

# *Viruses*

# *Part I*

## **Content:**

- History of Viruses.
- General properties of viruses.
- Viral structure.
- Viral classifications.
- Virus-like agents.

# *History*

- Through the 1800s, many scientists discovered that something smaller than bacteria could cause disease and they called it **virion** (*Latin word- poison*)
- In the 1930s, after the invention of **electron microscopes**, viruses finally could be seen.
- The first photographs of viruses were obtained in 1940.

# *Viruses*

## ➤ **Virus:**

It is a microorganism smaller than a bacterium and it cannot grow or reproduce apart from a living cell.

## ➤ **Virology:**

Study of viruses

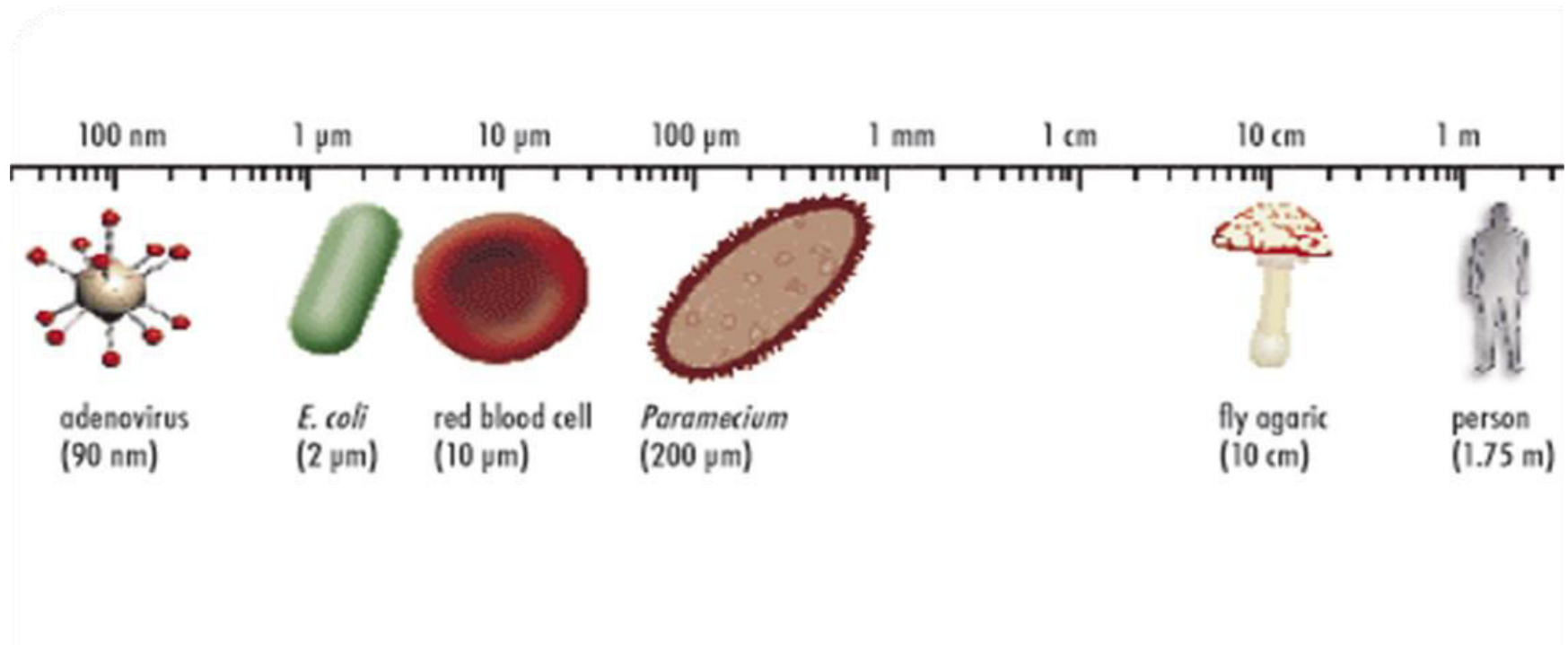
# *General Properties of Viruses*

- They are a cellular microbes.
- They can't produce energy (no ATP generating system)
- They lack the ribosomes that necessary for protein production.
- They are unable to replicate on their own (Viruses must invade live host cells to replicate).

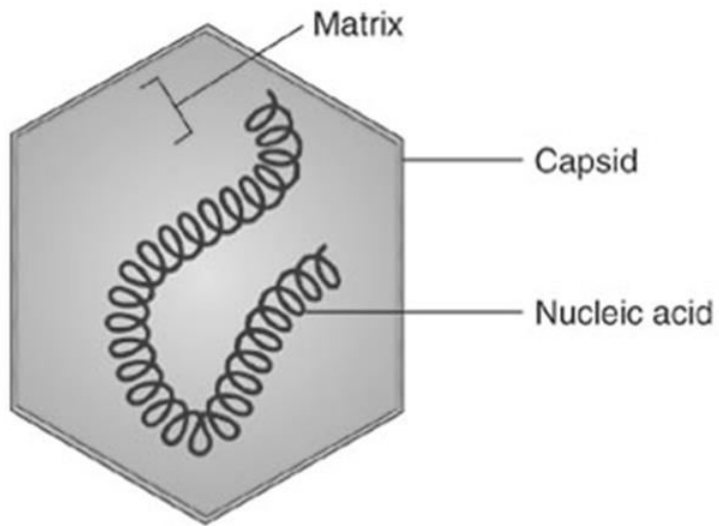
# *General Properties of Viruses*

- They have either DNA or RNA (living cells have both).
- Their sizes ranging from 10 to 300 nm (viruses can be seen only by the electron microscope).
- They can infect all types of life forms, from humans, animals and plants to bacteria and archaea.

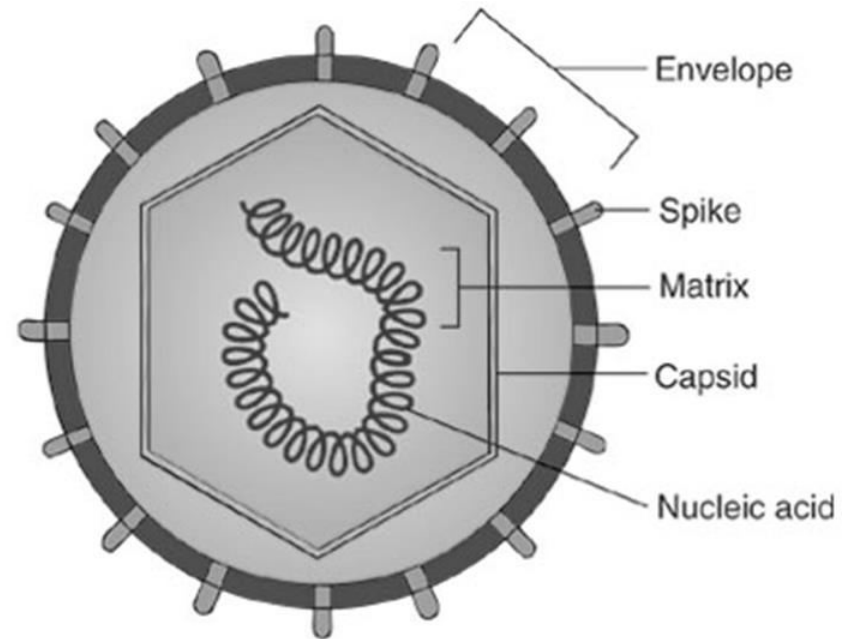
# *Viral size*



# *Structure of virus*



(a) **Naked Nucleocapsid Virus**



(b) **Enveloped Virus**



# *Structure of virus*

## **1) Genome:**

The nucleic acid (NA) material containing the genetic information and its either DNA or RNA.

## **2) Capsid:**

A protein structure designed to protect the genome. It is composed of many small protein units called *capsomeres*.

## **3) Envelope:**

A lipid bilayer membrane found in some viruses.

# *1-Virus Genome*

- Viruses have either DNA or RNA, never both.
- Viral NA are usually circular but some are linear.
- Both DNA and RNA can be Single Strand (ss) or Double Strand (ds). Based on that viruses have four categories:

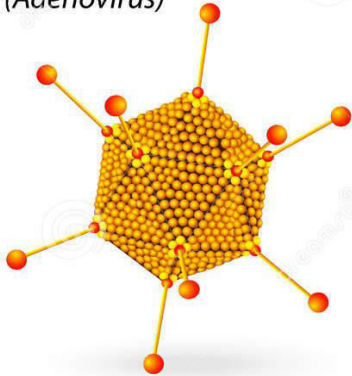
1. **ss DNA viruses**
2. **ds DNA viruses (most common)**
3. **ss RNA viruses (most common)**
4. **ds RNA viruses**

## *2- Capsid*

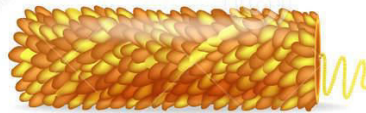
- The capsid is designed to give shape, size, and protect the virus NA from environmental damage.
- Capsid and NA are called “**neocleocapsid**” or “naked virus”.
- Capsids of viruses have different shapes. Based on that viruses can be classified into:
  1. **Helical viruses (coiled tubes).**
  2. **Icosahedral viruses (many sided).**
  3. **Bullet shaped viruses.**
  4. **Spherical viruses.**
  5. **Complex viruses (combination of shapes).**

# VIRAL SHAPES

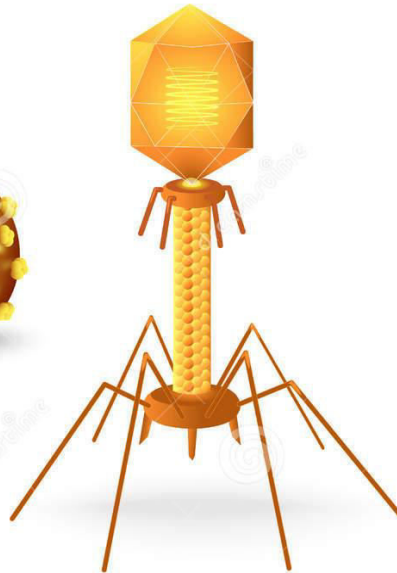
**Polyhedral**  
(Adenovirus)



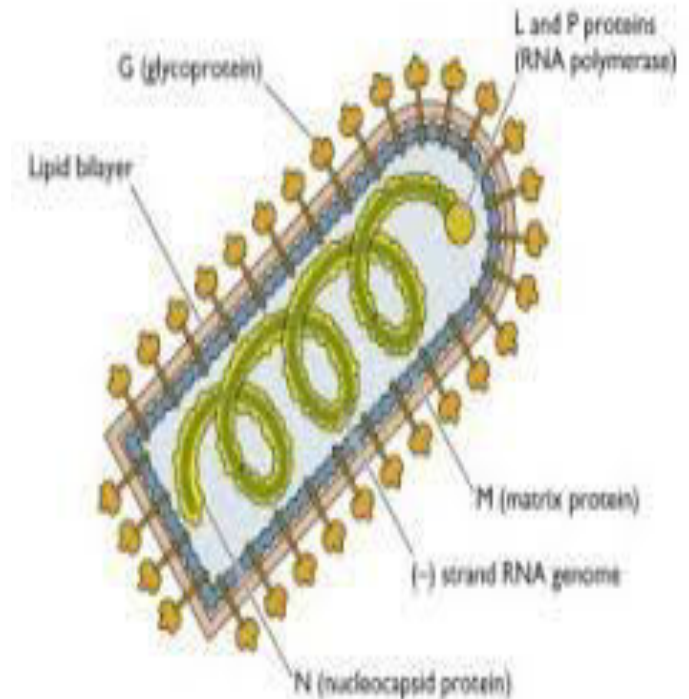
**Spherical**  
(Influenza)



**Helical**  
(Tobacco mosaic virus)



**Complex**  
(Bacteriophage)



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### *3- Envelope*

- Lipid bilayer membrane surrounding the nucleocapsid, and used in defining a viral family
- The virus that is not enveloped is referred to as “*naked virus*”.
- The envelope is derived from the host cell membrane or nuclear membrane and never made by the viruses themselves.
- Then, viruses can alter these membranes by adding protein spikes and knobs which are important in viral attachment to the host cells.

# *Classification of Viruses*

Viruses can be classified by the following characteristics:

1. Type of genetic material (DNA or RNA).
2. Shape of capsid.
3. Number of capsomeres.
4. Size of capsid.
5. Presence or absence of an envelope.
6. Type of host that it infects.
7. Type of disease that it produces.
8. Target cells.
9. Immunologic or antigenic properties.

# *Virus-Like Agents*

## **Viroids**

- ss RNA without protein coat or envelop
- Cause different plant diseases (plant pathogens)

## **Prions**

- Composes of protein without genome (no DNA or RNA)
- Cause fatal neurological disease in animals such as **Mad cow disease** and **Creutzfeldt-Jakob disease** (CJD) in human

# *Part II*

## **Content:**

- Viral replication
- Types of viral infection
- Prevention of viral infections
- Treatment
- Examples of viral infections



# *Three problems every virus must solve*

- 1) How to reproduce during its “visit” inside the cell and cause diseases.
- 2) How to spread from one individual to another.
- 3) How to evade the host defenses.

# *Virus Replication*

- **It is the ability of viruses to infect or invade the target cell and multiply inside it and subsequent escape outside the cell.**

# *Virus Replication Steps*

## **1) Attachment (adsorption) :**

It involves attachment of viral surface proteins or spikes to the cell surface receptor proteins

## **2) Penetration:**

The entire virus enters the cells.

## **3) Un-coating:**

Release of the viral genome from its protective capsid to enable the viral NA to replicate.

# *Virus Replication Steps*

## **4) Biosynthesis:**

This step result in the production of pieces /parts of viruses (e.g. viral DNA and viral proteins)

## **5) Assembly:**

The viral parts are assembled to create complete viruses inside the host cell

## **6) Release:**

Escape of the complete viruses from the host cell.

Naked viruses >> Cell lysis (cell death).

Enveloped viruses >> Budding.

Host Cell Cytoplasm

Cell membrane

Receptors

Spikes

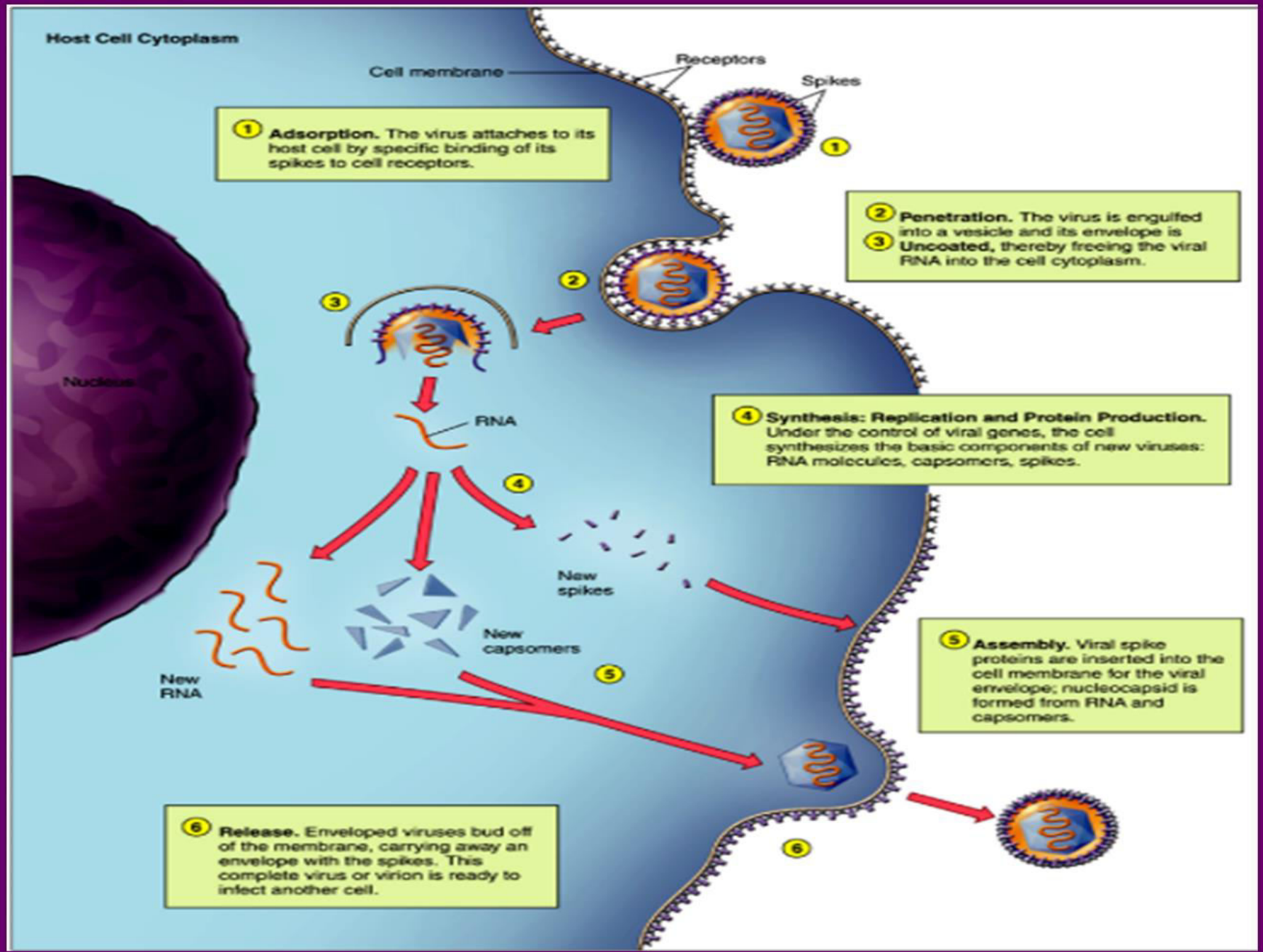
**1 Adsorption.** The virus attaches to its host cell by specific binding of its spikes to cell receptors.

**2 Penetration.** The virus is engulfed into a vesicle and its envelope is  
**3 Uncoated,** thereby freeing the viral RNA into the cell cytoplasm.

**4 Synthesis: Replication and Protein Production.** Under the control of viral genes, the cell synthesizes the basic components of new viruses: RNA molecules, capsomers, spikes.

**5 Assembly.** Viral spike proteins are inserted into the cell membrane for the viral envelope; nucleocapsid is formed from RNA and capsomers.

**6 Release.** Enveloped viruses bud off of the membrane, carrying away an envelope with the spikes. This complete virus or virion is ready to infect another cell.

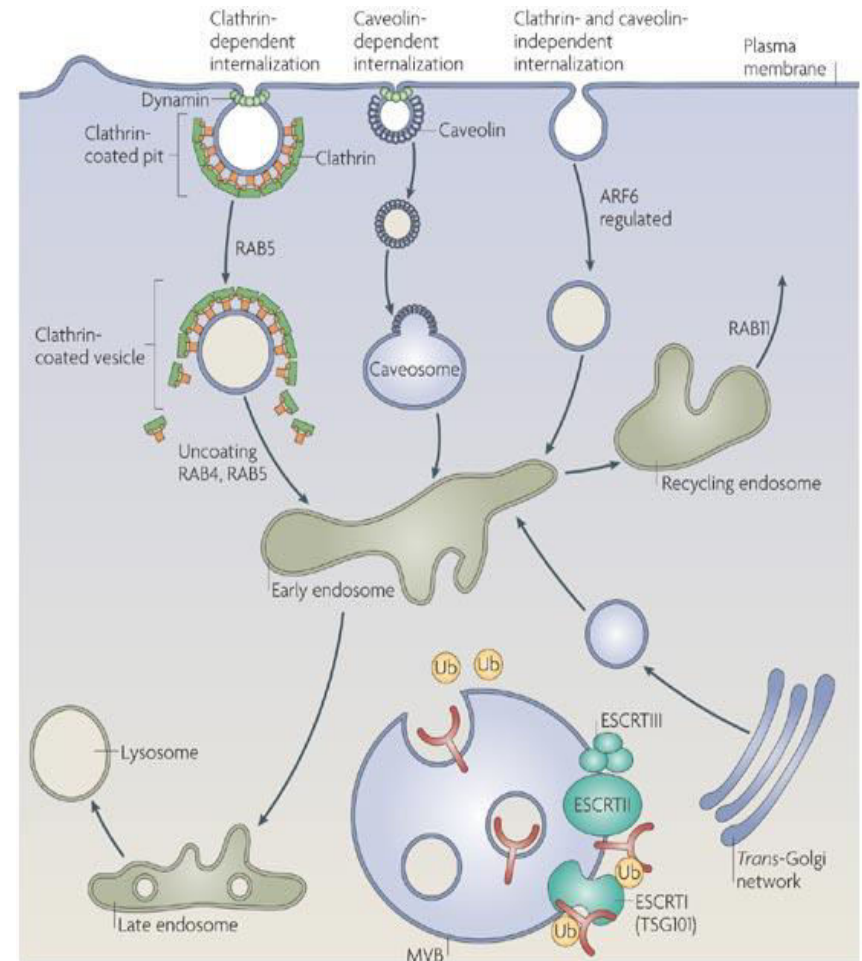


## Penetration Step

A. Some enveloped viruses fuse directly with the plasma membrane. Thus, the internal components of the virion are immediately delivered to the cell cytoplasm of the cell.

## B. Entry via **endosomes** at the cell surface.

- Some viruses are unable to fuse directly with the plasma membrane. These viruses are taken into endosomes. Then internal components of the virus is released into the cytoplasm of the cell.



# *Viral Infections*

## **Terminology**

- Bacteriophage:

Viruses that infect bacteria.

- Oncogenic viruses:

Viruses that can cause specific types of cancers **e.g.** leukemia, lymphomas.

- Cytopathic effects:

It is the structural and biochemical effects that viruses have on the host cell.



# Overview of Viral infections

## Encephalitis/ meningitis

- JC virus
- Measles
- LCM virus
- Arbovirus
- Rabies

## Common cold

- Rhinoviruses
- Parainfluenza virus
- Respiratory syncytial virus

## Eye infections

- Herpes simplex virus
- Adenovirus
- Cytomegalovirus

## Pharyngitis

- Adenovirus
- Epstein-Barr virus
- Cytomegalovirus

## Gingivostomatitis

- Herpes simplex type 1

## Parotitis

- Mumps virus

## Pneumonia

- Influenza virus, Types A and B
- Parainfluenza virus
- Respiratory syncytial virus
- Adenovirus
- SARS coronavirus

## Cardiovascular

- Coxsackie B virus

## Hepatitis

- Hepatitis virus types A, B, C, D, E

## Myelitis

- Poliovirus
- HTLV-I

## Skin infections

- Varicella zoster virus
- Human herpesvirus 6
- Smallpox
- Molluscum contagiosum
- Human papillomavirus
- Parvovirus B19
- Rubella
- Measles
- Coxsackie A virus

## Gastroenteritis

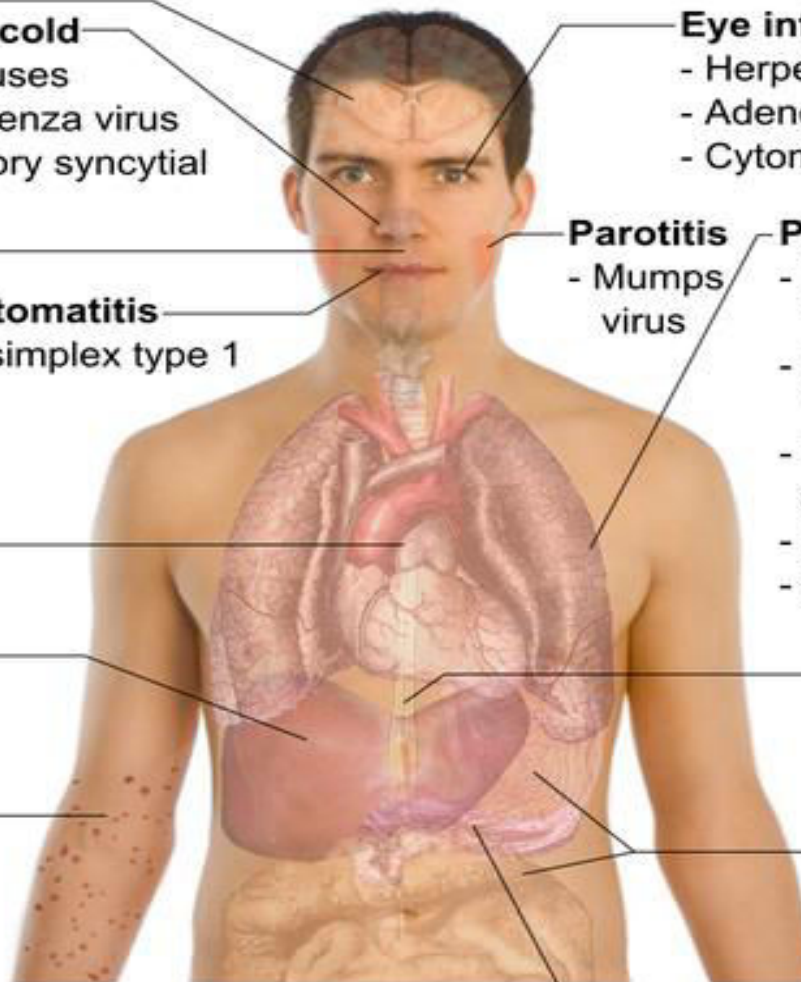
- Adenovirus
- Rotavirus
- Norovirus
- Astrovirus
- Coronavirus

## Sexually transmitted diseases

- Herpes simplex type 2
- Human papillomavirus
- HIV

## Pancreatitis

- Coxsackie B virus



# *Types of Viral Infections*

- **Lytic Infection** → Host cell dies at the end of virus replicative cycle (e.g. influenza & polio)
- **Persistent Infection** → Host cell remains alive and continues to produce progeny virions (e.g. Hepatitis B infections)

# *Types of Viral Infections*

- **Latent Infections** → Host cell remains alive, and viruses enter a dormant state where it does not replicate until some trigger causes them to activate and replicate again. (e.g. HIV & Herpes infections).
- **Transformation Infections** → Infected host cell is transformed by the virus. (those are viruses that carry oncogenes which may lead to cancer in host cells) (e.g. HBV, HCV).

# *Prevention of Viral Infections*

- By using vaccines (Vaccines are available to prevent over 13 viral infections of humans)

## **Types of Vaccines:**

- 1. Live vaccines (attenuated ):** contain weakened forms of the virus, which do not cause the disease but triggers immunity. Live vaccines can be dangerous when given to people with a weak immunity (immunocompromised). **e.g.** MMR vaccine
- 2. Killed vaccines:** contain killed, but previously virulent, micro-organisms that have been destroyed with chemicals, heat, radioactivity or antibiotics. **e.g.** influenza vaccine
- 3. Subunit vaccines:** produced by biotechnology and genetic engineering techniques. These vaccines use only the capsid proteins of the virus. **e.g.** Hepatitis B vaccine

# *Treatment of Viral Infections:*

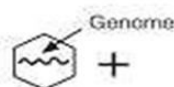
## *Antiviral Drugs*

- Until recent years, there were no drugs for the treatment of viral infections.
- Antiviral drugs are difficult to develop and use because viruses are produced within host cells.
- Antiviral drugs work by inhibiting viral replication inside cells.
- **NB:** Antibiotics are not effective against viral infections.

# *Examples of Viral Infections*

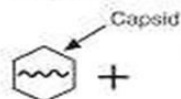
## RNA Viruses

**Picornavirus**



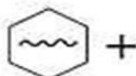
C = 32  
22-30 nm

**Astrovirus**



C = 32?  
30-35 nm

**Calicivirus**



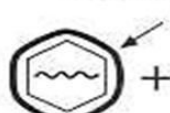
C = 32 (holes)  
35-39 nm

**Flavivirus**



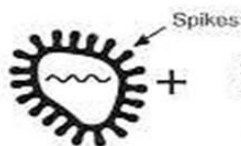
Icosahedral  
45-50 nm

**Togavirus**



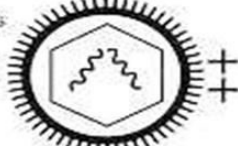
Icosahedral  
70 nm

**Coronavirus**



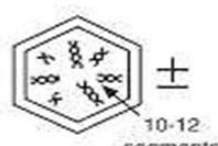
Pleomorphic  
120-160 nm

**Retrovirus**



Icosahedral  
90-120 nm

**Reovirus**



C = 132  
60-80 nm

**Bunyavirus**



90-120 nm

**Orthomyxovirus**



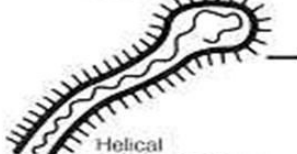
Helical, Pleomorphic  
80-120 nm

**Arenavirus**



Pleomorphic  
110-130 nm

**Filovirus**



Helical  
80x800-2500 nm

**Rhabdovirus**



Helical  
60x180 nm

**Paramyxovirus**



Helical, Pleomorphic  
150-300 nm

## DNA Viruses

**Circovirus**



Icosahedral  
17-22 nm

**Parvovirus**



C = 12  
18-26 nm

**Hepadnavirus**



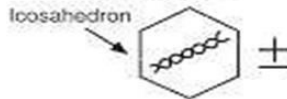
C = 180 Icosahedral  
40-48 nm

**Papovavirus**



C = 72  
45/55 nm

**Adenovirus**



C = 252  
75-80 nm

**Herpesvirus**



C = 162  
150-200 nm

**Poxvirus**



Complex  
240x300 nm

# DNA viruses

```
graph TD; A[DNA viruses] --> B[Non enveloped]; A --> C[Enveloped]; B --> D[Human papilloma virus (ds)]; C --> E[Herpesviruses (ds)];
```

Non enveloped

Human papilloma virus (ds)

Enveloped

Herpesviruses (ds)



# *Herpes Infections*

## ➤ **Herpes type 1 ( Fever blisters or Cold sores):**

- Infection in the skin or mucus membrane of the mouth and lips
- Caused by Herpes Simplex Virus (HSV) Type 1

## ➤ **Herpes type 2 (Genital Herpes):**

- Infection in the skin or mucus membrane of the genitalia
- Caused by HSV Type 2

# *Herpes Infections*

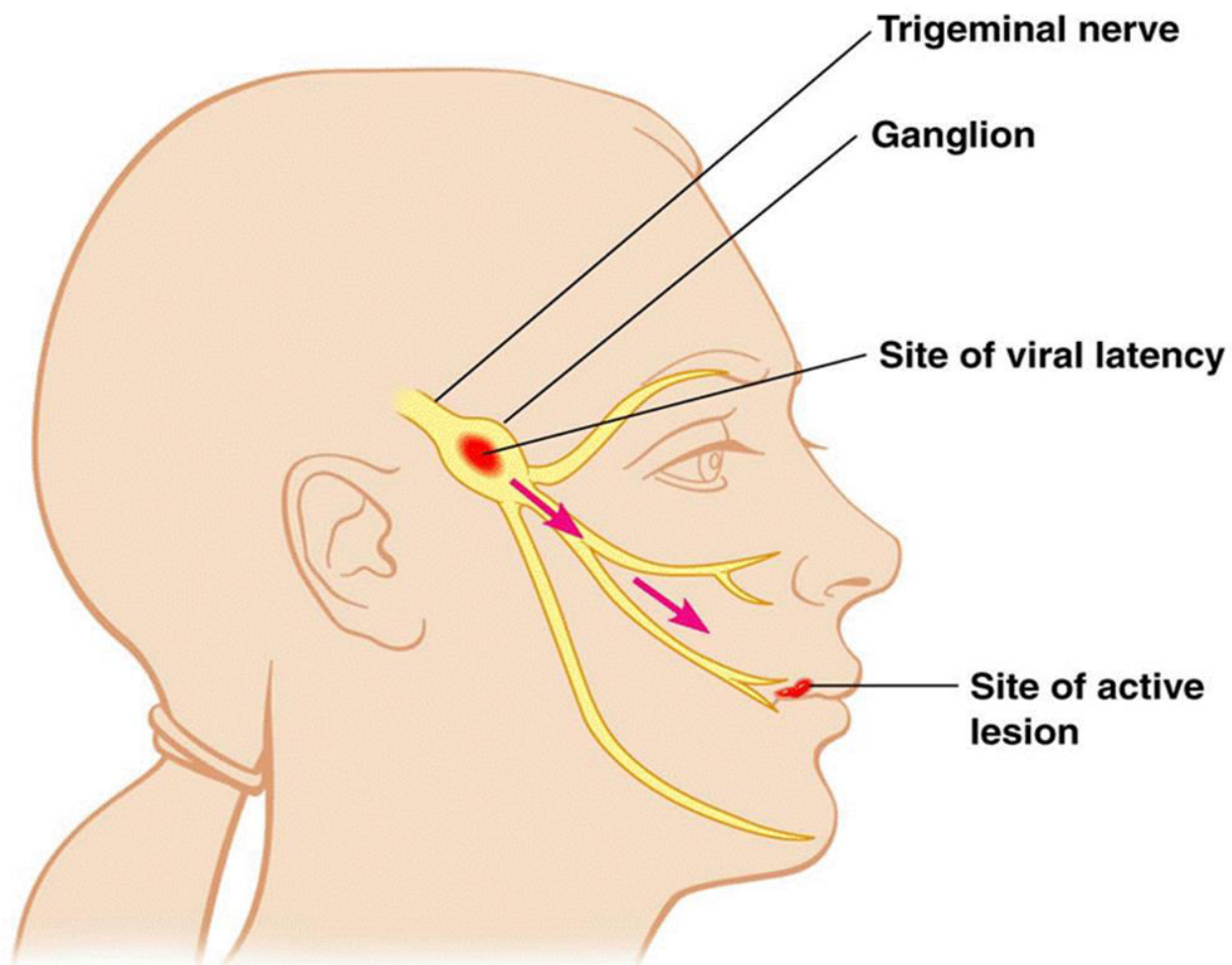
- **Herpes type 1 (Fever blisters or Cold sores):**
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  - Caused by Herpes Simplex Virus (HSV) Type 1
  
- **Herpes type 2 (Genital Herpes):**
  - Infection in the skin or mucus membrane of the genitalia
  - Caused by HSV Type 2

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- **Symptoms:** sores or blisters around the mouth and lips, or around the genitals
- **Transmission:** through close contact with infected person, sexual contact.
- *Primary infection:* a lesion called **Blister** which is watery and cause itching.
- When the blister is healed the **virus shed to the nerve to hide from the immune system.**
- *latent infection:* recurrent infection can happen when there is a decrease in the immunity.

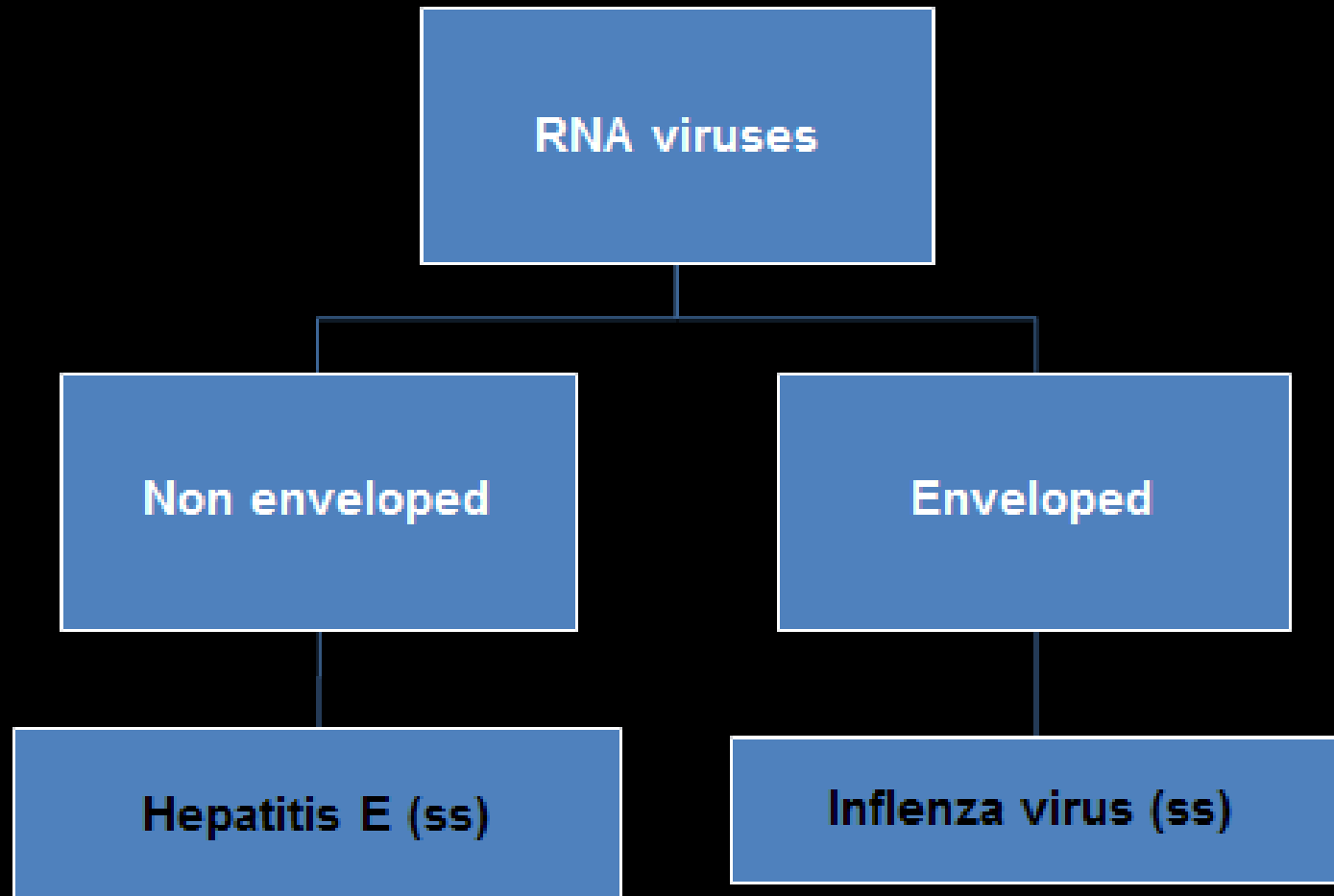


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Figure 1

# *Human papillomaviruses*

- It is also called Wart viruses
- It is sexually transmitted disease.
- Can cause different types of cancers  
(**Transformation infection**).



# *Influenza (Flu)*

- **Caused by** Influenza virus
- There are 3 types of influenza viruses:
  1. **Influenzavirus A:** causes severe symptoms and it is the causes of all flu pandemics, ex: Swine Flu .
  2. **Influenzavirus B:** cause less sever symptoms.
  3. **Influenzavirus C:** usually do not cause significant disease.

# *Influenza (Flu)*

Influenza viruses are constantly changing. They change in two different ways:

## ➤ **Antigenic Drift:**

Small changes in the genes of influenza viruses that happen continually as the virus replicates. (These small genetic changes usually produce viruses that are pretty closely related to one another so the immune system can recognize them).

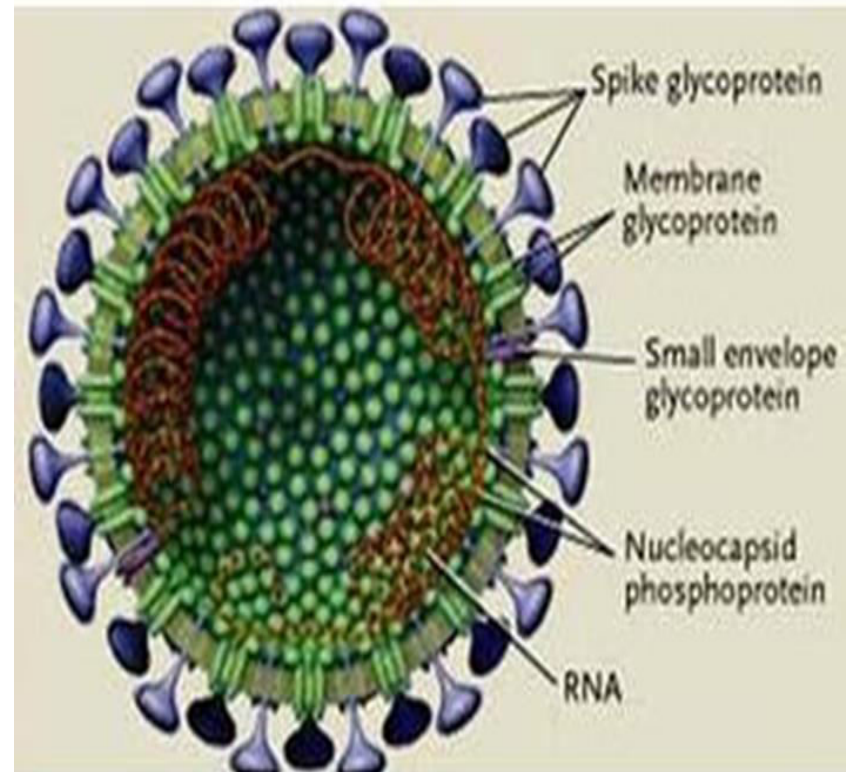
## ➤ **Antigenic Shift:**

Accumulation of small changes result in viruses that have different antigen. (Immune system don't recognize those viruses)



# *Corona Virus*

- RNA>> enveloped>> ss
- Coronaviruses are named for the crown-like spikes on their surface
- Coronaviruses are a large family of viruses that can cause diseases ranging from the common cold to Severe Acute Respiratory Syndrome (SARS).



- Six human CoVs (HCoVs) have been identified :

1- HCoV-229E

2- HCoV-OC43

3- HCoV-NL63

4- HCoV-HKU1

5- SARS-CoV

5- Middle East Respiratory Syndrome  
Coronavirus (MERS-CoV)

# *Middle East Respiratory Syndrome Coronavirus (MERS-CoV)*

- first identified in Saudi Arabia (September 2012)
- By an Egyptian virologist, who isolated corona virus that different from any other corona virus previously found in people, from the lungs of a 60- year-old patient with pneumonia and renal failure.

# *MERS-CoV*

## **Transmission:**

- By coughing and sneezing.
- By close personal contact, such as touching or shaking hands.

## **Incubation period:**

2-14 days

**Symptoms:** most people with MERS-CoV infection have severe acute respiratory illness with >>

Fever, cough, shortness of breath, some people had gastrointestinal symptoms including diarrhea and nausea/vomiting.

## **Complications:**

Pneumonia, kidney failure and some people die.

# *MERS-CoV*

- people with pre-existing medical conditions (diabetes; cancer; and chronic lung, heart, and kidney disease) are more likely to become infected with MERS, or have a severe case

## **Treatment:**

- No vaccine currently available
- Treatment is supportive and based on the patient's clinical condition.

# *MERS-CoV*

- Coronaviruses are enveloped viruses so use of proper hand hygiene with hand disinfectants is enough to significantly reduce the risk of being infected by Coronaviruses.
- Statistics in KSA according to ministry of health  
Since 2012 till 2-10-2016:  
1457 cases>> 611 passed away, 844 recovered, 2 cases under treatment.

# Independent reading

Viral Hepatitis



1 Palm to palm



2 Right palm over left dorsum  
and left palm over right dorsum



3 Palm to palm  
fingers interlaced



4 Backs of fingers to  
opposing palms with  
fingers interlocked



5 Rotational rubbing of  
right thumb clasped in  
left and vice versa



6 Rotational rubbing, backwards  
and forwards with clasped  
fingers of right hand in left  
palm and vice versa