SPARKCHARTS™

MICROBIOLOGY

INTRODUCTION

Microbiology is the study of organisms that are visible only with a microscope.

HISTORY OF MICROBIOLOGY

A. Robert Hooke: first described cells in 1665 when he used a microscope to observe a slice of cork.

B. Anton van Leeuwenhoek: discovered microscopic life forms in droplets of pond water and on his teeth. In 1683, he dubbed these organisms "animalcules."

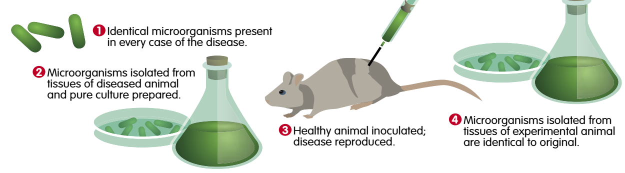
C. Louis Pasteur:

1. Identified microorganisms as the cause of alcohol fermentation and souring dairy products.
2. Disproved the notion of *spontaneous generation*—the idea that organisms may arise from lifeless matter, such as beef broth.
3. Proposed the **germ theory of disease,** which states that microorganisms cause infectious diseases.
4. Developed immunization techniques.

D. Robert Koch: proved Pasteur's germ theory of disease through experimentation with anthrax. His methods are known as **Koch's postulates:**

1. The same microorganisms are observed in every case of the disease.
2. The microorganisms are isolated and cultured outside the body of the sick animal.
3. The microorganism is injected into a healthy animal of the same species, causing the same illness.
4. An identical microorganism is isolated from the newly sick animal.

KOCH'S POSTULATES



THE CELL THEORY

Every living organism is made up of cells, which are the lowest level of structure capable of performing all the activities of life. All cells arise from preexisting cells.

PROKARYOTIC VS. EUKARYOTIC MICROORGANISMS

Several cell components exist in all types of cells:

A. Cell membrane: serves as an external barrier and encloses organelles.

1. The basic unit is a **phospholipid molecule,** with a polar phosphate group as its hydrophilic head and two nonpolar fatty acid chains as hydrophobic tails.
2. Individual phospholipids form a fluid **phospholipid bilayer,** with hydrophilic heads facing out, and hydrophobic tails facing in to form a nonpolar zone that separates the watery cell interior from the extracellular environment.
3. Cell membranes are **semipermeable,** allowing passage of gases, lipids, and small polar molecules. Cell membranes are not permeable to charged molecules (ions and proteins) and large polar molecules.

B. Membrane Proteins: protein molecules embedded in the bilayer *transport* molecules unable to cross the membrane independently, *assist* in biologically important reactions, and *interact* with membranes of neighboring cells.

C. Cytoplasm: a semifluid medium called **cytosol** and all the organelles inside the plasma membrane but outside the nucleus.

D. Cytoskeleton: system of protein filaments in the cytoplasm including **microtubules** and **microfilaments** that gives the cell shape and helps direct movement.

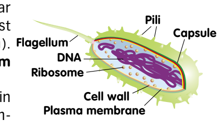
E. Ribosomes: proteins that work with RNA to synthesize polypeptides.

PROKARYOTES

The simplest unicellular organisms and the earliest cells to evolve (**bacteria**). Their major **differences from eukaryotes include:**

A. Genetic material floats in the cytoplasm in a concentrated but unbounded region called the nucleoid.

B. No membrane-bound organelles.



PROKARYOTIC CELL

EUKARYOTES

Found in unicellular protists and multicellular plants and animals; contain membrane-bound organelles, each of which performs a specific function and increases efficiency:

A. Nucleus: the storage site of genetic information that determines heredity and directs the activities of a cell.

B. Mitochondria: double-membraned power plants of the cell. Location of aerobic respiration.

C. Smooth/rough endoplasmic reticulum (SER/RER): a network of membranes covered with ribosomes where lipids/proteins are synthesized.

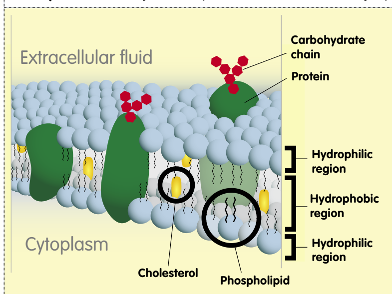
D. Golgi complex (a.k.a. **Golgi apparatus**): packages proteins and lipids produced in the ER for export in secretory vesicles.

E. Vesicles: sacs in which substances are transported or stored.

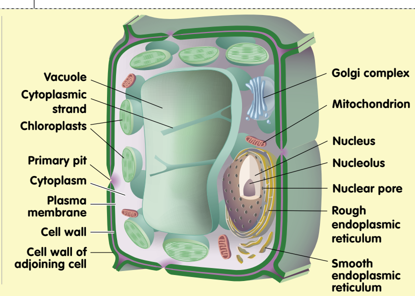
F. Lysosomes: vesicles of digestive enzymes that degrade old cellular components.

G. Special plant organelles: plant cells contain additional components:

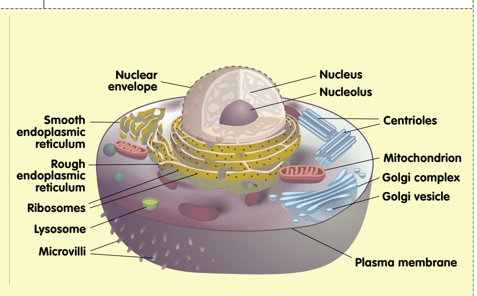
1. **Chloroplasts:** site of photosynthesis; contain chlorophyll (a green pigment) and have a double membrane.
2. **Vacuole:** large vesicle used to store water, proteins, and waste.
3. **Cell wall:** a rigid layer of cellulose surrounding the cell membrane.



CELL MEMBRANE



PLANT CELL



ANIMAL CELL

METABOLISM

CELLULAR RESPIRATION

Cellular process of oxidizing glucose or food molecules to obtain energy in the form of **adenosine triphosphate (ATP)**.

GLYCOLYSIS

The oldest metabolic pathway, used by all cells, and a precursor to both the aerobic and anaerobic respiratory pathways. Glycolysis occurs in the cytoplasm. The six-carbon sugar glucose is degraded to form two molecules of three-carbon pyruvate, resulting in two NADH and two net ATP.

FERMENTATION

In the absence of oxygen, respiration relies on glycolysis to produce ATP. This **anaerobic** process uses an organic molecule to accept the electron from NADH and reform NAD+ for glycolysis to run again. Much energy remains in bonds of by-products, such as ethanol or lactic acid. Three types of fermentation exist:

A. Homolactic: bacteria converts pyruvate to lactic acid.

B. Alcoholic: yeast and bacteria convert pyruvate into ethanol and CO_2.

C. Heterolactic: organisms produce lactic acid as well as other acids and alcohols.

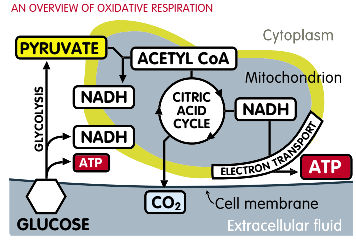
OXIDATIVE RESPIRATION

If oxygen is present, glycolysis leads to **aerobic** respiration, which produces a net total of 36 ATP per molecule of glucose.

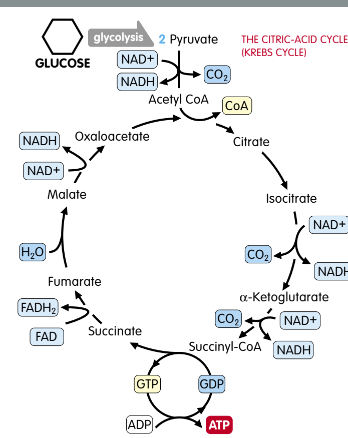
A. Oxidation of pyruvate: carbon dioxide splits off from pyruvate to produce acetyl-CoA and NADH.

B. Citric-acid cycle (Krebs cycle): begins with acetyl-CoA joining oxaloacetic acid to form citric acid, which is oxidized to CO_2, yielding ATP, NADH, and $FADH_2$. Oxaloacetic acid is regenerated for another cycle. Occurs in the mitochondria of eukaryotes and the cytoplasm of aerobic prokaryotes.

AN OVERVIEW OF OXIDATIVE RESPIRATION



THE CITRIC-ACID CYCLE (KREBS CYCLE)



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> “FOR EACH ILLNESS THAT DOCTORS CURE WITH MEDICINE, THEY PROVOKE TEN IN HEALTHY PEOPLE BY INOCULATING THEM WITH THE VIRUS THAT IS A THOUSAND TIMES MORE POWERFUL THAN ANY MICROBE: THE IDEA THAT ONE IS SICK.”
>
> MARCEL PROUST

METABOLISM (continued)

C. Chemiosmotic (oxidative) phosphorylation: in mitochondria, electrons from NADH and $FADH_2$ flow through an **electron transport chain** from high to low energy states through energy-releasing steps, establishing an electrochemical proton gradient across the inner membrane of mitochondria. O_2 accepts the electrons to form water. ATP is synthesized when H^+ ions diffuse back across the membrane through embedded proteins.

CREATING ENERGY

Micoorganisms can be classified by the ways they produce energy.

A. Autotrophs: use carbon dioxide as a carbon source.

1. **Photoautotrophs:** use light energy to perform photosynthesis and convert carbon dioxide and water to organic compounds. The chemical summary of **photosynthesis:**
   $6CO_2 + 12H_2O \longrightarrow C_6H_{12}O_6 + 6H_2O + 6O_2$
2. **Chemoautotrophs:** use chemical reactions to obtain energy and produce nutrients from simple inorganic compounds.

B. Heterotrophs: use organic compounds as a carbon source.

1. **Photoheterotrophs:** use light energy via photosynthesis to create energy and organic compounds.
2. **Chemoheterotrophs:** use chemical reactions to create energy and organic compounds.

OXYGEN USAGE

A. Obligate aerobes: require an ample oxygen source to perform respiration.

B. Microaerophilic/microaerobic: require small amounts of oxygen. **Capnophilic** microbes require low oxygen and high carbon dioxide concentrations.

C. Facultative anaerobes: organisms that perform anaerobic glycolysis in the absence of oxygen but can perform aerobic respiration in the presence of oxygen.

D. Obligate anaerobes: die in presence of oxygen because they lack chemistry to produce organic compounds via reduction of oxygen.

NITROGEN METABOLISM

A. Nitrogen fixation: bacteria convert atmospheric nitrogen to compounds (ammonia and nitrates) useful to other organisms. Cyanobacteria perform this as part of their metabolism: $N_2 \longrightarrow NH_3$

B. Nitrogen conversion (nitrification): various chemoautotrophic bacteria can convert nitrogen in NH_3 to nitrite NO_2, and nitrite to the more usable form, nitrate NO_3^-.

C. Denitrification: facultative anaerobes obtain oxygen by converting NO_3 to atmospheric nitrogen (N_2).

EXTREME BACTERIA

A. Psychrophiles: can withstand low temperatures.

B. Extreme halophiles: thrive in water with high salt concentrations.

C. Thermoacidophiles: tolerate high temperatures, highly acidic conditions.

D. Methanogens: anaerobic decomposers that use hydrogen to reduce carbon dioxide to methane gas.

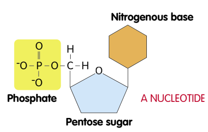
E. Spore formers: form spores for protection against extreme conditions.

GENETICS

NUCLEIC ACIDS

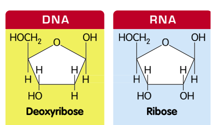
A. Polymers of **nucleotides** that encode genetic information. Two forms: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Individual nucleotides are linked together with phosphodiester bonds and contain three basic parts:

1. **Phosphate group:** forms the molecular backbone with the sugar.
2. **Five-carbon sugar:** deoxyribose in DNA and ribose in RNA.
3. One of four **nitrogenous bases:**
   a. **adenine** and **guanine** are double-ringed **purines.**
   b. **thymine** and **cytosine** are single-ringed **pyrimidines.**
   c. RNA contains the pyrimidine **uracil** instead of thymine.



B. Any linear strand of DNA or RNA will always have a free **5′-phosphate group** at one end and a free **3′-OH group** at the other.

C. DNA is most often found as a **double-helix**—a sort of spiral staircase composed of two nucleotide chains hydrogen-bonded to each other. The chains bind in opposing directions: the 5′ end of one chain is hydrogen-bonded to the 3′ end of the other.



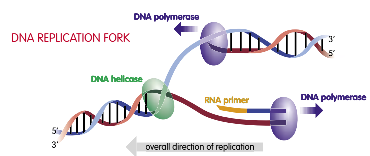
D. In double-stranded DNA, adenine is hydrogen-bonded to thymine; guanine is hydrogen-bonded to cytosine.

1. In DNA, the proportion of adenine is always equal to that of thymine; and the proportion of guanine is always equal to that of cytosine: **A = T, G = C.**
2. There is always an equal proportion of purines (A, G) and pyrimidines (C, T).

DNA REPLICATION

A. Complementarity: the base sequence of one chain of DNA completely determines the sequence of its partner in the double-helix. Each chain is a complementary mirror image of the other: AGCCTAT must pair with TCGGATA.

B. Semiconservative replication: after one round of replication, the original pair is not conserved, but each strand becomes part of a new duplex.



GENE EXPRESSION (PROTEIN SYNTHESIS)

A. RNA Transcription

1. The region of DNA encoding the desired gene is unzipped, and the enzyme **RNA polymerase** copies the nucleotide sequence to make a strand of messenger (m)RNA. Though the two strands of DNA are complementary, only one strand (the template strand) is transcribed into mRNA.
2. Noncoding sequences of mRNA called **introns** are removed, and the remaining sequences, called **exons,** are spliced together.
3. The mRNA leaves the nucleus to be translated by a ribosome into a protein.

B. Translation

1. A ribosome (a complex of ribosomal (r)RNA and protein) binds to an mRNA transcript and reads a triplet of nucleotides, called a **codon.**
2. The ribosome binds the matching **anticodon** of a transfer (t)RNA molecule, which is attached to a specific amino acid, into the ribosome’s **A-site.**
3. Sequential mRNA codons call new tRNA-amino acids into the A-site, shifting previous tRNA-amino acids to the **P-site,** where they link to form a polypeptide chain until a *stop codon* is reached.

CONJUGATION

Temporary union of two unicellular organisms, during which genetic material is transferred from one cell to another. Bacteria link with protein connections called **pili.** Circular DNA **plasmids** carry **F factors** that code for donors (F^+) and recipients (F^-).

TRANSFORMATION

Introduction of novel genetic material by diffusion into bacteria, based on their **competence,** or ability to accept. From a virus, donor cell, or manipulation of a cell genome that results in a heritable alteration, e.g., a carcinogen may warp a cell’s genome such that the cell acquires cancerlike properties.

TRANSFECTION

Introduction of foreign DNA into a eukaryotic cell, followed by expression of one or more genes instructed by the novel DNA.

RECOMBINATION

When chromosome or DNA molecules in a genome are broken up and rejoined in a new arrangement. Occurs during crossing-over in meiosis or may be performed artificially in the laboratory with restriction enzymes that break DNA strands.

TRANSDUCTION

Transfer of genes between organisms; this recombination occurs when **transducing phage viruses** inject genetic material into bacteria, or when viruses accidentally incorporate host-cell DNA and transfer it to subsequent hosts.

THE FIVE KINGDOMS

MONERA

Prokaryotes such as bacteria and blue-green algae (cyanobacteria).

PROTISTA

Unicellular eukaryotes, including protozoa, unicellular algae, and slime molds.

FUNGI

Uni- and multicellular eukaryotes, including molds, mushrooms, and yeasts.

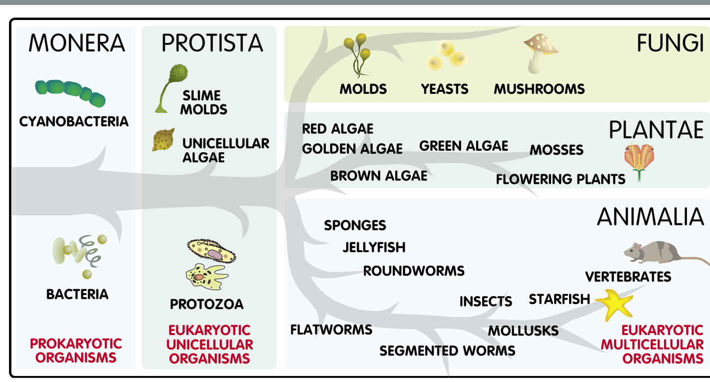
PLANTAE

Complex uni- and multicellular eukaryotes, characterized by ability to produce organic nutrients via photosynthesis.

ANIMALIA

Complex multicellular eukaryotes; characterized by high mobility and the practice of obtaining food by ingesting other organisms.

Note: Other systems exist for classifying biological organisms, including a three-domain system and an eight-kingdom system.



CONTINUED ON OTHER SIDE

IDENTIFYING MICROBES

CULTURE MEDIA

A. TSP broth: contains all the nutrients bacteria require.
B. Blood agar: contains red blood cells. Useful for testing for the presence of hemolytic bacteria, which lyse red blood cells.
C. Selective media: discourages growth of unwanted organisms while supporting growth of desired organisms.
D. Differential media: provides environment in which bacteria can be differentiated from each other.
E. Enriched media: contains nutrients for the specific needs of the bacteria being cultured.

STAINING

A. Simple stain: basic dyes (crystal violet and methylene blue) are used to stain the sample.
B. Negative stain: negatively charged dyes (nigrosin and Congo red) repel the negatively charged cytoplasm of cell specimens to create a colored background.
C. Gram stain
1. Crystal violet is applied to the specimen, then iodine, which kills cells and fixes the stain.
2. Slide is washed with alcohol. *Gram-positive* cells retain the crystal violet iodine stain.
3. *Gram-negative* bacteria are subsequently stained with safranin dye.

D. Acid-fast stain: differentiates species of mycobacterium from other bacteria.
1. Sample is stained red with carbolfuchsin and heat.
2. Cells are then washed with acid-alcohol solution; the mycobacterium species (acid-fast bacteria) retains the color.
3. Other bacteria (nonacid-fast bacteria) lose color and stain blue after subsequent application of methylene blue.

MICROSCOPY

A. Compound (two-lensed) light microscope: also called a **bright-field microscope.** Light is projected through an opening below the specimen and an image is magnified by the objective lens. This image becomes an object for the ocular lens, which remagnifies the image.
B. Dark-field microscope: a special condenser scatters light and causes it to reflect off the specimen at different angles. The specimen appears illuminated on a dark background.
C. Phase contrast microscope: a series of condensers and filters throws a single light "out of phase." The separated beams of light pass through the specimen at different wavelengths to show the details of living and unstained cells.
D. Transmission electron microscope: thin slices of specimen are stained with gold or palladium. The coated parts of the specimen deflect or absorb a beam of electrons differently based on their densities so that the internal structures of the cell can be seen.
E. Scanning electron microscope: an electron beam scans the surface of a specimen, giving a three-dimensional and textural view without sectioning.

BACTERIA

Simple prokaryotes lacking a nucleus. They appear as spheres (cocci), rods (bacilli), or spirals (spirochetes or spirilla). They reproduce via binary fission, and can thrive in most environments despite extremes in temperature and oxygen availability.

SPIROCHETES AND SPIRILLA

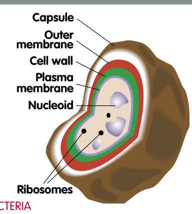
A. Spirochetes:
1. Spiral shape and a flexible cell wall.
2. Some species inhabit watery environments; others are parasites of insects and warm-blooded animals.
3. Cause Lyme disease (*Borrelia burgdorferi*), syphilis (*Treponema pallidum*).

B. Spirilla:
1. Spiral shape and a rigid cell wall.
2. Widely dispersed among numerous environments.
3. Cause rat bite fever (*Spirillum minor*), campylobacteriosis—intestinal infection with diarrhea (*Campylobacter jejuni*).

GRAM-NEGATIVE RODS AND COCCI

Have thin cell walls of **peptidoglycan** enclosed by an outer membrane layer.
A. Photoautotrophic bacteria: perform photosynthesis to obtain energy from light.
1. **Anoxygenic photoautotrophs:** rod-shaped; grow under anaerobic conditions. Do not use water as a source of hydrogen; do not produce oxygen from photosynthesis.
2. **Oxygenic photoautotrophs (cyanobacteria):** rod-shaped and spherical; perform photosynthesis using water as hydrogen source and producing oxygen.

B. Chemoautotrophic (chemolithotrophic) bacteria: derive energy from chemical processes; use inorganic material; reside outside the body in soil and water.
1. Some use carbon dioxide as carbon source and grow among inorganic compounds.
2. *Thiobacillus* metabolizes sulfur compounds.
3. *Nitrosomonas* and *Nitrobacter* metabolize nitrogen compounds.
4. Others use hydrogen gas or metals such as manganese and iron.



STRUCTURE OF EUBACTERIA

GRAM-POSITIVE BACTERIA

Have thick peptidoglycan layer with an additional polysaccharide called **teichoic acid.** No outer membrane present.
A. Streptococci:
1. Spherical bacteria that align in chains as they divide
2. Aerobic and anaerobic metabolism.
3. Cause of strep throat, rheumatic fever, meningitis.
4. Used in production of yogurt, buttermilk, cheese.
5. Hemolytic properties: affect red blood cells on blood agar.

B. Staphylococci:
1. Arrange in clusters as they divide.
2. Inhabit skin and mucous membranes.
3. Cause skin boils, abscesses, food poisoning (*Staphlococcus aureus*).

C. Bacillus and clostridium:
1. Rod-shaped; produce endospores for protection in harsh conditions.
2. Bacilli are aerobic metabolizers; clostridia are anaerobic.
3. Cause of anthrax (*Bacillus anthracis*), tetanus, botulism (*Clostridium*).
4. Applications: *Bacillus thuringiensis* is used to produce caterpillar insecticide; *Clostridium* is used to produce chemicals (i.e., butanol).

ACID-FAST BACILLI

A. Mycobacteria:
1. Rod-shaped.
2. Free-living: thrive in nearly all conditions.
3. Cause tuberculosis (*M. tuberculosis*), leprosy (*M. leprae*).

ARCHAEBACTERIA

Evolved before eubacteria but have not undergone significant evolution since. Grow in extreme conditions (**extremophiles**), have unusual lipids in cell membranes and unique RNA molecules in their cytoplasm. Lack peptidoglycan in their cell walls.
A. Methanogens: anaerobic bacteria that reduce carbon dioxide to methane gas; reside in areas of decomposing matter (swamps, sewage).
B. Halobacteria: obtain energy from light via a mechanism different from photosynthesis; live in high-salt environments.
C. Thermoacidophiles: use sulfur metabolism, often producing sulfuric acid as an end product; live in habitats of extremely high temperatures and low pH.

SUBMICROSCOPIC BACTERIA

A. Rickettsiae:
1. Extremely small; rod-shaped or spherical; Gram-positive.
2. Intracellular parasites of humans and insects.
3. Cause Rocky Mountain spotted fever, typhus.

B. Chlamydiae:
1. Extremely small; Gram-negative.
2. Invade cells and differentiate into reticulate bodies, which reproduce and form new chlamydiae called elementary bodies
3. Cause reproductive tract infections, diseases of eye and lung.

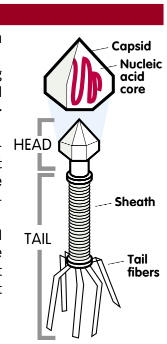
C. Mycoplasmas:
1. Lack cell walls; resist antibiotics; vary in shape (pleomorphic).
2. Cause respiratory and urinary tract infections.

VIRUSES

Protein shells containing bits of DNA or RNA. Viruses have no metabolism and hijack the chemical machinery of host cells to reproduce.

STRUCTURE

A. Genome: viral genetic information is encoded either in RNA or DNA.
B. Capsid: protein coat surrounding the genome. The genome/capsid combination is called the **nucleocapsid**.
C. Envelope: membrane-like structure that encloses the capsid; not common to all viruses. Among the envelope viruses are herpes simplex and chicken pox.
D. Bacteriophages: have head and tail regions: capsid comprises the head; and a protein structure that helps bind the virus to the host cell's surface is the tail.

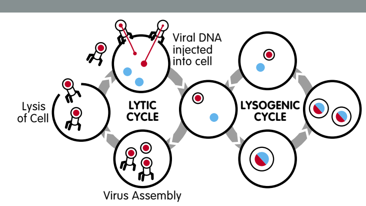


GENERAL VIRUS STRUCTURE

LIFE CYCLE

A. Lytic cycle: replication process resulting in destruction, or lysis, of the host cell. Involves six basic steps:
1. **Attachment:** the virus attaches itself to the host cell using special glycoproteins on the viral envelope.
2. **Penetration:** either the whole virus penetrates the host cell, or the viral genetic material is introduced into the cytoplasm.
3. **Uncoating:** if the entire capsid enters, the genetic material is uncoated to interface with the cell's replication machinery.
4. **Replication:** the genetic material is replicated and structural proteins are synthesized.
5. **Assembly:** new viral particles are assembled.
6. **Release:** viral particles are released, destroying the host cell.

B. Lysogenic cycle: with some viruses, called **prophages** (or **proviruses** in animals), the lytic phase becomes arrested after penetration/uncoating. In the lysogenic phase, the dormant viral genetic material is integrated with the host's genetic material, replicated, and passed on to host-cell progeny before the lytic phase is reactivated and the hosts are destroyed.

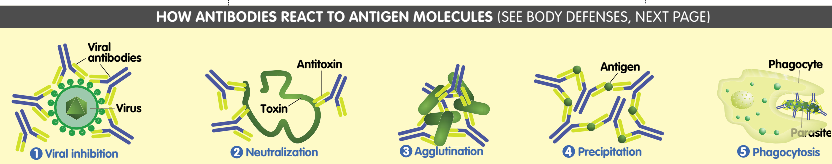


LYTIC AND LYSOGENIC CYCLE

VIRAL VACCINES

Vaccines provide protection against viral diseases by exposing the immune system to a relatively avirulent version of the virus, so that when the virulent variety is encountered, a rapid immune response may be initiated.
A. Inactivated viruses: "dead" viruses that are unable to replicate due to a chemical or physical treatment. Example: the Salk polio vaccine.
B. Attenuated viruses: "live" viruses that are weakened so that replication occurs very slowly; generally do not produce disease when a healthy individual is exposed. Examples: the measles and rubella vaccines.

HOW ANTIBODIES REACT TO ANTIGEN MOLECULES (SEE BODY DEFENSES, NEXT PAGE)

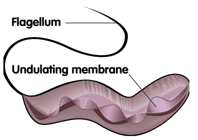


PROTOZOANS

Single-celled eukaryotes. Lack cell walls, so shape varies significantly. Some are motile, making use of flagella, cilia, or pseudopodia (cytoplasmic feet). Others are nonmotile. Heterotrophic, ingest food via phagocytosis.

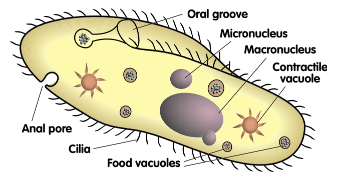
CLASSIFICATION

A. Kinetoplastids/mastigophora:
1. Move by a whipping motion of one or more flagella.
2. Reproduce by fission, although sexual reproduction has been observed.
3. Inhabit a variety of environments, ranging from animal intestines and blood streams to pond and swamp water.



A TYPICAL KINETOPLASTIC

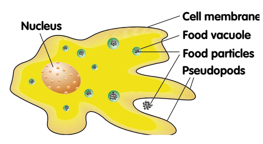
B. Ciliophora:
1. Move by waving rows of hairlike structures called **cilia** distributed along their body; cilia beat in patterns to move the cell and propel food particles toward a primitive mouth.
2. Two types of nuclei, unlike any other group of protozoans
   a. **Macronucleus:** controls cell growth and function and may have hundreds of copies of the cell's DNA.
   b. **Diploid micronucleus:** responsible for inheritance of genetic material at reproduction.
3. Asexual reproduction or sex through conjugation.
4. Found on parasites; inhabit pond and swamp water.



A TYPICAL CILIATE: THE PARAMECIUM

C. Sarcodina:
1. Movement by amoeboid motion: actin filaments help the cytoplasm flow beneath the cell membrane into new branches called **pseudopods.**
2. Reproduce by fission.
3. Inhabit marine environments and animal intestines.

D. Apicomplexa/sporozoa:
1. No means of locomotion in adult form.
2. Found in parasites.
3. Cause of malaria and a form of lethal pneumonia.



SARCODINA

FUNGI

Unicellular or multicellular eukaryotes including mushrooms, yeasts, and molds. Most have cell walls made of **chitin.** Yeasts are spherical and slightly larger than bacteria; molds are filamentous, branched fungi.

METABOLISM

A. **Chemoheterotrophs:** grow best in acidic conditions that are rich in organic matter near room or body temperature (37°C).
B. Mostly aerobic; use glucose or maltose for energy metabolism and glycogen for long-term energy storage.
C. Fermentation yeasts can grow in both aerobic and anaerobic environments.

REPRODUCTION

A. Asexual reproduction:
1. Molds form spores by mitosis.
2. Under normal conditions, yeast divide by binary fission (budding).

B. Sexual reproduction:
1. In molds, compatible nuclei within mycelium fuse to form diploid sexual spores. After a spore is released, it undergoes several divisions until the haploid state is reestablished.
2. Under starvation conditions, yeast cells (haploid) fuse and form diploid nuclei that undergo meiosis and produce haploid spores. These spores go on to become haploid cells.

CLASSIFICATION

A. **Zygomycota:** typical fungi of fruits, vegetables, and breads. They anchor to the substratum (organic surface) with special hyphae called rhizoids.
B. **Ascomycota (sac fungi):** include mildews and fungi that cause tree diseases (Dutch elm disease; chestnut blight). Include the fermentation yeast *Saccharomyces* used in production of alcohol and breads.
C. **Basidiomycota (club fungi):** typical mushrooms, as well as pathogens like *Cryptococcus neoformans,* which causes meningitis.
D. **Deuteromycota (imperfect fungi):** include causes of athlete's foot and ringworm. Called "imperfect" because they do not appear to have a sexual cycle of reproduction (unusual for molds).

HOST-PARASITE RELATIONSHIP

NORMAL FLORA

Population of microorganisms on a larger individual; these microorganisms permanently occupy the region of interface on body tissues and their environment.

TRANSIENT FLORA

Portions of the normal flora that are present for a time and then disappear.

SYMBIOSIS

A. **Commensalism:** a relationship where an individual benefits in close association with another without doing harm to the host.
B. **Mutualism:** a relationship in which both organisms benefit from their association.
C. **Parasitism:** a form of predation in which one organism lives in or on another and benefits while harming the host.

INFECTIOUS MICROBES

In addition to bacteria, viruses, protozoa, and fungi, there are several other infectious microbes.

VIROIDS

Naked RNA molecules that do not code for any specific protein but are replicated in passing from one damaged cell to another (cells lacking a protective membrane).

PRIONS

A theoretical class of infectious particles that consist only of a hydrophobic protein lacking any genetic material. A prion is believed to be the pathogen that causes bovine spongiform encephalopathy (mad cow disease).

DNA/RNA

Carriers of genetic material that can cause harmful changes in cells when giving instructions incompatible with the lifestyle of the host organism (transformation, transfection, transduction).

MODES OF INFECTION/DISEASE TRANSMISSION

RESERVOIR OF INFECTION

Any living or nonliving substance on which pathogens live and multiply.

CONTACT

A. **Direct transmission:** occurs by physical contact between organisms.
B. **Indirect transmission:** occurs when a nonliving thing (indeterminate host) is the bridge between an infected organism and the subsequent victim (definitive host).

VECTOR

Living organism that transmits disease.
A. **Mechanical vectors:** carry pathogens without their replication occurring, such as on body parts.
B. **Biological vector:** carry pathogens while pathogens replicate, such as in saliva.

VEHICLES

Nonliving modes of disease transmission: food, water, air.

BODY DEFENSES

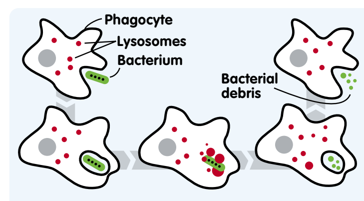
NONSPECIFIC BODY DEFENSES

Mechanisms with the task of preventing microorganisms from gaining access to the body, destroying them if they penetrate deep tissues.

A. Mechanical barriers: the body's first line of defense.
1. **Skin:** the outer layers of skin consist of compacted cells held in a matrix of the protein keratin. If unbroken, this layer is impervious to infection.
2. **Mucous membranes:** although moist and permeable, mucous membranes secrete fluids (tears, mucus, saliva) that help rid the membrane of potential pathogens.

B. Chemical barriers: body secretions that help defend against pathogen invasion.
1. **Lysozyme:** enzyme found in tears and saliva which breaks down peptidoglycan in the cell wall of Gram-positive bacteria.
2. **Lactic acid:** provides antimicrobial protection in the vagina.
3. **Hydrochloric acid:** provides antimicrobial protection in the stomach (gateway to the intestines).
4. **Spermine:** substance in semen that inhibits bacteria in the male urogenital tract.

C. Phagocytosis: process by which phagocytes engulf and destroy pathogens. Phagocytes include neutrophils and macrophages.
1. **Attachment and ingestion:** microbial particles attach to the surface of the phagocyte and are ingested by a bubblelike organelle called a phagosome.
2. **Formation of phagolysosome:** phagosome merges with lysosome containing digestive enzymes.
3. **Egestion:** elimination of microbial debris after destruction of microorganisms.



PHAGOCYTOSIS

D. Inflammation: response to trauma occurring in tissues; accompanied by heat, swelling, redness, and pain. Inflammation activates immune system components and repair mechanisms, and encourages phagocytosis.

E. Fever: circulating substances in bloodstream (pyrogens) increase body temperature and stimulate the immune reaction and phagocytosis, slowing the growth of temperature-sensitive microorganisms.

F. Interferon: an antiviral agent produced by infected host cells and immune system cells exposed to a virus. Interferons do not protect the infected cell, but stimulate neighboring cells to produce chemicals that protect against viral replication.

SPECIFIC IMMUNE SYSTEM

Immunity is a specific resistance to an infection and the particular type of organism causing it. The immune system helps the body identify foreign microbes and proceeds to neutralize, kill, and eliminate them.

A. **Antigens:** also, **immunogens.** Bits of foreign protein that help the immune system recognize nonself substances and orchestrate the immune response.

B. **Antibody-mediated (humoral) immunity:** an **antibody** is a specialized protein produced by the **B-cells** (**B-lymphocytes**) of the host immune system in response to an antigen; it reacts specifically to the foreign agent. There are five types of interaction (see diagrams at the bottom of the previous page):
1. **Viral inhibition:** viruses bound by antibodies cannot attach to host cells and replicate.
2. **Neutralization:** toxins bound by specific antibodies are neutralized.
3. **Agglutination:** antigens react with antibodies to cause clumping, facilitating phagocytosis.
4. **Precipitation:** antibodies combine with antigens to precipitate out of solution.
5. **Phagocytosis:** antibody/antigen complex stimulates phagocytosis by direct interaction.

C. **Cell-mediated immunity:** determined by long-lived **T-lymphocytes.** T-lymphocytes "remember" antigens from previous infections and immunologically commit to creating an extensive immune response whenever that antigen is subsequently encountered.

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