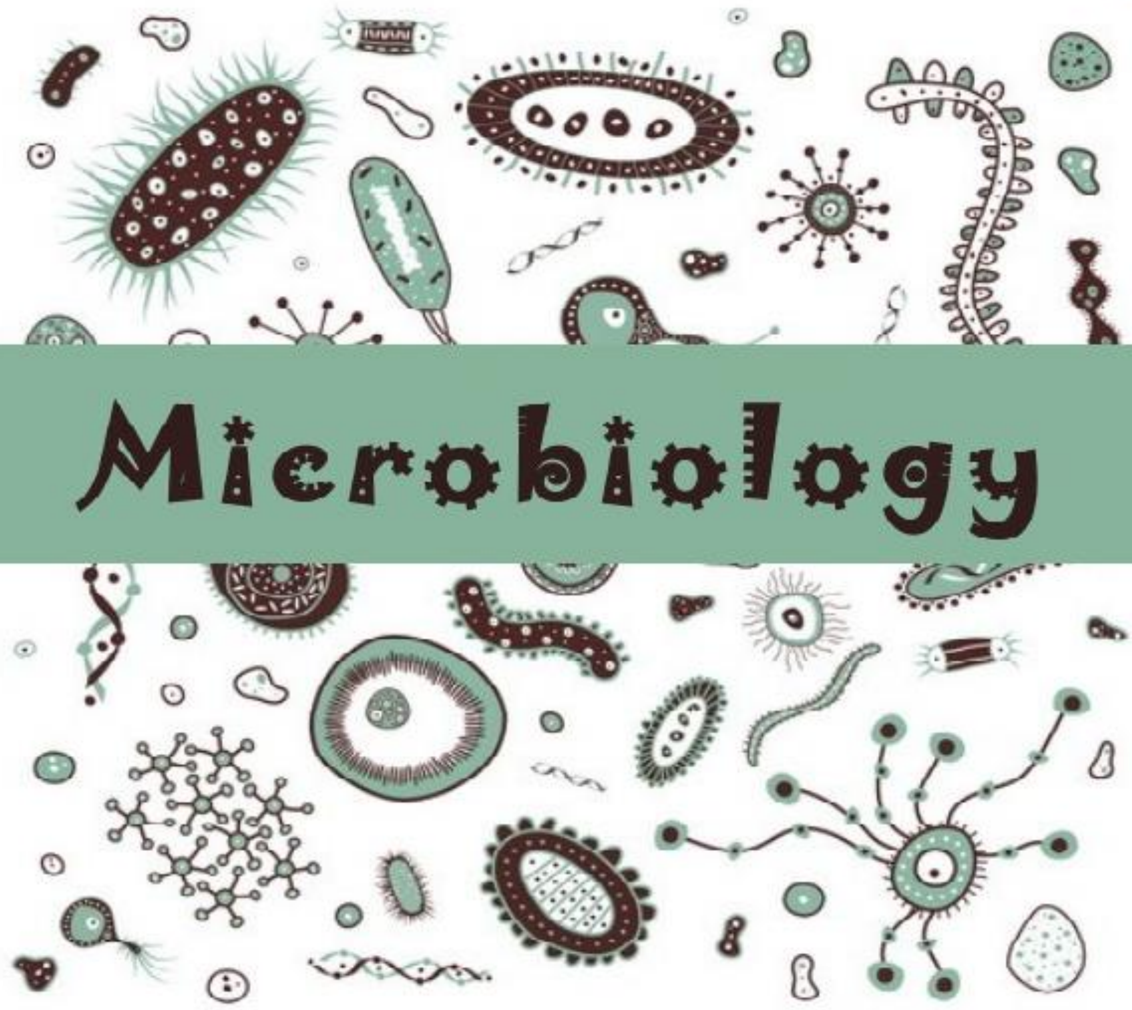

Microbiology

◉ Sheet ○ Slides

Number: Virology-1

Done by: Dania Haj-Yassin

Corrected by: Mohammed Qussay Al-Sabbagh

Subject: Viruses

Doctor: Ashraf Khasawneh

/10/2015

....

Introduction to virology:

Simply, **virology** is the study of viruses. And during our lectures we are going to cover the basic principles of virology, then we will study individual viruses that affect our body systems.

Virus infections are universal. What do mean by that?

- Viruses are all around us in the environment, they can contaminate our food (here we are talking about human viruses that affect the food quality, and we can't see them), and as a result, the presence of the virus in contaminated food gains entry into the GI tract and then it might cause gastroenteritis (التهاب المعدة والامعاء) or other infections.

- Viruses also present around us in the environment, present in the soil, air … , good examples here are about respiratory viruses, we have many known respiratory viruses such as (influenza virus – it causes flu- , corona virus, rhino virus, mumps, measles).

- Also there are some **zoonotic viruses**. What do we mean by **zoonotic**?
It's the viruses that transmitted from animals to humans.

Examples (H5N1 انفلونزا الطيور، corona – it's still under investigation, they say that it's transmitted by camels or cats-, rabies داء الكَلَب- Which is transmitted from dog bite-)

Now, let's talk about viral properties in general:

- ❖ A virus is an obligate intracellular parasite or organism, containing genetic material surrounded by protein.

Obligate organism means that the virus is not a living entity by itself, it requires a living host cell in order to grow and replicate itself.
Now, the virus containing genetic material (core of nucleic acid) which might be either DNA or RNA... but NEVER both like other cells, this genetic material is surrounded by a protein coat which is called **"capsid"**

- ❖ Viruses vary in size, but all of them are within 20-450 nm in diameter, so virus particles can only be observed by electron microscope.
  (remember: n=10^-9)

Note: in some references or books you might find that the size range is within 10-450 nm , that means, the lower limit might differ from one reference to another, but the upper one is fixed.

- ❖ Viruses are inert (nucleoprotein) filterable agents.

This piece of information is not too important nowadays, but previously they didn’t know about the existence of viruses, so they use to take samples from sick patients or ill patients, and filter these samples, and then put them back into animals and see the effect of this on animals.
Because filters can most of the time filter out bacteria, get rid of bacteria from these samples, so, they use to think that there is something else cause illness, now we know that this is a virus.

- ❖ Viruses cannot make energy or proteins independent of a host cell

If we ask why viruses are nonliving entities by themselves and they require the cell? , the answer comes in this point, they don't have the organelle necessary for protein synthesis which is the ribosome.
So, all viruses require the cellular ribosomes in order to synthesize and replicates their proteins; whether structural or non-structural proteins.

What do we mean when we say structural and non-structural proteins?

- Structural proteins: are proteins which play a role in making up the virus.
Such as the capsid protein that surrounds the genetic material, and glycoproteins which are embedded within the envelope in the enveloped viruses, we will come to that later on.

- Non-structural proteins: enzymes which are synthesized by viruses.

- ❖ DNA viruses are more dependent for the host cell than RNA viruses. WHY?

- All DNA viruses replicate in the nucleus, so already the host cell is going to replicate its genetic material with the use of cellular enzymes and machinery,
Once the DNA viruses replicate in the nucleus, they use cell's content (enzymes and cellular machinery) in order to replicate themselves.

-RNA viruses replicate in the cytoplasm, so they make their own enzymes and proteins in order to use them in the process of replication.

General role:

All DNA viruses replicate in the nucleus EXCEPT:

- Pox virus (it’s among the largest viruses)
  this excepted virus replicates in the cytoplasm.

All RNA viruses replicate in the cytoplasm.

❖ Now, as we mentioned before, the simplest virus structure is:

genetic material (DNA or RNA) surrounded by the protein coat which is the capsid.
The genetic material with the capsid called **"nucleocapsid"**.

Some viruses may have another layer which is **the envelope,** we call these viruses: **enveloped viruses.**
The viruses that don’t have envelope we call them either: **non-enveloped or naked viruses.**

❖ Viruses don’t have genetic capability to multiply by division like other cells, otherwise, they multiply by **binary fission.**

The comparison between viruses and cells:

Property	**viruses**	**Cells**
Type of nucleic acid	DNA or RNA	DNA and RNA
Proteins	Few	Many
Lipoprotein membrane	Envelope, present in enveloped viruses	Present in all cells
Ribosomes	Absent	Present
Mitochondria	Absent	Present
Enzymes	None or few	Many
Multiplication by binary fission	No	Yes, in most cells

Remember:

- RNA viruses have more enzymes and proteins than DNA viruses.
  Because DNA viruses can use the cellular machinery and enzymes, some of them are totally dependent, while others might have some enzymes and proteins.
  On the other hand, RNA viruses cannot access to cellular machinery, they have their own enzymes and proteins since they replicate in the cytoplasm.

- binary fission: is a method of asexual reproduction that involves the splitting of a parent cell into two approximately equal parts, then the two become four and so on.

Refer to slide 7, which shows the comparison of sizes between viruses.

You can see pox virus - which is a DNA virus that replicates in the cytoplasm, and it's among the largest viruses - , herpes virus, influenza virus, polio virus.

You can compare them with the size of bacteria, and with the size of cells, proteins, molecules, atoms... on the scale in the next slide.

Some terminology:

- virus particles = virion

When we say virus or virion we mean the same thing.
When the virus is* released from the host cell, *mature, * and capable of infecting new cells, we can give this virus the term virus or virion.

In conclusion; we can say that the virus and virion have the same meaning.

- Protein which coats the genome = capsid
  capsid usually symmetrical.

- capsid + genome = nucleocapsid (naked virus)
  may have an envelope (enveloped virus)

We said previously that there are two examples of structural proteins in viruses, one of them are glycoproteins in the enveloped viruses
so, enveloped viruses contain proteins or spikes, which are called: **viral encoded proteins** and most of the time they are embedded within the envelope.

For certain viruses, the glycoproteins or spikes composed of two units:
one Tran’s membrane, and the other subunit, which is attached to the Trans membrane outer unit.

The primary role of spikes is recognizing receptors on the target cells, so attachment of glycoproteins or spikes with receptors of the target cell initiates the entry of the virus into the target cell.

The complete infectious unit of virus particle composed of the genetic material surrounded by the capsid. And some viruses have viral envelope with glycoproteins embedded to it.

See figures in slides 10&11

The process of replication in viruses involves **disassembly and reassembly**.
If we want to come to the simplest definition of viral replication, we say:
disassembly and then reassembly, because once the virus enters into the host cell, it's going to be disassemble into the basic structures that the virus is made of.

That means, genetic material is going to be released from the capsid into the cytoplasm, also the capsid is going to disassemble.

But what about the envelope?
Once the enveloped virus enters into the target cell, most of the time, the viral envelope is left as part of the target cell membrane.

So, when the virus reaches the host cell, the nucleocapsid will enter into the cell, and the envelope will become part of the host cell membrane.

Where does the envelope come from?

When we mentioned viral proteins, we talked about capsid and glycoproteins, we don’t mentioned the envelope!
So, envelope comes from the host cell. HOW?

Once the virus exits the cell after replication, it acquires or takes part of cellular membrane as its own envelope.

Now we are going to talk about **naming viruses:**

How do we name viruses?

No taxa above family.
That means that the family is the largest group, then comes the subfamily, then the genus then the type.

- We classify viruses according to many characteristics such as structure, size, nucleic acid, host species, target cells. We are going to talk about this later.
- We have 20 families of animal viruses or human viruses (7 DNA \ 13 RNA) we used to say 19 families (6 DNA / 13 RNA), but recently one of these DNA families has been divided into two.

Family name ends in **-viridae**
subfamily ends in **-virinae** (the usage of subfamily is not that common)
genus name ends in **-virus**

Examples:

- Family > herpesviridae
- subfamily > herpesvirinae
- genus > simplex virus
- common name > herpes virus (herpes simplex virus 1 (HSV-1))
- disease > fever blisters, cold sores

- Family > retroviridae
- subfamily > lentivirinae
- genus > HIV
- type > 1 and 2

We are going to mention the 7 DNA virus families, and you need to know them, you should be able to distinguish between DNA and RNA virus families.

DNA viruses:
1A, 2H, 4P

Adenoviridae
Herpesviridae
Hepadnaviridae
Poxviridae
Parvoviridae
Papillomaviridae
Polioviridea

* Papilloviridae and polioviridae used to be under the family papovaviridae

* Once you know the DNA viruses, you are going to be able to know the RNA virus families by exclusion.

* Under the herpes virus family, we have 8 kinds of viruses or 8 genera. So, by knowing the families, not most of the time we are going to be able to tell whether this is DNA or RNA virus.

How are viruses named?

Based on:

- The disease they cause
  Poliovirus (شلل الأطفال), rabies virus (داء الكَلَب)

- The type of disease (approximately the same as the previous point)
  murine leukemia virus (it causes leukemia in mice)

- Geographic locations (towns or cities where the virus was first identified)
  sendai virus, coxsackie virus

- Their discovers (scientists)
  Epstein-Barr virus

- How they were originally thought to be contracted
  dengue virus ("evil spirit"), influenza virus (the "influence" of bad air)

- Combinations of the above
  rous sarcoma virus

Now we are going to talk about capsid types:

Capsid is the structural protein which surrounds the genetic material.

We have 3 main types of capsid:

- Helical
- Icosahedral
- Complex

Helical and icosahedral capsid could be naked or enveloped, so the total number of types might be 5.
(Helical / enveloped helical / icosahedral / enveloped icosahedral / complex).

- Most of the **helical viruses are enveloped viruses.**
So once you talk about naked **viruses** you should think about viruses with **icosahedral capsid**.

Viral structure:

- Viruses vary in size, shape, and symmetry
- There are 3 types of capsid symmetry

  - Cubic (icosahedral)
    - Has 20 faces, each an equilateral triangle... e.g.: adenovirus.
  - Helical
    - Protein binds around DNA/RNA in a helical fashion... e.g.: Coronavirus.
  - Complex
    - Is neither cubic nor helical ...e.g.: poxvirus.

Slide 18 shows naked nucleocapsid virus and envelope virus.

What does the envelope do for the virus?

- It Protects genome during passage from one cell to another.
- It Aid in entry process of the virus into the target cell.
- It Package enzymes for early steps of infection.

We are going to differentiate between helical and icosahedral capsids in terms of depending units.

In helical capsid;

Single rod represents the building unit, we call it **"the capsomer ".**

Then,
these rod shape structures arrange side by side in order to make a ring shape disc.

Then,
these discs arrange on the top of each other in both direction. (We started from the

central disc, then, one is added above and one below in order to make the hollow structure.

- refer to slide 19

Note:

** All DNA viruses have icosahedral capsid except poxvirus which has complex one.
** All RNA viruses have helical capsid.

Once the discs are made and arranged on the top of each other, the genetic material (which is RNA in the case of helical capsid) winds up with every new disc.
So, we finally have hollow structure (discs) with genetic material inside.

Icosahedral capsid;

Is made up of 20 faces, each face represents an equilateral triangle.

The building unit in the icosahedral is not the capsomer as in the helical, the building unit is **"protomer".**

Protomer are the circles within the equilateral triangle (see slide 22),
and these 20 triangles meet in 12 corners.
In these corners, the protomers arranged as 5 protomers side by side.
We called those 5 protomers or pentaprotomers: **"capsomer ".**

So, in the helical capsid, the capsomer represent the rod structure, but here, capsomer is the pentamers or hexamers (5 or 6 protomers).

Pentamer is the capsomer in the corners.
Hexamer is the capsomer in the face of triangle.

- Viruses Vary in the number of capsomers, depending on the size of the virus.

- Each capsomer may be made of 1 or several proteins.

- Viruses with icosahedral capsid could be either naked or enveloped.

Best of luck ☺