
# IDHAYA COLLEGE FOR WOMEN-KUMBAKONAM

## DEPARTMENT OF MICROBIOLOGY

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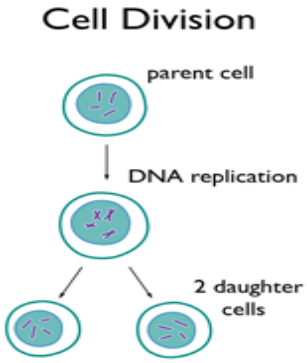
|---|---|---|
| **COURSE** | **:** | **I M.SC MICROBIOLOGY** |
| **SEMESTER** | **:** | **II** |
| **SUBJECT** | **:** | **MICROBIAL PHYSIOLOGY** |
| **SUBJECT CODE** | **:** | **P16MB21** |
| **UNIT** | **:** | **V-SPORE STRUCTURE AND FUNCTION** |
| **INCHARGE FACULTY** | **:** | **Mrs. A. LAKSHMI** |

# CELL DIVISION

- **Cell division is the process by which a parent cell divides into two or more daughter cells. Cell division usually occurs as part of a larger cell cycle.**
- **In eukaryotes, there are two distinct types of cell division:**
  - **Vegetative division,**
  - **Reproductive cell division,**
- **Prokaryotes (bacteria) undergo a vegetative cell division known as binary fission,**
- **where their genetic material is segregated equally into two daughter cells.**
- **While binary fission may be the means of division by most prokaryotes, there are alternative manners of division, such as budding, that have been observed.**
- **All cell divisions, regardless of organism, are preceded by a single round of DNA replication.**

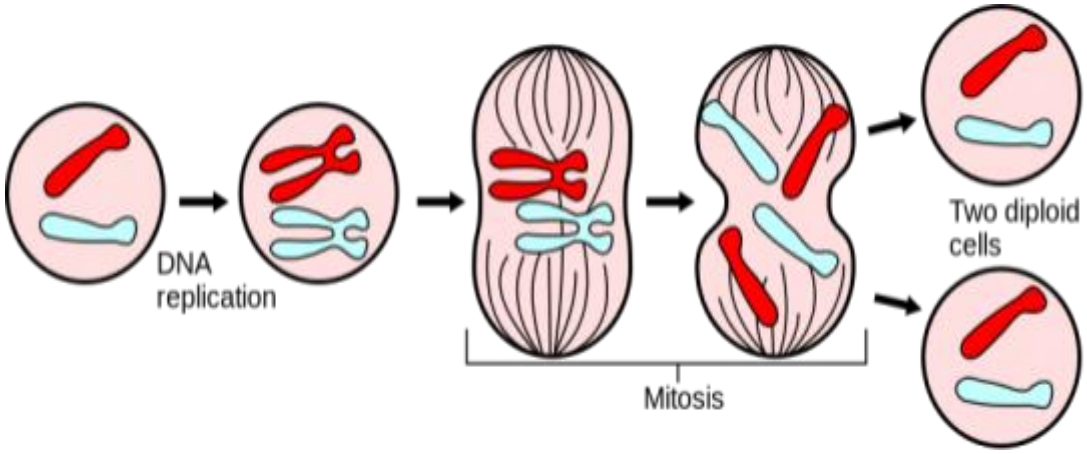


## TYPES OF CELL DIVISION:

- **Mitosis**
- **Meiosis**
- **Binary fission.**

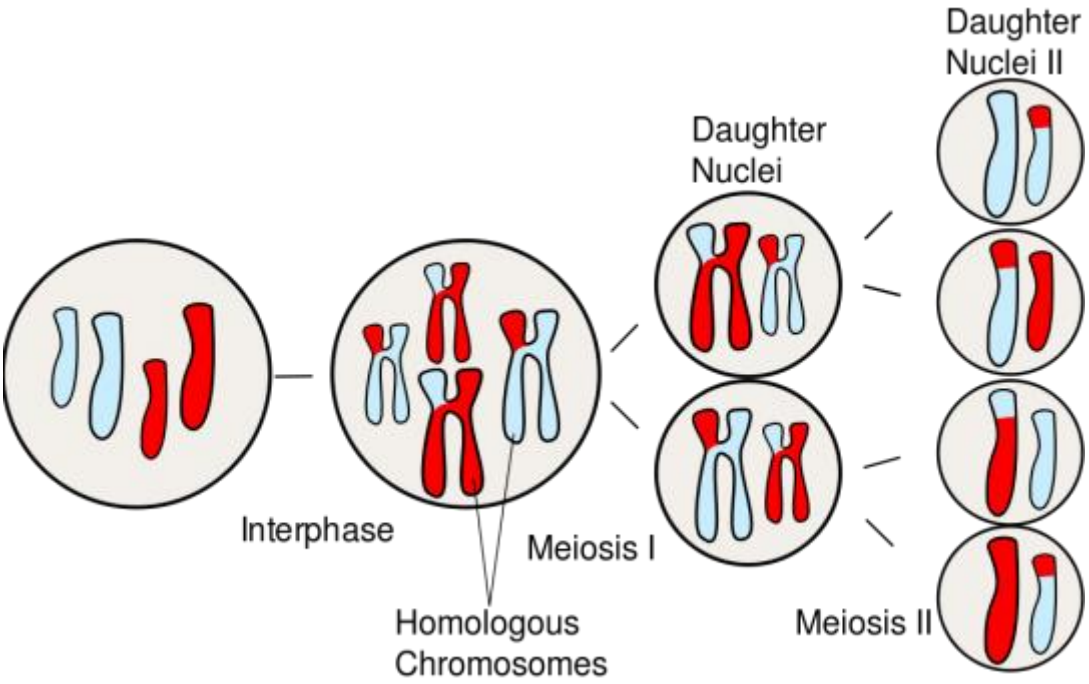
# MITOSIS

- **Mitosis is how somatic—or non-reproductive cells—divide.**
- **Somatic cells make up most of your body's tissues and organs, including skin, muscles, lungs, gut, and hair cells.**
- **Reproductive cells (like eggs) are not somatic cells.**



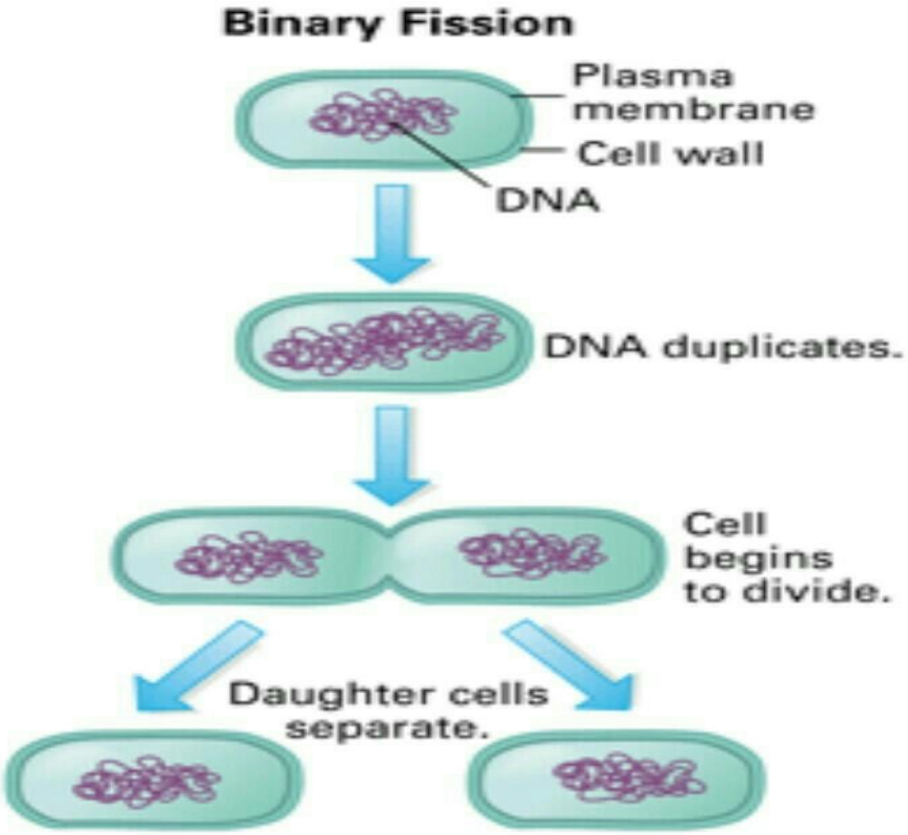
# MEIOSIS

- **Meiosis is cell division that creates sex cells, like female egg cells or male sperm cells.**



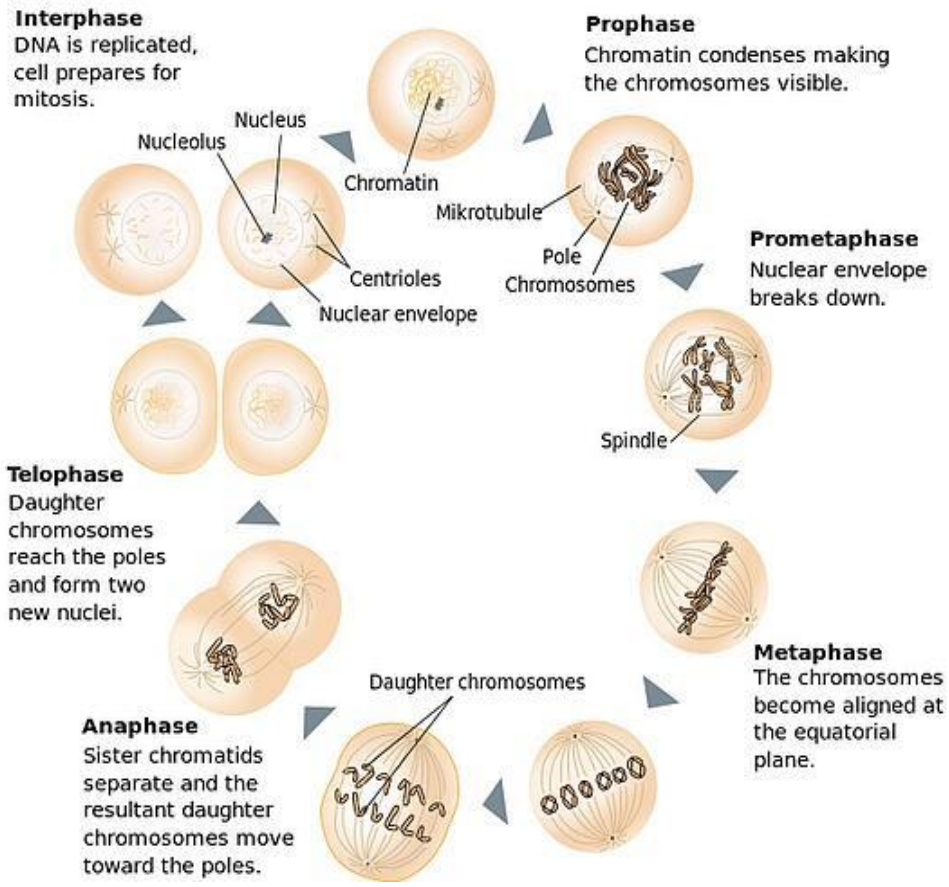

# BINARY FISSION

- **Binary fission, asexual reproduction by a separation of the body into two new bodies.**
- **In the process of binary fission, an organism duplicates its genetic material, or deoxyribonucleic acid (DNA), and then divides into two parts (cytokinesis), with each new organism receiving one copy of DNA.**




# STAGES OF CELL DIVISION

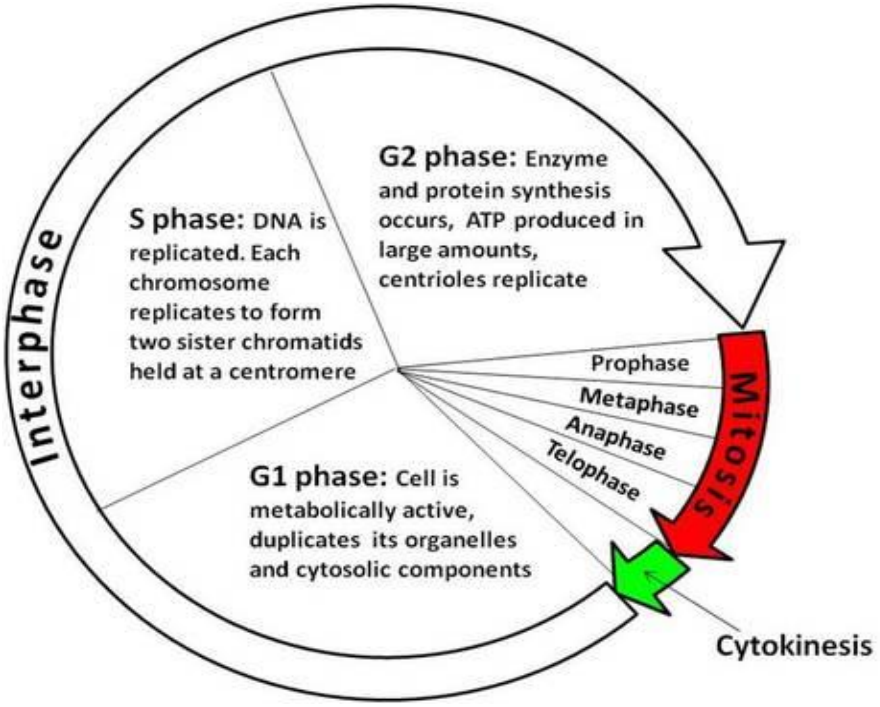
- **Interphase**
- **Prophase**
- **Metaphase**
- **Anaphase**
- **Telophase**
- **Cytokinesis**




# INTERPHASE

- **There are three stages of interphase: $G_1$ (first gap), S (synthesis of new DNA ), and $G_2$ (second gap).**
- **Cells spend most of their lives in interphase, specifically in the S phase where genetic material must be copied.**
- **The cell grows and carries out biochemical functions, such as protein synthesis, in the $G_1$ phase.**
- **During interphase, the cell copies its DNA in preparation for mitosis.**

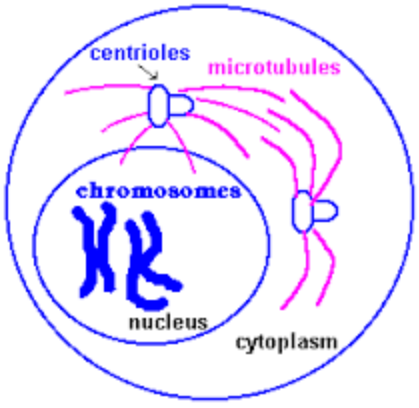
- **Interphase is the 'daily living' or metabolic phase of the cell, in which the cell obtains nutrients and metabolizes them, grows, reads its DNA, and conducts other "normal" cell functions.**




# PROPHASE

- **Prophase is the first phase of mitosis, the process that separates the duplicated genetic material carried in the nucleus of a parent cell into two identical daughter cells.**

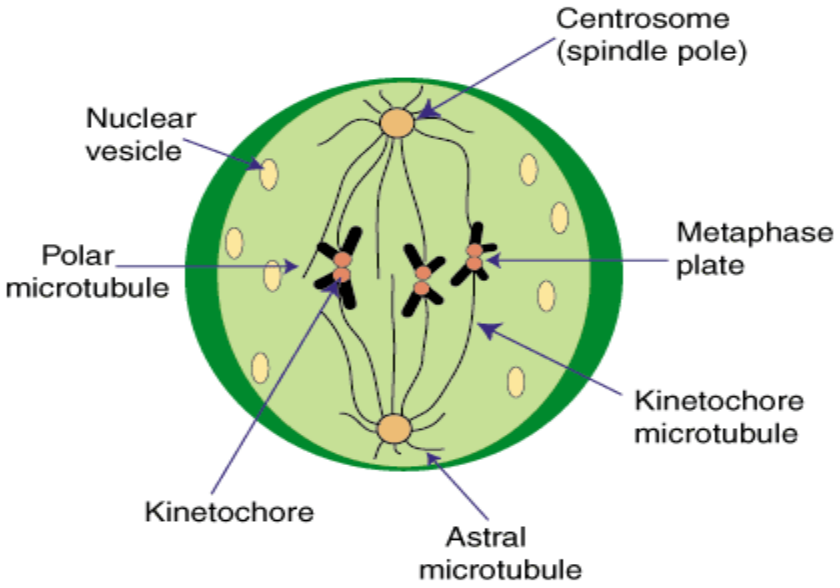
- **During prophase, the complex of DNA and proteins contained in the nucleus, known as chromatin, condenses.**
- **chromatin condenses into chromosomes, and the nuclear envelope, or membrane, breaks down. In animal cells, the centrioles near the nucleus begin to separate and move to opposite poles (sides) of the cell. As the centrioles move, a spindle starts to form between them.**
- **MITOTIC PROPHASE-The main events of prophase are: the condensation of chromosomes, the movement of the centrosomes, the formation of the mitotic spindle, and the beginning of nucleoli break down.**
- **MEIOTIC PROPHASE- Meiosis involves two rounds of chromosome segregation and thus undergoes prophase twice, resulting in prophase I and prophase II.**
- **Prophase I the most complex phase in all of meiosis because homologous chromosomes must pair and exchange genetic information.**
- **Prophase II is very similar to mitotic prophase. Prophase I. Prophase I is divided into five phases: leptotene, zygotene, pachytene, diplotene, and diakinesis. The most noticeable difference is that prophase II occurs with a haploid number of chromosomes as opposed to the diploid number in mitotic prophase.**



Prophase

# METAPHASE

- **Metaphase is a stage of mitosis in the eukaryotic cell cycle in which chromosomes are at their second-most condensed and coiled stage.**
- **These chromosomes, carrying genetic information, align in the equator of the cell before being separated into each of the two daughter cells.**
- **The first metaphase of meisosis I encompasses the alignment of paired chromosomes along the center (metaphase plate) of a cell, ensuring that two complete copies of chromosomes are present in the resulting two daughter cells of meiosis I.**
- **Metaphase I follows prophase I and precedes anaphase I.**
- **Metaphase II. The second stage in meiosis II after prophase II, and highlights the alignment of chromosomes along a single plane in the center of the cell.**



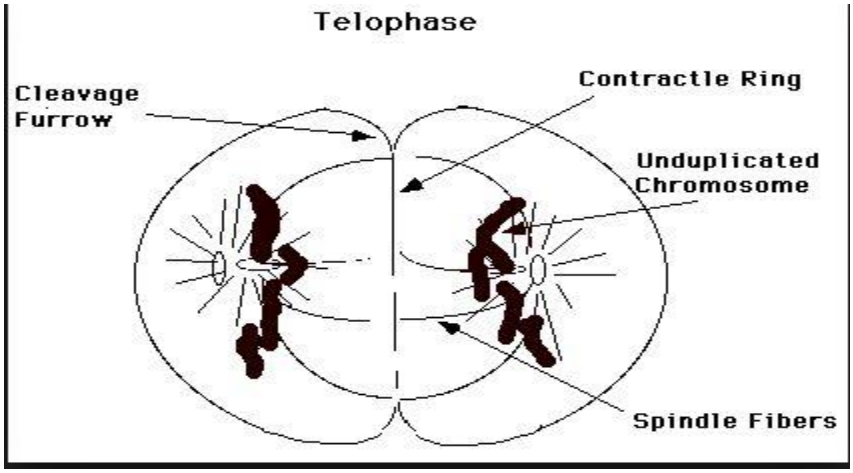
## ANAPHASE

- Anaphase, is the stage of mitosis after the process of metaphase, when replicated chromosomes are split and the newly-copied chromosomes are moved to opposite poles of the cell.
- In anaphase, sister chromatids (now called chromosomes) are pulled toward opposite poles.
- In telophase, chromosomes arrive at opposite poles, and nuclear envelope material surrounds each set of chromosomes.
- Finally, in cytokenesis, the two daughter cells are separated.
- Anaphase I. During this stage of meiosis, the cell starts to lengthen.
- The two homologs of each chromosome pair separate and move toward opposite poles, drawn by the microtubules of the spindle apparatus.
- This contrasts with mitosis, where the sister chromatids of each homolog separate and move toward opposite poles.
- Anaphase is primarily characterized by the separation of the sister chromatids.
- This process occurs by degrading the protein securin, which binds the chromatids together.
- By degrading this protein, anaphase physically allows the sister chromatids to separate.

## TELOPHASE

- Telophase is the final stage in both meiosis and mitosis in a eukaryotic cell.
- During telophase, the effects of prophase and prometaphase are reversed. Telophase I.

- At each pole, during this stage, there is a complete haploid set of chromosomes (but each chromosome still has two sister chromatids).
- A cleavage furrow appears, and by the end of this stage the parent cell has divided into two daughter cells.
- This separation of the cytoplasm is called cytokinesis.

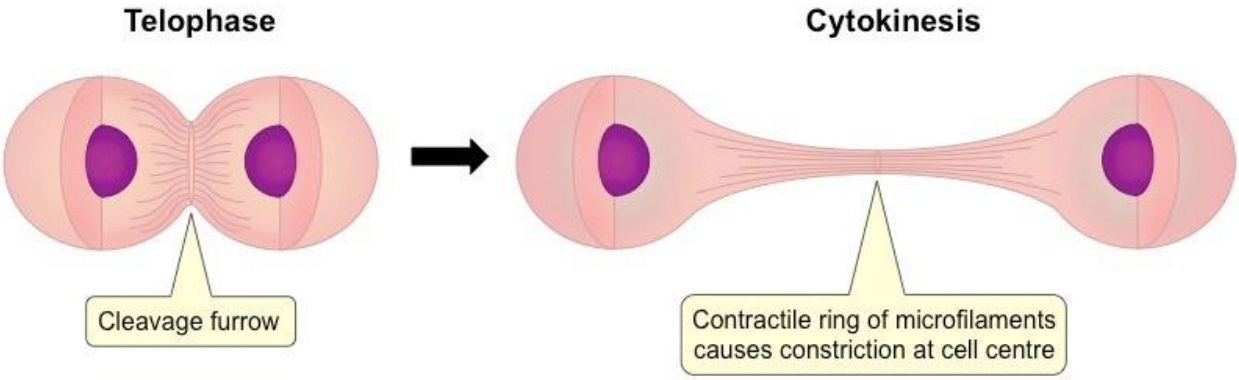



- During telophase 1, the movement of separated homologous chromosomes is completed to the opposite poles of the cell.
- During telophase 2, the movement of sister chromatids is completed to the opposite pole of the cell.
- Telophase II. A nuclear envelope forms around each set of chromosomes and cytokinesis occurs, producing four daughter cells, each with a haploid set of chromosomes.

- **Because of crossing-over, some chromosomes are seen to have recombined segments of the original parental chromosomes.**

## CYTOKINESIS

- **Cytokinesis is the physical process of cell division, which divides the cytoplasm of a parental cell into two daughter cells.**
- **It occurs concurrently with two types of nuclear division called mitosis and meiosis, which occur in animal cells**.




- **Cytokinesis takes place in four stages: initiation, contraction, membrane insertion and completion.**
- **The events occurring within these stages differ in animal and plant cells.**

## ENDOSPORE

An endospore is a dormant, tough, and non-reproductive structure produced by some bacteria and archaea in the phylum Firmicutes. The name "endospore" is suggestive of a spore or seed-like form, but it is not a true spore. It is a stripped-down, dormant form to which the bacterium can reduce itself.

## STRUCTURE

The resilience of an endospore can be explained in part by its unique cellular structure. The outer proteinaceous coat surrounding the spore provides much of the chemical and enzymatic resistance. Beneath the coat resides a very thick layer of specialized peptidoglycan called the cortex.

Proper cortex formation is needed for dehydration of the spore core, which aids in resistance to high temperature. A germ cell wall resides under the cortex. This layer of peptidoglycan will become the cell wall of the bacterium after the endospore germinates.

The inner membrane, under the germ cell wall, is a major permeability barrier against several potentially damaging chemicals. The center of the endospore, the core, exists in a very dehydrated state and houses the cell's DNA, ribosomes and large amounts of dipicolinic acid.

This endospore-specific chemical can comprise up to 10% of the spore's dry weight and appears to play a role in maintaining spore dormancy. Small acid-soluble proteins (SASPs) are also only found in endospores.

These proteins tightly bind and condense the DNA, and are in part responsible for resistance to UV light and DNA-damaging chemicals. Other species-specific structures and chemicals associated with endospores include stalks, toxin crystals, or an additional outer glycoprotein layer called the exosporium.

## PROPERTIES

Endospores can survive environmental assaults that would normally kill the bacterium. These stresses include high temperature, high UV irradiation, desiccation, chemical damage and enzymatic destruction.

The extraordinary resistance properties of endospores make them of particular importance because they are not readily killed by many antimicrobial treatments.

A variety of different microorganisms form "spores" or "cysts", but the endospores of low G+C Gram-positive bacteria are by far the most resistant to harsh conditions.

**GERMINATION.**

**Germination** involves the dormant **endospore** starting metabolic activity and thus breaking hibernation. It is commonly characterised by rupture or absorption of the spore coat, swelling of the **endospore**, an increase in metabolic activity, and loss of resistance to environmental stress.

Reactivation of the endospore occurs when conditions are more favourable and involves activation, germination, and outgrowth. Even if an endospore is located in plentiful nutrients, it may fail to germinate unless activation has taken place.

This may be triggered by heating the endospore. Germination involves the dormant endospore starting metabolic activity and thus breaking hibernation. It is commonly characterised by rupture or absorption of the spore coat, swelling of the endospore, an increase in metabolic activity, and loss of resistance to environmental stress.

Outgrowth follows germination and involves the core of the endospore manufacturing new chemical components and exiting the old spore coat to develop into a fully functional vegetative bacterial cell, which can divide to produce more cells.

**MICROBIALSPORULATION AND MORPHOGENESIS – BACTERIA INCLUDING CYANOBACTERIA AND ACTINOBACTERIA,**

Essentially, **sporulation** refers to the formation of spores from vegetative cells during unfavorable environmental conditions. As such, it may be described as an adaptive response that allows the organism to survive given adverse conditions (radiation, extreme heat or cold, lack of nutrition etc)

Compared to vegetative cells, spores (formed during sporulation) are multilayered structures that tend to be dormant (or relatively dormant). These characteristics make it possible for some of the spores to preserve the genetic content of the organism during harsh environmental conditions.

During certain unfavorable conditions (depending on the organism), some of the vegetative cells go through a series of morphological changes (and some level of programmed gene expression) that ultimately produce spores. Apart from genetic material, spores also contain some cytoplasm, specific acids, ribosome, and the appropriate enzymes among others that allow the spore to germinate during favorable environmental conditions

Depending on the organism, spores vary significantly.

There are also different types of spores including:

- Asexual spores (e.g. exogenous spores produced by Conidia oidia)
- Sexual spores such as Oospores and Zygote
- Vegetative spores (e.g. Chlamydospores)
- Megaspores of plants (female gametophyte)
- Microspores of plants (develop to formmale gametophyte)

- Endospores - Type of spores that are produced within the organism (e.g. bacteria)
- Exospores - Exospores are a type of spores that are produced outside the cell (e.g. in the genus Methylosinus)
- Mature spores are released into the environment and are capable of surviving high temperatures, certain chemicals that can destroy the vegetative cell and radiation among other extreme environments. Once environmental conditions improve, the spore can germinate as the organism returns to the original vegetative growth.
- ***** Mutation has been shown to result in the production of twin endospores (two viable spores). Some mutations may also produce more than two endospores.

**FUNGI AND ALGAE**

Fungi are some of the most studied spore-producing organisms in the world. They produce a wide variety of spores that significantly vary in size, shape and other surface features that suit their environment (for dispersal etc).

Whereas the spores produced sexually (through meiosis) remain dormant for survival (e.g. ascospores), those that are produced asexually (mitospores) are for dispersal.

Produced through mitosis, asexual spores are released in high numbers and are genetically identical. This allows them to play an important role in reproduction when they land on the appropriate substrate in the environment following dispersal.

* **Chlamydospore** - This is a type of fungal spore that develops from the hyphal structures during unfavorable conditions. Chlamydospores are characterized by a thick, melanized wall that protects the contents of the spore.

**Different types of fungi may produce different types of spores.**

The following are some of the main groups of fungi and the type of spores they produce:

· Zygomycota - Members of Zygomycota are known as zygomeycetes. They produce both sexual (zygospores) and asexual (sporangiospores) spores.

· Ascomycota - Ascomycetes also produce both sexual (ascospores) and asexual (conidia) spores.

· Basidiomycota - Compared to the other groups of fungi, basidiomyecetes are largely known to produce sexual spores that are known as basidiospores.

**ALGAE**

During **sporulation** in land plants and **algae**, solar energy is absorbed and transferred by photosystems and eventually, together with carbon dioxide, is transformed into biomass through the carbon fixation cycle to support these energy-requiring processes. Spores can be differentiated by whether they can move or not.

- **Zoospores**: mobile spores that move by means of one or more flagella, and can be found in some algae and fungi.
- **Aplanospores**: immobile spores that may nevertheless potentially grow flagella.
- **Autospores**: immobile spores that cannot develop flagella.

- **Ballistospores**: spores that are forcibly discharged or ejected from the fungal fruiting body as the result of an internal force, such as buildup of pressure. Most basidiospores are also ballistospores, and another notable example is spores of the genus *Pilobolus*.

- **Statismospores**: spores that are discharged from the fungal fruiting body as the result of an external force, such as raindrops or a passing animal. Examples are puffballs. **Carpospores**: spores produced by a carposporophyte, characteristic of red algae.
- **Tetraspores**: spores produced by a tetrasporophyte, characteristic of red algae.