Microbiology Review

PATHOGENS AND DISEASE

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Editor's Note: This article presents a brief overview of basic microbiology concepts and serves as an introduction to microbiology for surgical technology students, a review for practicing surgical technologists, and an exam preparation tool for individuals planning to take the national certification exam. It is not a comprehensive review.

ORGANISM CLASSIFICATION

The organism classification system, also called biological classification or scientific classification, is a method for grouping and categorizing organisms by biological type. The current system, developed by Carl Linnaeus, a Swedish botanist/medical doctor in the 1700s, is currently under review; changes in the nomenclature (rules for naming) and taxonomy (practice and science of classification) are likely. The Linnaean system is a hierarchal structure that utilizes the following terms for identification of all organisms.

Domain
Kingdom
Phylum
Class
Order
Family
Genus
Species

Several mnemonics are available to assist the learner in remembering the Linnaean classification system. For example, "**D**o **k**ings **p**lay **c**hess **o**n **f**ine **g**rained **s**and?"

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.
- Outline the infectious process and list the methods by which the human body is protected from infection.
- Understand the immunologic defense mechanism and provide examples of the different types of immunity.

STRUCTURE AND FUNCTION OF AN ANIMAL CELL

All living organisms are composed of cells that contain information that regulate cell functions and transfers information to the next generation of cells. The components of a cell include a nucleus, cytoplasm and plasma membrane.

The cell membrane is the outer covering of the cell. It is also called the plasma membrane or plasmalemma. The cell membrane 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.

The protoplasm is the liquid portion of the cell. The portion of protoplasm that is inside of the cell membrane, but outside of the nucleus is called the cytoplasm. The main constituent of cytoplasm is water that contains chemical compounds (*eg,* mineral salts) in solution and organic compounds in colloidal suspension. The cytoplasm also contains organelles, storage granules, fat droplets and vacuoles.

A vacuole is an area within the cytoplasm that is surrounded by a membrane filled with a watery mixture of nutrients or waste products.

The mitochondria are considered the powerhouses of the cell. They are composed of two membranes. The outer membrane is shaped in a capsular form, and the inner membrane folds into itself to increase surface area. The folds are called cristae. The aerobic phase of cellular respiration occurs in the mitochondria.

Lysosomes are small structures in the cytoplasm that contain powerful digestive enzymes. Lysosomes perform three important functions.

- They work with food vacuoles to digest stored food.
- They provide maintenance and repair of other organelles and are the building blocks of protoplasmic structures.
- They destroy old or weakened cells.

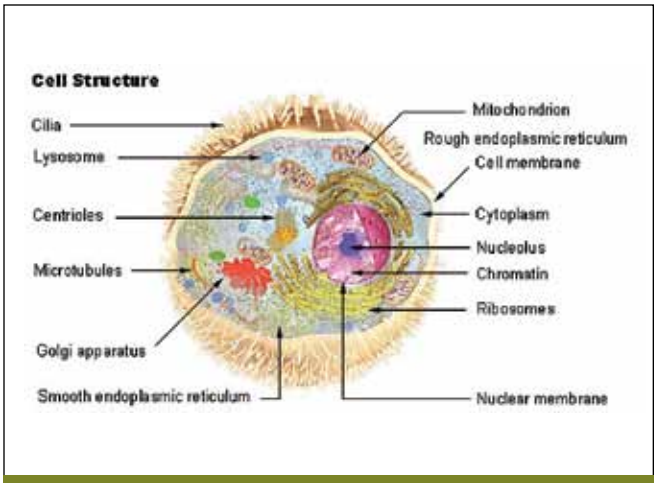
The endoplasmic reticulum (ER) is a complex system of membranes that make up channels called cisternae, which connect the outer nuclear membrane with the cell membrane. ER exists in two forms: rough and smooth. All cells have a rough ER, which has attached ribosomes that synthesize protein. Only certain cells have a smooth ER, which transports fat or synthesizes sex hormones.

The Golgi apparatus, also called Golgi body, is a collection of flat, sac-like cisternae that store compounds secreted by the cell and aid in the synthesis of necessary substances, such as carbohydrates.

Ribosomes are small granules distributed throughout the cytoplasm and are attached to the ER. Protein synthesis occurs in the ribosomes.

Centrioles are found in pairs. The centrioles form microtubules that assist in cell division.

The nucleus is the control center of the cell and contains the genetic material. The nucleus is surrounded by a membrane called the nuclear membrane. The nuclear membrane



Anatomy of an animal cell.

is a porous double membrane that allows passage of materials (*eg,* messenger RNA) to the cytoplasm. The inner layer of the nuclear membrane surrounds the nucleoplasm, which is the protoplasmic portion of the nucleus, and the outer layer connects with the endoplasmic reticulum. The nucleolus is a spherical particle within the nucleoplasm that produces ribosomes.

Chromatin contains the genetic material within the nucleoplasm. Chromatin consists of darkly stained threads of nucleic acids. The chromatin duplicates, shortens, and thickens during cell division and becomes visible as chromosomes.

DNA

DNA (deoxyribonucleic acid) is 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). DNA is secluded from the rest of the cell within the nucleus for protection and 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) is involved with protein synthesis for all cells and carries genetic information for reproduction of certain viruses. There are 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.

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.

MITOSIS

Mitosis is the process of cell division when two duplicate cells result. Mitosis is a four-stage process with a resting/functional phase in between divisions.

Prophase. The DNA coils, 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. The chromosomes line up across the center (equator) of the cell and attach to the spindle fibers.

Anaphase. The centomere splits, and the duplicated chromosomes separate and move toward opposite ends of the cell.

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 cell divisions is called interphase. During interphase, the cell functions normally and prepares for mitosis.

MEIOSIS

Meiosis only applies to the formation of the sex cells (sperm and ovum). During meiosis, the number of chromosomes are cut in half.

PASSIVE AND ACTIVE 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

Passive transport uses no energy, and the substances move from an area of high concentration to an area of low concentration. There are four types of passive transport.

- Diffusion. Substances move through a medium, such as air or a permeable membrane.
- Osmosis. This particular type of diffusion requires passage of a substance through a semi-permeable membrane.
- Filtration. A substance passes through a membrane, using force such as pressure or gravity.
- Facilitated diffusion requires use of a transporter.

Active Transport

Active transport uses energy in the form of adenosine triphosphate (ATP), and the substances move from an area of low concentration to an area of high concentration.

Endocytosis is bulk movement of materials into the cell. Phagocytosis, receptor-mediated phagocytosis, and pinocytosis are examples of endocysotis. During phagocytosis, large particles are engulfed by the plasma membrane and moved into the cell. During receptor-mediated phagocytosis receptors on the cell surface detect specific molecules and allow rapid movement of the molecule into the cell. During pinocytosis, fluid droplets are engulfed by the plasma membrane and moved into the cell.

Exocytosis is bulk movement of materials out of the cell. During exocytosis, vesicles are employed as transporters.

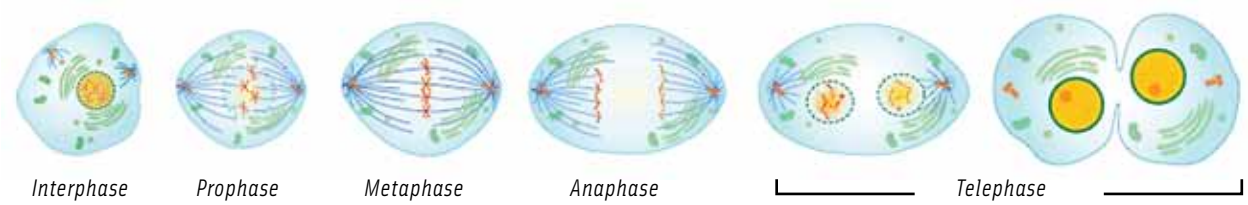


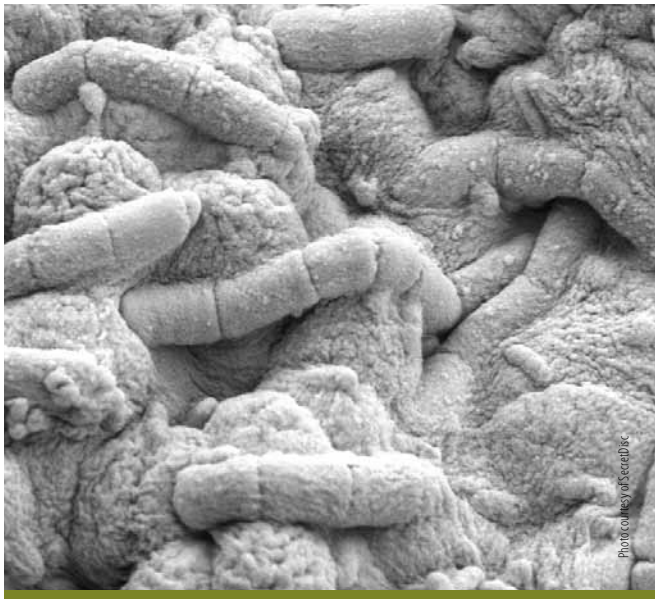
TABLE 1- CHARACTERISTICS OF BACTERIA	
Aerobic – requires oxygen to sustain life	**Anaerobic** – capable of living without oxygen
Motile – capable of spontaneous movement; usually due to the presence of flagella	**Nonmotile** – not capable of movement
Free-Living – capable of making their own food; not dependent	**Commensal** – dependent on another organism for food; the relationship is not harmful to either organism
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
Pathogenic – capable of producing disease	**Beneficial** – advantageous; such as normal flora

TYPES OF MICROORGANISMS THAT CAUSE HARM TO HUMANS

There are five main types of microorganisms that cause harm (disease) in humans. They include bacteria, viruses, fungi, protozoa, and prions.

Bacteria

Bacteria are prokaryotic (lack a true nucleus), unicellular organisms that usually multiply by cell division. Some bacteria are capable of producing spores, which are 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. Table 1 identifies some of the basic characteristics of bacteria in general.



Algae and bacteria in a Scanning Electron Microscope, magnification 5000x

Bacteria are classified according to their shape. Bacilli are straight, slender, rod-shaped bacterial cells that may have tapered ends. Examples of diseases caused by bacilli include tetanus (*clostridium tetani*), tuberculosis (*mycobacterium tuberculosis*), and typhoid (*salmonella typhi*). Vibrio, such as cholera (*vibrio cholera*), are comma-shaped rods. Spirilla, such as *spirillum volutrans,* which is a cause of dysentery, are corkscrew-shaped rods. Spirochetes, such as *treponema pallidum,* which causes syphilis, are corkscrew-shaped rods that are capable of waving and twisting motions.

Cocci are spherical or round cells that appear in characteristic arrangements. Diplococci, such as gonorrhea (*neisseria gonorrhoeae*) and bacterial meningitis (*neisseria meningitides*) appear in pairs. Streptococci, such as strep throat (*Streptococcus pyogenes*), appear in chains. Staphylococci such as staph (staphylococcus aureus) appear in clusters.

Bacteria are also classified by the way they react to the gram-staining procedure, when the organism is affixed to a slide and stained with blue/purple dye; a weak iodine solution is then 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 is then stained with pink/red dye to enhance visibility.

Viruses

Viruses are small microorganisms (smaller than bacteria) that 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

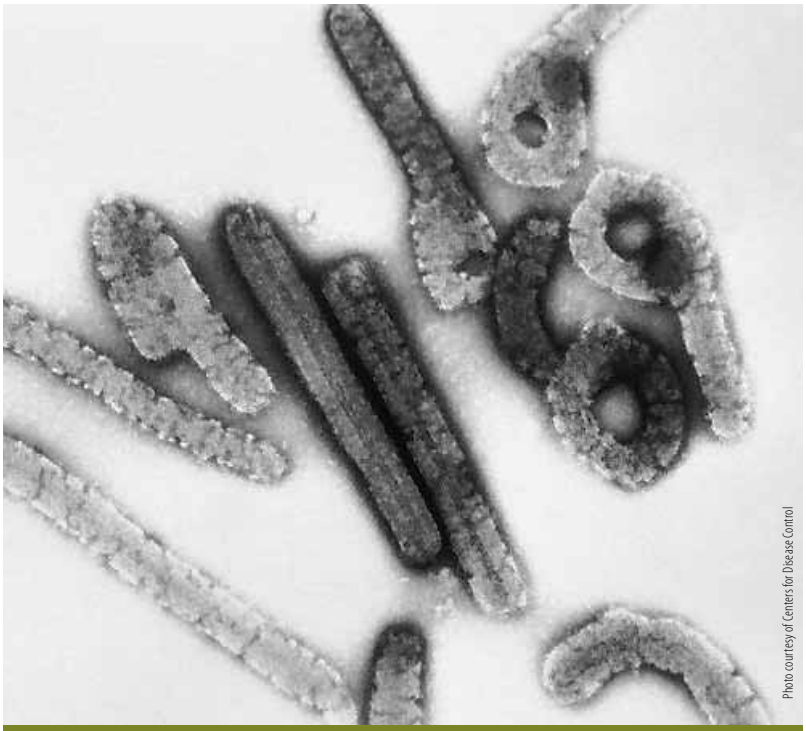


Photo courtesy of Centers for Disease Control

Marburg virus magnified 100,000x

are not affected by antibiotics. Examples of viral pathogens include rhinovirus (common cold), hepatitis viruses A-G, rubella (German measles), rubeolla (measles), varicella (chicken pox), human immunodeficiency virus (the cause of acquired immune deficiency syndrome – AIDS), etc.

Fungi

Fungi are eukaryotic (contain a true nucleus), unicellular or filamentous (threadlike in structure) organisms that multiply by budding (sexual) or spore formation (asexual). Some fungi resemble plants; however, fungi lack roots, stems, leaves, and chlorophyll and grow in irregular masses. Yeasts, molds and mushrooms are all considered fungi. They require an external carbon source and are chemoheterotrophic (use chemicals as their energy source). Fungi may be saprophytic or parasitic. Antimycotic (antifungal) drugs are effective against fungi. Fungi are 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. Pathogens that cause mycoses include aspergillosis (mold that commonly affects the respiratory tract and sinuses), candida albicans (yeast that is normal human mucosal flora that can easily become an opportunistic infection when the patient is undergoing chemotherapy or is on antibiotic therapy), and cryptococcus neoformans (yeast that causes a form of meningitis).

Protozoa

Protozoa are unicellular, animal-like microorganisms that are saprophytes. Amoeba are a type of protozoa. Protozoan infections are spread by fecal-oral contamination, ingestion of contaminated food or water, and vectors such as mosquitoes. Examples of protozoan infections include gastroenteritis (*entamoeba histolytica, giardia lamblia*), malaria (*plasmodium maleriae*), and vaginitis (*trichomonas vaginalis*).

Prions

Prions (pronounced "pree-ons") were first identified in 1982, by Stanley Prusiner of the University of California, San Francisco. Prions are simple proteins that are much smaller than a virus and are unique, because they lack a genome (all other known infectious agents contain genetic material). The word prion represents the term proteinaceous infectious particle. Protein particles exist in two forms. The normal, an innocuous (harmless) protein called PrPc can change its shape to a harmful, disease-causing form called PrPSc. The 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. Prion diseases affect animals (scrapie affects sheep, bovine spongiform encephalopathy or mad cow disease affects cattle, chronic wasting disease affects deer) and humans (Kuru, which has now been eradicated, and Creutzfeldt-Jacob Disease – CJD).

INFECTIOUS PROCESS

Infections that are contagious are called communicable. Communicable diseases are classified in three ways.

- Epidemic – affects many people in the same region at the same time.
- Endemic – continuously affects some people in a particular region.
- Pandemic – prevalent throughout an entire country, continent or the world.

Infections are also classified according to how they are acquired. A nosocomial infection occurs as a result of receiving health care. For example, a surgical site infection would be considered nosocomial. A community-acquired infection, such as the common cold, occurs as a result of being part of society.

A diagnosis is a conclusion related to the nature of the disease. Diagnosis is reached by identifying symptoms (conditions noted subjectively by the patient), signs (conditions noted objectively by the health care provider), and tests, such as laboratory studies and diagnostic imaging that provide factual information concerning the patient. The term prognosis represents a prediction of the probable outcome of the disease (based on the condition of the patient and the expected course of the disease).

Sources of infectious disease (contamination) are the environment (fomites, air and vectors including humans who harbor pathogens in their hair, skin, subungual areas, blood and other body fluids).

Modes or routes of transmission of pathogens include air currents, direct and indirect contact, common vehicle (infection carried in the blood), and vectors.

The infectious process involves several conditions. Every exposure to a pathogen may not result in infection. First, the individual must be exposed to a pathogen, and the pathogen must be able to gain entry to the body. Portals of entry include the skin (intact or traumatized), respiratory tract, digestive tract, urinary tract, and the reproductive system. The dose (number of organisms that invade the body) must be sufficient to produce an infection, and the organism must have the power (virulence) to overcome the defenses of the host and the ability to produce toxins.

Certain individuals may be predisposed to infection because of age, gender, heredity, life situations/habits, occupation, exposure to the elements, preexisting comorbid conditions, and/or psychogenic influences.

IMMUNITY

The human body has several defenses against disease. They are nonspecific and specific immune responses.

Nonspecific Defenses

Nonspecific defenses against disease are effective in reducing the risk of infection from all pathogens. Examples of nonspecific defenses include:

- Skin – Acts as a mechanical barrier (often referred to as the "first line of defense").
- Mucous Membranes – Also act as a mechanical barrier, secretions trap foreign material, cilia move impurities out of the body.
- Body Secretions – Such as tears, sweat, saliva, digestive juices wash away organisms and contain acids, enzymes, or chemicals to destroy invaders.
- Reflexes – Such as coughing and sneezing remove foreign matter.
- Vomiting and Diarrhea – Expel organisms and toxins.
- Phagocytosis – White blood cells, primarily neutrophils and macrophages, take in and destroy waste and foreign material.
- Natural Killer Cells – Type of lymphocyte that recognizes abnormal cells and destroys them.
- Inflammation – The body's protective response to pathogens. The classic local signs of inflammation are pain (dolor), heat (calor), redness (rubor), and swelling (tumor). The classic systemic sign of inflammation is fever.
- Interferon – Proteins produced by lymphocytes that "interfere" with the infectious process by triggering an immune response.

SPECIFIC DEFENSES

Specific defenses are the power of an individual to resist or overcome the effects of a specific pathogen (often referred to as the "final line of defense"). There are several types of specific immunity.

Certain individuals may be predisposed to infection because of age, gender, heredity, life situations/habits, occupation, exposure to the elements, preexisting comorbid conditions, and/or psychogenic influence.

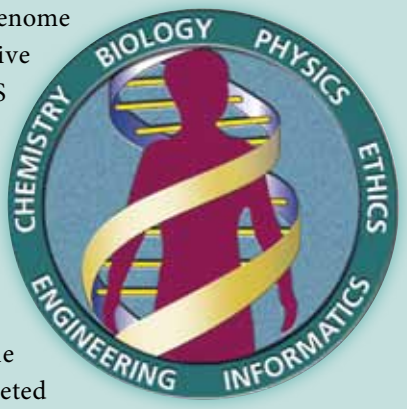
- Inborn Immunity – An individual is born with certain defenses because of their species (Humans don't "usually" get animal diseases, such as distemper, and animals don't get measles); their race (Some racial groups appear to be more immune to certain diseases, such as polio), or their individuality (inherited immunity).
- Acquired Immunity – Certain defenses develop during an individual's lifetime. Acquired immunity may be naturally acquired or artificially acquired.
- Naturally Acquired Immunity – Results from contraction and survival of a specific disease, because the body produces antibodies against the invading agent. Natural immunity may be active or passive.
- Active – The host is directly involved in production of antibodies (usually effective for an extended period of time, possibly lifetime).
- Passive – Antibodies are passed from mother to fetus through the placenta or breast milk (may be effective for up to six months).
- Artificially Acquired Immunity – Results from purposeful exposure to an attenuated (weakened) or biotechnologically engineered (recombinant DNA technology) agent. Artificially acquired immunity may be active or passive.
- Immunization (active) – Vaccination stimulates antibody production.
- Immunization (passive) – Antiserum contains antibodies from other sources. Examples include gamma globulin (given to individuals exposed to HAV, measles, etc. who have not been immunized) RhoGAM (human), antivenin (snakebite sera), and rabies antiserum (to treat victims of bites of rabid animals).

There are a number of public health considerations that are also important in reducing the spread of pathogens. They include:

- Disposal of sewage and garbage
- Water purification
- Prevention of food contamination
- Pasteurization

In the health care setting, policies and procedures are in place to reduce the risk of the spread of infection. Procedures include implementation of standard precautions such as frequent hand washing as well as disinfection and sterilization procedures.

HUMAN GENOME PROJECT (HGP)



In 1990, the US Human Genome Project was a collaborative effort launched by the US Department of Energy and the National Institutes of Health. The original timeframe was projected to span 15 years, but the advances in technology truncated the timeline, and it was completed in 2003. The project proposed lofty goals that included:

- Identification of the estimated 20,000 to 23,000 human DNA genes
- Determining the sequences of the three billion chemical base pairs composing human DNA
- Recording this information in databases
- Sharing related technologies with the private sector
- Discussing the related ethical, legal and social issues

Initially, the researchers studied the genetic composition of many other organisms, some nonhuman, including Escherichia coli, fruit fly and a laboratory mouse.

The importance of genomes

A genome is a term representing all DNA in an organism, including its genes. The genes incorporate all of the information for making all the required proteins. In turn, these proteins determine the appearance of the organism, how the body metabolizes food or combats infection and, in some cases, behavior.

Four chemicals, or bases, compose DNA. Adenine, cytosine, guanine and thymine (A, C, G and T) are repeated by the millions (possibly billions) throughout a genome. The human genome has three billion pairs of bases.

What is crucial is the particular order, or sequencing, of these bases. This order is responsible for the diversity of life. The sequencing determines whether an organism is human or plant, insect or animal. Each specie has its own genomes. Since all living organisms have some DNA similarities, knowledge obtained

from the research into nonhuman genomes, has the future possibility of benefiting human biology.

Understanding the effects of DNA variations among individuals will help science to develop new methods to diagnose, treat and possibly prevent disorders that affect humanity. It is also important for researchers to engage in nonhuman DNA scientific exploration, since understanding many of the characteristics in plants, animals and bacteria can contribute knowledge that may be applied to benefit human health, agriculture, environmental remediation and carbon sequestration.

Specific current and potential applications include

- Molecular medicine
- Energy sources and environmental applications
- Risk assessment
- Bioarcheology, anthropology, evolution and human migration
- DNA forensics
- Livestock breeding

The first printout of the human genome to be presented as a series of books, displayed in the "Medicine Now" room at the Wellcome Collection, London. The 3.4 billion units of DNA code are transcribed into more than a hundred volumes, each a thousand pages long, in type so small as to be barely legible.

The developing technology that resulted from the Human Genome Project is exerting a dramatic influence on biomedical research, and in the future holds the promise of revolutionizing the broad expanse of biological research and clinical medicine. Teams have been able to produce detailed genome maps that have aided medical researchers exploring genes associated with numerous genetic conditions, including myotonic dystrophy, fragile X syndrome, neurofibromatosis types 1 and 2, inherited colon cancer Alzheimer's disease and familial breast cancer.

What looks promising is a new direction for molecular medicine that places less emphasis on treating symptoms and instead stresses exploring the most fundamental causes of the disease. Rapid and more exact diagnostic tests will facilitate earlier treatment in hundreds of conditions. Gene therapy will enable researchers to develop new classes of drugs, immunotherapy techniques, avoidance of environmental conditions that may trigger disease and potentially augmentation or replacement of defective genes.

For energy and environmental applications, it is interesting to note that microbial enzymes have been used to bleach paper pulp, stone wash denim, remove lipstick from glassware, break down starch in brewing and coagulate milk protein for cheese production.

Learning more about human genomes will help individuals exposed to toxic agents since some people are more susceptible to such agents than others. Such knowledge about human variability will aid in predicting the effects of low-level radiation exposure and other substances, particularly in terms of cancer risk.

Knowledge of the human genome aids in the understanding of human evolution and the common biology shared by all life. Comparative genomics between humans and mice has led to similar genes associated with diseases and traits.

DNA forensics has already proven critical in the release of individuals who were wrongly convicted of crimes. It is also crucial in organ donor matching, identifying protected species and determining bacterial contamination in food.

Knowledge of plant and animal genomes will facilitate the development of stronger, more disease-resistant plants and animals. In one application using tobacco, a researcher produced a bacterial enzyme that breaks down explosives such as TNT and dinitroglycerin. These substances would normally require centuries to break down in the soil, and now plants can be grown in the polluted area to remediate the contamination.

Controversies concerning gene research exist and more dialog needs to take place. But the wide-ranging benefits are impressive and hold great promise for the future.

ABOUT THE AUTHOR

Teri Junge, CST, CSFA, FAST, is the current program director of San Joaquin Valley College in Fresno, California. She was one of the original contributing authors to the first edition of the *Surgical Technology for the Surgical Technologist: A Positive Care Approach*; served as a senior editor on the second edition and is currently working on a new surgical technology related book. In addition, she anticipates completing her master's degree in education, curriculum and instruction in fall 2011.

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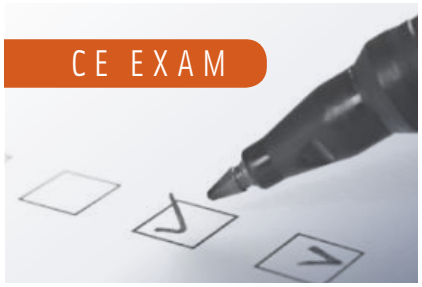

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Microbiology Review: Pathogens and Disease

326 **FEBRUARY 2011** 2 CE credits

1. Biological classification as we currently know it was developed by ___.
a. Charles Darwin
b. Carl Linnaeus
c. The Human Genome Project
d. None of the above

2. The components of a cell do not include ___.
a. Nucleus
b. Plasma membrane
c. Cytoplasm
d. Organisms

3. The liquid portion of the cell is called ___.
a. Cytoplasm
b. Protoplasm
c. Fat droplets
d. Vacuole

4. Cristae occur in the ___ of the cell.
a. Vacuole
b. Storage granules
c. Mitochondria
d. All of the above

5. There are ___ types of RNA.
a. 2
b. 3
c. 4
d. 5

6. In ___, the centromere splits and the duplicated chromosomes separate.
a. Prophase
b. Metaphase
c. Anaphase
d. Telophase

7. The resting/functional phase between cell divisions is called ___.
a. Prophase
b. Metaphase
c. Anaphase
d. None of the above

8. Diffusion, osmosis and filtration are examples of ___.
a. Passive transport
b. Active transport
c. Exocytosis
d. None of the above

9. There are ___ types of microorganisms that can cause disease in humans.
a. 2
b. 3
c. 4
d. 5

10. ___ are susceptible to antibiotics.
a. Viruses
b. Fungi
c. Bacteria
d. All of the above

11. ___ must be within a living cell to replicate.
a. Viruses
b. Fungi
c. Bacteria
d. Protozoa

12. ___ are spread by fecal-oral contamination and vectors, like mosquitos.
a. Viruses
b. Fungi
c. Bacteria
d. Protozoa

13. ___ do not contain genetic material.
a. Fungi
b. Protozoa
c. Prions
d. None of the above

14. Communicable diseases are classified as ___.
a. Epidemic
b. Endemic
c. Pandemic
d. All of the above

15. Skin, body secretions and body reflexes are examples of ___.
a. Nonspecific defenses
b. Specific defenses
c. Immunization
d. Acquired immunity

16. An animal's inability to contract the measles is a result of ___.
a. Naturally acquired immunity
b. Inborn immunity
c. Acquired immunity
d. Antibodies

17. ___ contain acids, enzymes or chemicals to destroy potential invaders.
a. Saliva
b. Tears
c. Sweat
d. All of the above

18. The "first line of defense" in the body's immune system is ___.
a. Reflexes
b. Skin
c. Inborn immunity
d. Acquired immunity

19. A genome represents ___.
a. Linnaean categorization
b. All DNA in an organism
c. The genes of a given organism
d. A social project

20. Potential applications for the Human Genome Project include ___.
a. Molecular medicine
b. DNA forensics
c. Energy sources
d. All of the above

MICROBIOLOGY REVIEW: PATHOGENS AND DISEASE 326 **FEBRUARY 2011** 2 CE credits

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Mark one box next to each number.
Only one correct or best answer can be selected for each question.