Chapter 4 Eukaryotic Microorganisms

Section 1 Comparison of the prokaryotic and eucaryotic cell

Items	Prokaryotic cell	Eucaryotic cell
Nucleus membrane	have	none
Chromosome	single	multiple
Organelles	simple	complex
Ribosomes	70S	80S
Size	small	large

Section 2 Main groups of eukaryotic microorganisms

The main characteristics of eucaryotes

Items	Fungi	Algae	Protozoans
Nutritionaltype	Chemoheterotroph	Photoautotroph	Chemoheterotroph
Multicellular	All except yeast	Some	None
Cellular arrangement	Unicellular, filamentous, fleshy	Unicellular, colonial, filamentous	Unicellullar
Food acquisition	Absorptive	Absorptive	Absorptive, cytostoma
Features	Sexual and asexual spores	Pigments	Mobility, some form cysts

Fungi are heterotrophic eukaryotic microorganisms. They are nonphotosynthetic and typically form reproductive spores.

Algae are phototrophic eukaryotes that contain photosynthetic pigments within a structure called the chloroplast

Protozoa are animallike organisms exhibiting heterotrophic nutrition and they usually can be defined as motile eukaryotic unicellular microorganisms.

Section 3 Cell structure of eucaryotic cell

Each cell is composed of cell wall, plasma membrane, cytoplasm and nucleolus.

1. Cell wall

Cell wall is mainly composed of polysacharride, small amount of protein and lipid. The polysacharride forms the frame of cell wall. Cell wall of low fungi contains mainly cellulose, yet in high fungi the cell wall contains mainly chitin, and in yeast the cell wall contains mainly glucan.

2 Plasma membrane

Plasma membrane of eucaryotes is basically similar with that of procaryotes.

3 Nucleus

Nucleus of eucaryotes is membrane-bounded round or oval structure containing DNA.

Neurospora crassa has 7 chromosomes, *Saccharomyces cerevisiae* has 17 chromosomes and *Agricus bisporus* has 13 chromosomes.

4 Organelles

Eucaryotes have a number of organelles such as cytomatrix, cytoskeleton, endoplasmic reticulum, eibosome(80S), Golgi body or Golgi apparatus, microbody, mitochodria, chloroplast, vacuole, lomsome, chitosome and hydrogenosome.

Section 4 Filamentous fungi-mould

1 Hyphae and mycelium

The filamentous fungus is made of filaments, called hyphae(pl-hypha). A hyphae is about 5-10 um wide and can be septate(higher fungi) or nonseptate (lower fungi).

Integrated masses of hyphae are called mycelium.

There are two types of mycelia:

Vegetative mycelium grows in substrate.

Aerial mycelium grows in air.

2 Special structure developed from vegetative mycelium

* **Rhizoid**, a root-like structure which takes up nutrition.
* **Haustorium,** a finger or palm-like structure which takes up nutrition.
* **Adhesive cell**, structure which attaches to the surface of host cells to take up nutrition.
* **Adhesive branch**, branch-like structure which attaches to the surface of host cells to take up nutrition.
* **Sclerotium,** hard strcture in which mycelium is in the dormancy.
* **Rhizomorph,** thread-like hard structure in which mycelium is in the dormancy.
* **Ring and net**, structures which catch nematodes.

3 Special structure developed from aerial mycelium

Special structures developed from aerial mycelium are mainly various fruiting body or sporocarp.

Simple fruiting bodies include:

conidial head(*Penicillium* and *Aspergilus*) and sporangium(*Rhizopus* and *Mucor*) which produce asexual spores, and basidium which produces sexual spores.

Complex fruiting bodies include:

Pycnidium, sporodochiumand acervulus, which produce asexual spores, and ascocarp（including cleistothecium, peritheciumand apothecium）which produces sexual spores。

Section 5 Reproduction of fungi

In asexual reproduction, there is no union of sexual cells.

Asexual spore, spores that are produced through asexual reproduction.

In sexual reproduction, there is union of sexual cells.

Sexual spore, spores that are produced through sexual reproduction.

1 Asexual spore

Asexual spores are formed by the aerial mycelium through mitosisand subsequent cell division. There is no fusion of the nuclei of cells.

When these spores germinate, they become organisms that are genetically identical to the parents.

Several types of asexual spores are produced by fungi.

Sporangiospore

Conidiospore

Arthrospore or Oidia

Chlamydospore

Zoospore

Ballistospore

2 Sexual spore

Sexual spores result from the fusion of nuclei from two opposite mating strains of the same species of fungus. Organisms that grow from sexual spores will have genetic characteristics of both parental strains.

1) Process of sexual reproduction

Plasmogamy:A haploid nucleus of a donor cell (+) penetrates the cytoplasm of a recipient cell(-) .

Karyogamy: The (+) and (-) nuclei fuse to form a diploid zygote nucleus.

Meiosis: By meiosis, the diploid nucleus gives rise to haploid nuclei (sexual spores), some of which may be genetic recombinants.

2) Sexual spores

Oospores are formed within a special female structure, the oogonium. Fertilization of eggs, or oospheres, by male gametes in an antheridium gives rise to oospores.

Zygospores are large, thick-walled spores formed when the tips of two sexually compatible hyphae of certain fungi fuse together.

Process of the formation of zygospores:

Mating hyphae(+,-)---contact---fusion septum---2 gametangia ---zygote

Process of the formation of ascospores:

Fusion of 2 mating cells(+,-)--plasmogamy--karyogamy--meiosis--Ascospore.

These single-celled spores are produced in a sac called an ascus. There are usually 8 ascospores in each ascus.

Basidiospore

Fusion of 2 mating cells(+,-)--plasmogamy--karyogamy--meiosis--Bsidiospore

These single-celled spores are borne on a club-shaped structure called basidium.

3 Classification of fungi

The classification of fungi, unlike that of bacteria, is based primarily on the characteristics of the sexual spores and fruiting bodies presenting during the sexual stages of their life cycles.

However, the perfect life cycle of many fungi are yet unknown. They are placed in a special class of Deuteromycetes.

The major classes of fungi are Oomycetes, Zygomycetes, Ascomycetes, Basidiomycetes and Deuteromycetes.

The features of the classes.

Fungi	Hyphae	Representives	Sexual spore
Oomycetes	Non –septate	Phytophthora	Oospores
Zygomycetes	Non -septate	Mucor Rhizopus	Zygospore
Ascomycetes	Septate	Neurospora; Saccharomyces	Ascospore
Basidiomyctes	Septate	Agaricus Amanita	Basidiospore
Deuteromycetes	Septate	Aspergillus Penicillium	Not found

Section 6 Typical species of filamentous fungi

Mucor (class Zygomycetes)

Mucor occurs abundantly in soil and on fruits, vegetables and starchy foods. Some are used in the manufacture of cheeses. Their mycelia are nonseptate and white or gray. Zygospores are produced when plus and minus strains are both present. They have no stolons or rhizoids.

Rhizopus (class Zygomycetes)

These are common bread molds, which cause much food spoilage. Sporangiospores are produced in a cyst called sporangium, which is formed on the end of sporangiophore.

Rhizopus forms rootlike hyphae called rhizoid, as well as stolons. Zygospores are produced when plus and minus strains are both present.

Neurospora (Class Ascomycetes)

This genus is widely used in the study of genetics and metabolic pathways.

Some species are responsible for food spoilage, and some species are used in industrial fermentations.

Certain species produce ascospores.Their conidia are usually oval.

Because of the characteristic pink or red color of the conidia, they are often called pink bread molds.

Agaricus (Class Basidiomycetes)

The best known species is *A. campestris*, the field mushroom and *A. bisporus*, the cultivated mushroom. Most of the larger species of Agaricus are edible

Penicillium (Class Deuteromycetes)

Members of them occur widely in nature.

Some species cause rot or other spoilage.

Some are used in industrial fermentations, and penicillin is produced by *P.notatum* and *P.chrysonegum.*
Some reproduce sexually by ascospore formation.
Penicillia have septate vegetative mycelium and produce Conidia.

Aspergillus (Class Deuteromycetes)
The Aspergilli are widespread in nature. Some species are involved in food spoilage.
They are important economically because they are used in a number of industrial fermentations, including the production of the citric acid and gluconic acid
The Aspergilli produce septate, branching mycelium and conidia, which are black, brown, or green.
The important Aspergilli are *A. flavus, A. oryzae* and *A.niger*

Section 7 Yeast

1 Features, distribution and impacts on life.
Features
Yeasts are unicellular, they can reproduce by budding and can obtain energy by fermentation of sugar. Acidic environments with moisture and sugar are favorable for the growth of yeast.

Distribution
Yeasts are widely found in nature, especially in acidic enviroments where sugar is present, for example, on the surface of fruits, vegetables and so on, in the soil of orchard. Yeasts could easily be isolated from the soil of oil fields and oil refinery plants.

Impacts on life
Yeasts are the ancient domestic organisms which have been used to produce wine, beer, liquor, bread, and other essential foods.
Yeast can cause troubles for human being. For example, few species of them cause disease in human being and other animals.

2 Cell structure
Yeasts are usually unicellular. Yeast cells are larger than most bacteria. They are 1-5 um in width and 5-30 um or more in length. They are commonly egg-shaped with no flagella.
The cell wall is a three layer structure. Out layer consists of mannan and inner layer consists of glucan. There is a layer of protein（mainly enzymes）in between.
Yeasts also have plasma membrane, nucleus and other organelles.

3 Reproduction
1) Asexual reproduction
Budding.
A bud always forms on the cell. When the rod-shaped celsl produce buds so quickly that the cells form a chain. It is called pseudohypae. When a bud departs from the mother cell, the scar left on the mother cell is called bud scar, and the scar on the offspring cell is called birth.

Yeasts, in some cases, produce asexual spores by binary fission.
Yeasts also produce asexual spores including arthrospore, ballistospore and chlamydospore.

2) Sexual reproduction
Yeasts produce sexual spores and ascospore.

4 Typical species of yeasts
Saccharomyces
There are about 30 species of Saccharomyces SPP. *S.cerevisiae* are used in the fermentation of beer and wine and in baking. They reproduce asexually by budding and in sexual reproduction they produce 4 ascospores.
Schizosaccharomyces
They reproduce asexually by binary fission and in sexual reproduction they produce 8 ascospores. Some species are used in the fermentation of beer.

Section 8 Mushroom

Mushroom is the largest flesh fungus. There are about 2000 edible mushrooms in the world, in which about 400 species are used today.
Most of mushrooms fall into Basidiomycetes, but a few fall into Ascomycetes.

Section 9 Algae

Algae cells are eukaryotic, unicellular or multicellular. Algae contain chlorophyll and are photosynthetic.
Algae have a wide range of sizes and shapes. Some colonies become quite complex and superficially resemble higher plants in structure.

1 Cell structure of algae
The cell wall is thin and rigid. The cell walls of many algae are surrounded by outer matrix, which often becomes pigmented and stratified.
There are 5 chlorophylls in algae and they are chlorophylls a, b, c, d, and e. Chlorophyll a presents in all algae.

2 Typical species of algae
Chlorella are green ,unicellular algae, with protein content of 55-62%.
Spirogyra are green filamentous algae. The walls of the filament are continuous. The chloroplasts of Spirogyra form a spiral within the filaments.
Diatoms are golden brown in color. They have two overlapping halves; one is larger than the other.
Red algae exhibit tissue differentiation and should be classified as plants. They contain phycocyanin and phycoerythrin in addition to chlorophyll. The red color is due to the phycoerythrin.

3 Roles of algae

Algae are an important part of any aquatic food chain because they fix carbon dioxide into organic molecules that can be consumed by chemoheterotrophs.

Seasonal changes in nutrients, light, and temperature cause fluctuations in algal populations; periodic increases in numbers of algae are called blooms. Blooms of a few species indicate that the water in which they grow is polluted.

Section 10 Protozoa

1 General features

Protozoa are unicellular nonphotosythetic eukaryotic microorganisms. They generally lack cell walls. There are 65000 species of protozoa.

Protozoas are mostly aerobic heterotrophs, although many intestinal protozoans are capable of anaerobic growth.

Some protozoa have one nucleus, but others have two or more nuclei.

Most protozoa reproduce asexually, most often by binary fission. Some protozoa also exhibit sexual reproduction , usually by conjugation

2 Typical species of protozoa

Euglena

Amoeba

Parameicium

Plasmodium