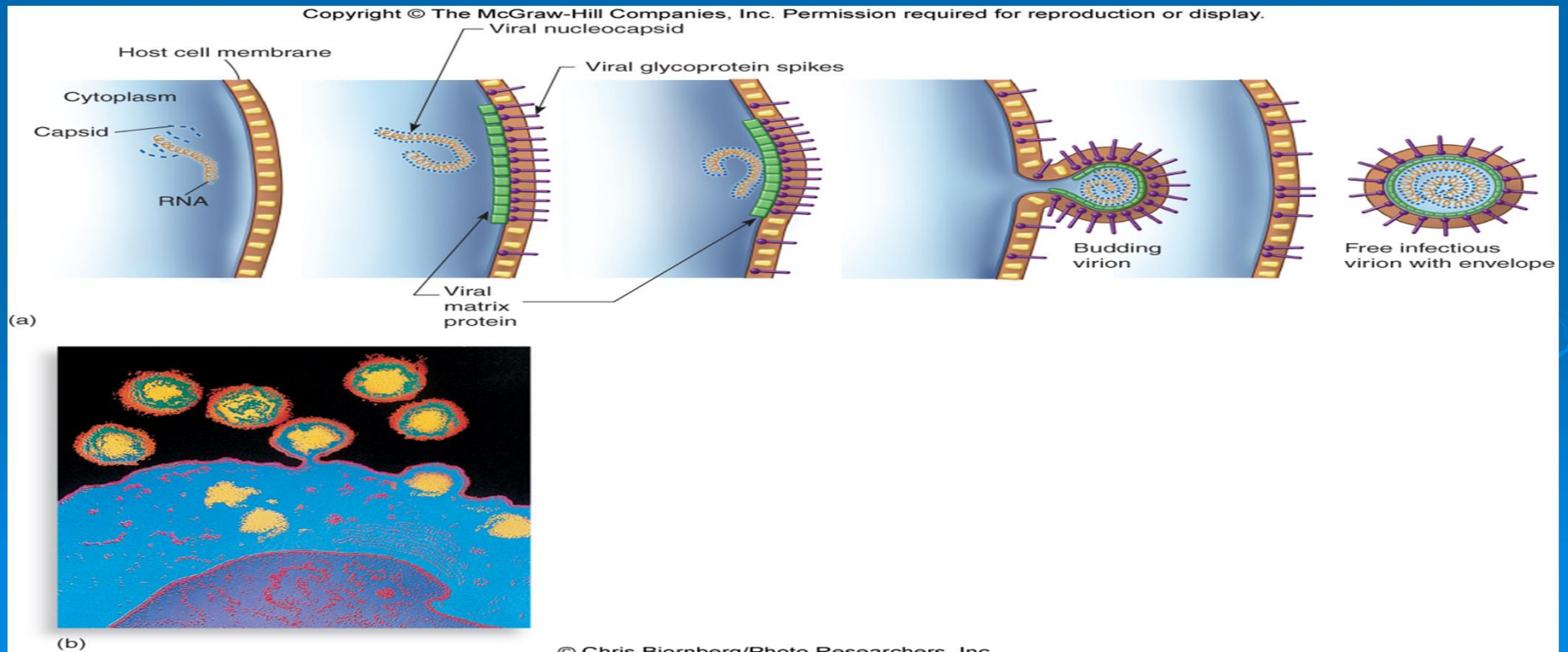
- Endocytosis , the viral particle is taken up inside the cell, in which the virus is accumulated inside cytoplasmic vacuole.
- Fusion ,in cases of enveloped viruses , the virus fuses with plasma membrane and enter into host cell

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## Uncoating

- Uncoating is removing the capsid proteins .
- A low pH within the vesicle and presence of cellular enzymes.
- which lead to dissolve the proteins of capsid, then result in uncoating and release of viral nucleic acid into infected host cell



# Effects of the virus on the host cell

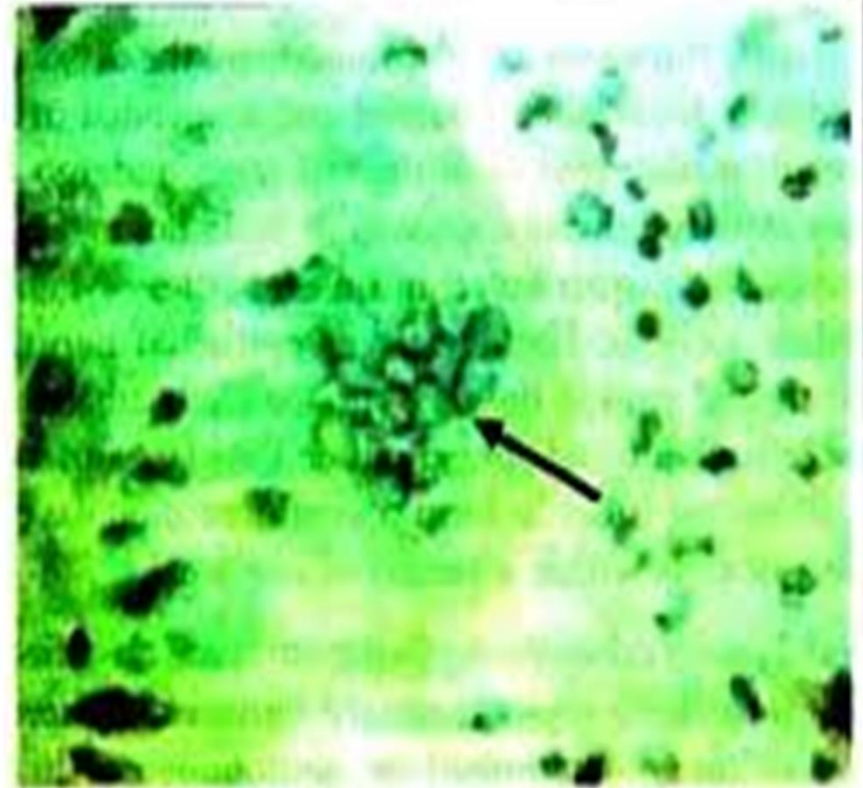
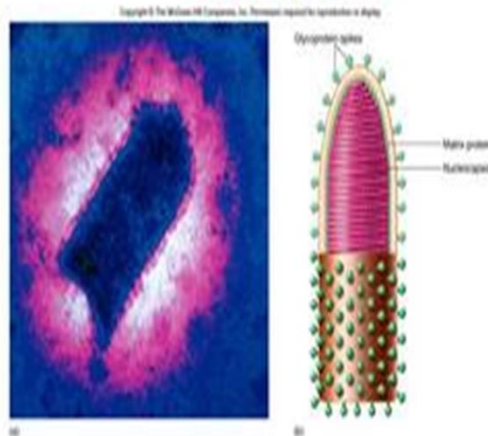
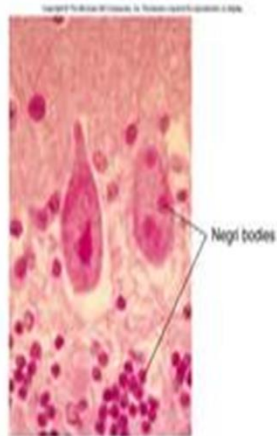
Cytopathic effects – are visible effects on the host cell caused by viral replication

- ▶ **Inclusion bodies** – site of active virus synthesis
  - Negri bodies of rabies virus
- ▶ **Syncytia formation** – giant, multinucleated cells formed by the fusion of plasma membranes example :Measles virus
- ▶ **Chromosomal damage**
  - Inhibition of host cell protein, RNA, or DNA synthesis , example :Poliovirus



# Rabies

- Causative agent:
  - Rabies virus
    - Lyssavirus
    - Enveloped ssRNA
    - Spiked bullet shaped virus
  - Virus multiplies in brain forming Negri bodies



**Fig. 13.1:** Syncytium (multinucleated giant cell) formation caused by measles virus (lung biopsy tissue of a case of viral-induced giant cell pneumonia).



## Some viral diseases



**Herpes virus**



**Measles virus**



**Hepatitis virus**



**Warts caused by  
papillomavirus**

**Table:** Comparison of medical important organisms.

<b>Characteristic</b>	<b>viruses</b>	<b>bacteria</b>	<b>fungi</b>	<b>protozoa</b>
Cells	no	yes	yes	yes
Diameter (µm)	0.02-0.3	1-5	3-10(yeasts)	15-25 (trophozoites)
Nucleic acid	either DNA or RNA	both	both	both
Type of nucleus	none	prokaryotic	eukaryotic	eukaryotic
Mitochondria	absent	absent	present	present
Ribosome	absent	70s	80s	80s
Nature of outer surface proteins	capsid and lipoprotein envelope	rigid wall contain peptidoglycan	rigid wall with chitin	flexible membrane
Motility	none	some	none	most
Method of replication	not binary fission	binary fission	budding or mitosis	mitosis


➤ **Infection:** The potential microbial pathogens have ability to cause disease(infection) in host. **Infection**(in general) is presence and multiplication of pathogenic microbe within human body ,and cause clinical symptoms.

➤ **Pathogen:** microbial infecting agent cause infection in human and other organisms.

**Characters of pathogen :**

- 1. Pathogenic organisms should be able to enter the host body.
- 2. Pathogenic organisms should be able to multiply in tissue.
- 3. Pathogenic organisms should be able to damage the tissue.
- 4. They must be capable of resisting the host defense

## Why do particular individuals get particular infections?

- ▶ Defect or suppress in immune system.
  - ▶ Disorder in physiologic state and hormones.
  - ▶ Stress ; increased susceptibility to infection due to steroid therapy
  - ▶ Pregnancy ; hepatitis viruses during pregnancy result in more lethal outcome. UTI and pyelonephritis are more common in pregnant.
  - ▶ Malnutrition; lead to more severe and more lethal in some infection
  - ▶ Personal hygiene.
  - ▶ Lifestyle.
- 



- **Normal microbial flora:** Are various non pathogenic bacteria and yeasts are permanent residents of certain body sites (especially skin, mouth, colon and vagina) without cause any disease.
- They have important role in GIT. They may produce some nutrients such as vitamin B or vitamin K.
- They have ability to limit the growth of pathogenic organism and Compete for nutrients with potential pathogens.
- **Commensalisms:** is the association between two organisms in which one partner (commensal) is benefit and other (host) is neither benefit nor harmed.

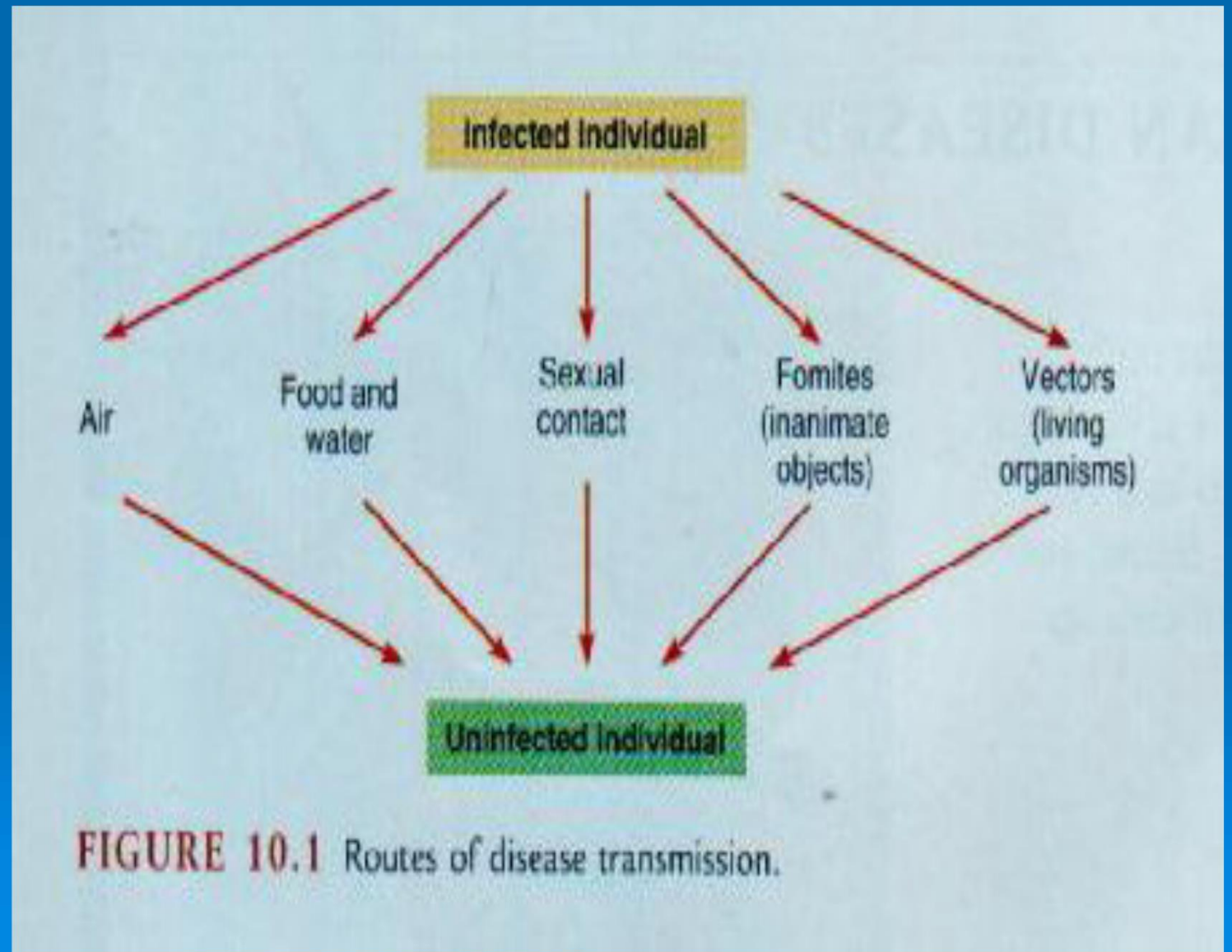
**Carrier:** is the person recovered from disease but harboring pathogenic organism in his body

# What influences the outcome of infection?

- The predisposing factors that involved in the development of infections include mainly three factors:
  - 1. Microbial factors.
  - 2. Susceptible host.
  - 3. Environmental factors.

# Main sources of infection

- Human
- Animals
- Soil
- Food
- Water
- Air



# Mode of disease transmission

- ▶ Direct when host directly contacts the source of infection or microbial reservoirs(microbial reservoirs include human, animal, water, food, air and soil),
- ▶ indirect when the host encounters the microorganisms by intervening agent of transmission. The intervening agents of transmission that bring microorganisms from reservoir to host may be living entity, in which case they are called **vectors**( such as animals, insects, others) or they may be non-living entity referred to as **vehicles**( such as water, food, air, medical devices





## Classification of bacteria

### 1. Gram positive

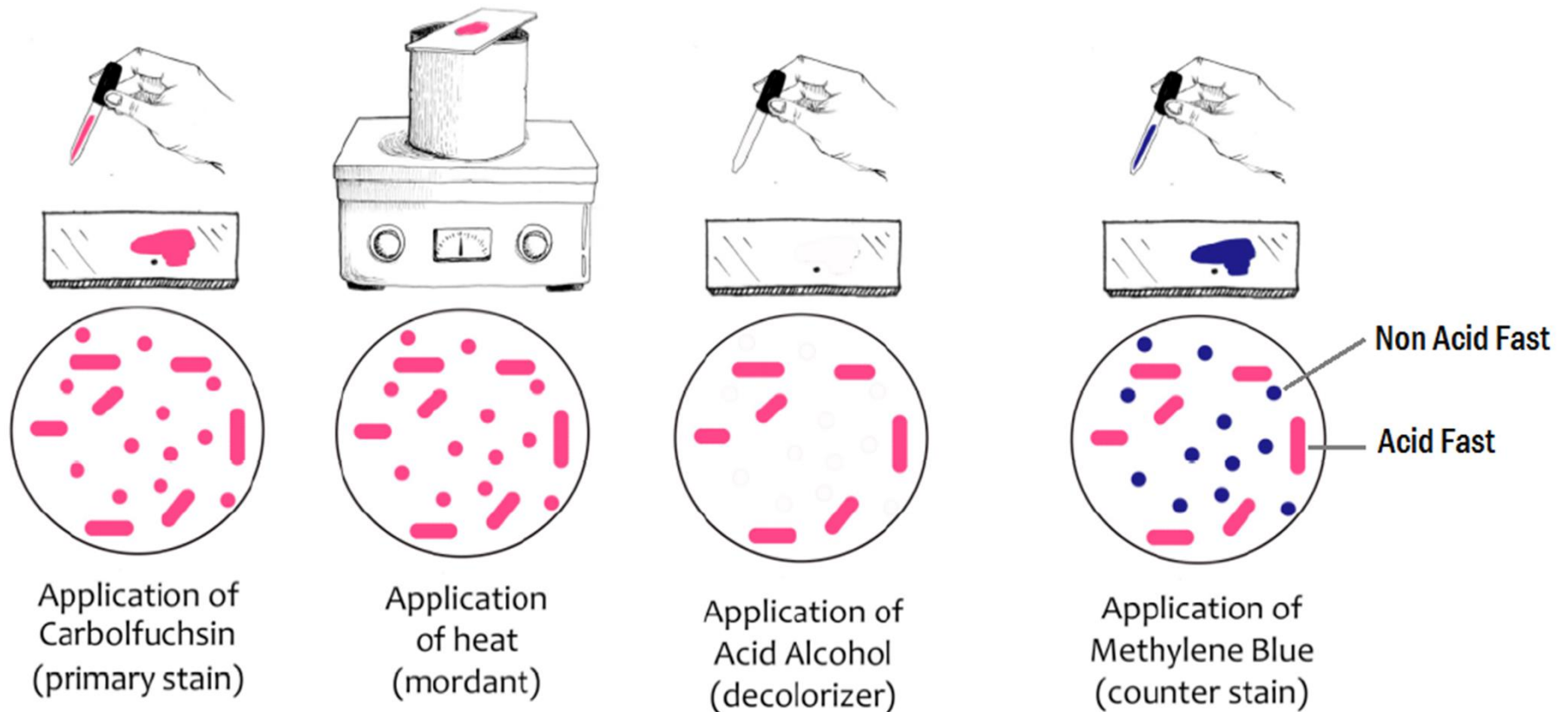
- Rods (bacilli)
- Cocci

### 1. Gram negative

- Can be further divided into anaerobic and aerobic

## Principle of Acid-Fast Stain

It is the differential staining techniques which was first developed by Ziehl and later on modified by Neelsen. So this method is also called Ziehl-Neelsen staining techniques. Used to stain Mycobacterium species including *M. tuberculosis*, *M. ulcerans*



# Ziehl-Neelson Staining Method (Hot Method)

Acid-Fast Bacteria

Other types of bacteria

Primary Stain (Carbolfuchsin)

\*\*\*\*\* *(WITH HEATING)* \*\*\*\*\*

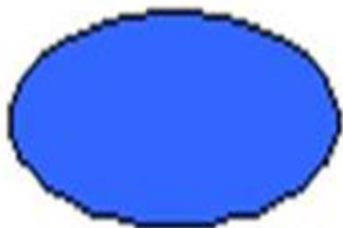
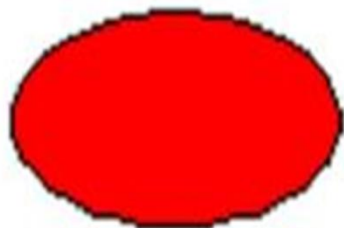
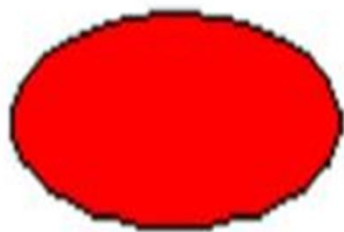
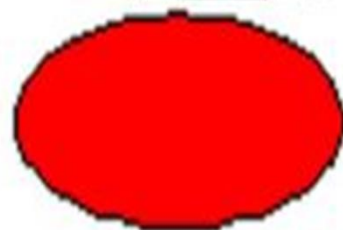
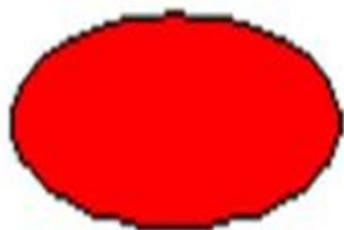
Washing Step

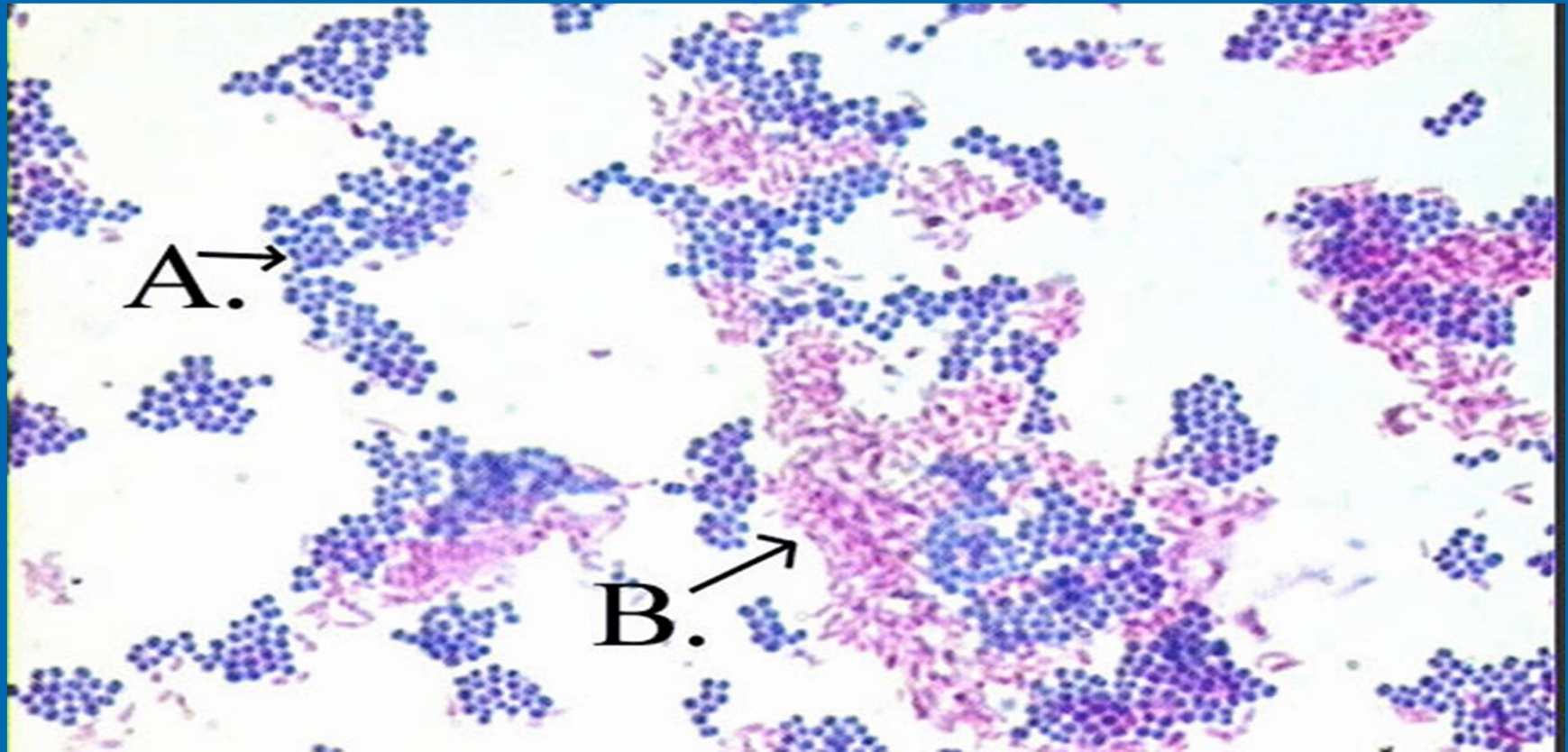
Decolorization Step by using acid-alcohol

Washing Step

Counter stain  
(Methylene Blue)

Washing Step





B :Acid fast: Bright red to intensive purple Red, straight or slightly curved rods, occurring singly or in small groups, may appear beaded. A:Non-acid fast: Blue color



## **Biochemical of bacteria to become resistant to antibiotics**

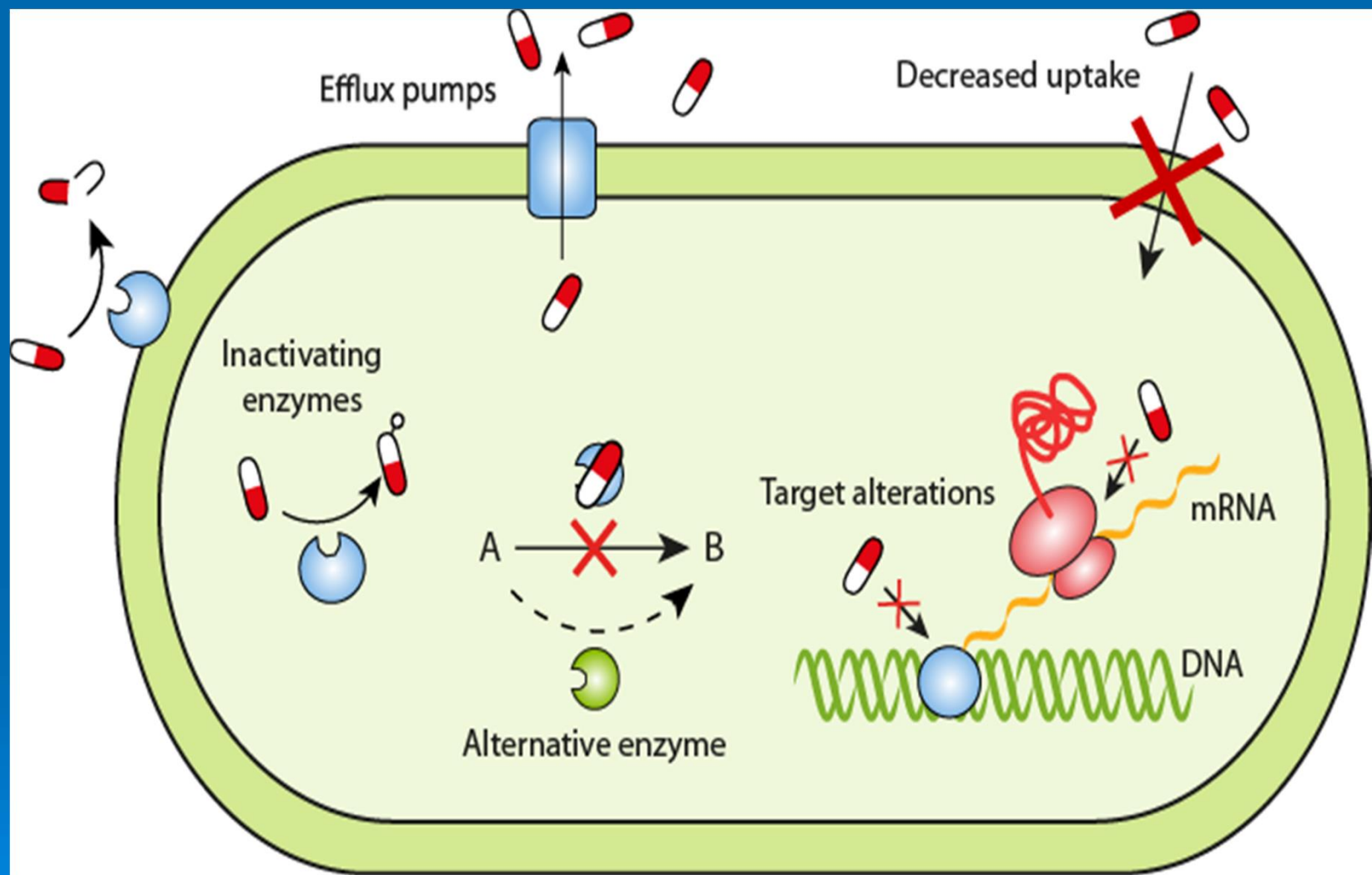
**1-Pump the antibiotic out from the bacterial cell.**

**2-Decrease permeability of the membrane that surrounds the bacterial cell**

**3-Destroy the antibiotic**

**4-Modify the antibiotic.**





## Genetic basis of bacterial susceptibility and resistance to antibiotics

**1-Transformation:** Uptake of DNA from the environment, incorporation into the genome, and gene expression formation.

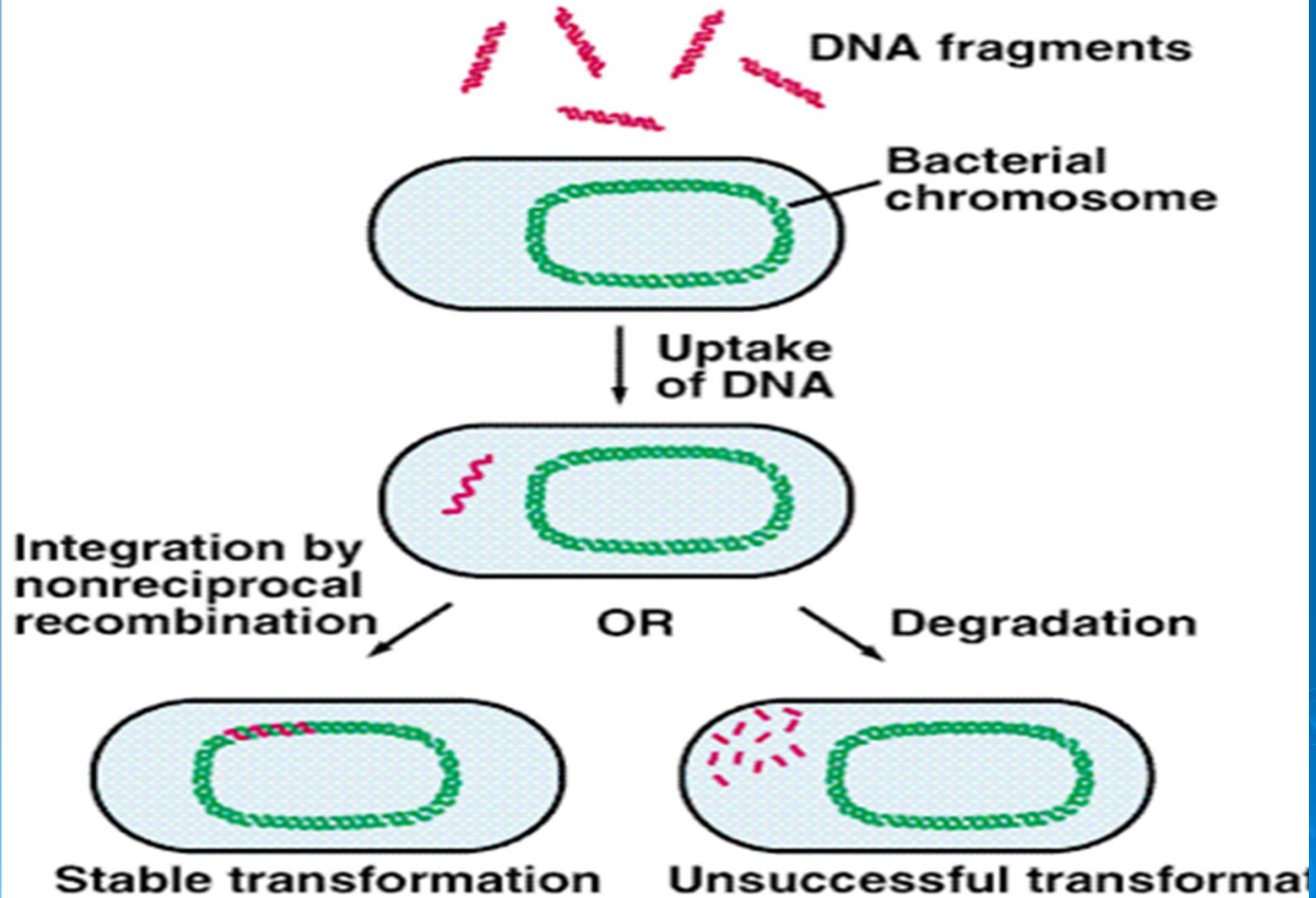
**2-Transduction:** The insertion of genetic material from a virus (Bacteriophage), and incorporation into the genome

**3-Vertical Gene Transfer:** Transfer of genetic material from parent to daughter cell (Generational Inheritance)



(a) Transformation with DNA fragments

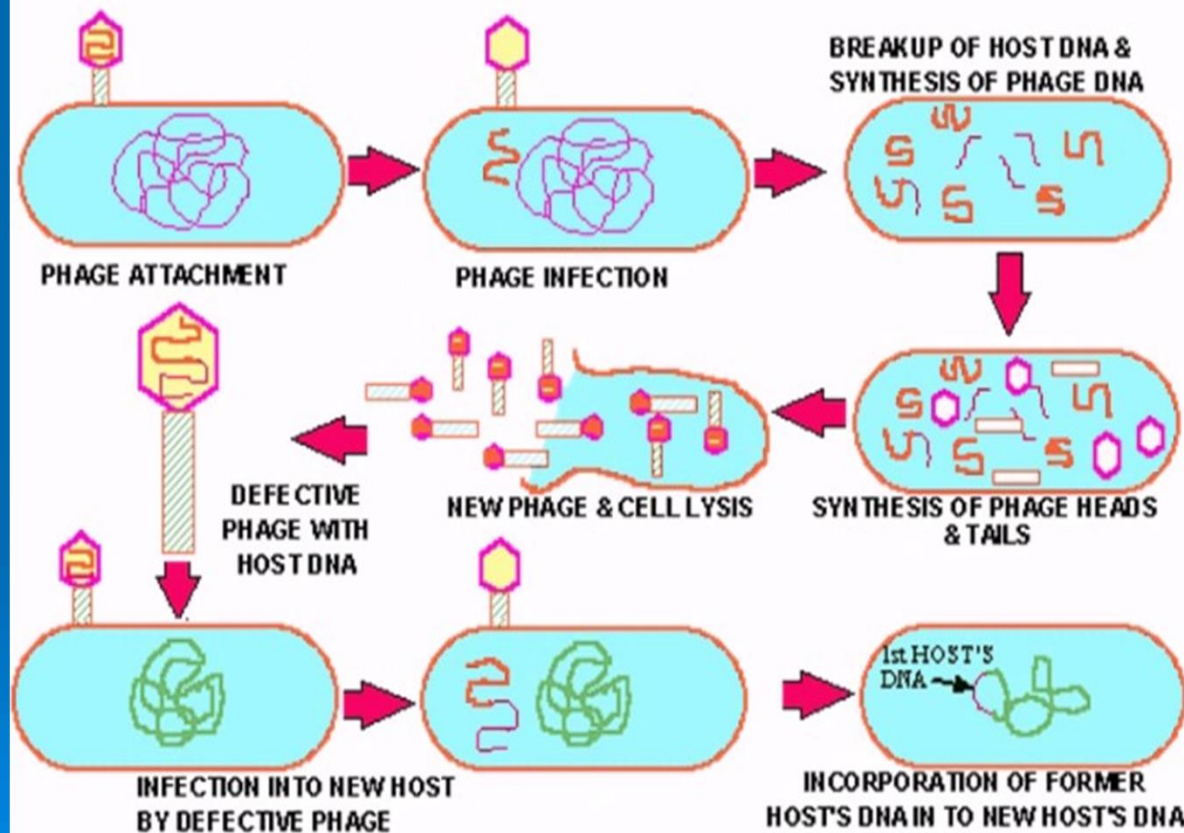
(b) T





# Transduction

**Transduction** is the process by which DNA is transferred from one bacterium to another by a virus



Does not need physical contact like conjugation

Dnase resistant

