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CELS191 LECTURE MATERIAL

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Research & Interests:

Diagnosis & Treatment of Relapsing Malaria, Biology & Epidemiology of Protozoal Parasites

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CELS191 2025

Microbiology

Lecture 33

Microbial Genetics

How DNA is transferred between microbes

Professor Bruce Russell
Te Tari Moromoroiti me te Ārai Mate
Department of Microbiology & Immunology

Microbial Genetics

How DNA is transferred between microbes

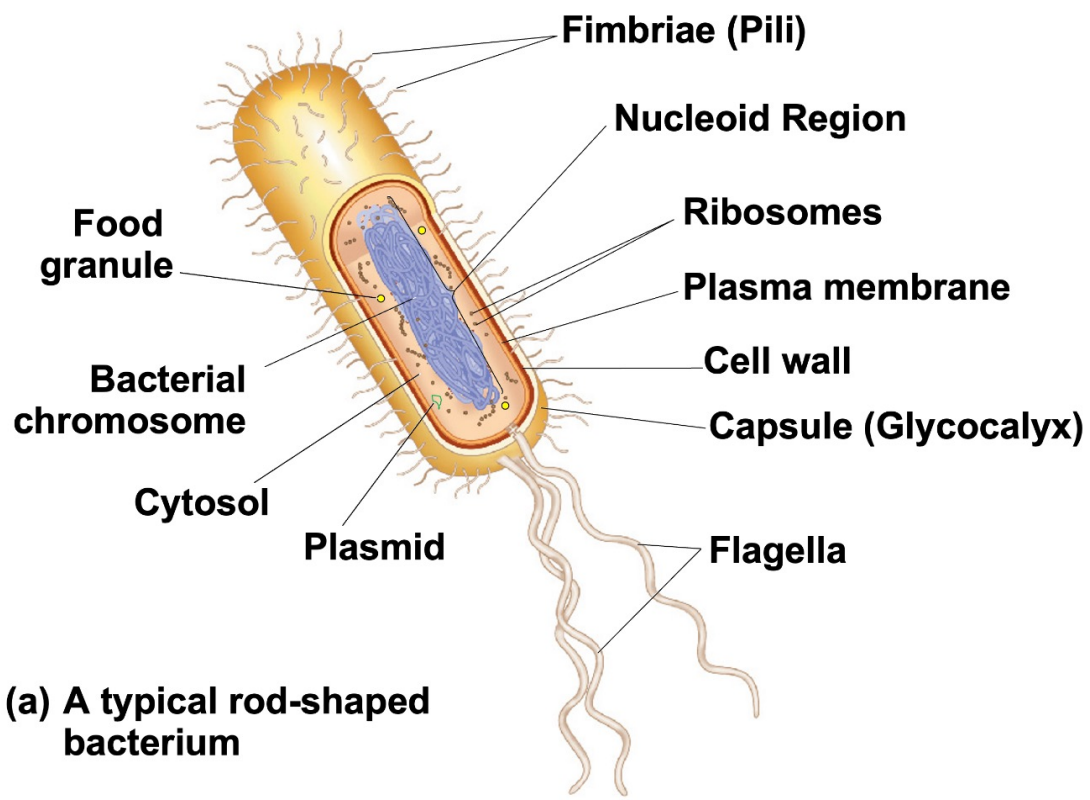
The main aim of this lecture is to understand how genetic information (DNA) is contained within bacteria and how it can be transferred to other organisms.

Lecture 33 Objectives

After you have revised this lecture you should be able to:

- List the properties of the bacterial genome.
- Outline the difference between vertical and horizontal gene transfer.
- List 2 important attributes transferred horizontally by bacteria (*Virulence and Drug Resistance Factors*).
- Outline the three types of horizontal gene transfer in bacteria (*transformation, transduction and conjugation*).
- Note that viruses can be used as a therapy (*Phage Therapy*).

Properties of the Bacterial Genome



(a) A typical rod-shaped bacterium

1. Typically a single circular chromosome

2. No nuclear membrane, however the chromosome is restricted to defined region of the bacterial cell known as the nucleoid

3. Other small circular self-replicating DNA molecules can be found in the cytosol (separate to the main chromosome) - these are known as 'Plasmids'

Difference between vertical and horizontal gene transfer

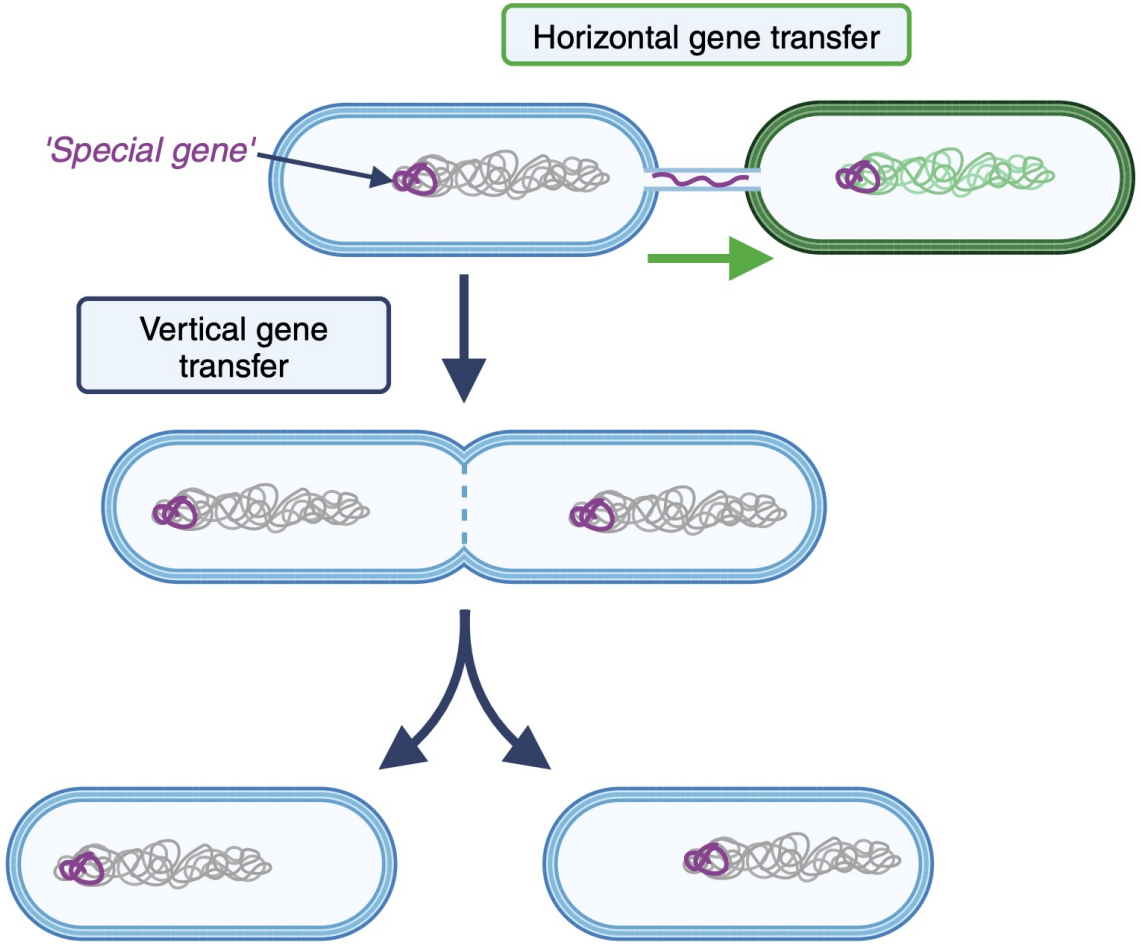
Image: CELS191 via Biorender

Gene Transfer:
Vertical & Horizontal

'De novo' Mutation is the engine behind:

Horizontal Gene Transfer = directly from one organism to another

Vertical Gene Transfer = from 'parent' to 'offspring'



Bacteria can transfer genes affecting Virulence and Drug Resistance horizontally

Image: Figure 7.33c/d – Microbiology: Diseases by taxonomy 5e

Horizontal Gene Transfer

Griffith's classic experiment demonstrating horizontal gene transfer

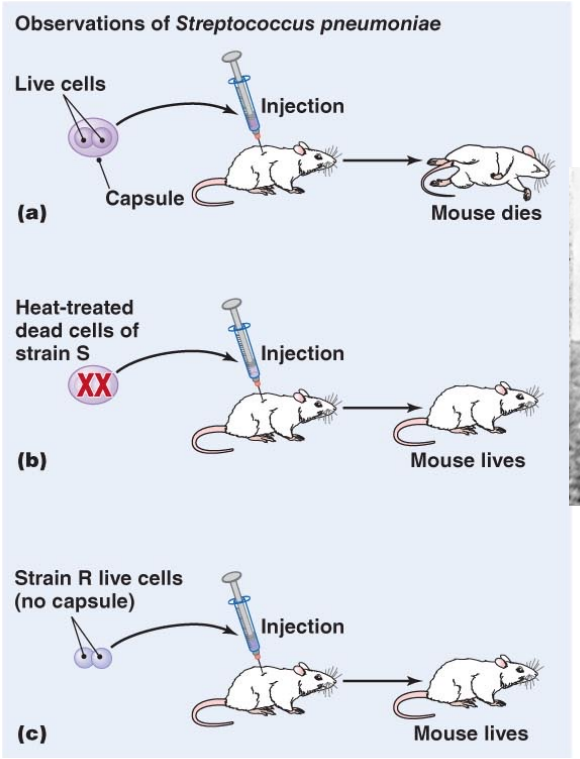
Streptococcus pneumoniae

Pneumococcal Disease

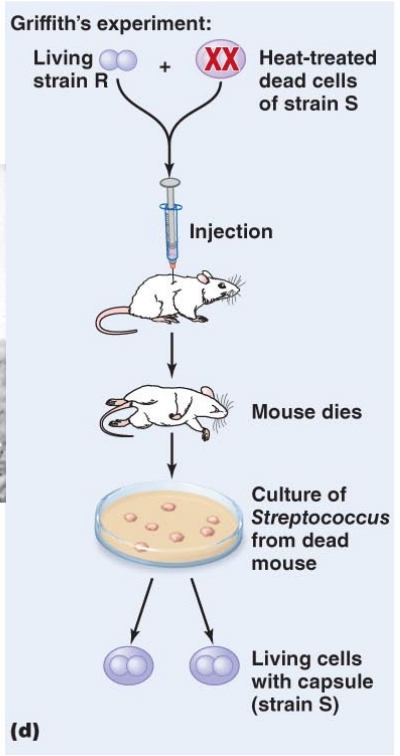
'Smooth' strain

polysaccharide capsule

'Rough' strain



Fred Griffith

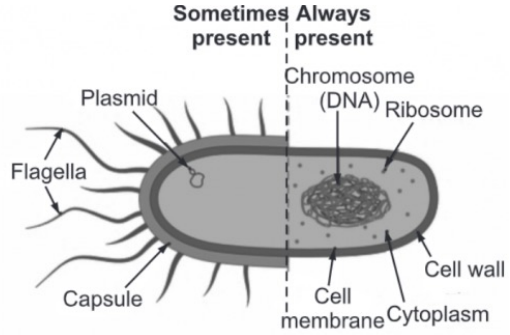


Two important attributes transferred horizontally by bacteria

1. Virulence Factors

Attributes that help bacteria survive in the host, sometimes at a cost to the host. A good example are the Capsules of *Streptococcus pneumonia*.

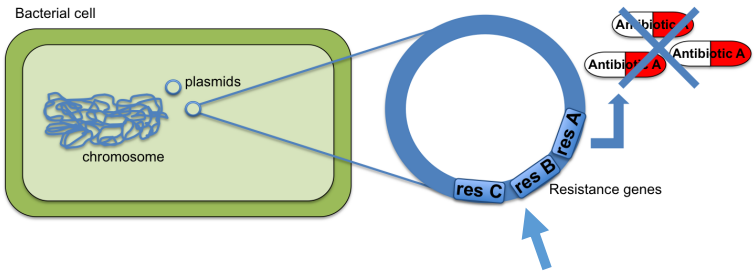
Lecture Link: We will discuss more examples of virulence factors in the Microbial Pathogenesis Lecture 34.



2. Antibiotic Resistance

Attributes that reduce the effectiveness of antibiotics against the targeted bacteria. A good example is the plasmid carrying the Beta-Lactamase enzyme which inactivates Penicillin.

Lecture Link: We will discuss Penicillin resistance in the Antibiotics Lecture 35.



Note that a single plasmid may carry multiple resistance factor genes

Core Slide

Type of horizontal gene transfer in bacteria:

- Transformation
- Transduction
- Conjugation

Image: CELS191 via Biorender

Gene Transfer:
Vertical & Horizontal

'De novo' Mutation is the engine behind:

Horizontal Gene Transfer = directly from one organism to another

Vertical Gene Transfer = from 'parent' to 'offspring'

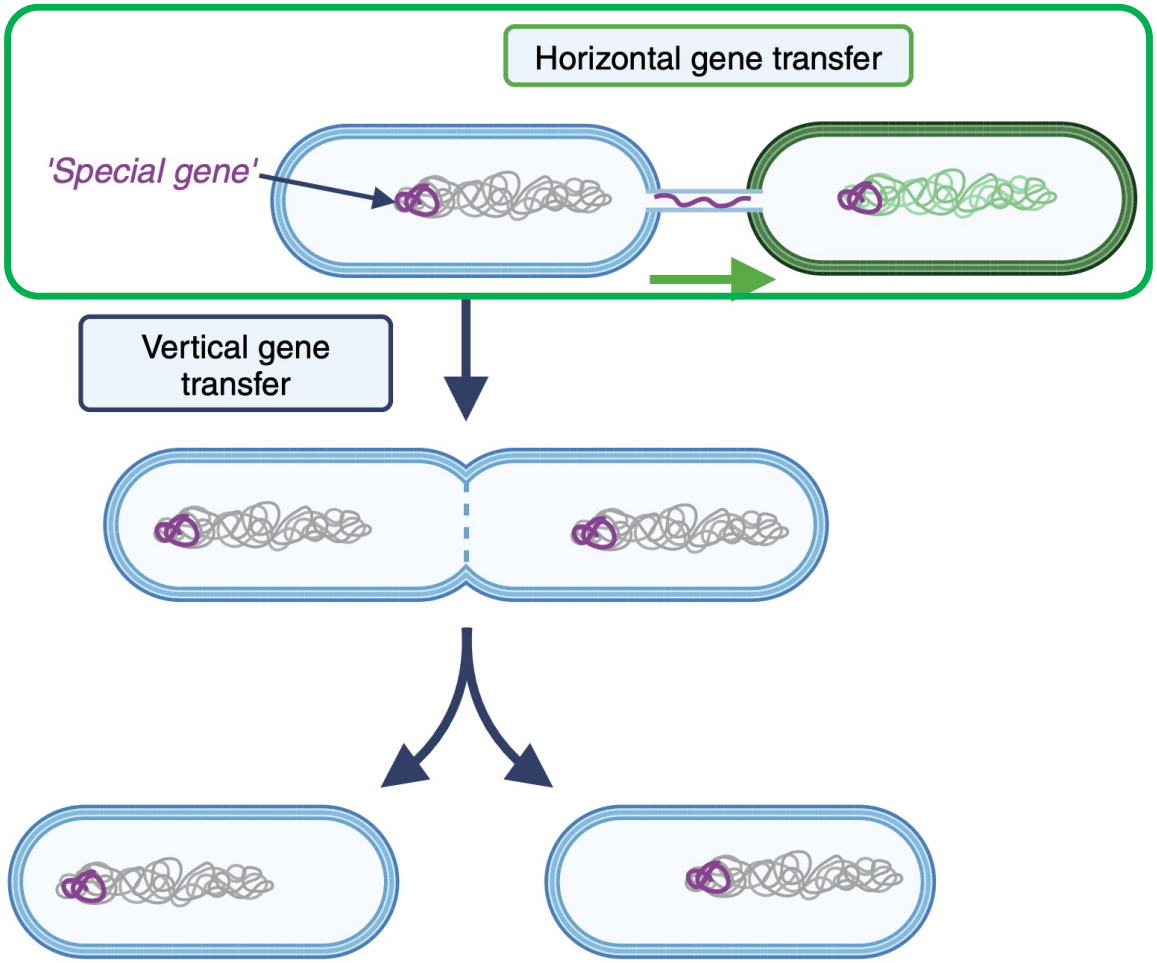
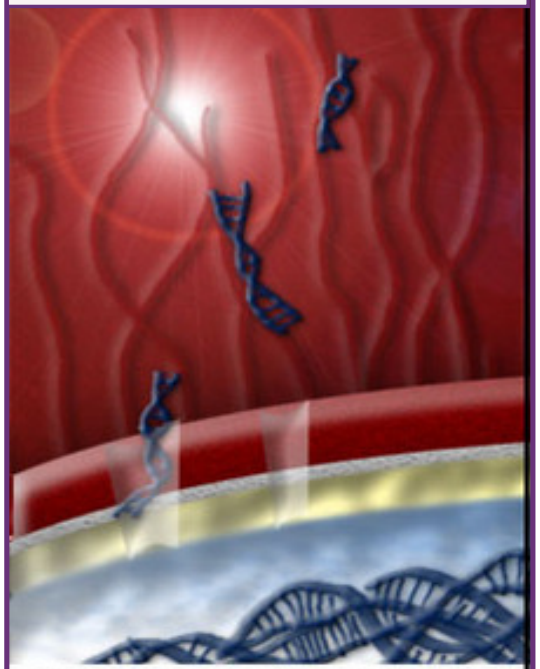


Image: https://bio.libretexts.org/Bookshelves/Microbiology - 14.4D: Plasmids and Lysogeny

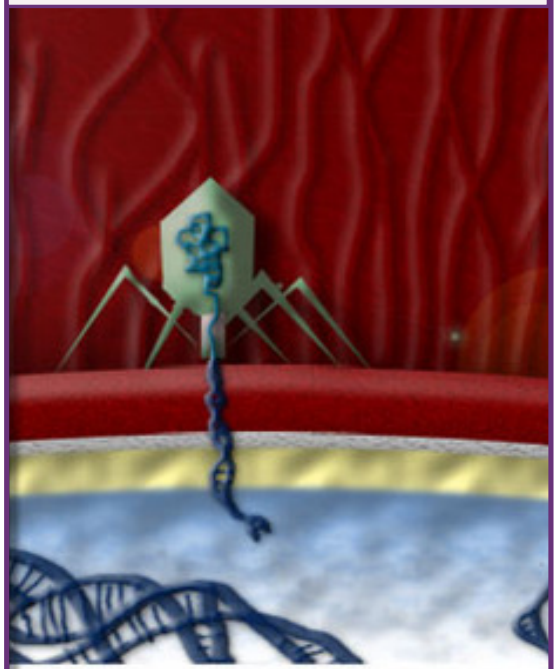
Horizontal Gene Transfer: 3 Strategies

Transformation



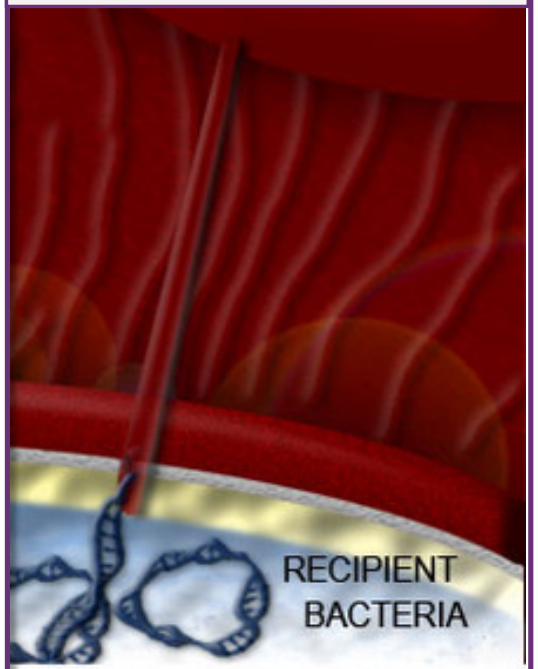
Transformation involves uptake of short fragments of naked DNA by naturally transformable bacteria.

Transduction



Transduction involves transfer of DNA from one bacterium into another via bacteriophages

Conjugation

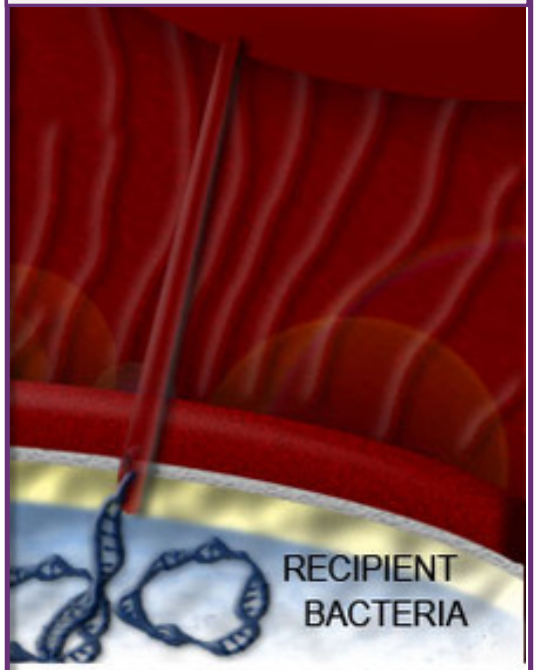


Conjugation involves transfer of DNA material via sexual pilus and requires cell-to-cell contact

Image Middle: Figure 3.11 'Pili' - Microbiology: with Diseases by Taxonomy 5e

Horizontal Gene Transfer: Via Bacterial Conjugation

Conjugation



Conjugation involves transfer of DNA material via sexual pilus and requires cell-to-cell contact

Pilus or 'Sexual Pilus'

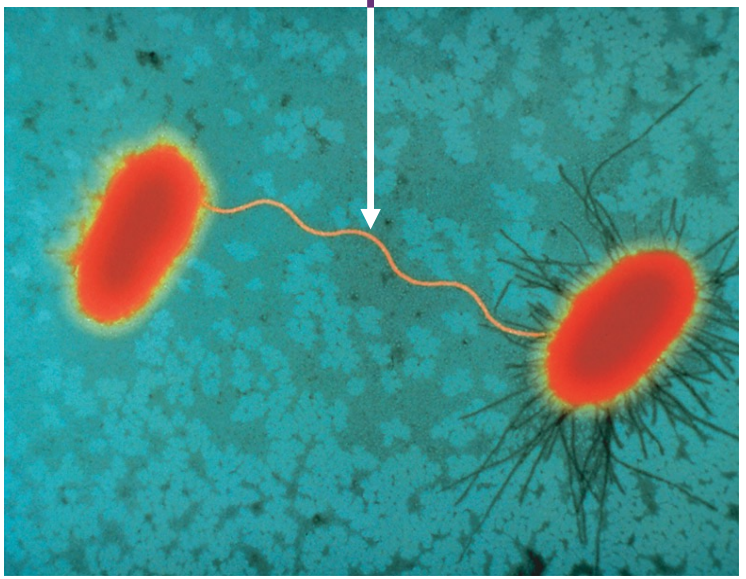
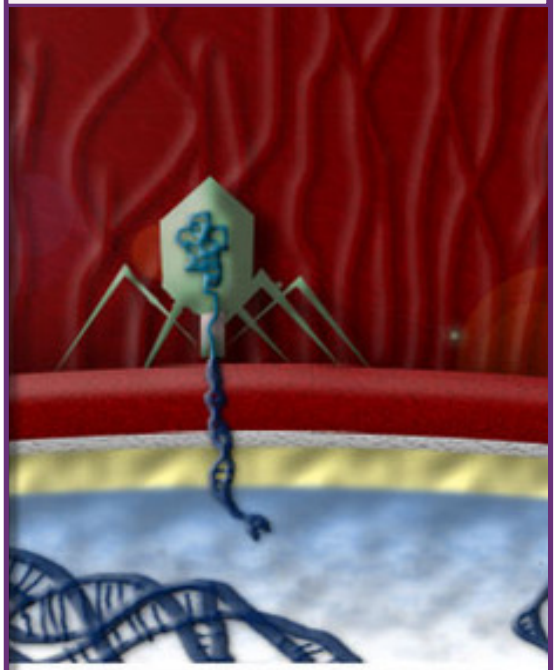


Image: Figure 13.6 / 8: Microbiology – Diseases by taxonomy 5e

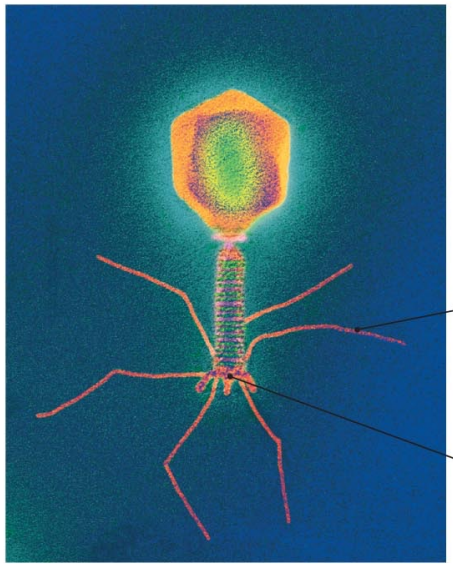
Horizontal Gene Transfer: Via Viral Transduction

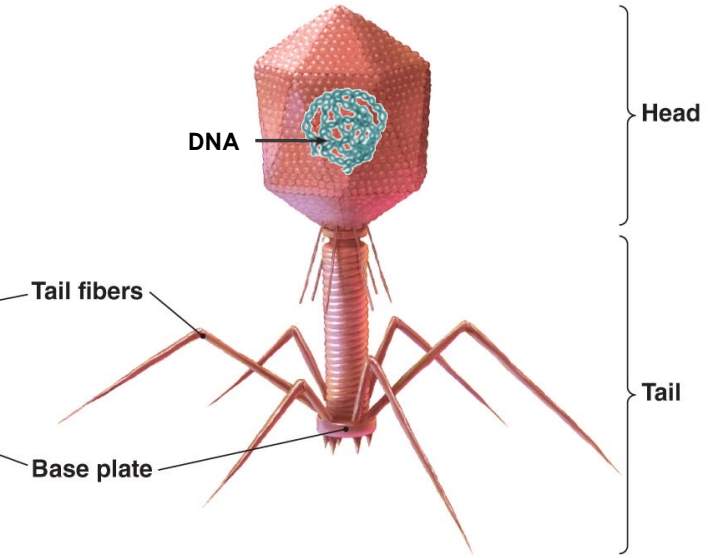
Transduction

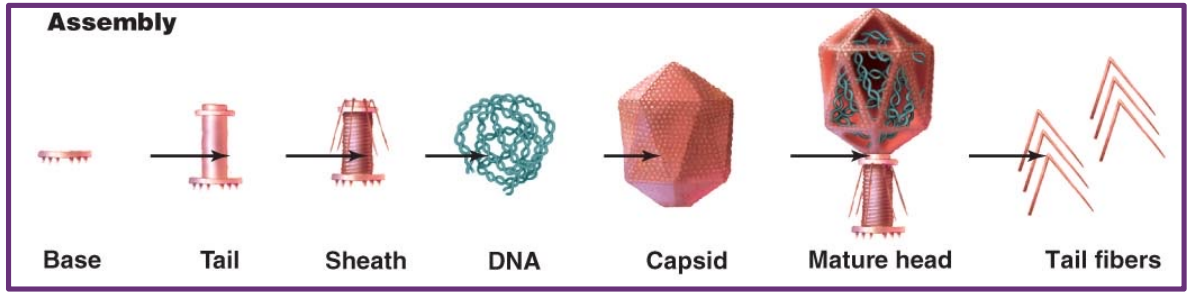


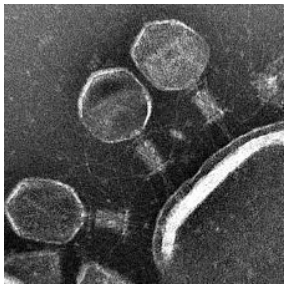
Transduction involves transfer of DNA from one bacterium into another via bacteriophages

Phage Viruses









Phage Therapy
Using viruses that target bacteria

Phage Therapy

Is the therapeutic use of bacteriophages (viruses that specifically kill bacteria) to treat pathogenic bacterial infections

Bacteriophage Therapy

Advantages

- Very specific (affect only targeted bacterial species)
- Replicate at the site of infection
- Occur naturally (easy to locate)
- Safe (no reports of serious adverse effects)
- Active against antibiotic-resistant bacteria

Disadvantages

- Additional research required (lack of studies)
- Development of phage resistance and phage-neutralizing antibodies
- Not accessible to intracellular pathogens
- Difficult to administer (special training required)
- Can transfer toxin genes between bacteria

Lecture 33 Summary

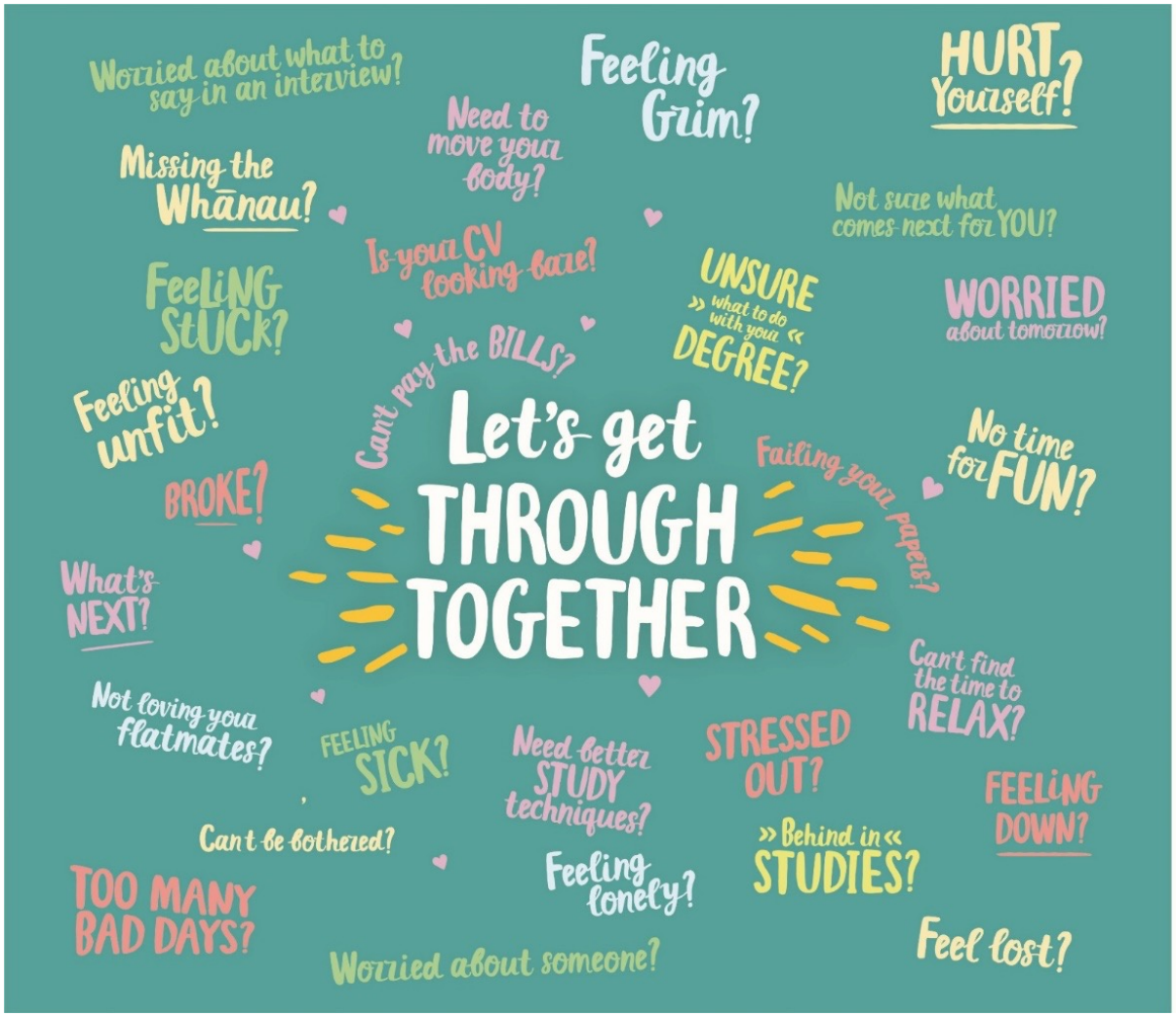
- The bacterial genome typically consists of a single circular chromosome located in the nucleoid region (no nuclear membrane), with additional genetic material often found in self-replicating plasmids.
- Vertical gene transfer occurs from parent to offspring during reproduction, while horizontal gene transfer allows direct DNA exchange between bacteria through transformation, transduction, or conjugation.
- Virulence factors (like the polysaccharide capsule in Streptococcus pneumoniae) and antibiotic resistance genes (such as those encoding beta-lactamase) are critical attributes that can be transferred horizontally between bacteria.
- Horizontal gene transfer in bacteria occurs through three main mechanisms: transformation (uptake of naked DNA), transduction (virus-mediated transfer), and conjugation (direct cell-to-cell transfer via pili). Note that Transduction and Conjugation usually only occur through bacteria of the same species.
- Phage therapy represents a practical application of bacterial viruses (bacteriophages) as a therapeutic approach to combat bacterial infections, utilizing the natural ability of phages to specifically target and kill bacteria.

Objective-Based Questions

- Complete the following:
  a) The bacterial genome is typically a _____ _____ chromosome.
  b) Although there is no nuclear membrane, the chromosome is restricted to a defined region of the bacterial cell known as the _____.

- Name **TWO** attributes of bacteria that can be transferred horizontally from one organism to another and give an example of each.

- List the three types of horizontal gene transfer found in bacteria.



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