

# Pathology Competencies for Medical Education and Educational Cases

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Barbara E. C. Knollmann-Ritschel, MD<sup>1</sup>, Donald P. Regula, MD<sup>2</sup>,  
 Michael J. Borowitz, MD, PhD<sup>3</sup>, Richard Conran, MD, JD, PhD<sup>4</sup>,  
 and Michael B. Prystowsky, MD, PhD<sup>5</sup>

Current medical school curricula predominantly facilitate early integration of basic science principles into clinical practice to strengthen diagnostic skills and the ability to make treatment decisions. In addition, they promote life-long learning and understanding of the principles of medical practice. The Pathology Competencies for Medical Education (PCME) were developed in response to a call to action by pathology course directors nationwide to teach medical students pathology principles necessary for the practice of medicine. The PCME are divided into three competencies: 1) Disease Mechanisms and Processes, 2) Organ System Pathology, and 3) Diagnostic Medicine and Therapeutic Pathology. Each of these competencies is broad and contains multiple learning goals with more specific learning objectives. The original competencies were designed to be a living document, meaning that they will be revised and updated periodically, and have undergone their first revision with this publication. The development of teaching cases, which have a classic case-based design, for the learning objectives is the next step in providing educational content that is peer-reviewed and readily accessible for pathology course directors, medical educators, and medical students. Application of the PCME and cases promotes a minimum standard of exposure of the undifferentiated medical student to pathophysiologic principles. The publication of the PCME and the educational cases will create a current educational resource and repository published through *Academic Pathology*.

## Keywords

pathology competencies, pathology objectives, educational cases, disease mechanisms, organ system pathology, diagnostic medicine, therapeutic pathology

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## Background

Becoming a competent physician requires the ability to gain a broad foundation of knowledge, skills, and attitudes essential for independent medical practice. Essential in this is the understanding of the normal and pathological processes of each organ system, the ability to apply disease mechanisms to describe the pathobiology, and the ability to continually improve the diagnostic acumen and optimal treatment decisions through life-long learning. The initial project to develop pathology competencies was described in the article “National Standards in Pathology Education,”<sup>1</sup> where over 60 pathology course directors and department chairs submitted pathology course objectives that were extensively revised and peer-reviewed,

<sup>1</sup> Department of Pathology, Uniformed Services University of the Health Sciences, Bethesda, MD, USA

<sup>2</sup> Department of Pathology, Stanford University School of Medicine, Stanford, CA, USA

<sup>3</sup> Department of Pathology, Johns Hopkins Medical Institutions, Baltimore, MD, USA

<sup>4</sup> Department of Anatomy and Pathology, Eastern Virginia Medical School, Norfolk, VA, USA

<sup>5</sup> Department of Pathology, Albert Einstein College of Medicine and Montefiore Medical Center, Bronx, NY, USA

## Corresponding Author:

Barbara E. C. Knollmann-Ritschel, Department of Pathology, Uniformed Services University of the Health Sciences, Bethesda, MD, USA.

Email: [barbara.knollmann-ritschel@usuhs.edu](mailto:barbara.knollmann-ritschel@usuhs.edu)



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then posted on the Association of Pathology Chairs (APC) Website in 2014, where they were available for both course directors and medical students. A website externally linked from the APC Website was maintained where anyone could leave a comment regarding the competencies. This project, the pathology competencies for medical education (PCME), was initiated and supported by the Undergraduate Medical Education Committee of the APC.<sup>2</sup>

Most medical schools have transitioned to an integrated organ-based curriculum,<sup>1</sup> where individual courses are no longer taught as distinct disciplines. The manner in which medical students are taught has also changed. The lecture format has largely been replaced with multiple types of active learning, including integrated small group discussions, team-based learning exercises, and flipped classrooms. Pathology course directors have a new challenge in education that has vastly transformed from the classic 1910 Abraham Flexner module of basic science education with individual basic science and clinical skills courses followed by 2 years of clinical practice apprenticeships<sup>3</sup> to an integrated and interdisciplinary medical school curriculum. In this transformation, individual disciplines are no longer presented as stand-alone courses, and the exponential expanse of medical knowledge requires an ever-changing and comprehensive understanding of pathobiology by the competent practicing physician. The importance of understanding pathobiology is underscored by the significant amount of questions included on the current US Medical Licensing Examination (USMLE), where pathobiology is tested in both Steps 1 and 3 of the licensing examinations.<sup>4</sup> Every medical student must master disease processes and therapeutics in order to become a competent intern, resident, and fully practicing physician. As stated in the current standard 7 of the Liaison Committee on Medical Education (LCME) publication “structures and functions of a medical school,”<sup>5</sup> there are important elements that must be understood including: (1) recognize and interpret symptoms and signs of disease and (2) develop differential diagnoses and treatment plans.

Pathology has a central role to assist students and physicians in (1) understanding the mechanisms of disease that lead to the signs and symptoms that must be recognized in patients, (2) forming a differential diagnosis, and (3) applying laboratory medicine that allows physicians to rule in or out individual diagnoses and make appropriate diagnostic and treatment decisions. This is in line with the Carnegie Foundation’s report calling for a new reform of learning that is “learner centered”<sup>6</sup> and for learning outcomes to be tied to competencies.

The goal of this endeavor is 3-fold: (1) to revise the previously Website-published pathology competencies as these must be a living document, meaning revised regularly to keep pace with current medical practice and understanding, to highlight the essential (or minimum) for all medical students to understand for the practice of medicine and remain current with medical practice; (2) to emphasize laboratory medicine, which is often not taught, or at best only superficially taught, in many medical school curricula; and (3) to develop a shared resource of pathology competencies and educational cases highlighting

the competencies for pathology faculty, educators, and students, which are developed by or with pathologists, peer-reviewed, and represent foundational understanding of pathobiology essential for clinical practice that can easily be adapted into any curriculum.

## Pathology Competencies for Medical Education

The PCME have detailed learning objectives under each goal that direct medical students and course directors to important facets of each learning goal that can be individually applied by learners. The competencies are divided into 3 sections—disease mechanisms and processes, organ system pathology, and diagnostic medicine and therapeutic pathology—and allow flexibility for each learning institution and learner to apply the learning goals and objectives in a way that can keep the unique design of each curriculum or learning plan. The competencies are purposefully kept broad as they represent the minimum requirements of what pathology course directors across the nation have agreed upon to prepare medical students for entry into any residency program and for the subsequent contemporary practice of medicine.<sup>1</sup>

The learning objectives of the competencies are meant to be a living document, being continually commented upon by pathologists, medical educators, and medical students, and revised accordingly after review by an editorial group. The topics, goals, and learning objectives, as well as the comments submitted on the PCME website before November 2016, have been extensively reviewed by the original editorial group to ensure the learning objectives are current with the changing and expanding medical knowledge. Compared with the original competencies, additional sections have been developed, learning objectives have been revised, the format has been standardized, and new introductions for each section have been added. The revised competencies are found in the following pages of this article.

## Educational Cases

Following publication of the original PCME, the Undergraduate Medical Educators Section (UMEDS) of APC began developing educational cases for the pathology competencies that are current, peer-reviewed, and highlight the pathology competencies in learning cases that can easily be adapted to multiple types of educational modalities. Some of the original cases were posted on the PCME website.

The format of the cases has evolved from the original cases posted on the PCME website to the present format of educational cases that are presented in this special edition of *Academic Pathology*. The educational cases reference the PCME from the following pages, and address at least 1 primary learning objective, but may have 1 or more secondary learning objective(s). The pathology competencies and learning objectives are clearly indicated in the beginning of each case so that the focus of the educational case is evident. Key elements of the current format

include clinical presentation, discussion questions or points, learning points, and references. The clinical presentation may include images or laboratory data for the patient's presentation. The discussion questions or points are questions or statements that promote clinical reasoning followed by detailed explanations of the pathology, medicine, or therapeutics brought up in the discussion point or question. The learning points at the end of the case highlight the main teaching points from the preceding discussion. Thus, the cases demonstrate the application of medical reasoning to clinical scenarios that allow the learner to understand and apply diagnostic principles, incorporating morphologic findings and laboratory values with discussion of the laboratory medicine essentials for accurate diagnosis and treatment. References are included in each case and will allow the reader to review the original sources used to create the learning case or gain additional in-depth information. Thus, the educational cases are written in a style that can be easily used or adapted to multiple educational formats, such as small group discussions or flipped classrooms.

## Discussion

Development of the PCME and the educational cases that support the individual learning objectives is a tremendous undertaking. On the broadest level, this effort supports the LCME standard 7, which requires all medical school curricula to prepare the undifferentiated medical student with sufficient breadth and depth of knowledge for the contemporary practice of medicine. This very broad view is the level at which the objectives were originally created, intended to be the minimum-level objectives course directors nationally felt were needed for adequate understanding for the practice of medicine. In addition, the PCME can be used by individual medical schools to gain leverage for additional curriculum development, especially in laboratory medicine, which is often only minimally taught, and to help expose students to pathology as a clinical specialty. Having a national repository of competencies that is peer-reviewed allows use of learning objectives and educational cases in individual curricula, potentially relieving some of the load on pathology course directors to continually update curricula to keep up with the exponential expanse of knowledge, laboratory testing, and treatment options. And lastly, a national repository of learning objectives and cases can potentially be used to support pathology exposure in integrated curricula to ensure exposure to a minimum amount of pathology for all students. We invite our audience to comment on the depth and breadth of the competencies found on the following pages.

The primary audience for the educational cases is our pathology educators, especially since not all pathology course directors are pathologists. The cases are peer-reviewed, appropriately referenced, and can be used as teaching material by faculty and students. Discussions that follow each discussion point should be broad enough to give faculty who may use these educational cases a deeper understanding of the pathobiology behind the learning objectives needed to teach or explain the concepts to the students. Here we emphasize that

the discussions should explain the basic science and medicine behind each objective at a deeper level than the bare minimum of the objectives. As educators, we must be able to explain and build on basic knowledge concepts for our students, tying the information together in a tightly woven fabric across disciplines. In addition, the discussions should explain the clinical reasoning behind each of the discussion points. Thus the educational cases are not intended to be a bare-bones review, but rather a fuller discussion building on concepts and explaining the thought process that will allow our students to become critical thinkers and apply new knowledge in the future. Having said this, the cases may be adapted to different levels or types of learners during different parts of the curriculum. For example, a case may present a simple benign lesion at a basic level where the intent is to highlight histologic features that help to differentiate between benign and malignant processes, however, another case may cover that same lesion in a different scenario to highlight clinical or diagnostic aspects of that specific disease.

Examples of educational cases can be found in the following pages for a variety of objectives from the three pathology competencies. The educational cases allow for individual use of the cases as students for primary learning or inclusion in medical school curricula in an adaptable format for a variety of teaching venues including laboratories, small group discussions or Team-Based-Learning. The educational cases are intended to facilitate knowledge integration and retention essential for clinical practice. Moving forward, we invite the broader community to submit educational cases to *Academic Pathology* to grow this national resource.

## Conclusion

The educational cases highlight principles of the 3 competencies—(1) disease mechanisms and processes, (2) organ system pathology, and (3) diagnostic medicine and therapeutic pathology—and are presented in a way to help the development of clinical reasoning and the application of basic science into medicine, as well as increase the diagnostic acumen and treatment of disease. Continuing to build and review the PCME and create educational cases to highlight what we as a pathology education community feel is essential knowledge for the practice of medicine requires broader input.

We encourage readers to comment on the pathology competencies to further shape what we as pathologists feel is essential for medical education. Comments regarding the PCME can be sent to Jen Norman, in the APC office, at [jjnorman@apcprods.org](mailto:jjnorman@apcprods.org). As stated above, the competencies are a living document requiring periodic updates. Comments will be reviewed and revised competencies will be published. In addition, we invite readers to submit educational cases directly to *Academic Pathology*, following the submission guidelines found on the *Academic Pathology* website.

We are grateful to *Academic Pathology* that the PCME and educational cases will be published as an easily accessible resource for educators and students.

# Pathology Competencies for Medical Education

## Competency I

### Disease Mechanisms and Processes

A foundational knowledge of mechanisms of disease including the etiology, local or systemic responses to disease, consequences of disease, and cellular events involved in disease or adaptive changes is essential for understanding disease processes in organ system pathology and in patients.

There are 10 topics within this competency area. Each topic includes general learning goals and specific objectives that students should be able to meet before step 1 of the USMLE. Table 1 lists the topic areas and reference codes and shows the number of goals and objectives for each.

**Table 1.** Disease Mechanisms and Processes.

Topic	Number of Goals	Number of Objectives	Reference Code
Genetic mechanisms	1	6	GM
Neoplasia	3	13	N
Environmental mechanisms	2	9	EM
Metabolic and nutritional mechanisms	1	5	MN
Inflammatory mechanisms	1	8	FLAM
Immunological mechanisms	1	10	IM
Infectious mechanisms	2	16	FECT
Tissue renewal, regeneration, and repair	1	7	RRR
Hemodynamic disorders and thromboembolic disease	2	6	HDTD
Adaptation and cell death	3	7	ACD

### Topic: Genetic Mechanisms (GM)

This topic includes a basic knowledge of genetic mechanisms of disease including inherited and somatic disorders with the resulting consequences leading to disorders of development, metabolism, aging, stem cell biology, immunology, and the development of cancer.

#### Learning Goal 1: Genetic Mechanisms of Developmental and Functional Abnormalities

Apply knowledge of the genetic mechanisms of disease to discuss how changes in the genome can cause developmental and functional abnormalities at the cellular, tissue, and organism levels.

**Objective GM1.1: Types of Mutations.** Describe different types of mutations that can occur in human disease, and discuss how each of these can produce abnormalities in DNA

transcription and/or alterations in the type or amount of protein produced.

**Objective GM1.2: Inheritance Patterns.** Compare and contrast the inheritance patterns of different types of Mendelian disorders and give examples of each type of pattern.

**Objective GM1.3: Genetic Diseases of Enzyme Function.** Provide examples of genetic diseases associated with abnormal enzyme function, and compare and contrast with genetic diseases that produce abnormal structural proteins or other nonenzyme proteins.

**Objective GM1.4: Chromosomal Abnormalities.** Discuss mechanisms that result in developmental abnormalities involving abnormal chromosomal number and provide examples of diseases associated with trisomies or chromosomal deletions.

**Objective GM1.5: Multifactorial Inheritance and Environmental Factors.** Discuss and give examples of disorders associated with multifactorial inheritance and describe how environmental factors can interact with genetic factors to produce or modulate disease.

**Objective GM1.6: Nonclassical Inheritance.** Describe the pathophysiologic mechanisms that result in disorders of a nonclassical inheritance and mitochondrial inheritance and give clinical examples of each.

### Topic: Neoplasia (N)

This topic includes a basic understanding of characteristics of benign and malignant neoplasms, epidemiologic and environmental factors that influence neoplastic change, as well as an understanding of the molecular basis of neoplasia including oncogenes, tumor suppressor genes, carcinogenic agents, and host defense.

#### Learning Goal 1: Genetic Basis of Neoplasia

Apply knowledge of the genetic basis of neoplasia to explain how genetic changes are acquired, how functional alterations in these mutated genes lead to the development of cancer, and how these alterations can be exploited with therapy.

**Objective N1.1: Genetic Mechanisms of Neoplasia.** Discuss and provide examples of molecular genetic mechanisms that underlie cancers, including germline mutations (including point mutations, deletions, amplifications, and translocations) and epigenetic changes.

**Objective N1.2: Oncogenes and Tumor Suppressor Genes.** Explain the action of oncogenes and tumor suppressor genes in growth factor-initiated signal transduction in both normal and

neoplastic cells and discuss how this information can be utilized for treatment.

**Objective N1.3: Genes that Promote Growth or Inhibit Cell Death.** Compare and contrast the actions of genes that promote cell growth in cancers with those that inhibit cell death and explain how this information influences the choice of therapeutic agents.

**Objective N1.4: DNA Fidelity.** Describe how cells maintain DNA fidelity and discuss, with examples, how mutations in these pathways produce genomic instability and clonal evolution.

### Learning Goal 2: Environmental Influences on Neoplasia

Apply knowledge of the environmental factors that influence neoplastic transformation.

**Objective N2.1: Prevalence and Geographic Impact on Neoplasia.** Describe the prevalence of neoplastic diseases and discuss the environmental factors that influence patients as they move between geographical regions.

**Objective N2.2: Mechanisms of DNA Damage Repair.** Describe the mechanisms by which exposure to radiation, tobacco, alcohol, or other environmental chemical agents can produce cancer.

**Objective N2.3: Influence of Viruses or Microbial Agents on Neoplasia.** Describe the mechanisms by which viruses and other microbiological agents can contribute to the development of cancer.

**Objective N2.4: Environmental Factors that Influence Neoplasia.** Describe environmental factors that influence the incidence of common tumors.

### Learning Goal 3: Characteristics of Neoplasia

Apply knowledge of the characteristics of neoplasia to discuss the morphologic appearance, classification, biological behavior, and staging of neoplasms.

**Objective N3.1: Morphologic Features of Neoplasia.** Describe the essential morphologic features of neoplasms and indicate how these can be used to diagnose, classify, and predict biological behavior of cancers.

**Objective N3.2: Cellular Capabilities of Neoplasia.** Discuss the cellular capabilities of neoplasms that enable them to invade tissues and to metastasize and recognize how this differentiates benign from malignant neoplasms.

**Objective N3.3: Stromal Elements in Cancer.** Discuss the dependence of cancers on stromal elements and ability to generate their own blood supply to maintain growth and explain how this information can be used to treat cancers.

**Objective N3.4: Paraneoplastic Syndromes.** Define and provide examples of paraneoplastic syndromes and describe how substances produced by cancers can produce systemic effects in the host.

**Objective N3.5: Grading and Staging of Neoplasia.** Compare and contrast the basic grading and staging of neoplastic diseases and describe the tumor, (lymph) nodes, metastasis (TNM) classification for common tumors such as breast and colon carcinoma.

### Topic: Environmental Mechanisms (EM)

Etiologies including physical damage resulting from trauma, particles, extreme temperature, and radiation and chemical exposures to small molecules and biologic toxins. The mechanism of injury usually causes direct damage that initiates a host response that can lead to a range of results from the process of resolution to a chronic complicated pathologic state.

#### Learning Goal 1: Cell Injury

Apply knowledge of biochemistry and cellular physiology to describe the mechanisms leading to cell injury induced by exposure to external agents including radiation, environmental toxins, drugs of abuse, and therapeutic agents.

**Objective EM1.1: Mechanisms of Cell Injury.** Compare and contrast different mechanisms of chemical injury, specifically agents that act by direct binding to and inactivation of cellular constituents with those that require metabolic activation to induce toxicity and discuss how genetic factors affect toxicity of different agents.

**Objective EM1.2: Tobacco Use.** Discuss the pathogenesis of tobacco use and the resultant pathologic changes in affected organs.

**Objective EM1.3: Alcohol Use.** Discuss the pathogenesis of alcohol abuse and the resultant pathologic changes in affected organs.

**Objective EM1.4: Drugs of Abuse.** Describe the mechanism by which drugs of abuse induce central nervous system effects and discuss, with examples, toxicities associated with both chronic use and acute overdose of these drugs, and withdrawal effects.

**Objective EM1.5: Occupational Exposure.** Provide examples of industrial, occupational, or environmental exposures that produce disease, the resultant pathologic changes in these affected organs from chronic exposure, and indicate what organ systems are most commonly affected by which agents.

**Objective EM1.6: Toxicity of Therapeutic Drugs.** Discuss, with examples, how therapeutic drugs can produce toxic effects on different tissues, distinguishing between idiosyncratic and dose-dependent effects.

**Objective EM1.7: Radiation.** Discuss the mechanisms by which radiation damages cells and tissues and compare and contrast how ultraviolet radiation, therapeutic radiation, and acute radiation sickness produce different disease manifestations in different organ systems. Discuss which organs are susceptible and why.

### Learning Goal 2: Physical Injury

Apply knowledge of biochemistry, anatomy, physiology, and mechanisms of cell injury to describe the pathogenic mechanisms of physical injury.

**Objective EM2.1: Mechanical Force Injury.** Compare and contrast the types of injuries associated with mechanical force (blunt vs. penetrating) with respect to effects on skin, blood vessels, and the directly affected organs and discuss systemic response to massive trauma.

**Objective EM2.2: Thermal Injury.** Discuss thermal injuries, comparing and contrasting the direct and systemic effects of thermal burns, hyperthermia, and hypothermia and mechanism of injury at the cellular level.

### Topic: Metabolic and Nutritional Mechanisms (MN)

This topic includes the etiologic mechanisms, host responses, and disease processes leading to impairment of absorption, transport, and utilization of nutrients and oxygen, storage disorders, and disposal of waste products.

#### Learning Goal 1: Nutrient Deprivation or Toxicity

Apply knowledge of biochemistry and cellular physiology to explain the pathogenic mechanisms resulting from nutrient deprivation or nutrient toxicity, and the resulting pathology at the cellular, tissue, and organism levels.

**Objective MNI.1: Fat- and Water-Soluble Vitamins.** Compare and contrast sources of fat-soluble and water-soluble vitamins (dietary sources) with respect to absorption, metabolism, and potential toxicity.

**Objective MNI.2: Vitamin-Deficiency Disease.** List vitamins and minerals whose deficiency can be associated with defined pathologic states, and explain the mechanisms by which these deficiencies produce disease.

**Objective MNI.3: Obesity.** Discuss the etiology and pathogenesis of obesity, comparing and contrasting genetic and environmental factors, and describe common clinical consequences.

**Objective MNI.4: Malnutrition.** Discuss the pathologic consequences of nutritional deficiencies other than vitamin deficiencies, with emphasis on severe protein-energy malnutrition, and discuss the pathologic states that have a significant impact on nutritional requirements.

**Objective MNI.5: Diet and Systemic Disease.** Discuss the effect of diet and nutritional state on systemic disease, emphasizing the role it plays in the development of atherosclerosis and cancer.

### Topic: Inflammatory Mechanisms (FLAM)

This topic includes the understanding of acute and chronic inflammation, patterns of inflammation, the cellular components, mediators, and systemic effects.

#### Learning Goal 1: Mechanisms of Inflammation

Apply knowledge of the biochemistry and cellular physiology to describe pathogenic mechanisms of acute and chronic inflammation, and the resulting pathology at the cellular, tissue, and organism levels.

**Objective FLAMI.1: Acute Inflammatory Response.** Describe the time course of the vascular and cellular events responsible for the acute inflammatory response to injury, and discuss the receptors and ligands that are responsible for these events.

**Objective FLAMI.2: Phagocytosis.** Describe phagocytosis and the molecular mechanisms of intracellular killing.

**Objective FLAMI.3: Mediators of Inflammation.** Discuss the chemical mediators of inflammation, classifying the mediators with respect to origins, targets, and mechanisms of action.

**Objective FLAMI.4: Systemic Changes in Inflammation.** Describe systemic changes seen in inflammation, including metabolic consequences of changes in levels of serum proteins (acute phase reactants) and other inflammatory mediators.

**Objective FLAMI.5: Outcomes of Inflammation.** Summarize the possible pathological outcomes of inflammation and discuss factors that determine what outcomes are seen under different circumstances.

**Objective FLAMI.6: Morphologic Patterns of Inflammation.** Recognize and classify the major types of inflammatory lesions that can be present in histologic sections, and identify the cellular and protein constituents in these lesions.

**Objective FLAMI.7: Acute, Chronic, and Granulomatous Inflammation.** Compare and contrast acute, chronic, and granulomatous inflammation with respect to the major cell type(s) involved in the processes, the types of etiologic agents that produce each of these, and the mechanisms of tissue injury seen with these different types of inflammation.

**Objective FLAMI.8: Extravascular Fluids Associated With Injury.** Classify types of extravascular fluids associated with injury based on their cellular and protein content, know the terminology used to define these, and provide examples of pathologic conditions in which these can be found.

### Topic: Immunological Mechanisms (IM)

This topic includes the understanding of normal and dysregulated innate and adaptive cellular immune responses resulting in inflammation, resolution, and disease.

### Learning Goal 1: Immune Dysfunction

Apply knowledge of basic mechanisms of immunology to explain how dysfunction can produce cellular injury, acute and chronic inflammation, autoimmunity, allergic reactions, and susceptibility to infection; how these changes affect organ function and the health of the organism; and how therapeutic intervention can mitigate these effects.

**Objective IM1.1: Innate and Adaptive Immunity.** Compare and contrast innate and adaptive immunity with respect to the molecules and cells involved in the immune response, and the role of these systems in host defense.

**Objective IM1.2: Cell Types.** Compare and contrast the roles played by T cells, B cells, Natural Killer (NK) cells, macrophages, and dendritic cells in the immune response.

**Objective IM1.3: Cytokines.** Discuss, with examples, the production of different cytokines by different immune cells, the roles that cytokines play in effecting the immune response, and how knowledge of cytokine action can be exploited in the treatment of disease.

**Objective IM1.4: Hypersensitivity.** Compare and contrast the mechanisms of the 4 hypersensitivity reactions with respect to the situations in which each is triggered, mechanisms of injury, resulting pathologic effects on tissue, and the ultimate clinical consequences.

**Objective IM1.5: Complement.** Discuss how the complement cascade is activated, the role its activation plays in both inflammation and cellular cytotoxicity, and how abnormalities in complement function can produce disease.

**Objective IM1.6: Immune Tolerance.** Define immunological tolerance, and describe the role that failure of tolerance plays in the development of autoimmune diseases.

**Objective IM1.7: Human Leukocyte Antigen (HLA).** Discuss the structure and function of human histocompatibility antigens and describe the role of this system in both transplantation and susceptibility to certain diseases.

**Objective IM1.8: Transplantation.** Discuss the consequences of tissue transplantation, including mechanisms and pathophysiology of graft vs. host organ rejection, and the possible therapeutic interventions that can mitigate these effects.

**Objective IM1.9: Immunodeficiencies.** Compare and contrast the genetic basis and inheritance patterns of the well-defined primary immunodeficiency syndromes, discuss the pathogenesis and clinical sequelae of these disorders, and describe therapeutic interventions that can mitigate or correct them.

**Objective IM1.10: Secondary Immune Deficiencies.** Describe the etiology, mechanisms of action, and possible clinical consequences of secondary immune deficiencies.

### Topic: Infectious Mechanisms (FECT)

This topic includes the mechanisms by which microorganisms, viruses, and parasites cause disease including virulence factors produced by microorganisms and host response.

#### Learning Goal 1: Mechanisms of Infection

Apply knowledge of biochemical and cellular physiology to describe the pathogenic mechanisms of infectious diseases including both pathogen and host factors, the resulting pathology at the cellular, tissue, and organism levels, and clinical manifestations.

**Objective FECT1.1: Host Barrier.** Explain the human host barrier to infection and describe how organisms spread within the body once the barrier is broken.

**Objective FECT1.2: Categories of Infective Agents.** Describe the general categories of infective agents including bacteria, viruses, fungi, and parasites and describe the morphologic patterns of infectious diseases and the general mechanisms by which each of these cause disease.

**Objective FECT1.3: Host Responses to Infection.** Compare and contrast host responses to different classes of infectious agents in terms of morphological features, mechanisms of action, and mechanisms of immune evasion.

#### Learning Goal 2: Pathogenic Mechanism of Infection

Apply knowledge of biochemical and cellular physiology to describe pathogenic mechanisms; the resulting pathology at the cellular, tissue, and organism levels; and the clinical manifestations of viral, bacterial, fungal, and parasitic infections.

**Objective FECT2.1: Viral Mechanisms.** Compare and contrast the mechanisms by which RNA, DNA, and retroviral viruses enter and damage cells.

**Objective FECT2.2: Patterns of Viral Infection.** Compare and contrast viruses that result in acute transient, chronic latent, chronic productive and transformative infections and discuss how these differences result in different disease pathogenesis.

**Objective FECT2.3: Histopathologic Features of Viral Infection.** Compare and contrast the histopathological features of herpes virus, cytomegalovirus, human papilloma virus, and adenovirus in terms of nuclear features, inclusions, size of cells, and other unique characteristics; recognize these histopathological features of viral infections in images of different tissues.

**Objective FECT2.4: Mechanisms of Bacterial Damage.** Describe the mechanisms by which bacteria damage cells and tissues, comparing and contrasting mechanisms characteristic of infection with particular categories of bacteria.

**Objective FECT2.5: Transmission Patterns of Bacterial Infection.** Discuss the different patterns of transmission of bacterial

diseases as a function of both the type of organism and the organ systems involved in the infection.

**Objective FECT2.6: Tissue Response to Bacterial Infection.** Describe the histologic patterns of tissue response to bacterial infection as a function of differences in the organisms involved, the specific organ affected, and the manner by which the bacterium enters the organ.

**Objective FECT2.7: Special Stains for Bacteria.** Recognize and compare morphology and cell wall features of bacteria using Gram stain, Warthin Starry (silver) stain, Acid Fast stain, Partial Acid Fast stain, and Periodic Acid Schiff stain, and correlate with diagnosis.

**Objective FECT2.8: Fungal Infection.** List the different types of fungal organisms that infect humans and compare and contrast the mechanisms by which they damage tissues, the inflammatory responses they induce, and the resultant diseases that arise.

**Objective FECT2.9: Histopathologic Features of Fungal Infection.** Recognize histopathologic evidence of fungal infections and compare and contrast the histopathological features and staining characteristics of the following fungi: *Candida albicans*, *Cryptococcus neoformans*, *Aspergillus*, *Histoplasma capsulatum*, *Coccidioides immitis*, *Blastomyces dermatitidis*, *Pneumocystis jiroveci*, and *Zygomycetes*.

**Objective FECT2.10: Fungal Infection in Immunosuppression.** Compare and contrast the types of fungal infections that occur in immunosuppressed and immunocompetent patients with respect to the organisms involved, the mechanisms of organ damage, and the resultant clinical manifestations.

**Objective FECT2.11: Parasitic Infections.** Describe classes of parasites that produce human disease, give examples of each class, and discuss their life cycle within humans and within other hosts.

**Objective FECT2.12: Tissue Response to Parasitic Infection.** Discuss the mechanisms of pathologic damage caused by different parasites in different tissues, and describe the diseases, complications, and possible outcomes associated with such infections.

**Objective FECT2.13: Histopathologic Features of Parasitic Infection.** Recognize tissues involved with parasitic infections and compare the histopathological features and staining characteristics of parasites producing the following parasitic diseases: toxoplasmosis, giardiasis, amebiasis, malaria, babesiosis, leishmaniasis, trypanosomiasis, strongyloidiasis, schistosomiasis, filariasis, and cestode infections.

### **Topic: Tissue Renewal, Regeneration, and Repair (RRR)**

This topic includes an understanding of the pathogenesis of cellular proliferation for regeneration of cells, including of stem cells, and tissue and signal mechanisms for the repair process.

### **Learning Goal 1: Mechanisms of Tissue Regeneration, Renewal, and Repair**

Apply knowledge of biochemistry and cellular physiology to describe the pathogenic mechanisms of tissue regeneration, renewal, and repair, the resulting pathology at the cellular, tissue, and organism levels, and describe clinical manifestations.

**Objective RRR1.1: Stem Cells.** Compare and contrast embryonic and adult (somatic) stem cells with respect to their ability to proliferate and differentiate into different cell types; define induced pluripotent stem cells and compare and contrast them with the other types of stem cells.

**Objective RRR1.2: Cell Cycles.** Describe the 5 stages of the cell cycle, and explain the role of cyclins, cyclin-dependent kinase, and other proteins in the regulation of progression through the cell cycle, and how disruption of the cell cycle can lead to disease with resultant pathology.

**Objective RRR1.3: Signaling Pathways.** Discuss the signaling pathways involved in the regulation of cell growth, listing important cell surface receptors, and describing the mechanisms whereby engagement of receptors by growth factors leads to cell growth.

**Objective RRR1.4: Extracellular Matrix.** List the important proteins of the extracellular matrix, describe the role of cell–matrix interactions in cell growth and differentiation, and provide examples of how structural alterations of matrix proteins produce disease.

**Objective RRR1.5: Angiogenesis.** Describe the regulation of angiogenesis, discussing receptors on vascular endothelium as well as the role soluble and stromal factors play in the process, and describe the effect of aberrant angiogenesis in certain diseases.

**Objective RRR1.6: Wound Healing.** Describe the phases of cutaneous wound healing, the mechanisms of healing by first intention (primary union) and second intention (secondary union) and possible clinical consequences of abnormal wound healing.

**Objective RRR1.7: Anti-inflammatory Drugs and Wound Repair.** Explain the effects of anti-inflammatory medications on wound repair.

### **Topic: Hemodynamic Disorders and Thromboembolic Disease (HDTD)**

This topic includes a basic knowledge of edema, congestion, and shock as well as a basic understanding of the coagulation cascade to understand the pathogenesis of thromboembolic disorders.

### **Learning Goal 1: Hemodynamics and Shock**

Apply knowledge of the biochemical and cellular physiology to discuss the pathogenic mechanisms resulting in alterations in hemodynamics and shock. Describe the resulting pathology at the cellular, tissue, and organism level and describe clinical manifestations associated with these pathologic changes.



**Objective HDTD1.1: Edema.** Describe the pathophysiologic categories of edema and compare and contrast, with examples, how edema can be produced as a result of changes in hydrostatic pressure or plasma oncotic pressure.

**Objective HDTD1.2: Hyperemia and Hemorrhage.** Explain the clinical, morphological, and physiological significance of hyperemia, congestion, and hemorrhage, with respect to the disease states that cause them.

**Objective HDTD1.3: Shock.** Classify different types of shock according to etiology and compare and contrast the pathogenesis of these different types.

### **Learning Goal 2: Clotting and Disruption of Blood Flow**

Apply knowledge of the biochemical and cellular physiology to discuss pathogenetic mechanisms that result in alterations in blood clotting or other disruptions to blood flow. Describe the resulting pathology at the cellular, tissue, and organism level and the clinical manifestations associated with these pathologic changes.

**Objective HDTD2.1: Blood Clotting.** Discuss the vascular, cellular, and humoral events involved in blood clotting and provide examples of genetic or acquired factors that can lead to either excess clotting or bleeding.

**Objective HDTD2.2: Thrombosis and Thromboembolism.** Compare and contrast thrombosis in situ and thromboembolism with respect to sites of involvement, risk factors, and attendant pathologic and clinical consequences.

**Objective HDTD2.3: Embolism.** Compare and contrast the etiology and clinical consequences of different types of embolism.

## **Topic: Adaptation and Cell Death (ACD)**

This topic includes a basic understanding of the cellular responses to cellular stress, mechanisms of cellular injury, and differentiating necrosis and apoptosis.

### **Learning Goal 1: Cellular Response to Injury**

Apply knowledge of membrane physiology, metabolism, signal transduction, and macromolecular synthesis to discuss cellular responses to injury at the cell, tissue, and organism levels; how these responses affect morphologic appearance; and how they can be used for diagnostic, prognostic, and therapeutic purposes.

**Objective ACD1.1: Adaptation.** Discuss the pathogenesis of hyperplasia, hypertrophy, atrophy, and metaplasia, and compare and contrast their possible physiologic and pathologic causes.

**Objective ACD1.2: Necrosis.** Define necrosis and compare and contrast the forms of necrosis produced in response to different etiologic agents with respect to their variable clinical and morphologic features.

**Objective ACD1.3: Ischemia.** Compare and contrast ischemia and hypoxia and discuss the time course of the molecular events that occur in a cell in response to lack of oxygen, emphasizing the events that distinguish reversible from irreversible injury.

**Objective ACD1.4: Reperfusion Injury.** Summarize the cell's response to reperfusion injury emphasizing how reperfusion can exacerbate injury produced by ischemia.

### **Learning Goal 2: Cell Death**

Apply knowledge of biochemistry and cellular physiology to differentiate between pathogenic and physiologic mechanisms of cell death, the resulting morphologic appearance, and the physiologic and clinical settings in which these mechanisms are activated.

**Objective ACD2.1: Apoptosis.** Contrast the etiology, mechanisms, and morphologic changes of apoptosis with those of necrosis. Discuss the circumstances in which dysregulation of apoptosis can produce disease, and circumstances that determine why cells undergo apoptosis vs. necrosis.

### **Learning Goal 3: Sublethal Injury**

Apply knowledge of cellular physiology, metabolism, and macromolecular synthesis to discuss cellular and subcellular responses to sublethal injury or stress on cells; how these responses affect morphologic appearance at the cell and tissue level; and how they can affect organ function.

**Objective ACD3.1: Cellular Response to Environmental Changes.** Discuss, with examples, the changes that occur in cellular organelles or cytoskeletal proteins of different cell types in response to environmental alterations.

**Objective ACD3.2: Intracellular Accumulations.** Describe the mechanisms of intracellular accumulations and the morphologic and clinical consequences of these accumulations.

## **Competency 2**

### **Organ System Pathology**

Once the student has mastered the fundamental mechanisms and processes for causing, sustaining, extending, or resolving injury, this knowledge can be integrated to understand how pathology in each organ system affects the initial pathologic site, multi-organ systems, and the overall function of the patient.

There are 23 topics within this competency area. Each topic includes general learning goals and specific objectives that medical students should be able to meet upon graduation from medical school. Table 2 lists the topic areas and shows the number of goals and objectives for each.

**Table 2.** Organ System Pathology.

Topic	Number of Goals	Number of Objectives	Reference Code
Cardiovascular: blood vessels	3	10	CBV
Cardiovascular: heart	6	22	CH
Hematopathology: red cell disorders	1	7	HRC
Hematopathology: white cell disorders	7	28	HWC
Hematopathology: platelets and coagulation disorders	2	19	HPCD
Respiratory system	4	26	RS
Head and neck	2	7	HN
Gastrointestinal tract	8	22	GT
Hepatobiliary	7	23	HB
Pancreas	2	5	P
Kidney	5	17	UTK
Bladder	3	10	UTB
Male reproductive: prostate	2	6	MP
Male reproductive: testes	2	5	MT
Breast	2	11	BR
Female reproductive: uterus, cervix, and vagina	4	10	FU
Female reproductive: ovary	2	6	FO
Female reproductive: disorders of pregnancy	1	7	FDP
Endocrine	6	19	EN
Skin	5	11	SK
Musculoskeletal system	2	12	MS
Nervous system: CNS	7	27	NSC
Nervous system: PNS and eye	3	7	NSP

Abbreviations: CNS, central nervous system; PNS, peripheral nervous system.

### Topic: Cardiovascular—Blood Vessels (CBV)

Cardiovascular disorders resulting from abnormal development, hypoxia, immune dysregulation, infections and smooth muscle changes as they relate to the blood vessels are enumerated.

#### Learning Goal 1: Mechanisms of Atherosclerosis

Apply knowledge of immunologic principles, inflammation, and tissue repair to explain atherosclerosis and its complications.

**Objective CBV1.1: Factors Contributing to Endothelial Injury.** Explain how environmental factors (including elevated cholesterol and LDL complexes, infection, and smoking) can contribute to endothelial cell injury.

**Objective CBV1.2: Feedback in Endothelial Damage.** Describe the positive feedback loop in which damaged endothelial cells cause further endothelial damage.

**Objective CBV1.3: Atherosclerosis Plaque Rupture.** Predict the local and distant consequences that are likely to follow rupture of an atherosclerotic plaque and the resultant clinical presentation.

**Objective CBV1.4: Vascular Aneurysm.** Describe the morphologic changes in atherosclerosis and discuss how atrophic changes in the vessel wall may result in aneurysm formation.

#### Learning Goal 2: Vascular Damage and Thrombosis

Apply knowledge of the cellular response to injury and basic hemodynamic principles to explain how defective or excessive inflammatory and reparative processes damage blood vessels and how this damage results in thrombus formation.

**Objective CBV2.1: Thrombus Formation.** Discuss the steps in thrombus formation and its predisposing factors.

**Objective CBV2.2: Aortic Aneurysm and Dissection.** Compare and contrast aortic aneurysms and aortic dissections in terms of their predisposing factors, the sites of involvement, and patient populations likely to be affected.

**Objective CBV2.3: Abdominal Aortic Aneurysm.** Describe the clinical consequences of an abdominal aortic aneurysm.

#### Learning Goal 3: Vasculitis

Apply knowledge of microbiological principles and mechanisms of immunologically mediated disease to discuss the pathogenesis, clinical presentation, morphological features, and laboratory diagnosis of the different vasculitides.

**Objective CBV3.1: Drug-induced Vasculitis.** Describe how a drug-induced vasculitis depends on a functioning immune system.

**Objective CBV3.2: Autoimmune Vasculitis.** Compare and contrast the mechanisms by which an autoimmune disease can appear as a vasculitis in 1 specific organ or as a generalized disease in many organs.

**Objective CBV3.3: Categories of Vasculitis (Vessel Size).** Describe the vasculitides that occur in large, medium, and small vessels.

### Topic: Cardiovascular—Heart (CH)

Cardiovascular disorders resulting from abnormal development, hypoxia, immune dysregulation, infections and intrinsic muscle disease as they relate to the heart are enumerated.

#### Learning Goal 1: Heart Failure

Apply knowledge of anatomy, physiology, and general pathophysiologic principles to describe the clinical presentation associated with heart failure.

**Objective CH1.1: Right- and Left-Sided Heart Failure.** Compare and contrast right heart versus left heart failure in terms of clinical features, pathologic features, and the short-term and long-term consequences.

**Objective CH1.2: Cardiomyopathy.** Compare and contrast the clinicopathologic features of dilated, restrictive, and hypertrophic cardiomyopathies.

### Learning Goal 2: Atherosclerosis in Heart Disease

Apply knowledge of anatomy, physiology, and general pathophysiological principles to explain how atherosclerosis leads to heart disease and death.

**Objective CH2.1: Ischemic Heart Disease.** Explain how ischemic heart disease can progress while remaining entirely free of symptoms for many years.

**Objective CH2.2: Angina.** Contrast the clinical, physiologic, and histologic differences between exercise-induced angina and unstable angina.

**Objective CH2.3: Reperfusion Versus Ischemic Injury.** Contrast the behavior of the myocardium that has been subjected to chronic ischemia alone from that of reperfused myocardium following therapy for infarction.

**Objective CH2.4: Timing of Changes in Myocardial Infarction.** Compare and contrast the gross and microscopic features of acute myocardial infarction and remote myocardial infarction, and at what point gross or microscopic pathology appears.

**Objective CH2.5: Histopathology of Myocardial Infarction.** Describe the histologic features of acute myocardial infarction and explain the pathophysiology underlying the histologic changes from initial infarction through fibrosis and relate to the laboratory diagnosis of myocardial infarction.

**Objective CH2.6: Complications of Myocardial Infarction.** Identify short-term and long-term complications of myocardial infarction.

### Learning Goal 3: Cardiovascular Malformation

Apply knowledge of embryologic principles to describe how improper development of the heart and blood vessels leads to cardiac dysfunction.

**Objective CH3.1: Congenital Heart Disease.** Name the most common forms of congenital heart disease and outline their clinical presentation, natural history, and long- and short-term complications.

**Objective CH3.2: Congenital Heart Disease Associated with Genetic Disorders.** Name several common genetic disorders associated with congenital heart disease, and describe the clinical presentation.

**Objective CH3.3: Paradoxical Embolism.** Describe a paradoxical embolus in terms of congenital heart disease.

**Objective CH3.4: Cardiac Shunts.** Define the concepts of left to right shunt, right to left shunt, and shunt reversal, and correlate with clinical presentation.

### Learning Goal 4: Cardiac Infection

Apply knowledge of immunological and microbiological principles to explain the role of infectious agents in myocardial dysfunction and describe the related clinical presentations.

**Objective CH4.1: Rheumatic Fever.** Describe the major manifestations of rheumatic fever and its effect on the endocardium, myocardium, and pericardium.

**Objective CH4.2: Rheumatic Fever and Endocarditis.** Compare the effects of rheumatic fever and bacterial endocarditis on the endocardium, myocardium, and pericardium.

**Objective CH4.3: Infective Endocarditis.** Describe the 2 major patterns of infective endocarditis and the pathologic changes seen in the cardiac valves.

**Objective CH4.4: Noninfective Endocarditis.** Discuss the pathologic features of noninfective endocarditis on the cardiac valves.

**Objective CH4.5: Myocarditis.** Describe the clinicopathologic features of myocarditis.

**Objective CH4.6: Pericarditis.** Summarize the common causes of pericarditis and their pathophysiological features.

### Learning Goal 5: Valvular Dysfunction

Apply knowledge of the anatomy and physiology of heart valves to explain how valvular dysfunction leads to heart failure and describe the related clinical presentation.

**Objective CH5.1: Valve Stenosis.** Discuss the complications associated with aortic stenosis.

**Objective CH5.2: Valve Insufficiency.** Describe the clinicopathologic features of mitral valve prolapse.

### Learning Goal 6: Hypertension and the Heart

Apply knowledge of the mechanism of response of cardiac muscle to increased resistance to describe the clinical and pathologic changes seen in systemic and pulmonary hypertension.

**Objective CH6.1: Cardiac Changes in Pulmonary Hypertension.** Describe the gross and microscopic adaptive changes in the myocardium that result from pulmonary hypertension.

**Objective CH6.2: Cardiac Changes in Systemic Hypertension.** Discuss the pathogenesis of hypertension and the gross and microscopic adaptive changes in the myocardium that result from systemic hypertension.

### Topic: Hematopathology—Red Cell Disorders (HRC)

Red blood cell disorders resulting from abnormal development, nutritional derangements, inherited disorders, and intrinsic disease as they relate to anemia are enumerated.

### Learning Goal 1: Anemia

Apply knowledge of nutritional biochemistry, erythropoiesis, and red blood cell structure and function to a discussion of the behavioral, hereditary, developmental, and chronic causes of anemia.

**Objective HRC1.1: Iron-Deficiency Red Blood Cell Development.** Explain the contribution of iron to red blood cell development and function. Describe behaviors and conditions that lead to iron deficiency and contrast the morphology and laboratory parameters of normal red cells versus iron-deficient cells.

**Objective HRC1.2: Hereditary Spherocytosis.** Discuss the pathophysiology of hereditary spherocytosis.

**Objective HRC1.3: Hepcidin Regulation, Iron Overload, and Anemia of Chronic Disease.** Discuss the role of hepcidin as an iron regulator and describe how different types of alterations in the hepcidin pathway can produce anemia of chronic disease or iron overload.

**Objective HRC1.4: B12 and Folate Deficiencies.** Discuss the role of vitamin B12 and folic acid in red cell development and describe the pathophysiology of anemia arising from B12 and folic acid deficiency.

**Objective HRC1.5: Anemias of Red-Cell Destruction.** Explain the mechanisms by which anemia is produced on the basis of shortened red cell survival, distinguishing between intrinsic and extrinsic causes of red cell destruction.

**Objective HRC1.6: Aplastic Anemia.** Compare and contrast congenital and acquired forms of aplastic anemia.

**Objective HRC1.7: Hemoglobinopathies and Thalassemia.** Describe the structural alterations and regulatory abnormalities associated with hemoglobinopathies and thalassemia, and discuss how these abnormalities give rise to the clinical manifestations of these diseases.

### Topic: Hematopathology—White Cell Disorders, Lymph Nodes, Spleen, and Thymus (HWC)

White blood cell disorders resulting from abnormal development, genetic mutations, infections, and intrinsic disease as they relate to reactive and neoplastic abnormalities are enumerated.

#### Learning Goal 1: Development of White Blood Cells and Nonneoplastic Causes of Neutropenia

Apply knowledge of anatomy and physiology to describe the normal development of white blood cells and nonneoplastic conditions leading to increased or decreased numbers of white blood cells.

**Objective HWC1.1: Morphology of White Cells.** Describe the maturational pathway of white blood cells, naming and

describing the morphology of the cells present at each stage for each white blood cell type.

**Objective HWC1.2: White Cell Growth Factors.** Define the role of growth factors in the development and maturation of white blood cells.

**Objective HWC1.3: Leukocytosis.** Define leukocytosis, describe several etiologies leading to it, and contrast it with leukemoid reaction.

**Objective HWC1.4: Leukopenia.** Compare and contrast the causes, mechanisms, and consequences of neutropenia and lymphopenia.

**Objective HWC1.5: Neutrophilia.** Describe the common causes for neutrophilia, lymphocytosis, monocytosis, eosinophilia, and basophilia.

**Objective HWC1.6: Neutropenia.** Discuss the common causes for neutropenia, lymphopenia, and leukopenia and compare with pancytopenia.

#### Learning Goal 2: Genetic Mutations in Hematologic Malignancy

Apply knowledge of general concepts of neoplasia to explain how genetic mutations can produce hematologic malignancies and how the clinical behavior of different malignancies can be explained by different mutations.

**Objective HWC2.1: Germline and Somatic Mutations in Hematologic Malignancy.** Explain the difference between germline and somatic mutations; give examples and explain how each mutation contributes to the development of hematologic malignancies.

**Objective HWC2.2: Translocations in Oncogenes.** Compare and contrast, with examples, translocations that result in malignancy by activation of oncogenes with those that produce fusion proteins.

**Objective HWC2.3: Cell Proliferation or Cell Death in Lymphomas.** Explain with examples how dysregulation of cell proliferation or of cell death can give rise to lymphomas, and compare and contrast diseases arising by each mechanism with respect to morphologic appearance and clinical behavior.

**Objective HWC2.4: Molecular Basis of Leukemia and Lymphoma.** Describe how understanding the molecular pathogenesis of leukemia and lymphoma can suggest targets for therapeutic intervention and give examples of diseases currently treated by targeted therapy.

**Objective HWC2.5: Multiple Myeloma.** Describe the clinicopathologic features of multiple myeloma in terms of clinical presentation, laboratory findings, radiologic findings, histologic features, and prognosis.

### **Learning Goal 3: Classification of Leukemia and Lymphomas**

Apply knowledge of hematopoiesis to discuss the pathophysiologic basis for the classification of leukemia and lymphomas.

**Objective HWC3.1: Morphology of Acute Leukemia and Lymphoma.** Describe the morphologic features that characterize typical cases of acute leukemia and lymphoma.

**Objective HWC3.2: Myeloid Neoplasia.** Compare and contrast myelodysplastic syndromes, myeloproliferative neoplasms, and acute myeloid leukemia with respect to morphologic appearance, clinical features, and underlying pathophysiology.

**Objective HWC3.3: Categories of Lymphoma.** Compare and contrast low-grade or indolent lymphomas and high-grade or aggressive lymphomas with respect to underlying pathophysiology that yields specific morphologic features and clinical behavior.

**Objective HWC3.4: Morphology of Acute Versus Chronic Leukemia.** Discuss the morphologic appearance of a blast and be able to distinguish acute myeloid leukemia from chronic myelogenous leukemia.

**Objective HWC3.5: Morphology of Lymphomas.** Describe the histologic appearance of typical cases of follicular lymphoma, diffuse large B-cell lymphoma, small lymphocytic lymphoma/chronic lymphocytic leukemia, and Hodgkin lymphoma.

**Objective HWC3.6: Hodgkin and Non-Hodgkin Lymphoma.** Compare and contrast Hodgkin lymphoma with at least 2 non-Hodgkin lymphomas with respect to age and clinical symptoms at presentation, sites and pattern of spread of disease, cell of origin, histologic appearance, and prognosis and response to therapy.

### **Learning Goal 4: Clinical Features of Hematolymphoid Neoplasms**

Discuss the clinical manifestations of hematolymphoid neoplasms including age distribution of different tumors, presenting symptoms and signs, disease complications, natural history, and response to therapy.

**Objective HWC4.1: Clinical Features of Bone Marrow Neoplasms.** Identify the tumors of bone marrow most likely to present with anemia, leukopenia, or thrombocytopenia and discuss the presenting clinical features most likely to be associated with each.

**Objective HWC4.2: B Symptoms in Hematolymphoid Neoplasia.** Define B symptoms, list which lymphomas are most and least likely to be associated with them, and discuss the prognostic implications of B symptoms in these diseases.

**Objective HWC4.3: Staging of Hematolymphoid Neoplasia.** Define staging as it applies to lymphoma and give examples of different lymphomas in which staging has different clinical implications.

**Objective HWC4.4: Extranodal Lymphoma.** Identify lymphomas most likely to present in or involve extranodal sites such as the gastrointestinal tract, bone marrow, blood, skin, or central nervous system.

### **Learning Goal 5: Stem Cells in Hematolymphoid Neoplasia**

Describe how stem cells give rise to the diverse cell populations seen in bone marrow and lymph nodes and discuss how knowledge of hematopoietic cell development can provide a framework for understanding hematolymphoid neoplasia.

**Objective HWC5.1: Cell of Origin and the Morphology of Neoplasia.** Outline, with examples, the difference between the cell of origin of a neoplasm and the morphologic expression of that disease.

**Objective HWC5.2: Stem Cells in Myeloid Leukemias.** Discuss the evidence that supports the existence of stem cells in myeloid leukemias and list the features of chronic myeloproliferative neoplasms that suggest they are derived from stem cells.

**Objective HWC5.3: Lymphoid Response to B-Cell Activation.** Describe the morphologic and molecular changes that take place within a lymph node in response to B-cell activation and explain how these changes relate to different types of B-cell non-Hodgkin lymphoma.

### **Learning Goal 6: Thymus**

Thymus Apply knowledge of the anatomy and function of the thymus to summarize how developmental anomalies, immune disorders, and malignant transformation of epithelial and lymphoid cells lead to immune dysfunction.

**Objective HWC6.1: Thymoma.** Compare and contrast thymoma from lymphoma and describe the clinicopathologic features of thymic neoplasms.

**Objective HWC6.2: Thymic Development.** Explain how deficits in particular stages of thymic development can produce specific types of disease.

### **Learning Goal 7: Spleen**

Apply knowledge of the anatomy and function of the spleen to explain how developmental anomalies, immune, and metabolic disorders neoplasia lead to splenic dysfunction.

**Objective HWC7.1: Splenic Function.** Explain the contribution of normal splenic function to nonneoplastic diseases.

**Objective HWC7.2: Splenomegaly.** Describe the clinicopathologic features of neoplastic and nonneoplastic disorders leading to splenomegaly.

## Topic: Hematopathology—Platelets and Coagulation Disorders (HPCD)

Platelet disorders resulting from abnormal development, inherited disorders, immune, and infectious diseases and their central role in blood clotting as they relate to coagulation and hemostasis abnormalities are enumerated.

### Learning Goal 1: Platelets

Apply knowledge of platelet structure and function to discuss qualitative and quantitative disorders leading to abnormal bleeding.

**Objective HPCD1.1: Platelets in Hemostasis.** Summarize the role played by platelets in hemostasis, including platelet adhesion, activation, and aggregation.

**Objective HPCD1.2: Thrombocytopenia.** Identify the examples of each of the following pathogenetic categories of thrombocytopenia: decreased production, decreased platelet survival, sequestration, dilutional effect.

**Objective HPCD1.3: Thrombocytopenic Syndromes.** Compare and contrast the following thrombocytopenia syndromes: immune thrombocytopenic purpura, drug-induced thrombocytopenia, heparin-induced thrombocytopenia.

**Objective HPCD1.4: Thrombocytopenic Purpura.** Compare and contrast thrombotic thrombocytopenic purpura with hemolytic uremic syndrome.

**Objective HPCD1.5: Platelet Disorders.** Explain the biochemical basis of the following congenital and acquired defective platelet disorders: Bernard-Soulier syndrome, Glanzmann thrombasthenia, storage pool disorders, aspirin-related dysfunction, uremia-related dysfunction.

**Objective HPCD1.6: Bone Marrow Aplasia.** Explain the bases of marrow aplasia/myelophthisis, nutritional deficiency, and myelodysplasia as causes of thrombocytopenia form of marrow failure.

### Learning Goal 2: Hemostasis

Apply knowledge of normal hemostasis, interaction of platelets, and procoagulant and anticoagulant factors to describe qualitative and quantitative disorders leading to abnormal bleeding and thrombosis.

**Objective HPCD2.1: Types of Hemorrhage.** Distinguish among the following manifestations of hemorrhage: hematoma, petechiae, purpura, and ecchymoses.

**Objective HPCD2.2: Stages of Hemostasis.** Compare and contrast the following stages of hemostasis: vasoconstriction, primary hemostasis, secondary hemostasis, and antithrombotic counterregulation.

**Objective HPCD2.3: Secondary Hemostasis.** Outline the process of secondary hemostasis, in terms of intrinsic pathway, extrinsic pathway, common pathway, fibrin formation, and fibrinolysis.

**Objective HPCD2.4: Proteases and the Coagulation Cascade.** Describe how particular proteins that regulate the proteases to activate the clotting cascade either promote or inhibit coagulation.

**Objective HPCD2.5: Mechanisms of Hypercoagulability.** Compare and contrast the roles of endothelial injury, stasis, and alterations in the regulation of blood clotting in the development of the hypercoagulable state.

**Objective HPCD2.6: Risk Factors for Thrombophilia.** Give examples and discuss the pathophysiology of inherited versus acquired conditions that increase the risk of thrombophilia.

**Objective HPCD2.7: Disseminated Intravascular Coagulopathy.** Discuss disseminated intravascular coagulopathy (DIC) in terms of etiologies, pathogenesis, clinical presentation, and course.

**Objective HPCD2.8: Inherited Hemophilia.** Discuss the pathogenesis and clinical and laboratory manifestations of hemophilia A and explain how it differs from hemophilia B.

**Objective HPCD2.9: Vitamin K and Liver Disease.** Describe the pathogenesis and clinical and laboratory findings in liver disease and vitamin K deficiency.

**Objective HPCD2.10: von Willebrand Disease.** Compare and contrast types I, II, and III von Willebrand disease and explain the quantitative or qualitative abnormalities and the laboratory features observed in each type.

**Objective HPCD2.11: Antiphospholipid Antibody Syndrome.** Describe the pathogenesis and clinical and laboratory findings in antiphospholipid antibody syndrome.

**Objective HPCD2.12: Heparin-Induced Thrombocytopenia.** Explain the mechanism of heparin-induced thrombocytopenia/thrombosis and describe its clinical presentation and approach to therapy.

**Objective HPCD2.13: Thrombophilia in Cancer.** Explain the risk of thrombophilia in cancer, describe the context of Trousseau syndrome, and give classic examples of malignancies associated with thrombophilia.

## Topic: Respiratory System (RS)

Respiratory disorders resulting from abnormal development, genetic mutations, immune, infections, and intrinsic disease as they relate to lung abnormalities are enumerated.

### Learning Goal 1: Vascular Diseases of the Lung

Apply knowledge of the structure and function of blood vessels to explain the pathogenesis, clinical manifestations, and pathologic findings in pulmonary embolism, pulmonary hypertension, and diffuse pulmonary hemorrhage syndromes.

**Objective RS1.1: Clinical Features of Pulmonary Embolism.** Compare and contrast the clinical manifestations, radiographic and

pathologic findings, and potential consequences of pulmonary embolism in terms of single versus multiple, and small versus large emboli.

**Objective RS1.2: Conditions Predisposing to Pulmonary Embolism.** Discuss the factors, including underlying conditions, which can impact the incidence and clinical significance of pulmonary embolism.

**Objective RS1.3: Pulmonary Hypertension.** Describe the structural cardiopulmonary conditions that are frequently associated with pulmonary hypertension.

**Objective RS1.4: Conditions Contributing to Pulmonary Hypertension.** Explain how each of the following cardiopulmonary conditions contributes to pulmonary hypertension: increased pulmonary blood flow or pressure, increased pulmonary vascular resistance, or left heart resistance to blood flow.

**Objective RS1.5: Pathogenesis of Pulmonary Hypertension.** Describe the pathogenesis of pulmonary hypertension in hereditary and secondary forms and the characteristic gross and microscopic morphologic features of each.

**Objective RS1.6: Goodpasture Syndrome and Wegener Granulomatosis.** Compare and contrast the clinical manifestations, pathogenesis, and pathologic findings in Goodpasture Syndrome and granulomatosis with polyangiitis (Wegener Granulomatosis).

### Learning Goal 2: Pulmonary Infection

Apply knowledge of the local pulmonary defense mechanisms and systemic host resistance to infection to discuss pathogenesis, classification, clinical manifestations, and pathologic findings in lower respiratory tract infections in immunocompetent and immunocompromised hosts.

**Objective RS2.1: Pulmonary Infections in the Immunocompromised Patient.** Discuss the common infectious agents that produce pulmonary disease that are generally associated with defects in innate, humoral, or cell-mediated immunity.

**Objective RS2.2: Classification of Pneumonia by Agent.** Describe the classification of pneumonias by clinical setting and name the common etiologic agents for each category.

**Objective RS2.3: Clinical Features of Pneumonia.** Compare and contrast the clinical presentation and manifestations, gross and microscopic pathology, prognosis, and potential complications for each category of pneumonia.

**Objective RS2.4: Categorization of Pneumonia.** Define bronchopneumonia, lobar pneumonia, and atypical pneumonia/interstitial pneumonitis and compare and contrast the common etiologic agents and pathologic findings for each.

**Objective RS2.5: Tuberculosis.** Compare and contrast the clinical presentation and gross and microscopic findings in primary, secondary/reactivation, and miliary tuberculosis.

**Objective RS2.6: Influenza.** Define antigenic drift and antigenic shift in influenza viruses and discuss how these can result in epidemics and pandemics.

**Objective RS2.7: Clinical Features of Upper- and Lower-Respiratory Infections.** Compare and contrast the pathologic findings in upper and lower respiratory tract influenza infections.

**Objective RS2.8: Aspiration Pneumonia.** Name risk factors for aspiration pneumonia and describe the pathology, prognosis, and potential complications.

**Objective RS2.9: Lung Abscess.** Define lung abscess in terms of pathogenesis, typical microorganisms, clinical presentation and course, and pathologic findings.

**Objective RS2.10: Fungal Pneumonia.** Compare and contrast the causative agents, geographic locations, clinical presentation, and pathologic findings in chronic pneumonia caused by fungal organisms.

**Objective RS2.11: Features of Pulmonary Infections in the Immunocompromised and Immunocompetent.** Discuss the differences in clinical presentation and etiologic agents of pneumonia in immunocompetent versus immunocompromised hosts.

### Learning Goal 3: Lung Neoplasia

Apply knowledge of the molecular basis of neoplasia to describe clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of lung neoplasms.

**Objective RS3.1: Lung Neoplasms.** Describe the common locations for the different types of lung cancer.

**Objective RS3.2: Morphologic Features of Lung Neoplasms.** Discuss key gross and histopathologic features that may help differentiate between small cell, adenocarcinoma, and squamous cell carcinoma.

**Objective RS3.3: Metastatic Carcinoma to the Lung.** Describe features that favor the diagnosis of metastatic carcinoma over a primary lung tumor.

**Objective RS3.4: Genetics of Lung Cancer.** Describe the contribution of specific genetic mutations that are found in particular lung cancers and explain how these mutations affect therapeutic decisions.

**Objective RS3.5: Environmental Factors Predisposing to Lung Cancer.** Explain the environmental factors that predispose to the development of lung cancer and illustrate how these factors interact with genetic factors in the development of cancer.

### Learning Goal 4: Obstructive Diseases of the Lung

Apply knowledge of the genetic and environmental factors leading to cell injury to explain the clinical and pathophysiological consequences that result in obstruction to airflow.

**Objective RS4.1: Emphysema.** Describe the role of smoking in emphysema; name the 4 different types of emphysema, which is most common, and which lobes of the lungs are most involved in centrilobular emphysema.

**Objective RS4.2: Bronchiectasis.** Explain the gross morphologic changes associated with bronchiectasis and name 2 diseases that may lead to bronchiectasis.

**Objective RS4.3: Pneumoconiosis.** Describe the clinicopathologic features identified with common forms of pneumoconiosis.

**Objective RS4.4: Asthma.** Compare and contrast the clinicopathologic features and causes of asthma and describe the morphologic changes and consequences that result in airflow obstruction.

## Topic: Head and Neck (HN)

Head and neck disorders resulting from abnormal development, genetic mutations, immune, and intrinsic disease as they relate to salivary and upper respiratory abnormalities are enumerated.

### Learning Goal 1: Nonneoplastic Salivary Gland Disorders

Apply knowledge of the structure and function of the salivary glands to an understanding of the clinicopathologic features associated with disorders presenting with gland enlargement.

**Objective HN1.1: Salivary Duct Obstruction.** Describe the potential causes for obstruction of the salivary gland duct.

**Objective HN1.2: Lymphocytic Sialadenitis.** Discuss disorders arising from lymphocytic infiltration of the salivary glands and discuss their potential neoplastic complications.

**Objective HN1.3: Sjögren Syndrome.** Describe Sjögren syndrome and discuss how it relates to salivary gland dysfunction, its effect on multiple organ systems, complications, and long term risks.

### Learning Goal 2: Head and Neck Neoplasia

Apply knowledge of the etiology, pathogenesis, morphological appearance; and classification of neoplasms involving the salivary glands, oral cavity, upper airways, and larynx to their diagnosis; and prediction of biological behavior, prevention, and treatment.

**Objective HN2.1: Benign and Mucoepidermoid Tumors of Salivary Glands.** Distinguish the clinicopathologic features of the 2 benign tumors (pleomorphic adenoma or mixed tumor and Warthin tumor) from the malignant mucoepidermoid carcinoma.

**Objective HN2.2: Squamous Cell Carcinoma of the Oropharynx.** Discuss the pathogenesis of squamous cell carcinoma of the oropharynx and the spectrum of histologic findings from normal mucosa to invasive disease.

**Objective HN2.3: Causes of Oropharyngeal Squamous Cell Carcinoma.** Compare and contrast human papillomavirus (HPV)-driven and alcohol-/tobacco-driven development of squamous cell carcinoma including precursor lesions, tumor formation and progression, anatomic location, and survival rate.

**Objective HN2.4: Developmental Neck Masses and Other Neck Tumors.** Compare and contrast developmental lesions that present as masses in the neck (branchial cyst and thyroglossal duct cyst) from a paraganglioma including pathogenesis and morphologic features of each.

## Topic: Gastrointestinal Tract (GT)

Gastrointestinal (GI) tract disorders resulting from abnormal development, genetic mutations, immune, infections, and intrinsic disease as they relate to the esophagus, small, and large intestine abnormalities are enumerated.

### Learning Goal 1: Embryology of the Gut

Apply knowledge of the embryology of the foregut, midgut, and hindgut to summarize the morphological features and clinical presentation of developmental anomalies.

**Objective GT1.1: Congenital Disorders of the Gut.** Discuss the clinicopathological features of tracheoesophageal fistula, pyloric stenosis, intestinal atresia, Meckel diverticulum, and Hirschsprung disease.

### Learning Goal 2: Anatomy and Blood Supply of the Gut

Apply knowledge of the gross anatomy of the GI tract and hemodynamic principles to discuss vascular disorders.

**Objective GT2.1: Ischemic Disorders of the Gut.** Explain the pathogenesis and clinicopathological features for common disorders of the GI tract that arise from hypoxia or ischemia.

**Objective GT2.2: Necrotizing Enterocolitis.** Compare and contrast the pathophysiology of necrotizing enterocolitis from bowel infarction due to shock and atherosclerosis.

### Learning Goal 3: Gastrointestinal Neoplasia

Apply knowledge of the molecular basis of neoplasia to explain the clinical presentation, inheritance risk, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of gastrointestinal neoplasms.

**Objective GT3.1: Precursors to Bowel Carcinoma.** Discuss the precursor lesions, risk factors, and hereditary cancer syndromes that lead to GI neoplasia.

**Objective GT3.2: Molecular Basis of Bowel Neoplasms.** Summarize the molecular basis and clinicopathologic features, local and systemic, for esophageal cancer, gastric cancer, GI lymphoma, GIST, colon, and anal cancer.



**Objective GT3.3: Esophageal Carcinoma.** Describe the location of adenocarcinomas versus squamous cell carcinomas of the esophagus and list the major risk factors for each.

**Objective GT3.4: Colon Carcinoma.** Discuss the 2 most important prognostic factors for colon cancer and explain why they are most important.

**Objective GT3.5: Colonic Polyps.** Compare and contrast the different types of polyps and their risk of developing cancer.

#### **Learning Goal 4: Features of Gastrointestinal Neoplasms**

Apply knowledge of the gross anatomy of the GI tract and its blood supply to describe presenting signs and symptoms and pattern of spread of gastrointestinal neoplasms.

**Objective GT4.1: Right- and Left-Sided Colon Carcinoma.** Distinguish between carcinomas arising in the left and right colon in terms of symptoms and morphology.

**Objective GT4.2: Staging of Colon Carcinoma.** Describe how colon cancers are staged and list the common sites of metastases.

#### **Learning Goal 5: Immune-Related Disorders of the Bowel**

Apply knowledge of immune system dysregulation to discuss specific immune-related disorders.

**Objective GT5.1: Inflammatory Bowel Disease.** Compare and contrast the pathophysiology and clinicopathological features of inflammatory bowel disease.

**Objective GT5.2: Celiac Disease.** Explain the pathophysiology of gliadin hypersensitivity (celiac disease).

**Objective GT5.3: Crohn's Disease and Ulcerative Colitis.** Describe the distribution of Crohn's disease, pathogenesis, and how transmural involvement is related to complications and compare and contrast Crohn's disease with ulcerative colitis

#### **Learning Goal 6: Malabsorption**

Apply knowledge of gastrointestinal anatomy and physiology to summarize the clinicopathologic features, diagnostic criteria, and therapy of disorders presenting with malabsorption.

**Objective GT6.1: Systemic Disorders With Malabsorption.** Compare and contrast the pathogenesis and clinicopathologic features of systemic disorders leading to malabsorption.

**Objective GT6.2: Pancreaticobiliary Causes of Malabsorption.** Outline disorders of the pancreas and bile acid metabolism, and discuss how they lead to malabsorption.

**Objective GT6.3: Inflammatory Causes of Malabsorption.** Explain how celiac disease, sprue, gastroenteritis, and inflammatory bowel disease lead to malabsorption.

#### **Learning Goal 7: Bowel Infections**

Apply knowledge of common pathogens and principles of immunity to describe the morphological features and clinical presentation of infectious diseases affecting immunocompetent and immunocompromised patients.

**Objective GT7.1: Bowel Infections.** Compare the underlying mechanism and clinicopathologic features of GI tract involvement by common bacterial, fungal, and parasitic pathogens.

**Objective GT7.2: Helicobacter Infection.** Relate the clinicopathologic features of *Helicobacter* to chronic gastritis and ulcer formation.

#### **Learning Goal 8: Mechanical Disorders of Bowel**

Apply knowledge of GI anatomy and physiology to explain the clinicopathologic features, diagnostic criteria, and therapy of disorders resulting in acid reflux, abnormal GI motility, and gastrointestinal tract obstruction.

**Objective GT8.1: Dysphagia.** Describe the pathophysiology and clinicopathological features of disorders presenting with dysphagia.

**Objective GT8.2: Bowel Obstruction.** Compare and contrast the pathophysiology of gastrointestinal disorders that present with GI obstruction, including disorders such as volvulus, hernias, adhesions, and intussusception.

**Objective GT8.3: Diverticulosis.** Describe the pathogenesis and complications of diverticulosis.

**Objective GT8.4: Appendicitis.** Describe the clinicopathologic features of acute appendicitis and discuss the clinical differential diagnosis and potential complications of this disorder.

### **Topic: Hepatobiliary (HB)**

Hepatobiliary disorders resulting from abnormal development, genetic mutations, immune, infections, toxins, and intrinsic disease as they relate to liver and biliary abnormalities are enumerated.

#### **Learning Goal 1: Hepatitis**

Apply knowledge of pathogenic organisms infecting the liver and their transmission, natural history, pathogenesis, laboratory profiles, and histopathological patterns of injury to the prevention and diagnosis of hepatitis.

**Objective HB1.1: Transmission of Hepatotropic Viruses.** Explain the routes of transmission of different hepatotropic viruses and how they relate to the public health measures that have been implemented to prevent their transmission.

**Objective HB1.2: Progression of Hepatitis.** Compare and contrast the possible clinical outcomes of the major hepatotropic viruses with particular reference to the incidence of progression to chronic hepatitis and cirrhosis.

**Objective HB1.3: Pathophysiology of Hepatitis.** Describe the pathophysiology associated with the major hepatotropic viruses and explain how this knowledge can be used to assess the presence of hepatitis, and the management and prognosis of this disease.

**Objective HB1.4: Histopathology of Hepatitis.** Explain the pathogenic mechanisms of injury that result in the histopathological findings observed in acute and chronic viral hepatitis.

**Objective HB1.5: Hepatic Abscess.** Describe the etiology of hepatic abscesses and the pathways that infectious agents may take to reach the liver.

**Objective HB1.6: Cirrhosis.** Classify types of cirrhosis, in terms of etiology, pathogenesis, morphologic pattern (gross and microscopic), and their relationship to neoplasia.

### Learning Goal 2: Liver Toxins

Apply knowledge of the cellular response to injury, the pathogenic mechanisms leading to disease and the biochemical alterations of hepatic function to explain the clinicopathologic features, prognosis, and treatment of disorders resulting from ethanol and other drugs and toxins.

**Objective HB2.1: Steatosis.** Describe the clinicopathologic features of excessive ethanol ingestion, focusing on biochemical pathways and short- and long-term complications, and compare and contrast alcoholic with nonalcoholic fatty liver disease.

**Objective HB2.2: Acetaminophen Toxicity.** Describe the clinicopathologic features of excessive acetaminophen ingestion focusing on biochemical pathways and short- and long-term complications.

**Objective HB2.3: Hemochromatosis.** Discuss the clinicopathologic features of excessive iron absorption, focusing on biochemical pathways, genetic factors, and short- and long-term complications.

### Learning Goal 3: Hepatic Neoplasms

Apply knowledge of the molecular basis of neoplasia to describe the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of hepatic neoplasms.

**Objective HB3.1: Causes of Hepatocellular Carcinoma.** Compare and contrast, in the context of geographic location, the epidemiological importance of the known etiologic agents associated with the development of hepatocellular carcinoma and suggest public health measures that might decrease its incidence.

**Objective HB3.2: Pathogenesis.** Discuss the pathogenesis of hepatocellular carcinoma arising in the setting of hepatitis B and hepatitis C, chronic hepatitis, and cirrhosis.

**Objective HB3.3: Molecular Basis of Hepatic Adenoma.** Describe how the molecular basis of a hepatic adenoma contributes to the risk of malignant transformation.

**Objective HB3.4: Radiology of Cirrhosis.** Identify the major space-occupying lesions that may be seen on radiographic imaging of the normal and cirrhotic liver, and discuss the complications of cirrhosis.

**Objective HB3.5: Metastasis to the Liver.** Describe the factors that lead to metastasis to the liver and the features of metastatic disease that distinguish it from primary neoplasms.

### Learning Goal 4: Inflammatory and Congenital Hepatobiliary Disorders

Apply knowledge of the cellular response to injury, the pathogenic mechanisms leading to disease and the biochemical alterations of hepatic function to describe the clinicopathologic features, prognosis, and treatment of intrahepatic and extrahepatic biliary tract diseases.

**Objective HB4.1: Inflammatory Disorders of the Liver.** Outline how autoimmune hepatitis, primary and secondary biliary cirrhosis, and primary sclerosing cholangitis differ regarding associated conditions, incidence, sex predilection, etiology, laboratory features, clinical features and prognosis.

**Objective HB4.2: Congenital Disorders of the Liver.** Compare and contrast the etiology and treatment of biliary atresia and neonatal hepatitis.

### Learning Goal 5: Molecular Basis of Biliary Neoplasia

Apply knowledge of the molecular basis of neoplasia to an understanding of the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of neoplasms involving the biliary tree.

**Objective HB5.1: Extrahepatic Biliary Carcinoma.** Describe the epidemiology, morphology, and clinical features of gallbladder and extrahepatic biliary tract carcinoma.

**Objective HB5.2: Cholangiocarcinoma.** Describe the presenting symptoms of cholangiocarcinoma and how the symptoms relate to the location.

### Learning Goal 6: Nonneoplastic Disorders of Biliary Tree

Apply knowledge of both the embryonic principles of hepatic and bile tract development and mechanisms of fibro-inflammatory injury to an understanding of disorders due to maldevelopment and acquired abnormalities of the biliary tree.

**Objective HB6.1: Congenital Hepatic Fibrosis.** Describe the inheritance, etiology, clinical and laboratory features, and prognosis of congenital hepatic fibrosis.

**Objective HB6.2: Polycystic Liver Disease.** Describe the inheritance, etiology, clinical and laboratory features, and prognosis of polycystic liver disease.

### Learning Goal 7: Cholelithiasis

Apply knowledge of general biochemical principles to an understanding of how gallstones develop, risk factors for their development, and their clinical presentation and complications.

**Objective HB7.1: Gallstones.** Describe the risk factors, clinical features, complications, mechanisms, and composition of gallstones.

**Objective HB7.2: Cholecystitis.** Differentiate the epidemiology, morphology, clinical features, and complications of acute and chronic cholecystitis.

**Objective HB7.3: Empyema and Hydrops of the Gallbladder.** Differentiate the etiology, pathogenesis, morphology, and clinical features of empyema and hydrops of the gallbladder.

### Topic: Pancreas (P)

Pancreas disorders resulting from abnormal development, genetic mutations, immune, infections and intrinsic disease as they relate to the exocrine pancreatic abnormalities are enumerated.

#### Learning Goal 1: Nonneoplastic Disorders of the Exocrine Pancreas

Apply knowledge of the structure and function of the pancreas to an understanding of the clinicopathologic features and diagnostic criteria of disorders resulting from cellular injury to the exocrine pancreas.

**Objective P1.1: Pancreatitis.** Compare and contrast acute and chronic pancreatitis in terms of etiology, pathogenesis, morphologic features, and complications.

**Objective P1.2: Genetic Disorders of the Pancreas.** Describe with examples genetic disorders that affect the function of the exocrine pancreas.

#### Learning Goal 2: Pancreatic Neoplasia

Apply knowledge of the molecular basis of neoplasia to an understanding of the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of pancreatic neoplasms.

**Objective P2.1: Neoplasia of the Pancreas.** Describe the major types of neoplasms affecting the exocrine pancreas.

**Objective P2.2: Clinical Features of the Pancreatic Adenocarcinoma.** Explain how the location of a pancreatic neoplasm determines its presenting symptoms and discuss the risk factors for pancreatic adenocarcinoma.

**Objective P2.3: Endocrine Neoplasms of the Pancreas.** Describe clinicopathological features of neoplasms of the endocrine pancreas.

### Topic: Kidney (UTK)

Kidney disorders resulting from abnormal development, genetic mutations, immune, infections, and intrinsic disease as they relate to renal abnormalities are enumerated.

#### Learning Goal 1: Renal Neoplasia

Apply knowledge of the molecular basis of neoplasia to explain the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of renal neoplasms.

**Objective UTK1.1: Renal Cell Carcinoma.** Compare and contrast the 3 major types of renal cell carcinoma (clear cell, papillary, and chromophobe) in terms of clinical presentation, diagnostic morphological features, and molecular pathogenesis.

**Objective UTK1.2: Urothelial and Renal Cell Carcinoma.** Compare and contrast pelvic urothelial malignancies with renal cell carcinomas in relation to risk factors, microscopic appearance, and biological behavior.

**Objective UTK1.3: Grading and Staging of Renal Carcinoma.** Describe how renal cell carcinoma is graded and staged and discuss the factors that determine prognosis.

**Objective UTK1.4: Wilms Tumor.** Describe the clinical and pathologic features and molecular basis for Wilms tumor and list the histologic features that are important to recognize in determining prognosis, and the etiology of Wilms tumor as part of different syndromes.

#### Learning Goal 2: Structure and Function of the Nephron

Apply knowledge of kidney structure and function to summarize how acquired and hereditary abnormalities of the renal tubules and interstitium cause acute and/or chronic renal dysfunction.

**Objective UTK2.1: Tubulointerstitial Diseases.** Describe the clinicopathological features and pathogenesis of tubulointerstitial diseases and discuss how their pathogenesis relates to treatment and outcomes.

**Objective UTK2.2: Nephritis.** Compare and contrast acute pyelonephritis, drug-induced interstitial nephritis, and lupus nephritis in terms of pathogenesis, clinical presentation, histopathological appearance, and treatment.

**Objective UTK2.3: Acute Tubular Injury.** Compare and contrast ischemic and nephrotoxic forms of acute tubular injury, including typical clinical contexts, pathogenesis of renal failure, microscopic appearance, and expected outcome.

**Objective UTK2.4: Chronic Inflammatory Injury.** Compare and contrast chronic pyelonephritis and reflux nephropathy, including the organisms commonly associated with each.

### Learning Goal 3: Renal Vascular Dysfunction

Compare and contrast the common causes of renal vascular dysfunction in terms of size and types of vessels involved, characteristic gross and microscopic morphology, pathogenesis, and clinical presentation.

**Objective UTK3.1: Renal Artery Occlusion.** Compare thrombotic and embolic causes of renal arterial occlusions in terms of underlying pathogenesis, gross and microscopic pathological anatomy, and clinical presentation.

**Objective UTK3.2: Renal Changes in Hypertension.** Discuss how the pathogenesis of hypertension leads to structural changes in the renal vasculature and how the characteristic pathological vascular lesions of the kidney seen in hypertension cause renal dysfunction.

**Objective UTK3.3: HUS and TTP.** Compare and contrast typical hemolytic uremic syndrome (HUS), atypical HUS, and thrombotic thrombocytopenic purpura (TTP) in terms of clinical presentation, renal histopathology, pathogenesis, and prognosis.

### Learning Goal 4: Congenital Disorders of the Kidney

Apply knowledge of the embryologic principles of kidney and lower urinary tract development to explain developmental anomalies.

**Objective UTK4.1: Inherited Renal Disorders.** Compare autosomal dominant and autosomal recessive polycystic kidney disease in terms of pathological anatomy, molecular pathogenesis, and clinical presentation.

### Learning Goal 5: Renal Syndromes

Apply knowledge of the structure and function of the kidney to describe the pathogenetic mechanisms, diagnostic criteria, and clinicopathologic features of glomerular diseases presenting with asymptomatic proteinuria, nephrotic and nephritic syndrome.

**Objective UTK5.1: Nephritic Syndrome.** Describe the proliferative and proinflammatory pathologies of conditions presenting with nephritic syndrome.

**Objective UTK5.2: Nephrotic Syndrome.** Describe the pathophysiology and morphologic features of nephrotic syndrome, and contrast with nephritic syndrome.

**Objective UTK5.3: Immune-Mediated Renal Disease.** Compare and contrast the mechanisms of immune complex and antibody-mediated glomerulonephritis.

**Objective UTK5.4: Diabetic Nephropathy.** Describe the pathogenesis of diabetic nephropathy and the associated clinicopathologic features.

**Objective UTK5.5: Dysproteinemic Nephropathies.** Describe the pathogenesis of the nephropathies associated with dysproteinemia.

### Topic: Bladder (UTB)

Bladder disorders resulting from abnormal development, genetic mutations, infections, obstructions and intrinsic disease as they relate to urothelial abnormalities are enumerated.

#### Learning Goal 1: Bladder Neoplasia

Apply knowledge of the molecular basis of neoplasia to describe the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of bladder neoplasms.

**Objective UTB1.1: Urothelial Carcinoma.** Compare and contrast the different precursor lesions of urothelial carcinoma in terms of architecture, cytologic features, molecular-genetic changes, and propensity for invasion/progression.

**Objective UTB1.2: Risk Factors for Urothelial Carcinoma.** Relate the risk factors for urothelial carcinoma to general principles of carcinogenesis.

**Objective UTB1.3: Diagnosis and Surveillance of Urothelial Carcinoma.** Describe the typical clinical presentation of urothelial carcinoma and the advantages and limitations of urine cytology in diagnosis and surveillance of urothelial carcinoma.

**Objective UTB1.4: Staging of Bladder Cancer.** Relate stage of bladder cancer to prognosis and therapy, including the role of BCG, in the treatment of low-stage tumors.

#### Learning Goal 2: Bladder Infection

Apply knowledge of innate and adaptive immunity, pathogenic organisms infecting the bladder and their transmission to explain the natural history, pathogenesis, diagnosis, laboratory profiles, histopathological features, and prevention of cystitis.

**Objective UTB2.1: Acute Cystitis.** Discuss the typical clinical symptomatology of acute cystitis and the organisms commonly causing this disorder.

**Objective UTB2.2: Noninfectious Cystitis.** Describe the most common noninfectious causes of cystitis.

**Objective UTB2.3: Cystitis Associated With Bladder Mass.** Describe examples in which cystitis may result in mass lesions or morphologic lesions of the urinary bladder, and describe the pathogenesis of the process.

#### Learning Goal 3: Urinary Obstruction

Apply knowledge of the anatomy and physiology of the kidney to describe how disorders may lead to obstruction of urinary outflow.

**Objective UTB3.1: Bladder Diverticula.** Describe the pathogenesis of bladder diverticula, including congenital and acquired, and their potential role in infection, lithiasis, and obstruction and occult carcinoma.

**Objective UTB3.2: Nephrolithiasis.** List the different chemical types of nephrolithiasis, and explain the pathophysiologic mechanisms related to development and therapy/prevention of urinary stones.

**Objective UTB3.3: Causes of Urinary Obstruction.** Explain and give specific examples of several causes of urinary obstruction.

## Topic: Male Reproductive—Prostate (MP)

Prostate disorders resulting from genetic mutations, infections, and intrinsic disease as they relate to prostate abnormalities are enumerated.

### Learning Goal 1: Prostate Neoplasia

Apply knowledge of the molecular and cellular origins of prostate cancers, specifically adenocarcinoma, to summarize the epidemiology, clinicopathological features, natural history, and treatment strategies for this disease.

**Objective MPI.1: Prostate Adenocarcinoma.** Outline the cellular phenotype of the typical adenocarcinoma cell and describe its molecular and immunohistochemical characteristics.

**Objective MPI.2: Histopathologic Criteria for Prostate Adenocarcinoma.** Define the histopathological diagnostic criteria for the diagnosis of adenocarcinoma.

**Objective MPI.3: Epidemiology of Prostate Adenocarcinoma.** Explain the epidemiology of prostate cancer with respect to age, race, and family history.

**Objective MPI.4: “Histological” versus “Clinically Significant” Adenocarcinoma.** Compare and contrast the significance of “histological” adenocarcinoma versus a “clinically significant” adenocarcinoma.

### Learning Goal 2: Nonneoplastic Disorders of the Prostate

Apply knowledge of the molecular and cellular origins of nonneoplastic disorders of the prostate, specifically prostatitis and nodular hyperplasia, to explain the epidemiology, clinicopathological features, natural history, and treatment strategy for these diseases.

**Objective MP2.1: Nodular Hyperplasia.** Explain the molecular and hormonal origins of nodular hyperplasia, the area of the prostate affected, the natural history of the disease, various treatment strategies, and anticipated outcomes of treatment.

**Objective MP2.2: Prostatitis.** Describe the pathophysiologic basis for inflammatory conditions affecting the prostate, including the organisms causing this condition.

## Topic: Male Reproductive—Testes (MT)

Testicular disorders resulting from abnormal development, germ cell lesions, infections, and intrinsic disease as they relate to testes abnormalities are enumerated.

### Learning Goal 1: Nonneoplastic Disorders of the Testes

Apply knowledge of the molecular and cellular origins of nonneoplastic disorders of the testis to explain the epidemiology, clinicopathological features, natural history, and treatment strategy for these diseases.

**Objective MT1.1: Cryptorchism.** Name the structure through which the testes descend during fetal development and what is brought with the testes in the descent. Describe the complications observed for failure of the testes to descend (cryptorchidism).

**Objective MT1.2: Testicular Torsion.** Describe the clinicopathologic features that occur in the testis due to torsion of the spermatic cord.

**Objective MT1.3: Orchitis.** Discuss several inflammatory conditions affecting the testis and the clinicopathologic features associated with each.

### Learning Goal 2: Testicular Neoplasia

Apply knowledge of the molecular and cellular origins of the common types of testicular cancer to explain the epidemiology, clinicopathological features, natural history, and treatment strategies for this disease.

**Objective MT2.1: Germ-Cell Tumors of the Testis.** Describe the most important risk factors for development of a germ cell tumor of the testis and outline the clinicopathologic features for the different morphologic patterns seen.

**Objective MT2.2: Diagnosis of the Testicular Mass.** Discuss a differential diagnosis for a testicular mass.

## Topic: Breast (BR)

Breast disorders resulting from abnormal development, genetic mutations, immune mediated, infections, and intrinsic disease as they relate to breast abnormalities are enumerated.

### Learning Goal 1: Nonneoplastic Disorders of the Breast

Apply knowledge of the embryology, cellular responses to injury, underlying etiology, and biologic and molecular alterations to describe the clinical presentation, inheritance risk, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and therapy of nonneoplastic disorders of the breast.

**Objective BR1.1: Clinical Presentation of Breast Lesions.** Identify the most frequently diagnosed breast lesions by age of the patient,

based on the most common clinical presentations in males versus females.

**Objective BR1.2: Silicone Breast Implants.** Discuss silicone breast implants in terms of the morphologic changes in the adjacent breast and the risk of subsequent autoimmune disease and cancer.

**Objective BR1.3: Reactive Breast Conditions.** Compare and contrast reactive breast conditions in terms of etiology, pathogenesis, morphology, and clinical features.

**Objective BR1.4: Fibrocystic Change.** Discuss the clinical significance of proliferative and nonproliferative fibrocystic change, with and without atypia, and describe how each of these changes and the family history affects the subsequent risk of developing breast cancer.

### **Learning Goal 2: Molecular Basis of Breast Neoplasms**

Apply knowledge of the molecular basis of neoplasia to describe the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of breast neoplasms.

**Objective BR2.1: Fibroadenoma and Phyllodes Tumor.** Compare and contrast fibroadenoma and phyllodes tumor in terms of clinical features, morphologic findings, and prognosis.

**Objective BR2.2: Precursors to Breast Carcinoma.** Describe the proposed precursor-carcinoma sequence in breast cancer and name the characteristic morphologic changes.

**Objective BR2.3: Ductal Carcinoma-in-Situ.** Compare and contrast ductal carcinoma in situ (DCIS) and lobular carcinoma in situ (LCIS) in terms of incidence, clinical presentation, morphology, biomarker expression, pattern of spread, natural history, treatment, and prognosis.

**Objective BR2.4: Breast Cancer Susceptibility Genes.** For the most common breast cancer susceptibility genes, describe the normal function of the gene product, incidence of gene mutation, reasons for its association with cancer, percentage of hereditary breast cancer, and risk of breast cancer by age 70.

**Objective BR2.5: Gene Expression in Breast Cancer.** Explain the major molecular classes of invasive ductal carcinoma of the breast identified by gene expression profiling, and describe how each correlates with prognosis and response to therapy.

**Objective BR2.6: Categories of Breast Cancer.** Construct a table to compare and contrast invasive ductal carcinoma (NOS), invasive lobular carcinoma, medullary carcinoma, colloid (mucinous) carcinoma, tubular carcinoma, and metaplastic carcinoma of the breast in terms of incidence, age predilection, etiology, pathogenesis, clinical presentation, gross and microscopic morphology, grade, molecular classification, patterns of spread, clinical course, prognostic indicators, treatment options, and survival rates, and indicate which are more common in males versus females.

**Objective BR2.7: Factors Affecting Response and Prognosis of Breast Cancer.** Explain the prognosis and likelihood of recurrence and response to therapy for breast cancer patients based on knowledge of molecular classification and/or gene expression profiling, morphologic classification, grade, prognostic marker studies, and other predictive factors.

### **Topic: Female Reproductive—Uterus (FU)**

Uterine disorders resulting from abnormal development, genetic mutations, infections, and intrinsic disease as they relate to uterine abnormalities are enumerated.

#### **Learning Goal 1: Uterine Neoplasia**

Apply knowledge of the molecular basis of neoplasia to describe the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of uterine neoplasms.

**Objective FU1.1: Clinical Features of Uterine Neoplasms.** Compare and contrast common benign and malignant uterine neoplasms, including important clinicopathological features related to treatment and prognosis.

**Objective FU1.2: Endometrial Carcinoma.** Compare and contrast the precursors, clinical setting, risk factors, pathologic findings and prognosis for type I and type II carcinomas of the endometrium.

**Objective FU1.3: Hereditary Colorectal Cancer and Endometrial Carcinoma.** Discuss the relationship of endometrial carcinoma to hereditary nonpolyposis colorectal carcinoma.

**Objective FU1.4: Smooth Muscle Tumors of the Uterus.** Discuss the natural history, clinical presentation, and management of benign smooth muscle tumors of the uterus and the risk for malignant transformation.

#### **Learning Goal 2: Nonneoplastic Uterine Disorders**

Apply knowledge of uterine physiology, endocrinology, and anatomy to compare and contrast the clinical presentation and pathology of common nonneoplastic uterine disorders.

**Objective FU2.1: Endometrial Hyperplasia.** Define endometrial hyperplasia and discuss its etiology, classification, and prognosis.

**Objective FU2.2: Menstrual Cycle.** Identify the phases of the menstrual cycle and the major hormonal changes that occur, comparing normal menstruation to common causes of abnormal bleeding in adolescents, perimenopausal, and postmenopausal women.

**Objective FU2.3: Uterine Adenomyosis.** Compare and contrast the pathology of adenomyosis with endometriosis.

**Objective FU2.4: Abnormal Uterine Bleeding.** Discuss causes of abnormal uterine bleeding including hormonal disturbances, acute and chronic endometritis, and endometrial polyps.

### Learning Goal 3: Cervical Disorders

Apply knowledge of cervical physiology and anatomy to compare and contrast the clinical presentation and pathology of common cervical disorders.

**Objective FU3.1: Clinical Features of Cervical Dysplasia and Neoplasms.** Discuss the common human papillomavirus (HPV) types that affect the cervix and discuss the pathogenesis of cervical dysplasia and neoplasia, and cervical screening methods and prevention.

### Learning Goal 4: Female Genital Tract

Apply knowledge of physiology and anatomy to compare and contrast the clinical presentation and pathology of common female genital tract disorders.

**Objective FU4.1: Clinical Features of Pelvic Infections.** Discuss the common pelvic infections including those affecting the vulva, vagina, cervix, and fallopian tubes, and describe the pathogenesis of pelvic inflammatory disease, common organisms involved, and its complications.

## Topic: Female Reproductive—Ovary (FO)

Ovarian disorders resulting from abnormal development, genetic mutations, infections, immune, and intrinsic disease as they relate to the ovary are enumerated.

### Learning Goal 1: Ovarian Neoplasia

Apply knowledge of the molecular basis of neoplasia to describe the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of ovarian neoplasms

**Objective FO1.1: Ovarian Development.** Describe the embryologic development and the histologic components of the ovary, including surface Müllerian epithelium, germ cells, and the sex-cord stromal cells.

**Objective FO1.2: Causes of Ovarian Neoplasm.** Describe the risk factors, genetic associations, and molecular basis, including hereditary cancer syndromes, for ovarian neoplasms, including those derived from epithelium, sex-cord stromal as well as germ cell neoplasms.

### Learning Goal 2: Nonneoplastic Disorders of the Ovary

Apply knowledge of infectious diseases, embryology, and immunology to explain the major pathologic features of processes affecting the ovary.

**Objective FO2.1: Infections Involving the Ovary.** Describe the pathogens, bacterial, fungal, and parasitic that can cause ovarian

disease and explain the underlying mechanisms, clinicopathologic features, and complications.

**Objective FO2.2: Polycystic Ovary Syndrome.** Explain the pathophysiologic basis of polycystic ovary syndrome.

**Objective FO2.3: Immune Diseases of the Ovary.** Explain the mechanism(s) by which the dysregulation of the immune system gives rise to ovarian disease and describe the pathology observed.

**Objective FO2.4: Menopause.** Describe the clinicopathologic features of menopause and the basis for treatment.

## Topic: Female Reproductive—Disorders of Pregnancy (FDP)

Pregnancy disorders resulting from abnormal implantation, genetic mutations, hemodynamic, immune, infections, and intrinsic disease as they relate to gestational disease abnormalities are enumerated.

### Learning Goal 1: Disorders of Pregnancy

Apply knowledge of embryology, cellular responses to injury, hemodynamics, and molecular alterations to summarize the clinical presentation, morphologic appearance, classification, diagnosis, biologic behavior of and therapy for disorders of pregnancy.

**Objective FDP1.1: Ectopic Pregnancy.** Describe risk factors, characteristic morphologic findings, potential outcomes, and the medical/surgical options for management of ectopic pregnancy in relation to the pathogenesis and likelihood of adverse consequences.

**Objective FDP1.2: Spontaneous Abortion.** List 2 fetal and 6 maternal causes for spontaneous abortion and indicate which is the most common.

**Objective FDP1.3: Late Pregnancy.** Describe how disorders of late pregnancy can lead to effects that threaten the mother and/or fetus.

**Objective FDP1.4: Infections during Pregnancy.** Discuss the ascending and hematogenous infections occurring during pregnancy in terms of etiology, pathogenesis, morphology, methods of diagnosis, prognosis, and treatment.

**Objective FDP1.5: Eclampsia.** Explain the principal pathophysiologic aberrations of the placenta and maternal circulation in preeclampsia and eclampsia; the characteristic morphologic features in the placenta, liver, kidney, and brain; and how management is affected by gestational age and severity of disease.

**Objective FDP1.6: Gestational Trophoblastic Disease.** Explain with specific examples how to differentiate forms of gestational trophoblastic disease based on etiology, pathogenesis, morphologic features, clinical features, and laboratory findings,

including potential consequences and/or subsequent risks, treatment, and prognosis for each.

**Objective FDPI.7: Gestational Diabetes.** Describe the pathophysiologic effects of diabetes mellitus on the mother and fetus.

## Topic: Endocrine (EN)

Endocrine disorders resulting from abnormal development, genetic mutations, immune, infections, and intrinsic disease as they relate to multiple endocrine organ abnormalities are enumerated.

### Learning Goal 1: Hyper- and Hypopituitarism

Apply knowledge of pituitary physiology to describe the pathophysiology and clinicopathologic features of disorders associated with hyperpituitarism and hypopituitarism.

**Objective EN1.1: Anterior Pituitary.** List several causes for destruction of the anterior pituitary and the clinicopathologic features associated with each.

**Objective EN1.2: Sheehan's Syndrome.** Define Sheehan's syndrome and discuss the clinicopathologic features associated with it.

**Objective EN1.3: Posterior Pituitary.** Outline the clinicopathologic features associated with disorders affecting the posterior pituitary gland.

### Learning Goal 2: Hyper- and Hypothyroidism

Apply knowledge of thyroid physiology to explain the pathophysiology and clinicopathologic features of disorders associated with hyperthyroidism and hypothyroidism.

**Objective EN2.1: Causes of Hyper- and Hypothyroidism.** Compare and contrast the causes of hyperthyroidism versus hypothyroidism.

**Objective EN2.2: Clinical Features of Hyper- and Hypothyroidism.** Compare and contrast the clinicopathologic features of hyperthyroidism versus hypothyroidism.

### Learning Goal 3: Autoimmune Thyroiditis

Apply knowledge of immune system dysregulation to summarize immune-related disorders of the thyroid.

**Objective EN3.1: Graves' Disease, Hashimoto Thyroiditis, and Subacute Thyroiditis.** Compare and contrast the pathophysiology and clinicopathologic features of Graves' disease, Hashimoto's thyroiditis, and subacute lymphocytic thyroiditis.

**Objective EN3.2: Granulomatous Thyroiditis.** Compare and contrast immune-mediated thyroid disease with subacute granulomatous thyroiditis (de Quervain's thyroiditis).

### Learning Goal 4: Hyper- and Hypoadrenalism

Apply knowledge of adrenal physiology to describe the pathophysiology and clinicopathologic features of disorders associated with adrenocortical hyperfunction (hyperadrenalism) and adrenocortical insufficiency.

**Objective EN4.1: Cushing Syndrome.** Compare and contrast the causes and clinicopathologic features of hypercortisolism (Cushing syndrome) and the pathophysiologic basis distinguishing between these causes and the management of this disease.

**Objective EN4.2: Hyperaldosteronism.** Compare and contrast the causes and clinicopathologic features of primary and secondary hyperaldosteronism.

**Objective EN4.3: Congenital Adrenal Hyperplasia.** Outline the clinicopathologic features of congenital adrenal hyperplasia.

**Objective EN4.4: Adrenocortical Insufficiency.** Compare and contrast the causes of adrenocortical insufficiency, including the pathogenesis of primary acute and chronic adrenocortical insufficiency.

### Learning Goal 5: Endocrine Neoplasms

Apply knowledge of the molecular basis of neoplasia to explain the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of endocrine neoplasms.

**Objective EN5.1: Thyroid Neoplasms.** Compare and contrast the clinicopathologic features of follicular adenomas, follicular carcinoma, and papillary thyroid carcinoma.

**Objective EN5.2: Medullary Thyroid Carcinoma.** Describe the molecular basis and clinicopathologic features of medullary thyroid carcinoma.

**Objective EN5.3: Pheochromocytoma and Paraganglioma.** Outline the clinicopathologic features of pheochromocytoma and compare and contrast the hereditary cancer syndromes associated with paragangliomas/pheochromocytomas.

**Objective EN5.4: Pituitary Adenoma.** Explain the clinicopathologic features of pituitary adenomas including their genetic mutations and their associated clinical syndromes.

**Objective EN5.5: Endocrine Neoplasia of the Pancreas including Islet Cell Tumors.** Compare and contrast the clinicopathologic features of the pancreatic endocrine tumors including the genetic alterations and complications of each.

### Learning Goal 6: Endocrine Pancreas

Apply knowledge of the structure and function of the endocrine pancreas and biochemical principles of carbohydrate metabolism to summarize the clinicopathologic features, diagnostic criteria, and therapy of disorders resulting from excess or decreased production of insulin and other islet cell hormones.



**Objective EN6.1: Features of Diabetes Mellitus.** Compare and contrast the clinicopathologic features of type 1 and type 2 diabetes.

**Objective EN6.2: Complications of Diabetes Mellitus.** Outline the pathologic complications of diabetes mellitus.

**Objective EN6.3: Multiple Endocrine Neoplasia (MEN) Syndromes.** Compare and contrast the clinicopathologic features of MEN 1 with MEN 2 and 3.

## Topic: Skin (SK)

Skin disorders resulting from abnormal development, genetic mutations, immune, infections, and intrinsic disease as they relate to dermal abnormalities are enumerated.

### Learning Goal 1: Classification of Skin Disease

Apply knowledge of histology, cell biology, inflammation, and neoplasia to an understanding of the clinical presentation, biologic behavior, morphologic appearance, and classification of diseases of the skin.

**Objective SK1.1: Pathophysiology of Changes in the Skin.** Describe the pathophysiologic basis for changes in the color, surface texture, swelling, temperature, and sensitivity of skin.

### Learning Goal 2: Infections of the Skin

Apply knowledge of the anatomic and immunologic structure of the skin to discuss the role of skin in protecting against direct invasion of skin and appendages by pathogens.

**Objective SK2.1: Barrier Function of Skin.** Explain the anatomic basis for the skin as a barrier and the role of normal flora that colonize the skin in this function.

**Objective SK2.2: Cutaneous Infections.** Describe common bacterial, viral, fungal, and parasitic agents that may cause cutaneous infections and the particular sites that they infect, and morphologic features and complications of these infections.

### Learning Goal 3: Immune-Related Disorders of the Skin

Apply knowledge of basic concepts in immunopathology and the key immunologic functions of components of the skin to understand the pathologic basis of disease caused by reactivity to exogenous agents versus immunologically driven disease with a genetic component.

**Objective SK3.1: Manifestations of Exogenous Antigens.** Describe the clinical features and pathologic basis for skin manifestations to exogenous antigens including infectious organisms, drugs, chemicals, and environmental agents.

**Objective SK3.2: Immune Diseases of the Skin.** Describe the clinical features and pathologic basis for the following immunologically driven diseases with a genetic component: eczema, psoriasis, and vitiligo.

## Learning Goal 4: Inherited Disorders of the Skin

Apply knowledge of genetics, skin structure, and function and basic principles of pathology to an understanding of nonneoplastic inherited disorders of the skin.

**Objective SK4.1: Inherited Blistering Diseases.** Describe the genetic basis for blistering diseases affecting the skin.

## Learning Goal 5: Skin Neoplasia

Apply knowledge of the molecular basis of neoplasia to an understanding of the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and therapy of benign and malignant skin neoplasms.

**Objective SK5.1: Benign Skin Neoplasms.** Describe the clinical presentation and histopathologic findings of benign skin growths of the following cellular origins: basal cell, squamous cell, melanocytes, as well as neoplasms of dermal origin.

**Objective SK5.2: Malignant Skin Neoplasms.** Describe the clinical presentation, precursor lesions, risk factors and hereditary cancer syndromes that lead to the following skin cancers: basal cell carcinomas, squamous cell carcinoma, and melanoma.

**Objective SK5.3: Genetic Disorders Predisposing to Skin Cancer.** Identify the genetic disorders with high risk of skin cancers and explain the molecular basis of that risk as well as the genomic mutations involved.

**Objective SK5.4: Sun Exposure.** Explain the role of ultraviolet light and other environmental factors in development of various skin cancers.

**Objective SK5.5: Cutaneous T-Cell Lymphomas.** Describe the various clinical presentations of cutaneous T-cell lymphoma/mycosis fungoides and discuss the natural course of the disease.

## Topic: Musculoskeletal System (MS)

Musculoskeletal disorders resulting from abnormal development, genetic mutations, nutritional, immune, infections, and intrinsic disease as they relate to lung abnormalities are enumerated.

### Learning Goal 1: Bone Neoplasia

Apply knowledge of the molecular basis of neoplasia to describe the clinical presentation, biologic behavior, morphologic appearance, classification, diagnosis, prognosis, and targeted therapy of bone neoplasms.

**Objective MS1.1: Categories of Bone Tumors.** Describe examples of bone forming, cartilage forming, and other common bone tumors including the clinicopathologic features, radiological features, treatment, and prognosis of each.

**Objective MS1.2: Bone-Forming Sarcomas in Children.** Describe the most common benign and malignant bone forming tumors in

children and adolescents in terms of clinical presentation, radiologic findings, histologic features, treatment, and prognosis.

**Objective MS1.3: Cartilage-Forming Sarcomas.** Describe the most common benign and malignant cartilaginous tumor of bone in children and adolescents in terms of clinical presentation, radiologic findings, histologic features, treatment, and prognosis.

**Objective MS1.4: Metastatic Tumors.** Describe the tumors that commonly metastasize to bone, the radiologic manifestations of metastatic lesion involving bone, and the difference between osteoblastic and osteolytic metastases.

**Objective MS1.5: Soft-Tissue Tumors.** Describe the common benign and malignant soft tissue tumors including the genetic contribution to tumor development and progression.

### **Learning Goal 2: Nonneoplastic Disorders of the Musculoskeletal System**

Apply knowledge of histology, immunology, microbiology, and biological and molecular alterations to discuss clinical presentation, biological behavior, morphological appearance, and natural history of nonneoplastic disorders of bones, joints, and skeletal muscle.

**Objective MS2.1: Osteomalacia and Rickets.** Compare and contrast osteomalacia and rickets with respect to pathogenesis and clinicopathologic features.

**Objective MS2.2: Osteomyelitis.** Discuss the pathogenesis of osteomyelitis, including predisposing factors, organisms involved, morphologic appearance, and complications.

**Objective MS2.3: Osteoporosis.** Distinguish primary from secondary osteoporosis in terms of etiology, pathogenesis, and morphology.

**Objective MS2.4: Spinal Degenerative Disease.** Describe the common degenerative diseases of the spine.

**Objective MS2.5: Pathologic Fracture.** Compare and contrast pathologic versus nonpathologic fractures including the potential for healing.

**Objective MS2.6: Paget Disease.** Discuss the clinicopathologic changes of Paget Disease including the histologic phases, genetic changes, and complications of this disorder.

**Objective MS2.7: Arthritis.** Compare and contrast rheumatoid and osteoarthritis including the etiology, pathogenesis, and morphology of each.

### **Topic: Nervous System—Central Nervous System (NSC)**

Nervous system disorders resulting from abnormal development, genetic mutations, vascular, immune, infections, and intrinsic disease as they relate to central nervous system (CNS) abnormalities are enumerated.

### **Learning Goal 1: CNS Neoplasia**

Apply knowledge of the pathological and molecular basis of common brain tumors to describe their clinical behavior, effects on the nervous system, and therapies.

**Objective NSC1.1: Features of Brain Tumors.** Explain the pathophysiology underlying the signs and symptoms associated with brain tumors.

**Objective NSC1.2: Classification of Brain Tumors.** Compare and contrast the common types of brain tumors that affect the cerebrum, the cerebellum, the meninges, and the cranial nerves in adults and children; and outline their molecular basis and clinicopathologic features.

**Objective NSC1.3: Hereditary Tumor Syndromes.** Describe the major hereditary tumor syndromes of the central nervous system, the genes responsible for each syndrome, and the spectrum of tumors associated with each syndrome.

**Objective NSC1.4: Grading of Brain Tumors.** Explain the pathophysiologic basis for grading primary brain tumors and discuss how grading relates to prognosis and governs patient management.

**Objective NSC1.5: Complications of Brain Tumors.** Describe several complications of brain tumors and give specific examples.

**Objective NSC1.6: Carcinomas Metastasizing to the CNS.** Discuss carcinomas that commonly metastasize to the central nervous system and describe the locations in which metastases may be seen.

### **Learning Goal 2: Infection**

Apply knowledge of clinical features, neuroimaging studies and location of lesion(s) to develop a differential diagnosis for CNS infection.

**Objective NSC2.1: Infections of the CNS.** Compare and contrast the clinical, gross, and microscopic manifestations of common bacterial, viral, and fungal infections of the central nervous system.

**Objective NSC2.2: Opportunistic Infections of the CNS.** Discuss 5 common opportunistic infections that involve the CNS of immunocompromised individuals and describe their pathologic features.

**Objective NSC2.3: Progressive Multifocal Leukoencephalopathy.** Describe the clinicopathologic features of progressive multifocal leukoencephalopathy (John Cunningham virus) and contrast them with infiltrative astrocytoma.

**Objective NSC2.4: Suppurative Meningitis and Abscess.** Describe the gross and microscopic features of acute suppurative meningitis and brain abscess; and name the organisms most commonly associated with each.

### Learning Goal 3: Spinal Cord Disorders

Apply knowledge of neuroanatomy, pathogenesis, and biologic behavior to develop differential diagnoses and determine appropriate therapy for disorders of the spinal cord.

**Objective NSC3.1: Ependymoma.** Describe the importance of distinguishing ependymoma from infiltrative astrocytoma intraoperatively and list the histologic features of each.

**Objective NSC3.2: Spinal Findings in Demyelinating and Neuromuscular Disorders.** Explain how examination of a spinal cord at autopsy is important for the diagnosis and classification of demyelinating and/or neuromuscular diseases.

**Objective NSC3.3: Multiple Sclerosis.** Describe the pathogenesis, clinical presentation, and gross and microscopic pathologic features of multiple sclerosis.

### Learning Goal 4: Neuromuscular Disorders

Apply knowledge of clinical, anatomic, and neuropathologic principles to the diagnosis of neuromuscular disorders.

**Objective NSC4.1: Amyotrophic Lateral Sclerosis.** Describe the etiology, pathogenesis, and clinical features of amyotrophic lateral sclerosis.

**Objective NSC4.2: Mitochondrial Disorders.** Describe the etiology, pathogenesis, and clinical features of 2 types of mitochondrial diseases affecting muscle, and explain why it may be important to obtain fresh frozen muscle to aid diagnosis.

### Learning Goal 5: Dementia

Apply knowledge of structure and function and general pathologic concepts to describe disorders where dementia is a component.

**Objective NSC5.1: Amyloid and Tau in Dementia.** Define the essential underlying abnormalities of amyloid and tau proteins in the most common causes of dementia in the United States.

**Objective NSC5.2: Abnormal Protein Processing in Neurodegenerative Disease.** Describe the protein processing abnormalities responsible for multiple neurodegenerative diseases.

**Objective NSC5.3: Alzheimer's Disease.** Describe the clinical features, gross pathology, and histopathology of Alzheimer's disease and name 3 regions of the brain that are usually involved.

**Objective NSC5.4: Genes Implicated in Alzheimer's Disease.** Discuss 3 genes in which mutations have been identified in patients with early onset Alzheimer's disease.

**Objective NSC5.5: Disorders of the Basal Ganglia.** Describe several diseases which involve the basal ganglia and describe how to distinguish among the diseases in terms of gross, microscopic, and clinical pathology.

### Learning Goal 6: Demyelinating Disorders

Apply knowledge of the structure and function of the brain and general immunopathology concepts to summarize disorders that result in demyelination in terms of their etiology, pathogenesis, clinical and morphologic features, natural history, and therapeutic options.

**Objective NSC6.1: Autoimmune Mechanisms in MS.** Describe the autoimmune mechanism mediated by CD4+ T cells that react against self myelin antigens in multiple sclerosis and outline the clinicopathologic features of the disease.

### Learning Goal 7: Ischemia of the Brain

Apply knowledge of the structure and function of the brain and general pathology concepts to discuss disorders resulting from altered blood supply and hypoxia to the brain.

**Objective NSC7.1: Stroke.** Compare and contrast the 2 major mechanisms for stroke and how treatment differs for each.

**Objective NSC7.2: Traumatic Brain Injury.** Describe the pathologic findings seen in the most common causes of traumatic brain injury.

**Objective NSC7.3: Cranial Hemorrhage.** Compare and contrast the etiologies and clinical presentations of epidural, subdural, subarachnoid hemorrhages, basal ganglionic, and lobar hemorrhages.

**Objective NSC7.4: Hypertensive Hemorrhage.** Describe the mechanism of hypertensive hemorrhage and name 3 common locations in which this occurs.

**Objective NSC7.5: Embolic Infarction.** Describe how embolic infarcts differ from atherothrombotic infarcts in pathologic appearance and name 3 sources of emboli.

**Objective NSC7.6: Acute Versus Chronic Brain Injury.** Compare and contrast the gross and histopathologic appearance of acute versus remote brain infarction.

## Topic: Nervous System—Peripheral Nervous System and Eye (NSP)

Nervous system disorders resulting from abnormal development, genetic mutations, vascular, immune, infections and intrinsic disease as they relate to peripheral nervous system (PNS) and ocular abnormalities are enumerated.

### Learning Goal 1: Peripheral Nerve Disorders

Apply knowledge of the structure and function of the peripheral nerves and general pathology concepts to discuss peripheral nerve disorders.

**Objective NSP1.1: Neuromuscular Junction Disorders.** Describe the clinicopathologic features of antibody-mediated disorders of

the neuromuscular junction such as myasthenia gravis and Lambert-Eaton myasthenic Syndrome.

**Objective NSP1.2: Neuropathy.** Compare and contrast the clinicopathologic features of inflammatory neuropathies, autoimmune neuropathy, and infectious neuropathy.

**Objective NSP1.3: Neurofibromatosis.** Compare and contrast the clinicopathologic features of neurofibromatosis types 1 and 2.

### Learning Goal 2: PNS Neoplasia

Apply knowledge of the pathological and molecular basis of common PNS tumors to describe their clinical behavior, effects on the nervous system, and therapies.

**Objective NSP2.1: Hereditary Tumor Syndromes.** Describe the major hereditary tumor syndromes of the peripheral nervous system, the genes responsible for each syndrome, and the spectrum of tumors, including the histology associated with each syndrome.

**Objective NSP2.2: Tumors of the Peripheral Nervous System.** Compare and contrast the common benign from malignant PNS tumors, and outline their molecular basis and clinicopathologic features.

### Learning Goal 3: Ocular Disorders

Apply knowledge of the structure and function of the eye and general pathology concepts to discuss common ocular disorders.

**Objective NSP3.1: Ocular Disorders.** Describe the clinicopathologic features of common primary and secondary disorders of the eye including macular degeneration and uveitis.

**Objective NSP3.2: Ocular Neoplasm.** Describe the clinicopathologic features of common neoplasms of the eye including ocular melanoma and retinoblastoma.

## Competency 3

### Diagnostic Medicine and Therapeutic Pathology

Diagnosis and patient management require the student to apply their knowledge of disease mechanisms and organ system pathology to achieve efficient and effective use of clinical laboratory testing. In addition, the student should learn the proper use of blood/blood product utilization to enable optional diagnosis, treatment, and patient care.

There are 10 topics within this competency area. Each topic includes general learning goals and specific objectives that medical students should be able to meet upon graduation from

medical school. Table 3 lists the topic areas and shows the number of goals and objectives for each.

**Table 3.** Diagnostic Medicine and Therapeutic Pathology.

Topic	Number of Goals	Number of Objectives	Reference Code
General principles	1	10	GP
Transfusion medicine	1	6	TM
Hematology	4	20	H
Microbiology	6	32	M
Chemistry	1	8	CHEM
Immunology	1	4	IMM
Genomics	5	20	GE
Autopsy	3	9	AU
Surgical pathology	5	10	SU
Cytopathology	2	7	CYP

### Topic: General Principles (GP)

Every physician should have an appreciation for the pre-analytical, analytical, and postanalytical phases of laboratory testing. In addition, physicians need an appreciation of the statistical treatment of data that underlies test utilization. This includes but is not limited to the ability to choose the correct test to make a diagnosis enabling treatment selection and to employ the appropriate testing paradigm to monitor patients with chronic diseases enabling optimal clinical management.

### Learning Goal 1: Laboratory Tests

Apply knowledge of clinical medicine, pathology, and statistics to determine the utility of a laboratory test in making a diagnosis and in monitoring chronic disease management. Explain the interpretation and limitations of clinical laboratory assays.

**Objective GPI.1: Pre- and Postanalytical Errors.** Give examples of common sources of preanalytical and postanalytical errors and categorize errors when the following procedures are not properly followed: pairing patient/specimen identification with the requisition forms, using correct specimen containers/tubes for specific tests, and timing of collection, transport, and storage.

**Objective GPI.2: Sensitivity and Specificity.** Evaluate the quality of an assay in differentiating disease versus nondisease states, including graphically presenting and interpreting the data. Determine the relationship between sensitivity and specificity for this assay.

**Objective GPI.3: Pretest Probability.** Determine the value of an assay by evaluating the impact of differing pretest probabilities such as prevalence on the positive and negative predictive value of the test. Give examples of the laboratory tests used

to evaluate clinical disorders where predictive values are used to develop screening, diagnostic, prognostic, and patient management protocols.

**Objective GPI.4: Reference Intervals.** Describe the methods used to establish reference intervals and how the following conditions apply: the effect of demographics, treatments, or disease states on reference intervals variability; the difference between reference ranges and therapeutic ranges and why 5% of laboratory test results fall outside a reference range; analytical versus clinical sensitivity; and mixing test results in the clinical information system from different laboratories that use different methodologies.

**Objective GPI.5: Test Variability.** Explain the difference between technical variability and biologic variability including how physical and chemical parameters, such as sample size, hemolysis, and lipemia, can affect test results. Define analytical uncertainty, precision, accuracy, and coefficient of variation, and describe factors that contribute to each.

**Objective GPI.6: Turn-around Time.** Compare and contrast appropriate uses of “stat” and “routine” test priorities with discussion of critical values and the elements of “turn-around time.” Predict which elements affect turn-around time the most.

**Objective GPI.7: Regulatory Issues.** Explain the broad differences between Food and Drug Administration (FDA)-approved tests and laboratory-developed tests, including Clinical Laboratory Improvement Amendments (CLIA) waived and nonwaived tests, and discuss the regulatory issues involved in physician-office laboratories, home testing, and provider-performed microscopy.

**Objective GPI.8: Point-of-Care Testing.** Explain how “point-of-care” (POC) testing in the physician office, multispecialty clinic, and hospital can enable better patient and population management of acute and chronic disease and why values generated using POC methods could differ from values generated in a high-throughput laboratory.

**Objective GPI.9: Test Utilization.** Create a clinical scenario that begins with a patient diagnosis and monitors a chronic disease for years, taking into account the following aspects: a laboratory testing decision tree to make the diagnosis, a protocol for monitoring the patient, the use of test panels and individual tests, the impact on healthcare cost for overutilization of laboratory testing, and the potential impact on cost for underutilization both at the diagnostic stage and in the management of chronic disease.

**Objective GPI.10 Test Economics.** Compare and contrast the cost of several common laboratory diagnostic tests, such as Complete Blood Count (CBC) and CBC with a manual differential. Discuss the cost of diagnostic testing and the impact on healthcare costs.

## Topic: Transfusion Medicine (TM)

Every physician needs an understanding of transfusion medicine which encompasses the transfusion of red blood cells, platelets, and plasma products in order to correct deficiencies in patients or remove offending antibodies. Transfusions are not without risk and knowledge of the pathophysiology of the disease and risks of transfusion are vital for physicians for optimal patient outcomes.

### Learning Goal 1: Concepts of Blood Transfusion

Apply knowledge of pathology, hematopoietic cell physiology and immunology to explain concepts of blood component transfusion and the therapeutic interventions in transfusion medicine.

**Objective TMI.1: Blood Components.** Define the blood components and blood component substitutes available for clinical use; the evidence-based indications and dosing for transfusion of these components; and how the efficacy of transfusion may be monitored.

**Objective TMI.2: Transfusion Reactions.** Compare and contrast the pathophysiology, presentations, prophylaxis, and acute management of the different types of transfusion reactions.

**Objective TMI.3: Infectious Risks.** Discuss infectious disease risks of transfusion.

**Objective TMI.4: HLA.** Explain the HLA system and its role in both transfusion and transplantation.

**Objective TMI.5: Apheresis.** Explain the clinical role of therapeutic apheresis in the management of the following disorders: sickle cell anemia, thrombotic thrombocytopenia, acute and chronic inflammatory demyelinating polyneuropathy, myasthenia gravis, antiglomerular basement membrane disease, organ transplantation, plasma cell dyscrasias, leukemia, and lymphoma.

**Objective TMI.6: Paternity Testing.** Explain the role of blood group testing in determining paternity identification.

## Topic: Hematology (H)

Every physician needs a thorough understanding of one of the most common tests ordered from the laboratory, the complete blood count or CBC. Differentiating between tests needed for diagnosis and treatment of anemias and coagulation disorders is important for appropriate treatment and monitoring of these disorders.

### Learning Goal 1: Normal Coagulation

Apply knowledge of biochemistry, pharmacology, and pathology to describe the basic cellular and molecular events associated with blood coagulation and explain laboratory tests for diagnosis and management of coagulation disorders.

**Objective H1.1: Platelet Aggregation After Injury.** Describe the process whereby platelets are activated and aggregate after blood vessel injury.

**Objective H1.2: Platelet Inhibitors.** Explain the action and the clinical use of common platelet function inhibitor drugs including, but not limited to, aspirin and clopidogrel.

**Objective H1.3: Coagulation Cascade.** Describe the process of fibrin formation in terms of the initiation of coagulation reactions by the exposure of tissue factor and/or “contact activation” and the subsequent proteolytic interactions that involve coagulation factor proteins.

**Objective H1.4: Anticoagulants.** Explain the actions and clinical use of commonly used anticoagulants including warfarin, the heparins, and the new oral direct inhibitors of thrombin and factor Xa.

## **Learning Goal 2: Diagnosis and Management of Coagulation Disorders**

Apply knowledge of biochemistry, pharmacology, and pathology to describe the use of specific laboratory tests to diagnose and manage coagulation disorders.

**Objective H2.1: Monitoring Anticoagulation Therapy.** Explain selection of appropriate tests for identifying the cause(s) of bleeding and to monitor therapeutic anticoagulation.

**Objective H2.2: Platelet Function Testing.** Explain platelet function testing and discuss how platelet function testing can be used to differentiate between disorders of low platelets versus abnormal function of platelets.

**Objective H2.3: Clotting Factor Deficiencies.** Identify the likely deficiency of clotting factor(s) using the prothrombin time and the partial thromboplastin time coagulation tests.

**Objective H2.4: Evaluations of Coagulopathies.** Compare and contrast the roles of the following in evaluating coagulopathies: clinical history, prothrombin time test, partial thromboplastin time test, D-dimer assay, platelet count, and platelet function tests.

**Objective H2.5: Evaluation of the Bleeding Patient.** Describe how to evaluate a bleeding patient with a hemorrhagic disorder, and explain how the history influences testing, including the uses and limitations of screening PT, PTT, and platelet counts.

**Objective H2.6: Disseminated Intravascular Coagulation.** Explain how bleeding occurs in patients with disseminated intravascular coagulation and in patients with severe liver disease using coagulation testing.

**Objective H2.7: Hereditary and Acquired Causes of Thrombosis.** Describe the major hereditary and acquired risk factors for thrombosis and how coagulation testing is used to confirm the diagnosis.

## **Learning Goal 3: Mechanisms of Anemia**

Apply knowledge of red blood cell (RBC) structure/function and nutrient metabolism, the mechanisms of anemia, and the clinical and pathological features of common causes of anemia, to develop an appropriate differential diagnosis.

**Objective H3.1: RBC Function.** Summarize laboratory testing for key cellular structures and functions of the RBC.

**Objective H3.2: Nutrients Required for Erythropoiesis.** Discuss the laboratory testing for specific nutrients including iron and vitamins to erythropoiesis.

**Objective H3.3: Blood Loss.** Differentiate between the pathophysiology of acute and chronic blood loss.

## **Learning Goal 4: Diagnosis of the Anemic Patient**

Apply knowledge of RBC structure/function and nutrient metabolism, the mechanisms of anemia, and the clinical and pathological features of common causes of anemia, to develop a diagnostic decision tree and recommend appropriate intervention for a patient with anemia.

**Objective H4.1: Causes and Diagnosis of Anemia.** Describe the primary causes of anemia, compare and contrast the clinical features and mechanisms of each, and discuss the different testing strategies for normocytic, macrocytic, and microcytic anemia.

**Objective H4.2: Interpreting the CBC.** Use the CBC and explain the contribution of each of the measurements of the CBC, how they are derived, and how they can help diagnose blood cell disorders using specific examples.

**Objective H4.3: Peripheral Smear Evaluation in Anemia.** Discuss the RBC and white blood cell morphology on a peripheral smear to develop a differential diagnosis for a patient with anemia.

**Objective H4.4: Inherited Anemia.** Correlate the genetic, pathological, and clinical features in patients with common inherited anemias.

**Objective H4.5: Acquired Anemia.** Compare and contrast the clinical features and pathophysiology acquired including mechanical trauma, toxic, and antibody-mediated anemias.

**Objective H4.6: Treatment of Anemia.** Discuss when specific interventions should and should not be used for patients with specific types of anemia.

## **Topic: Microbiology (M)**

Infectious diseases are extremely common and every physician needs to be able to correlate clinical findings with the appropriate testing needed. Some infectious disorders will require immediate organism identification, and susceptibility to pharmacotherapy, and understanding principles underlying the different types of microorganisms and their identification is

essential. Many newer techniques have been recently implemented, including molecular techniques, that allow more definitive identification and specialized treatment for infectious organisms.

### **Learning Goal 1: Pathogenesis, Diagnosis, and Treatment of Infectious Disease**

Apply knowledge of infectious organisms to explain the pathogenesis of disease and clinical syndromes, appropriate collection of patient samples, organism identification and classification, antibiotic choice, and selection of medical/surgical interventions.

**Objective M1.1: Preanalytic Factors.** Explain the types of preanalytical variables that affect diagnostic accuracy and discuss factors that affect length of turn-around time for microbiological workups.

**Objective M1.2: Gram Stain.** Compare and contrast the interpretations of Gram stains for rapid diagnosis of causative bacterial agents from sterile and contaminated sites and discuss the clinical settings where recognition of bacteria is most meaningful.

**Objective M1.3: Identification.** Give examples of the types of testing, and their optimal usage, performed in microbiology to identify an infectious disease.

**Objective M1.4: Coordination of Treatment.** Explain how a process that coordinates identification of the infectious organism, antibiotic sensitivity susceptibility testing, and reporting to the pharmacy antibiotic steward team and treating physician will optimize patient care and reduce health-care costs.

### **Learning Goal 2: Antimicrobials**

Integrate knowledge of antimicrobial agents with bacterial culture and susceptibility testing results to guide treatment of infectious diseases.

**Objective M2.1: Mechanisms of Antibiosis.** Associate mechanisms of action with antimicrobial agents including the following: disruption of cell wall synthesis, inhibition of protein synthesis, inhibition of DNA synthesis, and antimetabolites.

**Objective M2.2: Antimicrobial Activity.** State the spectrum of activity for common antimicrobial agents.

**Objective M2.3: Antibiotic Resistance.** Describe mechanisms of resistance found in common pathogens including the following: Penicillinase and *mecA* in *Staphylococcus* subspecies, *vanA* and *vanB* in *Enterococcus* subspecies, extended spectrum  $\beta$ -lactamases and carbapenemases in *Enterobacteriaceae*.

**Objective M2.4: Antimicrobial Susceptibility Testing.** Describe the standardized techniques used in antimicrobial susceptibility testing, why standardization is important, and the differences between a qualitative and quantitative result including disk diffusion, broth microdilution, and automated antimicrobial susceptibility testing systems.

**Objective M2.5: Genetics of Susceptibility.** Name the genetic element detected by extrapolate cefoxitin and oxacillin susceptibility tests and describe how the results for *Staphylococcus* subspecies are used to predict activity of other  $\beta$ -lactam antibiotics.

**Objective M2.6: Choice of Antibiotics.** Describe how the microbiology laboratory determines if an isolate from a blood culture is susceptible or resistant. Describe how the pharmacokinetic (PK)/pharmacodynamic (PD) models may influence a clinician's choice of antibiotics given the susceptibility of an organism using specific examples.

**Objective M2.7: Antimicrobial Stewardship.** Outline the principles that guide an institution's reporting cascade for the following: FDA indications, The Clinical and Laboratory Standards Institute (CLSI) guidance, site of infection, institution formulary, and antimicrobial stewardship.

**Objective M2.8: Institutional Antibigram.** Use the institutional antibiogram to prescribe therapy before susceptibility test results are available.

**Objective M2.9: Molecular Testing in Microbiology.** List examples of molecular tests that are commonly used in clinical microbiology, and explain how they have an important impact on clinical care.

**Objective M2.10: Mass Spectrometry in Microbiology.** Explain how the application of Matrix-assisted Laser Desorption/Ionization-time of Flight (MALDI-TOF) mass spectrometry in the clinical microbiology laboratory can impact patient care.

**Objective M2.11: Urine Studies for Cystitis.** Explain the role of urine studies, including culture, in selecting antimicrobial therapy for infectious cystitis.

**Objective M2.12: Diagnosis of UTI.** Describe a testing strategy for a typical uncomplicated community acquired urinary tract infection (UTI) versus a nosocomial UTI in a patient with a Foley catheter and list the key microbiological tests in diagnosis of UTIs.

**Objective M2.13: Diagnosis and Management of Syphilis.** Explain the role of Venereal Disease Research Laboratory / rapid plasma reagin (VDRL/RPR) and *Treponema*-specific tests in the diagnosis and management of syphilis.

### **Learning Goal 3: Virology**

Integrate concepts of virology with diagnostic techniques including culture, molecular, and antigen diagnostics to identify viral infections and guide treatment.

**Objective M3.1: Hepatotropic Viruses.** Describe the laboratory findings that diagnose hepatitis and correlate with the different possible clinical outcomes for each of the major hepatotropic viruses.

**Objective M3.2: Influenza.** Explain the diagnosis of influenza in terms of diagnostic tests used, major antigens present, and the implications of a major shift in these antigens.

**Objective M3.3: Serology, PCR, and Culture.** Describe the role of serology, Polymerase Chain reaction (PCR), and culture in the diagnosis of viral infections and name which viruses are most rapidly identified by each.

**Objective M3.4: HIV Infection.** Explain the testing strategy used to diagnose HIV and the role of viral load and CD4 count in monitoring HIV infection.

**Objective M3.5: Response to HIV Treatment.** Describe the tests available to examine the response of an HIV virus to therapeutic agents, explaining how each test works.

### Learning Goal 4: Mycobacteria

Integrate concepts of mycobacteriology with diagnostic techniques including culture, molecular, and antigen diagnostics to identify mycobacterial infections and guide treatment.

**Objective M4.1: Identification of Mycobacteria.** Describe the diagnostic tests available for the identification of mycobacteria including culture methods and new molecular tests.

**Objective M4.2: Antimycobacterial Susceptibility.** Compare and contrast the methods, culture, and molecular tests used to identify mycobacteria drug susceptibility and the time required for results by each method.

### Learning Goal 5: Mycology

Integrate concepts of mycology with diagnostic techniques including culture, molecular, and antigen diagnostics to identify fungal infections and guide treatment.

**Objective M5.1: Types of Fungi and Yeast.** Differentiate among filamentous fungi, dimorphic fungi and yeast, and describe the diagnostic approaches for each type.

**Objective M5.2: Sensitivity Testing.** Define sensitivity testing and describe its role and use in the management of yeast infections.

**Objective M5.3: Special Testing for Fungi and Pneumocystis.** Explain the basis for the galactomannan and  $\beta$ -glucan tests and how they are utilized to detect fungi and *Pneumocystis*.

### Learning Goal 6: Parasitology

Integrate concepts of parasitology with diagnostic techniques including culture, molecular, and antigen diagnostics to identify parasitic infections and guide treatment.

**Objective M6.1: Metazoan and Protozoan Parasites.** Compare and contrast metazoan and protozoan parasites and the diagnostic approaches to each.

**Objective M6.2: Stool Testing for Parasites.** Explain the role of stool samples, including number examined, role of microscopy, and coproantigen detection in the diagnosis of parasitic disease.

**Objective M6.3: Serologic Testing for Parasites.** Summarize the role of serology and serological tests to diagnose toxoplasmosis and assess the risk of transmission during pregnancy.

**Objective M6.4: Malaria and Babesiosis.** Contrast *Plasmodium falciparum* with other malaria species and babesiosis on a blood smear and explain the role of thick and thin smears in the diagnosis and management of malaria.

**Objective M6.5: Rapid Testing for Malaria.** Name the rapid tests that do not require blood smears to identify malaria and explain how these tests work.

### Topic: Chemistry (CHEM)

Every physician needs to be able to differentiate between multiple different chemical tests in order to confirm a diagnosis or to follow disease progression. An understanding of the major chemical tests, their relationship to pathophysiology of disease progression, and understanding of limitations of such tests is essential for treatment.

### Learning Goal 1: Pathogenesis, Diagnosis, and Treatment of Common Disorders

Apply knowledge of biochemistry, pharmacology, and pathogenesis of disease and clinical syndromes to describe the basic cellular and molecular events associated with diseases of specific tissues and organ systems, and the use of laboratory tests to diagnose and manage these diseases including the selection of medical/surgical interventions.

**Objective CHEM1.1: Thyroid Disease.** Discuss the clinical presentation and the pathophysiologic bases of thyroid diseases including the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

**Objective CHEM1.2: Cardiac Disease.** Discuss the clinical presentation and the pathophysiologic bases of cardiac diseases including the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

**Objective CHEM1.3: Endocrine Disease.** Discuss the clinical presentation and the pathophysiologic bases of other endocrine diseases including the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

**Objective CHEM1.4: Liver and Gastrointestinal Disease.** Discuss the clinical presentation and the pathophysiologic bases of liver and gastrointestinal diseases including the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

**Objective CHEM1.5: Renal Disease.** Discuss the clinical presentation and the pathophysiologic bases of renal diseases including



the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

**Objective CHEM1.6: Lung Disease.** Discuss the clinical presentation and the pathophysiologic bases of lung diseases including the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

**Objective CHEM1.7: Toxicology.** Determine the value of testing for drugs and toxins accounting for the routes of administration, distribution and metabolism of the agent of interest, including the specimen source, the analytes to be detected given the medical questions, and the timing constraints for specimen collection.

**Objective CHEM1.8: Cancer Diagnostics.** Select and interpret appropriate tests for specific cancer diagnostics, including tumor markers and serum monoclonal protein analysis.

## Topic: Immunology (IMM)

Every physician needs an understanding of specific laboratory tests to differentiate between inflammatory and immune-mediated diseases. Many newer techniques have been recently implemented that allow more definitive diagnosis and specialized treatment for these disorders.

### Learning Goal 1: Pathogenesis, Diagnosis, and Treatment of Immunologic Disorders

Apply knowledge of immunology, biochemistry, and pathology to describe the basic cellular and molecular events associated with immune system diseases of specific tissues and organ systems and the use of laboratory tests to diagnose and manage these diseases.

**Objective IMM1.1: Markers of Inflammations.** Compare and contrast markers of inflammation in terms of the pathophysiologic basis and stages of the inflammatory response.

**Objective IMM1.2: Autoimmune, Immune Deficiencies, and Allergen Testing.** Select and interpret appropriate tests for workup and interpretation of autoimmune disease, immunodeficiencies, and allergy testing.

**Objective IMM1.3: Serologic Testing for Infection.** Discuss, with examples, the application of serological testing in infectious diseases to establish immune status and diagnose infection.

**Objective IMM1.4: Autoimmune Diseases.** Discuss the clinical presentation and pathophysiologic bases of autoimmune diseases including the efficient use of laboratory tests to make a definitive diagnosis and manage the disease.

## Topic: Genomics (GE)

Every physician needs an appreciation of the complex field of genomics including Mendelian inheritance patterns to the ever evolving molecular techniques that are essential for diagnosing

diseases as accurately as possible, and for many diseases correlated with specific targeted immune or chemotherapy to maximize effectiveness of treatment, decrease side effects, and optimize patient survival.

### Learning Goal 1: Genes

Apply knowledge of genetics including the structure and organization of the human genome and regulation of gene expression, genetic variation, and inheritance patterns to basic disease processes.

**Objective GE1.1: Mendelian Inheritance.** Describe molecular testing of Mendelian inheritance including autosomal dominant, autosomal recessive, X-linked; non-Mendelian inheritance including mitochondrial and imprinting; unstable repeat expansions; and cytogenetic translocations.

**Objective GE1.2: Pedigrees and Mutations.** Demonstrate how to take a 3-generation family history and draw a pedigree. Distinguish between a nonpathogenic polymorphism and a pathogenic mutation, and describe the mechanisms that produce different types of mutations.

**Objective GE1.3: Inheritance Patterns.** Compare diagnostic testing of single-gene disorders to diseases with complex inheritance patterns and include the role of rare, high-risk variants, and common, low-risk variants.

**Objective GE1.4: Linkage Analysis.** Outline the principles that underlie genetic linkage analysis and association studies and how they are used to identify genes associated with diseases.

**Objective GE1.5: Population Genetics.** Define the concepts “founder effect” and “genetic drift” and explain how genetic variants are distributed within populations.

**Objective GE1.6: Genetic Risk.** Explain how genetic risk is determined by carrier status and carrier frequency of a condition and determine carrier frequencies and incidence of recessive conditions using Hardy-Weinberg Laws.

**Objective GE1.7: Phenotypic Expression.** Distinguish dominant and recessive phenotypes and alleles and describe how incomplete penetrance, variable expressivity, imprinting, and pleiotropy affect the phenotypic expression of diseases.

**Objective GE1.8: Modifier Genes.** Describe the concept of a modifier gene and its contribution to phenotypic variability.

**Objective GE1.9: Cytogenetics.** Define the following cytogenetic terms and nomenclature: karyotype, euploidy, aneuploidy, monosomy, trisomy, deletion, ring chromosome, inversion, isochromosome, translocation, balanced reciprocal translocation, Robertsonian translocation.

**Objective GE1.10: Mosaicism.** Define mosaicism and explain how it affects the phenotype of a chromosomal disorder.

### Learning Goal 2: Chromosomal Disorders

Apply knowledge of genetics to explain the molecular basis of single-gene and nonneoplastic chromosomal disorders.

**Objective GE2.1: Testing for Genetic Disorders.** Describe the genetic and epigenetic causes, pathophysiology and clinical manifestations, and optimal laboratory tests used to diagnose the following specific genetic disorders: Mendelian, autosomal disorders (dominant and recessive), X-linked disorders, chromosomal disorders, and disorders of nonclassic inheritance.

### Learning Goal 3: Genetic Basis of Neoplasia

Apply knowledge of genetics to explain the genetic basis for neoplasia, and the role of genetic testing in diagnosis and treatment of diseases.

**Objective GE3.1: Genetic Redisposition to Neoplasia.** Describe 3 mechanisms by which genes predispose to neoplasia: oncogenes, tumor suppressor genes, DNA repair genes.

**Objective GE3.2: Genetic Mechanisms of Neoplasia.** Describe the molecular genetic mechanisms that underlie cancers: germline mutations; somatic mutations including point mutations, deletions, amplifications and translocations; epigenetic changes.

**Objective GE3.3: Molecular Testing in Oncology.** Explain the application of molecular testing for diagnosis, prognostication, and therapeutic follow-up of oncologic diseases.

### Learning Goal 4: Reproductive Genetics

Apply knowledge of genetics to explain the role of reproductive genetics and population screening.

**Objective GE4.1: Carrier Testing.** Describe the role of preconception and prenatal carrier testing for genetic disorders depending upon family history and ethnic background.

**Objective GE4.2: Newborn Screening.** Describe the rationale for newborn screening for genetic diseases and explain the difference between screening and diagnostic testing.

### Learning Goal 5: Diagnosis, Treatment, and Counseling

Apply knowledge of genetics to explain the role of genetic testing in diagnosis and treatment of diseases and in counseling of patients and families.

**Objective GE5.1: Treatment Mechanisms.** Explain the mechanisms involved in the treatment of genetic diseases: organ transplantation, manipulating metabolic pathways, correction of defective structural proteins or enzymes, modulation of RNA expression, alteration of DNA sequence, and alteration of gene expression.

**Objective GE5.2: Genetic Variation in Response to Treatment.** Describe how genetic variation can predict response to medications, dosing, and risk for adverse effects.

**Objective GE5.3: Factors to Prevent Disease in the Genetically Predisposed.** Describe how modification of nongenetic factors can prevent or mitigate disease in genetically predisposed individuals.

**Objective GE5.4: Genetic Counseling.** Describe the role of genetic counselors in patient care and when to make appropriate referrals for genetics evaluations.

## Topic: Autopsy (AU)

Autopsy is a division of anatomic pathology that encompasses the examination of a deceased person, either for medical or legal reasons. Understanding the value of the autopsy, both for scientific investigation of potential inherited disorders and for understanding the diseases that led to a patient's demise will allow clinicians appropriately discuss this end-of-life medical evaluation.

### Learning Goal 1: Value of the Autopsy and Obtaining Consent

Apply knowledge of clinical medicine and quality management to discuss the value of the autopsy and procedures for obtaining permission for postmortem examination.

**Objective AU1.1: Value of the Autopsy.** Provide examples demonstrating the value of the autopsy toward improvement in clinical diagnosis and management, quality control, medical education, research, and elucidation of "new" diseases.

**Objective AU1.2: Consent for Autopsy.** Identify the legal next of kin or individual authorized to consent when obtaining consent for an autopsy.

**Objective AU1.3: Obtaining Consent from the Family.** Describe how to approach a family to request consent for an autopsy, including a discussion of the autopsy procedure in language that the patient's family can understand.

**Objective AU1.4: Professionalism in the Autopsy.** Discuss the psychosocial-emotional aspects of the autopsy experience, including its role in closure, and the importance of communication and professionalism among the health-care team.

### Learning Goal 2: Death Certificate

Apply knowledge of quality management to discuss the utility of death certificates and proper approaches for completing them.

**Objective AU2.1: Public Health.** Describe the importance of death certificates for tracking and analysis of public health trends.

**Objective AU2.2: Components of the Death Certificate.** Discuss the key components of the death certificate; differences among immediate, intermediate, and underlying (proximate) cause of death based on disease process; and the role of mechanisms of death on a death certificate.

**Objective AU2.3: Medical Errors.** Explain how under- or overutilization of medical care, and incorrect diagnoses, therapeutics, or informed consent can lead to medical errors and give examples of how an autopsy can identify errors thereby improving health care and decision-making.

### **Learning Goal 3: Forensic Autopsy**

Apply knowledge of clinical medicine and postmortem examination to discuss the indications for medical examiner referral and special procedures in the forensic postmortem examination.

**Objective AU3.1: Role of the Medical Examiner.** Define the role of a medical examiner in terms of public health and protection of legal rights.

**Objective AU3.2: Reportable Deaths.** Identify circumstances of death that need to be reported to the medical examiner/coroner.

## **Topic: Surgical Pathology (SP)**

Surgical pathology is the area of anatomic pathology where all tissues or hardware removed from a patient is evaluated. Specimens sent to surgical pathology may range from minute endoscopic biopsies to large organ resections. Special techniques are commonly used by pathologists in evaluating these specimens that allow for definitive diagnosis and the recommendation of appropriate treatment for both benign and malignant lesions.

### **Learning Goal 1: Role in Diagnosis**

Apply knowledge of clinical medicine and pathology to describe the roles cytology and surgical pathology play in diagnosis and treatment of benign and malignant disorders. Use specific examples from the most common diseases and forms of cancer.

**Objective SP1.1: Obtaining the Specimen.** Describe the procedures for obtaining a biopsy of a tissue lesion or mass in different sites, including superficial and deep soft tissues, solid organs, and tubular organs. Associate each procedure and specimen type to either cytology or surgical pathology and give examples of possible reasons and follow-up for false negative biopsies.

**Objective SP1.2: Differential Diagnosis.** List the major differential diagnoses for each type of cytology or surgical pathology specimen derived from a lesion or mass and describe appropriate further studies, both special stains and immunohistochemistry.

**Objective SP1.3: Special Studies.** After looking at slides of a tissue lesion or mass, the pathologist makes a diagnosis. List options for surgical and nonsurgical treatment and describe prognostic and therapy-guiding tests that may be performed on the tissue.

**Objective SP1.4: Staging.** Describe the information that the pathologist obtains from a resected tissue specimen, how this information is reported, how it is combined with clinical

information to stage the tumor, and how staging information is used to guide treatment.

### **Learning Goal 2: Immune and Infectious Diseases**

Apply knowledge of clinical medicine and pathology to describe the roles cytology and surgical pathology play in diagnosis and treatment of inflammatory disease, in particular those with immune or infectious etiologies.

**Objective SP2.1: Examples of Inflammatory Conditions.** Give examples of specific sites and diseases in which specific pathologic diagnoses of inflammatory and/or infectious conditions are critical to treatment and prognosis.

### **Learning Goal 3: Congenital Disorders**

Apply knowledge of clinical medicine and pathology to describe hereditary/malformative disorders, in terms of clinically useful information that anatomic pathology diagnosis can provide.

**Objective SP3.1: Terminology.** Define general terminology for pathologic features that are associated with hereditary/malformative disorders.

### **Learning Goal 4: Interpretation of Reports**

Apply knowledge of clinical medicine and communication skills to interpret pathology reports and communicate the results to patients in the context of risk assessment and patient prognosis. Determine appropriate action including additional testing and clinical evaluation.

**Objective SP4.1: Explaining the Report to the Patient.** Explain the results of a pathology report to a patient in language the patient can understand.

### **Learning Goal 5: Classification of Leukemia and Lymphomas**

Apply knowledge of pathology and the application of diagnostic decision trees to discuss the classification systems of leukemia and lymphomas, and describe the relative roles of ancillary laboratory studies in classification.

**Objective SP5.1: Special Studies.** Describe the roles of immunohistochemistry, flow cytometry, cytogenetics, and molecular diagnostics in the diagnosis and classification of lymphoma, and explain how, with examples, different techniques are most appropriate in diagnosis, staging, and management of disease.

**Objective SP5.2: Use of Special Studies.** Explain how the work up of lymph nodes at the frozen section bench differs from routine frozen sections, and how examination of touch preparations of slides are used to streamline use of additional special techniques.

**Objective SP5.3: Differential Diagnosis.** Discuss how a pathologist can use a diagnostic decision tree to make a diagnosis

efficiently, minimize the time to report results to the oncologist, and optimize treatment decisions.

### Topic: Cytopathology (CYP)

Cytopathology focuses on the individual cellular components of disease. Cytopathological examination is an essential tool for its wide-ranging reach in screening, diagnostics, prognostics, and prevention of advanced disease states. Furthermore, the minimally and noninvasive nature of ascertaining most cytological specimens allows for immediate access to viable cellular material for advanced testing, molecular, and biochemical analyses.

#### Learning Goal 1: Cytologic Diagnosis

Apply knowledge of general and systems pathology to understand the meaning and context of cytologic diagnoses.

**Objective CYP1.1: Obtaining the Specimen.** Compare and contrast the 3 basic methods to obtain cytologic material for diagnosis, describe the settings in which these can be used to diagnose benign and malignant conditions, and discuss the limitations of each.

**Objective CYP1.2: Categorizing Diagnostic Certainty.** Compare and contrast the degree of diagnostic certainty applied to general categorization in cytologic diagnosis.

**Objective CYP1.3: Identifying Infectious Diseases.** Describe the uses and limitations of cytology, with examples, in identifying common infectious diseases.

**Objective CYP1.4: Use of Cytology for Staging of Neoplasms.** Describe how cytologic specimens can add valuable information for tumor staging.

#### Learning Goal 2: Advantages of Cytopathology

Apply knowledge of clinical medicine, pathology, and health-care delivery to describe the advantages cytopathologic examination offers over conventional pathologic tissue examination.

**Objective CYP2.1: Screening.** Describe the principles of an effective screening test and the uses and limitations of cytology.

**Objective CYP2.2: Adjunct Testing (HPV).** Describe how adjunct testing is used in conjunction with cytology examination.

**Objective CYP2.3: Cervical Screening.** Describe how to find and utilize current algorithms for management of cervical screening.

#### Authors' Note

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