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History of Food Microbiology

Although processes of food spoilage and methods of food preservation and food fermentation have been recognized since ancient times. It was not until the 1800s that the relationship between foods and micro-organisms was established. In 1837, Schwann proposed that the yeast which appeared during alcoholic fermentation was a microscopic plant, and between 1857 and 1876, Pasteur showed that micro-organisms were responsible for the chemical changes that take place in foods and beverages. The observations laid the foundation for the development of food microbiology. Knowledge in terms of the role that micro-organisms play in food preservation, food spoilage and food preservation, food spoilage and food poisoning accelerated rapidly until food microbiology gradually emerged as a discipline. Not all groups of micro-organisms are of equal interest to the food microbiologist. Bacteria come on top of the list with molds and yeasts also of considerable importance and viruses.

The history and scope of food microbiology has been classified during various time periods and these have been stated as follows:

7000 BC – Evidence that the Babylonians manufactured beer (fermentation). Wine appeared in about 3500 BC. In early civilizations and even in the present world in underdeveloped countries, where modern sanitation is lacking, alcoholic beverages like beer and wine were much safe to consume than the local water supply. The reason being, the water was often contaminated with intestinal micro-organisms that caused cholera, dysentery and other serious diseases.

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6000 BC – The first apparent reference to food spoilage in recorded history.

3000 BC – Egyptians manufactured cheese (fermentation) and butter (fermentation, low aw). Fermented foods, such as cheese and sour milk (yogurt) were safe to consume and repelled damage better as compared to their raw agricultural counterparts. Several cultures also learned to use salt (low aw) to preserve meat and other foods around this time.

1000 BC – Romans made use of snow to preserve shrimp. As it has to be preserved in low temperature, records of smoked and fermented meats also appeared. Even though early human cultures revealed effective ways to preserve food, i.e. fermentation, salt, ice, drying and smoking, they did not understand how these practices, inhibited food spoilage or food borne disease.

1665 – An Italian physician, Franceso Redi established that maggots on putrefying meat did not arise unexpectedly but were instead the larval stages of flies. This was the first step away from the doctrine of spontaneous generation.

1683 – Anton van Leeuwenhoek from the Netherlands scrutinized and researched upon bacteria through a microscope. At about the same time, the Royal Society was established in England to communicate and publish scientific work. They invited Leeuwenhoek to impart information regarding his observations. He did so for nearly 50 years until his death in 1723. As a result, Leeuwenhoek's

reports were comprehensively disseminated and he is justly regarded as the person, who discovered the microbial world.

1765 – Italian named Spallanzani tried to disprove the theory of spontaneous generation of life by demonstrating that beef broth, which was boiled and then sealed

remained sterile. His work was criticized because they believed O_2 was excluded, which they thought was vital for generation that was unstructured.

1795 – The French government offered 12,000 francs to anyone who could develop a practical way to preserve food. A French confectioner, named Nicholas Appert was issued the patent after showing that meat could be preserved when it was placed in glass bottles and boiled. This was the beginning of food preservation by canning.

1837 – Schwann validates that healed infusions remain sterile in the presence of air, which he passed in through heated coils, again to invalidate spontaneous generation.

The first person to actually acknowledge and understand the causal relationship between micro-organisms in infusions and the chemical changes that took place in those infusions was Louis Pasteur. Through his experiments, Pasteur convinced the scientific world that all fermentative processes were caused by micro-organisms and that explicit types of fermentations e.g. alcoholic, lactic or butyric were the result of precise types of micro-organisms.

In 1857, he showed that souring milk was caused by microbes and in 1860, he demonstrated that heat destroyed unwanted microbes in wine and beer. The latter process is now used for a variety of foods and is called pasteurization. Because of the importance of his work, Pasteur is known as the founder of food microbiology and microbiological science.

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Why Study Food Microbiology?

1. provide Clean, Safe, Healthful Food to Consumer
    a. Food Permits Growth
    b. Control of Microbial Growth
2. Prevent Food Spoilage
3. Prevent Foodborne Illnesses
4. Food Preservation and Production

What organisms are studied in food microbiology?

1. **Bacteria**-bacteriology*
2. **Fungi**-mycology: molds and yeasts *
3. **Protozoa**—parasitology—Example: amoeba, Giardia *
4. **Algae**— Example: dinoflagellates *
5. **Viruses**-virology — Example: Hepatitis
6. **Worms**—parasitology (helminthology)
7. **Prions**—pathogenic neural derived proteins

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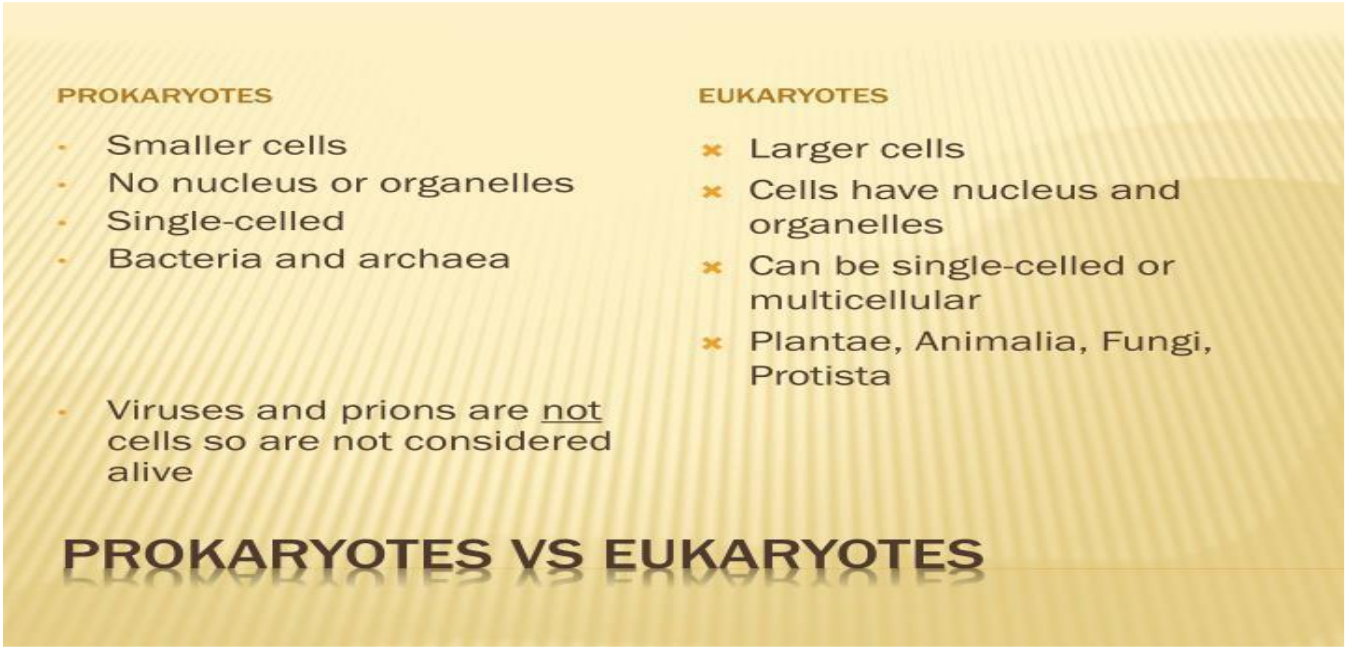

Bacteria

The organisms that constitute the microbial world are characterized as prokaryotes or eukaryotes; all bacteria are prokaryotic—single-celled organisms without a membrane-bound nucleus. Their DNA (the genetic material of the cell), instead of being contained in the nucleus, exists as a long, folded thread with no specific cell location.

Gram stain: A method of differentiating bacterial species into two large groups (Gram-positive and Gram-negative).

One of the major characteristics of bacteria is their reaction to the Gram stain. Depending upon the chemical and structural composition of the cell wall, some

bacteria are gram-positive, taking on the stain's purple color, whereas others are gram-negative.

What is the Importance of Micro-Organisms in Food?

The importance of micro-organisms in food has been recognized in terms of areas, which have been stated as follows:

Food-Borne Diseases

Many pathogenic micro-organisms (bacteria, molds and viruses) can contaminate foods during various stages of their management, between production and consumption. Consumption of these foods can cause food-borne diseases. Food-borne diseases can be fatal and may also cause economic losses to a large extent. Foods of animal origin are associated, more with food-borne diseases than foods of plant origin. Mass production of food, introduction of new technologies in the processing, storage of food, changes in food consumption patterns, and increased import of food from other countries have increased the chances of large outbreaks as well as the introduction of new pathogens.

Food Spoilage

Except for sterile foods, all foods harbour micro-organisms. Food spoilage stems from the growth of these micro-organisms in food or is due to the action of microbial enzymes. New marketing trends, the desire for foods on the part of consumers that are not overly processed and preserved, extended shelf life, and chances of temperature abuse between production and consumption of foods have significantly increased the chances of food spoilage and, in some instances, with new types of micro-organisms.

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Food Bioprocessing

Many food-grade micro-organisms are used to produce different types of fermented foods, using raw materials from animal and plant sources. There have been immense changes in the production and availability of these micro-organisms to meet the large demand.

Food Additives

Microbial enzymes are also being used to produce food and food additives. By adopting genetic recombination techniques, and making use of different microbial sources, enzymes of higher purity and activity are obtained. Many types of additives from microbial sources are being developed and utilized in food. Some of these include, single-cell proteins, essential amino acids, colour compounds, flavour compounds, stabilizers and organic acids.

Food Bio-preservation

Anti-microbial metabolites e.g. bacteriocins and organic acids like acetic, propionic and lactic acids of needed micro-organisms are being developed and used in foods in place of preservatives of non-food, i.e. chemical origin to control pathogenic and spoilage micro-organisms in food.

Probiotics

Consumption of foods containing live cells of bacteria and that have apparent health benefits has generated interest among consumers. The role of these bacteria for health and bacterial efficacy benefits is being researched upon.

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What is the sorting of all living things based on their related or differentiating features?

Taxonomy: (is the study of phylogenetic relationships between organisms)

1. Kingdom: the highest level in the classification

2. Phylum: related classes

3. Class: related orders

4. Order: related families

5. Family: related genera

6. Genus: closely related species

Genus: organisms share a set of biological traits and reproduce only with their exact kind.

8. Strain—organisms within a species varying in a given quality

Strain: refers to a genetic change made in an organism that makes it different from the predominant species organism.

9. Type—organisms within a species varying immunologically

Type: refers to surface changes that make the organisms distinguishable from others of its species.

What is the scientific name of the microorganism?

All living organisms have a first name and a second name:

The first name is always capitalized (Genus)

The second name is always denoted in lower case letters (species)

Both names are always italicized or underlined

Example: Escherichia coli

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Important Microorganisms in Food- Molds, Yeast

Characteristics of Fungi

1. Yeasts

Unicellular fungi, nonfilamentous, typically oval or spherical cells.

Reproduce by mitosis:

Fission yeasts: Divide evenly to produce two new cells (*Schizo saccharomyces*). Budding yeasts: Divide unevenly by budding (Saccharomyces).

Yeasts are facultative anaerobes

When oxygen is available, they carry out aerobic respiration.

When oxygen is not available, they ferment carbohydrates to produce ethanol and carbon dioxide.

2. Molds and fleshy

Fungi Multicellular,

filamentous fungi.

Identified by physical appearance, colony characteristics, and reproductive spores.

Thallus: Body of a mold or fleshy fungus. Consists of many hyphae.

Hyphae (Sing: Hypha): Long filaments of cells joined together.

Septate hyphae: Cells are divided by cross-walls (septa).

Coenocytic (Aseptate) hyphae: Long, continuous cells that are not divided by septa. Hyphae grow by elongating at the tips.

Each part of a hypha is capable of growth.

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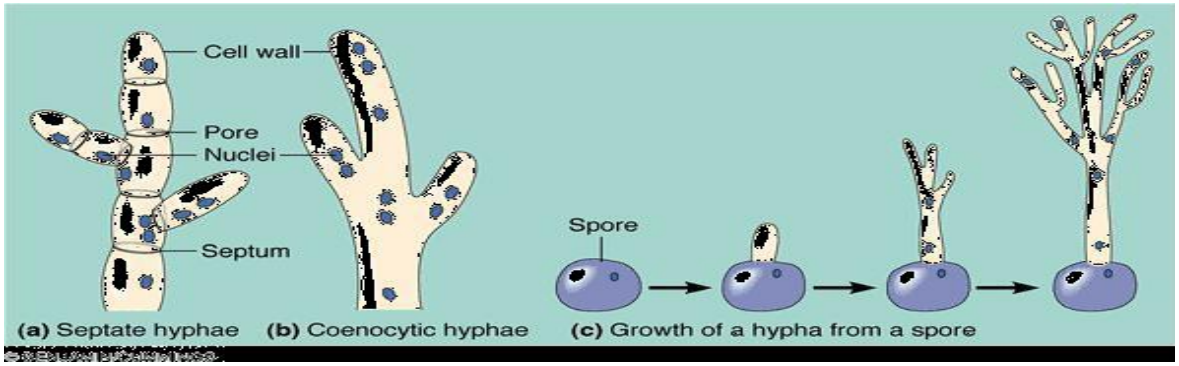
Vegetative Hypha: Portion that obtains nutrients.

Reproductive or Aerial Hypha: Portion connected with reproduction.

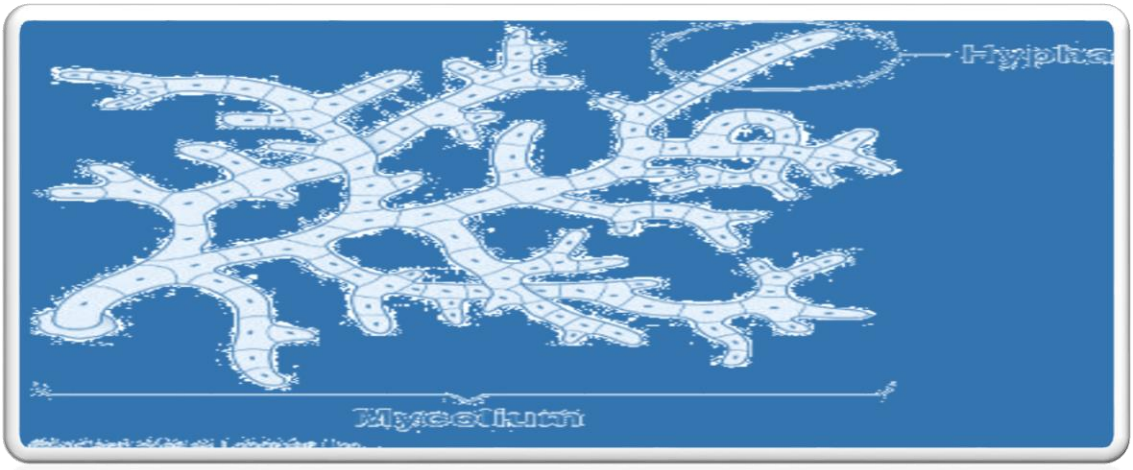
Mycelium: Large, visible, filamentous mass made up of many hyphae.

Characteristics of Fungal Hyphae:

Septate versus Coenocytic



Mycelium: Large, Visible Mass of Hyphae



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Dimorphic Fungi

Can exist as both multicellular fungi (molds) and yeasts.

Many pathogenic species.

Mold form produces aerial and vegetative hyphae.

Yeast form reproduces by budding.

Dimorphism in pathogenic fungi typically depends on temperature:

At 37ºC: Yeast form.

At 25ºC: Mold form.

Dimorphism in nonpathogenic fungi may depend on other factors:

Carbon dioxide concentration.

Examples:

Amanita: Mushroom produces lethal toxins to humans.

Claviceps purpurea: Produces ergot toxin in wheat and rye.

Rhizopus nigricans: Common black bread mold.

Saccharomyces cerevisiae: Bread yeast

Aspergillus (Carcinogenic aflatoxin in peanuts),

Nutrition Adaptation of Fungi

Fungi absorb their food, rather than ingesting it.

Fungi grow better at a pH of 5,which is too acidic for most bacteria.

Almost all molds are aerobic. Most yeasts are facultative anaerobes.

Fungi are more resistant to high osmotic pressure than bacteria.

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Fungi can grow on substances with very low moisture.

Fungi require less nitrogen than bacteria to grow.

Fungi can break down complex carbohydrates (wood, paper), that most bacteria cannot.

Economic Importance of Fungi:

25-50% of harvested fruits and vegetables are damaged by fungi.

Fungal infections of plants are commonly called rots, rusts, blights, wilts, and smuts.

Phytophthora infestans: Caused great potato famine in mid-1800s. Over 1 million people died from starvation in Ireland. Many immigrated to the U.S.

Beneficial fungi:

***Candida oleophila*:** Prevents fungal growth on harvested fruits.

***Saccharomyces cerevisiae*:** Used to make bread and wine.

Genetically engineered yeast strains are used to make proteins (Hepatitis B vaccine).

Trichoderma: Produces cellulase. Used to make fruit juice.

2- Important Microorganisms in Food

A. Important Mold Genera

1. Genus Aspergillus

a. Widely distributed and contain many species important in food.

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b. Septate hyphae and produce asexual spores on conidia.

c. Xerophilic; causing spoilage in grains, jams, nuts and vegetable.

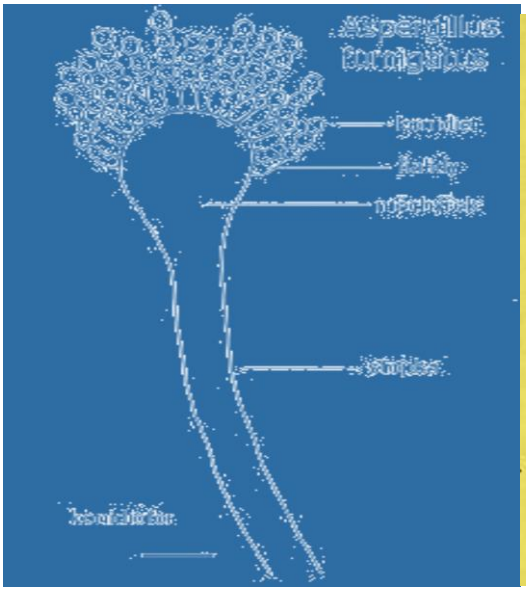
d. Example:

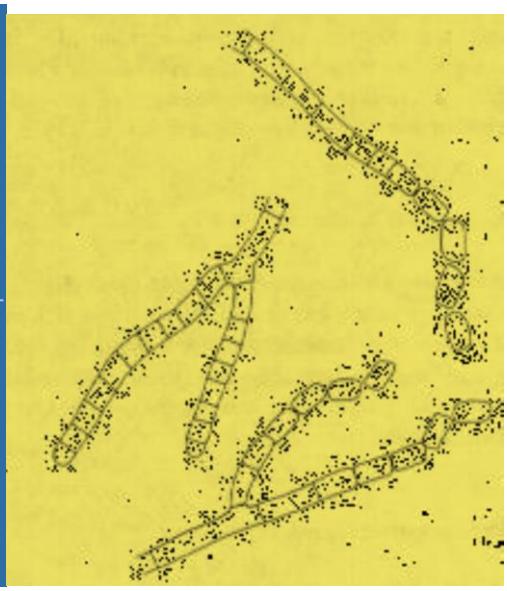
1- *Aspergillus flavus* produce aflatoxin (a kind of mycotoxin)

2- Strains used in food processing:

A. oryzae: hydrolyze starch in sake production.

A. niger: citric acid production.





Aspergillus **Geotrichum**

2. Genus Geotrichum

a. Septate hyphae and produce arthrospore.

b. Grow and forming a yeastlike cottony, creamy colony.

c. Often grow on dairy products.

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d. Example: *Geotrichum candidum*

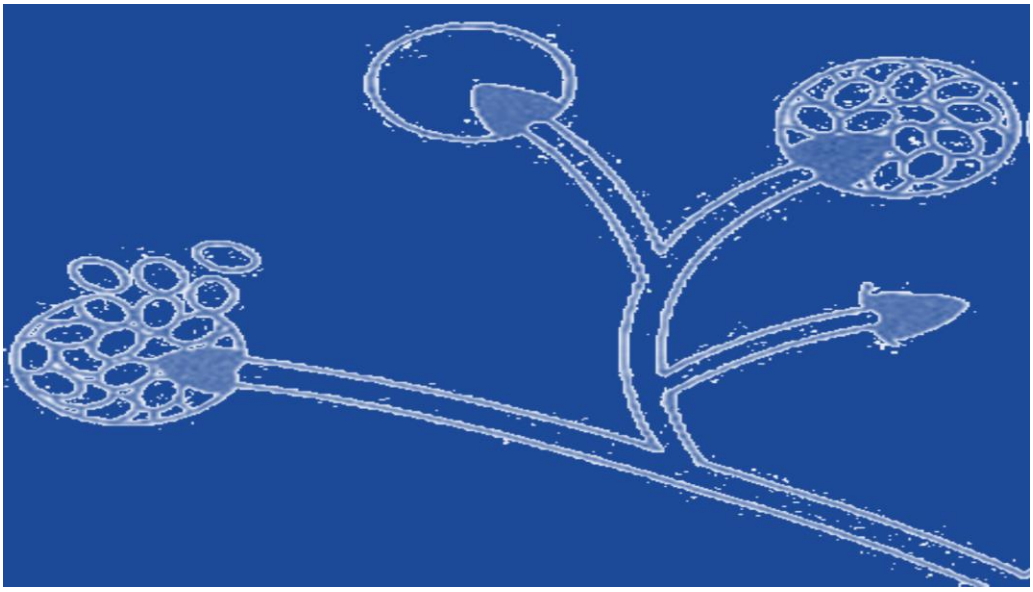
3. Genus Mucor

a. Widely distributed

b. Non septate hyphae and produce sporangiophores

c. Some species are used in food fermentation.

d. Others can cause spoilage of vegetables e.g.: *Mucor rouxii*



Mucor

4. Genus Rhizopus

a. Hyphae are aseptate and form sporangiophores

b. Common in spoilage of foods and vegetables

c. *Rhizopus stolonifer*: common black bread mold

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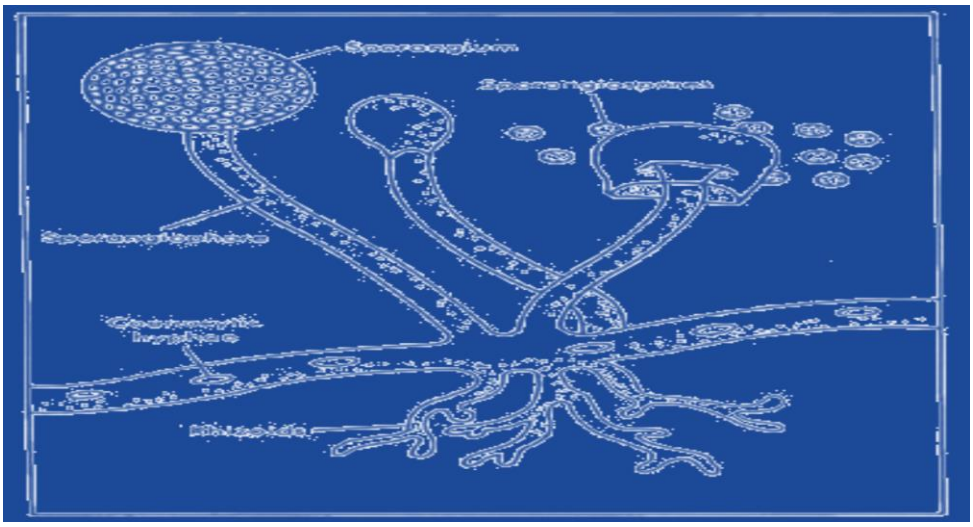

Rhizopus

5. Genus penicillium

a. Widely distributed and contain many species

b. Septate hyphae and form conidiophores on a brush like conidia head.

c. *penicillium roquerfortii* and *Penicillium camembertii* are used in cheese production.

d. Some species can cause spoilage in fruits, vegetables, grains, bread etc.

e. The can also produce mycotoxin

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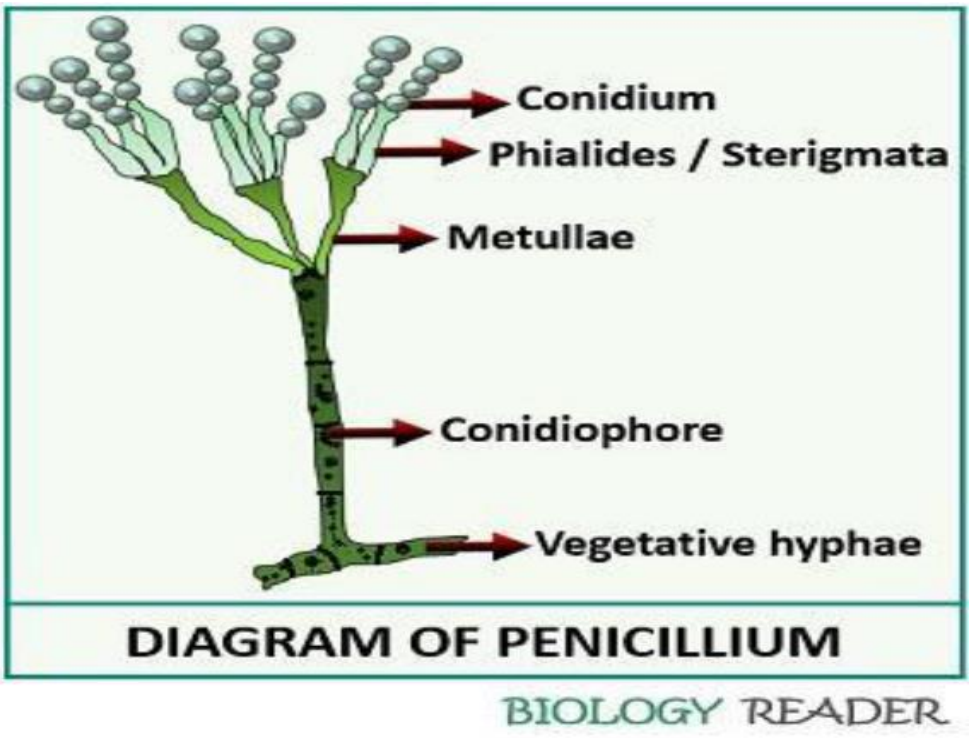
Conidium
Phialides / Sterigmata
Metullae
Conidiophore
Vegetative hyphae
DIAGRAM OF PENICILLIUM
BIOLOGY READER


Penicillium

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Important Yeast Genera

1- Genus saccharomyces

a. Cells may be round, ovate, and elongated.

b. Reproduction is by budding or by acospore formation.

c. *S. cerevisiae* is employed in many food industries e.g. bread manufacturing, wines, alcohol etc.

d. *S. fragilis* and *S. lactis* is important in milk and milk products because they are common spoilage microorganism.

2- Genus Torulopsis

a. General spoilage yeast.

b. Spoils a variety of food products e.g.: beer, milk products, fruit juices and some refrigerated foods.

3- Genus Candida

a. Many spoil foods with high acid, salt and sugar form pellicle on the surface of liquids.

b. Some can cause rancidity in butter and dairy products e. g.: *Candida lipolytica*.

c. Can form pseudo hyphae or true hyphae with many budding cells.