Viruses

Viruses	Obligate Parasites	<u>Explain why viruses are obligate parasites.</u> Viruses do not have **translation machinery** such as **ribosomes** and **amino acids**. Hence, they have to rely on **host ribosomes** and building blocks such as **amino acids** for production of capsids and tail fibers. Viruses do not have **transcription machinery** such as **RNA polymerase** and **free ribonucleic acids**. Hence, they are **unable** to form **mRNA** for the purpose of translation. Viruses are unable to **replicate** genome as they have no **free deoxyribonucleic acids** and no **DNA polymerase**. Hence, they have to used **host machinery** to replicate genome. Thus viruses are **obligate parasites** as they require the **host cell** to **complete their life cycle** and **reproduce**.
	Characteristics	<u>Describe the characteristics of viruses.</u> Viruses can be considered as **living** or **non-living**. Viruses are **very small** with sizes ranging from 10 nm to 300 nm. They have **geometric shapes** and may exist as **crystalline forms** outside the host cells. They can be considered as non-living as viruses are **acellular** and do **not** have **organelles**, **cytoplasm** and are **not enclosed** by **plasma membranes**. Instead, they are enclosed by a protein coat called the **capsid** that is made of smaller units known as **capsomeres**. Outside the host cell, viruses do **not** carry out **metabolic processes** such as **respiration**. However, viruses can be considered as living as also **contain genetic material** such as **RNA** or **DNA** but **not both**. Once inside the host cell, viruses can **reproduce** and replicate many copies of the viral genome using the **host cell machinery** like enzymes such as **RNA polymerase** for **transcription** and **ribosomes** for **translation** to produce **viral proteins**. They also use other host resources such as **tRNA**, **nucleotides**, **amino acids** and **ATP** to replicate. Thus, viruses are known as **obligate parasite**s as they require the host cell to complete their life cycle and reproduce.

Viruses	Evolution	Antigenic Drift	**Antigenic drift** refers to **mutations** in a gene coding for antigens such as **viral glycoproteins**. If the **accumulation** of mutations causes antigens to no longer to be complementary in shape and charge to antibodies, the host antibodies do not recognize the mutated antigens and become susceptible to the virus. Antigenic drift can also change the structure of **viral glycoproteins** such as haemaglutinin and neuraminidase such that they have a **more precise binding site** to the **receptor** or a **more precise active site**, increasing their ability to infect. <u>Explain why mutations take place more frequently in viruses.</u> Viruses have a **single stranded RNA genome** and hence have **no backup copy** for genome repair. The RNA genome is also **more reactive** due to the –OH group on C2. RNA-dependent RNA polymerase in influenza and reverse transcriptase in HIV **lacks proof-reading ability**, leading to **errors** in viral genome replication.
		Antigenic Shift	Antigenic shift occurs when **two or more different strains of viruses** infect the **same cell** simultaneously. The host cell will form new viruses that **combine their antigens**, forming a new strain of virus with a mixture of the antigens of the original strains.
		Origins	<u>Suggest a possible evolutionary origin for viruses.</u> Viruses are **host specific** and do not have a common host thus the nature of their evolution is **polyphyletic**. For example, **bacteriophages** only attack bacteria while **HIV viruses** only attack the **T helper cells** and **macrophages** in humans. Different types of viruses may have originated from **different cell types**, from cellular **nucleic acids** of **injured cells** or from **plasmids** or **transposons**. They **evolve with their host cells** and thus viral genomes are more similar to that of the host cells than that of other types of viruses. The processes that lead to viral evolution include **mutation** such as **antigenic drift*** or through **antigenic shift**.

		Point of Comparison	T4 Phage (Lytic Cycle)	Lambda Phage (Lysogenic Cycle)
Bacteriophages	Structure	Genome	**Double stranded DNA**.	
		Protein Coat	**Icosahedral capsid head** containing genome and a **tail** surrounded by a **contractile sheath**.	
		Others	**Collar**, **base plate**, **tail pins** and **tail fibers**.	**Tail fiber**.
	Life Cycle	Attachment	Attachment sites on **tail fibers adsorb** to **complementary receptor sites** on the bacterial host **cell wall**.	
		Penetration	The bacteriophage releases **lysozyme**, an enzyme which digests the bacterial cell wall resulting in a **change** in the **base plate conformation**, causing the **tail sheath** to **contract** and thrust the **hollow core tube** through the bacterial **cell wall**. The **phage DNA** will then be injected into the bacterial host cell. The empty **capsid remains outside** the host cell.	
		Replication	**Early phage proteins** coded for by the **phage genome** degrades the host DNA. Virus DNA escapes degradation due to **methylation**. The virus uses the host cell **macromolecular synthesizing machinery** such as enzymes and nucleotides to synthesize **phage proteins** such as enzymes and structural components and **phage DNA**. During the **eclipse period**, **complete infective virions** are not yet present.	The linear phage DNA **circularizes** and is incorporated into the host cell genome by enzyme **integrase**. The virus is now called a **prophage**. The prophage gene expresses **phage repressor proteins** which **block expression** of **other phage genes** involved in phage replication. Hence, new phages are not synthesized and the prophage replicates along with the bacterial chromosome. Phage undergoes a **latent stage** where it does not undergo replication. During **spontaneous induction**, cellular **proteases** are activated which destroy the repressor proteins. The prophage Is then **excised** from the host genome, **activating phage genes** and causing **phage enzymes** and **phage components** to be synthesized.

Bacteriophages	Point of Comparison		T4 Phage (Lytic Cycle)	Lambda Phage (Lysogenic Cycle)
	Life Cycle	Maturation	**Phage DNA** and **capsid** assemble into the DNA filled head. The **head**, **tail** and **tail fibers** are assembled **independently** and join in a **specific sequence** where **tail fibers** and **then** the **DNA filled head** joins the tail.	
		Release	Phage **lysozyme** synthesized within the cell breaks down the bacterial **cell wall**. The bacterial **cell membrane lyses** and releases the newly formed virions.	
	Advantages		-	In the **lysogenic pathway**, the lambda phage DNA is **integrated** into the bacterial genome forming a **prophage**. Every time the host cell's machinery replicates the bacterial chromosome the **prophage DNA** is also **replicated**. This allows **continuous replication** of the prophage without killing the host bacteria.
	Defense Mechanisms		What are the possible defense mechanisms of bacteria against phages? Bacterial DNA can **mutate** to code for receptor sites that are **no longer complementary in shape and charge** to the phage **attachment sites** such that the phage can no longer attach. The bacteria can synthesize **restriction enzymes** which recognize foreign phage DNA and **cleave** it. The bacteria's own DNA is **methylated** and hence is not cleaved. The bacteria can develop a **lysogenic relationship** with the phage.	

		Point of Comparison	Influenza	Human Immunodeficiency Virus (HIV)
Animal Viruses	Structure	Shape	Usually **spherical** or **ovoid**.	**Spherical**.
		Genome and Capsid	**Negative strand RNA genome** made up of **eight single-stranded RNA segments**. The RNA genome is bound to proteins forming a **helical nucleoprotein** that is surrounded by a **protein capsid** serving as a protective layer. There are **three RNA segments** coding for **three different polymerase** which can **combine** to form a **RNA-dependent RNA polymerase** for the transcription and replication of the viral genome.	**Positive strand RNA genome** comprising of **two identical single-stranded RNA** bound to **nucleocapsid proteins**. The **RNA genome**, **reverse transcriptase**, **protease** and **integrase** are encapsulated in a **conical protein capsid**.
		Envelope	The capsid is surrounded by a **phospholipid envelope** derived from the **host cell plasma membrane**.	
		Glycoproteins	**Viral glycoproteins hemagglutinin** and **neuraminidase** stud the phospholipid envelope.	**Viral glycoproteins gp120** and **gp41** stud the phospholipid envelope surface.
	Life Cycle	Attachment	The viral **glycoprotein hemagglutinin** on the viral surface **binds specifically** to **complementary sialic acid receptors** found on the membrane of host cells, such as **epithelial cells** lining the respiratory tract.	The viral **glycoprotein gp120** recognizes and **binds specifically** to the **complementary CD4 receptor** found on the membrane of host cells such as **helper T cells** or **macrophages**.

		Point of Comparison	Influenza	Human Immunodeficiency Virus (HIV)
Animal Viruses		Penetration and Uncoating	The virus then enters the host cell by **endocytosis** as the plasma membrane **invaginates**, placing the virus into an **endocytotic vesicle**. **Acidification** of the endocytotic vesicle occurs when it **fuses** with a **lysosome** triggers the **fusion** of the **viral envelope** with the **phospholipid bilayer** of the membrane of the **endocytotic vesicle**, releasing the **nucleocapsid** into cytoplasm. The **capsid layer** is then **degraded** by **cellular enzymes**. The **eight viral RNA segments** are released into the cytoplasm and then **enter the nucleus** of the host cell.	With the help of **gp41**, the viral envelope **fuses** with the host cell membrane to **release the capsid** into the **cytosol** leaving the envelope behind. The **capsid** is **degraded** by **cellular enzymes** so that the **viral RNA** and **viral enzymes** are released into the **cytoplasm**.
	Life Cycle	Replication	Within the nucleus, **RNA-dependent RNA polymerase transcribes** the **negative sense RNA strands**, forming **complementary** positive strands which then act as **templates** for the synthesis of new copies of **viral RNA** and serve as **mRNA**. The **mRNA** leaving the nucleus of host cells may be **translated** into viral components. At the **rough endoplasmic reticulum**, **glycoproteins hemagglutinin** and **neuraminidase** are formed and packed into **vesicles** for transportation to the **plasma membrane** where they are **embedded**. mRNA translated in the cytoplasm will give rise to **capsid proteins** which will **associate** with the proteins at **cytoplasmic side** of the cell membrane.	Viral **reverse transcriptase** first synthesizes a **complementary DNA strand** to the viral RNA strand to form a **RNA-DNA hybrid**. The RNA strand will be **degraded** and a second complementary DNA strand is synthesized to form a **double-stranded viral DNA molecule** which then **enters the nucleus** of the host cell to be **incorporated** into the **host cell genome** by the viral enzyme **integrase**, becoming a **provirus** which may remain latent for a long time until activation. Upon activation, the **provirus** is **transcribed into RNA** which exits the nucleus. These RNA can serve as the **viral genomes** for the **new** viruses or as **mRNA**. The mRNA is **translated** into viral components. At the rough endoplasmic reticulum, glycoproteins **gp120** and **gp41** are synthesized and packaged into **vesicles** for transportation to the plasma membrane where they are **embedded**. mRNA translated in the cytoplasm forms the viral **polyprotein**.

		Point of Comparison	Influenza	Human Immunodeficiency Virus (HIV)
Animal Viruses	Life Cycle	Maturation	The **viral genome** associates with proteins to form the **nucleoprotein** which will interact with the **capsid proteins** at the cell membrane to initiate the **budding** process.	The **viral genome** and **polyprotein** assembles at the cell membrane.
		Release	The new viruses will **bud off** from the cell by **evagination**, acquiring its envelope from the host cell membrane which is embedded with **viral glycoproteins**. The release is facilitated by **neuraminidase**, which **cleaves sialic acid** from the host cell receptor.	The new viruses will **bud off** from the cell by **evagination,** acquiring its envelope from the host cell membrane which is embedded with the **viral glycoproteins**. The viral **polyprotein** is **cleaved** by **protease** to produce **viral enzymes** and **proteins**. The **viral genome** and **enzymes** are then encapsulated by a **protein coat** to form a **capsid**.