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Public Health Journeyman

Volume 1. Mission and Organization/Medical Fundamentals

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Welcome to Volume 1 of career development course (CDC) A4E051, Public Health Journeyman. This course has three volumes.

In this volume you will learn about the USAF Medical Service mission and organization. Unit 1 introduces you to the USAF Medical Service mission and organization along with the Aerospace Medicine Enterprise mission and organization. It also specificially discusses Public Health operations to include the Public Health mission and the federal agencies that provide assistance to public health. The last section of this volume covers program and personnel management to include types of inspections and Air Force manpower requirements.

In unit 2 you will learn medical terminology used within public health. This unit also discusses chemistry and concepts of matter and energy as well as elemental parts and characteristics of the atom. The second section of this unit explains the human cell and cell growth and multiplication. The last section discusses body fluids, tissues, and organs.

Unit 3 introduces you to anatomy and physiology. The musculo-skeletal, circulatory, respiratory, endocrine, nervous and sensory systems are discussed along with the basic principles of immunology.

Unit 4 discusses medical record documentation. This unit explains the medical environment and medical record documentation.

Volume 2 covers the principles of communicable disease to include principles of epidemiology and communicable disease.

Volume 3 is the Food Safety and Facility Sanitation information which discusses food microbiology and chemistry, food procurement and inspections, surveillance inspections and conducting evaluations.

A glossary is included for your use.

Code numbers on figures are for preparing agency identification only.

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This volume is valued at 12 hours and 4 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Page

Unit 1. USAF Medical Service Mission and Organization

THE PUBLIC HEALTH CAREER FIELD is very broad in scope. The information you received during apprentice training is basic to understanding your mission, responsibilities, and specific duties as a public health apprentice. As in all serious undertakings, your reward will be equal to the effort you place in your duties.

1–1. The USAF Medical Service and Aerospace Medical Enterprise

You'll start by taking a look at the United States Air Force Medical Service (AFMS) and learn what the overall mission is and how we in public health help accomplish that mission.

001. USAF Medical Service mission and organization

The mission and organization of the AFMS has evolved over the last several decades into what we are today. Healing sickness and injury has always been primary roles of the healthcare professional; but today's professional studies provide more lifetime healthcare management than ever before. This lifetime approach to healthcare is reflected in the mission and organizational structure of the AFMS.

Mission

The mission of the AFMS is to enable medically fit forces, provide expeditionary medics, and improve the health of all we serve to meet our nation's needs. The AFMS provides seamless health service support to the USAF and combatant commanders and assists in sustaining the performance, health and fitness of every Airman. The AFMS strives to transform deployable medical capabilities for rapid response, build patient-centered care and focus on prevention to optimize health and to invest in education, training and research to sustain our capabilities. The AFMS priorities align with AF priorities. Tactical action plans to accomplish the AFMS mission includes the following:

- Deliver the best medical reliability for the nuclear mission.
- Enhance full spectrum medical capabilities to support winning today's fight.
- Implement patient-centered care to sustain healthy and resilient Airmen/families.
- Advance medical capabilities through research and infrastructure recapitalization.
- Build interoperability and medical acquisition expertise.

Organization

You need to know how your efforts fit into the total effort of your unit and where your unit fits into the big picture. Three command levels you need to be familiar with are covered below.

Surgeon General, USAF

The Surgeon General, USAF, is the head of the AFMS and is the medical staff advisor to the Secretary of the Air Force, Chief of Staff, USAF and Assistant Secretary of Defense.

Major command surgeon

The surgeon at each major command (MAJCOM) is responsible for implementing the Surgeon General's programs and policies. This person responds to and advises his or her MAJCOM commander on medical service matters.

Medical treatment facility commander

The medical treatment facility (MTF) commander (normally the Medical Group [MDG] commander) is responsible for directing all medical programs for a base or wing, and is responsible to the base or wing commander.

Medical Group structure

Medical groups normally consist of four subordinate squadrons: (1) Medical Support, (2) Medical Operations, (3) Aerospace Medicine, and (4) Dental. Smaller medical groups often contain only two subordinate squadrons: Medical Operations and Medical Support. As bases resize, different organizational structures will emerge to meet the base's mission. These new structures may be hybrids of those mentioned earlier.

002. Aerospace Medicine Enterprise mission and organization

The Aerospace Medicine Enterprise (AME) varies from base to base according to factors such as population, geographical location, and mission. There are many areas of concern within the AME. Air Force Instruction (AFI) 48–101, *Aerospace Medicine Enterprise*, gives the areas of professional concern and the functions of each.

Mission

The AME mission is to provide direct support to Air Force operations by promoting and sustaining force health, preventing injury and illness, restoring health, and sustaining human performance. Key mission effects are accomplished at the unit level through effective management of six major Aerospace Medicine programs:

1. Flying, Operations, and Special Duty Program.
2. Occupational and Environmental Health Program.
3. Force Health Readiness Program.
4. Community Health Program.
5. Human Performance Sustainment Program.
6. Emergency Response/Disaster Management Program.

Organization

The AF Surgeon General provides strategic guidance, resources, policies and procedures to execute the AME.

The approved flights in the Aerospace Medicine Squadron include: Aeromedical Staging Flight, Aerospace and Operational Medicine Flight, Aerospace Physiology Flight, Audiology Flight, Bioenvironmental Engineering Flight, Health Promotions Flight, Hyperbaric Medicine Flight, Occupational Medicine Flight, Optometry Flight, Personnel Reliability Program Flight, Public Health Flight, and Trainee Health Flight, Trainee Health Behavior Analysis Flight, Trainee Health Drug Demand Reduction Flight, Trainee Health Surveillance Flight, and Dental Operations Flight (if MDG does not have a dental squadron).

On most bases, the Aerospace Medicine squadron is structured into five core flights: Aerospace and Operational Medicine, Health Promotion, Public Health (PH), Optometry, and Bioenvironmental Engineering.

Roles and responsibilities

The following paragraphs delineate the roles and responsibilities of each Aerospace Medicine Squadron Flight.

Aerospace and Operational Medicine Flight

This flight does the following:

- Provides primary care to flying and special operational duty personnel and their families.
- Determines fitness for flight and special operational duties.
- Acts as Human Systems Integration consultant to the wing and to air operations, space, weapons, and warfare centers.

Key elements in this flight may include: Medical Standards Management, Occupational Medicine, Operational Hyperbaric Medicine, and Optometry.

Health Promotion Flight

This flight does the following:

- Provides programs that encourage healthy lifestyles (e.g., tobacco-free living, healthy weight, nutritional fitness and physical activity).
- Manages health and wellness centers.

Key elements in this flight include: increasing the health of Airmen and the AF community, increasing workforce productivity, and increasing community resiliency.

Public Health Flight

This flight does the following:

- Recommends and implements programs to prevent disease, disability, morbidity, and death through effective use of population-based PH programs.
- Conducts epidemiological surveillance and analysis of communicable, environmental, and occupational morbidity and mortality to establish and prioritize strategies for prevention and intervention.
- Provides programs for both individuals and groups to clearly communicate risks and hazards in the workplace/environment and best practices to safeguard health.

Key elements in this flight include: Community Health and Force Health Management, Occupational Health and Education, Epidemiological Surveillance, Communicable Disease Control, Health Risk Assessment and Communication, Food Safety and Food Facility Sanitation. PH also manages the Aeromedical Services Information Management System (ASIMS) program.

Optometry Flight

This flight does the following:

- Examines, diagnoses, treats and manages diseases and disorders of the visual system.
- Provides primary eye care and refractive services to flying and non-flying military personnel.
- Manages the spectacle/gas mask insert, contact lens, and warfighter aviation corneal refractive surgery programs.

Bioenvironmental Engineering Flight

This flight does the following:

- Provides operational health risk assessment expertise to enhance commander decision making and health service support capabilities
- Evaluates occupational workplaces through routine and special surveillance to ensure hazards are identified, assessed and controlled through engineering controls, administrative controls or personnel protective equipment.
- Identifies, evaluates, and recommends controls for chemical, biological, radiological, nuclear and physical occupational and environmental health threats.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

001. USAF Medical Service mission and organization

1. What are the three medical command levels you should be familiar with?

2. What are the responsibilities of the MTF commander? To whom is the MTF commander responsible?

3. Medical groups normally consist of what four subordinate squadrons?

002. Aerospace Medicine Enterprise mission and organization

1. Name the five most common flights of the aerospace medicine squadron.

2. Which flight provides primary care to flying and special operational duty personnel and their families?

3. Which flight identifies, evaluates, and recommends controls for chemical, biological, radiological, nuclear and physical occupational and environmental health threats?

1–2. Public Health Operations

Now that you have looked at the mission of the AME and studied all of the functional areas, take a closer look at PH and see how it fits into the big picture.

003. Public Health mission and organization

In general terms, PH does just what the name implies whether Active Duty, Guard, or Reserve. In the Air National Guard we have the opportunity to help communities in need and support our nation’s

homeland defense efforts both locally and abroad. Operating in various locations around the world, the Air Force Reserve has evolved from a “stand by” force for emergencies into a MAJCOM of the Active Duty Air Force.

In PH, our mission statement is preventing disease, disability, and premature death. We are most concerned about the health of the population at large. By identification and statistical tracking of specific situations, and prevention measures, we can often provide sound council to individuals, leadership, and the populace in applicable health management.

These objectives are accomplished by performing tasks in the areas of preventive medicine, communicable disease control, epidemiology, medical entomology, occupational health, food safety, PH readiness, and force health management.

Public health organization

Public health is organized into two functional areas; Community Health Management and Force Health Management.

Community Health Management

This function encompasses the preventive medicine, communicable disease, epidemiology, medical entomology, food safety, and public health deployed/disaster relief programs.

Preventive medicine program

This program evaluates hygiene practices and the usability of equipment in base facilities according to AFI 48–105, *Surveillance, Prevention, and Control of Diseases and Conditions of Public Health or Military Significance*, AFI 48–117, *Public Facility Sanitation*, AFI 34–248, *Child Development Centers*, and AFI 34–276, *Family Child Care Programs*. We report findings and recommend corrective action through the MTF commander to the responsible agencies. The program also offers support to all base preventive medicine programs.

Communicable disease control

General procedures for controlling communicable diseases are contained in AFI 48–105, and in the *Control of Communicable Diseases Manual*, an official report of the American Public Health Association.

Methods of communicable disease control include immunizations and testing for various communicable diseases. Immunization and testing procedures are generally performed by the medical unit’s immunization element or laboratory. However, PH closely monitors tuberculosis skin testing to be sure the procedures in AFI 48–105, are understood and followed. PH encourages consultation when there is doubt about the medical or administrative disposition of a case and ensures revisions and special requirements in the testing program are received and acted upon.

Epidemiology

Epidemiology is the study of how disease and injury occur in a population. Epidemiology evaluates the distribution and dynamics of health and disease. This information helps us understand the causes of disease and injury and how best to prevent them. The epidemiologic functions performed by PH include maintaining biostatistics relating to disease and injury incidence, prevalence, morbidity, mortality, and military noneffectiveness. Significant epidemiological trends are reported to all health care providers through the Chief, Aeromedical Services.

Medical entomology

There are two areas in medical entomology that PH is concerned with— pest/vector biology and surveillance.

PH determines the identity, source, and prevalence of pests affecting AF health and efficiency. We advise commanders on the incidence of disease vectors, control measures, and health education requirements and also selecting recreation sites when disease vectors are of concern.

Food safety

The public health officer monitors the medical aspects of the food safety program. The program includes the following:

Food Safety Program	
Responsibility	**Explanation**
Food inspection	Inspects food to determine wholesomeness, condition, and quality. We advise the accountable officer of proper action to dispose of contaminated, deteriorated, or otherwise nonconforming food items.
Food sanitation	Evaluates establishments and facilities where food is produced, prepared, stored, or otherwise handled. Corrective actions are recommended when unsanitary practices or improper methods are found in accordance with the Food and Drug Administration (FDA) Food Code, or AFI 48–116, *Food Safety Program*.

Deployed/disaster relief

Public health supports deployable forces through reduction of disease and injuries (DI). We reduce DI through sound application of PH principles. The Disease Surveillance Program helps us to monitor the results of our efforts and also helps us pinpoint areas for future public health attention. The Disease Surveillance Program tracks the health of deployed troops prior, during, and after they return from a deployment. Other methods to reduce DI are medical intelligence briefings, field hygiene and sanitation program, field food and water safety, and field occupational health programs. AFI 41–106, *Medical Readiness Program Management*, provides guidance for public health plans and responsibilities of the medical intelligence officer.

Force Health Management and Occupational Health programs

Force health management duties include providing administrative oversight of ASIMS. ASIMS has three separate access levels: (1) medical staff members who provide direct patient care, (2) designated unit points of contact (POC), and (3) AF members who can access their own individual medical readiness (IMR) status. Medical staff has the ability to view specific information regarding the health and worldwide qualified status for Active Duty members. Primary care managers are able to review specific information on the health of their enrolled Active Duty members. As a unit POC, commanders, unit health monitors, and appointed personnel are provided with real-time information on the medical readiness status of their forces. Lastly, AF members have the ability to access their own IMR information so that they may complete medical readiness requirements in a timely manner before becoming due or overdue.

The Air Force meets its obligation to promote good employee health through the occupational health program, which is consistent with the Occupational Safety and Health Act of 1970 (29 U.S.C 668(a)). Medical services provided to federal civilian employees are authorized by Public Law 70–568 (5 U.S.C 7901). All occupational health medical examinations must be conducted in accordance with AFI 48–145, *Occupational and Environmental Health Program*, and DOD 6055.05-M, *Occupational Medical Examinations and Surveillance Manual*. PH provides epidemiologic surveillance in the occupational setting, provides risk communication consultation as needed, and ensures the administrative aspects of the program are conducted correctly and efficiently.

PH also provides supervisor and worker education, fits some personal protective equipment, and performs shop visits. Force Health duties also include conducting a preventive health assessment (PHA). A PHA is an annual process which requires a review of preventive health and individual medical requirements for all Air Force Active Duty members. Along with conducting PHAs, Force

Health may be tasked to help review medical records for mass deployments. Managing pre- and post-deployment checklists, and conducting medical intelligence briefings, are all responsibilities of PH technicians.

004. Federal agencies that provide assistance to public health

As a public health journeyman you are trained to handle any problem that may arise, however, you may need some assistance from agencies outside of the Air Force in order to do your job.

Federal public health agencies

The federal government sets health standards for most aspects of our lives. It also surveys and makes recommendations on the general public health, its status, and areas needing improvement. Various agencies are assigned these tasks. You'll learn some of those agencies you'll come into contact with as a member of public health.

United States Department of Health and Human Services

The United States Departement of Health and Human Services (USDHHS) is comprised of several operating divisions concerned with public health. These are shown in the following table:

The United States Departement of Health and Human Services	
Agency	**Explanation**
Food and Drug Administration (FDA)	Is a major operating division of the USDHHS. The FDA is a scientific regulatory agency responsible for the safety of the nation's domestically produced and imported foods, cosmetics, drugs, biologics, medical devices, and radiological products.
US Public Health Service (USPHS)	Is also part of the USDHHS. Their mission is to protect, promote, and advance the health and safety of our nation. They achieve their mission by rapid and effective response to public health needs, leadership and excellence in public health practices and advancement of public health science.
Centers for Disease Control and Prevention (CDC)	Is another major operating division of the USDHHS, it is the primary Federal agency for conducting and supporting public health activities in the United States. Their main focus is increasing support to local and state health departments, improving global health, decreasing leading causes of death, strengthening surveillance and epidemiology, and reforming health policies.

Federal food inspection agencies

The food inspection program provided by public health involves a great deal of interaction between local, state, and federal inspection agencies and your food inspection office. Many of the publications used to inspect foods on military installations are written and used by these agencies in civilian inspection programs.

Food Inspection Program	
Agency	**Explanation**
US Department Of Agriculture (USDA)	The Food Safety and Inspection Service (FSIS) is the public health agency in the USDA responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products are safe, wholesome, and correctly labeled and packaged.
US Department of Commerce (USDC)	Through the National Oceanic and Atmospheric Administration (NOAA) Seafood Inspection Program, provides inspection services for fish, shellfish, and fishery products to the industry. The program offers a variety of professional inspection services on a fee-for-service basis which assures compliance with all applicable food regulations. The program also offers product quality evaluation, grading and certification services.

Federal occupational safety and health agencies

Again, public health interacts in many areas with occupational safety and health agencies for guidance, regulatory clarification, assistance, and training. The following table discusses the three most commonly used agencies.are the (OSHA), the (NIOSH) and (EPA).

Federal Occupational Safety and Health Agencies	
Agency	**Explanation**
Occupational Safety and Health Administration (OSHA)	Is an agency within the US Department of Labor. This agency, or administration, provides the regulations, guidance, and enforcement necessary to meet the requirements of the Occupational Safety and Health Act of 1970. The act affords the opportunity for every man and woman in the United States to expect a safe and healthful workplace. Training workers to be more aware of job safety and health hazards helps reduce the incidence of occupational injury and disease. As a public health journeyman, you'll be involved in this kind of training. OSHA standards are used to evaluate AF workplaces and train AF civilian and military workers.
National Institute for Occupational Safety and Health *(*NIOSH)	Is part of the CDC, a subagency of the USDHHS. NIOSH produces new scientific knowledge and provides practical solutions vital to reducing risks of injury and death. NIOSH standards are used by the Air Force when evaluating working environments at base-level industrial sites.
Environmental Protection Agency *(*EPA)	Is responsible for designing and enforcing programs that guarantee the continued safety and purity of our environment. The air and water, and the active prevention of their pollution are the domain of the EPA. Regulations written by the EPA are used by the Air Force to protect the base environment.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

003. Public Health mission and organization

1. What is the study of how disease and injury occur in a population?

2. To whom are significant epidemiological trends reported?

3. What are the two areas PH is concerned with in the medical entomology program?

4. What two areas is PH responsible for under food safety?

5. What duties does PH provide under the Occupational Health Program?

004. Federal agencies that provide assistance to public health

1. The FDA falls under what agency?

2. Which agencies main focus is on increasing support to local and state health departments, improving global health, and decreasing leading causes of death?

3. What are the responsibilities of the USDA?

4. What does the Air Force use to evaluate working environments at base-level industrial sites?

1–3. Program and Personnel Management

The purpose of the Air Force Inspection System (AFIS) is threefold; (1) to enable and strengthen commanders' effectiveness and efficiency, (2) to motivate and promote military discipline, improve unit performance, and improve managerial excellence up and down the chain of command, in units and staffs, and (3) to identify issues interfering with effectiveness, efficiency, compliance, discipline, readiness, performance, surety and management.

The AFIS is focused on assessing and reporting on a unit's readiness, economy, efficiency, effectiveness and state of discipline to execute assigned missions. The AFIS gives the Secretary of the Air Force (SECAF), the Chief of Staff of the Air Force (CSAF) and commanders, at all levels, an independent assessment of a unit's compliance with established directives.

The Air Force Inspection Agency (AFIA) provides independent inspection, evaluation, and analysis to advance the continuous improvement of mission effectiveness at all AF levels. Its mission set includes: nuclear surety inspections (NSI), NSI oversight, management inspections (MI), and unit effectiveness inspections (UEI). Additionally, when directed, the AFIA evaluates and reports on high-impact, high-visibility programs that are of significant interest to SECAF, CSAF, or Secretary of the Air Force/Inspector General (SAF/IG). The AFIA provides medical inspectors to support UEIs AF-wide.

Within the Air Force inspection system are internal and external inspections. An *internal inspection* is defined as any inspection conducted by a Wing on a subordinate agency. Internal inspections allow commanders to control the depth, scope and frequency of inspections. Commanders conduct internal inspections and actively support and participate in external inspections affecting their unit(s). An *external inspection* is defined as any inspection conducted by authorities outside the inspected unit. External inspections can serve two purposes: (1) to provide an independent accountability of readiness, economy, efficiency and state of discipline and (2) to validate and verify the internal inspection process.

005. Types of inspections

As a public health technician it is important that you become familiar with the three major inspections that are provided through the AFIS and the different major graded areas (MGA) of each inspection. MGAs represent key processes, procedures, and requirements based on either public law, executive

orders, directives and/or instructions. There are three main inspections: management, unit effectiveness, and commander's inspection program. These inspections are rated on the following five-tier scale: outstanding, highly effective, effective, marginally effective, and ineffective.

Management inspection

The management inspection is an external inspection. The MI is conducted above the Wing level; for example this inspection is performed at Headquarters Air Force (HAF), MAJCOM, Numbered Air Force (NAF), and select field operating agencies (FOA)/direct reporting units (DRU). It inspects the management functions of different organizations, assessing the efficiency, effectiveness, economy, and discipline of the organization, activities, or programs within that organization. They are rated using the five-tier scale with overall management performance or operations in mind. The major graded areas of the MI are: strategic planning, organizational management, customers, process operations, resources, data-driven decisions, and organizational performance.

Unit effectiveness inspection

This inspection is an external inspection. The UEI is conducted by MAJCOM /IG, AFIA and Air Force Intelligence, Surveillance, and Reconnaissance Agency (AFISRA) on Wings. The UEI validates and verifies a Wing's Commander's Inspection Program (CCIP) for accuracy, adequacy and relevance. It provides an independent assessment of the Wing's resource management, leadership, process improvement efforts and ability to execute the mission. The UEI is a year-long continual evaluation of performance throughout the inspection period. It integrates elements of compliance and readiness. It is intended to help the Wing commander understand the areas of greatest risk. The MGAs that are inspected during a UEI are: managing resources, leading people, improving the unit, and executing the mission.

The inspection period begins immediately after the close-out of the previous UEI report. The inspection frequency for a UEI is 24–30 month cycle for each active duty and reserve Wing, and 48–60 month cycle for Air National Guard (ANG) Wings. All elements of the UEI will be completed within this timeframe. The elements of a UEI are: continual evaluation, UEI survey, on-site capstone visit, UEI reports, and UEI augmentee support to MAJCOM/IG.

The Commander's Inspection Program

This inspection is an internal inspection. The CCIP is mandatory for Wings and inspects Wing-wide and subordinate unit effectiveness, as well as assessing cross-unit programs as directed by the Wing commander. Commanders determine the appropriate scope, scale, timing and methodology to most effectively accomplish the objectives of the CCIP. The CCIP is executed by the Wing IG with support from subject matter experts (SME) on the Wing Inspection Team (WIT). The MGAs that are inspected during a CCIP are: managing resources, leading people, improving the unit, and executing the mission.

Air Force nuclear inspection programs

Nuclear weapon systems require special consideration because of their political and military importance, their destructive power, and the potential consequences of a nuclear weapon incident. There are many different types of nuclear inspections, the most common one being the *nuclear surety inspection* (NSI). The NSI assesses a unit's ability to accomplish its assigned nuclear weapons mission and produce reliable nuclear weapons in a safe and secure environment in compliance with applicable directives. The type of nuclear inspection determines how they are rated.

Authorized inspections

There are other inspections that are authorized besides the ones listed above. Some of these are completed *independent from* the MI, UEI, and CCIP. However, others are completed *in conjunction with* the MI, UEI, and CCIP. One that is completed for MDGs is the Accreditation Association for Ambulatory Health Care (AAAHC). This inspection is done if you have AAAHC accreditation which

means that your organization (Medical Group) participates in on-going self-evaluation, peer review, and education to continuously improve its care and services. The organization also commits to a thorough, on-site survey by AAAHC surveyors, who are healthcare professionals, at least every three years.

Self-inspections

Public Health consists of a wide variety of duties and responsibilities. A self-inspection is a means by which you can evaluate your work to see if you are performing to established standards. Your office has checklists to use to conduct an inspection for each area of responsibility within Public Health.

Self-inspections are done to determine if you are preforming to standards, but more importantly, to ensure you are meeting the needs of your customer. If deficiencies are noted, don't just ignore them. Plan and implement corrective measures to correct the problem. Once changes are made, it is equally as important to monitor your corrective measures to ensure they are working within standards. Self-inspections are done on a continual basis.

More information on the AFIS can be obtained in AFI 90–201, *The Air Force Inspection System*, or on the Air Force Inspection Agency Website at http://www.afia.af.mil/index.asp.

006. Air Force manpower requirements

Military positions needed to accomplish Air Force missions are identified by grade and skill using manpower requirements determination processes. A manpower requirement is the manpower needed to accomplish a job, workload, mission, project or program. There are three types of manpower used by the Air Force to perform required work: military personnel (Active Duty, Reserve, individual mobilization augmentees [IMA], and National Guard), in-service civilian employees, and contracted services.

The Air Force considers manpower a resource to support approved programs. It is a limited resource which is sized to reflect the minimum essential level to accomplish the required workload. The Air Force documents all funded and unfunded military manpower requirements in the Manpower Programming and Execution System (MPES). MPES delivers a detailed account of Air Force position data to personnel systems and other Air Force/DOD manpower and readiness data systems. It accurately accounts for every position to ensure the right person can be delivered to the right place at the right time and that manpower services and systems are available to meet these needs.

There are two important documents used when determining manpower requirements: the unit manning document (UMD) and the unit personnel management roster (UPMR). The UMD is a computer-generated document that details manpower listings reflecting the distribution of manpower allocations into a limited structure of authorizations. It includes information such as the number of positions authorized, grade/rank, occupational series, AF specialty code (AFSC), and security access requirements. The UPMR describes personnel assigned to a unit and is commonly referred to as the *alpha roster*. It contains Privacy Act Information and is used by the AF Personnel Center (AFPC) to make permanent change of station (PCS) decisions.

As a PH technician you should understand that organizations are authorized positions based on mission requirements and workload. For more information on Public Health manpower requirements, work with your Public Health Flight noncommissioned officer in charge (NCOIC). Questions regarding manpower requirements should be addressed to your local Resource Management Office or Manpower Office.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

005. Types of inspections

1. What is the difference between an internal and external inspection?

2. What are the categories of the five-tier rating system used on MIs, UEIs, and CCIPs?

3. Which type of inspection is an external inspection that validates and verifies a Wing's CCIP for accuracy, adequacy and relevance?

4. Which type of inspection is a means by which you can evaluate your work to see if you are performing to establish standards?

006. Air Force manpower requirements

1. Which computer generated document details manpower listing reflecting the distribution of manpower allocations into a limited structure of authorizations?

2. Which document describes personnel assigned to a unit and is commonly referred to as the alpha roster?

Answers to Self-Test Questions

001

1. Surgeon General, USAF; MAJCOM surgeon; and MTF commander.
2. For directing all medical programs on a base or wing; to the base or Wing commander.
3. Medical Support, Medical Operations, Aerospace Medicine, and Dental.

002

1. Aerospace and Operational Medicine, Health Promotion, Public Health, Optometry, and Bioenvironmental Engineering.
2. Aerospace and Operational Medicine Flight.
3. Bioenvironmental Engineering Flight.

003

1. Epidemiology.
2. To all health care providers through the Chief, Aeromedical Services.
3. Pest/vector biology and surveillance.
4. Food inspection and food sanitation.
5. Provides epidemiologic surveillance in the occupational setting, provides risk communication consultation as needed, ensures the administrative aspects of the program are conducted correctly and efficiently, provides supervisor and worker education, fits personal protective equipment, and performs shop visits.

004

1. USDHHS.
2. CDC.
3. Ensuring the nation's commercial supply of meat, poultry, and egg products are safe, wholesome, and correctly labeled and packaged.
4. NIOSH standards.

005

1. An internal inspection is any inspection conducted by a Wing on a subordinate agency. An external inspection is any inspection conducted by authorities outside the inspected unit.
2. Outstanding, highly effective, effective, marginally effective, and ineffective.
3. UEI.
4. Self-inspection.

006

1. UMD.
2. UPMR.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to Air Force Career Development Academy (AFCDA).

1. (001) The medical treatment facility (MTF) commander is responsible for
   a. directing the USAF Medical Service.
   b. directing all medical programs for a base or wing.
   c. implementing MAJCOM medical policies throughout a MAJCOM.
   d. advising the MAJCOM commander on medical matters.

2. (002) Approved flights within the Aerospace Medicine Squadron include Aerospace and Operational Medicine, Public Health, Bioenvironmental Engineering,
   a. Health Promotion, Readiness, and Aeromedical Staging.
   b. Health Promotion, and Physiological Training.
   c. Health Promotion, and Optometry.
   d. and Readiness.

3. (002) Which flight within an aerospace medicine squadron manages health and wellness centers?
   a. Public Health Flight.
   b. Health Promotion Flight.
   c. Flight/Missile Medicine Flight.
   d. Bioenvironmental Engineering Flight.

4. (002) Which Aerospace Medicine Flight is responsible for identifying, evaluating, and recommending controls for chemical, biological, radiological, nuclear, and physical occupational and environmental threats?
   a. Aerospace and Operational Medicine Flight.
   b. Bioenvironmental Engineering Flight.
   c. Health Promotions Flight.
   d. Public Health Flight.

5. (003) What are the two functional areas of Public Health?
   a. Force Health Management and Epidemiology.
   b. Community Health Management and Epidemiology.
   c. Force Health Management and Occupational Health.
   d. Community Health Management and Force Health Management.

6. (003) The study of how disease and injury occur in a population is known as
   a. entomology.
   b. epidemiology.
   c. microbiology.
   d. parisitology.

7. (003) Who monitors the medical aspects of the food safety program?
   a. Medical group commander.
   b. Base commander/wing commander.
   c. Public health officer (PHO).
   d. Food facility managers.

8. (003) Who is responsible for providing worker education, fitting personal protection equipment such as ear plugs and ensuring the proper administration of the AF Occupational Health Program?
   a. Public Health.
   b. Local public health service.
   c. Center for Disease Control and Prevention (CDC).
   d. National Institute for Occupational Safety and Health (NIOSH).

9. (004) Which agency is responsible for the safety of the nation's domestically produced and imported foods?
   a. Public Health Service.
   b. Department of Commerce.
   c. Department of Food Purity.
   d. Food and Drug Administration.

10. (004) Public health uses Occupational Safety and Health Administration (OSHA) standards to
   a. ensure a safe and healthful workplace for every man and woman in the United States.
   b. evaluate Air Force workplaces and to train Air Force civilian and military workers.
   c. monitor the incidence of occupational injuries and illnesses.
   d. reduce the incidence of occupational injuries and illnesses.

11. (005) Which inspection provides an independent assessment of the Wing's resource management, leadership, process improvement efforts and ability to execute the mission?
   a. Management Inspection (MI).
   b. Nuclear Surety Inspection (NSI).
   c. Unit Effectiveness Inspection (UEI).
   d. Commander's Inspection Program (CCIP).

12. (006) Which manning document contains positions authorized, grade/rank, occupational series, Air Force Specialty Code, and security access requirements?
   a. Unit Personnel Management Roster (UPMR).
   b. Unit Manning Document (UMD).
   c. Alpha roster.
   d. Recall roster.

Please read the unit menu for unit 2 and continue ➔

Student Notes

Unit 2. Medical Terminology

CHEMISTRY IS AN IMPORTANT PART OF YOUR LIFE. One way or another, chemistry permeates every aspect of Public Health. The use of chemical compounds to eradicate disease carrying pests on farm fields, the mixing of chlorine chemistry to combat waterborne bacteria and viruses, and the use of vaccines to eradicate once crippling diseases, all involve some form of chemistry.

2–1. Chemistry

What comes to mind upon hearing the word *chemical*? Chemicals are not limited to laboratory environments. Chemicals are everywhere. The human body is a collection of chemicals, the most abundant of which is water. Chemical reactions underlie all body processes: movement, digestion, pumping of the heart, and even your thoughts. Therefore, we can say that when we study chemistry, we also are studying life. This section presents the basics of chemistry, providing the background you will need to understand body functions.

007. Concepts of matter and energy

Matter is any substance that occupies space and has mass (weight). It is the “stuff” of the universe. Chemistry studies the nature of matter and how its building blocks are put together and how they intereact.

Matter

Matter has three basic forms: solid, liquid and gas. Examples of each state are found in the human body. The state depends on the temperature, atmospheric pressure, and specific characteristics of the particular type of matter.

1. A *solid*, like bones and teeth, has a definite shape and volume. When heat is applied to a solid it will become a liquid.
2. A *liquid* has definite volume but lacks shape. A liquid will take the shape of its container. Examples of body liquids are blood plasma and the interstitial fluid that bathes all body cells. When enough heat is applied to a liquid, it becomes a gas.
3. A *gas* lacks both volume and shape. The air we breathe is composed of a mixture of gases. Some matter can actually exist in all three states whereas other matter will break down into new substances when an attempt is made to change its physical state.

Characteristics of Matter	
Solid	1. Lack of expansion. 2. Definite shape. 3. Constant volume. 4. Rigid and difficult to compress. 5. High density. 6. Severly limited mixability.
Liquid	1. Limited expansion. 2. Lack of characteristics shape. 3. Maintenance of volume. 4. Slightly compressible. 5. High density. 6. Diffusion in other liquids.
Gas	1. Infinite and uniform expansion. 2. Indefinite shape or volume. 3. Easily compressible. 4. Low density. 5. Complete and rapid mixing in other gases.

Scientists like to classify things. One way that scientists classify matter is by its composition. Ultimately, all matter can be classified as compounds, elements, and mixtures.

1. A *compound* is any pure substance that can be broken down by chemical means into two or more different simpler substances.
2. An *element* is a simplest form of pure substance. They cannot be broken into anything else by physical or chemical means.
3. *Mixtures* are two or more substances that are not chemically combined with each other and can be separated by physical means. The substances in a mixture retain their individual properties. For example, soluntions which are a special kind of mixture where one substance dissolves in another.

Energy

In contrast to matter, energy is massless and does not take up space. It can only be measured by its effects on matter. Energy is commonly defined as the ability to do work or to put matter into motion. When energy is actually doing work (moving objects), it is referred to as *kinetic energy*. When it is inactive or stored (as in the batteries of an unused toy), it is called *potential energy*. All forms of energy exhibit both kinetic and potential work capacities.

008. Elemental parts and characteristics of the atom

As stated above, an element is a pure substance that cannot be broken down into a simpler substance by ordinary chemical means. An *atom* is the smallest particle of an element that possesses the chemical properties of that element. Each atom is composed of three fundamental particles that are best described in terms of their electrical charge and mass.The three parts of an atom are the electron, proton, and neutron.

The proton, abbreviated “p” or “p+”, has a positive electrical charge (+1) and a mass of approximately 1 amu or atomic mass number. The number of protons in a nucleus is called the *atomic number* – this number determines what the element is. The next particle is the neutron, abbreviated “n” or “n0”, which has no electrical charge and a mass of approximately 1 amu. The protons and neutrons are found in the nucleus of the atom. The total number of protons and neutrons in an atom is called the *mass number*. Slight variations in the number of neutrons found in the nucleus of the atom

result in different atomic masses but may not affect the chemical properties of the element. The third particle of an atom is the electron.

The electron, abbreviated "e-," has a negative electrical charge (–1) and a mass of 0.0005486 amu (which is considered negligible for most practical purposes). The electrons exist in orbit around the nucleus. Each higher orbit from the nucleus represents a higher energy level of the electron.

The number of protons, neutrons, and electrons in an atom can be determined from a set of simple rules:

- The number of protons in the nucleus of the atom is equal to the *atomic number* (*Z*).
- The number of electrons in a *neutral* atom is equal to the number of protons.
- The *mass number* of the atom (*M*) is equal to the sum of the number of protons and neutrons in the nucleus.
- The number of neutrons is equal to the difference between the mass number of the atom (*M*) and the atomic number (*Z*).

The properties of chemical elements depend on the structure of the atom and vary with atomic number.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

007. Concepts of matter and energy

1. What is defined as any substance that occupies space and has mass?

2. What are the three basic forms of matter?

3. What is a form of matter but is massless and does not take up space?

008. Elemental parts and characteristics of an atom

1. What is a pure substance that cannot be broken down into a simpler substance by ordinary chemical means?

2. What are the three fundamental particles that compose an atom?

3. What particle has no electrical charge and a mass of approxiamately 1 amu?

2–2. The Human Cell

Biology is the study of living organisms and life processes. Microbiology is a branch of biology dealing more specifically with microscopic forms of life. You'll learn general microbiology principles necessary for understanding how the body functions in health and disease. This section discusses the structure and function of the human cell.

From a single cell, called a fertilized ovum, a human organism develops. The basic sequence of growth is, simply stated, cells combine to form tissues, similar tissues join to form organs, and the related tissues and organs become the various systems of a living organism. The cell is the smallest unit capable of performing life functions; therefore, you'll begin studying at the lowest level of the organism.

009. The cell

A cell is the microscopic unit of structure of all living things. An entire organism consists of either a single cell (unicellular) or many cells (multicellular). Cells can be further defined as plant or animal. All living matter is composed of cells; however, animal cells and plant cells significantly differ from one another.

Plant cells

Plant cells contain chlorophyll, a green pigment that mixes with sunlight and water to form energy for plants. Plant cells also have a cell wall around them made up of a very complex carbohydrate known as cellulose. Neither chlorophyll nor a cell wall is present in animal cells.

Animal cells

A typical animal cell includes a cell membrane, a nucleus, protoplasm, organelles. A typical animal cell also includes endoplasmic reticulum, ribosomes, vacuoles, Golgi complex, mitochondria, centrioles, and lysosomes (discussed in the following table).

Cell membrane

The cell membrane surrounds and separates the cell from its environment. It selectively allows certain substances, such as nutrients, to pass through as they enter or leave the cell. It can also be referred to as the plasma membrane.

Nucleus

The nucleus lies within the cell and stores information that guides the life processes of the cell. This information is stored in a chemical form called chromatin material, which is made of the protein deoxyribonucleic acid (DNA). At the time of cell division, the chromatin material collects into individual structures known as chromosomes. Chromosomes are composed of both nucleic acid and protein. Each chromosome has a set of specific genes that determine all of the physical and chemical characteristics of the body. Genes are the basic units of heredity, which pass from parents to their children, and guide the activities of each individual cell.

Protoplasm

Protoplasm is used to describe the matter within the walls of the cell. It's a combination of water and a variety of materials dissolved in the water. Inside the cell nucleus, protoplasm is called nucleoplasm; outside the cell nucleus, it's called cytoplasm.

Organelles

Within the cytoplasm are certain structures called organelles. These organelles include structures such as the endoplasmic reticulum, Golgi complex, ribosomes, vacuoles, mitochondria, centrioles, and lysosomes.

Structure	Explanation
Endoplasmic reticulum	Resembles a circulatory system for the individual cell. It's a network composed of unit (single-thickness) membranes. In many cells, it connects the nucleus with the outside of the cell.
Golgi complex	The "traffic director" for cellular proteins, receives certain protein substances from the endoplasmic reticulum. It aids in the final preparation of these proteins and mucus-like substances and in the movement of these substances.
Ribosomes	These are granular particle "protein factories" in the cell. They contain ribonucleic acid (RNA). Ribosomes are found free in the cytoplasm, clustered, or attached to the endoplasmic reticulum.
Mitochondria	These are the "powerhouses" of the cell. They recharge adenosine diphosphate (ADP) molecules to form adenosine triphosphate (ATP) molecules, the chemical energy of the body.
Centrioles	There are ordinarily two centrioles. These organelles play a major role in cell division.
Lysosomes	These are membrane-bound spheres that contain enzymes that can digest intracellular structures or foreign substances, such as bacteria.

010. Cell growth and multiplication (mitosis)

Individual cells have the capacity to grow and multiply. This lesson explains how the cells grow and multiply through mitosis.

Cell growth

Individual cells have the capacity to grow. They do this by acquiring various substances from the blood and converting them into appropriate cellular elements.

Individual cells have specific life spans. Some types of cells have longer life spans than others. For example, the average life span of a red blood cell is 100 to 120 days, whereas the life span of a white blood cell varies from 100 to 300 days, depending on the body's need. During the growth and repair process, new cells are formed.

Cell multiplication

Cell multiplication is accomplished through a process called mitosis. In mitosis, the genetic material of the cell is doubled, divided equally inside the parent cell, forming two daughter cells. The two new daughter cells each have the same genetic composition as the original cell.

Hypertrophy/hyperplasia

Hypertrophy and hyperplasia are two ways in which the body's cell mass increases. With hypertrophy, there is an increase in the size of the individual cell. No new cells are formed. An example of hypertrophy is muscle enlargement. The diameter of individual muscle fibers enlarges due to exercise.

On the other hand, increased tissue mass can also result from greater numbers of cells. This is called hyperplasia. An example of abnormal hyperplasia is cancer.

Atrophy

Atrophy is the loss of cellular mass or a wasting away of the cell. For example, if a muscle cell does not receive impulses to contract for an extended period of time, the cell will shrink in size and eventually be replaced with fibrous tissue. Such a change can be irreversible, depending on the cause. One example is the loss of neurons to the brain. The brain shrinks due to loss of neurons and will not regain original size.

Energy

The human body depends on external sources for energy. Plants use solar radiation to make glucose and other nutrients. The human body takes glucose and other nutrients directly or indirectly from plants and animal tissues and receives oxygen from the air. The energy within the plant and animal tissue is released within human cells by the process of *metabolic oxidation*. This involves the combination of glucose and other nutrients with oxygen; thus releasing the stored energy.

The mitochondria of the cells use this released energy to form ATP molecules from ADP molecules. ADP is converted to ATP by the addition of a part of a molecule called a phosphate radical. The binding of the phosphate radical requires a large quantity of energy, which can be released later when the phosphate radical is lost. ATP provides energy for cellular processes such as active transport of substances across cell membranes, synthesis of chemical compounds for the body, and mechanical work such as muscle contraction. When an ATP molecule provides energy for such a process, it loses a phosphate radical and becomes ADP. Then, the cycle begins again as ADP is converted into ATP within the mitochondria.

Certain cells, such as muscle cells and nerve cells, require great amounts of energy. These cells have well-developed mitochondria.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

009. The cell

1. What is the microscopic unit of structure of all living things?

2. What is the green pigment that plant cells contain but not animal cells?

3. What is the name of the animal cell component that surrounds the cell and allows certain materials to pass through it?

4. What are the basic units of heredity that guide the activities of each individual cell?

5. Which organelles are the “powerhouses” of the cell that recharge ADP to form ATP molecules?

010. Cell growth and multiplication (mitosis)

1. What is the name of the process in which the genetic material of the cell is doubled?

2. What is the name of the condition when size of the individual cells increases?

3. What do we call increased tissue mass that results from greater numbers of cells?

4. What is the loss of tissue mass that results from a wasting away of the cell?

2–3. Human Fluids and Tissues

This section covers fluid compartments and continues with the unique role of water and dissolved substances. You'll complete this section by learning the tissue fluid cycle and how the body maintains its water and electrolyte balances.

Approximately 56 percent of the human body consists of fluids. Some tissues consist almost completely of fluids. About two-thirds of the fluid is located in the cells with the remainder of the fluid located on the outside of the cells. These body fluids are composed largely of water; thus, water is the major component of living substances. The body strives to be in fluid balance or contain the required amount of water distributed to the various compartments according to their needs.

011. Body fluids

In this lesson, we will discuss human body fluids. Body fluids are an essential part of life and could lead to serious illness or death if they aren't maintained at correct levels. Some examples of body fluids are blood, saliva, tears, urine and sweat.

Fluid compartments

The human body contains fluid compartments or spaces that contain the intracellular and extracellular fluids.

Compartment	Explanation
Intracellular	Water is the major constituent within the cell. This fluid is called intracellular or within the cell fluid.
Extracellular	All other fluids are extracellular. The extracellular fluids are found in two different compartments. Interstitial (also called intercellular) fluid is tissue fluid located between the cells of the body. In some systems, fluids serve as a vehicle to carry items around the body. These systems are called circulatory systems. The circulating fluid is called the plasma—the noncellular component of blood.

Water

Water is the main constituent of the human body and is often considered to be a universal solvent because it has the ability to dissolve many substances within itself. Water accounts for 60–80 percent of our body weight. Thus, water is an excellent vehicle for the circulatory systems. Water is very useful in the body's temperature control mechanisms. This is due to its heat-carrying capacity and tendency to remove large numbers of calories during evaporation.

Sources

Thirst and satisfaction are controlled by special centers in the hypothalamus of the brain. The human body obtains water in two primary ways:

1. Drinking—Most of what humans drink or eat consists largely of water.
2. Metabolic oxidation—As various food substances are oxidized within the individual cell water is one of the main byproducts. This water is referred to as *metabolic water*.

Losses

The ways the human body can lose water are through perspiration, respiration, urination, and vomiting and diarrhea.

Ways Body Gets Rid of Water	Explanation
Perspiration	Water is continuously lost from the body in the form of perspiration or sweat. With high surrounding temperatures and vigorous exercise, the sweat is obvious. This is called *sensible perspiration*. Even when sweat is not obvious, there is a low level of water loss. This is called *insensible perspiration*.
Respiration	The surfaces of the lungs must be moist to ensure the passage of gases to and from the blood. Air is moistened within the respiratory passages and the alveoli of the lungs. Thus, moisture passes out of the body along with the exhaled breath.
Urination	Water is also lost from the body in the form of urine. Urine carries nitrogenous wastes of protein metabolism dissolved in water.
Vomiting and diarrhea	During vomiting and diarrhea, the body loses large quantities of water and dissolved electrolytes. In infants and the elderly, this loss of water and electrolytes can be very dangerous. Death may result.

Dissolved substances

As mentioned before, one of the characteristics of water that makes it so desirable is its capacity to dissolve almost anything, as explained in the following table:

What is Dissolved	Explanation
Gases	Oxygen and carbon dioxide are exchanged between the air in the lungs and the blood. They are also exchanged between the blood and the individual cells of the body. In part, these gases are carried as dissolved substances in the water of the blood.
Nutrients	Nutrients are the end products of digestion and vitamins and minerals absorbed from the digestive system. They are dissolved in the water portion of the blood and distributed to the individual cells of the body.
Wastes	Wastes result from the metabolic processes of the body. Wastes are picked up from the individual cells and delivered dissolved in the water to the excretory organs of the body, such as the kidneys.
Hormones	Hormones, while dissolved in the water of the blood, are carried from the endocrine glands to specific target organs.

Tissue fluid cycle

The extracellular fluid found between the cells is called the tissue fluid or *interstitial fluid*. Tissue fluid originates primarily from the fluid portion of the blood, some of which escapes into the tissue from the capillaries. Part of this escaped fluid enters the beginning of the venous vessels. However, a large percentage of the tissue fluid is picked up by the lymphatic system. Thus, there is a continuous flow of fluids throughout the body. In addition, the intracellular fluid and the immediate extracellular fluid are continually being exchanged.

Homeostasis

Homeostasis is the body's tendency to maintain a steady state of balance. Body fluids play an important role in homeostasis. The tissue fluids form the immediate environment of the living cell.

Appropriate concentrations of oxygen, carbon dioxide, nutrients, electrolytes, and other substances must be present in the tissue fluid to maintain the life processes of the individual cells.

One of the chief functions of any organ system is to help maintain this steady state. For example, the digestive system helps to maintain a steady concentration of nutrients. The respiratory system helps maintain steady concentrations of oxygen and the removal of carbon dioxide.

All organ systems are partially controlled by a feedback mechanism that operates in a manner similar to a household thermostat. When the concentration of a substance is too low, the feedback mechanism stimulates increased production and distribution of that substance. Once the level returns to normal, the feedback mechanism signals a decrease in production. There is a similar feedback mechanism for body temperature.

Water balance

The body has a natural requirement for certain amounts of water to function properly. Lack of fluid in the circulatory system can result in heart failure. Excess fluid in the tissue spaces can result in swelling or edema of the body. There are feedback mechanisms to maintain water balance.

Electrolyte balance

There are certain chemicals within the body fluids known as electrolytes. Electrolytes are chemicals that dissociate (break up) into ions (charged particles) when they are dissolved. To maintain life and good health, electrolytes must be in balance. That is, they must be present in certain proportions and concentrations in each fluid compartment. The following table discusses some conditions when proprotions are out-of-balance:

Some Conditions When Electrolytes are Out-of-balance	
Condition	**Explanation**
Hypertonicity	If the overall electrolyte concentration is *greater in extracellular fluid than in intracellular fluid*, the fluid is *hypertonic*. The cell may be destroyed because it loses its fluid to the hypertonic environment.
Hypotonicity	If the overall electrolyte concentration is *lesser in extracellular fluid than in intracellular fluid,* the fluid is *hypotonic*. In a hypotonic intracellular environment, fluid will enter the cell and cause it to swell and possibly burst.
Isotonicity	If the electrolyte concentrations of extracellular fluid *equal that of intracellular fluid*, the situation is balanced (homeostatic). That is, the fluids are *isotonic*.

Movement in and out of the cell

You learned earlier that all substances entering or leaving the cell must pass through the cell membrane. This is done through diffusion, osmosis, filtration, phagocytosis, and pinocytosis.

How Cells Move In and Out	
Process	**Explanation**
Diffusion	Molecules of either gases, liquids, or solids readily pass through the cell membrane from an area of higher molecular concentration to an area of lower molecular concentration until equilibrium is reached is the definition of diffusion. In the body, oxygen moves by diffusion from the lungs to the bloodstream because the oxygen concentration is higher in the lungs and lower in the blood.
Osmosis	Diffusion of water through a selectively permeable membrane. Sometimes a substance is not able to pass through the cell membrane. When the concentration of this substance is greater on one side of the cell membrane than the other, water will tend to pass through the membrane to the area of greater concentration. This process is called osmosis.
Filtration	Movement of water and small solute particles through a filtration membrane; movement occurs from area of high pressure to area of low pressure.

How Cells Move In and Out	
Process	**Explanation**
Phagocytosis	"Cell eating"; cell engulfs some large particle or solid material, such as bacteria, through the plasma membrane and into the cytoplasm. An example of this would be white blood cells destroying bacteria in the body through phagocytosis.
Pinocytosis	"Cell drinking"; the movement of fluid and dissolved molecules into a cell by trapping them in a section of the plasma membrane that pinches off inside the cell.

Membrane potentials

In living cells there is generally a higher concentration of positively charged ions on the outside of the cell and a higher concentration of negatively charged ions on the inside of the cell. Thus, there is a concentration gradient (an electrical potential or polarity) across the membrane (called the membrane potential), which creates an electrical gradient.

Resting potential

In neurons, there are fewer positive ions inside the neuron than there are in the tissue fluid that surrounds it. This charge difference or electrical gradient is maintained by the Sodium (Na+)-Potassium (K+) Pump. This pump continually transports three positive sodium ions to the outside of the cell membrane and two positive potassium ions to the inside of the cell (3 + ions traded for 2 + ions gives a "more negative" overall charge on the inside of the neuron). As long as the inside of the cell stays more negative and the outside of the cell stays more positive, the neuron remains inactive or in a resting state.

Action potential

The electrical activity that occurs in stimulated neuron or muscle fiber and involves depolarization and subsequent repolarization is called the action potential First, sodium ions move into the cell by diffusion. This reverses the polarity (depolarization). Second, potassium moves out of the cell by diffusion, which causes repolarization. The sodium/potassium pump then restores the ionic balance by actively (energy required) pumping sodium back out and potassium back into the cell. These various electrical potentials can be measured with appropriate instruments.

012. Tissues and organs

In human beings and other multicellular organisms, the cells tend to be organized in specific ways. Cells grouped together to perform a common function or functions are called tissues. Tissues that are grouped together to perform a common function are called organs. Examples of organs are the lungs and the heart. When organs are grouped together to perform a specific function, they are part of an *organ system*. An example of an organ system is the digestive system.

It's important to point out that, in some cases, a term can be used to describe both a type of tissue and a kind of organ. For example, we speak of bone tissue and of bones. We speak of muscle tissue and of muscles.

There are several major types of tissues. The most common types are epithelial, connective, muscle, and nervous tissues.

Epithelial tissue (epithelium)

Epithelial tissue is tissue that covers surfaces, lines cavities, and forms glands. It covers the outer surface of the body and lines the intestines, heart, blood vessels, lungs, and other hollow organs.29 The functions of the epithelium include protection, absorption, filtration, excretion, secretion, and sensory reception.

Connective tissue

Connective tissue is found everywhere in the body. It is the most abundant and widely distributed tissue in the body. It is found in skin, membranes, muscles, bones, nerves, and all internal organs. There are four main classes and several subclasses of connective tissue. The main classes are connective tissue proper (which includes fat and fibrous tissue of ligaments), cartilage, bone tissue, and blood. The major functions of connective tissue include: binding and support, protection, insulation, and transportation of substances within the body . For example, bone and cartilage support and protect body organs by providing the hard underpinnings of the skeleton and cushions of fat insulate and protect body organs and provide reserve energy fuel.

The fibers of connective tissue provide support. There are three different types:

1. Collagenous— These fibers are also the main component of dense connective tissue found in mucous membranes and nerves; they are tough and resistant, but flexible to a pulling force. They occur in bundles and are composed of tiny fibrils lying parallel to each other.
2. Elastic— These elastic fibers are smaller than collagenous fibers and provide strength and stretching ability. They are found in the walls in arteries, lung tissue, and bronchial tubes. They can stretch up to 50 percent of their length.
3. Reticular— These fibers are very thin, provide support and strength, and form the framework for many soft organs.

Types of connective tissue

Connective tissue proper is divided into two subclasses, loose connective tissue and dense connective tissue. The majority of connective tissues belong to this class *except for cartilage, bone, and blood*.

Loose connective tissue

In some locations, there are more cells with fewer fibers loosely arranged around them. This tissue is known as loose connective tissue or areolar tissue and serves as filler material in the spaces between the organs. This tissue is also found between the skin and the underlying structures of the body. Thus, the skin is able to move more or less freely over the surface of underlying structures. The subclasses of loose connective tissue include areolar, adipose, and reticular.

1. *Areolar connective tissue* has four functions to include supporting and binding other tissues, holding body fluids, defending against infection, and storing nutrients as fat.
2. *Adipose (fat) tissue* accounts for 90 percent of the tissue mass. Without the adipose tissue, we could not live for more than a few days without eating. In a person with an average body weight it can constitute 18 percent of their body fat; in a person who it considered obese it can account for 50 percent of their body fat. The functions of adipose tissue include providing reserve food fuel, insulating against heat loss, and supporting and protecting organs.
3. *Reticular connective tissues* are made up of reticular fibers. Function of the reticular connective tissue is to form a soft internal skeleton that supports white blood cells, mast cells, and macrophages.

Dense connective tissue

The fibers of dense connective tissue are closely packed and more or less parallel. As membranes, dense connective tissue surrounds areas or structures of the body (as in capsules around organs such as the kidneys, heart, liver and lymph nodes). Other examples of dense connective tissue are ligaments and tendons. A ligament is a band of dense connective tissue that holds the bones together at a joint. A tendon attaches a muscle to a bone.

The elasticity of a connective tissue is more or less proportional to temperature. The cooler it is the less elastic and more subject to damage. On the other hand, as the fiber becomes warmer, it becomes more elastic and resistant to damage. Elasticity is the basis of warmup exercises before participating in strenuous activities such as sports. By exercising to the point of sensible perspiration, the body

temperature is raised. At this point, the connective tissues are able to stretch and withstand the various forces applied to them.

Cartilage

Cartilage can stand up to both tension and compression. It has the consistency of a firm plastic or gristle-like gel, which is tough but flexible. Cartilage lacks nerve fibers and receives its nutrients by diffusion from blood vessels. Cartilage matrix contains a large amount of tissue fluid, in which water makes up 80 percent of the fluid. There are three types of cartilage in the human body: (1) hyaline cartilage, (2) elastic cartilage, and (3) fibrocartilage. Listed are some functions of cartilage:

- Supports and reinforces.
- Has cushioning properties.
- Resists compressive stress.
- Maintains the shape of structure while allowing for flexibility.
- Has tensile strength with the ability to absorb compressive shock.

Bone

Bone is one of the most highly specialized forms of connective tissue. It has the ability to support and protect body structures. Bones is a storage area for calcium and other minerals and is able to provide cavities for fat storage and synthesis of blood cells. Bones also provide levers for the muscles to act on.

Blood

Blood is the most unusual form of connective tissue. It has both transportation and protective functions in the body. It is classified as connective tissue because it develops from mesenchyme and consists of blood cells, surrounded by a nonliving fluid matrix called blood plasma. Blood functions as the transport vehicle for the cardiovascular system, carrying nutrients, wastes, respiratory gases, and many other substances throughout the body.

Muscle tissues

Muscles are made of muscle tissues. Muscle tissues are the movement specialists of the body. They have a higher degree of being able to shorten or contract than any other tissue cells. There are three types of muscle tissues and are categorized by their location and structure.

1. Skeletal—The cells or muscle fibers of skeletal muscle tissue are long and cylindrical and have numerous nuclei. The arrangement of the cellular contents is very specific and results in a striated or band-like structured appearance when viewed with the microscope. This type of muscle tissue is found mainly in the skeletal muscles. These muscle tissues are *voluntary* because they can be made to contract through conscious control.
2. Cardiac— The cells of cardiac muscle tissue are short, branched, contain one nucleus, and are striated or banded. This tissue makes up the myocardium or wall of the heart and is under *involuntary control*.
3. Smooth— The cells of smooth muscle tissue are spindle-shaped, containing one nucleus, and are not striated. Smooth muscle tissue is generally found in the walls of hollow organs such as the organs of the digestive and respiratory systems, blood vessels, ureters, urinary bladder, urethra, and reproductive ducts. These muscles are under *involuntary control*.

Nervous tissue

Nervous tissue is a collection of cells that respond to stimuli and transmit information concerning sensory feeling or motor control of muscles. It is the main component of the nervous system, which consists of the brain, spinal cord, and nerves. Nervous tissue consists of two cell types: neurons and neuroglia.

Neuron

A neuron, or nerve cell, is the cell of the nervous tissue that actually picks up and transmits a signal from one part of the body to another. Neurons have branching cells called processes which allow them to respond to stimuli and to transmit electrical impulses over substantial distances within the body.

A *synapse* is a junction between two neurons and is the point at which a signal passes from one neuron to the next

Neuroglia

The neuroglia or glia cells are special cells that support and protect the nervous system. About 50 percent of the brain is made up of these glia or glial cells. The physiology of the nervous system is covered later in the volume.

Organs systems

Tissues make up organs. An organ is a structure composed of different types of tissues that perform a particular function such as the lungs or the heart. For example, the heart is composed of cardiac muscle, nervous tissue, and epithelial tissue.

An *organ system* is a group of organs that together perform an overall function such as the digestive system. The digestive system, which functions in the breakdown of food, is composed of the mouth, saliva-producing glands called salivary glands, pharynx or throat, esophagus or gullet, stomach, small intestine, large intestine, rectum, liver, gallbladder, and pancreas. All of these systems functioning together form an organism or one living individual.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

011. Body fluids

1. Where is extracellular fluid found?

2. Why is water called the universal solvent?

3. What are the two ways in which the human body obtains water?

4. What are ways that the human body can lose water?

5. What is the water loss called when sweat is not obvious?

6. What are four examples of dissolved substances carried in body fluids?

7. What do you call the body's tendency to maintain a steady state of balance?

8. What are the chemicals in the body fluids that dissociate into ions and must be present in certain proportions and concentrations in each fluid compartment?

9. What do you call the extracellular fluid that has a greater concentration of electrolytes than the intracellular fluid?

10. How does hypotonic extracellular fluid destroy the cell?

11. What is the process by which gases move from a region of higher molecular concentration to a region of lower molecular concentration?

12. What is the process by which water tends to pass through the cell membrane to the areas of greater concentration?

13. What is the term used to describe the cell membrane's engulfing a large particle such as bacteria or other cells?

14. What is the situation in living cells where there is generally a higher concentration of positively charged ions on the outside of the cell and a higher concentration of negatively charged ions on the inside of the cell?

15. What do you call the electrical gradient when there is more negative charge inside the cell and a positive charge outside the cell?

16. What do you call the electrical activity that occurs in stimulated neuron or muscle fiber?

012. Tissues and organs

1. What do you call groups of like cells that together perform a common function or functions?

2. What are grouped tissues that perform common functions called?

3. What do you call the tissue that covers surfaces and whose function is to protect, absorb, or secrete?

4. What are the major functions of connective tissues?

5. Name the fiber of connective tissue that is tough, resistant, but flexible to a pulling force.

6. What is the function of loose connective tissue?

7. Name two examples of dense fibrous connective tissues.

8. The elasticity of fibrous connective tissues is more or less proportional to what factor?

9. Name three types of cartilage in the human body.

10. What connective tissue serves as the storage area for calcium and other minerals?

11. Name the connective tissue that has both transportation and protective functions in the body.

12. Which muscle tissues are long and cylindrical and have numerous nuclei?

13. Which muscle tissues are short, branched, contain one nucleus, and are striated or banded?

14. What is the function of the neuron or nerve cell?

15. Name the junction between two neurons and is the point at which a signal passes from one neuron to the next.

16. What is a neuroglia or glia?

Answers to Self-Test Questions

007

1. Matter.
2. Solid, liquid, gas.
3. Energy

008

1. An element.
2. Electron, proton, neutron.
3. Neutron.

009

1. The cell.
2. Chlorophyll.
3. The cell membrane or plasma membrane.
4. Genes.
5. Mitochondria.

010

1. Mitosis.
2. Hypertrophy.
3. Hyperplasia.
4. Atrophy.

011

1. In the interstitial fluid between the cells and in the circulating fluid called plasma.
2. Because of its ability to dissolve many substances within itself.
3. Drinking and metabolic oxidation.
4. Perspiration, respiration, urination, and by vomiting and diarrhea.
5. Insensible perspiration.
6. Gases, nutrients, wastes, and hormones.
7. Homeostasis.
8. Electrolytes.
9. Hypertonic.
10. Fluids enter the cell and cause it to swell and burst.
11. Diffusion.
12. Osmosis.
13. Phagocytosis.
14. Membrane potential.

15. Resting potential.
16. Action potential.

012

1. Tissues.
2. Organs.
3. Epithelial tissue.
4. Binding and support, protection, insulation, and transportation of substances.
5. Collagenous.
6. Filler material in the spaces between the organs.
7. Ligaments and tendons.
8. Temperature.
9. Hyaline, elastic, and fibrocartilage.
10. Bone.
11. Blood.
12. Skeletal muscle tissues.
13. Cardiac muscle tissues.
14. To pick up and transmit a signal from one part of the body to another.
15. Synapse.
16. Special cells that support and protect the nervous system.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

13. (007) One way scientist classify matter is by its
    a. Composition.
    b. Expression.
    c. Anatomy.
    d. Industry.

14. (007) Energy at work is referred to as
    a. stored.
    b. kinetic.
    c. physical.
    d. potential.

15. (008) The total number of protons and neutrons in an atom is called
    a. total weight.
    b. brief particle.
    c. mass number.
    d. electrical charge.

16. (008) The number of what is equal to the difference between the mass number of the atom and the atomic number?
    a. Proton.
    b. Charge.
    c. Electron.
    d. Neutron.

17. (009) Substances must pass through which typical animal cell component to get into the cell?
    a. Nucleus.
    b. Organelles.
    c. Cell membrane.
    d. Golgi complex.

18. (009) The basic units of heredity that pass from parents to their children are called
    a. genes.
    b. chromosomes.
    c. chromatin material.
    d. deoxyribonucleic acid.

19. (009) Which organelles are the “powerhouses” of the animal cell?
    a. Vacuoles.
    b. Lysosomes.
    c. Mitochondria.
    d. Endoplasmic reticulum.

20. (010) The release of stored energy from the combination of glucose and other nutrients with oxygen is called
    a. phosphate radical.
    b. metabolic oxidation.
    c. adenosine diphosphate.
    d. adenosine triphosphate.

21. (011) What do we call the body's tendency to maintain a steady state of balance?
    a. Tissue fluid cycle.
    b. Hypertonicity.
    c. Hypotonicity.
    d. Homeostasis.

22. (011) When a cell is in its resting state, what status are the charges inside and outside the cell?
    a. More positive inside and negative outside.
    b. More positive outside and negative inside.
    c. Negative inside and outside.
    d. Positive inside and outside.

23. (012) Epithelial tissue is found in
    a. bones.
    b. tendons.
    c. intestines.
    d. hyperplasia.

24. (012) What is the dense connective tissue that holds the bones together at a joint?
    a. Collagenous fiber.
    b. Reticular fiber.
    c. Ligament.
    d. Tendon.

Please read the unit menu for unit 3 and continue ➔

Student Notes

Unit 3. Anatomy and Physiology

YOU HAVE ALREADY STUDIED the basics of microbiology, including the structure of the human cell. You've also seen how cells are organized into tissues, organs, and organ systems. This unit covers the structures making up these organ systems, *anatomy*, and the functions these organ systems perform, *physiology*. A thorough understanding of anatomy and physiology will give you a deeper appreciation for medical conditions you've heard about. But more importantly, it provides the rationale for why many of our public health programs are conducted as they are. Medical terminology is found later in this volume. You may find it useful as you study this and other units.

3–1. Musculo-Skeletal System

The musculo-skeletal system provides the shape and support for the body. The skeleton and muscles not only protect the vital internal organs, but also work together to enable body movement.

013. Skeletal system

The skeletal system is made up of 206 bones and performs the following major functions:

- Supports surrounding tissues by providing a rigid framework within the body.
- Assists in body movement by providing the site for muscle attachment. The interaction of a muscle contracting across a joint involving two or more bones causes the different parts of the body to move.
- Protects the vital internal organs and other soft tissues. The skull surrounding the brain is an excellent example of this protective function.
- Makes the red blood cells (RBC) and white blood cells (WBC) within the marrow of some of the bones.

- Stores mineral salts, especially phosphorous and calcium salts. These mineral salts are continuously removed and replenished and are essential for normal metabolic balance.

Axial and appendicular skeletons

The axial skeleton is made up of the bones in the skull, the hyoid bones (supports the larynx), the sternum, the 12 pairs of ribs, and the vertebrae. The vertebral column is further divided into seven cervical vertebrae in the neck, 12 thoracic vertebrae where the ribs attach, five lumbar vertebrae of the lower back, and the sacrum formed by five fused vertebrae. The axial skeleton makes up 80 bones out of the 206 bones. You should realize that all these bones lie along the body's midline axis; thus the name *axial skeleton*.

By contrast, the appendicular skeleton forms the appendages—arms and legs. The arms are attached to the axial skeleton through the shoulder girdle. The clavicle (collarbone) and the scapula (shoulder blade) form the shoulder girdle. The upper arm is supported by a single bone, the humerus, and the forearm is supported by two bones, the radius and the ulna. The legs are attached to the axial skeleton through several fused bones forming the pelvic girdle. The thigh is supported by the femur and the lower leg by the tibia and fibula. Note that the functional anatomy is very similar between the arm and leg. In both cases, the appendage is attached to the axial skeleton by a bony girdle. Next, the upper part of the extremity is supported by a single bone. Two bones provide the support to the lower portion of each limb. The appendicular skeleton makes up 126 bones out of the 206 bones.

Accessory structures

There is more to the skeletal system than the bones themselves. The accessory structures hold the skeleton in its proper position and enable the bone surfaces to move smoothly over one another. One of the accessory structures are the ligaments. Ligaments are fibrous bands that hold one bone to another. They are not very elastic and will tear if stressed in the wrong direction. Torn knee ligaments are a common football injury resulting from stresses applied to the side of the knee.

Another accessory structure is tendons. Tendons make the actual connection between a contracting muscle and a moving bone. Tendons are enclosed within protective, lubricated sheaths that facilitate their sliding over adjacent structures. Joints are formed by the cartilage-covered ends of two moving bones. However, others, like the joints between the skull bones, are immovable and tightly fused.

Bone marrow

Another, often overlooked part of the skeletal system is bone marrow. Bone marrow is fat- or blood-forming tissue found within bone cavities; called yellow or red bone marrow. *Yellow marrow* is formed in the medullary cavity in the shaft of long bones. Yellow marrow contains fat cells. *Red bone marrow* is found in spongy bone of long bones and in the diploë (spongy bone) of flat bones. The red marrow is the production site for the RBC that carry oxygen in the blood and some WBC that are elements of the immune system. Yellow marrow in the medullary cavity can revert to red marrow if a person becomes very anemic and needs enhanced RBC production.

Fractures

The last topic you will study in regards to the skeletal system is fractures. As with most other medical topics, there exists a whole nomenclature associated with the classification of fractures. Only four of the most common fracture types are covered:

Fractures	
Type	**Description**
Simple	The bone is broken, but does not protrude through the skin. This is also known as a closed fracture.
Compound	The broken bone does protrude through the skin. This is also known as an open fracture.

Fractures	
Type	**Description**
Comminuted	Exists when many small pieces and bone chips have been created.
Compression	Results from tremendous forces that cause the bone to telescope within itself. This type of fracture is common in the leg bones of people jumping from burning buildings.

No matter what the fracture type, the healing process is the same. It involves four major stages:

1. *Hematoma forms*—Hematoma (mass of clotted blood) forms at the fracture site. The area will become swollen, painful, and inflamed because the bone cells are deprived of nutrients and die.

2. *Fibrocartilaginous callus forms*—The formation of soft granulation tissue (soft callus) forms. Capillaries begin to grow into the hematoma and phagocytic cells invade the area. Fibroblasts and osteoblasts also invade the fracture site to begin reconstructing the bone. The fibroblasts will produce the collagen fibers that will connect the broken bone ends while the osteoblasts begin forming the spongy bone.

3. *Bony callus forms*—New bone begins to appear in the fibrocartilaginous callus and begins converting it to a bony callus of spongy bone. The bony callus will continue until a firm union is formed.

4. *Bone remodeling occurs*—Bony callus is remodeled which continues over several months. Excess material on the diaphysis exterior and within the medullary cavity is removed, and compact bone reconstructs the shaft walls. The final result is a remodeled area that resembles the original unbroken bone.

014. The muscular system

The following are the primary functions of the muscular system:

1. Moves the whole body and its appendages through muscular contraction and the resulting movement of the skeleton.
2. Moves blood throughout the body; both by contraction of the heart muscle moving blood through the arteries and by the contraction of muscles throughout the body moving blood through the veins.
3. Moves food through the digestive tract by contractions of muscles located in the walls of the stomach, intestine, and other digestive organs.
4. Moves urine through the urinary tract.
5. Enables us to breathe due to the contractions of muscles in the chest, abdomen, and diaphragm.

These five functions are absolutely essential to life itself, and the failure of any one of them will lead to death. Now that you have learned what the functions of the muscular system are, let's take a look at the different parts of muscles that perform these functions.

Anatomy

When you examine a muscle or think about a muscle in your own body (e.g., the gastrocnemius or calf muscle in your lower leg), you'll realize that it has three main parts—origin, belly, and insertion:

- The *origin* of a muscle is the fixed or stationary attachment of the muscle to the skeleton. In our example of the gastrocnemius muscle, the origin of this muscle is on the back side of the femur or thigh bone.

- The *belly* of a muscle is the large, fleshy prominence that forms the bulk of the muscle. Most of the muscle fibers that perform the actual work of contraction are located in the belly of the muscle.
- The *insertion* of a muscle is the point on which the action of the muscle is applied, resulting in motion. As was mentioned earlier, the attachment between muscle and bone is a tendon. The gastrocnemius muscle inserts on the heel bone by way of the Achilles' tendon.

Mechanism of contraction

Within each muscle are tiny muscle fibrils. These myofibrils are composed of two different types of protein, actin and myosin. Cross bridges connect the proteins to each other. When stimulated by a nerve impulse, the cross bridges "reach out" from a myosin filament, attach to an actin filament and pull the actin filaments inward. This pulling shortens the muscle fibrils, and when it takes place throughout a muscle, it shortens the overall length of the muscle. This microscopic method of contraction involving the proteins actin and myosin is called *the sliding filament mechanism*.

Myoglobin

Another protein found in muscles is myoglobin. As you may have guessed from its name, myoglobin is the muscle tissue's answer to hemoglobin. Like hemoglobin, myoglobin can store oxygen until it is needed by the muscle cell. Large amounts of oxygen are needed by a muscle cell when it contracts.

An interesting correlation exists between the color of meats, the type of work the muscle performed for the animal, and its myoglobin content. Chickens are not renowned flyers and are more adept at fleeing on foot; in fact they fly very poorly. Not surprisingly, then, since little work is performed by the breast muscles and great work is done by the thighs and legs, breast meat contains less myoglobin than does the thigh or leg muscles. The low myoglobin content in breast meat makes it paler than the dark meat of the thigh and leg tissue, which contains more myoglobin. Unlike chickens, ducks are excellent flyers and can travel thousands of miles on their annual migrations. The breast muscles of the duck perform great amounts of work and are high in myoglobin; therefore, the breast meat of duck is quite dark.

Meat color can also be influenced by diet. Veal calves are fed milk, a food very low in iron. Iron is a component of myoglobin (as well as hemoglobin). Since these calves receive insufficient amounts of iron, they produce insufficient amounts of myoglobin in their muscle tissue. This deficiency results in a meat that is very light in color. Finally, pork is lighter in color than beef because, as a species, hogs produce less myoglobin than do cattle.

Enzymes

Enzymes are present in many tissue cells, not just muscle, and enable the cells to perform different metabolic jobs. Some enzymes are found only in certain tissues, while other enzymes are common to several types of tissue. *Serum glutamic oxaloacetic transaminase* (SGOT), also known as *aspartate amino transferase* (AST), is an enzyme found in several tissues including liver, muscle, and brain. When these tissues are damaged, SGOT leaks from the damaged cells into the bloodstream and can then be found in high levels in blood samples.

In the public health field, we commonly use SGOT to evaluate liver toxicity for those taking isoniazid (INH) as a result of tuberculosis infection. You must remember, though, that SGOT is not liver specific. A person who has recently exercised may have elevated SGOTs from the muscle tissue damage caused by extensive exercise. However, those who exercise regularly do not damage muscle cells during exercise and will probably add muscle bulk through a process known as muscular hypertrophy.

Muscular hypertrophy and atrophy

These two terms are opposites. Hypertrophy is the process of increasing both the size and number of muscle fibers. As you know, forceful muscular activity will, over time, result in muscular

hypertrophy. However, no new myofibrils will develop unless the muscle contracts to 75 percent of its maximum ability. The point is short, hard workouts will do more to build strength and muscle mass than will prolonged, mild workouts that never push the muscle groups to 75 percent of their capability.

The opposite of hypertrophy is atrophy, and atrophy is a wasting away of the muscle. There are two causes of atrophy— (1) loss of the nerve supply to the muscle and (2) lack of use. When the nerve supply to a muscle is cut or interrupted, the muscle very rapidly and dramatically atrophies.

Evidently, the muscle is very dependent on the nerve for its normal metabolism. A more common cause of atrophy is disuse. Disuse atrophy occurs when the muscle is not used; for example, when a limb is in a cast or when there is long-term confinement to a bed. This type of atrophy is reversible, and with routine exercise, the muscle will regain its former size and function.

Trichinosis

The last condition affecting the muscular system is caused by the parasitic worm, *trichinella spiralis*. Trichinosis is a disease affecting the muscles of both animals and man. Infection results from eating meat containing infective *trichinella* cysts. Within the digestive tract, the cysts break open and the worms migrate through the body tissues until they reach muscles where they, too, encyst. The presence of these cysts in the muscles is quite painful, but this disease can be prevented by properly and thoroughly cooking all meats. In the past, most cases of trichinosis resulted from eating undercooked pork—hence the public education efforts on the importance of thoroughly cooking pork. Recently, though, most reported cases have occurred after people on hunting trips have eaten undercooked, home-prepared portions of polar bear or other large trophy animals.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

013. Skeletal system

1. What makes up the appendicular skeleton?

2. Which bones form the shoulder girdle?

3. What makes the actual connection between a contracting muscle and a moving bone?

4. What is a comminuted fracture?

5. What is the first major stage in the healing process of a facture?

014. Muscular system

1. What is the microscopic method of contraction involving the proteins actin and myosin called?

2. What causes the darker meat in animals, especially the meat of working muscles?

3. What is another name for serum glutamic oxaloacetic transaminase?

4. What are the two causes of muscle atrophy?

5. What is trichinosis and what causes this condition?

3–2. Circulatory and Respiratory Systems

The circulatory and respiratory systems work together to deliver oxygenated blood to and remove carbon dioxide and other metabolic byproducts from body tissues.

015. Circulatory system

In addition to transporting different gases, hormones, nutrients, and waste products around the body, the circulatory system helps regulate body temperature. When the outside temperature is hot, capillaries in the skin dilate or enlarge to allow more blood to flow through the skin. Since the skin is in contact with the air, it acts as a large radiator to transmit heat from the blood to the air. When the outside temperature is cold, the capillaries of the skin constrict or close down to reduce heat transfer through the skin to the environment; thus conserving available body heat.

Now, turn your attention to the largest part of the circulatory system, the blood.

Blood

Blood is the only fluid tissue in the body. It is a sticky, opaque fluid with a characteristic of having a metallic taste. Blood accounts for approximately eight percent of body weight. Blood is broken down into components. Blood will break down into layers. The top layer is called plasma, which is the least dense component and is made up of 55 percent of whole blood. Formed elements make up the bottom two layers; which are broken down into the buffy coat and erythrocytes. The buffy coat is a thin, whitish layer that contains the leukocytes and platelets and makes up of less than one percent of whole blood. Finally, the bottom layer is erythrocytes. It is the densest component and makes up about 45 percent of whole blood.

Components of blood

As mentioned earlier there are four components of blood; plasma, platelets, erythrocytes, and leukocytes. Blood performs multiple functions including distributing substances, regulating blood levels of particular substances, and protecting the body.

Plasma is a straw-colored, sticky fluid that is made up of approximately 90 percent water but it also contains over one hundred different dissolved solutes to include nutrients, gases, hormones, wastes, and products of cell activity, ions and proteins. The plasma has several functions: dissolving food and

salts, dissolving waste that cells must get rid of, and dissolving hormones and other regulatory chemicals that help control the cells' activities.

One must remember that platelets, erythrocytes, and leukocytes make up the *formed elements* of blood. Platelets have an important role in the blood clotting process that occurs in plasma when blood vessels are ruptured or their lining is injured. Platelets will stick to the damaged site and help form a seal.

Erythrocytes or RBCs are small cells that look like doughnuts because of their biconcave discs appearance. RBC makes up 99 percent of the total number of cells in the blood. These cells have no nucleus, but are rich in hemoglobin, the oxygen carrying protein of blood. RBCs are dedicated to transporting respiratory gases such as oxygen and carbon dioxide. Hemoglobin, a protein that makes RBCs red, easily binds to oxygen and oxygen that is carried in blood is bounded to hemoglobin. About twenty percent of carbon dioxide that is transported in blood also combines with hemoglobin. The normal life span of RBC is about four months. An insufficient number of RBC causes anemia, which is a decrease in the oxygen-carrying ability of the blood. A type of anemia that we are concerned with is sickle cell anemia. Sickle cell anemia is caused by an abnormal hemoglobin causing the RBC to become crescent shaped. If one is infected with malaria then their RBC will sickle.

The final formed elements are leukocytes or WBCs, which is the only formed element that is considered to be a complete cell, with a nuclei and organelles. WBCs function as part of the body's immune system to eliminate foreign material by producing antibodies. There are five different types of leukocytes:

1. *Neutrophils* are our body's bacteria slayers; function is to phagocytize (devour) bacteria such as meningitis and appendicitis.
2. *Eosinophils* kill parasitic worms, such as flatworms and roundworms. These types of worms are most often ingested in food or invade the body through the skin, which then burrow into the intestines. They also play a complex role in allergy and asthma related diseases.
3. *Basophils* release histamines and other mediators of inflammation. Basophils represent 1 percent or less of the total WBC count. An increase in numbers is seen during the healing phase of inflammation.
4. *Lymphocytes* mount immune response by direct cell attack or via antibodies. They play a crucial role in immunity. *T cells* function in the immune response by acting directly against the virus and tumor cells. *B cells* produce antibodies that are released to the blood.
5. *Monocytes* phagocytic and crucial in the body's defense against viruses, intracellular bacterial parasites, and chronic infections such as tuberculosis.

Human blood types

People have different blood types; therefore, if a person is transfused with the wrong blood type, the resulting reaction can be fatal. The presence or absence of an antigen allows for a person's blood to be classified into different blood groups. Antigens determine the antibodies blood group (ABO) and Rhesus (Rh) blood type.

Human Blood Types		
Type	**Contains or Identifies**	**Description**
Type A	Contains A antigens and anti-B antibodies.	Can receive Type A or O blood.
Type B	Contains B antigens and anti-A antibodies.	Can receive Type B or O blood.

Human Blood Types		
Type	**Contains or Identifies**	**Description**
Type AB	Contains both A and B antigens but no antibodies.	Can receive Type A, B, AB, or O blood. Considered the *universal recipient* because type AB can receive blood transfusions from any ABO.
Type O	Contains no antigens, but both anti-A and anti-B antibodies.	Can receive Type 0 blood. Considered the *universal donor* because type O contains no antigens, it can be transfused into anyone
Rh factor (First identified in the Rhesus monkey)	Identifies the presence or absence of another antigen, the Rh antigen.	If the Rh antigen is present, the blood is called *Rh positive.* If absent, the blood is *Rh negative*. Transfusion reactions can occur following transfusion of Rh positive blood into an Rh negative recipient.

Heart

Your heart, about the size of your fist, is located in the left center of your chest. It is surrounded by a membranous sac, the pericardium. If the heart or pericardium becomes damaged, then it could fill with blood, compress the heart, and restrict its proper filling and pumping.

The heart is divided into right and left sides with four chambers. The two upper chambers are called the atria (singular- atrium) and two lower chambers called ventricles. The atria are often referred as the receiving chambers because the blood enters through the heart through veins and goes into the atria. Now on the other hand, the ventricles are referred to as the discharging chambers because it takes the blood that is within the heart and pumps it out through arteries that exit the heart. Myocardium is the muscle tissue that surrounds the chambers of the heart. There is a septum that separates the atria and the ventricles. The septum that separates the atria is the interatrial septum and interventrical septum separates the ventricles.

Valves separate the atrium from its corresponding ventricle and the ventricle from the artery leaving it. Blood low in oxygen returning from the body enters the right atrium through the vena cava. As the right atrium contracts, this blood is pumped through the tricuspid valve into the right ventricle. When the right ventricle contracts, blood is forced out of the pulmonary artery to the lungs where carbon dioxide in the blood is exchanged for oxygen in the lungs. Oxygen-rich blood then returns from the lungs to the left atrium through the pulmonary veins. The left atrium contracts which forces blood through the mitral valve into the left ventricle. Blood moves through the aorta and on to all body tissues when the left ventricle contracts. These contractions take place in a coordinated, two-step rhythm. First, both atria contract filling the ventricles, then both ventricles contract forcing blood into the pulmonary and systemic circulatory systems. These two separate circulatory systems separate the oxygen-rich blood and oxygen-deficient blood, and ensure that only oxygen-rich blood is pumped from the heart to the body.

Although great volumes of blood pass through the heart, the heart itself has its own system of blood vessels called coronary vessels, supplying its needs.

Blood vessels

There are three different types of blood vessels: arteries, veins, and capillaries. The aorta is the largest artery in the body. Arteries will become smaller and become arterioles which controls blood flow into the capillaries, from the capillaries blood will exit and enter the venules which become bigger and become veins. The largest veins are the superior vena cava and the inferior vena cava. It is important to keep in mind that the *arteries carry blood away from the heart* toward the capillaries and the *ventricles will carry blood toward the heart* and away from the capillaries.

Arteries, veins, and capillaries have a specific function. Arteries and arterioles are responsible for distributing blood from the heart to capillaries which distributes blood to all parts of the body. The arterioles specifically maintain arterial blood pressure, ensuring that it is maintained at a normal level. Venules and veins collect from the capillaries and return it to the heart. Venules and veins are also blood reservoirs, carrying blood under lower pressures and expand to hold larger volumes of blood or constrict to hold smaller volumes. Capillaries are known as exchange vessels. Glucose and oxygen go into cells through capillaries and carbon dioxide goes into the capillaries from cells. The main arteries supplying the brain are the carotid arteries. The carotid pulse can be felt in the neck, alongside the windpipe. The brachial arteries supply the arms, and the brachial pulse can be felt on the inside of the upper arm. The femoral artery enters the leg in the groin area. Regardless of which tissue is supplied, all of these arteries eventually branch into arterioles, which, in turn, branch into capillaries. The capillaries are the tiny vessels that actually carry the blood through the tissue. After leaving the tissues, the venous capillaries carry venous blood to venules, which join to form veins. Eventually, these veins return the blood back to the heart.

Shock

If there is an insufficient volume of blood to meet the body's needs, the condition is known as circulatory shock. The most common reason for an insufficient blood volume is bleeding; because circulating blood volume is low, blood pressure will also drop. This series of events can be life threatening and must be rapidly corrected. Therapy usually involves increasing blood volume as quickly as possible by administering large amounts of IV fluids. These fluids can be whole blood, plasma, or various salt solutions like lactated ringers solution. Shock may be secondary to another injury; however, the person may not live to have the primary injury treated unless the shock is corrected first. Excessive loss of fluids through vomiting and diarrhea can also lead to circulatory shock.

016. Respiratory system

The maintenance of life depends on a sufficient supply of oxygen (O_2) and the removal of carbon dioxide (CO_2). The respiratory system functions in this gas exchange between the organism and the environment. Take a look at the anatomy of the respiratory tract to determine how it carries out this function.

Anatomy

You'll study the anatomy in the same order as air passes through the respiratory tract, beginning with the nose. After air enters the nostrils, the bones within the nose, called turbinates, deflect the air from a straight pathway causing it to twist and turn. This tortuous pathway; as well as, the hairs inside the nose, cause fine particles like dust to be filtered out before passing further down the tract. In addition to filtration, the nose also warms and humidifies the air on its way to the pharynx.

The pharynx is the common passageway for both the respiratory and digestive systems. Air then moves into the larynx or voice box. As you know, the main function of the larynx is phonation, or the production of sound. The pitch of these sounds is controlled by changing the shape and tension of the vocal chords. Just like the strings of a guitar, thin, high tension vocal chords produce a higher pitch than thick, low tension vocal chords. Several cartilages form the larynx. The large butterfly-shaped cartilage in front is the thyroid cartilage. Below this are the ring-like cricoid cartilage and the membrane between these two cartilages, called the cricothyroid membrane. This membrane is punctured in an emergency procedure called a cricothyrotomy or tracheotomy to provide an open airway in the event of upper airway obstruction.

The trachea or windpipe exits the larynx and carries the air into the chest cavity. It is made of a series of cartilage rings. These cartilages can be cut during a tracheotomy as another means of providing an emergency airway should obstruction occur in the upper airway. Much of the trachea and other parts of the respiratory tract are lined with small hair-like projections called cilia. These cilia perform an

extremely important protective function for the respiratory tract. They rhythmically beat in the direction of the pharynx, moving debris trapped within a protective mucous coat. When the material reaches the pharynx, it is either swallowed or expectorated (coughed up or spit out). Cigarette smoke and other airborne contaminants can paralyze the cilia and, thus, eliminate one of the most effective protective mechanisms of the respiratory tract.

Within the chest, the trachea divides into two bronchi, which divide even further to form bronchioles. Eventually, a tiny airway will lead to an alveolus. The alveoli, which are the plural form of alveolus, are the actual sites of the gas exchange. These grape-like clusters of cells provide very thin membranes between the blood contained within capillaries and the air within the alveolus. Oxygen and carbon dioxide readily cross these membranes in response to pressure gradients.

Relative pressures

The pressures of oxygen and carbon dioxide in the alveolus are 40 millimeters of mercury (mmHg) and 104 mmHg, respectively. Blood flowing through the capillary approaches the alveolus with the pressures of oxygen at 40 mmHg and carbon dioxide at 45 mmHg. Since this blood entering the lung contains less oxygen and more CO_2 than the air in the alveolus, oxygen moves from the alveolus into the blood, and carbon dioxide moves from the blood to the alveolus. By the time the blood leaves the lungs, the oxygen pressure has been raised to 104 mmHg and the carbon dioxide pressure has been lowered to 40mmHg, the same pressures found in the inspired air in the alveolus.

These pressures are dramatically changed, though, as pilots ascend to high altitudes in aircraft. At 10,000 feet, the pressure of oxygen is only about 70 percent of the value at sea level. At 50,000 feet, the oxygen pressure is only about 11 percent of the value at sea level. Although the pressure of oxygen in air changes with altitude, the same pressures exist in the human bloodstream, regardless of the altitude. It's easy to see that the pressure gradients that cause the necessary movements of oxygen and carbon dioxide do not work effectively at high altitudes. This is why aircrews carry supplemental oxygen and aircraft cabins are pressurized to approximate sea-level conditions.

Interestingly enough, hemoglobin, which normally carries oxygen, will bind to other gases as well. For example, it binds with carbon monoxide 210 to 250 times more readily than oxygen. Therefore, only very small concentrations of carbon monoxide can prevent oxygen binding and cause death.

You've learned how the gases move in and out of the bloodstream and the alveoli. But how is the air actually moved in and out of the respiratory system? You'll see as you study the mechanics of breathing.

Mechanics of breathing

The abdominal and thoracic (chest) cavities are separated by a heavy sheet of muscle called the diaphragm. Between the lungs and the wall of the thorax, negative pressure or a vacuum exists. This negative pressure causes the lungs to be fully expanded to the maximum limits allowed by the confines of the thoracic cavity. As the diaphragm contracts and the chest walls are expanded during inspiration, the volume within the thorax is increased. The negative pressure causes the lungs to expand and fill the increasing thoracic volume. As the lungs are expanded outward, air is drawn in through the nose and down the trachea to fill the newly created space within the lungs. On expiration, the diaphragm relaxes and the chest wall falls, both compressing the lungs. As the lungs are compressed, the air is forced out of the respiratory tract to the outside. This arrangement works very nicely as long as the thoracic cavity is able to maintain the required negative pressure. However, should the integrity of the thoracic cavity be broken, outside air will flow into the chest cavity and the negative pressure expanding the lungs will be lost (e.g., a sucking chest wound). Efforts to expand the chest wall will be fruitless, and as a result, no air will be moved in or out of the lungs. This condition, called pneumothorax, can occur any time a penetrating chest wound occurs. It can be corrected by inserting a chest tube and drawing out the accumulated air. This procedure re-establishes the negative pressure required to keep the lungs fully expanded within the confines of the chest cavity.

Pathology

The first topic you'll study under pathology deals with the action of different chemical warfare agents on the respiratory system. Blood agents, such as cyanide, prevent the body tissues from using the oxygen carried by the blood's hemoglobin. The blood contains plenty of oxygen, the mucous membranes and fingernail beds have a healthy pink color, but the tissues are dying from a lack of oxygen. When choking agents are inhaled, they cause severe irritation to the respiratory tract. This irritation causes the fluid components of the blood, normally contained within the pulmonary capillaries, to pass through the vessel walls into the alveolus. This fluid accumulates in the lungs and interferes with the normal oxygen-carbon dioxide exchange process. This condition, sometimes referred to as "dry-land drowning," is known medically as pulmonary edema. The following table lists some other conditions:

Condition	Explanation
Pneumonia (also called pneumonitis)	Is caused by a variety of agents including bacteria, viruses, fungi, and chemicals. As WBCs and fluids accumulate in the lungs, gas exchange is impaired.
Asthma	An allergic response causing a narrowing of the small airways making it difficult to move air in and out.
Emphysema	The destruction of lung tissue and the blockage of small bronchioles make less lung tissue available for gas exchange and increase the labor of breathing.

A worker with any of these conditions may have enough respiratory problems already without being required to work wearing a respirator.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

015. Circulatory system

1. Besides transporting gases, hormones, nutrients, and waste products, what is another function of the circulatory system?

2. Which type of blood cells make up 99 percent of the total number of cells in the blood?

3. What is the condition of having an insufficient number of RBC called?

4. A person having blood containing B antigens and anti-A antibodies has which blood type?

5. What antigen is present in a person having blood type O positive?

6. What is the name of the membranous sac that surrounds the heart?

7. Which portion of the heart receives oxygen-rich blood from the lungs?

8. What is the condition called where there is an insufficient volume of blood to meet the needs of the body?

016. Respiratory system

1. What are the bones in the nose called that twist and turn the air as it enters?

2. What emergency procedures could be performed in the event of upper airway obstruction?

3. What carries air into the chest cavity?

4. What is the name of the muscle separating the abdominal and thoracic cavities that creates breathing?

5. What is the condition called where no air goes into or out of the lungs due to a penetrating chest wound?

6. What is the medical terminology for “dry-land drowning?”

3–3. Digestive and Urogenital Systems

Although these organ systems perform a variety of different functions, they both perform the vital role of eliminating solid and liquid wastes from the body. The digestive system eliminates the unused byproducts of ingested food, while the kidney filters metabolic impurities from the blood.

017. Digestive system

Living organisms can survive only if adequate raw materials are available to supply energy and support growth, maintenance, and repair. Although the circulatory system actually transports these materials to and from the tissues, they are made available through the digestive and absorptive functions of the digestive tract. The first function of the digestive tract involves both mechanical (chewing) and chemical (enzymatic and acidic) breakdown of food into components that can be absorbed through its walls into the bloodstream. Secondly, the absorptive function is carried out by cells throughout the tract, but only certain components are absorbed from the gut contents. Finally, after the food has been digested and the useful materials absorbed, the digestive system performs its third function, elimination of the unusable wastes.

The digestive system can be divided into two main elements—the alimentary canal and the accessory glands, which secrete chemicals important in the digestive process.

Alimentary canal

The alimentary canal begins at the mouth and ends approximately 28 feet later at the anus. The digestive process begins in the mouth as saliva is mixed with food, and the food is broken down into smaller particles by the process of chewing. When the food is swallowed, it moves through the pharynx and into the esophagus. The esophagus is a muscular tube passing through the thorax and diaphragm. Food is moved by gravity and muscular contractions through the esophagus and into the stomach.

The stomach, lying primarily on the left side of the body, is the most dilated portion of the digestive tract. It functions as a holding vat, storing food after a meal, and then, over time, releasing small amounts into the intestine. Digestion also takes place in the stomach. Protein digestion begins with the release of the enzyme pepsin.45 The gastric secretion of hydrochloric acid also helps digestion by breaking down food into smaller particles. The stomach itself is protected from the acid secretions by a heavy mucous coating. If the coating is incomplete, the hydrochloric acid begins to digest the stomach wall. This condition, which can also occur in the first section of the small intestine, is known as an ulcer. The erosion of blood vessels in the stomach wall can cause a chronic blood loss or massive acute bleeding, depending on the vessels involved.

Besides hemorrhage, there are other types of stomach inflammation that exist. When the stomach is inflamed by bacterial toxins or other irritants, it will try to rid itself of these materials. Vomiting is a protective mechanism for eliminating potentially dangerous contents from the upper gastrointestinal tract.

Leaving the stomach, food enters the small intestine, which is approximately 20 feet long. The small intestine is lined by a large number of finger-like protrusions called villi. These villi are microscopic projections that greatly increase the absorptive surface area of the small intestine. In fact, the small intestine is the area of greatest nutrient absorption within the digestive tract.

The cecum is a blind pouch attached at the junction of the small intestine and the next section of the gut, the large intestine. The appendix lies at the end of the cecum and is called a vestigial organ. Vestigial organs serve no useful purpose, and the only time we are interested in the appendix is when it becomes inflamed and has to be removed during an appendectomy.

The next section of the alimentary canal is the large intestine. Besides nutrients, there is another material essential to life absorbed within this section of the alimentary canal. The material is water, and more is absorbed in the large intestine than anywhere else in the gut. The large intestine also serves to store fecal material until expelled. The fecal material moves through the large intestine into the rectum, and is eliminated through the anus. Just as the upper gastrointestinal tract has a protective mechanism for eliminating irritants, the process of vomiting, so does the lower gastrointestinal tract. As the irritant passes through the small and large intestine, it causes the gut to secrete more fluids and to increase its normal contractions. These two factors work together to sweep the irritant out of the intestinal tract as quickly as possible, resulting in diarrhea. Cholera toxin directly stimulates the gut cells to increase their secretions, and the excessive fluid loss can result in rapid and severe dehydration.

Accessory structures

Accessory structures (all are glands) do not perform any of the absorption duties; instead, their secretions aid the digestion processes. You’ve already briefly studied the salivary glands and their secretions during your 3-skill level technical school.

Parotid salivary glands

Actually, there are several salivary glands: the parotid, submandibular, and sublingual. Their function is to secrete saliva into the mouth which starts the digestive breakdown of foods. As PH technicians we are primarily concerned with the parotid glands because they are the target of the mumps virus and become quite swollen when inflamed. The parotid salivary glands lie under the jawbone and can be seen and felt when swollen. With the trivalent measles, mumps, rubella (MMR) vaccine, mumps is much less common today than a few years ago.

Pancreas

The pancreas secretes digestive enzymes into the small intestine through small ducts. This is referred to as an "exocrine" function. These enzymes function in the digestion process by breaking down all three major nutrient groups, proteins, carbohydrates, and fats, into forms the body can use and/or store.

Liver

The liver is a large and an important accessory structure. Besides producing bile, which aids in the digestion and absorption of fats, the liver performs many other functions, including producing blood clotting factors and detoxifying certain chemicals. The liver also excretes bilirubin, which is a breakdown product formed from the hemoglobin in RBC. As RBCs reaches the end of their four-month life span, they rupture and release their hemoglobin. The hemoglobin is degraded to bilirubin and is then filtered from the blood by liver cells. Eventually, the liver cells incorporate this bilirubin into bile, which is secreted into the small intestine. If the bile duct leading into the intestine becomes blocked or the liver cells are damaged and unable to process the bilirubin, this yellow chemical accumulates to high levels in the bloodstream. This causes a yellowing of the skin and eyes known as jaundice which is an indication of liver damage. One example of jaundice as a symptom is in persons adversely reacting to INH, a medication taken for tuberculosis infection.

Gallbladder

This small pear-shaped reservoir is located between two lobes of the liver. The gallbladder stores concentrated bile and releases it when it is needed to digest a high fat meal.

018. Urogenital system

The urogenital system is composed of the urinary system and the reproductive system. They have very different functions, yet anatomically are closely related.

Structure and function of the urinary system

The urinary system is made up of two kidneys, two ureters, a bladder, and a urethra. The urinary system has an excretory function. Blood passes through the two kidneys where urine is formed. The urine is carried from each kidney by a ureter to the urinary bladder, where it is stored until it is voided. The last portion of the urinary tract is the urethra, which carries the urine from the bladder to the outside

Urine formation

Approximately 1,200 milliliter (ml) of blood (1/4 of the total cardiac output) passes through the kidney per minute. As blood passes through the kidney, a filtrate (filtered fluid) very similar to plasma is produced. For every 125 ml of filtrate produced, only 1 ml leaves the kidney as urine. Through the process of reabsorption, useful components, like glucose, sodium, and water, are removed from the filtrate and returned to the circulation. Other substances, like organic acids produced by metabolic processes in the body's cells, are secreted into the forming urine. The final concentration of the urine is determined by the body's need to conserve water. If the body is well or overhydrated, diluted urine is produced. When dehydrated, water is conserved by the kidneys forming very concentrated urine. The kidney's ability to produce concentrated urine is one measure of its normal function.

Urine analysis

The urine analysis (UA) is commonly performed in hospital laboratories to assess kidney health and function. By comparing the amounts of different organic and inorganic compounds excreted in the urine, trained observers can gain insight into the function of the kidney(s) and several different body systems. Additionally, a microscopic examination of the urine sediment may identify specific damage to kidney cells.

Reproductive system

Having covered the urinary system, you will focus on the other main component of the urogenital system, the reproductive system.

Structure of the male reproductive system

The reproductive organs consist externally of the penis and scrotum. Internally, the system is made up of several glands and the ducts that connect these glands.

Male Reproductive System	
Part	**Explanation**
Penis	Composed of erectile tissue (spongy mass of blood vessels). During stimulation, arteries dilate and veins constrict, allowing blood to flow in, but not out, causing the penis to become erect. The penis is designed to deliver sperm into the female reproductive tract. The end of the penis is covered by a structure called the prepuce or foreskin. Frequently, the foreskin is removed during the first few days of life—a procedure called *circumcision*. This operation is done to prevent irritation and facilitate cleanliness.
Scrotum	Ann external pendulous sac containing the testes and epididymis. The external location of the scrotum keeps the temperature of the testes lower than body temperature. It is about 3°F cooler than normal body temperature. This is necessary for proper sperm development.
Testis	The singular form of testes, which are two oval-shaped glands, suspended by the spermatic cords in the scrotum. They originate in the abdomen of the male fetus and descend into the scrotum about two months before birth. Occasionally, a child is born with undescended testes and must undergo surgery to bring the testes into the scrotum.
Urethra	A tube-like structure extending from the bladder to the external meatus (opening) of the penis. The urethra transmits urine from the bladder during urination and sperm from the testes during ejaculation.
Epididymis	The first part of a long duct or tube leaving the testes. The epididymis is a tightly coiled tube and sperm enter the epididymis for final maturation and storage. The continuation of the tube after the epididymis is called the *vas deferens* and it is important in transmitting sperm to the urethra during ejaculation. The vas deferens is the site of a common birth control procedure in males called a vasectomy. In this procedure, a portion of the vas is removed and the two ends sealed. The male continues to produce sperm normally, but the sperm are not able to reach the urethra.
Seminal vesicles	A gland that secretes nutrients for sperm.
Prostate	A doughnut-shaped gland that lies below the bladder. The urethra passes through the center of the prostate. It secretes a fluid to increase the motility of the sperm and protects sperm from the acid environment of the female tract.

Function of the male reproductive system

The testes are responsible for hormone and sperm production. Testosterone, the primary male hormone, directs sexual differentiation (in males) during early fetal development. Production

increases at onset of puberty and results in secondary male characteristics such as facial hair, deepening voice, and increased musculature. Sperm production, known as spermatogenesis, is a continuous, cyclical 74-day renewing process. Sperm cells (spermatogonia) mature into spermatids through a series of cell divisions. Spermatids have 23 chromosomes, which is half of the 46 chromosomes in the parent cells. Spermatids develop in the seminiferous tubules and when released are non-motile and incapable of fertilization. Final maturation and storage occurs in the epididymis.

Structure of the female reproductive system

The female reproductive system includes the vagina, cervix, uterus, fallopian tubes, ovaries and external genitalia.

Female Reproductive System	
Part	**Explanation**
Vagina (or birth canal)	A collapsed muscular tube. It is capable of tremendous amount of expansion during the birthing process.
Cervix	A fibrous tube between the vagina and uterus. The cervix normally closes during pregnancy, helping to maintain the pregnancy.
Uterus	A muscular organ with a glandular inner lining. The uterus nourishes the implanted embryo during pregnancy. At the end of the pregnancy, the uterine muscles undergo powerful rhythmic contractions to expel the infant.
Fallopian tubes (or oviducts)	Hollow tubes which stem from each side of the uterus. Fringe-like structures called *fimbriae* are located at the end of each fallopian tube and partially surround each ovary. However, there is no direct communication or linkage between the tube and ovaries. When an ovum is discharged from the ovary, it enters the abdominal cavity. The fimbriae draw ovum into the fallopian tubes. If sperm are present in the fallopian tubes, fertilization occurs and the fertilized ovum travel into the uterus for implantation. The open fallopian tubes create a direct channel from the outside environment into the abdomen; this enhances the potential for serious disease, especially abdominal complications of sexually transmitted diseases.
Ovaries	Two oval-shaped structures located in the abdominal cavity on each side of the uterus. These organs produce the female sex cells called ova and the female hormones, estrogen and progesterone.

Function of the female reproductive system

The ovaries are responsible for hormones and ova production. What are the hormones used for within the female?

Hormone production

The hormone estrogen is produced by the ovaries then released into the bloodstream. Estrogen is responsible for sexual differentiation in females, increased growth of the uterus and vagina, and repair of the uterine lining after menstruation. Progesterone is also produced by the ovaries and is important in preparing the uterus for implantation of the fertilized ovum and in maintaining pregnancy.

Oogenesis

Unlike spermatogenesis, oogenesis is not a continuous process.54 Approximately seven million stem cells called oogonia are produced by the seventh month of fetal life. By puberty, this number has fallen to around 400,000. Of that number, only 400 will become capable of ovulation. During oogenesis, oogonia mature by a series of cell divisions similar to spermatogonia. A mature ovum develops about every 28 days, which coincides with ovulation. The mature ovum has half, or 23, of the normal complement of 46 chromosomes.

Menstrual cycle

Menstruation is the periodic sloughing off of the lining of the uterus. The cycle is regulated by rhythmic changes in estrogen levels. Onset (menarche) is at puberty, usually between ages 11 to 15 years. It ends at menopause approximately 40 years later. The first day of menstrual flow is the first day of the cycle. The full cycle is 28 days long on the average.

At the beginning of the cycle, several ova start to grow and develop. After approximately one week, all but one degenerate. Simultaneously, the old lining of the uterus is sloughed causing menstrual flow. This sloughing is completed by the fifth day. The remaining ovum continues to grow until around day 14 when it literally "explodes" (ovulation) from the ovary and is drawn into the fallopian tube, where it travels into the uterus. During this time, the uterine lining has been thickening and rebuilding in preparation for a fertilized ovum. If there is none, the lining is shed and the cycle starts anew. Menstruation can enhance the spread of certain sexually transmitted diseases from the vagina into the uterus, oviducts, and abdomen.

Physiology of fertilization

Although only one sperm fertilizes an ovum or egg, many sperm are necessary to "peck away" the layer of protective cells surrounding the ovum. Because of this, and because so many sperm are lost along their journey through the female reproductive tract, unless a man's semen contains upwards of 20 million sperm cells per milliliter, the man may be considered sterile. Sperm cells can survive in the female tract for 24 to 72 hours and fertilize the egg, which is normally ovulated on the 14th day of the 28-day menstrual cycle. Fertilization occurs in the fallopian tube, and the fertilized ovum or zygote then moves into the uterus where it will freely migrate for approximately 10 days.

Embryology

Certain chemicals or other agents present in the workplace can be very hazardous to a developing fetus, especially during first three months of development (first trimester). Once the embryo attaches to the placenta in the uterine lining, blood is exchanged between the fetus and mother. This blood, flowing through the fetal umbilical cord, takes nutrients, like food and oxygen, to the embryo and carries away waste products, like carbon dioxide. Thus, whatever is contained within the mother's bloodstream will soon pass into the fetal bloodstream. These materials can be life sustaining or life threatening to the fetus depending on their source.

During the first trimester, all the major body systems are developing and are thus very susceptible to developmental abnormalities. For example, only four weeks after conception, the fetal heart is pumping blood, the spinal cord and digestive system are forming, and arm and leg buds are present. By eight weeks of age, the facial features are forming, the arms and legs are developed, and fingers and toes are forming. At the end of the first trimester or 12 weeks, the fetus is 3 inches long and all the major body systems have developed. From this point on in the pregnancy, the likelihood of major malformations drops off rapidly. What are some of the factors that place the fetus at risk?

Adverse influences

Adverse influences on the fetus or fertility can usually be grouped into one of four categories—teratogens, mutagens, carcinogens and gametotoxins.

Adverse Influence on the Fetus or Fertility	
Adverse Influence	**Explanation**
Teratogen	A substance that causes physical defects in the developing embryo.
Mutagens	Disrupt the cell's DNA resulting in a genetic defect. In addition, because the DNA carries the genetic information from parent to child, these defects may be inherited by future generations.

Adverse Influence on the Fetus or Fertility	
Adverse Influence	**Explanation**
Carcinogens	Substances capable of causing cancer. If the mother is exposed to carcinogens while she is pregnant, not only may she develop cancer later in life, but the child exposed while in the womb may also develop cancer much later. For example, radiation exposure may later result in leukemia.
Gametotoxins	Either reduces the number or the function of the gametes, the sperm, or ova. As we have already seen, a reduction in the number of sperm, even though millions are still present, can render a man functionally sterile. If the gametes do not function normally, this, too, can result in sterility (e.g., exposure to a gametotoxin can affect the function of the sperm's tail). If the tail does not work normally, the sperm cannot fertilize the egg and sterility results.

These concepts of fertilization, embryology, and the adverse influences in our environment that can affect the fetus provide the background for the fetal protection program you'll study later.

019. Human growth and development

The terms *growth* and *development* are both dynamic processes. Growth refers to the physical changes that can be measured and occur in a steady and orderly manner. Height and weight are two examples. Development relates to changes in psychological and social functioning. Different age groups generally act appropriately for their age. Certain developmental tasks should also be accomplished during each stage. Each stage lays the foundation for the next.

Growth and development occur from the moment of fertilization until death. The processes proceed from simple to complex. There is a sequence, order, and pattern to growth and development. This lesson explains nine age groups and the growth and development stages that usually occur in each stage. Though some people may either be slightly ahead of or behind these general expectations, an average view of each group is covered in this lesson. Understanding these expected characteristics is important for those involved in patient care. Knowing appropriate growth characteristics can help to identify abnormalities. Your knowledge of expected developmental characteristics serves to anticipate behavior for patients of various ages.

Infant growth and development (birth to 1 year)

Rapid physical, psychological, and social development characterize this period. The developmental tasks that have been identified for this period are developing stable sleep patterns, beginning to have emotional relationships with parents and siblings, beginning to talk and communicate with others, learning to eat solid foods, and learning to walk.

Average newborns weigh seven to seven and one-half pounds and are 20 to 21 inches long. Their birth weight usually doubles by the fifth or sixth month, and by the end of the first year, their weight triples and they should also grow 10–12 inches in the first year.

The newborn's central nervous system is not well developed. Movements are uncoordinated and generally without purpose. As the nervous and muscular systems develop, the infant develops specific voluntary and coordinated movements. Certain reflexes and involuntary movements normally are present and disappear as the central nervous system develops.

Infants can see at birth, but their vision is not clear. They respond to bright objects. They can also hear well and are startled by loud noises and soothed by soft sounds. At birth, they respond to touch, and their senses of smell and taste are developed.

During the first six months of life, the infant's diet usually consists of breast milk or formula. Solid foods, such as strained fruits and vegetables, are gradually added to the diet about the sixth month. Around the eighth month, the infant normally advances to junior foods, still remaining on breast milk

or formula until one year of age. Table food usually is introduced at the end of the infant stage. Note the various stages of development during the first 12 months of an infant's life:

Stages of Infant Development	
Month	**Description**
1	Can hold their head up while lying on their stomach.
2	Can smile and follow objects with their eyes.
3	Can raise their head and shoulders while lying on their stomachs, sit for a short time, and hold an object in their hand.
4	Can roll over, sit up when supported, and may sleep all night. The Moro and rooting reflexes have disappeared by this time. Can hold objects with both hands, puts objects in the mouth, and babbles when spoken to.
5	Can grasp objects and play with their toes. Teeth begin to erupt.
6	Usually have two lower front teeth and begin to chew finger food. Able to hold a bottle for feeding and can sit alone for short periods of time. Can manipulate small objects and vocalize one syllable sounds.
7	Upper teeth begin to erupt. Infants can respond to their name and begin to show a fear of strangers. Can transfer objects from one hand to another. Begin to imitate simple acts and sounds.
8	Can usually stand while holding onto something, respond to the word "no," and cry when scolded. Can feed themselves finger food and reach with open arms to be picked up. At this point, usually bashful and nervous with strangers.
9	Crawls and can pull to a standing position. Comply with simple verbal commands and can communicate with hand gestures (such as waving). Show a fear of being left alone, which may be evident when going to bed.
10	Can walk while holding onto objects, will look under objects for a toy, and can pull into a sitting position. Are also aware of their own names by this age.
11	Can stand momentarily and can play interactive games using body language. Can also communicate disapproval by shaking their head "no."
12	Begins to walk with help and can hold a cup for drinking. Demonstrates emotions such as anger and affection, and cling to parents in unfamiliar situations.

Toddler growth and development—one to three years

Physical growth is not as rapid during the second year of life as it is during the first year; however, the rate of development increases dramatically.

At one year, visual acuity is fairly well established. Between the ages of one and two years, toddlers grow approximately four to five inches. Fine muscle coordination and gross motor skills improve during the toddler years. At about 18 months, they can walk up stairs with assistance and pick up small objects and place them in a receptacle.

Several other things also occur with toddlers at the two-year point:

- Can be expected to weigh four times the birth weight.
- Lose most of their "baby look;" they are usually chubby, with relatively short legs and a large head. They have a protruding abdomen, which flattens as the child grows and the abdominal muscles develop.
- Can use spoons correctly, are able to run, balance on one foot, and ride a tricycle.

Toilet training is a major developmental task for the toddler. Bowel and bladder control is directly related to the development of the central nervous system (CNS). By three years, most children are toilet trained, although they may still have accidents while playing or during the night.

Speech and language skills begin to increase by age three. Speech becomes clearer, and the vocabulary increases as words are learned by imitating others. Toddlers understand more words than they use, and are capable of constructing two- to three-word sentences. They begin to play alongside

other children, but not with them. They are very possessive and do not agree with the concept of sharing. The word “mine” is used frequently. Temper tantrums are the way toddlers deal with frustration. They often respond to discipline by kicking and screaming.

At three years, the integration of visual and neuromuscular mechanisms is fairly well developed. This allows a child to look away from an object prior to reaching out and picking it up. Also, the senses of hearing, taste, smell, and touch become more developed and associated with each other. Hearing in the three year old is at adult levels. Touch is extremely important to toddlers; they are often soothed by tactile sensations.

Preschool growth and development—three to six years

The preschool stage is characterized by less physical growth than the toddler stage. Both gross and fine motor skills are fairly well developed. In this stage, the child shows increased independence and intellectual development. Preschoolers are less quarrelsome than the toddler; they are developing a sense of right and wrong, and they usually try to comply with the rules.

Growth is steady but slow at this stage. Height usually increases by two to three inches per year and weight increases about five pounds per year.

At three years old, play is very important. They usually play in a group of two or three children and are able to share toys. They play simple games and can follow simple rules. They may create imaginary playmates if there is no one to play with. They may also begin to imitate adults by playing “house” and “dress-up.” Three-year-olds also begin to understand time and begin to speak in the past, present, and future tenses. They become less fearful of strangers and can tolerate separation from their primary caregiver for short periods of time.

At age four, children can hop, skip, jump, and catch a ball. They can lace their shoes, draw faces, and try to print letters. Four-year-olds can bathe with supervision and take care of toileting needs with some help. Their vocabulary increases to about 1,500 words. They ask numerous questions and exaggerate when telling stories. They can sing simple songs, count to (at least) three, and name a few colors. Four-year-olds tend to verbally attack others by teasing or tattling on them. They may also physically attack others. They are proud of their accomplishments, but can be very moody. They have a strong preference for the primary caregiver of the opposite sex, and rivalries exist between siblings.

At five years, coordination continues to develop. These children can jump rope, skate, dress, and bathe. They can print a few letters and numbers and their first name. The ability to communicate also increases. Vocabulary consists of about 2,100 words. Sentences now consist of six to eight words, and more meaningful questions are asked. They may request definitions for unfamiliar terms and try to participate in conversations. Five-year-olds can name the days of the week, the months, and four or more colors. They are more responsible and truthful, and quarrel less. They strive to do things the right way, and begin to develop manners. These children also enjoy simple games. They enjoy adults during play and have a greater interest in watching television. They also enjoy spending time with their parents, as well as activities such as housecleaning, shopping, yard work, and sports. They are more tolerant of younger siblings and are usually protective of them. Although they have fewer fears, they may experience occasional nightmares.

Middle childhood growth and development—six to eight years

Physical growth during this stage is rapid. School is the greatest event that takes place during this stage. The child is exposed to a whole new world with new values, ideas, and challenges. Height increases at a rate of one to two inches per year, and weight increases at a rate of three to six pounds per year. Body proportions continue to change and become more adult-like. Body fat decreases and muscle and bone mass increase. Primary teeth are replaced by permanent teeth.

At six years, children have a vocabulary of about 2,500 words. They know all the letters of the alphabet, and can usually read and spell. They play well with others, but prefer playing with children of the same sex. Their play interest includes collections, cards, paints, games, and so forth.

At seven years, excellent eye-hand coordination is evident. Children learn to write in cursive rather than print. They enjoy quiet time alone and are more serious and concerned about being liked by other children. They are very sensitive and do not like being teased or criticized; they enjoy school and learning, especially reading; and their play activities include swimming, biking, working puzzles, and playing ball.

At eight years, children continue to be physically active. Movements become faster and more graceful. The process of learning continues to develop as they become curious about science, history, geography, etc. Social opportunities with peers are enjoyed. This age group has interests in fads, opinions, and activities involving peer groups. Eight-year-olds develop manners, relate well to adults, and participate in adult conversations. They are also friendly and affectionate.

Late childhood growth and development—nine to twelve years

Late childhood is also known as preadolescence. During this stage, males grow at a rate of one inch per year and gain about three to four pounds per year. Females grow at a rate of about two inches per year and gain between fourth and five pounds per year. Body movements are more graceful and coordinated, and there is an increase in physical skill.

The developmental tasks are similar to middle childhood; however, the preadolescent is expected to be more mannerly and refined. By age 12, the child uses about 7,000 words and can understand about 50,000 when reading. Interest in science, history, and geography continues and the use of reference books, such as the encyclopedia and dictionary, increases.

The preadolescent begins to question the authority of adults and often rebels against authority. The peer group is the center of the preadolescent's activities. The group influences the attitudes and behaviors of the child. They still prefer companions of the same sex; however, the association between girls is stronger than that of boys.

Adolescent growth and development—12 to 20 years

Adolescence is the stage of life between school age and adulthood. The adolescent is neither a child nor an adult, yet has characteristics of each. It is a period of growth, change, and emotional crisis. This is usually the period of separation from the parents and the establishment of lifetime goals. Adolescence is the last period of significant physical growth during the lifetime of a person. You grow in height and weight and mature sexually.

Usually, females have entered into puberty by age 12, but boys usually enter puberty around age 13. Body changes begin to occur due to the onset of puberty. Girls begin to develop breasts, the pelvis broadens, and fat appears on the hips and chest. Boys show fewer signs of maturing sexually at this time.

Some females may experience the onset of puberty as early as 10 years of age; most begin at age 12. This period is marked by *menarche*, the beginning of menstruation. Secondary sex characteristics appear, including increase in breast size, the appearance of pubic hair, and a slight deepening of the voice. During this stage, girls grow an average total of two to eight inches and gain anywhere from 15 to 50 pounds. They usually stop growing around age 18, but some will continue to grow until 21 years of age.

Puberty in males is signaled by *nocturnal emissions*, which occurs during sleep when the penis becomes erect and semen is released. Other secondary sex characteristics begin to develop, such as the appearance of facial hair, axillary hair, hair on the arms, chest, legs, and deepening of the voice. During this stage the male will grow an average total of four to twelve inches and gain about 15 to 60 pounds. The male will usually stop growing around age 21, but some may continue to grow until age 23.

The adolescent is often awkward and clumsy. This is due to the uneven growth of muscles and bones. As the muscles and bones develop, so do more graceful and coordinated movements.

Emotions vary in the adolescent from high to low. They can be happy one minute and sad the next. Teenagers begin to control their emotions as they progress toward adulthood. Adolescents need to become independent of adults, especially parents. Many work towards adulthood by having a part-time job, baby-sitting, and dating. Adolescents usually begin dating at this time and become more concerned with personal appearance. They spend a lot of time talking to friends on the phone, listening to music, and reading popular magazines. They still need guidance, discipline, and support from parents, although arguments and disagreements are common at this stage of development. Teenagers often would rather be with their peers than with their parents.

Adolescents begin to think about careers and college. Their interests and skills influence the choice of further education or seeking employment. Many social factors influence adolescents, such as parents, friends, television, culture, and school. In cases of troubled teens, common problems may include alcoholism, drug abuse, unwanted pregnancy, and criminal acts. Normally, at the end of this stage, adolescents have developed into young, self-sufficient adults. They usually are totally emancipated from parents, and have established goals and individual lifestyles.

Young adult growth and development—20 to 40 years

During this stage, the young adult continues to mature physically and emotionally. One of the main goals in young adulthood is choosing a career or occupation. Many career choices involve extensive education. The young adult may still be in school when he or she reaches this stage. Education enhances employment opportunities and helps to ensure economic stability. Entering a career usually means starting at the bottom and working upward. The young adult is faced with proving his or her abilities to older adults.

Another goal for the young adult is choosing a partner. Most young adults need to feel a sense of love and belonging that comes from having a long-term relationship. Many factors influence the selection of a partner, such as age, interest, religion, and most importantly, love. These two people must work together to build a loving relationship based on trust, respect, caring, and friendship. Most couples decide to have children. They must agree on child rearing practices and discipline methods. Starting a family involves a major change in lifestyle, and both must be ready to accept these changes.

During young adulthood many changes occur, both mentally and physically. After age 30 some physical deterioration will start, but it is usually gradual and not very noticeable. At the end of this period, young adults are close to accomplishing the goals of youth. They have made their place in society and are ready to move toward the next stage of life.

Middle adult growth and development—40 to 65 years

Middle adulthood is usually a time when people look back at the goals that have been accomplished so far. The adult is now mature mentally and physically. He or she has usually met most of his or her goals and now must guide others in doing the same. During this time many physical changes begin to occur. The hair begins to turn gray. Metabolism slows, resulting in a potential weight problem. Women experience *menopause*, which is the cessation of menstruation. They can no longer bear children. Calcium loss is common among women in this age group. Men experience a decrease in hormones, which can lead to a decrease in sex drive as well as thinning of the hair.

Adults have more time for themselves during this stage. Their children are growing up or have already grown up. Another factor middle adults may have to contend with is caring for elderly parents. This may result in the parents either moving in with them or possibly being relocated to a nursing care center.

Late adult growth and development—65 years and older

An increase in life expectancy has led to the creation of gerontology, which is the scientific study of the problems of aging. This science includes biological, psychological, and sociological aspects. A change in the appearance and the texture of the skin is a normal process of growth. The skin of the elderly person is usually thin and delicate and extremely sensitive to trauma. Proper skin care for the

elderly is very important. As the aging process occurs, there is a normal loss of subcutaneous (SC) fat near the skin surface. The loss of fat and the hardening of small arterioles cause the skin to become wrinkled. Decreases in blood supply and a gradual atrophy of the sweat glands and excretory functions result in the skin, becoming dry and more susceptible to infection.

Another physical change is the decline in stamina. With age all body cells change and undergo progressive deterioration. Body tissues gradually become less active. Unused muscles begin to atrophy and contribute to the decline of physical stamina.

There are also changes in the blood vessels. A loss of elasticity and/or the buildup of fatty deposits will limit the amount of oxygen that can get to the cells. The veins lose their strength; valves weaken, and often become distended. The loss of muscle tone and reduced physical activity will also affect the efficiency of the vessels. It is unknown if the changes that occur are due to simple aging or some other pathological cause. Some contributing factors may include trauma, obesity, malnutrition, and stress.

Psychologically, the aging adult needs respect, security, and self-esteem. The elderly need to feel appreciated and valued by others. There may be many emotional adjustments that the elderly have to deal with, such as the death of a spouse, children, or friends. Socioeconomic losses and the loss of health are also major psychological adjustments the elderly have to make.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

017. Digestive system

1. What are the three functions of the digestive tract?

2. What are the two main elements of the digestive system?

3. How is food moved through the digestive tract to the stomach?

4. What are the finger-like protrusions called that line the small intestine?

5. Which portion of the digestive tract serves to store fecal material until expelled?

6. What salivary glands are the primary targets for the mumps virus?

7. Which organ produces blood clotting factors and detoxifies certain chemicals?

8. High levels of bilirubin in the bloodstream cause what condition?

018. Urogenital system

1. How much urine leaves the kidney from 125 ml of filtrate production?

2. What is indicated when the kidneys are forming very concentrated urine?

3. What is the external pendulous sac that contains the epididymis?

4. What is the function of the epididymis?

5. What is the primary male hormone?

6. What are some examples of secondary male characteristics?

7. Which structures produce female hormones estrogen and progesterone?

8. Which female hormone is responsible for repairing the uterine lining after menstruation?

9. What is oogenesis?

10. How long can the sperm cells survive in the female tract and fertilize the egg?

11. Which substances reduce the number of sperm or ova?

019. Human growth and development

1. During which stage of life does the development of stable sleep patterns occur?

2. During late childhood, how many words are children capable of understanding?

3. What ages are included in the adolescent stage?

4. At which stage of life does physical deterioration start?

5. During which stage of life do people often look back at the goals they have accomplished so far?

3–4. Endocrine and Nervous Systems

The endocrine and nervous systems function as the body's internal communication system. The nervous system functions through a complex network of incoming and outgoing nerve tracts that pick up sensations, control muscles, and enable thoughts and memory.

020. Endocrine system

The endocrine system acts by releasing hormones into the bloodstream. These hormones can then act on only certain cells or on virtually every cell in the body. Before you look at some specific endocrine glands, let's see what hormones are and how their secretion is regulated.

Hormones and feedback systems

Hormones are chemical substances secreted into body fluids, usually the bloodstream, and they exert physiologic control on other cells of the body. Their secretion is controlled by a process known as *negative feedback*. In this process the *absence of a stimulus causes a greater response*. Put another way, the presence of a stimulus causes a shutdown of the response. A good example of this negative feedback system is illustrated in the interaction between the pituitary gland and the thyroid gland.

One of the hormones produced by the pituitary gland is thyroid stimulating hormone (TSH). TSH causes the thyroid to produce the hormone thyroxine. When the thyroid has produced enough thyroxine, the pituitary gland stops releasing TSH and the thyroid stops producing more thyroxine. The presence of the stimulus (in this case thyroxine) caused a shutdown of the response (pituitary release of TSH). However, as thyroxine levels begin to drop again, the pituitary senses the low thyroxine level and releases TSH, which in turn stimulates the thyroid to release thyroxine. In this case, the absence of the stimulus caused a greater response. This cycle goes on continually and is a good example of the way hormone levels are finely tuned by negative feedback systems.

Pituitary gland

The pituitary gland or hypophysis, located within the skull at the base of the brain, is called the *master gland* because it controls the secretions of so many other endocrine glands. In fact, the pituitary gland secretes eight different hormones:

The Pituitary Glad	
Hormone	**Explanation**
Thyroid stimulating hormone (TSH)	Controls the secretion of thyroxine from the thyroid gland.
Prolactin	Promotes mammary gland development and milk production in the female.
Corticotropin	Influences the adrenal glands.

The Pituitary Glad	
Hormone	**Explanation**
Follicle stimulating hormone (FSH) and luteinizing hormone (LH)	Both influence the reproductive organs in the male and the female.
Antidiuretic hormone	Controls the amount of water excreted by the kidney into the urine.
Oxytocin	Promotes milk let down and uterine contractions.
Growth hormone	Causes growth of all body tissues. If insufficient amounts of growth hormone are secreted during childhood, the affected individual is called a dwarf. In contrast, if too much is secreted during childhood, the individual may reach a height of 8 or 9 feet and is called a giant. Even after adulthood, a small amount of growth hormone secreted by the pituitary gland is necessary for a normal healthy state.

Thyroid gland

The thyroid gland, located immediately below the larynx, secretes the hormone thyroxine. Iodine is necessary for the thyroid's production of thyroxine; many people use iodized salt to ensure they eat adequate amounts of this important element. The disease, known as goiter, characterized by swelling of the thyroid gland, can result from a dietary deficiency of iodine. Normal amounts of thyroxine are essential to maintain a normal basal metabolic rate. If too much thyroxine is produced, the person becomes excitable and nervous and exhibits a rapid pulse, and in some cases, the eyes protrude slightly. This condition is called hyperthyroidism. If too little thyroxine is produced, the person always feels cold, has no energy, and is mentally sluggish. This condition is known as hypothyroidism.

Adrenal glands

Located just above the kidneys, the adrenal glands are really two separate organs joined as one, but very different in structure and function. The outer layer, or cortex, is absolutely essential to life. Its secretions influence salt absorption by the kidneys and the metabolism of sugars. The inner layer or adrenal medulla produces epinephrine and norepinephrine (sometimes called adrenaline and noradrenalin). These are responsible for the body's "fight or flight" response. They cause the body to mobilize energy and strength in response to a life-threatening situation.

Testes and ovaries

The ovaries in the female and the testes in the male are influenced by the pituitary hormones luteinizing hormone (LH) and follicle stimulating hormone (FSH). In the male, FSH regulates sperm production while LH controls secretion of the male hormone, testosterone. In the female, the ovaries secrete two different hormones, estrogen and progesterone. Estrogen causes the development of the secondary sex characteristics at puberty, and progesterone is necessary for implantation and to maintain the state of pregnancy during fetal development.

Pancreas

Although the pancreas has an exocrine function, as mentioned in the discussion of the digestive system, it also has an important endocrine function. The pancreas secretes two hormones, insulin and glucagon, which have essentially opposite functions. Insulin enables all body tissues to metabolize sugar circulating in the bloodstream, thus lowering blood sugar level. The lack of insulin causes a disease called diabetes mellitus. In the diabetic, since insufficient insulin is produced to enable cells to metabolize the blood sugar, the level of sugar in the blood rises to extremely high levels. Diabetes can usually be managed by a regulated diet and, in some cases, insulin injections. Glucagon increases blood sugar levels when they are too low.

021. Nervous system

You have just finished studying one of the body's internal communications systems, the endocrine system. Now, take a look at another, which acts even more quickly. The nervous system is composed of over 10 billion individual nerve cells (neurons), but no matter where in the nervous system they are located, they all have the same basic structure. The nervous system is the master controlling and communicating system of the body.

The nervous system has three main functions: sensory input, integration, and motor output.

1. Sensory input is the gathered information that the body receives from both the inside and outside of the body. The human body has millions of sensory receptors that are used by the nervous system.
2. Integration is how the nervous system processes and interprets the sensory input. At this moment the integration is deciding what should be done.
3. Motor output is the response of the nervous system. The motor output activates the effector organs which include the muscles and glands.

Anatomy of a neuron

The anatomy of neurons enables them to perform their primary function, conducting electrical impulses from one part of the body to another. All neurons consist of a cell body and two types of protrusions or processes. These processes are the axons and dendrites. Axons carry the impulses *away* from the cell body, while dendrites carry impulses *toward* the cell body. There are three types of neurons: sensory neurons, motor neurons, and interneurons. These types of neurons are classified on how they transmit impulses. Sensory neurons are responsible from transmitting the impulses they receive from the spinal cord and brain and transmitting to all of the body. Now, motor neurons do the complete opposite of sensory neurons; they are responsible for transmitting away from the brain and spinal cord to muscle and glandular tissue. The final neuron, interneuron, has the important job of transmitting impulses from sensory neurons to motor neurons. Although neurons are similar in anatomy and physiology, the nervous system is divided into the central nervous system (CNS) and the peripheral nervous system (PNS).

Central and peripheral nervous systems

The CNS is made up of the brain and spinal cord, which contains both gray and white matter. Gray matter is gray in color because it contains so many cell bodies. White matter derives its color from the nerve fibers and the insulating myelin coatings they contain. Much of the gray matter is found in the cerebrum, which accounts for $^{7}/_{8}$ of our total brain weight. The cerebrum is divided into frontal, parietal, temporal, and occipital lobes and accounts for our ability to speak, think, and function at higher levels than other animals. The spinal cord contains nerve tracts running to and from the brain and, thus, is largely made of white matter. The brain and spinal cord are well protected by several structures. First, they are well protected by bone. The skull protects the brain, and the bony vertebral column provides excellent protection for the spinal cord. Beneath this bony protection, the meninges also cover the brain and spinal cord protecting them. The meninges are multilayered membranous coverings. When they are inflamed by viruses, bacteria, and fungi, the condition is called meningitis. Finally, within and around the brain and spinal cord, cerebrospinal fluid (CSF) provides a protective layer that functions as an excellent shock absorber. CSF can be withdrawn and analyzed; its composition can provide important diagnostic information during illness.

The peripheral nervous system consists of cranial nerves and spinal nerves and serves as the communication line between the CNS and the rest of the body. There are main divisions of the PNS, the sensory division and the motor division. The sensory division is responsible to provide input from the body into the CNS. The motor division is responsible for carrying signals to muscles and gland. The motor division is further broken down into the somatic nervous system and autonomic nervous system (ANS). The somatic nervous system is responsible for conducting impulses from the CNS to

the skeletal muscles; it is often referred to as the voluntary nervous system. The ANS is responsible for conducting impulses from the CNS to cardiac and smooth muscles and the glands; it is often referred to as the involuntary nervous system. Finally, the ANS is broken down into two divisions: sympathetic (fight or flight responses) and parasympathetic nervous system (rest and digest). Regardless of what part of the nervous system we are talking about though, the method by which nerves carry impulses is the same.

Nerve conduction

Impulses travel *electrically within a single nerve and travel by chemical means when crossing from one nerve to the next*. In electrical transmission a nerve impulse travels down an axon because the electrical voltage within the nerve changes from negative to positive. This advancing electrical discharge carries the impulse down the length of the nerve until it reaches the synapse. The synapse is a small cleft or space between nerve cells. The electrical voltage reversal cannot cross this gap, but chemicals can. When the electrical impulse arrives at the end of the axon, a chemical is released that crosses the synapse. When this chemical reaches the next neuron, it sets up the same reversal of electrical voltage, and the impulse then moves down that neuron electrically. A chemical substance that crosses the synapse and enables the impulse to move from one neuron to the next is called a neurotransmitter.

One example of a neurotransmitter is the very common acetylcholine. Botulism toxin exerts its effects by inhibiting the release of acetylcholine, thus blocking the conduction of impulses from one nerve to the next. Absence of acetylcholine can lead to paralysis and death. Too much of a good thing, in this case acetylcholine, is not good either. Once the acetylcholine is released into the synapse, it continues to stimulate the neurons as long as it is present. There must be some way of removing it once it has served its purpose; otherwise, once stimulated by acetylcholine, the nerve might continue to discharge for hours. Acetylcholine is removed from the synapse by an enzyme, acetylcholine esterase. This chemical prevents acetylcholine from accumulating in the synapse and causes repeated nerve stimulation.

Understanding the physiology of nerve conduction simplifies understanding the toxicology of different nerve agents used in warfare, as well as, the organophosphate pesticides commonly used on Air Force installations. These poisons interfere with the activity of acetyl cholinesterase. If this enzyme is nonfunctional, acetylcholine in the synapse is not inactivated, and once released the acetylcholine continues to stimulate the nerve or muscle. In man, this poisoning causes pinpoint pupils, salivation, diarrhea, and can be fatal.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

020. Endocrine system

1. What process controls the secretion of hormones?

2. Which organ produces growth hormone?

3. What is the condition that produces too much thyroxine, where the person becomes excitable, nervous, exhibits a rapid pulse, and in some cases the eyes protrude slightly?

4. Which organ produces epinephrine?

5. Which hormone in males controls secretion of the male hormone testosterone?

6. What is the function of insulin in the body?

021. Nervous system

1. Which structure of a neuron carries impulses away from the cell body?

2. What are the two divisions of the nervous system?

3. What are the two parts to the central nervous system?

4. Name the four lobes in the cerebrum.

5. What is a multilayered protective membranous covering around the spinal cord underneath the bony protection?

6. Which division of the PNS carries impulses to a muscle or gland?

7. Which chemical crosses the synapse of a neuron to enable an electrical impulse to move from one neuron to the next?

8. Which substance stops the chemical stimulation action in the neuron?

3–5. Sensory Systems

We gather information about the world we live in with our sensory systems. The importance of this input is put into its proper perspective when one realizes that those experimentally deprived of all sensory input begin to hallucinate in only a few hours. Any sensation you can imagine will occur if only four requirements are met. First, a stimulus must be present. This stimulus, a physical event, may be a light or sound wave, a change in temperature, a painful stimulus, or something else. Second, you must have a receptor capable of responding to the stimulus and of changing the physical event into a set of nerve impulses. The receptor can be a hair cell in the inner ear, a rod or cone in the retina of the eye, or another receptor specially adapted to receive special stimuli. Third, there must be a conducting pathway from the receptor to the CNS. This pathway is found in the PNS. Fourth, the CNS must interpret the impulses and bring about a conscious sensation of the stimulus. You'll now study two of the major sensory systems: skin and eyes, as they pertain to public health.

022. Human skin

The skin is the largest organ of the body and has four primary functions; sensation, protection, secretion, and temperature regulation. The skin's receptors sense pain, touch, temperature, and pressure. The skin also serves a protective function by protecting the underlying tissues from harmful chemical, physical, and biological agents, and inhibiting the excessive loss of water and electrolytes. The third function of the skin is that of secreting sebum from sebaceous glands and sweat from sweat glands. The last function performed by the skin is that of temperature regulation. As a public health professional, your focus is more on temperature regulation than the other three functions of the skin.

Temperature regulation

The skin helps regulate the internal temperature of the body by adjusting its blood flow and by sweating. Take a look first at how a change in blood flow to the skin can affect body temperature. When the body is hot, the vessels in the skin can dilate and accept up to seven times the normal amount of blood. Heat in the blood can then be efficiently radiated from the skin to the surroundings like a car radiator. On the other hand, when the body is cold and needs to conserve heat, blood flow to the skin is restricted. It may be so restricted that it actually slows fingernail growth due to inadequate circulation and nutrition of the nail bed. This system of heat radiation is effective only when the surroundings are cooler than the body. Once the ambient temperature rises above body temperature, this mechanism is no longer effective. In fact, heat is actually radiated to the body from the hot environment. At this point, the other method of heat regulation, sweating, must take over. As the sweat evaporates off the skin surface, a considerable amount of heat is lost in the process. When the humidity in the air is high, evaporation is less effective and the heat seems more oppressive. Under very hot conditions, a person can sweat up to four liters per hour. Not only is a lot of fluid lost, but also tremendous amounts of electrolytes (salts). These substances must be replenished or serious metabolic problems can occur.

Common lesions

When studying tuberculosis skin tests and the symptoms associated with different communicable diseases, you'll hear these medical terms tossed around. A good understanding of these terms will be very useful in your dealings with patients and other medical personnel.

Common Lesions	
Term	**Definition**
Dermatitis	Inflammation of the skin.
Erythema	Reddening of the skin.
Induration	Swelling.
Pustule	A blister filled with pus.

Common Lesions	
Term	**Definition**
Vesicle	A blister or elevation filled with fluid, not pus.
Ulcer	An erosion of the skin surface.
Papule	Reddened, solid elevation of the skin.
Macule	A reddened, flat spot on the skin.

023. Eyes

The eye is a receptor capable of responding to a very narrow frequency band within the electromagnetic spectrum. This narrow frequency band is called visible light.

The sclera is the white protective layer on the outside of the eyeball. It is continuous with the cornea, which is the clear protective layer on the front of the eyeball. Within the eyeball, the iris, or colored part of the eye, dilates and constricts depending on the amount of available light, allowing the light rays to pass through an opening, the pupil, on into the deeper parts of the eye. Light then passes through the lens, which focuses the light onto the back surface of the eye, the retina. The retina contains the receptor cells known as the rods and cones, which are capable of changing a physical event (light rays entering the eye) into a nerve impulse that is then carried to and interpreted by the brain as vision. This is the normal course of events. However, changes in the shape and structure of these organs can cause visual abnormalities.

Visual Abnormalities of the Eye		
Condition	**Cause**	**Correction**
Myopia (nearsightedness)	Caused by an eyeball that is too long. Instead of the image clearly focusing on the retina, it is focused in front of the retina and blurred by the time it reaches the retina.	A biconcave lens will diverge the incoming light rays so they will be clearly focused on, not in front of, the retina.
Hyperopia (farsightedness)	The opposite situation exists when someone has hyperopia or farsightedness. In this case, the eyeball is too short and the image has not had a chance to be focused by the time it strikes the retina.	A biconvex lens converges the incoming light rays so they will be clearly focused on, not in back of, the retina.
Astigmatism	Someone with astigmatism has a cornea or lens that is not evenly curved resulting in a distortion of the image.	A specially shaped corrective lens can counteract the image distortion. The lens of the eye is normally clear allowing unobstructed passage of light to the retina.
Cataracts	Cataracts occur when the lens becomes cloudy; thus restricting vision.	In some cases, vision is improved by removing the clouded lens.
Color blindness	The most common type of color blindness is red-green color blindness. In this condition, either the red-sensitive or green-sensitive cones are missing, so the person cannot perceive the difference in these colors, and both appear the same.	There is no correction for color blindness.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

022. Human skin

1. What are the four main functions of the skin?

2. Under very hot conditions, how much sweat can a person lose?

3. What does erythema mean?

4. What is meant by vesicle?

5. What is a papule?

023. Eyes

1. What is the white protective layer on the outside of the eyeball called?

2. Which portion of the eye contains the receptor cells known as rods and cones?

3. What is another name for nearsightedness?

4. Which type of lens is used to correct farsightedness?

5. What can be a corrective action for cataracts?

3–6. Basic Principles of Immunology

The earliest recognition of the immune phenomenon was associated with smallpox. Thousands died as a result of this and other deadly diseases. Nevertheless, the fact that those who had recovered from an attack of smallpox did not become reinfected led Orientals to practice self-inoculation with smallpox matter. As you may recall, it was Edward Jenner (1749–1823) who undertook an exact approach to vaccination by vaccinating people with cowpox, which led to today's smallpox vaccine.

This section is concerned with an infected person's defense mechanisms against an infectious agent. This requires an understanding of natural and acquired defenses and the laboratory tests used to monitor a patient's response. Your study of immunity is important in aiding the health care provider in the diagnosis and treatment of infectious diseases and contributes directly to your successful management of communicable disease programs.

024. Mechanics of immunity

When a person comes in contact with microbes that cause an infectious disease, the body responds in an attempt to counteract the effect of the disease-producing agents. If the response is such as to provide partial or complete protection, then that person is said to have a certain degree of immunity. Immunity, which may be either natural or acquired, is the subject matter of the science of immunology.

Natural resistance

When we speak of natural resistance to disease, we are referring to immunity dependent on some special anatomical or physiological property of an animal species rather than to a specific antibody. For instance, the fact that we are human gives us a certain nonsusceptibility that is different from that of dogs, cats, or other lower animals. On the other hand, many animals have a natural resistance quite different from that of humans. We know, for example, that foot-and-mouth disease rarely affects man, but it produces a possible fatal infection in cattle, sheep, and goats. Hepatitis B virus and syphilis are diseases unique to humans. Tuberculosis is common in humans, cattle, pigs, and chickens, but it is uncommon in sheep, cats, dogs, and horses.

Many defense mechanisms are active in natural resistance. Although there is much overlapping, these defense mechanisms can be divided into two categories: anatomical and chemical. Examples of anatomical mechanisms include the physical barrier of the intact skin, which prevents disease organisms from entering the body; WBCs, called phagocytes, which actively engulf (phagocytize) foreign substances; and the sweeping action of the cilia in the respiratory tract, which physically removes disease agents. Examples of chemical natural defense mechanisms include lysozyme, an enzyme present in many body fluids that attacks bacteria; interferon, a substance the body produces to fight viral infections; and the highly acidic pH (potential of hydrogen; measure of acidity) of the stomach that destroys most microbes.

Acquired immunity

Acquired immunity develops before birth and throughout the lifetime of the individual. A baby passively receives protective immune substances from the mother's blood during fetal development and, after birth, in breast milk. Exposure to organisms after birth often results in the development of active immunity. There are important differences between the passive and active types of acquired immunity.

Passive immunity

Passive immunity is a type of acquired immunity because antibodies are involved. It differs from active immunity by the fact that the antibodies produced by another person are passed on to the recipient. The recipient receives the immunity from these "borrowed" antibodies, but is not actively producing them. Passively transferred antibodies are important to the recipient because they give *immediate protection*. However, since they are gradually destroyed by the body, this protection

decreases, and the recipient eventually becomes susceptible to reinfection. Passive immunity can be acquired both naturally and artificially.

Naturally acquired passive immunity

Naturally acquired passive immunity is significant mainly in the survival of newborn infants. Infants passively acquire antibodies from their mothers. The antibodies may pass from the immune mothers to the fetuses across the placental barrier. Additionally, infants acquire these antibodies from their mothers' milk, which is rich in antibodies for a short time after birth. Of course, immunity is transferred only if a mother is immune to a given disease. Passive immunity is especially important to newborns because they are incapable of producing antibodies of their own for a few months after birth. The antibodies received via natural transfer from the mother are relatively short-lived, with protection seldom exceeding six months. Fortunately, by this time the infant's immune system is fully functional.

Artificially acquired passive immunity

Antibodies that were produced in one person and injected into another (the recipient) provide this type of immunity. This method is used for prophylaxis following exposure to such diseases as rubella and as antitoxins against tetanus, botulism, and snake venoms. Passive immunization is also used in conjunction with active immunization to provide immediate, temporary protection against diseases such as rabies and hepatitis B until the body can produce its own antibodies.

Active immunity

Active immunity is another type of acquired immunity because it involves specific antibodies against a foreign substance. It is called active immunity because the body actively produces antibodies in response to an exposure of an agent. This exposure may be from an infection or in response to vaccinations.

Active immunity is not always perfect and can be graded into a series of levels that extend from complete immunity to a state approaching complete susceptibility. Since the body's defenses can often be overcome if the challenging dose of microbes is large enough, several grades of illness can occur between the two extremes. Antibodies may or may not contribute to immunity; for example, an individual may produce antibodies to human immunodeficiency virus (HIV) that have no apparent protective value at all, but their detection may be useful in diagnosis.

Naturally acquired active immunity

When a person is infected with a specific disease organism, antibodies develop, and the person is resistant to reinfection by the organism. The result of natural infection is active production of antibodies, which provides naturally acquired active immunity. In many diseases, such as smallpox, mumps, measles, and chickenpox, infection and resulting antibody production results in permanent immunity. However, this is not always the case in other infections. For example, influenza and gonorrhea result in very short-lived immunity and repeated attacks are common.

Artificially acquired active immunity

For many diseases, vaccination has proven to be an effective method of providing immunity. Antibodies are actively produced in the body in response to vaccination, an artificial infection. This immunity is not absolute and the ability of vaccines to provide long-term protection varies considerably. For example, plague vaccine must be given every six months for protection, but yellow fever shots every 10 years. Obviously, the yellow fever vaccine is much more effective than plague vaccine.

An example of the use of active and passive immunization is the use of rabies vaccine and immune globulin. Rabies is a viral disease and 100 percent of those infected die if not vaccinated. Since humans rarely have any naturally acquired immunity to rabies, an unvaccinated person exposed to the disease would have to rely solely on artificially acquired immunity. Rabies immune globulin would

be given to provide immediate short-term protection (passive immunity). Rabies vaccine would also be used to stimulate the person's antibody production (active immunity) to provide long-term protection. Susceptible or nonimmune individuals exposed to hepatitis B virus are treated in a similar fashion. Hepatitis B immune globulin (HBIG) provides immediate, temporary protection, and hepatitis vaccine stimulates active production of antibodies for long-term protection.

025. Serology

The diagnosis of disease by detection of antibodies in the blood (serum) is called serology. Serology plays an important role in our communicable disease control programs. Frequently, serology is the only practical means of diagnosing a given disease. Perhaps isolation of the causative agent would be impossible, too expensive, or take too long to benefit the patient. We use serology in our sexually transmitted disease program to identify syphilis infections, discriminate between hepatitis A and hepatitis B viral infections, and determine the susceptibility of hospital employees to rubella (German measles) and rubeola (measles). Serology can also be used for the detection of other substances such as hormones to diagnose noninfectious conditions. Pregnancy is diagnosed using serology.

Antibodies

Especially significant to the health care provider and you in the diagnosis of infectious disease is the level of antibody or titer produced during the course of a disease. The presence of antibodies can indicate either a past (old) or current (active) infection. The presence of antibodies can also indicate the individual was vaccinated against a particular disease.

In most cases, serology cannot determine whether antibodies are the result of infection or vaccination. In most diseases, the titer (antibody level) increases in response to an active infection. A person may be considered actively infected if the titer rises or if it reaches a certain level, such as fourfold the normal level. To detect a rise in antibody level, you must take at least two blood samples, the first early in the disease (acute), and the second during recovery (convalescent) several days or weeks later.

After the infection is controlled or eliminated, the titer gradually falls. Frequently, the antibody may still be detected, but this does not mean the person has an active or current infection. Rather, it is an indication of past infection. As an example, someone may have a low antibody titer to influenza virus, indicating immunity from a previous infection. The same person would be considered actively infected if the titer showed an increase over two to three weeks or the titer was high (four-fold normal) in a single sample.

Antigen-antibody interaction

Much is known today about antigens, antibodies, and their interactions. To understand how the body fights infection, you must first learn the characteristics of antigens and antibodies.

Antigens

Any foreign substance that stimulates the body to produce an immune response is called an antigen. An antigen might be a microbe, part of a microbe, a microbial toxin, or even some foreign product completely unrelated to microorganisms such as pollen. In general, an antigen is anything the body recognizes as foreign or "not self." Antigens stimulate the formation of specific antibodies, and these antibodies must react with the antigen in some observable way.

Antibodies

Antibodies are found in the globulin fraction of serum proteins. More specifically, most antibody activity is in the gamma globulin fraction of serum globulin. Thus, antibodies are frequently called immunoglobulins.

Just as antigens are defined in terms of their reactivity with antibodies, all antibodies are intimately associated with their antigens. These antibodies must be able to react in some demonstrable way with

the antigen, which stimulated their production. In general, each antibody will react only with the antigen that stimulated the body to produce that antibody. In other words, each antibody possesses a high degree of specificity, although there are some exceptions to the rule.

Immunoglobulin

The immunoglobulin (Ig) orantibodies of man can be further categorized into five main classes: (1) IgG, (2) IgM, (3) IgA, (4) IgD, and (5) IgE. Most antibody activity is due to IgG, IgM, or IgA, with certain diseases causing the production of more of one class than another. Additionally, the class that is produced in greatest quantity varies with the number of times the individual has been exposed to a particular antigen. Usually, on the first contact, such as vaccination, IgM is the main antibody produced, but on subsequent contacts, IgG usually predominates. The five classes of antibodies vary somewhat in their functions, as explained in the following table.

Immunoglobulin	
Antibody	**Explanation**
IgG	Is the most abundant class, comprising about 75 percent of the total serum immunoglobulin. IgG is the only antibody small enough to cross the placenta in the immune mother; thus protecting the newborn child. IgG antibodies neutralize toxins and viruses in the bloodstream and in tissues. IgG is usually the antibody involved in secondary response to infection and immunization, and is most often detected later than IgM in initial infections.
IgM	Constitute 6 to 8 percent of the serum antibodies, but is very important because it's usually the first antibody to respond to infection. IgM antibody is 700 to 1,000 times more effective than IgG in neutralizing bacteria because it is the largest of the immunoglobulin and has many antigen-antibody reaction sites.
IgA	Occupies a unique position among the immunoglobulin in that it is found in body secretions in addition to comprising about 20 percent of the serum immunoglobulin. IgA occurs in large amounts in tears, colostrum, saliva, mucus, and other internal secretions, and provides immune response to pathogens that enter by the respiratory or gastrointestinal tracts.
IgD and IgE	Are found in very small amounts in the serum. IgE is responsible for allergic responses and believed to be important in the activation of B cells.

026. Immune system cells and tissues

The immune system encompasses the whole body, but the lymphoid system is the site and source of most immune activity. This system is composed of organs, tissues, and cells that constantly combat any infectious agent that tries to invade the body. The lymphoid system is also called the reticuloendothelial system. Additionally, lymphatic system structures, such as lymph vessels and lymph nodes, serve as the site for removal of most large foreign agents such as bacteria.

The lymphoid or reticuloendothelial system involves organs and tissues where lymphocytic cells originate, mature, and differentiate or specialize. Once mature, the lymphoid cells either lodge in the lymphoid organs or move throughout the body.

Lymphoid organs

The bone marrow, spleen, thymus, and lymph nodes are organs where the cells of the immune system develop, mature, and differentiate.

Lymphoid cells

The lymphocyte is the cell that protects the body from infection once a foreign agent has entered. All lymphocytes come from stem cells formed in the bone marrow. However, during the maturing process, lymphocytes differentiate into B-lymphocytes and T-lymphocytes, also called B- and T-cells. Both are very important in immunity, but they respond to infection in very different ways.

B-lymphocytes (B Cells)

The B-lymphocyte is the basis for humoral immunity, that is, immunity involving antibodies. When a B-cell detects an antigen, it further differentiates into a plasma cell or a memory cell. The plasma cell produces antibodies against the antigen. The memory cell waits until a later time when the same specific antigen enters the system.

T-lymphocytes (T-cells)

T-lymphocytes are the basis for cellular immunity and do *not* produce antibodies. Instead, they produce a number of chemicals that recruit other cells, such as B-cells and phagocytes, in the immune response. T-cells further differentiate, for example, into killer, helper, and memory cells. Killer T-cells have a special function in detecting and destroying abnormal (not self) cells such as tissue grafts, tissue damaged by radiation or chemicals, bacteria, viruses and tumor cells. T-cells also destroy cells of the body (self) that have been made abnormal by infectious agents such as bacteria, viruses, fungi, protozoa or worms. To illustrate the importance of the T-cell, the HIV infects and destroys the T (helper)-cell. When a sufficient number of helper cells are destroyed, the individual immune cells cannot respond effectively, and the individual develops Acquired Immunodeficiency Syndrome (AIDS). Additionally, the T-cell is responsible for coordinating the positive tuberculosis skin test reaction in persons previously exposed to the tuberculosis organism.

Structures of the lymphatic system

The lymphatic system is a drainage system that collects fluid from interstitial (intercellular) spaces and returns it to the cardiovascular circulation of the body. This is part of the fluid regulation cycle in which fluid leaves the blood, goes into the intercellular spaces, and returns to the bloodstream via the lymphatic (lymph vessels). Lymph is similar to plasma, the fluid portion of blood. The structures of the lymphatic system include lymph capillaries, lymph vessels, lymphatic ducts, and lymph nodes.

Lymph capillaries

Lymph capillaries are the smallest of the system. They are microscopic and blind-ended. They branch throughout the intercellular space and collect lymph. The capillaries eventually come together to form a vessel.

Lymph vessels

Lymph vessels are similar to veins and collect the lymph from the capillaries. Physiologically, lymph vessels are very similar to veins. They have one-way valves located within them and have very low pressure. The one-way valves keep the lymph flowing toward the lymphatic ducts. Flow through these valves is possible for several reasons. Lymph is propelled by skeletal muscle action and natural artery pulsation. Pressure changes within the thorax and smooth muscle contraction in vessel walls also force lymph through vessels. Finally, the formation of new lymph pushes the old forward toward the ducts.

Lymphatic ducts

Lymph vessels empty into two main trunks. The largest is called the thoracic duct, which collects fluid from all of the body except the right lobe of the liver, right arm, and right side of the head, neck and thorax, including the right lung and right side of the heart. The smaller duct is the right lymphatic duct. Both ducts empty lymph into the venous circulation of the body.

Lymph nodes

Along the lymphatic vessels, at various intervals, are small structures known as lymph nodes. The nodes consist of an inner core of lymphatic tissue surrounded by a fibrous capsule. The lymph nodes act as a filter, removing foreign substances from the lymph as it passes through the nodes. In healthy people, the lymph nodes usually go unnoticed. However in certain diseases, such as lymph granuloma venereum or plague, the lymph nodes may become swollen, painful, and hard due to infection.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

024. Mechanics of immunity

1. What is natural resistance?

2. What are white blood cells called that engulf foreign substances?

3. Give three examples of anatomic natural defense mechanisms.

4. Give three examples of chemical natural defense mechanisms.

5. When does acquired immunity occur?

6. In naturally acquired passive immunity, how does the fetus acquire antibodies from its mother?

7. Why is passive immunity especially important to the newborn?

8. Why are passive immunizations used in conjunction with active immunizations?

9. What is active immunity?

10. Which type of immunity is the result of a natural infection?

11. Give two examples of diseases that produce a short-lived immunity and two examples of those producing life-long immunity.

025. Serology

1. Name three diseases that can be diagnosed by serology.

2. Define antibody titer.

3. What happens to the antibody titer in response to infection?

4. What two patterns of an antibody titer are characteristic of active infection?

5. What is an antigen?

6. What is a synonym for antibody?

7. What are the five identified classes of immunoglobulin?

8. Most antibody activity in human serum is due to what three classes of immunoglobulin?

9. On the first contact with a particular antigen, what antibody is mainly produced?

10. On a second or subsequent contact with an antigen, what antibody usually predominates?

11. Which antibody crosses the placenta and is responsible for protection of the newborn?

12. Which immunoglobulin is the primary responder to entry of pathogens through the respiratory or gastrointestinal tracts?

13. Which two classes of immunoglobulin are found in minute quantities in the serum?

026. Immune system cells and tissues

1. Lymphocytes develop into what two types of cells?

2. The B-lymphocyte can further differentiate into what two types of cells?

3. What does a B-lymphocyte produce in response to an antigen?

4. Cellular immunity is the basis of which type of cell?

5. Which cell is destroyed by the human immunodeficiency virus?

6. Which cell is involved in the tuberculosis skin test positive reaction?

7. What are the structures of the lymphatic system?

Answers to Self-Test Questions

013

1. The arms and legs.
2. The clavicle (collarbone) and the scapula (shoulder blade).
3. Tendons.
4. Small pieces of bone and bone chips are created through a fracture.
5. A hematoma (mass of clotting blood) forms at the facture site.

014

1. The sliding filament mechanism.
2. High myoglobin content.
3. Aspartate amino transferase.
4. Loss of nerve supply to the muscle and lack of use.
5. A disease affecting muscles of both animals and man and is caused by eating meat containing infective trichinella cysts.

015

1. To help regulate body temperature.
2. Red blood cells.
3. Anemia.
4. Group B.
5. No antigens.
6. The pericardium.
7. Left atrium.
8. Circulatory shock.

016

1. Turbinates.
2. Cricothyrotomy or tracheotomy.
3. Trachea or windpipe.
4. Diaphragm.
5. Pneumothorax.
6. Pulmonary edema.

017

1. Breakdown (mechanical and chemical); absorption; and elimination of wastes.
2. The alimentary canal and the accessory glands.
3. Gravity and muscular contractions.
4. Villi.
5. The large intestine.
6. The parotid salivary glands.
7. The liver.
8. Jaundice.

018

1. 1 ml.
2. The body is dehydrated.
3. Scrotum.
4. Final maturation and storage of sperm.
5. Testosterone.
6. Facial hair, deepening voice, and increased musculature.
7. Ovaries.
8. Estrogen.
9. The maturing of oogonia by a series of cell divisions into a mature ovum.
10. From 24 to 72 hours.
11. Gametotoxins.

019

1. Infant.
2. 50,000.
3. 12 to 20 years.
4. Young adult, after 30.
5. Middle adult.

020

1. Negative feedback.
2. The pituitary gland.
3. Hyperthyroidism.
4. Adrenal glands.
5. Luteinizing hormone.
6. Enables the tissues of the body to metabolize sugar circulating in the bloodstream; thus lowering blood sugar levels.

021

1. Axons.

2. Central nervous system and the peripheral nervous system.
3. Brain and spinal cord.
4. Frontal, parietal, temporal, and occipital.
5. The meninges.
6. Motor division.
7. Acetylcholine.
8. Acetylcholine esterase.

022

1. (1) Sensation, (2) protection, (3) secretion (sebum and sweat), and (4) temperature regulation.
2. Up to 4 liters per hour.
3. Reddening of the skin.
4. A blister or elevation filled with fluid, not pus.
5. A reddened, solid elevation of the skin.

023

1. The sclera.
2. The retina.
3. Myopia.
4. A biconvex lens.
5. Removing the clouded lens.

024

1. Immunity dependent on some special anatomical or physiological property of an animal species rather than a specific antibody.
2. Phagocytes.
3. (1) Physical barrier of the skin, (2) phagocytes, and (3) sweeping action of the cilia in the respiratory tract.
4. (1) Lysozyme (enzyme), (2) interferon (antiviral agent), and (3) high acid content of stomach fluids.
5. An immunity that develops before birth and throughout the lifetime of the individual.
6. Across the placental barrier and through the mother’s milk.
7. The newborn is incapable of producing antibodies of its own for a few months after birth.
8. For immediate temporary protection against diseases such as rabies and hepatitis B until the body can produce its own antibodies.
9. An immunity where the body actively produces antibodies in response to an exposure of an agent.
10. Naturally acquired active immunity.
11. Influenza and gonorrhea for short-lived immunity; while smallpox, mumps, measles, and chickenpox result in life-long immunity.

025

1. Any three of the following:
   (1) Syphilis.
   (2) Hepatitis A or B.
   (3) Rubella.
   (4) Rubeola.
2. It is the antibody level.
3. The titer rises or reaches a specific level.
4. An increase in titer over a period of weeks or a single sample that is a very high titer (such as a four times normal reading).
5. Any foreign substance that stimulates the body to produce an immune response.

6. Immunoglobulin.
7. (1) IgG, (2) IgM, (3) IgA, (4) IgD, and (5) IgE.
8. IgG, IgM, and IgA.
9. IgM.
10. IgG.
11. IgG .
12. IgA.
13. IgD and IgE.

026

1. B-lymphocytes and T-lymphocytes (B- and T-cells).
2. Plasma or memory cells.
3. Antibodies.
4. T-cell.
5. T helper cell.
6. T-cells.
7. Lymph capillaries, lymph vessels, lymphatic ducts, and lymph nodes.

Do the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter.

Do not return your answer sheet to AFCDA.

25. (013) Which is *not* part of the skeleton system?
    a. Bone marrow.
    b. Ligaments.
    c. Tendons.
    d. Blood.

26. (014) What is the point on which applied muscle action results in motion?
    a. Attachment.
    b. Insertion.
    c. Origin.
    d. Belly.

27. (014) Wasting away of muscle is called
    a. atrophy.
    b. hypertrophy.
    c. myoglobin reduction.
    d. Sliding filament mechanism.

28. (015) The blood group containing B antigens and anti-A antibodies is group
    a. A.
    b. B.
    c. AB.
    d. O.

29. (016) The common passageway for both the respiratory and digestive systems is the
    a. pharynx.
    b. trachea.
    c. cricoid.
    d. larynx.

30. (016) Emphysema causes
    a. white blood cells and fluids to accumulate in the lungs, impairing gas exchange.
    b. destruction of lung tissue making less tissue available for gas exchange.
    c. an allergic response resulting in narrowing of the small airways.
    d. dry-land drowning from fluids due to choking agents.

31. (017) Protein digestion begins
    a. with the release of the enzyme pepsin into the stomach.
    b. by contact with hydrochloric acid in the stomach.
    c. when proteins enter the small intestine.
    d. when proteins enter the large intestine.

32. (017) In which area of the digestive tract does the greatest nutrient absorption take place?
    a. Cecum.
    b. Stomach.
    c. Large intestine.
    d. Small intestine.

33. (017) An example of a vestigial organ is the
    a. cecum.
    b. stomach.
    c. appendix.
    d. pancreas.

34. (017) Which organ secretes digestive enzymes into the small intestine?
    a. Liver.
    b. Pancreas.
    c. Appendix.
    d. Gallbladder.

35. (018) How much filtrate does it take to produce approximately 1 milliliter (ml) of urine under normal kidney function?
    a. 50 ml.
    b. 125 ml.
    c. 200 ml.
    d. 275 ml.

36. (018) The meatus is part of which structure in the male?
    a. Testes.
    b. Urethra.
    c. Scrotum.
    d. Epididymis.

37. (018) What are the fringe-like structures that draw ovum into the fallopian tubes?
    a. Cilia.
    b. Oogonia.
    c. Fimbriae.
    d. Mycogenera.

38. (018) Which process is *not* continuous?
    a. Spermatogenesis.
    b. Menstruation.
    c. Oogenesis.
    d. Ovulation.

39. (018) At how many weeks in the development of a fetus are fingers and toes forming?
    a. 4.
    b. 5.
    c. 8.
    d. 12.

40. (018) Substances that cause physical defects in the developing embryo are called
    a. teratogens.
    b. mutagens.
    c. carcinogens.
    d. gametotoxins.

41. (018) Which substances reduce the numbers of sperm or ova in the body?
    a. Mutagens.
    b. Teratogens.
    c. Carcinogens.
    d. Gametotoxins.

42. (019) A toddler is expected to weigh four times the birth weight at age
    a. 12 months.
    b. 18 months.
    c. 24 months.
    d. 30 months.

43. (019) This stage is usually the period of separation from parents and the establishment of lifetime goals
    a. Late childhood growth and development–9 to 12 years.
    b. Adolescent growth and development–12 to 20 years.
    c. Young adult growth and development–20 to 40 years.
    d. Middle adult growth and development–40 to 65 years.

44. (020) What is the condition where too much thyroxine is produced?
    a. Goiter.
    b. Hypothyroidism.
    c. Hyperthyroidism.
    d. Thyroid stimulating hormone deficiency.

45. (020) Which hormone controls the production of testosterone in the male?
    a. Follicle stimulating hormone.
    b. Corticotropin.
    c. Lutenizing.
    d. Growth.

46. (021) Which contains insulating myelin coatings and is found in the spinal cord?
    a. Parietal lobes.
    b. White matter.
    c. Gray matter.
    d. Meninges.

47. (021) What protects the brain beneath the skull and the spinal cord beneath the vertebral column?
    a. Meninges.
    b. Cerebrum.
    c. Myelin coating.
    d. Occipital lobes.

48. (021) What chemical substance crosses the synapse and enables the impulse to move from one neuron to the next?
    a. Acetylcholine.
    b. Dendrites.
    c. Axons.
    d. Villi.

49. (022) Up to how many liters of fluid per hour can be lost through sweat under very hot conditions?
    a. 4.
    b. 6.
    c. 8.
    d. 10.

50. (022) Reddening of the skin is called
    a. dermatitis.
    b. erythema.
    c. induration.
    d. vesicle.

51. (022) A blister or elevation filled with fluid, not pus, is a
    a. pustule.
    b. papule.
    c. macule.
    d. vesicle.

52. (023) The white protective layer on the outside of the eyeball is the
    a. sclera.
    b. retina.
    c. cortex.
    d. cornea.

53. (024) Which is an example of an anatomical defense mechanism?
    a. Interferon.
    b. Lysozyme.
    c. Phagocytes.
    d. Stomach acids.

54. (024) Which immunity produces antibodies following an actual infection?
    a. Naturally acquired active immunity.
    b. Naturally acquired passive immunity.
    c. Artificially acquired active immunity.
    d. Artificially acquired passive immunity.

55. (025) Which antibody is usually the first to respond to an infection?
    a. IgA.
    b. IgD.
    c. IgG.
    d. IgM.

56. (025) Any foreign substance that stimulates the body to produce an immune response is called a/an
    a. immunoglobulin.
    b. antibody.
    c. antigen.
    d. serum.

57. (026) What produces chemicals that recruit other cells such as phagocytes in the immune response?
    a. Plasma cells.
    b. Lymph vessels.
    c. B-Lymphocytes.
    d. T-Lymphocytes.

58. (026) Lymph vessels empty into which structure?
    a. Lymph capillaries.
    b. Lymphatic ducts.
    c. The aorta.
    d. The liver.

Student Notes

Please read the unit menu for unit 4 and continue ➔

Unit 4. Medical Record Documentation

AS YOU HAVE ALREADY LEARNED, our career field requires knowledge of many medical terms and concepts. Undoubtedly, you'll be required to read medical records or even write in a patient's record during your career.

4–1. The Medical Environment

This section explains some of the more common medical terms and abbreviations. Occasionally rereading this section will help you remember these terms.

027. Medical terminology

This lesson covers the terms used to describe locations or directions on the human body as well as common root words, prefixes, and suffixes found in medical terms.

Locational terms

The human body can be divided several ways to describe the location of a particular portion of the body. These divisions include the mid-sagittal, transverse, and coronal planes. A directional term is usually associated with the use of one of these planes. These directional terms are covered as you study the respective planes.

Mid-sagittal plane

The mid-sagittal plane is an imaginary plane that extends the length of the body, dividing it into equal right and left portions. The directional terms used with this plane are usually medial and lateral. Medial describes a point closest to the mid-sagittal plane. Lateral describes a point further away from the mid-sagittal plane. For example, the ear is lateral to the eye, and the nose is medial to the eye.

Transverse plane

A transverse plane is an imaginary plane that extends the width of any portion of the body dividing it into upper and lower portions. The directional terms used with this plane are superior (means a point above) and inferior (means a point below another point on the body). For example, the chest is superior to the abdomen, while the genitals are inferior to the abdomen.

Coronal plane

The coronal, or frontal, plane is an imaginary plane that extends the length of the body dividing the body into front and back portions. The directional terms used with this plane are anterior (means to the front) and posterior (means to the back of the coronal plane). For example, the nose is anterior to the esophagus, while the buttocks are posterior to the esophagus.

Other directional or locational terms

There are some other terms used to describe direction or location, which are explained in the following table:

Some Directional and Locational Terms	
Term	**Definition**
Point of origin	Is the beginning of an extremity or a system. For example, the mouth is the point of origin for the digestive system. Directional terms associated with the point of origin are proximal (closest to the point of origin) and distal (furthest away from the point of origin). The stomach is proximal and the anus is distal to the mouth.
Unilateral and bilateral	Unilateral means affecting only one side of the body or one of a pair of body organs. Bilateral means affecting both sides of the body or both pairs of body organs. A bilateral ear infection affects both ears.
Adduction	Movement toward the mid-line of the body
Abduction	Movement away from the mid-line of the body.
Flexion	Movement to *close* an angle such as the arm movement in a salute (closes the elbow joint).
Extension	Movement to *open* an angle such as reaching out with your arm to turn on a light (opens the elbow joint)

Root words

Roots form the basis for word meanings. If you can recognize the root of many medical terms, you may be able to determine the meaning of the whole word. Some of the more common root words used in medical terminology is explained in the following table:

Common Root Words and their Meaning		
Root	**Meaning**	**Example**
Aden	Gland	Adenectomy means removing a gland.
Adip	Fat	Adipose means of a fatty nature.
Arteri/o	Artery	Arteriogram is a test which traces the pulse in an artery by means of radiography.
Cephal	Head	Cephalgia is a headache.
Chondri	Cartilage	Subchondral means under the cartilage.
Cost	Rib	Epicostal means upon the rib.
Crani	Skull	A craniectomy would be the surgical removal of the skull.
Cyst	Bladder	Cystitis is inflammation of the urinary bladder.
Derma or dermat/o	Skin	Dermatology is the study of the skin.
duct	Tube	An oviduct is a tube through which eggs pass.
Gastr	Stomach	Gastritis is an inflammation of the stomach.
Gen	To produce	Carcinogen is something which causes cancer.
Glossal	Tongue	Glossalgia means a pain in the tongue.
Hepat	Liver	Hepatitis is inflammation of the liver.
Myo	Muscle	The myrocardium is the heart muscle.
Nephr (more commonly used) and ren	Kidney	Nephritis is an inflammation of the kidney. “Ren” is used with the suffix “al” as in renal.
Neuro	Nerve	A neurocyte is a nerve cell.
Opthalm	Eye	An opthalmologist is a physician who specializes in the eye and its pathology.

Common Root Words and their Meaning		
Root	**Meaning**	**Example**
Oste	Bone	Ostectomy is bone removal.
Ot	Ear	An otoscope is the instrument used to see inside the ear.
Ov	Egg	Ovarigenic means originating in the ovary.
Thrombo	Blood clot	A thrombosed vein contains clotting cells or thrombocytes.
Vas	Vessel	Vascularization is the development of blood vessels in tissue. A vasoneuropathy is any nerve and vessel disease.

Prefixes

Prefixes are beginnings of words. If you can recognize the root word and its prefix, you may be able to figure out the meaning of a medical term. Some of the more common prefixes and examples of their use are explained in the following table:

Common Medical Prefixes		
Prefix	**Meaning**	**Example**
A or an	Without	Abrachial means without an arm, and anorexia means without appetite.
Ad	To or toward	Adneural means toward a nerve.
Ante	Before	Antebrachial means before the forearm.
Bi	Two	Bisection means cutting into two parts.
Bio	Life	Biology is the study of life.
Epi	Upon or on	Epispinal means upon the spine
inter	Between	Intercostal means between the ribs.
intra and endo	Within	Intracranial and endocranial both mean within the skull.
Erythr/o	Red	An erythrocyte is a red blood cell.
Hem/o or hemat	Blood	Hematology is the study of blood.
Hyper	Above or an excess	Hypertension is elevated blood pressure.
Hypo	Below or deficient	Hypoglycemia is deficient blood sugar.
Leuk/o or leuc/o	White	A leukocyte is a white blood cell.
Peri	Around	Pericardium means around the heart.
Pneum/o or pneumon/o	Refers to air, breath, or lungs.	Pneumonitis is an inflammation of the lung, and pneumothorax is a build-up of air outside of the lungs in the thoracic cavity.
Retro	Behind	Retronasal means behind the nose.
Sub	Under	Subcutaneous means under the layer of skin.

Suffixes

Suffixes are endings of words. If you recognize both the root word and its suffix, you may be able to determine what a specific medical term means. Some of the more common medical suffixes with examples of their use are explained in the following table:

Common Medical Suffixes		
Suffix	**Meaning**	**Example**
algia	Pain	Arthralgia is painful joints.
blast	Forming cell	An erythroblast is a newly forming red blood cell.

Common Medical Suffixes		
Suffix	**Meaning**	**Example**
cyte	Cell	Leukocytes and erythrocytes are blood cells.
ectomy	Surgical removal of a part of the body	A pneumonectomy is the removal of a lung.
it is	Inflammation	Otitis is inflammation of the ear.
logy	Study of	Neurology is the study of nerves.
osis	Condition of	Dermatosis means any skin disease which is not characterized by inflammation.
pathy	Disease	Dermopathy is a disease of the skin.
scopy	Visual examination of	Endoscopy is the visual examination of the inside of a body organ.
stasis	Standing still	Hemostasis means blood that is not moving properly through the circulatory system.
stenosis	Narrowing	Arteriostenosis means narrowing of the arteries.
tomy	Surgical incision	A cystotomy is the surgical incision into the bladder.

Other word endings can be used to make a word a noun, an adjective, or a word meaning *pertaining to*. For example, the root word for heart is *card*. Nouns often end with either *um* or *ium*. So the noun form of the word for heart muscle becomes myocardium. The root becomes an adjective with the addition of the suffix *al*—ardial, as in mycocardial attack. Words ending with *ac* mean *pertaining to*—cardiac means pertaining to the heart.

Medical abbreviations

Use of abbreviated terms is a timesaver. Abbreviations generally help medical personnel document large amounts of information without completely writing out all of the details word by word. Only specific abbreviations are authorized for use and some of the more common follow:

q.d., b.i.d., t.i.d., and q.i.d.

If a patient's medication was labeled one tablet, q.d., the medication should be taken once daily. The abbreviation b.i.d. means twice per day, t.i.d. means three times per day, and q.i.d. means four times per day.

With and without

The symbol that means "with" is a *c with a line over it.* This comes from the Latin word con meaning *with*. The symbol that means "without" is an *s with a line over it*. This is from the Latin word sin meaning *without*.

P.O.

P.O. is from the Latin word "per os" that means *mouth or orally*. If a doctor writes two tabs P.O. t.i.d., the patient would take two tablets orally three times per day.

Other abbreviations

Hx means *history*, and c/o or c/c means *complains of* or *chief complaint*. The symbol for *male* is an O with an arrow pointing at a 45° angle from it (♂), and the symbol for *female* is the same circle with a cross pointing directly down from the bottom (♀). The provider may request a B/P meaning *blood pressure* on a patient. S&S means *signs and symptoms*. The abbreviation for *left eye* is O.S., while the abbreviation for *right eye* is O.D. The physician may want to R/O or *rule out* a specific Dx or *diagnosis* such as "common cold R/O allergy." Test results may be WNL meaning *within normal limits* or TNTC meaning *too numerous to count*. If the patient is on medication, the doctor may increase medication using an upward arrow pointing (↑) or may decrease medication using a downward pointing arrow (↓).

For other terms and abbreviations not covered here, consult a medical dictionary or ask for assistance from your local medical administration office.

028. Medical ethics

Ethics are moral principles or values held by a group, person, or profession. Ethical behaviors are the established standards of behavior to be followed by everybody within a specific group, such as the health care professions. One ethical behavior for medical personnel is to maintain patient confidentiality. On those occasions when you have access to medical records or discuss personal information with patients, you must protect this information from public disclosure.

Working and patient relationships

Your job requires you to work with many people in the medical and nonmedical communities. These relationships are very important to establish your professional credibility. However, it only takes one incident of unprofessional behavior to ruin that trustworthiness.

One of the most important relationships you have is with your patients. Your confidence, combined with a sensitive and honest approach, should reassure them they are receiving the best professional care. The patient trusts you to keep sensitive information confidential. Since your training has made you more knowledgeable about preventive health procedures than the average person, you must determine what information your patients need and educate them whenever possible.

Release of information

AFI 33–332, *The Air Force Privacy and Civil Liberties Program*, covers the release of medical and other personal information. One helpful principle to remember in this regard is to keep disclosure to a minimum. Only persons or agencies with a verified need to know may have access to patient medical records. These people could include, but are not limited to, the patient, the patient's primary health care provider, and other health care personnel; medical inspectors and statisticians; and special agencies such as the Air Force Office of special Investigations (AFOSI); and federal, state, or local public health offices. Patients must provide written consent for release of information to their insurance companies, legal representatives, and other third parties.

Public Health does not release medical information unless directed by AFI, AF Phamphlet, or another responsible authority. The Patient Administration Office is the official office for release of personal medical information. Personnel accomplishing patient administration activities, whether assigned to the patient administration element or in a clinical setting, must be aware of the contents of AFI 41–210, *Tricare Operations and Patient Administration Functions.* Health records are the property of the United States government, not the individual. This designated record set consists of electronic health records, outpatient records, inpatient records, mental health records, and dental records. Information in the health record is personal to the individual and will be properly safeguarded. Take necessary precautions to avoid compromise of medical information during the movement of the record within and outside the MTF and from the facility to any person authorized to receive them. As public health technicians it is very important that you secure records properly. Lock them in an office or in a drawer if you must keep them overnight; otherwise send all medical records back to the records section.

Medical personnel must comply with the Privacy Act, Freedom of Information Act, Health Insurance Portability and Accountability Act (HIPAA), Drug Abuse Offense and Treatment Act, and Comprehensive Alcohol Abuse amendments. Each of these laws must be complied with regarding maintenance, access and disclosure of information from health records and related documentation. Medical records are maintained within a system of records protected by the Privacy Act. Disclosure to third parties is prohibited, except with written consent of the individual to whom the record pertains or in specified limited circumstances as outlined in the Privacy Act (as implemented by AFI 33–332), and the HIPAA Privacy Rule.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

027. Medical terminology

1. Which body plane is an imaginary plane that extends the length of the body, dividing it into equal right and left portions?

2. What does medial mean?

3. What is a coronal plane?

4. What does adduction mean?

5. What does the root word *adip* mean?

6. What does the root word of cystitis mean?

7. What does the root *oste* mean?

8. What does the prefix *endo* mean?

9. What does the prefix in leukocyte mean?

10. What does the prefix *peri* mean?

11. What does the suffix *algia* mean?

12. What does the suffix *stenosis* mean?

13. What does the word ending *ac* mean?

14. What is the abbreviation for taking medication by mouth or orally?

15. What is the abbreviation for a person's right eye?

028. Medical ethics

1. What are ethics?

2. Which AFI covers the release of medical and other personal information?

3. Which office has the official responsibility for releasing medical information?

4–2. Medical Record Documentation

You've read about medical terminology and ethics used in medical professions. This section teaches you about the medical records used to document the patient's medical problems. There are specific guidelines for documenting medical records. Most of the forms are legally binding and admissible in a court of law. Rules for documenting are standardized so that all health care personnel can easily read the record. You should be able to find and read specific patient information to effectively perform your duties.

029. Medical records—types and documentation

Before you learn about the forms associated with the communicable disease program that are found in medical records, you must be able to identify the different types of Air Force medical records. They include the inpatient record used for hospitalizations, dental record, and outpatient record, which is most frequently used by medical personnel. The patient's full name with sponsor's social security number must appear on each form in the record. Family prefixes include the following: "20" preceding the social security number indicates the record is for the sponsor; "30" indicates spouse; and "01" indicates the first child, "02" the second child, and so on. You should look on the outside cover of the records to see if the patient has drug allergies or is currently undergoing some specific treatment such as isoniazid (INH) for exposure to tuberculosis or specific chemotherapies for the treatment of cancer.

In addition to its use for documenting patients' medical problems or progress, the medical record is used as a communication tool among health care providers. As a legal form, entries must reflect that an organized and scientific approach was used to diagnose and treat the patient. Each entry includes the date and time of entry and is written in black, blue, or blue-black reproducible ink. Entries must be legible with correct grammar, spelling, and the author's signature. Correct mistakes legibly with a single line through the mistake and the author's initials signed above the correction. Original copies of all forms should remain in the medical record; if this not possible, photo or carbon copies are acceptable documents.

Standard Form 600, Chronological Record of Medical Care

This form is the most often used form in the medical record. On each Standard Form (SF) 600, entries must follow a specific format to standardize documentation. This format is called SOAPP, denoting subjective, objective, assessment, plan, and prevention entries.

SOAPP Format	
Entry	**Explanation**
Subjective	Includes what the patient, family, or other observers say about the patient, such as "she's allergic to penicillin." All entries in this section must be relevant to the patient's problem and be concise, yet complete.
Objective	Includes any observations made about the patient such as laboratory test results. You would also include any completed actions such as discussing preventive health teaching or completing patient contact interviews.
Assessment	Is the professional opinion about the patient's problem based on the subjective and objective information previously gathered by the person making the entry. This section may be difficult to understand if it is a medical diagnosis made by a healthcare provider who used unfamiliar medical terminology and abbreviations. It is important to remember that PH cannot make a medical diagnosis. A PH technician can make entries about the patient's knowledge of a disease process, methods to prevent the transmission of disease, or motivation to follow the health care provider's orders.
Plan	Is the plan or list of actions to help solve the patient's problem. This section must be specific and tell what, how, when, and any other pertinent information such as follow-up actions, if necessary.
Prevention	Is the strategy to prevent recurrence of the patient's problem.

Common errors made in SOAPP entries include poor grammar, misspellings, and illegibility. Other errors include too general or too wordy entries and entries that do not pertain to the patient's problem. Significant problems also occur when PH personnel write a medical diagnosis in the assessment section.

030. Reviewing medical records

Your duties in public health require you to recognize and read many different forms contained in medical records. This lesson briefly covers the various forms used for Community Health Management and Force Health Management programs. Details pertaining to these forms are explained in subsequent volumes as they apply within each section.

Community Health Management forms

Three forms you'll see in the medical records are AF Form 2453, Tuberculosis Detection and Control Data; AF Form 570, Notification of Patient's Medical Status; as well as DD Form 2341, Report of Animal Bite - Potential Rabies Exposure. You'll also see some laboratory reports for tests ordered.

Reading laboratory results

You need to recognize various laboratory test results. The most common way you will receive these results is through the Composite Health Care System (CHCS). Test results that are abnormal will be highlighted. The normal limits for various tests may differ depending on the procedures your lab uses. Check with your own laboratory for its normal numbers.

Other forms

Some other forms you may need to review are for radiology and special consultation.

SF 519B, Radiologic Consultation Request/Reports

Review this form for patients either suspected of active tuberculosis or who were exposed to a person with active tuberculosis. The respiratory system is the target organ for the mycobacterium. This form is also used for requesting and reporting X-rays for personnel on the occupational examination program. You may need to bring test results to the attention of the occupational health consultant. If you are performing an occupational trend analysis, you might compare chest X-ray results for a group of employees assigned to the same workplace.

SF 513, Medical Record -Consultation Sheet

This form is used when one medical section needs the expertise of another medical section. If a physician suspects a patient's medical problem could be work-related, the physician refers the patient to PH using this form. You receive this form, investigate the workplace situation, and report to the requesting physician. The SF 513 is also used in the Fetal Protection Program to request PH input regarding potential duty restrictions for pregnant employees.

Force Health Management forms

The next area you'll review records for is the occupational health program. You might perform a special trend analysis or review incoming personnel for prior exposures. One big area in the occupational health program is occupational illnesses and injuries.

Aeromedical Services Information Management System Occupational Illness Report

A physician who suspects an occupational illness or an occupational injury with chronic health consequences refers patients to PH for interview with an SF Form 513. PH interviews the patient and consults with Bioenvironmental Engineering. A workplace evaluation may be necessary. If an occupational illness is validated, an Occupational Illness Report, found in ASIMS Air Force Reportable Event Surveillance System (AFRESS) Epidemiology Module, is completed. The form is forwarded to the appropriate agency automatically with the monthly ASIMS data transfer. The Occupational Illness and Injury Program is discussed in detail in volume 3.

Hearing conservation forms

All personnel enrolled in the Hearing Conservation Program should have these forms in their medical records.

- DD Form 2215—Used to record all reference audiograms.
- DD Form 2216—If the employee experiences a significant hearing threshold shift, subsequent 15- and 40-hour audiograms are recorded on this form.
- AF Form 1672— Used to request and record further audiologist evaluation: if the patient requires a detailed follow-up.

Medical examination and history forms

The following lists medical examination and history forms you may use.

- SF Form 78, Certificate of Medical Examination —Completed for civilian workers' initial occupational medical examinations.
- SF 88, Report of Medical Examination— Is completed for military patients' initial occupational medical examinations.
- SF 93, Report of Medical History— Patients who provide a complete medical history do so on this form.
- AF Form 1527, History of Occupational Exposure to Ionizing Radiation— Workers exposed to ionizing radiation will complete this form.

- OEHED, Occupational and Environmental Health Exposure Data Form— Workers assigned to hazardous work areas surveyed by BE have this form placed in their medical records. *Exception*: those workplaces whose only exposure is to hazardous noise.
- AF Form 469, Duty Limiting Condition Report— Is used to temporarily or permanently limit a military person's duty. PH personnel see this most often for employees in the Fetal Protection Program.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

029. Medical records—types and documentation

1. What does a "20" in front of the social security number of Air Force medical records indicate?

2. What markings must be on the outside cover of medical records for specific treatments or exposures?

3. What is the most often used form in the medical record?

4. Which SOAPP entry includes information given from a family member about a patient?

5. Which SOAPP entry includes laboratory test results?

030. Reviewing medical records

1. Which form will be filled out when there is a potential exposure to rabies?

2. How are abnormal lab tests identified in CHCS?

3. Which form would you review to find the result of a chest X-ray?

4. Which form should accompany a patient being referred to your office for a suspected occupational illness?

5. Which form would you review for a pregnant employee transferring to a new occupational shop?

Answers to Self-Test Questions

027

1. Mid-sagittal plane.
2. Describes a point closer to the mid-sagittal plane.
3. An imaginary plane that extends the length of the body dividing it into front and back portions.
4. Movement toward the mid-line of the body.
5. Fat.
6. Bladder.
7. Bone.
8. Within.
9. White.
10. Around.
11. Pain.
12. Narrowing.
13. Pertaining to.
14. P.O.
15. O.D.

028

1. The moral principles or values held by a group, person, or profession.
2. AFI 33–332, *The Air Force Privacy and Civil Liberties Program.*
3. The Patient Administration Office.

029

1. The record or document belongs to the sponsor.
2. Drug allergies, specific treatments such as INH, and specific chemotherapy for cancer.
3. SF Form 600, Chronological Record of Medical Care.
4. Subjective.
5. Objective.

030

1. AF Form 2341 Report of Animal Bite – Potential Rabies Exposure.
2. They will be highlighted.
3. SF 519, Radiological Consultation Requests/Reports.
4. SF 513, Medical Record - Consultation Sheet.
5. AF Form 469, Duty Limiting Condition Report.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field Scoring Answer Sheet.

Do not return your answer sheet to AFCDA.

59. (027) Which suffix means narrowing?
    a. Stenosis.
    b. Stasis.
    c. Algia.
    d. Osis.

60. (028) Which Air Force instruction (AFI) covers the release of medical and other personal information?
    a. AFI 48–145, *Occupational and Environmental Health Program*.
    b. AFI 41–210, *Tricare Operations and Patient Administration Functions*.
    c. AFI 33–332, *Air Force Privacy and Civil Liberties Program*.
    d. AFI 33–102, *Communications and Information Specialized Publications*.

61. (029) The prefix “20” in front of a social security number on a medical record indicates the record is for the
    a. spouse.
    b. sponsor.
    c. first child.
    d. second child.

62. (029) How should a patient’s medical record indicate he or she has drug allergies?
    a. Outside of the record should be marked.
    b. Inside of the record should be marked.
    c. Record will be yellow.
    d. Record will be red.

63. (030) Which form should you review to determine the particular duty restrictions of a military worker?
    a. AF Form 190, Occupational Illness/Injury Report.
    b. AF Form 469, Duty Limiting Condition Report.
    c. SF 513, Medical Record - Consultation Sheet.
    d. SF 88, Report of Medical Examination.

Glossary

Abbreviations and Acronyms

AAAHC	Accreditation Association for Ambulatory Health Care
ABO	antibodies blood group
ADP	adenosine diphosphate
AFI	Air Force Instruction
AFIA	Air Force Inspection Agency
AFIS	Air Force Inspection System
AFISRA	Air Force Intelligence, Surveillance, and Reconnaissance Agency
AFMS	Air Force Medical Service
AFOSI	Air Force Office of Special Investigations
AFPC	Air Force Personnel Center
AFSC	Air Force specialty code
AFRESS	Air Force Reportable Event Surveillance System
AIDS	Acquired Immunodeficincy Syndrome
AME	Aerospace Medicine Enterprise
amu	atomic mass number
ANG	Air National Guard
ANS	autonomic nervous system
ASIMS	Aeromedical Services Information Management System
AST	aspartate amino transferase
ATP	adenosine triphosphate
CCIP	Commander’s Inspection Program
CDC	Centers for Disease Control and Prevention
CHCS	Composite Health Care System
CNS	central nervous system
CO_2	carbon dioxide
CSAF	Chief of Staff of the Air Force
CSF	cerebrospinal fluid
DI	disease and injury

DOD	Department of Defense
DNA	deoxyribonucleic acid
DRU	direct reporting unit
EPA	Environmental Protection Agency
FDA	Food and Drug Administration
FOA	field operating agency
FSH	follicle stimulating hormone
FSIS	Food Safety and Inspection Service
HAF	Headquarters Air Force
HBIG	hepatitis B immune globulin
HIPAA	Health Insurance Portability and Accountability Act
Ig	immunoglobulin
IMA	individual mobilization augmentee
IMR	individual medical readiness
INH	isoniazid
LH	luteinizing hormone
MAJCOM	major command
MDG	Medical Group
MGA	major graded area
MI	management inspection
Ml	milliliter
mmHG	millimeter of mercury
MMR	measles, mumps, and rubella
MPES	Manpower Programming and Execution System
MTF	medical treatment facility
NAF	numbered Air Force
NIOSH	National Institute for Occupational Safety and Health
NCOIC	noncommissioned officer in charge
NOAA	National Oceanic and Atmospheric Administration
NSI	nuclear surety inspection
OSHA	Occupational Safety and Health Administration

PCS	permanent change of station
PH	public health
PHA	Preventive Health Assessment
PNS	peripheral nervous system
POC	point of contact
RBC	red blood cell
Rh	Rhesus
RNA	ribonucleic acid
SAF/IG	Secretary of the Air Force/Inspector General
SC	subcutaneous
SECAF	Secretary of the Air Force
SF	standard form
SGOT	serum glumatic oxaloacetic transaminase
SME	subject matter expert
SOAPP	subjective, objective, assessment, plan, prevention
TSH	thyroid stimulating hormone
UA	urine analysis
UEI	unit effectiveness inspection
UMD	unit manning document
UPMR	unit personnel management roster
USDA	United States Department of Agriculture
USDC	United States Department of Commerce
USDHHS	United States Department of Health and Human Services
USPHS	United States Public Health Service
WBC	white blood cell
WIT	Wing Inspection Team

Student Notes

Student Notes

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