Extra info :

A **virus** is a submicroscopic infectious agent (not an organism) that replicates (doesn't divide or multiply) only inside the living cells of an organism.

virus is an infectious particle consisting of little more than genes packaged in a protein coat.

Virus properties :

1-viruses are much smaller and simpler in structure than eukaryotes and prokaryotes .

2- Lacking the structures and metabolic machinery found in a cell.

3- viruses cannot reproduce or carry out metabolic activities outside of a host cell

4- they are not alive but exist in a shady area between life-forms and chemicals.

5- viruses are only 20 nm in diameter (seen by EM). Even the largest known virus, which has a diameter of 1,5 nanometers (1.5 µm), is barely visible under the LM (some seen with LM).

*6- A virus is called a DNA virus **OR** an RNA virus based on the kind of nucleic acid that makes up its genome.*

7- Their genomes may consist of double-stranded DNA, single-stranded DNA, double-stranded RNA, or single-stranded RNA, depending on the type of virus.

8- the genomes of some viruses consist of multiple molecules of nucleic acid(linear or circular molecule).

9- Some viruses carry a few viral enzyme molecules within their capsids.

10- Each particular virus can infect cells of only a limited number of host species, called the host range of the virus.

★ **Viruses can cause**: -Simple diseases like cold and the flu .

-Serious illnesses such as AIDS, dengue fever, measles, small pox and bird flu.

★ **All viruses infect cells and hijack (invest) the host cellular machinery for their own benefit.**

★Viruses have predatory nature <<طبيعة الافتراس>>.

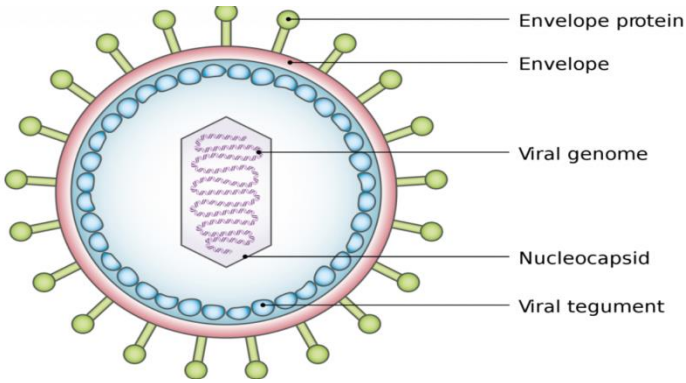
★ **Virtually all living organisms have viral parasites including bacteria.**

parasites : an organism that lives on or in another organism of another species , the host, causing it some harm, and is adapted structurally to this way of life.

★**Viral particles are made from**

1-protein codes (capsid)

2- nucleic acid pores



★**Regarding to effect ,viruses are extracellular organelles.**

★There is more biological diversity within viruses than in all the rest of the bacterial, plant, and animal kingdoms put together ,and this is the result of the successful viruses in parasitizing all known groups of living organisms.

★**Viruses are submicroscopic (small) obligate intracellular(must be inside the cell to be effective) parasites that differ from all other organisms (means the viruses that infect plants differ of those which effect bacteria)**

★ **Virus particles are produced from the assembly of preformed components (means the virus give the** host cell its genome and the cell produced its component , then new viruses will be assembled from these component)(where as the agents grow from an increase in the integrating some of their components and they produce by division. Their particles themselves don't grow or undergo division) the picture in page 4 for further explanation .

★Viruses lack the genetic information for generation of metabolic energy for protein synthesis, they lack ribosomes. Outside the cell, viruses are nearly like metabolically inert chemicals whereas inside cells behave like living organisms.

★**The novel pathogenic entities possess properties which are in viruses, are known as prions and viroids.**

★**Viroids**

composed of a short strand of circular, single-stranded RNA (200-400 nt<<neocleotide>>)that has no protein coating with a rod-like secondary structure (smallest infectious pathogens known).

They have no capsid or envelope and are associated with certain plant disease. they different from viruses because they lack the protective protein coat (capsid)

★ **Virusoids** :Satellite, viroid - like molecules,(1000 nt) packaged into virus capsids as passengers.

★ **Prions** Infectious agents generally believed to consist of a single type of protein molecule with no nucleic acid component, confusion arises from the fact that prion protein and gene which encodes it are also found in the normal non infected cell.

Virusoids are circular single-stranded RNA(s) dependent on viruses for replication and encapsidation. This genome does not code for any proteins.

Virusoids are essentially viroids that have been encapsulated by a helper virus coat protein.

Prions are misfolded proteins with the ability to transmit their misfolded shape onto normal variants of the same protein.

2) The origin of "virology"

★Virology is a " new" discipline in biology and it's as far as the pharmatic recognitional viruses that is distinct form from other living organisms.

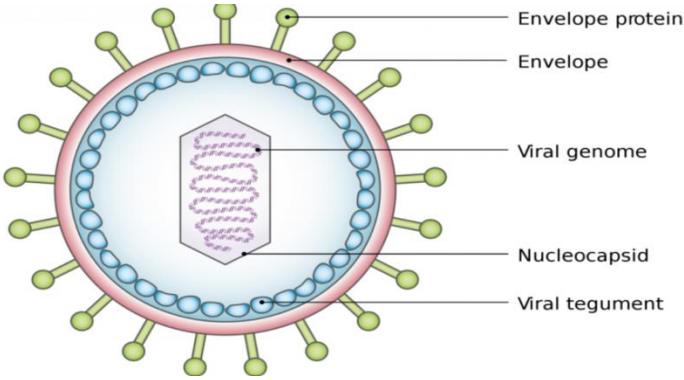
★Viral diseases were discovered much earlier before the discovery of the causative agents

of these disease (120-130 years before)

★ In summary:

− Viruses are commonly defined as " the smallest (20-300 nm) infectious agents that are obligate intracellular parasites, contain either DNA or RNA and depend on the biochemical machinery of living cells to copy themselves, they're hugely variable."

− Viruses cannot be regarded as microorganisms for they are not cells, they have no ribosomes, mitochondria or other organelles, and are metabolically inert.



Virus Structure

★ Virus particles form regular geometric shapes even though the proteins which viruses are made are irregularly shaped and they come in a great variety of shapesnand sizes.

★ Structural features are determined by requirements for assembly, exit, transmission, attachment and other functions of viruses.

★ Size: 17 nm – 3000 nm diameter ★ Basic shape ★Rod-like or "Spherical"

★ Enveloped or non-enveloped (naked) (((note : the envelopes differ from capsid)))

★ Capsid :Protective protein Shell that surround the viral nucleic acid:

1)Made of many identical protein subunits 2)Symmetrically organized 3)50% of weight

• Genomic material: nucleic acid of the virus, it can be:

– DNA / RNA – Single/ double-stranded – Circular /linear – RNA can be positive /negative sense

Structures compared

★ Viral structural components include:-

★Capsid : The protein shell directly surrounding viral nucleic acid (coat, shell).Composed of capsomeres.

★Genome : Nucleic acid of the virus (RNA or DNA). ★Nucleocapsid : the complete protein – nucleic acid complex.

-The capsid is composed of smaller protein components referred to as capsomers.
-The capsid+genome combination is called a nucleocapsid.
-The envelope is actually acquired from the nuclear or plasma membrane of the infected host cell, and then modified with viral proteins called peplomers.
-Some viruses contain viral enzymes that are necessary for infection of a host cell and coded for within the viral genome

★Envelope: The lipid bilayer and associated glycoproteins that surround some viruses(receptors that help the virus to attach the target cell)

★Virion: The entire infectious virus particle.

- Basic rules of virus architecture, structure, and assembly are the same for all families.

★Some structures are much more complex than others, and require complex assembly and disassembly

★The capsid (coat) protein is the basic unit of structure;

functions that may be fulfilled by the capsid protein are to:

– Protect viral nucleic acid – Interact specifically with the viral nucleic acid for packaging

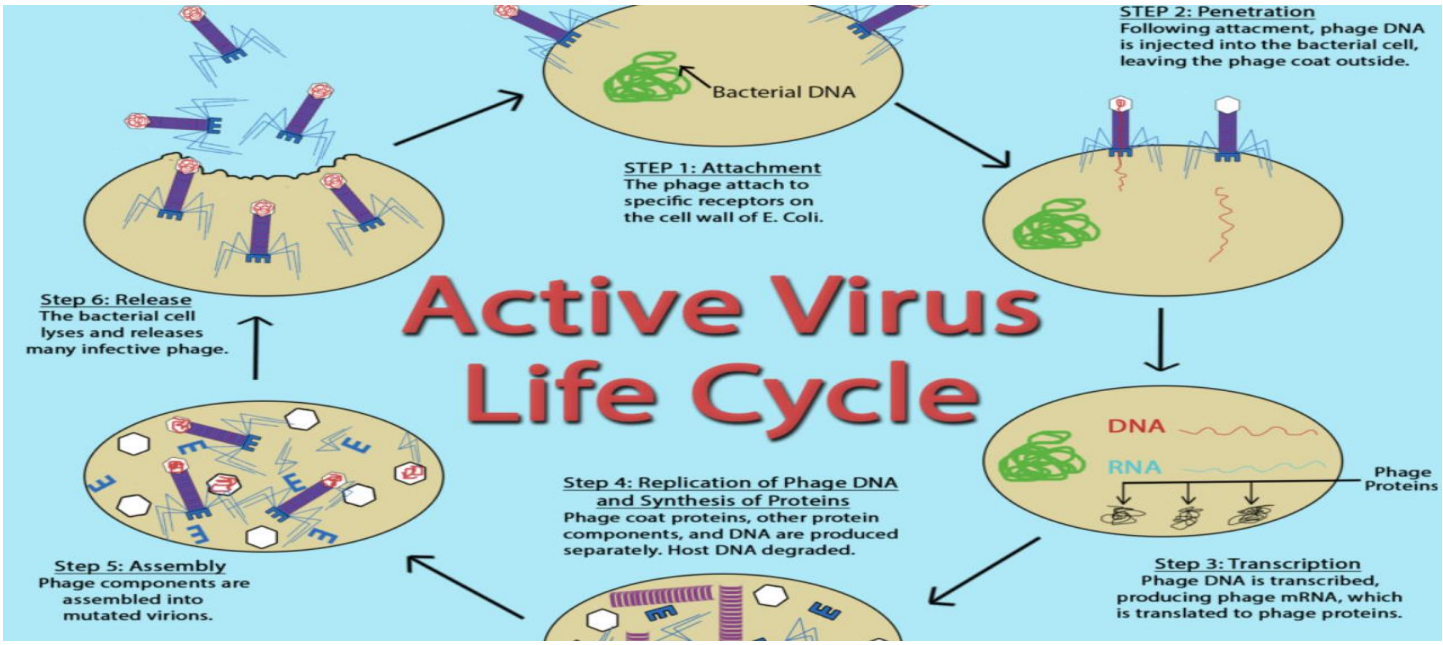
– Interact with vector for specific transmission – Interact with host receptors for entry to cell

– Allow for release of nucleic acid upon entry into new cell

– Assist in processes of viral and/or host gene regulation

– Virus capsid must be made up of multiple protein molecules (subunit construction) and viruses must overcome the problem of how these subunits are arranged.

– It was demonstrated that when mixtures of purified virus nucleic acid and coat proteins were incubated together, virus particle formed.



Capsid symmetry and Virus Architecture

★Virus capsid must be made up of multiple protein molecules (subunit construction) and viruses must overcome the problem of how these subunits are arranged.

★It was demonstrated that when mixtures of **purified** virus nucleic acid and coat proteins were incubated together, virus particle formed.

★Stability is an important feature of the virus particle, some viruses are fragile (unable to survive outside the protected host cell environment), many are able to survive for a long period (for years in some cases)

★The forces, which drive assembly of virus particles, include hydrophobic and electrostatic interactions.

★Only rarely are covalent bonds involved in holding together the multiple subunits.In biological terms, this means that protein – protein, protein – nucleic acid,and protein – lipid interactions are used.

★Capsid consists of a homeoprotein (A protein that shows sameness or similarity to another known protein, usually of another species). molecule which as it fall to assume it's mature conformation, it traps the virus genome inside.

★ In practice, this arrangement can't occur because: the triplet nature of the genetic code means that 3 nucleotides for double strand genomes are necessary to encode one amino acid. Viruses can't utilize an alternative genetic code because this could not be deciphered(decode) by the host cell since the approximate molecular weight of a nucleotide triplet is 1000 and the average molecular weight of a single amino acid is 150, a nucleic acid can only encode protein (usually) that is 15% of it's weight, therefore virus capsid must be made up of multiple protein molecules.(each protein weight is 15% from its nucleotide triplet weight)

★viruses must overcome a problem that is: how can we arrange protein subunits? It was demonstrated that when mixtures of **purify** nucleic acid and coat proteins were connected together so virus particles are formed, **virus particles could form continuously from purified subunits without any extraneous information indicates that the particle was in the free energy minimum and the favored state was formed of the component**

Types of capsids:

1) Helical Capsids 2) Icosahedral (Isometric) capsids 3) Complex structure

1. Helical Capsids

★ The simplest way to arrange multiple identical protein subuints is to use the rotation symmetry and to arrange the irregularly shape of the protein around a circumference of a circle to form a desk, multiple desks form a cylinder, this cylinder coats the virus genome.

★ Some helices are rigid, but some helical viruses demonstrate considerable flexibility and longer helical viruses are often curved or bent(less possibility to be damaged).

★ Helical naked(not enveloped) animal viruses do not exist. All have a similar design (- ssRNA and basic structural features).

2. Icosahedral (Isometric) capsids

★Hollow quasi spherical structure enclosing the genome within them, it's arrangement is more complex than helical capsid.

★An Icosahedron is a solid shape consisting of 20 triangular faces arranged around the surface of a sphere. It has 12 vertices and 30 edges.

★Since protein molecules are irregularly shaped and are not regular equilateral triangles, the simplest icosahedral capsids are built up by using three identical subunits to form each triangular faces.

★This means that (60) identical subunits are required to form a complete capsid Icosahedral Symmetry

★12 vertices ★20 faces(equilateral triangles) ★5-3-2 symmetry axes ★60 identical subunits

- in identical environments can form icosahedral shell

3. Complex structure

★ Such viruses often consist of several layers of protein and lipid.

★ The larger and more complex viruses can not be simply defined by a mathematical equation, like icosahedral and helical capsids

★ Because of complexity, they have defied attempts to determine detailed atomic structures using the techniques used for viral studies.

Enveloped viruses

★ Viruses have devised strategies to effect an exit from the infected cell without its total destruction.

★ Viruses leaving the cell must allow cell membrane to remain intact. This is achieved by extrusion (budding) of the particle through the membrane

★ The envelope may be acquired from intracellular structures.

Naked Viruses (protein)

Properties

★ Viruses modify their lipid envelope with several classes of proteins:

- Matrix proteins

Internal virion proteins that link nucleocapsid to envelope.

- Glycoproteins --- Transmembrane proteins of two types:-

★External glycoproteins (spikes). ★Internal glycoproteins

Transport channel proteins: They enable the virus to alter permeability of the membrane(M2 of influenza) .

★Environmentally stable to drying , heat, acid, protease and detergents

★Released from infected cells by lysis

Consequences

★Can be spread easily (fomites, hand, dust,etc.....) ★Can dry out and retain infectivity

★Can survive adverse conditions in the gut. ★Resist poor sewage treatment

★Can elicit a protective antibody response

★Lysis: releasing viruses from the infected cell when it dies

★This strategy sometimes is wasteful resulting in the premature death of the cell, it also reduces the possibilities infection

★Therefore, many viruses have other strategies that they effect and exit without destroying it, the difficulty of this method that cells have lipid bilayer

★ The viability of the cell depends on the integrity of it's membrane, viruses leaving the cell must therefore allow the membrane to remain in tact , this is achieved by the budding of the particles through the membrane, so the particle become coated in a lipid envelope derived from the host cell membrane with a similar composition.

★ The envelope may be acquired from intracellular structures.

★ In the surface of the virus discovered only with this layer wouldn't permit recognition of receptor molecules on host cells

★ Viruses therefore modify the lipid in the loop with several classes of proteins (e.g.matrix proteins which are internal proteins whose function is to link the nucleocapsid to the envelope) these are most abundant and unglycosylated

★ Glycoproteins (proteins with sugar) are two types:

1) external glycoproteins like the spikes

2) Internal glycoproteins

★ Transport channel proteins enable the virus to altered permeability of the membrane

★ Transport channel proteins are important to modify the internal environment of the virion driving biochemical changes necessary for maturation of the particle and the development of the infectivity (e.g. M2 of influenza)

★ The presence of an envelope significantly effects virion as following:

for naked viruses: they're environmentally stable for drying, heating , proteasing detergents

the ssRNA can either positive-sense (+ssRNA, meaning it can transcribe a message, like mRNA) or it can be negative-sense (-ssRNA, indicating that it is complementary to mRNA). Some viruses even start with one form of nucleic acid in the nucleocapsid and then convert it to a different form during replication.

Genomes

★ The proposition and structure of virus genomes are more vary than any other creature

★ The genome may be DNA or RNA (never both), SS (single stranded) (usually RNA)or ds (double stranded) (usually DNA) , in a linear, circular or segmented configuration (e.g. Influenza)

★ Single – stranded virus genomes may be either (+) Sense having the same polarity of nucleotide sequence as mRNA, (-) sense or ambience (usually access template for production of the positive sense)

★ Genome size ranges from 3500 nucleotides (there are smaller in fact as the genome of some defective viruses 1700 nucleotides) to 470000 (235 KPB) nucleotides.

★ The Physical nature of nucleic acid dictates the strategy of replication and forms a basis for classification.

Effects of Physical and chemical Agents

★ **Vital dyes**

Neutral red, toluidine blue and Proflavin (bind to the nucleic acid and deactive the virus)

Photodynamic inactivation: some viruses are refractory penetration by these dyes but they incorporate them in incubation in dark so visruses are inactive.

★ **Proteolytic enzymes**

Pronase inactivates viruses whereas GI enzymes(trypsin, chemotrypsin, and pepsin) are inefficient.

★ Ether and chloroform (Inactivate enveloped viruses).★ Detergents, iodine, chlorine, and alcohol: Variable effects.

★ Phenol: Most viruses are relatively stable.★ PH: All viruses are stable at a pH of 5 to 9.

★ Salts and glycerol: Stabilize viruses.

Classification of Viruses

★ Different Bases ★Type of nucleic acid ★ Clinical ★Size and morphology ★ Epidemiology

★ Presence of an envelope ★ Effect of Ether

- *Viruses usually replicate(not reproduce or multiplicate or grow or divide).*
- *The importance of capsid : -protection -receptor that play important role In virus specificities .*
- *Viruses inter the cell by phagocytosis / endocytosis .*
- *Viruses affect any nucleated cell(don't affect RBC).*
- *CPE (cytopathic effect)measured by : 1-degeneration 2-necrosis 3-Ballooning*
  4-inclusion bodies (bodies that usually have red colour(acidophilic) exist in the cytoplasm / nucleoplasm (polio or herpes) /both . 5-Transformation : normal cell-→ cancerous cell
  *6- virus interference(**when any cell infect with a viruse ,adjacent cells will be immunized temporarily against any virus (same or other viruses).why? because infected cell send them interferons which induce them against all viruses.***