CHAPTER

5 Variety of Life

Animation 5: Virus
Source & Credit: whyfiles

Over one and a half million species of animals and over a half million species of plants are known. To deal with such a large collection of dissimilar forms, certainly we need some system by which species can be classified in a reasonable way. Many types of classifications are possible. We could , for example , classify flowering plants according to their colour, height, or any other character. This type of classification is not meaningful since it does not provide any information about the basic differences and similarities among different individuals.

All organisms are related to one another at some point in their **evolutionary histories**. However, some organisms are more closely related than others. Sparrows are more closely related to pigeons than either to the insects. Classification is based on relationship amongst individuals, that is, similarity in form or structure. Biologists have classified all living things into groups showing similarities, based upon homologies, comparative biochemistry, cytology and genetics. Large groups are divided into smaller groups upto species level. **"A species is a group of natural population which can interbreed freely among themselves and produce fertile offsprings, but are reproductively isolated from all other such groups in nature".** However "interbreeding" cannot be used as a criterion for species recognition among predominantly asexually reproducing organisms. Each species possessed its own distinct structural, ecological and behavioral characteristics, hence species are independent evolutionary units. Different species do not exchange genes between them. Since long the living things are divided in two **kingdoms: plants** and **animals.** Next each kingdom is divided into smaller groups called phyla (also divisions for plants, algae and fungi).

A phylum, in turn, is divided into **classes,** classes into **orders,** and an order into **families**. A family contains related **genera,** and a genus is composed of one or more **species.** Species is the basic unit of classification. Conversely speaking, the organisms are grouped into larger, more inclusive categories (taxa), each category is more general than the one below it and has emergent properties. The taxonomic categories from species to kingdom form a hierarchy as described in the classification of corn.

Biological classification of Corn, Zea mays

Kingdom..... Plantae
Division (Phylum)..... Anthophyta (Tracheophyta)
Class ..... Angiospermae
Order ..... Poales
Family ..... Poaceae
Genus ..... Zea
Species ..... mays

Members of a lower category resemble one another more than do the members of a higher taxon.

NOMENCLATURE

From the earliest times plants and animals have been given common names by the people. Since no system was used in choosing common names, in many cases, various regions had their own names for the same plant or animal . Take 'Onion' for example; its common urdu name is 'Piyaz' but in different regions of Pakistan it is also known as 'ganda' or 'bassal' or 'vassal'. In different countries it would have another set of names. Similarly 'amaltas', 'argvad', 'gurmala', 'golden shower', purging cassia' are common names for the same plant. Thus the same plant may have different names. In some cases, a single name refers to several different plants or animals. What is 'blue bell'? Dozen of plants with bell shaped flowers are called **'blue bells'**. Similarly the word **'black bird'** would mean a crow as well as a raven.Common names have no scientific basis. To a biologist, a fish is a vertebrate animal with a backbone, fins and gills. But 'silver fish' is an insect, and a 'cray fish', 'jelly fish' and 'starfish' do not fit the biologist's definition of a fish.

Common names had long caused confusion. During the 18th century, Carlous Linnaeus (1707-1778), a Swedish botanist, devised a system for naming and classifying all the organisms known to him. His system is used today internationally. He discarded the common names of **plants** and gave each one a scientific name. He took the scientific name from Latin word. Linnaeus publishes the list of names of plants in 1753. The scientific name of each plant had two parts. Usually, the name referred to some characteristics of the organisms or the person who collected it. His system spread rapidly and became so popular that he used it later on in naming **animals** and published his list in 1758. Many of his names are in use today.

Linnaeus's system of giving each species a scientific name comprising two words is known as **binomial nomenclature.** The first name refers to the **genus** (p1. genera) and is called generic name and always begins with a capital letter. The **specific** name follows the generic name and begins with small letter. Scientific name for onion is *Allium cepa,* for amaltas *Cassia fistula* and for man *Homo sapiens*. Botanical name for potato is *Solanum tuberosum* and for brinjal *Solanum melangena*. The same generic name for potato and brinjal reflects close relationship between theses two-species. Every specie has only one scientific name the world over. Initially the classification was based on the appearance or **morphology** of plants and animals but with advancement in the knowledge of cytology, physiology, genetics and molecular biology the classification of organism has been modified.

TWO TO FIVE KINGDOM CLASSIFICATION SYSTEMS

Different classification systems recognize two to six kingdoms. For centuries , the living organisms have been classified into two kingdoms, **plants** and **animals**. Plants can prepare their own food from simple inorganic material and store energy **(autotrophs)**, while animals can not synthesize their own food from simple inorganic material and depend for their food either on autotrophs or on decaying organic matter **(heterotrophs)**. Bacteria were included in plants. Many biologists found this system satisfactory, while others found it unworkable' for many unicellular organisms like Euglena that have both plant like (presence of chlorophyll) and animal like (lack of cell wall) characters and also because it ignores the differences between prokaryotic and eukaryotic cells. In 1866, Ernst Hackel proposed a third kingdom protista to accommodate Euglena like organisms and bacteria. In 1937, E-Chatton suggested differentiating terms **procariotique** (from Greek pro, meaning before, and karyon, meaning nucleus) used to describe bacteria and blue-green algae, and the term **eu-cariotique** (from Greek eu, mean true) to describe animal and plant cells. Some biologists also disagree about the classification of **fungi,** such as bread mold, yeast and mushrooms, which resemble plants in many ways but are not autotrophs. Fungi are special forms of heterotrophs that obtain energy and structural material by breaking down **(decomposing)** and **absorbing** food substances from the surroundings, and possess chitin as a major structural component in their cell walls.

A relatively recent system of classification, the five kingdom system, was proposed by Robert Whittaker (1969). This system of classification shown in Fig 5.1 is based on three different levels of cellular organization associated with three principal modes of nutrition- **photosynthesis,**

absorption and **ingestion.** The five kingdoms proposed (i) the prokaryotic unicellular organisms **(Monera)** such as bacteria, (ii) the eukaryotic predominantly unicellular organisms **(Protista)** such as *Euglena* and *Amoeba*, (iii) the eukaryotic multicellular autotrophs **(Plantae),** (iv) the eukaryotic multicellular reducers (Fungi) for example mushrooms and (v) the eukaryotic multicellular consumers (Animalia). Plants are autotrophic in nutritional mode, making their own food by photosynthesis such as mosses, ferns, flowering plants. Fungi are heterotrophic organisms that are absorptive in their nutritional mode. Most fungi are decomposers that live on organic material, secrete digestive enzymes and absorb small organic molecules which are produced by digestion. Animals live mostly by ingesting food and digesting it within specialized cavities. They lack cellulose and show movements for example birds and reptiles. In five kingdom classification, all eukaryotes that did not fit the definition of plants, fungi or animalia were included in Protista. Most Protists are unicellular forms, but this kingdom also includes relatively simple multicellular organisms that are believed to be direct descendants of unicellular protists.

Lynn Margulis and Karlene Schwartz (1988) modified five kingdom classification of Whittaker by considering cellular organization , mode of nutrition, cytology, genetic and organelles of symbiotic origin (mitochondria , chloroplast). These five kingdoms are **Prokaryotae** (Monera), **Protoctista** (Protists), **Plantae, Animalia** and **Fungi** (Fig 5.1).

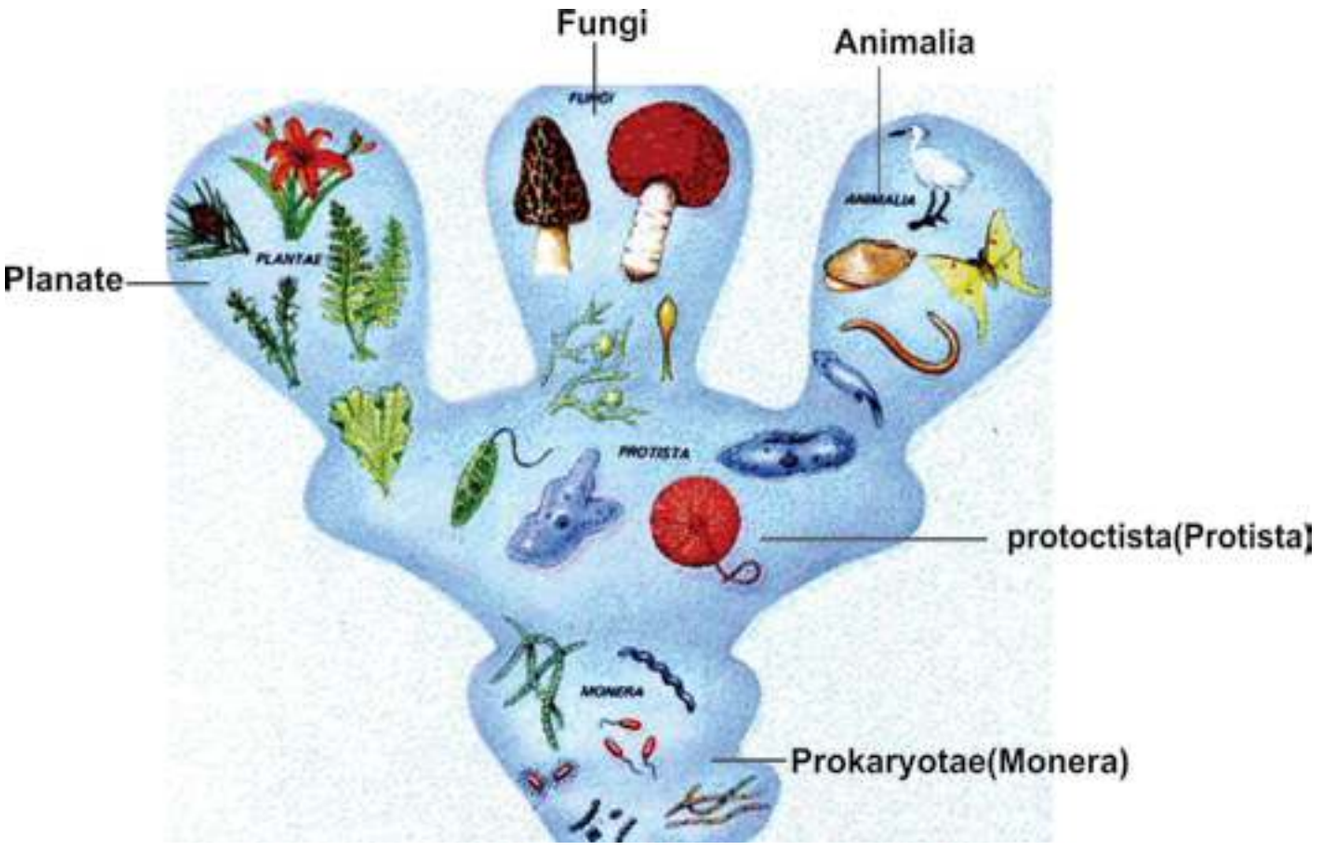


Fig 5.1 Relationship of Five kingdom

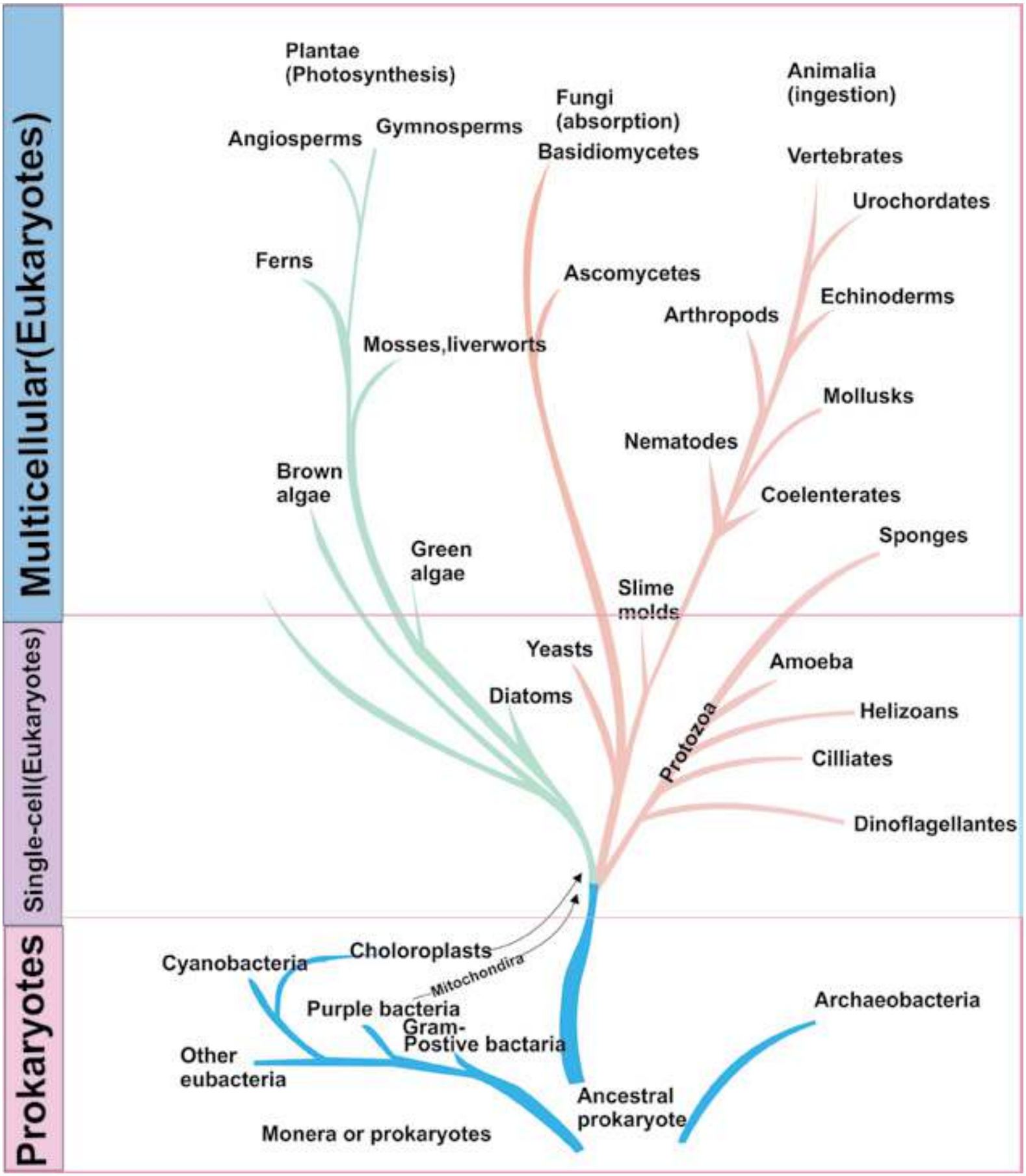


Fig. 5.2 Five kingdom classification by Whittaker

VIRUSES

About a century ago at the time of Louis Pasteur (1822-1895) and Robert Koch (1843-1910), the word "virus" was generally referred to as a poison associated with disease and death. The present notion of virus is entirely different. Now viruses are recognized as particles of nucleic acid often with a protein coat. They replicate in living cells and cause many diseases such as influenza, hepatitis, small pox and AIDS. In this section the focus is on the properiies of viruses and life cycle of bacterial viruses, also known as bacteriophages. Some diseases caused by viruses shall also be discussed in this section. The branch which deals with the study of viruses is known as **virology**.

The word virus is derived from Latin word **venome** meaning poisonous fluid. It can be defined as non cellular infectious entities which contain either RNA or DNA, normally encased in proteinaceous coat, and reproduce only in living cells. Viruses utilize the biosynthetic machinery of the host for its own synthesis and then transfer themselves efficiently to other cells.

Some viral diseases have been known for centuries. In fact, the first infectious disease against which effective method of prevention was developed was a viral disease. In 1796, Edward Jenner first vaccinated an 8 years old boy with material removed from cowpox lesion on the hand of milkmaid. After six weeks the boy was inoculated with pus from a small pox victim, but he did not develop the disease. Later, Jenner used material for vaccination from cowpox lesions and successfully vaccinated 23 persons. As the material he used was obtained from cow (latin **vacca**), latter the term **vaccination** was used by Louis Pasteur for inoculation against disease.

In 1884, one of Pasteur's associates, Charles Chamberland, found that bacteria can not pass through porcelain filters, while agent responsible for rabies (a disease which is transferred to human by bites of rabid dogs, foxes, cats, bats and other animals) can pass through these filters. As in those days the word virus was loosely used to describe any toxic substance that caused disease, those unseen filterable agents of disease were described as filterable viruses. In 1892, Ivanowski discovered that the agent which caused tobacco mosaic disease was filterable. He obtained bacteria free filtrate from ground up infected plants and placed it on healthy leaves of tobacco. He observed that filtrate produced the disease in healthy plants. After that, presence of similar filter-passing, ultramicroscopic agents was seen in the victims of many diseases, including foot and mouth disease (1898) and yellow fever (1901).

The filterable agents were first purified in 1935, when Stanley was successful in crystallizing the **tobacco mosaic virus**. Chemical analysis of these particles showed that they contained only nucleic acid and protein. This suggested that, unlike other forms, viruses are of simple chemical composition.

Bacteriophages, viruses that infect bacteria, were discovered independently by Twort in 1915 and D'Herelle in 1917. Twort observed that bacterial colonies sometimes undergo Lysis (dissolved and disappeared) and that this lysis can be transferred from one colony to other. Even highly diluted material from lysed colony can transfer the lytic effect. However, heating the filtrate destroyed its lytic property. From these observations he concluded that lytic agent might be a virus. D'Herelle rediscovered this phenomena in 1917 and used the word bacteriophages meaning "bacteria eater".

Animation 5.1: Virus
Source and Credit: geocities

Characteristics

Viruses are extremely small infectious agents, which can only be seen under an electron microscope. They range in size from 250 nanometer (nm) of poxviruses to the 20 nm of parvoviruses. They are 10 to 1000 times smaller than most bacteria, so they can pass through the pores of filter, from which bacteria cannot pass. Viruses cannot be grown on artificial media. They can reproduce only in animal and plant cells or in microorganisms, where they reproduce by replication (a process by which many copies or replicas of virus are formed). Thus the viruses are **obligate intracellular parasites**. Viruses lack metabolic machinery for the synthesis of their own nucleic acid and protein. They depend on the host cell to carry out these vital functions. During reproduction in the host cells, viruses may cause disease. All viruses are generally resistant to broad range of available antibiotics such as penicillin, streptomycin and others.

Structure

The complete, mature and infectious particle is known as **virion**. The virions are composed of a central core of **nucleic acid**, either DNA or RNA, which is also known as **the genome** and is surrounded by a protein coat, **the capsid**. Capsid gives definite shape to virion. Capsid is made up of protein subunits known as **capsomeres**. The number of capsomeres is characteristics of a particular virus. For example 162 capsomeres are present in the capsid of **herpes virus** and 252 in the capsid of **adenovirus** which cause some common colds. In some animal viruses the **nucleocapsid** (nucleic acid and capsid) is covered by another membrane derived from the host cell, **the envelope**. Non enveloped viruses are known as naked virions. Animal and plant viruses may be polyhedron (having many sides), helical (Spiral), enveloped or complex.

The most recently discovered (1983) and least upderstood micro organisms are the **prions,** *which may be infectious proteins. Their nature is very controversial. They are composed of protein only that contains the information that codes for their own replication. All other organisms contain their genetic information in nucleic acid (DNA or RNA). Prions are responsible for mad cow infection and mysterious brain infection in man.*

Bacterio-phages occur in two structural forms having cubical or helical symmetry. In general appearance cubical phages are regular solid or **icosahedral** (having 20 faces), and **helical** phages are rod shaped. Many phages consist of head and tail. In those cases heads are polyhedral but tails are rod shaped. Morphology of some viruses and bacteriophages has been shown in Fig 5.3.

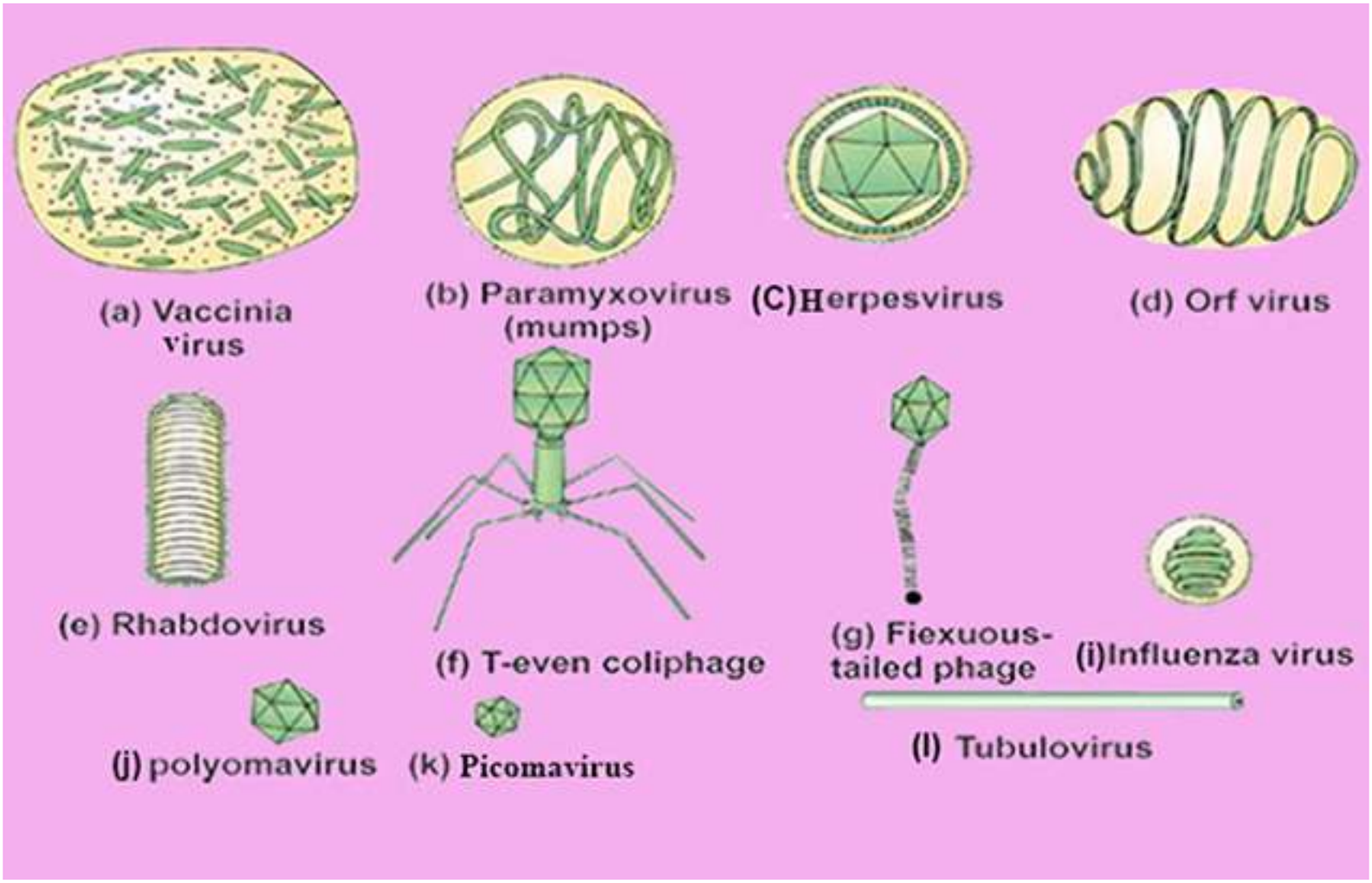


Fig. 5.3 Different types of viruses

Life Cycle of Bacteriophages

Earlier researches on bacteriphages were mainly on limited number of phages that infect *Escherichia coli***.** Of these the best known phages are T phages (T for type).

Among T phages, the T_2 and T_4 phages are mainly used in phage studies. The overall structure of T_4, studied with electron microscopy, resembles that of tadpole, consisting of head and tail (Fig 5.4). The head is an elongated pyramidal (having two triangular structures with common base), hexagonal , prism -shaped structure, to which straight tail is attached. Within the head double stranded DNA molecule is present. The structure of phage tail is more complex than head. A layer of distinct protein forms the inner tube or core, which is enclosed in **sheath** made up of another type of protein. On one side of sheath is **collar** and on other side is end plate. To end plate six **tail**

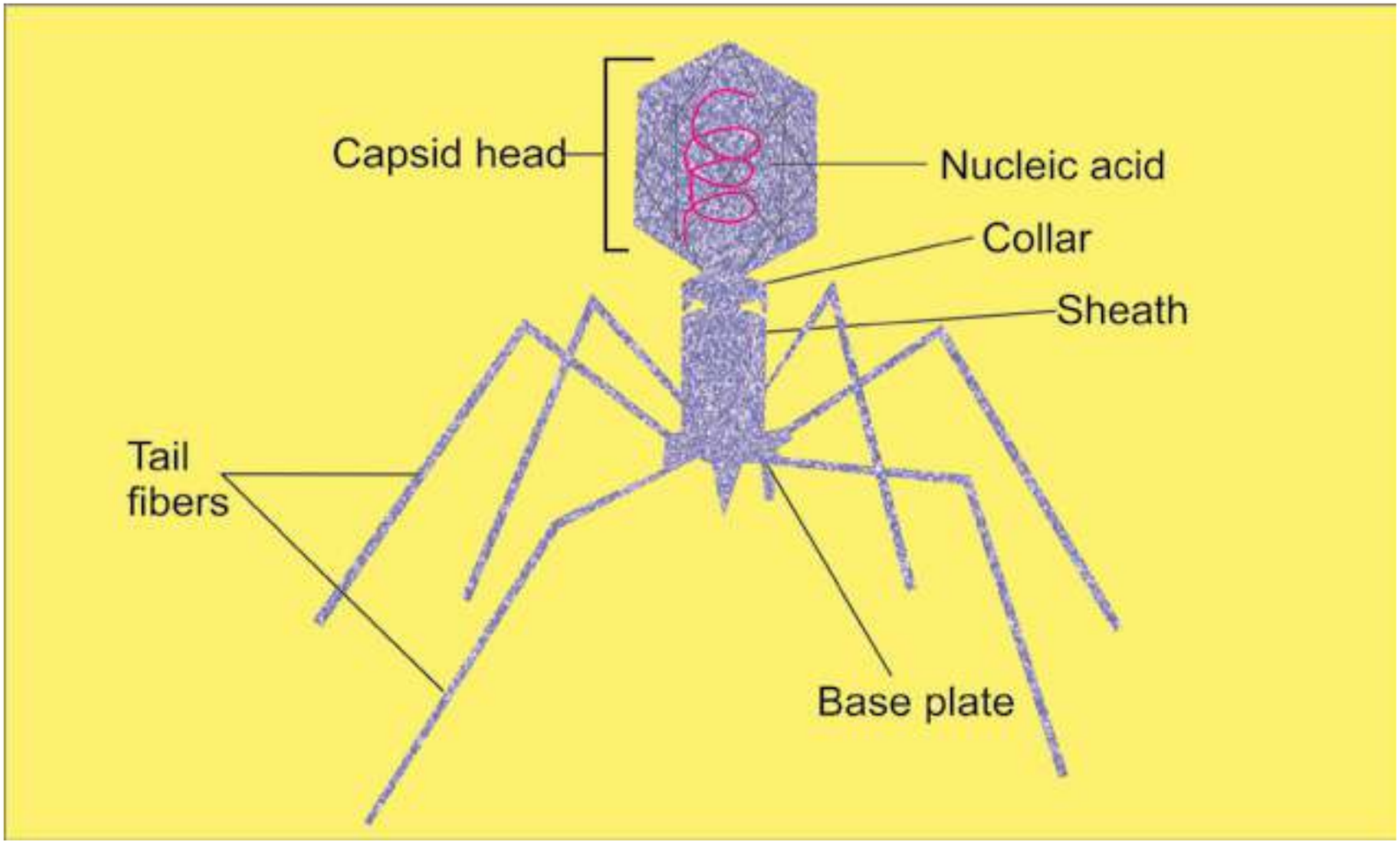


Fig. 5.4 A Bacteriophage

fibers are attached, which are the structures for attachment. The volume of the phage is about 1/1000 of the host.

The bacteriophage replicates only inside the bacterial cell. The first step in the replication of a bacteriophage is its **attachment (adsorption)** to host cell at receptor site on the cell wall of bacterium. During attachment, week chemical union between virion and **receptor site** takes place. In the next step, **penetration**, the tail releases the enzyme **lysozyme** to dissolve a portion of the bacterial cell wall. The tail sheath contracts and tail core is forced into the cell through cell wall and cell membrane. The virus injects its DNA into the cell just as the syringe is used to inject the vaccine. The protein coat, which forms the phage head and tail structure of virus remains outside the cell (Fig 5.5). Many animal viruses, however enter the host cell as a whole.

Immediately after entering the host cell , the viral nucleic acid takes the control of the host's biosynthetic machinery and induces the host cell to synthesize necessary viral components (DNA, proteins), and starts **multiplying**. About 25 minutes after initial infection, approximately 200 new

bacteriophages are formed, bacterial cell bursts, i.e., it undergoes lysis. Newly formed phages are released to infect the bacteria and another cycle, **the lytic cycle** begins (Fig. 5.6). The phage which causes lysis of the host cell is known as **lytic or virulent phage.**

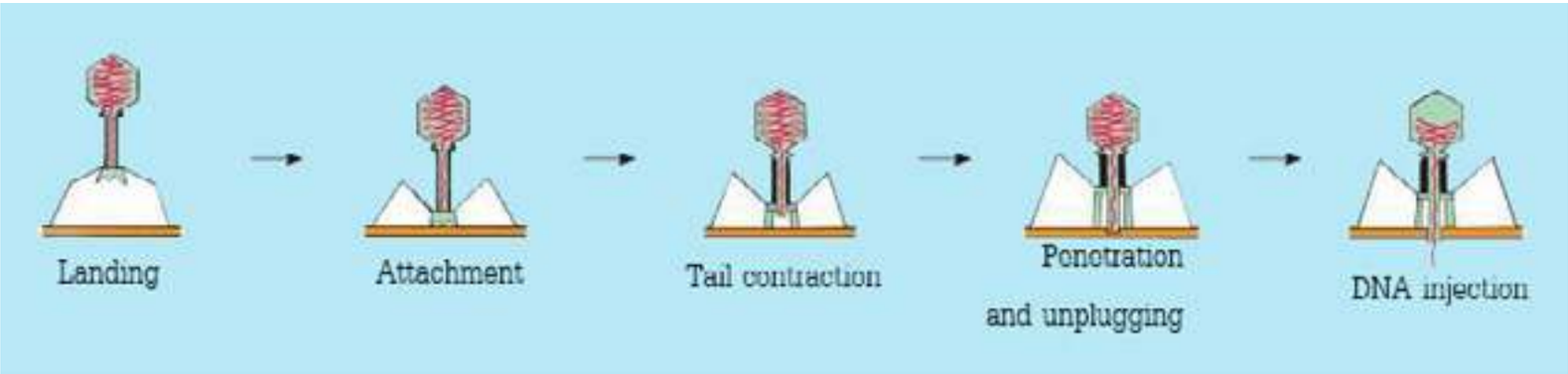


Fig 5.5 A phage injecting its DNA in to host

Animation 5.2: Viruses
Source and Credit: geocities.ws

Video 5.3: Endoplasmic Reticulum (ER),Ribosomes
Source and Credit: Sabaq

Animation 5.4: Life Cycle of Bacteriophages
Source and Credit: faculty.ccbcmd

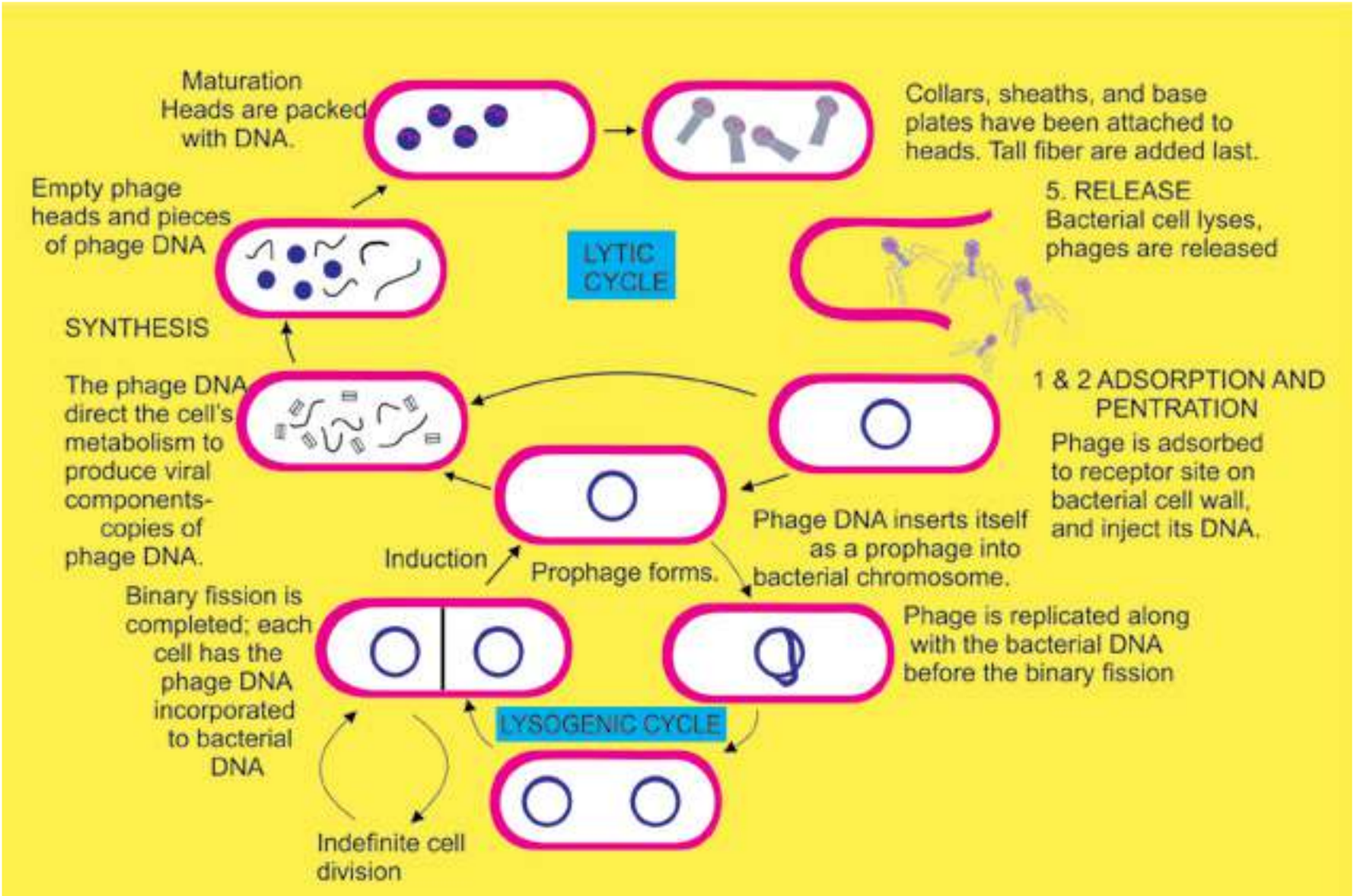


Fig. 5.6 Replication of a bacteriophage. After adsorption and penetration, the virus DNA undergoes prophage formation (1) In the lysogenic cycle, phages can exist harmlessly as a prophage with in the host cell for long periods of time. Each ti.ne the bacterial chromosome is replicated, the prophage also is replicated, and hence all daughter bacterial cell are "infected"! with the prophage. Induction involves either a spontaneous or environmentally induced excision of the prophage from the bacterial chromosome. (2) A typical lytic cycle, involves synthesis and maturation of phage and new phages are released.

All infections of bacterial cells by phages do not result in lysis. In some cases viral DNA, instead of taking over the control of host's machinery, becomes incorporated into the bacterial chromosome. Phage in this state is called **prophage** and this process is known as **lysogeny.** In this condition the bacterium continues to live and reproduce normally. Viral DNA being the part of bacterial chromosome passes to each daughter cell in all successive generations. Some times, however, the viral DNA gets detached from the host's chromosome and lytic cycle starts. This process is called **induction.** Lysogenic bacteria are resistant to infection by the same or related phages. The phage which causes lysogeny is called **temperate (lysogenic) phage**.

Classification of Viruses

Virus morphology and nucleic acid properties are most important for classifying plant, animal and bacterial viruses. The genetic material may be DNA or RNA naked, enveloped or complex. On the basis of morphology viruses are classified into rod shaped (T.M.V), spherical (poliovirus) and tadpole like bacteriophage viruses etc. Fig. 3.5 and 5.4.

Some Viral Diseases

There are many diseases which are caused by viruses. Only those are being mentioned here which have been or are common in Pakistan.

Small pox: Smallpox, which is caused by pox viruses (the DNA enveloped virus) is an ancient disease that is known to have occurred as epidemic in China as early as the twelfth century B.C. Until the early twentieth century , small pox was a common disease throughout the world. In small pox, raised fluid-filled vesicles are formed on the body which become pustules later on and form pitted scars, **the pocks**. By 1950's immunization and other control measures had largely decreased the danger, but it is still present in the third world countries where many people are affected. In 1980, it was declared by World Health Organization that small pox has been eradicated from the world.

Herpes simplex: Herpes virus (DNA virus) is responsible for this disease. It is naturally occurring disease of mankind. In this vascular lesions in the epithelial layers of ectodermal tissues are formed. Most commonly this disease occurs in the mouth, on the lips, and at other skin sites.

Influenza: Influenza viruses are enveloped RNA viruses. Influenza is wide spread disease in man and occurs in epidemic form.

Mumps and Measles: Mumps and Measles viruses belong to group **paramyxoviruses**. They are large, enveloped, RNA viruses. Mumps is highly contagious, wide spread, but seldom fatal. About 60% of adults are immune to it. Measles is one of the commonest diseases of the childhood and adult human population is equally susceptible the world over. This disease develops immunity in its victim.

Polio: Poliomyelitis, caused by polio virus, is found all over the world . It occurs mostly in childhood.

The age at which primary infection occurs varies with social and economic factors. The polioviruses are the smallest known viruses and contain RNA in spherical capsid. Some common human viral dieases are shown in Fig 5.7.

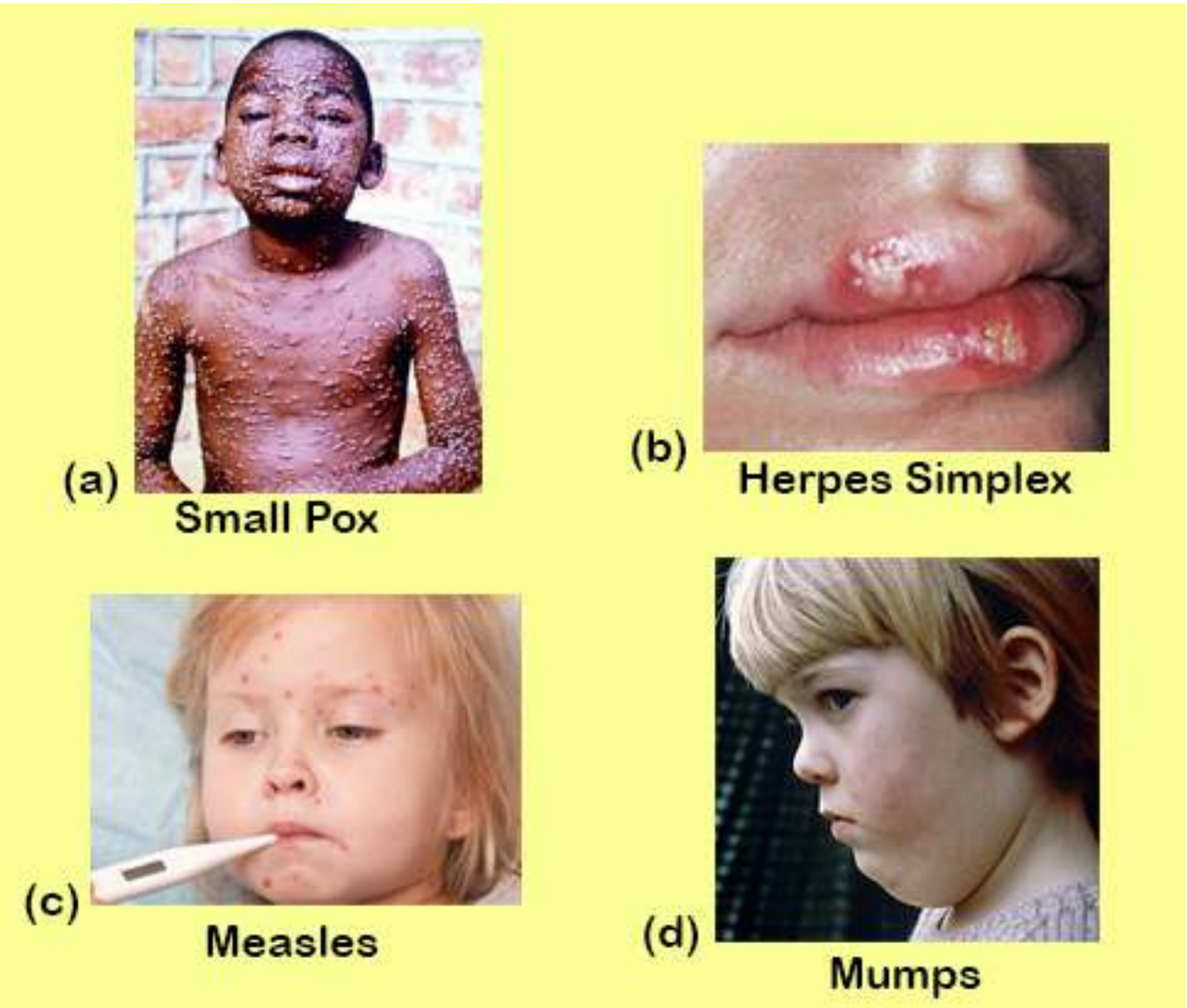


Fig. 5.7 Some common human viral diseases

Retroviruses

RNA tumor viruses have been known for many years. These viruses are widely distributed in nature and are associated with tumor production in a number of animal species, such as fowl, rodents and cats. The most familiar of viruses is the **human immunodeficiency virus (HIV)** which causes **acquired immune deficiency syndrome (AIDS).**

The single stranded RNA tumor viruses, which also include **retroviruses (oncoviruses),** are spherical in form , about lOOnm in diameter and enveloped by host plasma membrane. Although a few retroviruses are non specific that is they can infect any cell, most of them can infect only host

cells that possess required receptors. In the case of AIDS virus, the host cell possesses a receptor that allows the viral adsorption and penetration in several types of **leukocytes** (white blood cells) and tissue cells. The retroviruses have a special enzyme called **reverse transcriptase,** which can convert a single -stranded RNA genome into double stranded viral DNA. Not only this DNA can infect host cells, but it also can be incorporated into host genome as a **provirus** that can be passed on to progeny cells. In this way, some of retroviruses can convert normal cells into cancer cells.

Acquired Immune Deficiency Syndrome (AIDS)

The AIDS was reported by some physicians in early 1980's in young males having one or more of complex symptoms such as severe pneumonia , a rare vascular cancer, sudden weight loss, swollen lymph nodes and general loss of immune functions. All these young patients were homosexuals. Soon after the disease was discovered in nonhomosexual patients who were given blood (blood transfusion) or blood products. In 1984 the agent causing the disease was identified by research teams from Pasteur Institute in France and National Institute of health in USA. In 1986 the virus was named as **human immunodeficiency virus (HIV)** (Fig 5.8). The major cell infected by HIV is the helper **T-lymphocyte**, which is major component of immune system. As the HIV infection continues in the host, the decrease of helper T-lymphocytes results in failure of the immuhe system and the infected person becomes susceptible to other diseases. Cells in central nervous system can also be infected by HIV Fig. 5.9. Recent studies on HIV reveal that the virus infects and multiplies in monkey but does not cause disease in them, which means that HIV is **host specific.**

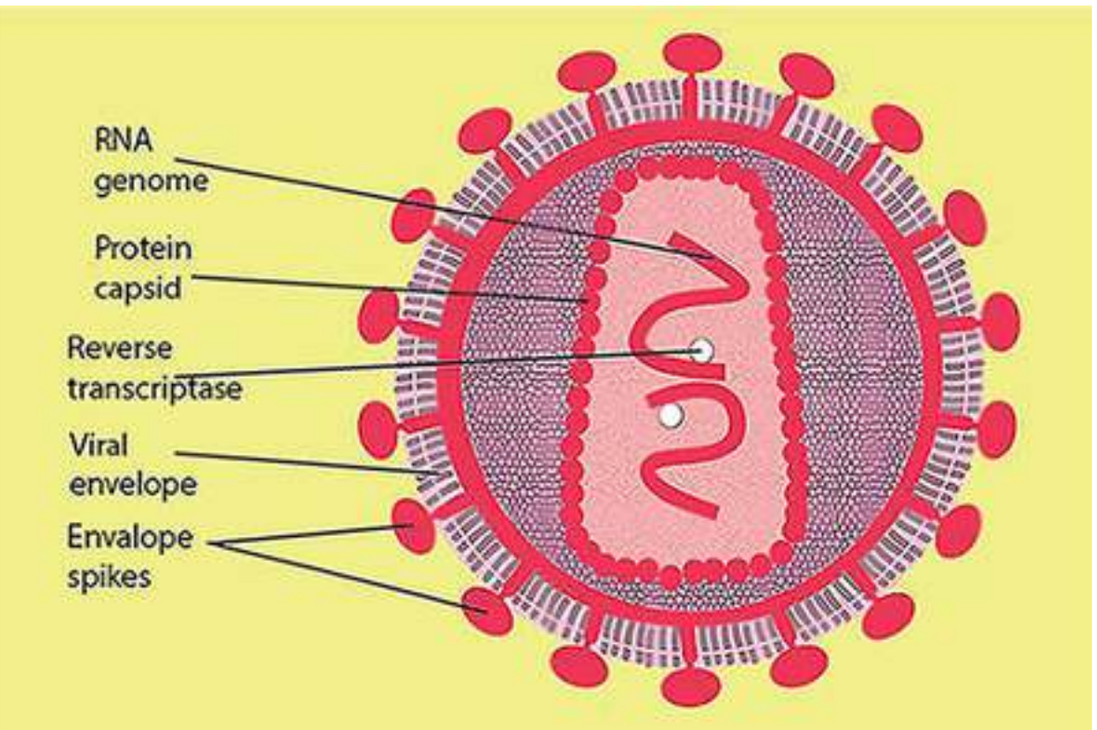


Fig. 5.8 Human immunodeficiency virus (HIV)

The HIV is transmitted by intimate sexual contact, contact with blood and breast feeding. Healthcare workers can also acquire HIV during professional activities. Avoiding the direct contact with HIV is important measure for preventing the disease. Prevention of' intravenous drugs with common syringes and use of sterile needles/syringes and utensils is important. Now vaccine against HIV has been synthesized and its experimental administration in humans started in early 2001 in South Africa.

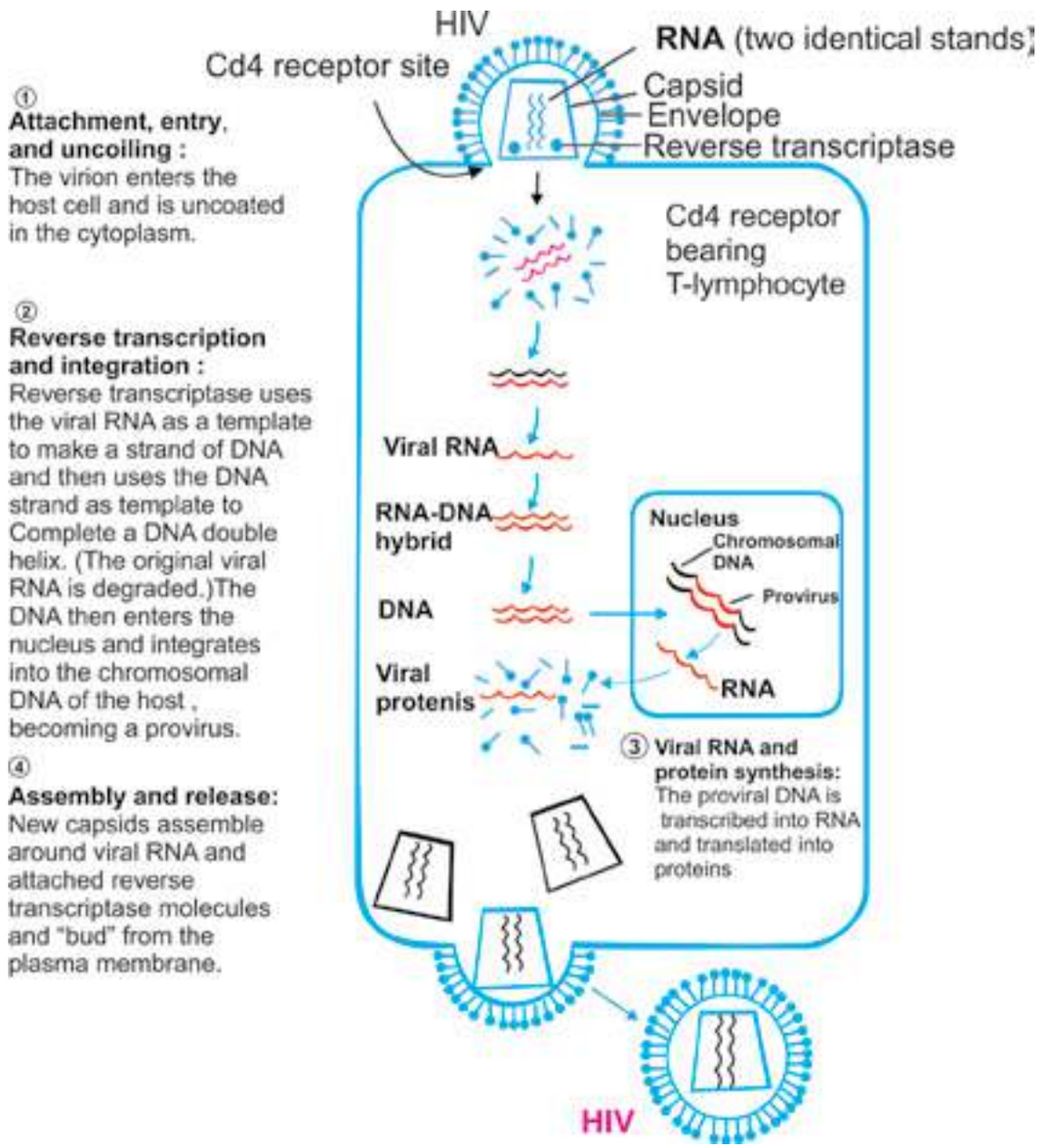


Fig 5.9 Infection cycle of HIV

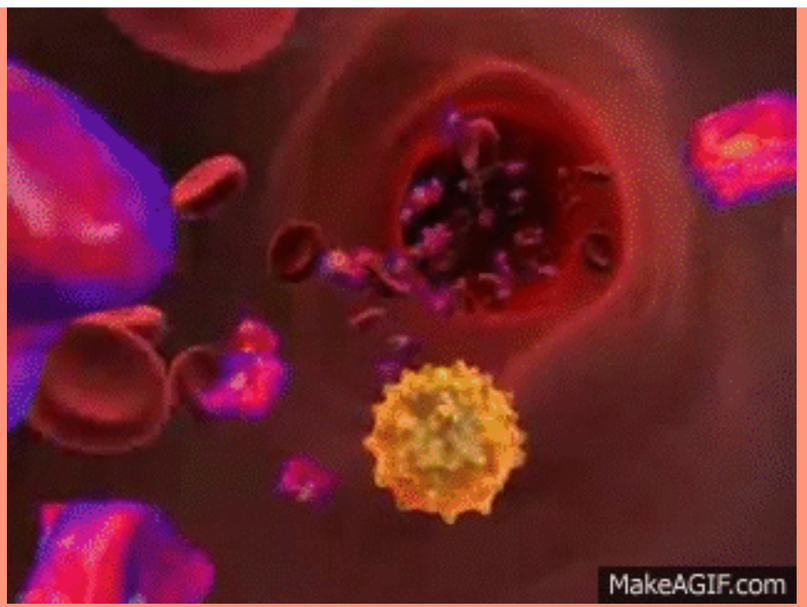
Hepatitis

Hepatitis is an inflammation of the liver. It is usually caused by viral infection, toxic agents or drugs. It is characterized by jaundice, abdominal pain, liver enlargement, fatigue and some times fever. It may be mild or can be acute and can lead to liver cancer. The different types of viral hepatitis are **Hepatitis A** (formerly called infectious hepatitis is transmitted by contact with faeces from infected

individuals.) **Hepatitis B** (serum hepatitis). **Hepatitis C** (formerly called non-A, non-B hepatitis) passes through blood, from mother to child during pregnancy and afterward and by sexual contact. **Hepatitis D** (delta hepatitis), **Hepatitis E** (a virus transmitted through the faeces of an infected person), **Hepatitis F, G** (caused by viruses yet unidentified). Viruses of hepatitis A, B and C are better known. Hepatitis A virus **(HAV)** is an RNA virus (non enveloped), which causes mild short term, less virulent disease. Hepatitis C virus **(HCV)** is also RNA virus (enveloped) causes infusion hepatitis, which is less severe than hepatitis A or hepatitis B, but hepatitis C often leads to chronic liver disease. Most recent work of Halbur and coworker (2001) reveals that pig could be the source of infection of hepatitis E.

Hepatitis B **(HBV)** is the second major form of hepatitis. It is caused by DNA virus which is very common in Asia, China, Philippines, Africa and the Middle East. Hepatitis B is transmitted by the exchange of body fluids, for example blood serum, breast milk and saliva, from mother to child during birth or afterward and by sexual contact.. During acute attacks of Hepatitis B fatigue, loss of appetite and jaundice are reported. Infected persons can recover completely and become immune to the virus. People with chronic hepatitis infection are at the risk of liver damage. Hepatitis can be controlled by adopting hygienic measures, with routine vaccination and screening of blood/ organ/ tissue of the donor.

Genetically engineered vaccine is available for HBV.
Vaccine is also available for HAV but not for HCV.



Animation 5.5: HIV
Source and Credit: makeagif

EXERCISE

Q.1. Fill in the blanks

(i) C. Linneaus divided all known forms of life into two kingdoms: _____ a n d ____. Bacteria were placed in the kingdom _____ because they have cell walls, and protozoa were placed in the kingdom _____because they move from place to place and ingest food.

(ii) The most common system of classification used today, developed in 1969 by Robert Whittaker of Cornell University, uses five kingdoms: _____ and_____.

(iii) Whittaker's five kingdom system of classification recognizes two basic types of cells : _____ and _____ .

(iv) In five kingdom system of classification proposed by Margulis and Schwartz organelles of symbiotic origin such a s an d _____ were also considered.

(v) A bacteriophage reproduces by using the metabolic machinery of_____.

(vi) The protein coat that encloses the viral genome is called :_____ It is made up of_____ .

(vii) Retroviruses are _____ viruses which have specific enzymes _____ by which they convert RNA to DNA.

(viii) HIV infects _____ and the defects in these cells lead to failure in _____ system.

(ix) Hepatitis is caused by _____ .

(x) Viral Hepatitis is of _____types. Hepatitis A and C are caused by _____ virus whereas _____ virus is the causative agent of Hepatitis B.