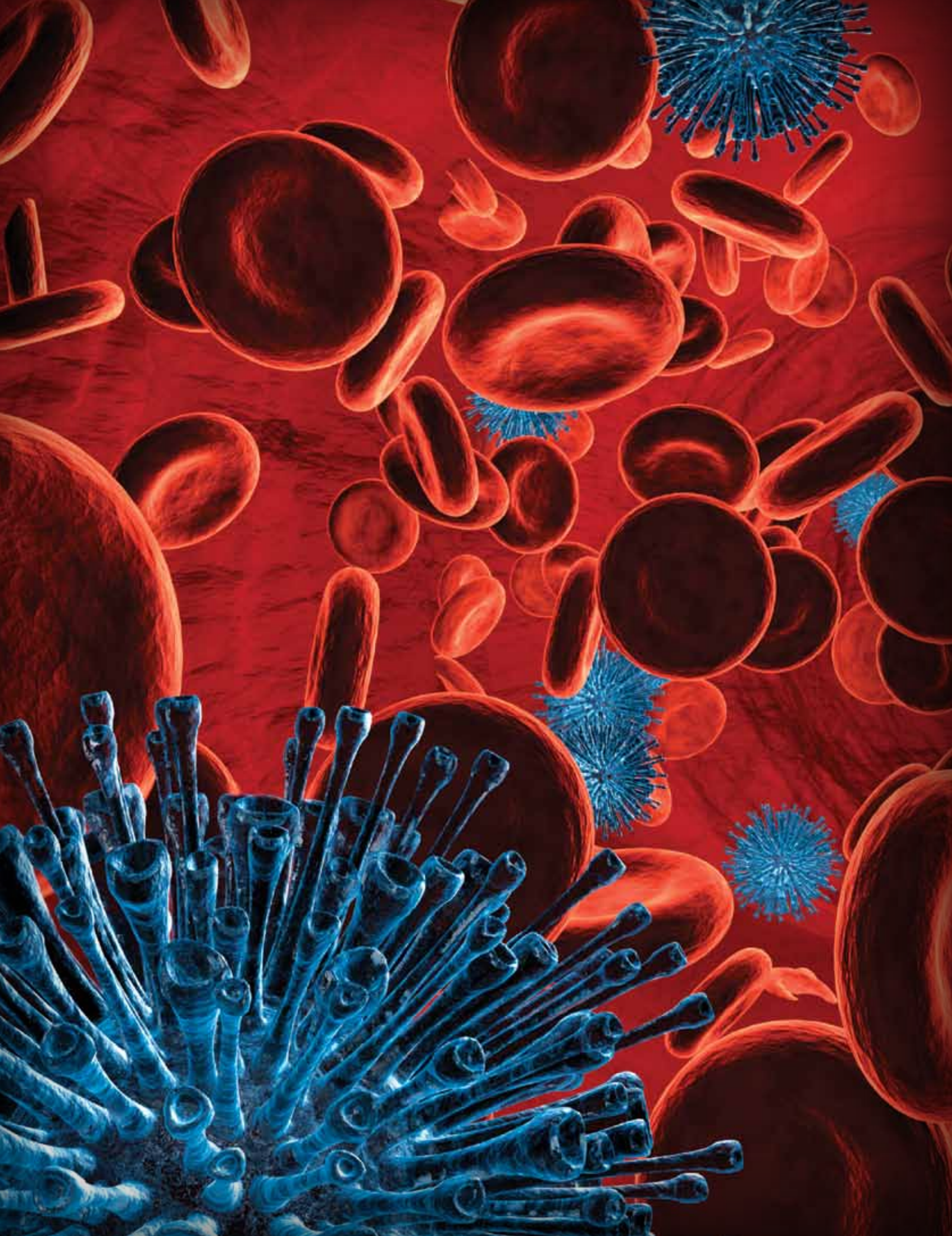


A Crash Course in Microbiology

A Review of Pathogens and Disease

TERI JUNGE, CST, CSFA, FAST

Did you know that a tradesman, dealing in fabrics, was the one who discovered the basis for biology? Antony van Leeuwenhoek (1632-1723) designed microscopes in order to better view the fabrics and cloths he was purchasing. By using these lenses that magnified material as much as 200 times greater, Leeuwenhoek discovered bacteria, free-living and parasitic microscopic protists, sperm cells, blood cells microscopic nematodes and rotifers on everyday items including his teeth, his clothes and on pond water. He created more than 500 microscopes during his lifetime.

Leeuwenhoek's discoveries opened the door for many others to research biology and the characteristics that make up the aspects of microbiology. The following article breaks down the basic microbiology concepts and lets you, the reader, interact as you test your knowledge about pathogens and disease. Use the blank spaces to write your answers down, and then flip the pages to see if you correctly answered the statements. The review section is for the reader's benefit only, and the answers do not need to be submitted. As usual, the normal CE exam follows the article.

Editor's Note: This article is only meant to serve as an introduction to microbiology for surgical technology students and a review for practicing surgical technologists. It is not a comprehensive review.

LEARNING OBJECTIVES

- Explain the organism classification system and describe how organisms are classified.
- Name the main structures of an animal cell and describe the function of each
- Describe the composition, location and function of DNA within a cell
- Explain the function of the three types of RNA within a cell
- List and describe the stages of mitosis
- Define meiosis
- Describe passive and active methods by which substances enter and exit cells
- List five types of microorganisms that cause harm to humans, identify the characteristics of each type of organism and provide at least one example of a disease caused by each organism

Explain the organism classification system and describe how organisms are classified.

List the structures of an animal cell and describe the function of each.

Describe the composition, location, and function of DNA within a cell.

Compare the function of the three types of RNA within a cell.

Name and briefly describe the stages in mitosis.

Briefly explain the process of meiosis.

List and describe the eight active and passive methods by which substances enter and leave cells.

List five types of microorganisms that cause harm to humans, identify the characteristics of each type of organism, and provide at least one example of a disease caused by each organism.

**Pages 62 and 63 are for the reader's benefit only. Please do not submit these pages to AST. The CE exam follows on 69.*

Write the meaning of each word in the space provided.	
Word Element	**Definition**
1. acute	
2. antisepsis	
3. asepsis	
4. chronic	
5. diagnosis	
6. disease	
7. disinfection	
8. epidemic	
9. etiology	
10. helminth	
11. microorganism	
12. nosocomial infection	
13. opportunistic infection	
14. pathogen	
15. pathophysiology	
16. prion	
17. prognosis	
18. sign	
19. spore	
20. sterilization	
21. symptom	
22. syndrome	
23. systemic	
24. therapy	
25. toxin	
26. vector	

ORGANISM CLASSIFICATION

The organism classification system, also called biological classification or scientific classification in biology, is a method for grouping and categorizing organisms by biological type.

- Organism classification system – method by which biologists group and categorize organisms by biological type
- Linnaean system is a hierarchal structure that utilizes the following terms for identification of all organisms (from most general to most specific):
  - Domain
  - Kingdom
  - Phylum
  - Class
  - Order
  - Family
  - Genus
  - Species

STRUCTURE AND FUNCTION OF AN ANIMAL CELL

All living organism are composed of cells that contain information that regulate cell functions and transfers information to the next generation of cells.

The structures and functions of each animal cell

- Cell membrane – outer covering of the cell (aka plasma membrane or plasmalemma)
- Consists of a double phospholipid layer that contains proteins and carbohydrates
  - Phospholipids allow free passage of water molecules through the cell membrane via osmosis.
  - The cell is either hydrophilic (attracts water) or hydrophobic (repels water).
  - Some proteins in the cell membrane allow passage of molecules and ions via transport channels or by active transport while other proteins act as receptor sites and identity markers.
- Protoplasm – liquid portion of the cell
  - Protoplasm that is inside of the cell membrane, but outside of the nucleus is called the cytoplasm.
  - Main constituent of cytoplasm is water that contains chemical compounds (e.g., mineral salts) in solution and organic compounds in colloidal suspension.
  - Cytoplasm also contains organelles, storage granules, fat droplets and vacuoles
- Vacuole – area within the cytoplasm
  - Surrounded by a membrane filled with a watery mixture of nutrients or waste products
- Mitochondria – considered the powerhouse of the cell
  - Composed of two membranes
  - Outer membrane is shaped in a capsular form
  - Inner membrane folds into itself to increase surface area (the folds are called cristae)
  - Aerobic phase of cellular respiration occurs in the mitochondria
- Lysosomes – small structures in the cytoplasm that contain powerful digestive enzymes.
  - Lysosomes perform three important functions:
    - Work with food vacuoles to digest stored food
    - Provide maintenance and repair of other organelles and are the building blocks of protoplasmic structures
    - Destroy old or weakened cells
- Endoplasmic reticulum (ER) – complex system of membranes that make up channels called cisternae that connect the outer nuclear membrane with the cell membrane
  - ER exists in two forms (rough and smooth):
  - All cells have rough ER which has attached ribosomes that synthesize protein
  - Only certain cells have smooth ER which transports fat or synthesizes sex hormones
- Golgi apparatus (also called Golgi body) – collection of flat saclike cisternae that store compounds secreted by the cell and aid in synthesis of necessary substances (eg, carbohydrates)

This photograph shows Legionella sp colonies which were cultured on an agar plate and illuminated using ultraviolet light

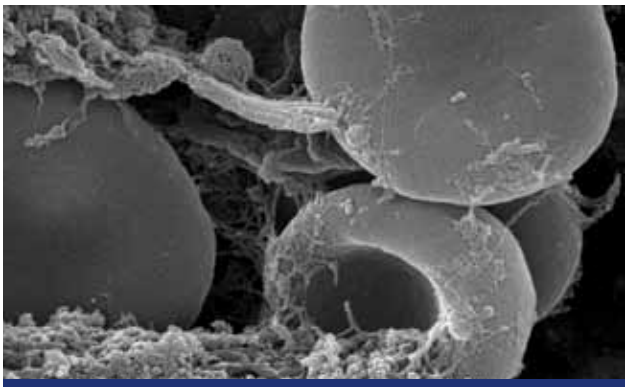
- ▲ Ribosomes – small granules distributed throughout the cytoplasm
  - Attached to the ER
  - Protein synthesis occurs in the ribosomes
- ▲ Centrioles – found in pairs
  - Centrioles form microtubules that assist in cell division
- ▲ Nucleus – control center of the cell
  - Contains the genetic material
  - Nucleus is surrounded by a membrane called the nuclear membrane
  - – Nuclear membrane is a porous double membrane that allows passage of materials (eg: messenger RNA) to the cytoplasm
    - Inner layer of the nuclear membrane surrounds the nucleoplasm, which is the protoplasmic portion of the nucleus
    - Outer layer connects with the endoplasmic reticulum
- ▲ Nucleolus – spherical particle within the nucleoplasm
  - Produces ribosomes
- ▲ Chromatin – contains genetic material within the nucleoplasm
  - Consists of darkly stained threads of nucleic acids
  - Chromatin duplicates, shortens and thickens during cell division and becomes visible as chromosomes

DNA

- ▲ DNA (deoxyribonucleic acid) – composed of two strands (double helix structure) of alternating sugars and phosphates with four protruding nitrogenous bases (adenine, cytosine, guanine and thymine provide the DNA sequence)
  - Secluded from the rest of the cell within the nucleus for protection
  - Contains the genes necessary for cell reproduction
  - – Genes contain all of the hereditary information for the cell and are organized into chromosomes

RNA

- ▲ RNA (ribonucleic acid) – Involved with protein synthesis for all cells and carries genetic information for reproduction of certain viruses
  - Three types of RNA
  - – Ribosomal RNA (rRNA) is involved in translation of the genetic message into a protein and along with that protein makes up the ribosomes which are the site of protein synthesis.



Janice Carr, CDC

This scanning electron micrograph (SEM) depicted a number of red blood cells found enmeshed in a fibrinous matrix on the luminal surface of an indwelling vascular catheter; magnified 11432x

- – Transfer RNA (tRNA) works with other types of RNA to transfer genetic information to proteins and carries an amino acid that may be used to build a protein at the ribosome.
  - – Messenger RNA (mRNA) is built on a strand of DNA and transcribes the nucleotide code. Messenger RNA moves to the cytoplasm and attaches to a ribosome to allow for protein synthesis.

THE PROCESS OF MITOSIS

- ▲ Mitosis – process of cell division in which two duplicate cells are the result
  - Four stage process with a resting/functional phase in between divisions:
  - – Prophase – during prophase the DNA coils and the nucleolus and nuclear membrane begin to disappear. The centrioles move toward opposite ends of the cell and spindle-shaped fibers form in between.
  - – Metaphase – During metaphase the chromosomes line up across the center (equator) of the cell and attach to the spindle fibers.
  - – Anaphase – During anaphase the centromere splits and the duplicated chromosomes separate and move toward opposite ends of the cell.
  - – Telophase – During telophase the membranes appear around each group of separated chromosomes forming two new nuclei completing division of the cell.
  - – The resting/functional phase in between dell divisions is called interphase. During interphase the cell functions normally and prepares for mitosis.

THE PROCESS OF MEIOSIS

- ▲ Meiosis – only applies to formation of the sex cells (sperm and ovum)

• During meiosis the number of chromosomes is cut in half.

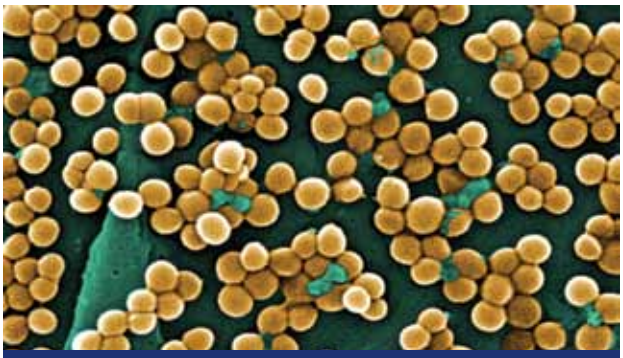
ACTIVE AND PASSIVE TRANSPORT

▲ For cells to function properly, it is necessary for materials such as nutrients and oxygen to be able to enter the cell and the products of cell activity such as hormones, neurotransmitters, digestive enzymes, and waste products to be able to exit the cell. Passive and active transport are the two main methods by which materials enter and exit the cell.

• Passive Transport
– Uses no energy
– Substances move from an area of high concentration to an area of low concentration
– Four types of passive transport
  • Diffusion – substances move through a medium such as air or a permeable membrane
  • Osmosis – special type of diffusion that requires passage of a substance through a semipermeable membrane
  • Filtration – involves passage of a substance through a membrane using force such as pressure or gravity
  • Facilitated diffusion – requires use of a transporter
• Active Transport
– Uses energy in the form of ATP
– Substances move from an area of low concentration to an area of high concentration
• Endocytosis
– Bulk movement of materials into the cell
– Three types:
  • Phagocytosis – large particles are engulfed by the plasma membrane and moved into the cell
  • Receptor-mediated phagocytosis – receptors on the cell surface detect specific molecules and allow rapid movement of the molecule into the cell
  • Pinocytosis fluid droplets are engulfed by the plasma membrane and moved into the cell
• Exocytosis
– Bulk movement of materials out of the cell
– Vesicles are employed as transporters

HARMFUL MICROORGANISMS

▲ Bacteria
• Prokaryotic (lack a true nucleus)



Janice Carr, CDC

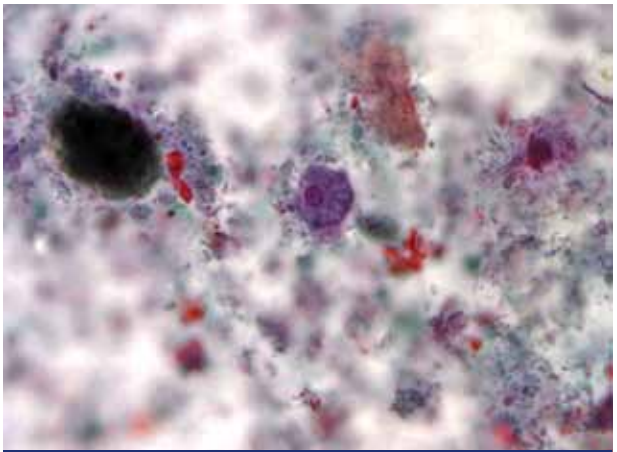
This 2005 scanning electron micrograph (SEM) depicted numerous clumps of methicillin-resistant Staphylococcus aureus bacteria, commonly referred to by the acronym, MRSA; magnified 9560x

• Unicellular organisms
• Usually multiply by cell division
• Some bacteria capable of producing spores
– A resistant form of the bacteria that can tolerate adverse conditions such as extreme heat, cold, humidity, etc.
• Bacteria compose the largest group of pathogens. Antibiotics are effective against bacteria.
• Additional characteristics of Bacteria
– Oxygen requirement
  • Aerobic – requires oxygen to sustain life
  • Anaerobic – capable of living without oxygen
– Motility
  • Motile – capable of spontaneous movement
    – Usually due to the presence of flagella
  • Nonmotile – not capable of movement
– Dependency
  • Free-Living – capable of making their own food; not dependent
  • Commensal – dependent on another organism for food; the relationship is not harmful to either organism
– Sustenance
  • Saprophytic – requires dead or decaying organic matter to sustain life
  • Parasitic – requires live organic matter to sustain life; the relationship is often harmful to the host
– Pathogenicity
  • Pathogenic – capable of producing disease
  – Beneficial – advantageous; such as normal flora
• Classified according to shape.
– Bacilli – straight, slender, rod-shaped bacterial cells that may have tapered ends
– Vibrio – comma shaped rods

– Spirilla – corkscrew shaped rods
– Spirochetes – corkscrew shaped rods that are capable of waving and twisting motions
– Cocci – spherical or round cells that appear in characteristic arrangements.
  • Diplococci – appear in pairs
  • Streptococci – appear in chains
  • Staphylococci – appear in clusters
• Also classified by the way they react to the Gram staining procedure during which the organism is affixed to a slide and stained with blue/purple dye, then a weak iodine solution is added to promote colorfastness and the slide is washed with alcohol.
– If the blue/purple dye remains the organism is called Gram positive.
– If the blue/purple dye is removed the organism is called Gram negative; the gram negative bacteria are then stained with pink/red dye to enhance visibility.

▲ Viruses
• Small microorganisms (smaller than bacteria)
• Cannot replicate unless they are within a living cell (obligate intracellular parasites)
• Most viruses are pathogenic with the exception of bacteriocidal viruses called bacteriophages
• All viruses are capable of mutation
• Viruses are not affected by antibiotics

▲ Fungi
• Eukaryotic (contain a true nucleus)
• Unicellular or filamentous (threadlike in structure)
• Multiply by budding (sexual) or spore formation (asexual)
• Some fungi resemble plants



CDC

This photomicrograph shows a trophozoite of an Entamoeba histolytica (center) using a trichrome stain. During the life cycle of E histolytica, trophozoites multiply by binary fission and produce cysts, which can be passed in the feces causing the spread of Amebiasis.

– Lack roots, stems, leaves, and chlorophyll and grow in irregular masses
• Yeasts, molds and mushrooms are all considered fungi
• Require an external carbon source
• Chemoheterotrophic (use chemicals as their energy source)
• May be saprophytic or parasitic
• Antimycotic (antifungal) drugs are effective against fungi
• Typically opportunistic in humans and are likely to occur in individuals who experience immune deficiency, immunosuppression, corticosteroid use, chemotherapy, antibiotic therapy or suffer from a comorbid condition such as diabetes

▲ Protozoa
• Unicellular, animal-like microorganisms
• Saprophytes
• Amoeba is a type of protozoa
• Protozoan infections are spread by fecal-oral contamination, ingestion of contaminated food or water and vectors such as mosquitoes

▲ Prions (pronounced "pree-ons")
• First identified in 1982 by Stanley Prusiner of the University of California, San Francisco
• Simple proteins
• Much smaller than a virus
• Unique because they lack a genome (all other known infectious agents contain genetic material)
• The term prion represents the term proteinaceous infectious particle.
– Protein particles exist in two forms:
  • Normal, an innocuous (harmless) protein called PrPc can change its shape to a harmful, disease-causing form called PrPSc
  • Abnormal, conversion from PrPc to PrPSc then proceeds via a chain reaction
    – Several PrPSc proteins form long filamentous aggregates that gradually damage neuronal tissue
• All known prion diseases affect the nervous system and are fatal because the immune system does not recognize proteins as foreign and protection does not develop.
– Theories concerning transmission of prion diseases include genetic transmission, spontaneous mutation of the proteinaceous particle, consumption of infected meat (including cannibalism), transplantation/injection of contaminated tissue such as dura mater grafts,

corneal transplants and injection of human growth hormone, and contact with contaminated surgical instruments.

ABOUT THE AUTHOR

Teri Junge has worked in surgery since 1973 and holds the credentials of Certified Surgical Technologist and Certified Surgical First Assistant. Her Associate Degree is in Surgical Technology, her Bachelor of Science degree is in Health Services Administration, and her Master of Arts in Education degree has a Curriculum and Instruction emphasis. In 2007, she was selected as a Fellow of the Association of Surgical Technologists. Ms Junge is currently the Surgical Technology Program Director for the San Joaquin Valley College, Fresno, California, campus.

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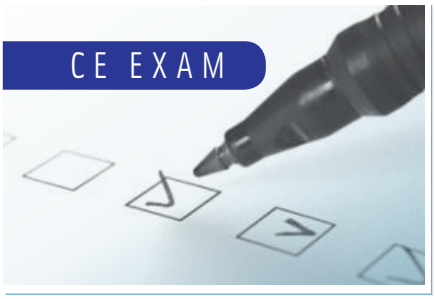

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