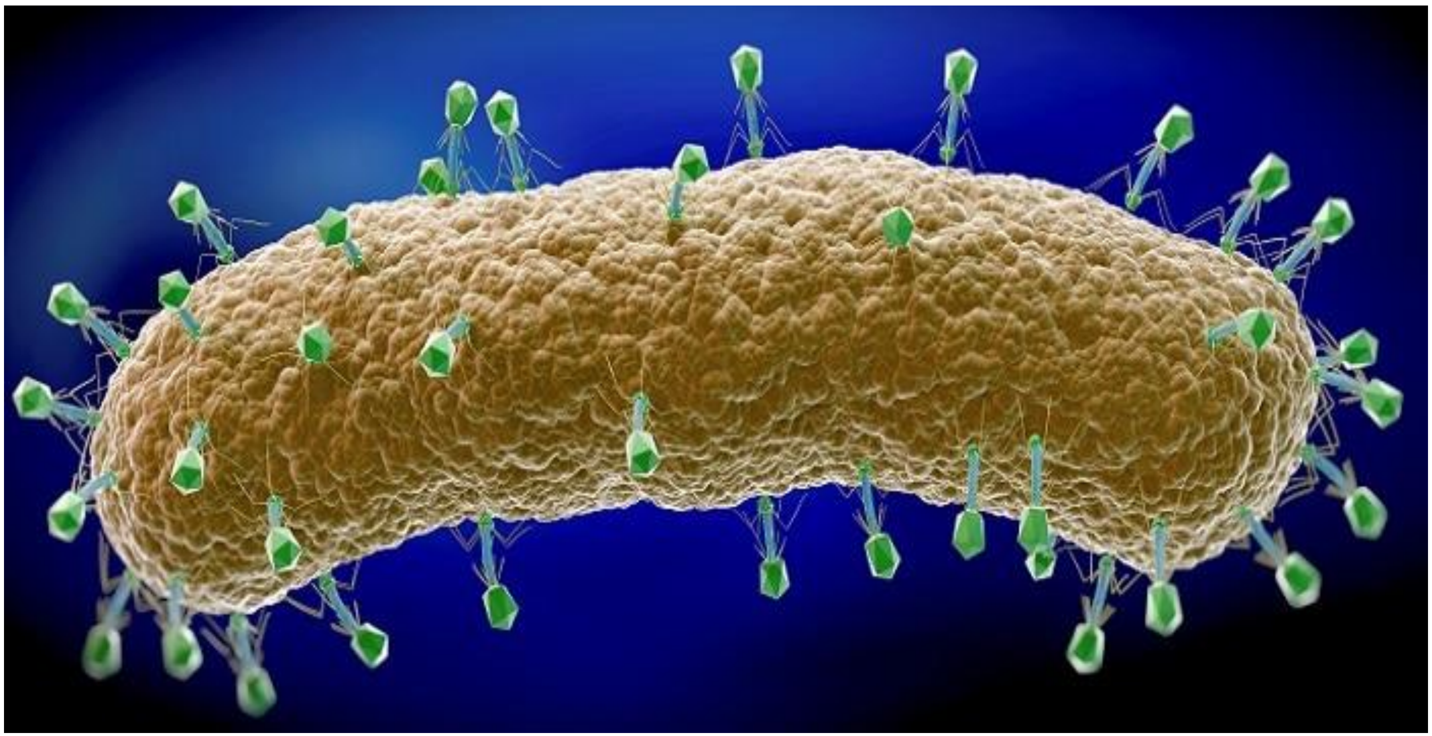
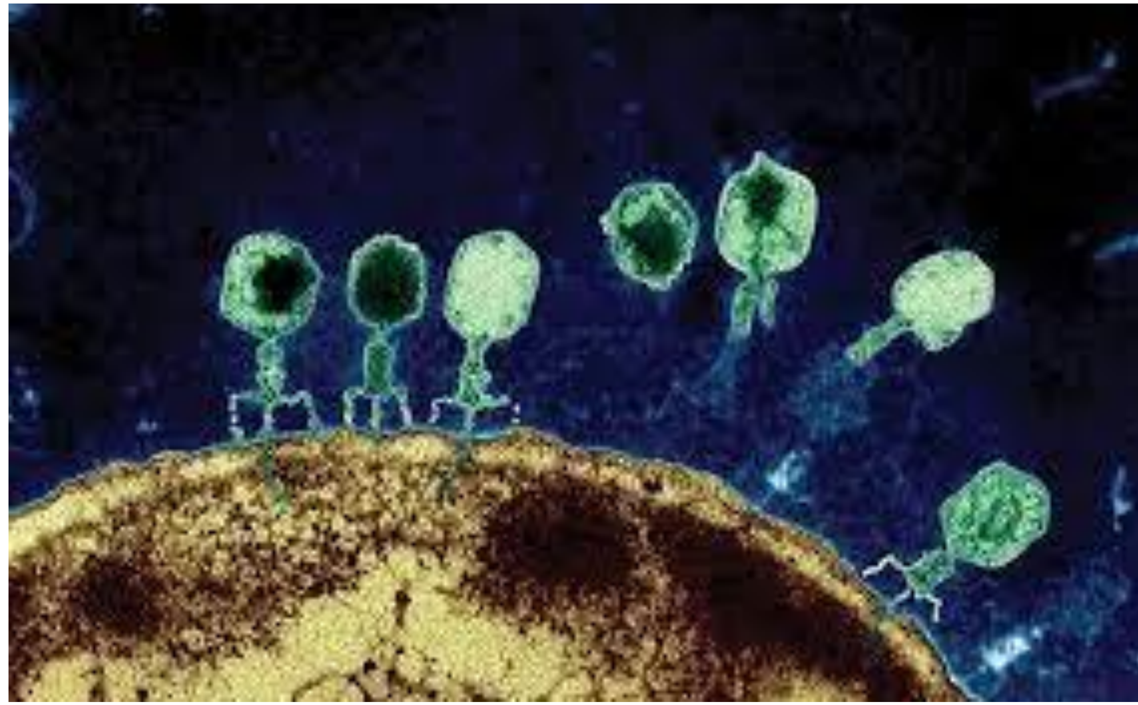
Bacteriophages

A **bacteriophage**, also known informally as a phage, is a virus that infects and replicates within **bacteria** and **archaea**.





- Bacteriophages are composed of proteins that encapsulate a **DNA or RNA genome**, and may have relatively simple or elaborate structures.

- Their genomes may encode as few as **four** genes and as many as **hundreds** of genes.

- Phages replicate **within** the bacterium following the injection of their genome into its cytoplasm.

- Bacteriophages are among the **most common** and **diverse** entities in the biosphere.

- It is estimated there are more than **10^{31} bacteriophages** on the planet, more than every other organism on Earth, including bacteria, combined.

- Phages are widely distributed in locations populated by **bacterial hosts**, such as soil or the intestines of animals.

- One of the densest natural sources for phages and other viruses is **seawater**.

- Up to **70%** of marine bacteria may be infected by phages.

Classification

- Phages are classified by the International Committee on Taxonomy of Viruses (ICTV) according to **morphology** and **type of nucleic acid**.

- **Nineteen** families are currently recognized by the ICTV that infect bacteria and archaea.

- Of these, **17 have DNA** and **only two** have **RNA genomes.**

- **Fourteen** families are **non-enveloped** and **only five** families are **enveloped.**

- Of the **17** families with **DNA genomes**, only **two have single-stranded genomes.**

- **Eight** of the viral families with DNA genomes have **circular** genomes while **nine** have **linear** genomes.

- **Nine** families infect **bacteria only; nine** infect **archaea only;** and **one (Tectiviridae)** infects **both bacteria and archaea**.

History

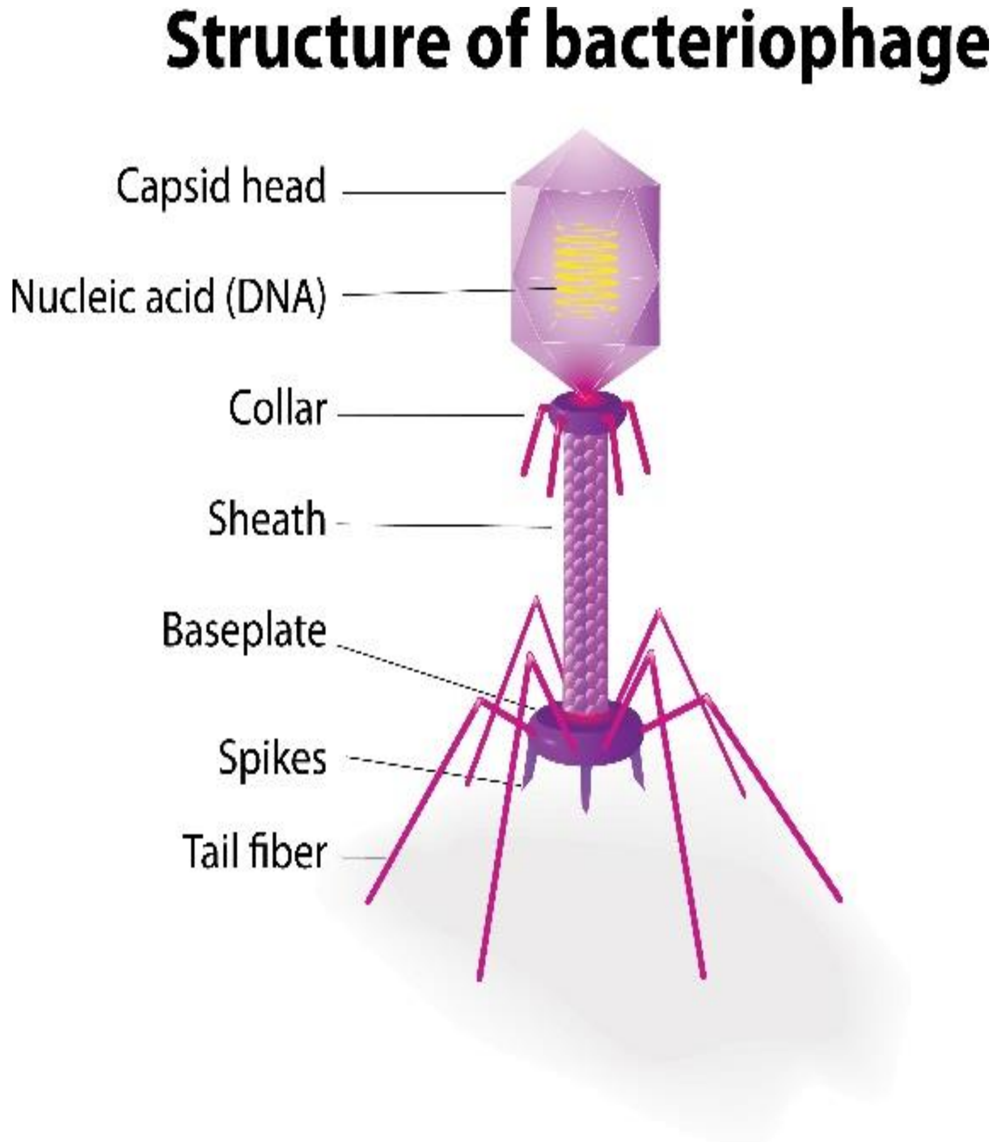
- In 1896, **Ernest Hanbury Hankin** reported that something in the waters of the Ganges and Yamuna rivers in India had marked antibacterial action against cholera and could pass through a very fine porcelain filter.

- French-Canadian microbiologist **Félix d'Hérelle**, working at the Pasteur Institute in Paris, announced on 3 September 1917, that he had discovered "an invisible, antagonistic microbe of the dysentery bacillus".

Structure:

The virion has a **polyhedral head** connected to a **helical tail** through a short collar.

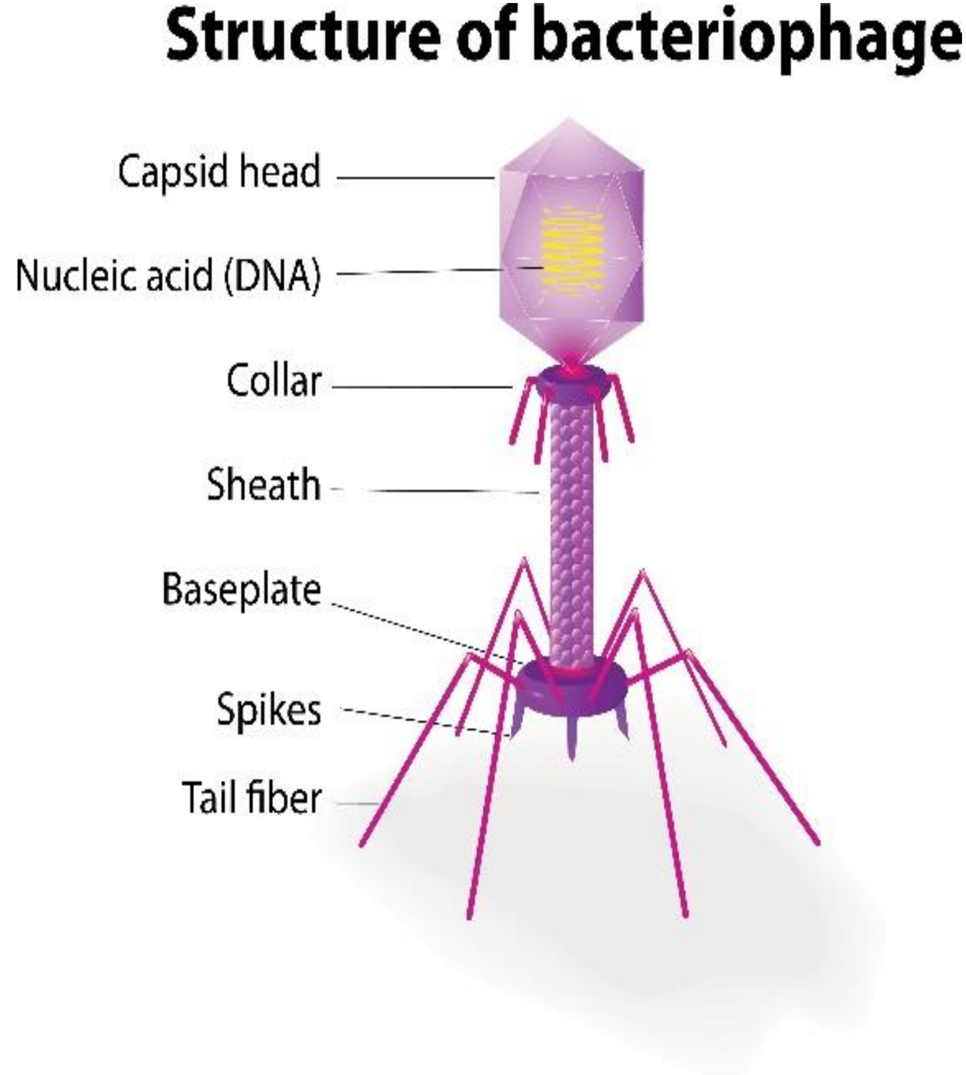
The **head** is composed of **capsomeres** which enclose a tightly packed **dsDNA (with few exceptions)**.



The **tail** has an **inner hollow tube called core**, surrounded by a **contractile sheath** which consists of **24 rings.**

The distal end of the tube is connected to a **hexagonal basal plate** with **spikes** at each corner.

Six long, flexible tail fibers also arise from the **basal plate** which helps in adsorption to bacteria



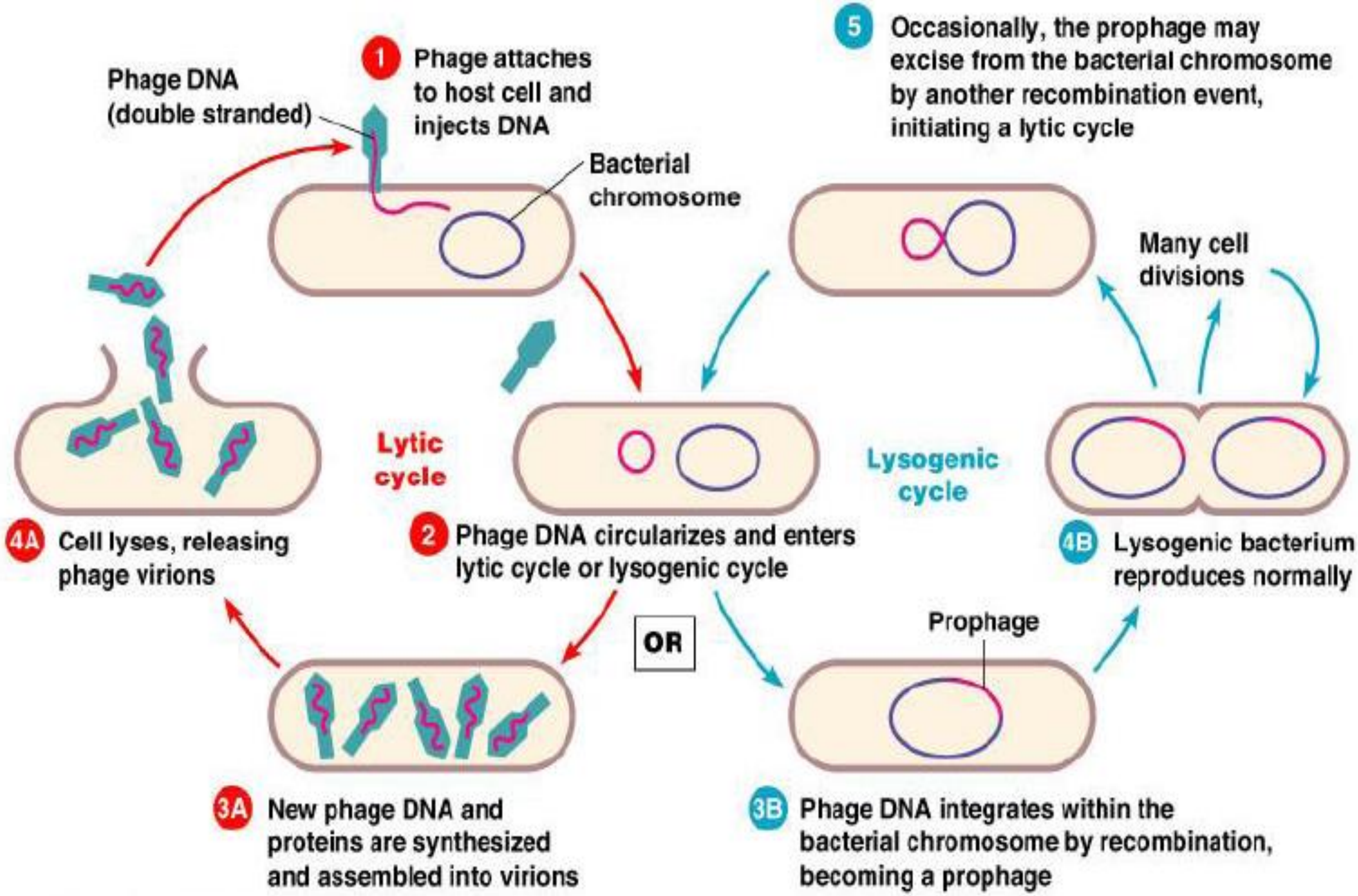
Replication

- Bacteriophages may have a **lytic cycle** or a **lysogenic cycle.**
- Some viruses are capable of carrying out **both**.
- With **lytic phages** such as the T4 phage, bacterial cells are **broken open (lysed)** and destroyed after immediate replication of the virion.
- As soon as the cell is destroyed, the phage progeny can find **new hosts** to infect.

- Some lytic phages undergo a phenomenon known as **lysis inhibition**, where completed phage progeny will not immediately lyse out of the cell if extracellular phage concentrations are high.

- This mechanism is **quite different** from lysogeny.

- In **lysogeny** the virus remains **dormant** until host conditions **deteriorate**, perhaps due to depletion of nutrients or radiation.
- Then, the endogenous phages (known as **prophages**) become **active**.
- At this point they initiate the reproductive cycle, resulting in **lysis** of the host cell.
- As the lysogenic cycle allows the host cell to continue to survive and reproduce, the virus is **replicated in all of the cell's offspring**.


Phage DNA (double stranded)
1 Phage attaches to host cell and injects DNA
Bacterial chromosome
5 Occasionally, the prophage may excise from the bacterial chromosome by another recombination event, initiating a lytic cycle
Many cell divisions
Lytic cycle
Lysogenic cycle
4A Cell lyses, releasing phage virions
2 Phage DNA circularizes and enters lytic cycle or lysogenic cycle
4B Lysogenic bacterium reproduces normally
OR
Prophage
3A New phage DNA and proteins are synthesized and assembled into virions
3B Phage DNA integrates within the bacterial chromosome by recombination, becoming a prophage

- An example of a bacteriophage known to follow the **lysogenic cycle and the lytic cycle** is the **phage lambda of *E. coli***.

- Sometimes prophages may provide benefits to the host bacterium while they are dormant by adding new functions to the bacterial genome in a phenomenon called **lysogenic conversion.**

- Examples are the conversion of **harmless** strains of *Corynebacterium diphtheriae* or *Vibrio cholerae* by bacteriophages to **highly virulent** ones, which cause diphtheria or cholera, respectively.

Medical importance

- They have been used for over 90 years as an **alternative to antibiotics** in the former Soviet Union and Central Europe as well as in France.

- They are seen as a possible treatment against **multi-drug-resistant** strains of many bacteria.

- On the other hand, phages of **Inoviridae** have been shown to **complicate** biofilms involved in pneumonia and cystic fibrosis.

  They **shelter the bacteria** from drugs and therefore promote persistent infection.

Phage typing

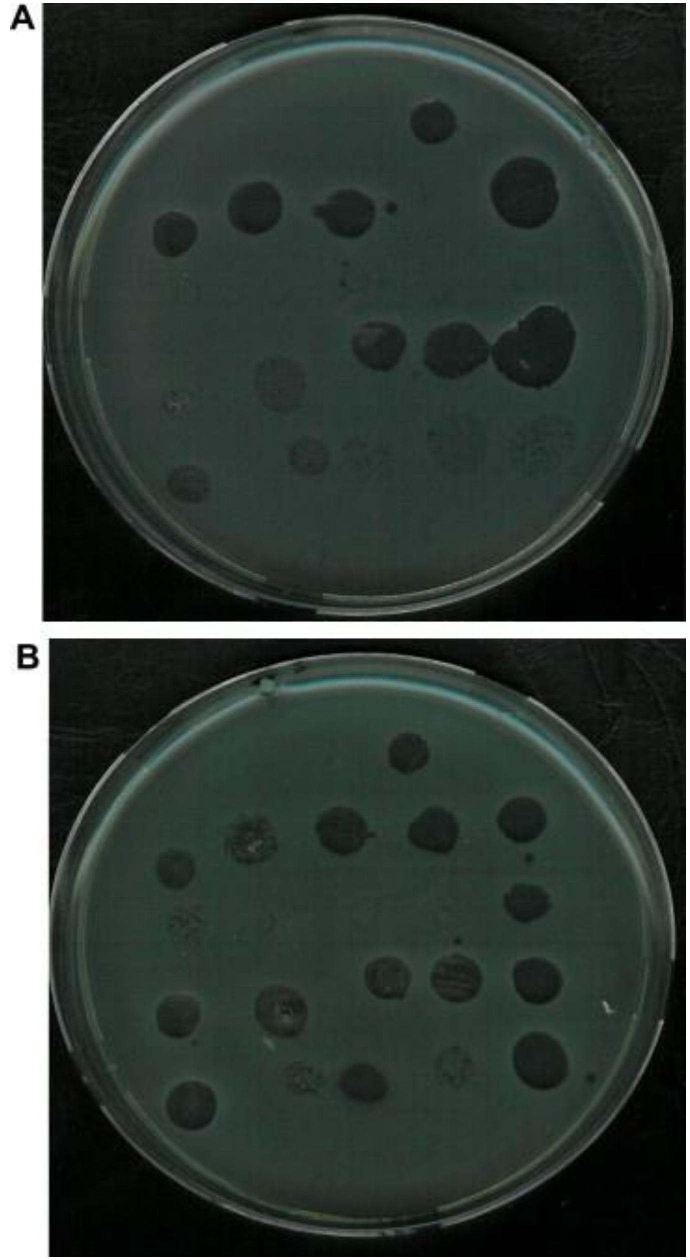
- Phage typing is a method used for **detecting single strains** of bacteria.

- It is used to trace the **source of outbreaks of infections**.

- Different phages are used to identify different strains of **bacteria within a single species.**

Phage typing method

- A culture of the strain is grown on a petri dish.
- **Squares** are drawn on the base of the Petri dish to mark out different regions.
- Inoculation of **each square** of the grid is done by a **different phage.**
- The phage drops are **allowed to dry** and are incubated.
- The susceptible phage regions will show a **circular clearing where the bacteria have been lysed**, and this is used in differentiation.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Thank You!