Bacterial Reproduction

Just like any other organism, bacteria also reproduce to continue their species. Since they are unicellular and do not have a well-organized cell, bacteria have been grouped under prokaryotes. A bacterial population grows in a geometric or exponential fashion, with each division cycle (generation) producing two cells, four cells, eight cells, sixteen cells, 32 cells, and so on. However, they do show both sexual and asexual means of reproduction.

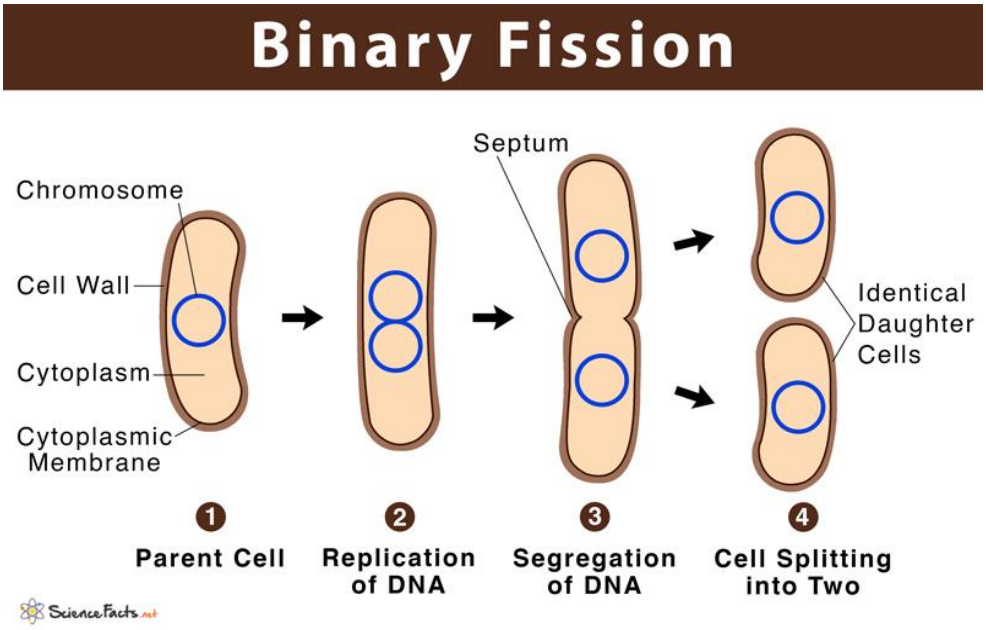
Asexual Reproduction in Bacteria

There are five following types of Asexual reproduction :

1. Binary fission
2. Conidia Formation
3. Budding
4. cyst
5. endospore

1. Binary Fission

In binary fission , a single bacterial cell divides into two daughter cells. At first, the bacterial cell reaches critical mass in its form and cell components. The circular DNA of the bacteria undergoes replication and new complementary strands are formed. These two strands of DNA are then moved to the different poles of the cell and a transverse septum then takes place and develops in the middle region of the cell which separates the two new daughter cells and thus binary fission I completed. It is a rapid process and takes minutes to complete.
Binary fission is used by most bacteria, including *Salmonella* and *E.coli*.



2. Conidia Formation

The formation of conidia can be seen in filamentous bacteria such as Streptomyces . Conidia are small, chain-like, spherical, spore-like entities created through the formation of a transverse septum at the apex of the filament. The part bearing the conidia is called the conidiophore , after it is detached from the mother cell and fall in appropriate substrate it germinates to new mycelium. This type of asexual reproduction is also called fragmentation.

3. Budding

Budding is an asexual reproduction method in which a bacterial cell generates a tiny protrusion or bud as a result of cell division at a single location. These buds grow into little individuals, and the nucleus divides at the same time. The bud is entered by one nucleus with some cytoplasm. When a bud reaches full maturity, a partition wall separates it from the parent cell. . Example : Rhodomicrobium vannielii .

4. Cysts

When the conditions become unfavorable for the *Amoeba* to survive, it withdraws its pseudopodia and becomes a round shape. It then secretes a hard

substance called cyst. The cyst then becomes a thick protective layer around the *Amoeba*. Inside the cyst, the nucleus goes through a process of repeated divisions to form multiple nuclei. Division of the cytoplasm follows nuclear division. Finally, many new daughter cells are produced inside the cyst. When the conditions become favorable again, cysts burst open and release the daughter cells.

5. Reproduction Through Endospore Formation

An endospore is a dormant, tough, and non-reproductive structure produced by some bacteria in the phylum Bacillota . The name "endospore" is suggestive of a spore or seed-like form , but it is not a true spore (i.e., not an offspring). Endospore formation is usually triggered by a lack of nutrients, and usually occurs in gram-positive bacteria. In endospore formation, the bacterium divides within its cell wall, and one side then engulfs the other. Endospores enable bacteria to lie dormant for extended periods, even centuries. There are many reports of spores remaining viable over 10,000 years, and revival of spores millions of years old has been claimed. When the environment becomes more favorable, the endospore can reactivate itself into a vegetative state . Examples of bacterial species that can form endospores include *Bacillus cereus*, *Bacillus anthracis*, *Bacillus thuringiensis*, *Clostridium botulinum*, and *Clostridium tetani***.**

Endospores contain a protoplast , DNA , ribosomes , enzymes and t-RNA , everything necessary for the formation of a new cell. Only one endospore is formed in one bacterial cell and on germination, it gives rise to a new bacterial cell. They are usually observed in old cultures on potato-dextrose agar and corn meal agar kept at room temperature. No special media have been devised to stimulate the development of endospores **.**

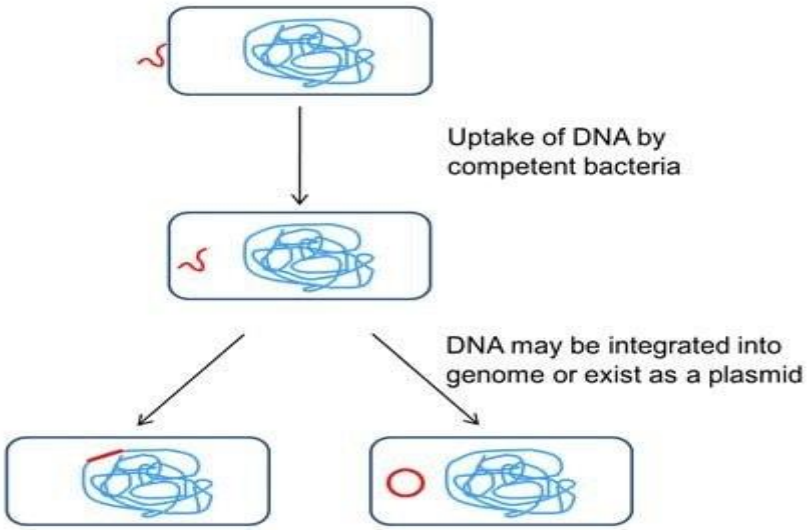
Sexual Reproduction in Bacteria

However, in asexual reproduction, genetic recombination is not observed and that is why sexual reproduction has high significance in the continuation of a bacterial species. This is because, in sexual reproduction, genetic material is exchanged between two cells which facilitates genetic recombination and creates a genetic drift in the species of bacteria. There are 3 ways bacteria reproduce sexually, these are:

1. Transformation
2. Transduction
3. Conjugation

1. Transformation

Bacterial transformation is a process of horizontal gene transfer by which some bacteria take up foreign genetic material (naked DNA) from the environment. It was first reported in *Streptococcus pneumoniae* , The process of gene transfer by transformation does not require a living donor cell but only requires the presence of persistent DNA in the environment. The prerequisite for bacteria to undergo transformation is its ability to take up free extracellular genetic material. Such bacteria are termed as competent cells. The DNA enters the cytoplasm, it may be degraded by nucleases if it is different from the bacterial DNA. If the exogenous genetic material is similar to bacterial DNA, it may integrate into the chromosome. Sometimes the exogenous genetic material may co-exist as a plasmid with chromosomal DNA.



2. Transduction

Transduction is a mode of genetic transfer from one bacteria to another through a virus. There is no direct contact between the bacterial cells. In this process, bacteriophages, which infect bacteria use host cells to multiplicate and while assembling they sometimes pack the bacterial DNA with them. Later, when these viruses infect new bacterial cells, the bacterial genome that they carry may get inserted into the host genome. Transduction is commonly used in genetic engineering for inserting foreign DNA into the host cell.

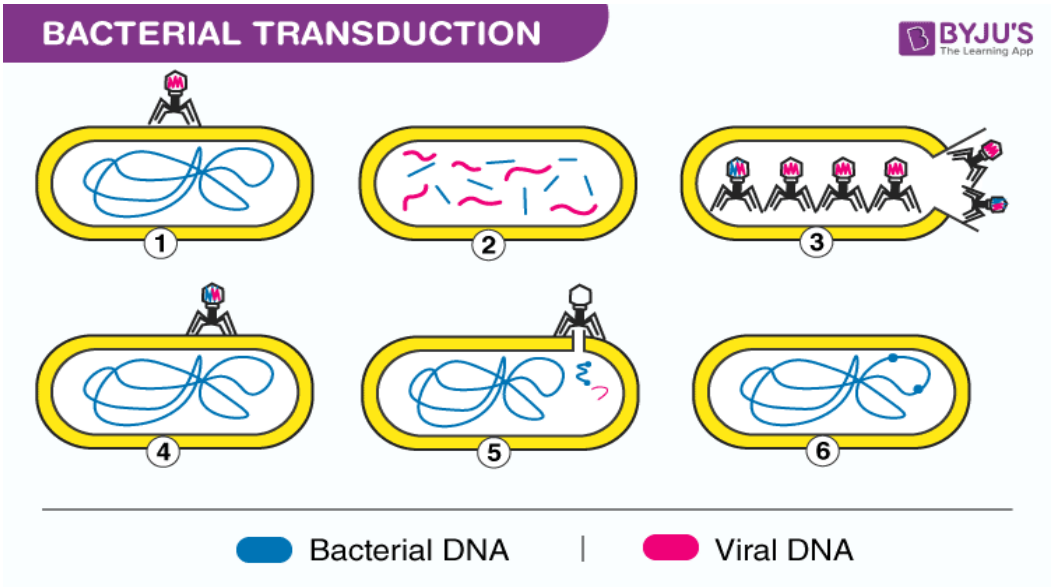
Bacterial Transduction Steps

1. Infection of the bacterial cell by bacteriophage.
2. The virus uses the host machinery to make multiple copies either directly by the lytic cycle or first gets incorporated into the bacterial genome by the lysogenic cycle and followed by the lytic stage.
3. During the assembly of bacteriophages, the bacterial genome also gets packed by mistake in the viral head alongside the viral genome.
4. When these viruses infect another bacterial cell, they inject the viral DNA as well as donor DNA into the host cell.

5. The bacterial DNA either forms plasmids or gets inserted into the recipient DNA if it is homologous to the recipient genome. Most of the time it remains as an extrachromosomal DNA. It can also get inserted with the prophage if it is a temperate phage. So the fate depends on the portion of bacterial DNA and also on the nature of bacteriophages.

There are two type of Transduction :

- Generalized Transduction – In this, the phage can carry any part of DNA.
- Specialized Transduction – In this, the phage carries only the specific part of DNA.



3. Conjugation

Bacterial conjugation is the transfer of genetic material between bacterial cells by direct cell-to-cell contact or by a bridge-like connection between two cells . This takes place through a pilus. It is a para-sexual mode of reproduction in bacteria. It is a mechanism of horizontal gene transfer as

are transformation and transduction although these two other mechanisms do not involve cell-to-cell contact. Conjugation steps include :

1. Donor cell produces pilus.
2. Pilus attaches to recipient cell and brings the two cells together.
3. The mobile plasmid is nicked and a single strand of DNA is then transferred to the recipient cell.
4. Both cells synthesize a complementary strand to produce a double stranded circular plasmid and also reproduce pili; both cells are now viable donor for the F-factor . The F-factor is (a plasmid that can integrate itself into the bacterial chromosome by homologous recombination) with a length of about 100 kb