King Saud University

250 MIC Course: General Virology

Lecture Two :

Terminology and General Properties of Viruses

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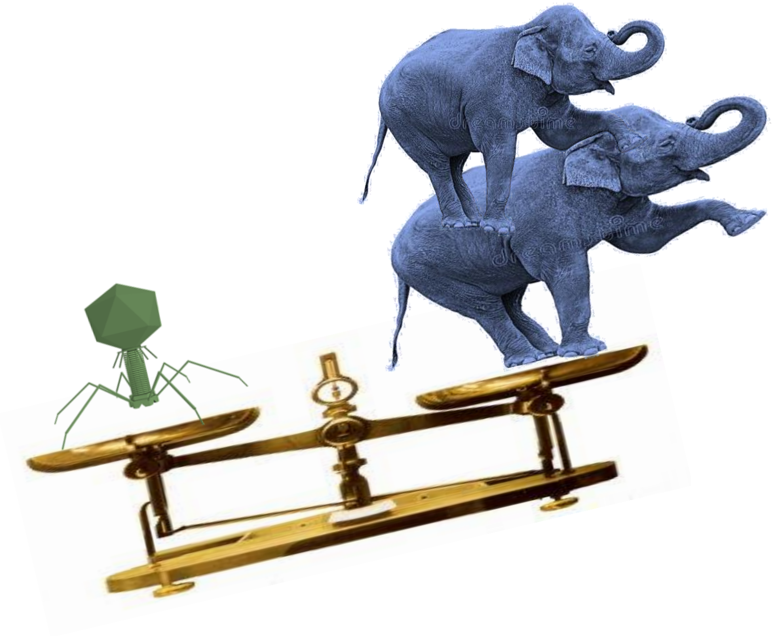
By the end of this lecture students will be able to:

- Describe the characteristics used to identify viruses as obligate intracellular parasites.
- Define the general characteristics of viruses as living pathogens
- Explain the different terms and definitions in general virology.

Some astounding numbers

Viruses are the most abundant entities in the biosphere.



The biomass on our planet of bacterial viruses (Bacteriophages) alone exceeds the elephants on planet by more than 1000-fold.

Quintillion 1,000,000,000,000,000,000,000,000 infections/se

More viruses in a liter of coastal seawater than people on Earth

General Properties of Viruses

- Obligate intracellular parasites and can infect all types of life forms.

- Ultramicroscopic size, ranging from 25 nm up to 300 nm.

- Contain only one type of nucleic acid, either DNA or RNA

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- Smallest Animal Virus: Foot and mouth disease virus, 20 nm
- Largest Animal Virus: Small Poxvirus (Variola), 350 x 250 x l00 nm

General Properties of Viruses

1. Viruses lack cellular organelles such as: nucleus, cytoplasm, mitochondria, ribosome, Golgi apparatus, and endoplasmic reticulum. (Not cellular in nature).
2. Viruses are not capable of independent replication, but they replicate only within living (dependent) host cell.
3. Viruses can not multiply by binary fission or mitosis, but they multiply by complex process called replication.
4. One virus can replicated and produce hundreds of progeny viruses, whereas other organisms, one cell divides to produce only two daughter cells.
5. Viruses inside living host cell are active, whereas outside living cells are inert metabolite.
6. Inactive macromolecules outside the host cell and active only inside host cells.
7. Viruses can not grow on inanimate culture media(non-living media), but grow in tissue cultures(living cells).
8. Viruses can not seen by light microscope, but they can seen by electronic microscope.
9. Basic structure consists of protein shell and surrounding nucleic acid core.
10. Viruses are unaffected by antibiotic agents but sensitive to antiviral chemotherapy agents and interferon.

General Characteristics of Viruses

Living Characteristics of Viruses	Nonliving Characteristics of Viruses
1. They reproduce at a fantastic rate, but only in living host cells. 2. They can mutate.	1.Viruses acellular, they contain no cytoplasm or cellular organelles. 2.Viruses are metabolically inert infectious agent (Viruses don't carry metabolism on their own) that replicates only within cells of living hosts using the host cell's metabolic machinery. 3.Viruses don't grow and divide. Instead, new viral components are synthesized and assembled within the infected host cell. 4.The viruses possess either DNA or RNA but not both.

Viruses can Be Beneficial

Ocean's food chain

- Viral infections in the ocean kill 20 to 40% of marine microbes daily, converting these living organisms into particulate matter, as well as carbon dioxide and other gases that affect the climate of the earth.

Viral vectors

Recombinant viruses as vaccines

Recombinant viruses for gene therapy

Retroviral vectors for gene therapy

Adenovirus vectors for gene therapy

Parvovirus vectors for gene therapy

Oncolytic viruses for cancer therapy

Recombinant viruses in the laboratory

Terms and definitions in virology

Virion: Morphologically complete (mature) infectious virus particle existing freely outside a host cell.

Definitions

Viroid: Autonomously replicating plant pathogens consisting solely of unencapsidated, single-stranded, circular (rodlike) RNAs of 200 to 400 nucleotides. Viroids do not encode any protein products.

Virusoids: Small satellite RNAs with a circular, highly base-paired structure similar to that of a viroid; depend on a plant virus for replication and encapsidation but do not encode any proteins.

Prion: A proteinaceous infectious particle, believed to be responsible for transmissible spongiform encephalopathies such as Creutzfeldte-Jakob disease (CJD) or bovine spongiform encephalopathy.

Prophage: The lysogenic form of a temperate bacteriophage genome integrated into the genome of the host bacterium.

Provirus: The double-stranded DNA form of a retrovirus genome integrated into the chromatin of the host cell.

Satellite: Small RNA molecules that are absolutely dependent on the presence of another virus for multiplication.

Definitions

Capsid: The protein shell, or coat, that encloses the nucleic acid genome.

Capsomeres: Morphologic units seen in the electron microscope on the surface of icosahedral virus particles.

Envelope: A lipid-containing membrane that surrounds some virus particles. It is acquired during viral maturation by a budding process through a cellular membrane.

Nucleocapsid: The protein-nucleic acid complex representing the packaged form of the viral genome.

Protomer : The basic protein building blocks of the coat. They are usually a collection of more than one nonidentical protein subunit.

Icosahedron: A solid shape consisting of 20 triangular faces arranged around the surface of a sphere; the basic symmetry of many virus particles.

Definitions

Genome: The nucleic acid comprising the entire genetic information of an organism.

Helix: A cylindrical solid formed by stacking repeated subunits in a constant relationship with respect to their amplitude and pitch.

Negative-sense: The nucleic acid strand with a base sequence complementary to the strand that contains the protein-coding sequence of nucleotide triplets or a virus whose genome consists of a negative-sense strand.

Receptor: A specific molecule on the surface of a cell to which a virus attaches as a preliminary to entering the cell. May consist of proteins or the sugar residues present on glycoproteins or glycolipids in the cell membrane.

Definitions

Spike: Surface projection of varying lengths spaced at regular intervals on the viral envelope, also called peplomers. Consist of viral glycoproteins

Structural Proteins: Those proteins which are present in the virion. this includes proteins present in low amounts. 'STRUCTURAL PROTEINS' do NOT necessarily play a skeletal role in maintaining a virus's shape

Definitions

Cytopathic Effect (CPE): Structural changes in host cells that are caused by viral invasion. e.g. rounding of the infected cell, fusion with adjacent cells to form a syncytia.

Viremia: The presence of the virus in the blood.

Virurea: The presence of the virus in the urine.

Tropism: Affinity of a certain virus to specific host tissue or cells in which it replicates.

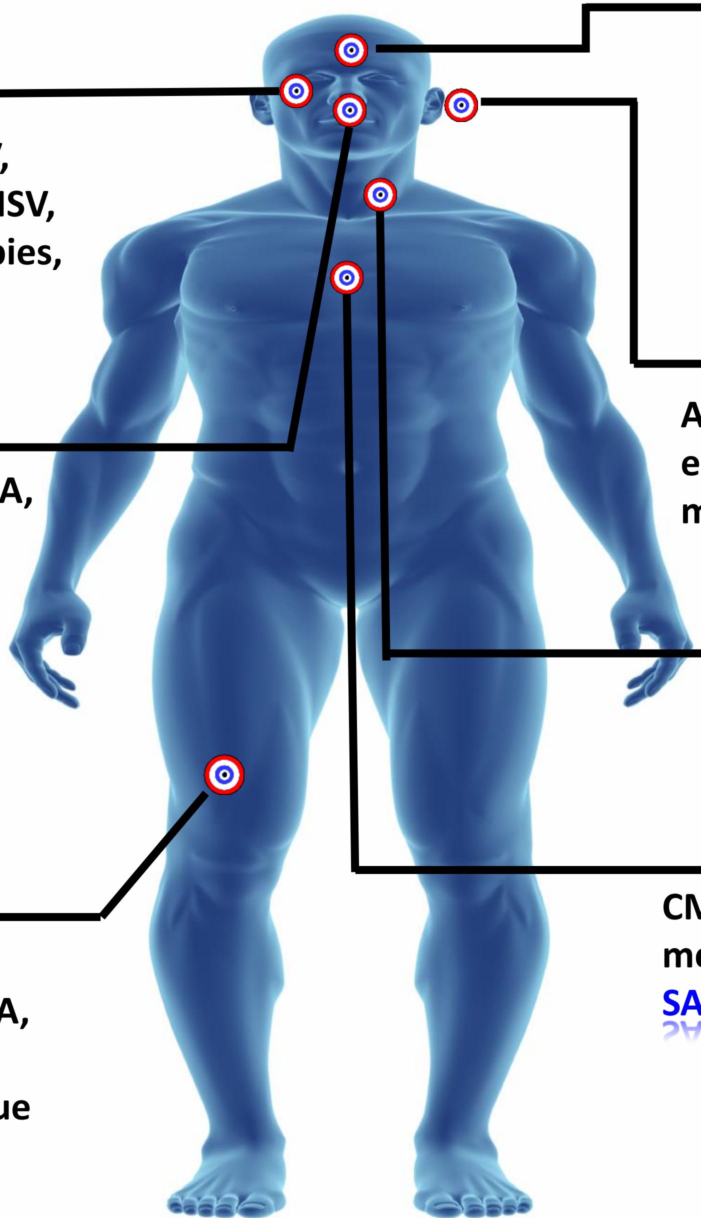
e.g. Influenza replicates in respiratory (lung) cells.

Virulence: The capacity of a Pathogen (infectious agent) to produce disease in the host.

Infection: The invasion of host body tissues by pathogenic micro-organisms resulting in tissue injury that may progress to disease.

Why We Study Viruses?

2- Viruses are important disease-causing agents



CNS

Adenoviruses, CMV, EBV, enteroviruses, filoviruses, HHV6, HIV, HSV, Lassa virus, measles, mumps, polioviruses, prions, rabies, rubella.

Eyes

Adenoviruses, CMV, Coxsackie A, EBV, enteroviruses, Rift Valley fever, HIV, HSV, influenza, measles, mumps, polio, rabies, rubella, varicella.

Ears

Adenoviruses, CMV (congenital), enteroviruses, influenza A, measles, mumps, RSV, rubella (congenital), varicella.

Nose

Adenoviruses, coronaviruses, Coxsackie A, EBV, enteroviruses, rhinoviruses, RSV

URT

HRSV, coronaviruses, enteroviruses, influenzaviruses, measles, metapneumovirus, parainfluenza, rhinoviruses.

LRT

CMV, metapneumovirus, influenza, measles, parainfluenza, rhinoviruses, RSV, SARS/MERS coronavirus.

Muscle and joints

Arboviruses, dengue, enteroviruses, filoviruses, hantaviruses, HBV, hepatitis A, HIV, HTLV, influenzaviruses, mumps, polioviruses, rubella, yellow fever, dengue

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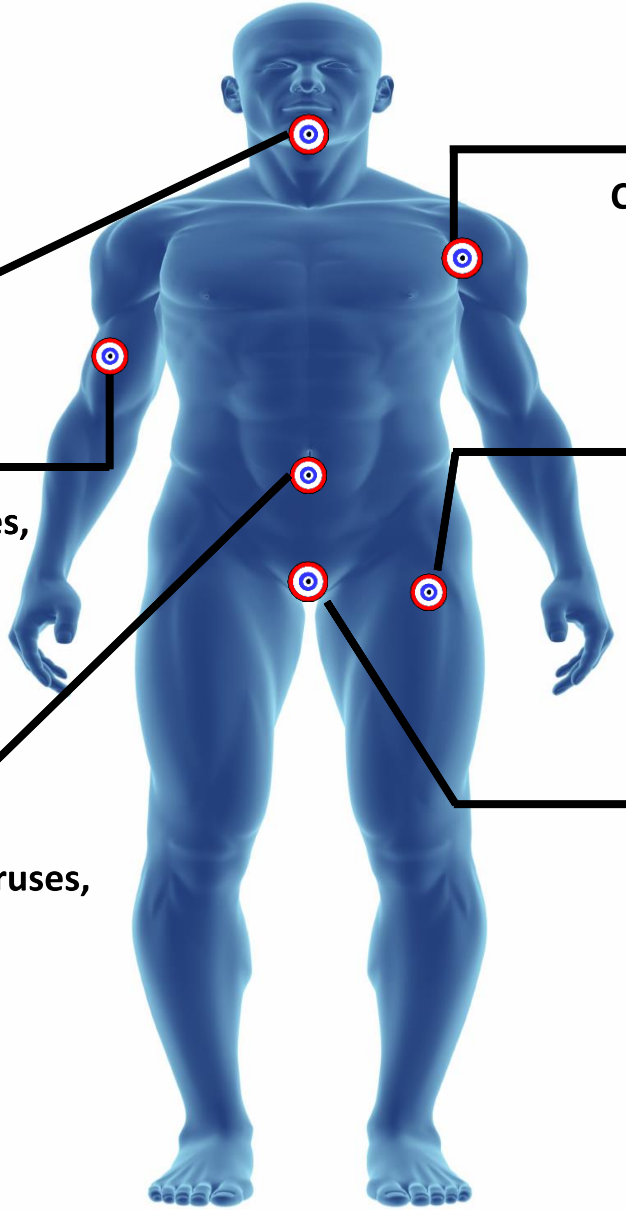

Mouth

CMV, Coxsackie A, EBV, enteroviruses, filoviruses, HIV, HPV, HSV, measles, mumps

Skin

HHV6, HHV7, HHV8, HIV, HPV, HSV, measles, parvovirus B19, rubella, varicella.

GIT

Adenoviruses, caliciviruses, CMV, enteroviruses, HIV, HSV, rotavirus, viral haemorrhagic fevers, influenza, coronaviruses

Lymph nodes and immune system

CMV, EBV, filoviruses, HIV, measles, mumps, rubella.

Blood

HIV, dengue, filoviruses, Lassa virus, Rift Valley fever, yellow fever, lymphocytic choriomeningitis virus

Genitalia

HPV, HSV, mumps, CMV, HBV, HCV, HIV, HPV, HSV, HTLV.

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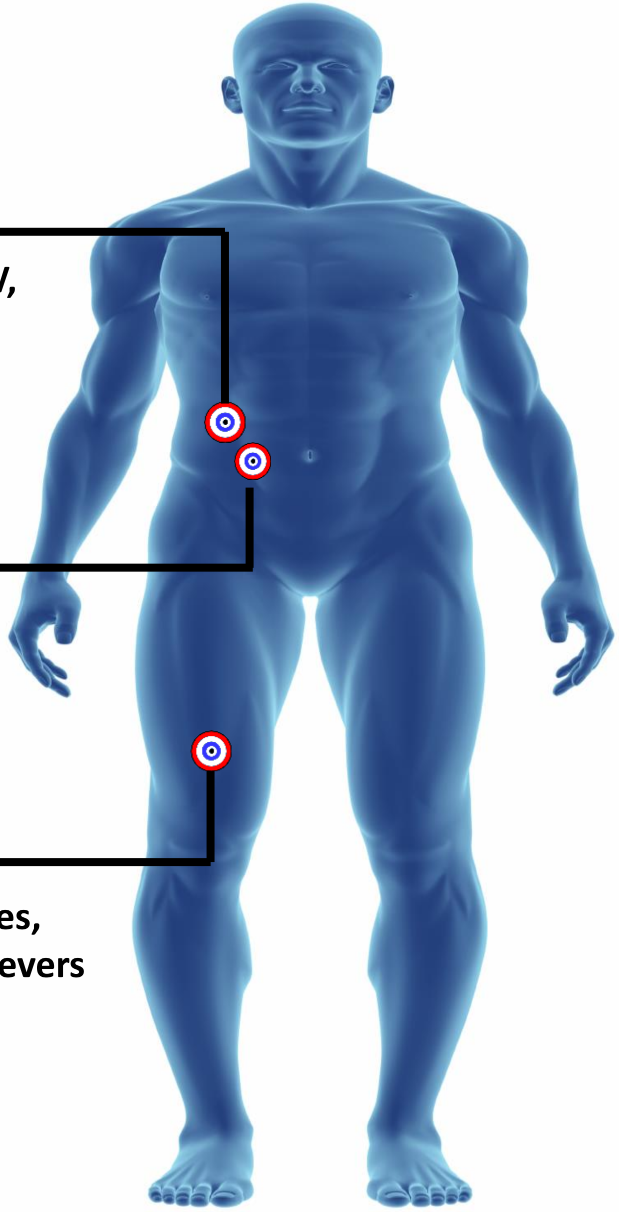


Liver

Hepatitis A, B, C, D, E, yellow fever, CMV, EBV, HSV, varicella.

Kidney

Adenoviruses, BK virus, CMV, enteroviruses, filoviruses, hepatitis B, hepatitis C.

Bone Marrow

CMV, EBV, enteroviruses, HIV, measles, parvovirus B19, viral haemorrhagic fevers

Cancers

EBV, HBV, HCV, HHV8, HPV, HTLV

Fetus

CMV, enteroviruses, hepatitis B, hepatitis C, HIV, HSV, HTLV, parvovirus B19, rubella, varicella.

Evolutionary origin of viruses

The origin of viruses is not known.

Two theories of viral origin can be summarized as follows:

- ✓ Viruses may be derived from DNA or RNA nucleic acid components of host cells that became able to replicate autonomously and evolve independently. They resemble genes that have acquired the capacity to exist independently of the cell. Some viral sequences are related to portions of cellular genes encoding protein functional domains. It seems likely that at least some viruses evolved in this fashion.

- ✓ Viruses may be degenerate forms of intracellular parasites. There is no evidence that viruses evolved from bacteria, although other obligately intracellular organisms (eg, rickettsiae and chlamydiae) presumably did so. However, poxviruses are so large and complex that they might represent evolutionary products of some cellular ancestor.

Summary

1.Viruses are infectious agents with both living and nonliving characteristics.

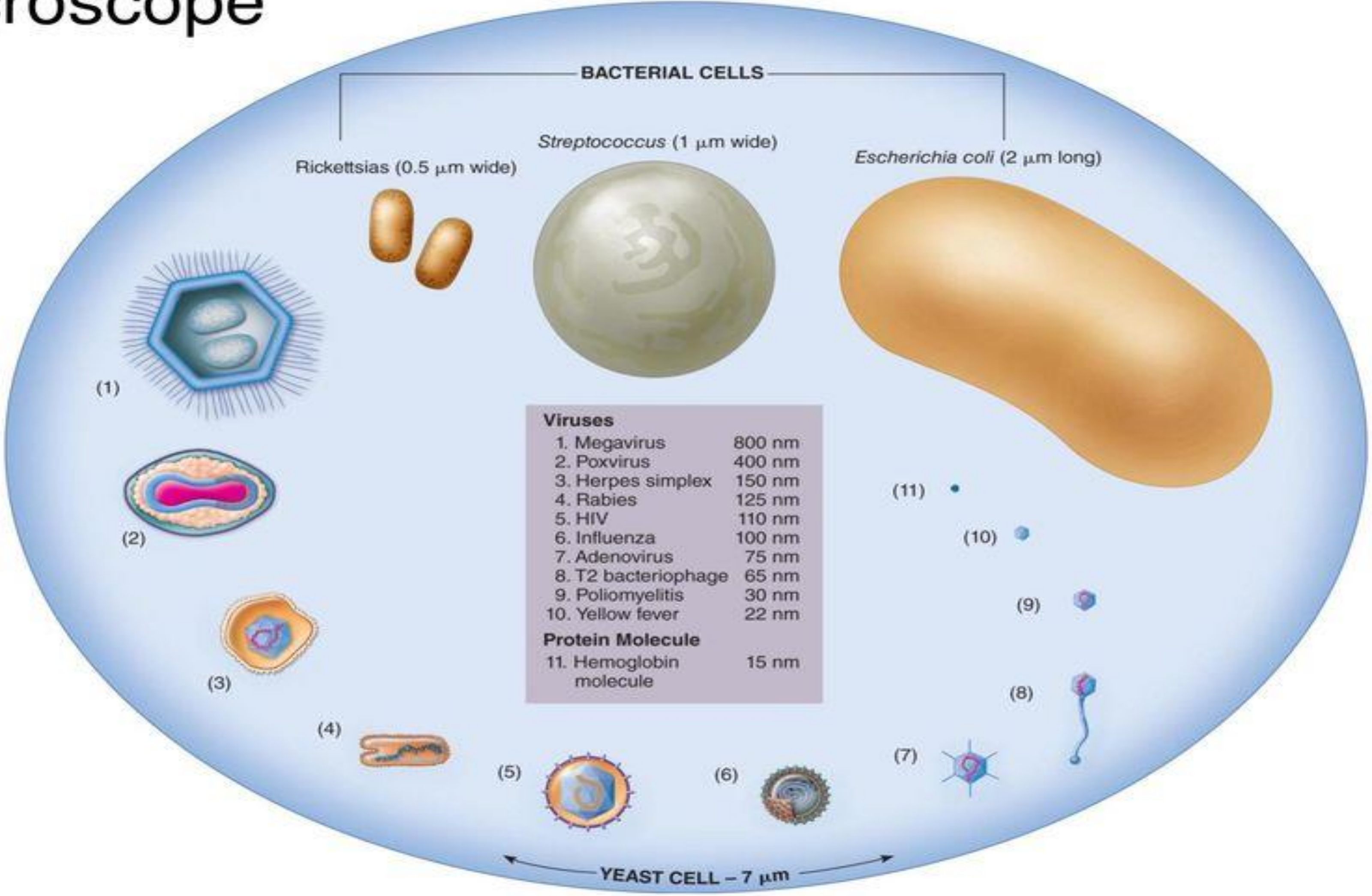
2.Living characteristics of viruses include the ability to reproduce-but only in living host cells-and the ability to mutate.

3.Nonliving characteristics include the fact that they are not cells, have no cytoplasm or cellular organelles, and carry out no metabolism on their own and therefore must replicate using the host cell's metabolic machinery.

4.Viruses can infect animals, plants, and even other microorganisms.

General Size of Viruses

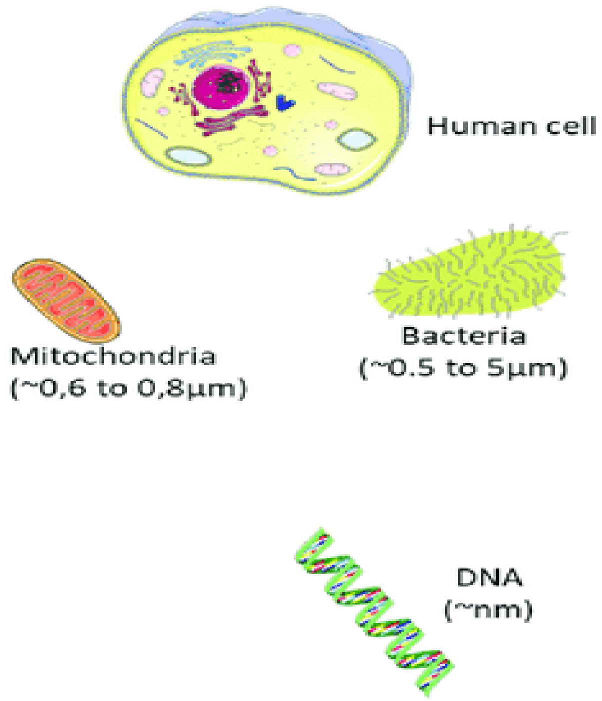
- Size range – most <0.2 µm; requires electron microscope

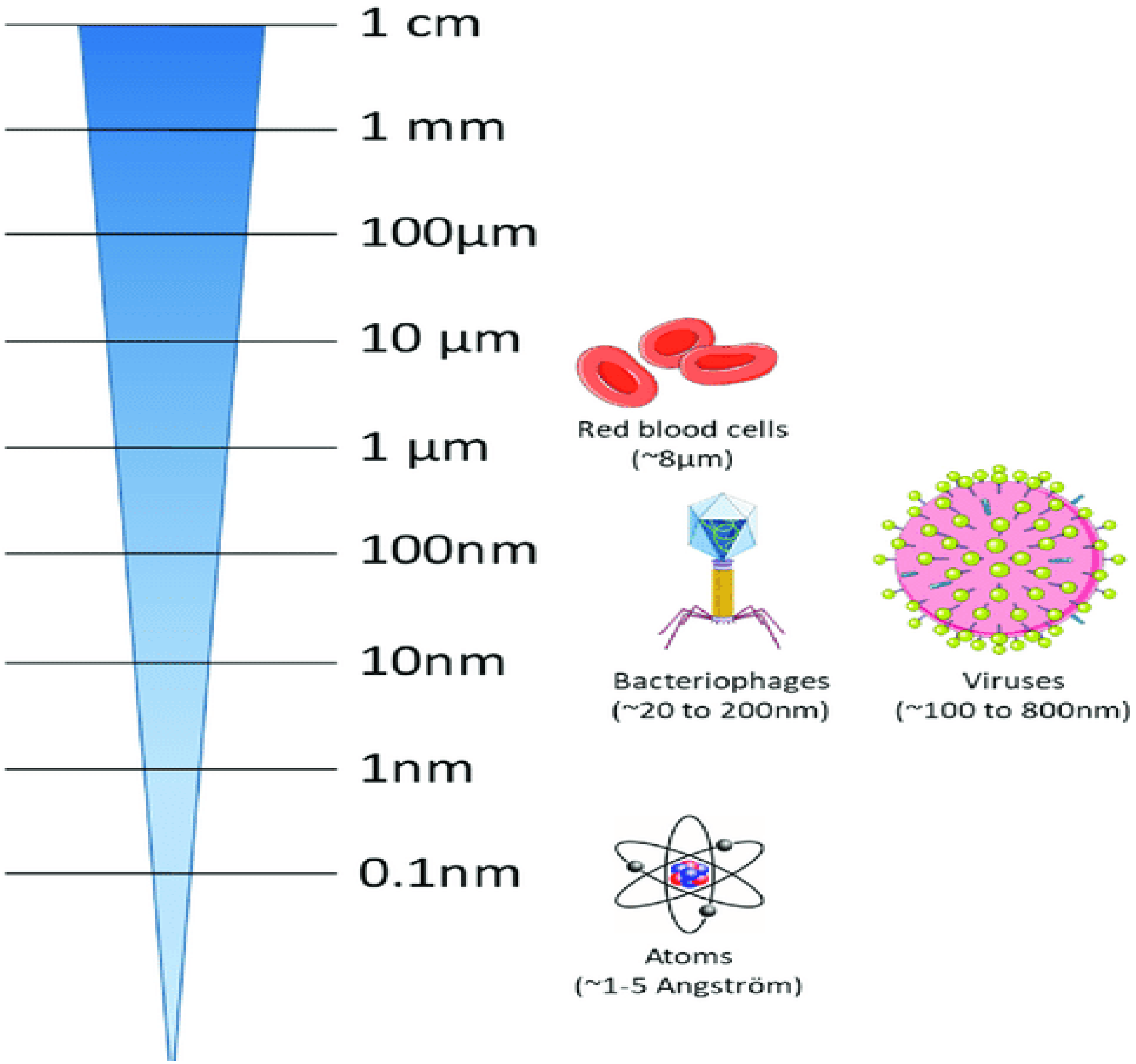


Numbers Matters Not the Size!

In the human body:

10^{13} « human cells »
10^{14} « microbial cells »
10^{12} bacteriophages/g of fecal material
10^{11} bacteria/g of fecal material





Viruses range in size from:
25-300 nm

Viruses:

- Are obligate intracellular parasites of bacteria, protozoa, fungi, algae, plants, and animals.
- Ultramicroscopic size, ranging from 20 nm up to 450 nm (diameter).
- Are not cells; structure is very compact and economical.
- Do not independently fulfill the characteristics of life.
- Are inactive macromolecules outside the host cell and active only inside host cells.
- Basic structure consists of protein shell (capsid) surrounding nucleic acid core.
- Nucleic acid can be either DNA or RNA but not both.
- Nucleic acid can be double-stranded DNA, single-stranded DNA, single-stranded RNA, or double-stranded RNA.
- Molecules on virus surface impart high specificity for attachment to host cell.
- Multiply by taking control of host cell's genetic material and regulating the synthesis and assembly of new viruses.
- Lack enzymes for most metabolic processes.
- Lack machinery for synthesizing proteins.

How many viruses can fit on the head of a pin?

2 mm = 2000 microns

500 million rhinoviruses

Questions

1. State TWO living and TWO nonliving characteristics of viruses?
2. Mention/ list FIVE general characteristics/properties of viruses?
3. What is the definition of virus?
4. Discuss why viruses cannot be cultivated on synthetic media (bacteriological media?
5. Definitions Slide 12-19.
6. What is one theory for how viruses may have originated?
7. Viruses range in size from:

A. 1-100 nm B. 25-300 nm c. 10-100 µm   D. 400-1000 nm   E. 1-10 µm

8. What is the size range of viruses in micrometers (µm)?

“ If you fell down yesterday. Stand up today”

H.G.wells

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