Chapter 5 – A Survey of Eukaryotic Cells and Microorganisms*

*Lecture notes are to be used as a study guide only and do not represent the comprehensive information you will need to know for the exams.

5.1 The History of Eukaryotes

The earliest known existence of eukaryotic cells dates as far back as a billion years ago (figure 5.1). It is thought that eukaryotic cells evolved from prokaryotic cells through a process called **symbiosis**. See also 5.1 Making Connections. It is thought that smaller prokaryotic cells became trapped in larger prokaryotic cells, and the smaller cells eventually became **organelles**. Over time, these early eukaryotic cells developed specialized functions that became tissues and organs. Eukaryotic cells can be unicellular, colonial, and multicellular (table 5.1).

5.2 Form and Function of the Eukaryotic Cell: External Structures

The “typical” eukaryotic cell is pictured in figure 5.2.

**Locomotor Appendages: Cilia and Flagella**

Both structures are involved in motility.

<table>
<thead>
<tr>
<th>Structure</th>
<th>Found in:</th>
<th>Composition</th>
<th>Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flagella</td>
<td>Protozoa, algae, a few fungal cells and animal cells</td>
<td>Microtubules, 9+2 arrangement (figure 5.3a and b)</td>
<td>Pushing the cell, or pulling the cell (figure 5.3c)</td>
</tr>
<tr>
<td>Cilia</td>
<td>Protozoa, animal cells</td>
<td>Microtubules, 9+2 arrangement (figure 5.3a and b); cells can have thousands of cilia</td>
<td>Beat back and forth; can also be used to assist in feeding and filtering</td>
</tr>
</tbody>
</table>

**The Glycocalyx**

Mostly composed of polysaccharides, it can be a slime layer or capsule. It can function in adherence, biofilms, and cell communication.
Form and Function of the Eukaryotic Cell: Boundary Structures

<table>
<thead>
<tr>
<th>Structure</th>
<th>Found in</th>
<th>Composition</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Wall</td>
<td>Fungi, algae</td>
<td>In fungi: chitin, cellulose</td>
<td>Structural support and shape</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In algae: varies, cellulose, pectins, mannans, silicon dioxide</td>
<td></td>
</tr>
<tr>
<td>Cell Membrane</td>
<td>All cells, but specific features differ between prokaryotic and eukaryotic cells</td>
<td>Phospholipids and proteins, sterols</td>
<td>Selectively permeable barrier</td>
</tr>
</tbody>
</table>

5.3 Form and Function of the Eukaryotic Cell: Internal Structures

<table>
<thead>
<tr>
<th>Cell Part</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nucleus</td>
<td>Surrounded by a nuclear envelope, contains the <strong>nucleolus</strong> where rRNA is produced (figure 5.5); contains most of the genetic material, chromosomes; cell divides by mitosis (figure 5.6)</td>
</tr>
<tr>
<td>Rough endoplasmic reticulum (RER)</td>
<td>Studded with ribosomes, carry out protein synthesis (figure 5.7)</td>
</tr>
<tr>
<td>Smooth endoplasmic reticulum (SER)</td>
<td>Synthesizes lipids, detoxification</td>
</tr>
<tr>
<td>Golgi Apparatus</td>
<td>Receives proteins and transports them to their final destination, ships material in vesicles (figure 5.8)</td>
</tr>
<tr>
<td>Lysosomes</td>
<td>Contains hydrolytic enzymes that help to digest material engulfed by the cell</td>
</tr>
<tr>
<td>Vacuoles</td>
<td>Membrane bound sacs that contain fluids or materials to be digested, such as food (figure 5.9)</td>
</tr>
<tr>
<td>Mitochondria</td>
<td>Completes the oxidation of carbohydrates, produces most of the ATP for the cell, found in eukaryotic cells (figure 5.10)</td>
</tr>
<tr>
<td>Chloroplast</td>
<td>Site for photosynthesis in the cell, found in algae and plants (figure 5.11)</td>
</tr>
<tr>
<td>Ribosomes</td>
<td>Site for protein synthesis, found in all cells</td>
</tr>
<tr>
<td>Cytoskeleton</td>
<td>Framework of proteins that function to give the cell shape and support; microtubules and microfilaments (figure 5.12)</td>
</tr>
</tbody>
</table>
5.4 Eukaryotic-Prokaryotic Comparisons and Taxonomy of Eukaryotes

Table 5.2 – comparison of eukaryotic, prokaryotic and viruses.

Overview of Taxonomy

A simplified version of classifying eukaryotic cells is presented in figure 5.13, which is based on ribosomal RNA (rRNA) comparisons.

5.5 The Kingdom of the Fungi

Fungi are in their own Kingdom, Kingdom Fungi, or Eumycota. Mycologists are scientists who study fungi. Fungi are broadly divided into two (2) groups: macroscopic and microscopic.

Fungi have chitin as their cell wall. Microscopic fungi are divided into hyphae, long and filamentous (figure 5.14), and yeasts, buds (figure 5.15). Some fungi are dimorphic, they exist in a yeast and hyphae forms.

Fungal Nutrition

All fungi are heterotrophic and saprobes. Fungi can live on a wide variety of materials, such as feather, wood and rubber.

Fungi have medical importance in that they are the causative agents of mycoses.

Organization of Microscopic Fungi

The colonies of yeast grow like bacteria. The colonies of filamentous fungi have a fuzzy, cottony appearance due to mycelium. Hyphae can be divided into septa (divisions) or non-septate.

Reproductive Strategies and Spore Formation

The primary mode of fungi reproduction is by forming spores. Spore formation can be for Asexual Spores: sporangiospores and conidia (figure 5.18); and Sexual Spores: zygospores (figure 5.19), ascospores (figure 5.20), and basidiospores (figure 5.21).
**Fungal Classification**

See table 5.3.

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**Fungal Identification and Cultivation**

Fungi can be isolated on specific media, like Sabouraud’s agar, which has a low pH. Other lab tests can include hyphae identification and biochemistry.

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**Fungi in Medicine, Nature and Industry**

Fungi are opportunistic pathogens. Most humans are naturally resistant to most fungi, except primary pathogens and opportunistic pathogens. **Mycoses** are fungal infections (table 5.4). Fungi can be responsible for allergies. Fungi are also known to destroy agricultural crops. Fungi can benefit the environment by decomposing dead material, and they can produce large quantities of antibiotics, alcohol, and vitamins.

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**5.6 Survey of Protists: Algae**

Most algae do not pose a direct threat to humans (figure 5.22), but *Prototheca* is one exception in that it can cause skin infections. Algae are a health threat in that some produce toxins in foods that we consume. See table 5.5.

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**5.7 Survey of Protists: Protozoa**

Protozoa are diverse, single-celled organisms. Many in this group are harmless, but some do cause infections in humans.

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**Protozoan Form and Function**

They are single cells without chloroplasts. Their cytoplasm is divided into **ectoplasm** and endoplasm. Their organelles and cell functions are divided between ectoplasm and endoplasm. They lack cell walls.
**Nutrition and Habitat Range**

They are heterotrophic, being able to consume other organisms and dead material. They vary in how they obtain, “eat”, their food, with humans serving as a nutrient source for some. They are typically found in moist environments, and can tolerate a wide range of pH and temperatures.

**Styles of Locomotion**

The most common type of motility means are pseudopods, flagella, and cilia. The arrangements and use of cilia vary greatly among the ciliates.

**Life Cycles and Reproduction**

Most protozoa have a trophozoite feeding stage and a resting stage called a cyst (figure 5.23). The life cycles can be simple to complex. Some protozoa remain in the trophozoite stage, while others can form a cyst.

**Protozoan Identification and Cultivation**

Protozoa are very diverse in terms of their shape, feeding patterns, lifecycles, and habitat. It make it very hard to easily group them. Lab identification uses a variety of methods, such as, size, shape, locomotion, and special organelles. In the medical setting, protozoa are isolated from body fluids and examined directly on a microscope slide. Protozoa can be cultured in some media and lab animals.

**Classification of Selected Medically Important Protozoa**

Most Protozoans fit into one of four categories (figure 5.24 and table 5.6):

1. flagellated mastigophorans
2. pseudopod amoebas
3. ciliophorans
4. apicomplexan
Important Protozoan Pathogens

Some of the medically important protozoa are found in the tropics and subtropics (table 5.7).

Pathogenic Flagellates: Trypanosomes

Two important members of this group are *Trypanosoma brucei* and *T. cruzi*. *T. brucei* causes African Sleeping Sickness. *T. cruzi* causes Chagas disease and is transmitted by the reduviid bug (figure 5.25).

Infective Amoebas: Entamoeba

The causative agent of amebic dysentery is *Entamoeba histolytica* (figure 5.26).

5.8 The Parasitic Helminths

*Helminths* are tapeworms, flukes, and roundworms. They are included in microbiology based on how we study their body parts.

There are two major groups of parasitic helminths:

I. Flatworms – thin, segmented body plan
   1. cestodes, or tapeworms – long ribbon-like body
   2. trematodes, or flukes – flat, ovoid bodies

II. Roundworms – also called nematodes, elongated, cylindrical unsegmented body plan

General Worm Morphology

All helminths are multicellular animals, with very few fully developed organs other than the reproductive tract (figure 5.27a).

Life Cycles and Reproduction

Trematodes can be *hermaphroditic*. Humans tend to become infected by contaminated soil, food, water, or infected animals.
A Helminth Cycle: The Pinworm

*Enterobius vermicularis*, the pinworm or seatworm, infects the large intestine (figure 5.28). The infection starts when a person swallows the eggs. The eggs hatch in the intestine, and the females migrate to the anus to release her eggs. This organism tends to attack younger children.

Helminth Classification and Identification

Classification is based on several physical characteristics. Microscopic examination is also done to help in classification.

Distribution and Importance of Parasitic Worms

Worms are distributed world wide. Part of the reason is due to easier travel.