SCHOOL OF MEDICINE
Undergraduate Medical Education
UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

CVPR

Cardiovascular, Pulmonary, Renal

Course Goals

Goals

1. Describe the normal gross structure, histology, and physiology of the heart, lungs, kidney, and their vascular beds.
2. Compare and contrast the physiology of the systemic and pulmonary circulations.
3. Describe the molecular, biochemical and cellular mechanisms that enable the cardiovascular, pulmonary, and renal systems to maintain the body's homeostasis, especially blood pressure and electrolyte balance.
4. Describe the causes (genetic, developmental, microbiologic, autoimmune, metabolic, toxic, and traumatic) of cardiovascular, pulmonary, and renal dysfunction.
5. Describe the gross structure, histology, and pathophysiology of the cardiovascular, pulmonary, and renal systems seen in common diseases and conditions.
6. Describe the epidemiology of common cardiovascular, pulmonary, and renal maladies within a defined population, and the systematic approaches useful in reducing the incidence and prevalence of those maladies.
7. Demonstrate clinical reasoning skills.
8. Demonstrate the ability to retrieve, evaluate, manage, and utilize biomedical information.
9. Describe the importance of life-long learning to the practice of medicine.
10. Describe the use of the scientific method to determine the causation of disease and to compare and contrast the efficacy of traditional and non-traditional therapies.
11. Apply the principles of pharmacology, therapeutics, and therapeutic decision making to cardiovascular, pulmonary, and renal dysfunction.
12. Demonstrate your understanding of the use and limits of laboratory diagnostic methods in the diagnosis of cardiovascular, pulmonary, and renal disease.

Spring 2019
Cardiovascular, Pulmonary, Renal
Session Learning Objectives

A Clinical Approach to Tachycardias (ARS-Based Lecture)

1. Describe how to approach the patient with a tachycardia, considering not only the ECG rate, rhythm, regularity and QRS width, but also the clinical condition of the patient.
2. Recognize sinus tachycardia and list important underlying conditions that may be responsible.
3. Recognize and explain the genesis of AV nodal re-entry tachycardia (AVNRT).
4. Choose management strategies for AVNRT, such as vagal maneuvers and adenosine.
5. Describe the origin of atrial fibrillation and the factors that determine the ventricular response.
6. Identify atrial fibrillation, when the rate is fast or slow, and when the QRS complex is wide or narrow.
7. Recognize atrial fibrillation when it is “pre-excited” (in a patient with Wolff-Parkinson-White Syndrome).
8. Recognize atrial flutter and differentiate this tachycardia rom sinus tachycardia and AVNRT.
9. Explain why ventricular tachycardia (VT) is the most common cause of wide-complex tachycardia.
10. In a patient with a wide-complex tachycardia, differentiate VT from atrial fibrillation.
11. Differentiate monomorphic VT, polymorphic VT and ventricular fibrillation.
12. Describe when to employ electrical cardioversion to terminate a tachycardia.

Acid/Base Disorders

1. Define simple and mixed acid-base disorders.
2. Define and discuss the utility of the serum and urine anion-gaps.
3. Discuss the concept (and rules) of compensation.
4. Discuss how to approach simple and mixed acid-base disorders.

Acid-Base Physiology and Respiratory Failure

1. Define Henderson-Hasselbalch Equation for Bicarbonate/CO2.
2. List the normal arterial blood gas values for pH, PaCO2, and [HCO3].
3. Identify the four major acid-base disorders and discuss the common causes of each.
4. Explain how the body compensates for four major acid-base disorders.
5. Demonstrate how to calculate the Anion Gap and discuss how it is used clinically.

Acute Coronary Syndromes

1. Describe the spectrum of acute coronary syndrome and its pathophysiology.
2. Distinguish non-ST elevation myocardial infarction (NSTEMI), ST-elevation myocardial infarction (STEMI), and unstable angina (UA).
3. Clinically diagnose acute coronary syndrome based on symptoms, ECG, and biomarkers.
4. Explain the basis behind the treatment of ST elevation myocardial infarction.
5. Explain the basis behind the treatment of non-ST elevation myocardial infarction and unstable angina.

Antiarrhythmic Drugs

1. Describe the basis of use-dependent block of Na+ channels by class I antiarrhythmic drugs.
2. Describe how class I antiarrhythmics increase Na+ channel refractory period, whether or not they prolong phase 2 of the fast response.
3. Describe how beta-adrenergic receptor blockers help suppress arrhythmias.
4. Describe how class III drugs increase refractory period.
5. Describe how class IV antiarrhythmic drugs (Ca2+ channel blockers) reduce re-entry via effects on conduction velocity through the AV node and refractory period of the AV node.
6. Describe how increasing refractory period may help suppress re-entrant arrhythmias.
7. Describe how some antiarrhythmic drugs can suppress arrhythmias by decreasing cardiac automaticity.
8. Describe how adenosine can help suppress cardiac arrhythmias.

Anxiety

1. Recognize symptoms/presentation of anxiety, primarily panic disorder, particularly in medical settings.
2. Describe the relationship of anxiety with depression.
3. Define basic etiologies of panic disorder, including risk factors and patient vulnerabilities, genetics, life experiences, stress, and basic neurobiology.
4. Identify very basic psychotherapeutic and pharmacologic treatments of panic disorder.

ARS: Cardiac Cycle & Heart Sounds

1. Discuss heart sounds in relationship to the cardiac cycle.
2. Describe the identifying characteristics of (i) systolic and (ii) diastolic murmurs.
3. Identify and accurately describe audible heart sounds.
4. Differentiate between valvular regurgitation from stenosis.
5. Describe how physical maneuvers can influence murmurs.

ARS: Cardiac Electrical Activity

1. Describe the role of ion concentration gradients, equilibrium (reversal; Nernst) potentials, and selective ion permeability in determining changes in membrane potential that occur upon ion channel opening.
2. Describe the role of changes in membrane potential (depolarization, hyperpolarization) in ion channel opening and, consequently, subsequent changes in membrane potential.
3. Describe the relationship between membrane potential and conformational states (closed, open, inactivated) for various cardiac ion channels.

ARS: ECG Interpretation

1. Determine cardiac rate and interval or segment durations.
2. Determine QRS axis.
3. Describe the ECG changes produced by atrial hypertrophy, ventricular hypertrophy, bundle branch block, myocardial ischemia, myocardial infarction, and electrolyte disorders.

Autonomic Nervous System Pharmacology

1. Compare and contrast the anatomy, physiology, and neurotransmitter pharmacology of the parasympathetic (PNS), sympathetic (SNS), and somatic nervous systems.
2. Know the gross distribution of adrenergic and cholinergic receptor subtypes on these organ systems and the effects of stimulating these receptors on heart, blood vessels, lungs, and kidney.
3. Describe the spectrum of effect one would see following parasympathetic activation (“rest and digest”) and sympathetic activation (“flight or fight response”).
4. Describe the baroreceptor reflex and its effect on heart rate.
5. Describe the mechanisms of action of direct-acting and indirect-acting adrenergic agonists.
6. Recognize the following SNS agonist drugs as either direct-acting (with receptors activated) or indirect-acting: Epinephrine (α1, α2, β1, β2), Norepinephrine (α1, α2, β1), Isoproterenol (β1, β2), Dobutamine (β1), Dopamine (D1, plus indirect via NE release), Albuterol (β2), Phenylephrine (α1), Pseudoephedrine (indirect).
7. Compare the characteristics and clinical utility of adrenergic antagonists that are receptor blocking versus sympatholytic agents.
8. Recognize the following as SNS antagonist drugs and the receptor subtypes blocked: Propranolol (β1, β2), Metoprolol - Atenolol (β1), Labetalol – Carvedilol (α1, β1, β2), Doxazosin (α1).
9. For the above drugs, relate the physiologic responses produced by their receptor actions at heart, blood vessels, lungs, and kidney to their therapeutic uses (major) and adverse effects (most common and most severe).

Autonomic Pharmacology (TBL Session)

1. Student practice in answering questions on autonomic pharmacology.

Basic Functions of the Lung

1. Describe in general terms the basic functions of the lung: gas exchange, protection of mediastinal contents, vascular filter, platelet maturation, immune surveillance, interaction with environment, trapping of inhaled particles, clearance of volatile gases, temperature regulation, blood pH regulation, facilitating exercise, and hormone regulation/metabolism by lung endothelium.
2. Describe the basic structure-function relationships in the lung relevant to these functions as discussed by Drs. Lavelle and Bendiak.

Bedside Electrocardiography: A Clinical Approach (ARS-Based Lecture)

1. Approach the 12-lead electrocardiogram in a logical manner, addressing the rhythm, QRS axis, PR-interval, QRS width, QRS voltage, QRS (R-wave) progression and ST-segments.
2. Identify normal sinus rhythm and differentiate normal sinus rhythm from junctional rhythms.
3. Recognize and classify the categories of heart (AV) block, including first-degree AV block, second-degree block (Mobitz Types 1 and 2) and complete heart block.
4. Understand the associated conditions and the typical presenting symptoms of patients with bradycardias and heart blocks.
5. Identify an abnormal right axis deviation and use this finding as a clue to diagnose acute pulmonary thromboembolism.
6. Use the 12-lead ECG to help diagnose left and right ventricular hypertrophy.
7. Recognize life-threatening conditions that present as “low voltage” electrocardiograms, including pericardial tamponade and acute myocarditis.
8. Identify important causes of an abnormally wide QRS complex, including ventricular premature beats, right and left bundle branch blocks and hyperkalemia.
9. Distinguish between pathologic Q-waves and normal (septal) Q-waves and use this information to diagnose “old” inferior, posterior and anteroseptal infarctions.
10. Identify acute ST-elevation myocardial infarctions (STEMIs) based on the ECG, and accurately predict the occluded (“culprit”) coronary artery.
11. In a patient with ST-elevations, distinguish between an acute STEMI and acute pericarditis.

Bladder & Micturition

1. Define the two primary functions of the urinary bladder: storage and emptying.
2. Detail the parasympathetic and sympathetic innervation to the lower urinary tract.
3. Describe the micturition cycle.
4. Categorize the types of urinary incontinence.
5. Compare/contrast the causes of incontinence in men and women.
6. Discuss the common causes of lower urinary tract obstruction in men.

Carcinogenesis & Cancer

1. Describe the epidemiology of Lung Cancer in the United States, including risk factors for disease development.
2. List the characteristics of solitary pulmonary nodules and the goals of evaluation.
3. Describe how to stage a subject with lung cancer and which broad treatment categories are applied to the various stages.
4. Describe common genetic alterations in non-small cell lung cancer and how these form the basis of targeted therapy.
5. Discuss the concepts of early detection, screening, and chemoprevention as they apply to lung cancer.

Cardiac Cycle

1. Describe changes in pressure and volume through the cardiac cycle as a function of time, and identify the 4 phases of the cardiac cycle.
2. Identify heart sounds correlated with valve opening and closing.

Cardiac Embryonic-Fetal Circulation

1. Name the four main regions of the heart present during the 4th week of development, and describe how the orientation of these regions shift during heart looping.
2. Describe when and how the endocardial cushions grow to bissect the atrioventricular canal.
3. Describe how and when the truncus arteriosus is subdivided into the pulmonary and aortic outflow tracts.
4. Describe the components of the embryonic heart that contribute to separation of the ventricles, and identify when this separation occurs.
5. Describe how and when the left and right atria are separated.
6. Identify which aortic arch vessels are lost, and which are maintained by eight weeks gestation, and what are the anatomical names of the remaining vessels.
7. Identify two components of fetal cardiac circulation which are no longer patent after birth.

Cardiac Imaging & Catheterization

1. Describe basic concepts and uses of the following tests in evaluation of patients with known or suspected cardiac disease: chest x-ray, echocardiogram, cardiac stress tests, cardiac magnetic resonance imaging (MRI), cardiac CT/CT angiography, and cardiac catheterization and coronary angiography.
2. Describe indications and contraindications for cardiac stress testing, including exercise ECG, echocardiography stress test and radionuclide stress test.
3. Describe the use of echocardiography, cardiac enzymes, cardiac stress tests, cardiac CT/CT angiography, cardiac catheterization and coronary angiography in evaluation of patients with shortness of breath, valve disease, chest pain, heart failure, coronary artery disease, and acute coronary syndromes including myocardial infarction.

Cardiac Ion Channels, Action Potentials & EC Coupling

1. Describe "fast" and "slow" cardiac action potentials, labeling both the voltage and time axes, and describe the cells in which each type of action potential is found.
2. Describe the properties of the ion channels that underlie "fast" and "slow" cardiac action potentials and describe ionic mechanisms that are likely to account for the ability of pacemaker cells to generate rhythmic firing without neural input.
3. Describe the significance of the IK1 channels in myocardial cells that have “fast” action potentials and the I(f) currents in cells having “slow” action potentials.
4. Describe the mechanism and significance of "overdrive suppression."
5. Describe the sequence of events between the initiation of an action potential in a cardiac muscle fiber through contraction (action potential spreads into t-tubule system, voltage-gated Ca2+ channel in t-membrane opens and allows extracellular Ca2+ to enter into the myoplasm, which triggers the opening of ryanodine receptors in the in the SR membrane, Ca2+ ions leave SR lumen and enter myoplasm, Ca2+ binds troponin C, allowing actin-myosin cross-bridge cycling and contraction.
6. Describe the processes that control relaxation of contraction by removing Ca2+ from the myoplasm (SERCA pumps are the most important, transporting the majority of Ca2+ ions from myoplasm back into SR lumen).
7. Describe how the exchange of 1 Ca2+ ion for 3 Na+ ions by the NCX Na/Ca exchanger, can lead to membrane depolarization.
8. List the basic elements of Ca2+ homeostasis in the myocardium.
9. Explain how stimulation of β-adrenergic receptors increases heart rate, and both contraction strength (inotropy) and rate of relaxation (lusitropy) of cardiac muscle.

Cardiac Valve Disease

1. Describe aortic and pulmonic valve anatomy and function.
2. Describe the etiology and pathophysiology of aortic and pulmonic valve disease.
3. Characterize the clinical presentation and physical exam findings of AV/PV disease.
4. Review the treatment options of Aortic Valve/Pulmonary Valve (AV/PV) disease.
5. Describe the anatomy and function of the mitral and tricuspid valves.
6. Identify the most common causes of mitral and tricuspid valve disease.
7. Review the clinical presentation of mitral and tricuspid disease.
8. Discuss the treatment of mitral and tricuspid disease.

Cardiomyopathy

1. Describe the clinical presentation and possible outcomes of acute myocarditis.
2. List the anatomic classes and features of cardiomyopathies.
3. Describe the causes, diagnosis and management of dilated cardiomyopathies, including the effect of neurohormonal activation on cardiac remodeling.
4. Understand the clinical presentation of dilated cardiomyopathy and how symptoms relate to pathophysiologic processes.
5. Outline the causes, pathophysiology and management of hypertrophic cardiomyopathy.
6. Describe the etiologies and clinical presentation of restrictive cardiomyopathy.

Cardiovascular System Physiology

1. Describe the basic anatomy of the heart, including the arrangement and names of the chambers, valves, and major vessels, and blood flow pathway through the heart.
2. Explain the relationship between pressure, flow, and resistance in the circulatory system (Flow equation).
3. Describe the relationship between vascular resistance and blood vessel radius affect (Poiseuille's equation).
4. Describe the relationship between vascular wall tension, transmural pressure, radius, and wall thickness (Laplace equation).
5. Describe the cross bridge cycle for interaction of myosin heads with actin.
6. Describe the length-tension relationship (Frank-Starling) in cardiac muscle.
7. Describe the molecular basis underlying regulation of cardiac output.
8. Describe the relation between cardiac output (CO), stroke volume (SV) and heart rate (HR): CO = SV x HR.
9. Describe preload, afterload and contractility.

Cardiovascular System Physiology & ECG (TBL Scratch-off Session)

1. Students will practice in answering questions on cardiovascular physiology and the electrocardiogram.

Cases and Q/A

1. Use the provided cases to improve your understanding of the material presented in days 1-2.

Cellular & Molecular Mechanisms of Arrhythmias

1. Describe the gene defects and molecular basis of long QT syndrome.
2. List the cardiac ion channels and the phases of the slow and fast responses that are targeted by the various antiarrhythmic drugs.
3. Describe the cellular mechanism of triggered (early and delayed) after depolarizations.
4. Describe how a re-entrant, or circus, arrhythmia originates.

Chronic Obstructive Pulmonary Disease

1. Describe the risk factors for COPD.
2. Describe the major symptoms of COPD.
3. Define emphysema and chronic bronchitis and understand how they relate to COPD.
4. Understand the natural history of COPD.
5. Review treatments for COPD.
6. Recognize other chronic diseases associated with COPD.
7. Describe pathophysiologic changes in the lung that produce the COPD phenotype.
8. Describe major physical exam findings in patients with COPD.
9. Understand diagnosis and staging of COPD.
10. Interpret pulmonary function test in patients with COPD.

Chronic Renal Disease

1. Identify the stages of chronic kidney disease and discuss the utility of this classification system.
2. Describe how balance is maintained for sodium, water, potassium and protons in chronic kidney disease.
3. Define the uremic syndrome and discuss the major theories of the pathogenesis of uremia.
4. Describe the pathogenesis of certain disorders that accompany chronic kidney disease, including anemia, hypertension, and mineral and bone disease.

Clearance and Acute Kidney Failure

1. Identify the physiologic determinants of glomerular filtration rate at a single nephron level as well as for the whole
2. Identify the mechanisms operant in autoregulation of renal blood flow and glomerular filtration rate.
3. Demonstrate how to calculate and/or estimate glomerular filtration rate.
4. Explain the concept of balance and the central role of the kidney in achieving sodium, water, potassium and acid balance.
5. Logically evaluate a case of acute kidney injury and "pigeon-hole" the case, based on clinical criteria, into different diagnostic groups to include: evaluate findings on a history and physical examination that suggest one diagnosis or another, discern the physiologic differences between pre-renal azotemia and other causes of acute kidney injury, and explain the urinalysis findings that suggest ATN or other causes of acute kidney injury.
6. Interpret urinary electrolytes and osmolality values and use them in the differential diagnosis of acute kidney injury.
7. Define the pathophysiology of decreased GFR in acute tubular necrosis.

Clinical Obstructive Lung Disease: Asthma

1. Describe the physiologic and pathologic abnormalities in asthma.
2. Describe the biologic mechanisms that lead to obstructive physiology in asthma.
3. Describe the management strategies for the treatment of asthma.
4. Describe the pathophysiologic abnormalities of bronchiectasis.
5. Describe the common causes of bronchiectasis.
6. Describe an initial approach to the treatment of non-cystic fibrosis bronchiectasis.

Clinical V/Q Assessment

1. Describe the assessment of ventilation by lung function tests, blood gas testing, and imaging.
2. Describe the assessment of perfusion/gas exchange by lung function tests, blood gas testing, and imaging.

Conduction System & Origin of ECG

1. Describe components of the cardiac conduction system and the sequence of electrical excitation throughout the heart.
2. Describe which parts of the heart give rise to the P wave, QRS complex, T wave, PR interval, QT interval and the ST segment.
3. Describe the general relationship between electrical activity in the heart and the electrocardiogram (ECG) measured at the surface of the body.
4. Describe the placement of ECG electrodes and the relationship of these electrodes to the 12 leads in the ECG.
5. Calculate heart rate and important segment or interval durations (PR, ST, QT) on a standard ECG chart record.
6. Describe the effects of electrolyte disturbances (K+, Ca2+) on the ECG.

Congenital Heart Disease I

1. Discuss the embryologic development of the heart with attention to the formation of: ductus venosis; ductus arteriosis; interatrial septum; intraventricular septum; and division of the arterial trunk into aorta and pulmonary artery.
2. Understand the ways in which errors in these processes lead to congenital cardiac abnormalities.
3. Describe the hemodynamics, clinical features, diagnostic approaches, and natural history for: atrial septal defects; ventricular septal defects; tetralogy of fallot; coarctation of the aorta; and congenital aortic stenosis.
4. Describe the linkage and pathophysiology of pulmonary hypertension to some congenital cardiac abnormalities.

Congenital Heart Disease II

1. Applying physiologic principles, discuss the consequences of a small vs a large ASD.
2. Applying physiologic principles, describe the consequences of a small vs a large VSD.
3. Applying physiologic principles, discuss the consequences of tetralogy of Fallot.
4. Applying physiologic principles, describe the consequences of a small vs a large sized ductus arteriosus.
5. Applying physiologic principles, describe the consequences of coarctation of the aorta.

Control of Ventilation and Perfusion

1. Describe how oxygen levels in the body are sensed and how regulatory mechanisms respond to restore homeostasis.
2. Describe how CO2 levels in the body are sensed and how regulatory mechanisms respond to restore homeostasis.
3. Explain how shunt, V/Q mismatch, and dead space affect arterial Blood Gas PaO2 and PaCO2 measurements.
4. Describe the normal changes in ventilation and perfusion during exercise.

Cough

1. Describe the function and physiological mechanisms of cough.
2. Classify cough according to its duration (acute, subacute, chronic).
3. Identify the most common causes of acute and chronic cough in adults.
4. Discuss the role of antibiotics in the treatment of acute cough.
5. Identify the symptoms, signs, and empiric treatment for the 4 most common causes of chronic cough in adults (UACS, asthma, GERD, NAEB).
6. Recognize important differences between chronic cough in children and adults.

Depression & Grief

1. List the cardinal symptoms of depression.
2. Describe symptoms which define a major depressive episode (MDE).
3. Differentiate between bereavement and major depressive episode (MDE).
4. Discuss the basic categories of mood disorders (bipolar and depressive).
5. Describe the relationship between depression and cardiovascular disease (review).

Development of the Kidney

1. Describe the early stages of development of the kidney—the position of the urogenital ridge, the nephrogenic cord, the formation of nephrotomes and the origin of the pronephric/mesonephric duct.
2. Outline the temporal and spatial relationships of the pronephros, the mesonephros, the themesonephric (Wolffian) duct, the paramesonephric (Mullerian) duct, and the metanephros.
3. Describe the development of the collecting system from the ureteric bud through various stages until the appearance of collecting tubules.
4. Describe the location and development of the metanephric vesicles and their elongation to form metanephric tubules, detail the relationship of the ends of these tubules
with the collecting system and with the glomerulus, and describe the portions of the nephron derived from regions of the metanephric tubules.
5. Outline the formation of the urogenital sinus and describe its development to the bladder and urethra and discuss what happens to the allantois and cloaca of the early embryo.
6. Describe the ascent of the kidney. Know the resultant structures that the Wolffian and Mullerianducts give rise to in males and females, respectively.
7. Be aware, although the specific molecular mechanisms of inductive processes will not bediscussed in class, that kidney development involves a complex series of mutual mesodermalinductive events and that mutations in molecules involved in these processes can haveprofound effects on kidney development, several effects of which can be observed clinically in neonates.

Developmental and Cystic Diseases

1. Define embryologic basis and clinical presentation of renal agenesis, renal hypoplasia, renal dysplasia, renal ectopia, and horseshoe kidney.
2. Classify conditions into one of the three major etiologies of cystic kidney disease; identify ADPKD and ARPKD in terms of phenotype, inheritance and associations; and describe the characteristics of multicystic dysplastic kidney (MCDK).
3. Discuss the essential facts about congenital mesoblastic nephroma and Wilms tumor including clinical presentation, gross and histologic appearance and underlying genetics.

Dialysis

1. Describe the indications for starting dialysis.
2. Describe the different modalities of dialysis.
3. Explain the complications of dialysis.

Diffusion and Perfusion

1. Identify the major determinants of diffusion of a given gas across the alveolar-capillary membrane.
2. Identify physiologic situations that result in poor diffusion.
3. Define the mechanisms for hemoglobin and plasma mediated oxygen and CO2 carriage in blood, and factors influencing that (2,3-DPG, pH, CO-HB, Met-Hb). a.) Also identify links between O2 and CO2 carriage.
4. Identify the major determinants of lung perfusion (Q) and normal heterogeneity of Q throughout the lung related to anatomic location/gravity.
   a.) Understand the classification of Zone I, Zone 2, and Zone 3 perfusion in the lung.
5. Describe V/Q throughout the lung related to anatomic location/gravity.
6. Differentiate shunt, dead space, and less severe forms of V/Q mismatch.
7. Identify physiologic situations that result in poor (regional or global) perfusion.
8. Describe how O2 is taken up by blood and how CO2 is released from blood. a.) Describe the mechanisms for hemoglobin and plasma mediated oxygen and CO2 carriage. b.) Identify links between O2 and CO2 carriage

Diseases of Potassium Regulation

1. Recognize the factors that influence potassium shifts between the intracellular and extracellular fluid spaces.
2. Discuss how to diagnostically approach a case of hypokalemia.
3. Describe the physiologic effects of hypo and hyperkalemia, particularly as they relate to excitable tissues.
4. Discuss how to diagnostically and therapeutically approach a case of hyperkalemia.

Diuretics and Anti-hypertensives

1. Identify the sites of action within the renal tubule for various diuretics.
2. Describe the mechanism of action for the different antihypertensive agents.
3. Explain common side effects associated with diuretics and antihypertensive agents.
4. Recognize compelling indications for selecting different antihypertensive agents.

Gas Transport and Exchange

1. Detail why efficient gas transport is needed to support metabolic needs.
2. Describe how partial pressures of gases at the alveolar-capillary membrane determine gas exchange.
   a.) Also know the normal mixture of gases in ambient air and effects of barometric pressure.
3. Describe how the degree of ventilation affects CO2 removal.
4. Describe how O2 is delivered to the alveolus and factors that affect its delivery.
5. Use the alveolar gas and alveolar ventilation equations (from memory) to calculate alveolar-arterial (Aa) 02 gradients and predict PaCO2 levels related to changes in ventilation.

Glomerular Filtration & Renal Blood Flow

1. Describe the arteriolar, capillary, and epithelial components of the filtration apparatus.
2. Describe the ultrastructural basis for molecular sieving during glomerular filtration.
3. Describe the Starling forces that drive and oppose glomerular filtration.
4. State the Starling equation for glomerular filtration rate.
5. State the typical magnitude of each of the Starling forces and the resultant net filtration pressure.
6. Define the process of autoregulation of GFR and RBF, including the structures involved, the cellular mechanisms, and physiological context and limitations under which this process operates.
7. Define the process of hypovolemic regulation of GFR and RBF including the structures involved, the cellular mechanisms, and physiological context under which this process operates.
8. Describe the role of renal prostaglandins in the renal response to hypovolemia.

Heart Failure Drugs

1. For the following diuretic classes describe their: (1.) Site and mechanism of action at the nephron
   (2.) Role in the treatment of heart failure and (3.) Adverse effects, especially as they relate to effects on plasma electrolytes.
   (a.)Loop (high ceiling): Furosemide - Torsemide - Bumetanide
   (b.)Thiazides: Hydrochlorothiazide - Chlorthalidone - Metolazone
   (c.)Potassium-sparing: Aldosterone antagonists (Spironolactone - Eplerenone) and Na+-channel blockers (Amiloride-Triamterene).
2. Describe renin-angiotensin-aldosterone system (RAAS) and the contribution of chronic RAAS activation to the underlying pathology of heart failure.
3. For the following classes of RAAS antagonists describe their target and mode of action, role in the treatment of heart failure, adverse effects - especially in relation to serum potassium and renal function, and interactions with other drugs used in heart failure: ACE inhibitors (Lisinopril, Ramipril, Quinapril, Moexipril, Benazepril, and Analapril); angiotensin receptor blockers (Valsartan, Losartan, Irbesartan, and Olmesartan; and aldosterone antagonists (Apironolactone and Eplerenone).
4. Describe the mechanism of action, effect on inotropy for heart failure treatment, and toxicity of cardiac glycosides (digitalis).
5. Describe the mechanism of action and clinical use of direct-acting vasodilators.

Heart Failure Pharmacology (TBL Scratch-off Session)

1. Students practice in answering questions on heart failure pharmacology.

Heart Failure: Pathophysiology, Diagnosis & Treatment

1. Define systolic and diastolic pressure-volume relations (PV loops) and ventricular function curves.
2. Define stroke volume, ejection fraction, stroke work, and pulse pressure, and identify them graphically on a pressure-volume loop diagram.
3. Recognize the major symptoms associated with heart failure, particularly those related to decreased cardiac output (fatigue), increased pulmonary venous pressure (dyspnea), and increased central venous pressure (edema).
4. Be acquainted with the functional classification schemes for heart failure (e.g. New York Heart Association [NYHA] functional class).
5. Identify the common precipitants of worsening heart failure symptoms, and the variable clinical course of heart failure.
6. Identify the key physical signs of heart failure, and how they relate to the underlying pathophysiology.
7. Describe the primary laboratory tests and imaging studies that are most helpful in making a diagnosis of heart failure, including natriuretic peptides, cardiac imaging studies (and how to assess left ventricular ejection fraction [LVEF]), and hemodynamics obtained from a pulmonary artery catheter.
8. Describe the major goals of therapy, including correction of any reversible causes, reduction of congestion, and optimization of cardiac function.
9. Describe the major classes of medications for heart failure, including diuretics, vasodilators, neurohormonal antagonists, and inotropes; appreciate how each class affects the deleterious cycle of heart failure.
10. Be familiar with other non-pharmacologic therapies for heart failure, including electrical therapies (defibrillators and resynchronization) and advanced therapies (transplantation, mechanical support devices, and hospice).
11. Describe the non-linear clinical course of heart failure, and how different therapeutic approaches are used at different stages of the disease process.
12. Understand that most specific heart failure therapies are indicated for patients with reduced ejection fraction (HFrEF); for the approximately 50% of patients with heart failure and relatively preserved ejection fraction (HFpEF), treatment consists of diuretics and management of underlying causes.
13. Explain the importance of prevention and list specific prevention goals.

High Altitude & Hypoxemia Physiology

1. Determine the inspired PO2 (PA02) at various barometric pressures and use this to understand the limitations of human exploration at high altitude.
2. Describe the ventilatory and cardiac adaptations to high altitude.
3. Describe the major illnesses associated with exposure to high altitude and their prevention and treatment.
4. Name several diseases which increase the risk of exposure to extreme environments (i.e. those with gas exchange, cardiac, or airflow limitations).

Histology of the Kidney

1. Describe the major anatomical regions of the kidney including the renal artery and vein, major and minor calyces, medulla, cortex, renal pyramids and regions containing collecting ducts.
2. Outline the flow of blood into and within the kidney finishing with its exit in the renal vein.
3. Describe the cellular dispostion of Bowman's capsule including the glomerulus and the cells and filtration barrier that comprise it and the visceral and parietal epithelia.
4. Describe the functions of later regions of the nephron after filtration through the glomerulus and outline each region and give one example of specialized functions of the different portions of the nephron involved in resorption of solutes.
5. Describe the unique epithelium of the ureters and bladder and know its functional significance.

Hypertension

1. Define the prevalence of hypertension in the U.S.
2. Define the incidence of cardiovascular and renal complications of hypertension.
3. Discuss the pathophysiology of essential and secondary hypertension.
4. Discuss the role of non-pharmacological therapies in treating hypertension.
5. Recognize the JNC approach to pharmacologic therapy of hypertension.
6. Describe the mechanics of antihypertensive drug actions.

Imaging of the Lung

1. Review the basic physics behind radiologic imaging of the thorax.
2. Identify key radiologic anatomy for both chest radiographs and CTs.
3. Develop a framework to discuss chest x-ray (CXR) findings.
4. Identify a subset of common or life-threatening chest x-ray (CXR) findings.

Integrated CV Pharmacology

1. Review of cardiovascular system pharmacology.

Intro to Psychiatry in CVPR

1. Discuss sequence organization and expectations.
2. Identify the parts of the mental status exam.
3. Discuss how psychiatric illness is identified and assessed.
4. Explain the Therapeutic 4-Par Assessment: Engage, Assess, Focus, and Plan.

Ischemic Heart Disease

1. Describe distinguishing features of the coronary circulation, including principle determinants of myocardial oxygen supply and demand.
2. Describe the progressive development of the atherosclerotic arterial wall: from fatty streak, endothelial dysfunction, lipoprotein entry and modification, leukocyte recruitment and foam cell formation.
3. Describe lipid metabolism and the central role of cholesterol in the development of atherosclerotic cardiovascular disease (ASCVD).
4. Describe the contributions of triglycerides and HDL-cholesterol to atherosclerotic cardiovascular disease (ASCVD) and its management.
5. Describe atherosclerotic plaque formation (smooth muscle cell migration to extracellular matrix metabolism) and plaque disruption (calcification, procoagulant exposure and thus thrombus formation, hemorrhage into plaque, plaque fragment embolization).
6. Describe determinates of myocardial oxygen supply and demand.
7. Identify risk factors for development of coronary atherosclerosis, and biomarkers of risk (lipoprotein (a), C-reactive protein, and other markers of inflammation).
8. Describe approaches to diagnosis of coronary artery disease.
9. Describe key elements of pathophysiology and treatment of stable coronary heart disease.
10. Describe pathophysiology and treatment of unstable coronary heart disease (unstable angina or myocardial infarction).
11. Describe approaches to treatment with medications.
12. Describe approaches to coronary angioplasty and stents.
13. Describe approaches to coronary bypass surgery.

Ischemic Heart Disease Pharmacology (TBL Scratch-off Session)

1. Students practice answering questions on ischemic heart disease pharmacology.

Kidney Microanatomy

1. Describe the gross structures of the kidney and blood flow into, through, and out of the kidney.
2. Explain the basic structure and function of the nephron.
3. Identify the detailed structures of the renal corpuscle and how they relate to function of the nephron, including the ultrastructure of the filtration barrier.
4. Identify the detailed structures of the different cell types along the renal tubule and collecting tubules/ducts and how they relate to the function of the kidney.
5. Describe the context of the structures and functional relationships of different regions of the nephron to their locations within the cortex and medulla.
6. Identify transitional epithelium of the bladder and know its function.

Lung Histology

1. Describe the basic construction of the lung - lobes, segments, pleura, and branching of the conduction and vascular systems, and the relationship of the visceral and parietal pleura to ventilation.
2. Explain the flow of blood through the lung, both the pulmonary and bronchial systems and identify a blood vessel (as compared to a bronchus or bronchiole) in the lung.
3. Identify the layers of the walls of the conduction system and the functional reasons for their differences: trachea, bronchi, bronchioles, and the respiratory bronchioles.
4. Describe the structure of alveolar septa, and the functions of their cellular and acellular components.
5. Outline the various defense mechanisms, both in the conduction system and alveoli, that prevent infection.
6. Describe the basic process of gas exchange at the blood-air barrier, the importance of surfactant, and be able to identify the layers of the blood-air barrier.
7. State the underlying mechanisms for pathologies of the congestive diseases of cystic fibrosis, Kartagener's syndrome, and the particulate overload diseases such as black lung and silicosis.

Lung Microanatomy

1. Describe the basic construction and anatomy of the lung—lobes and segments, the conduction system, pleura and pleural cavity and blood flow through the lung.
2. Delineate differences in the layers of the walls of the conduction system at different parts of the conduction “tree” and their functions—within the trachea, bronchi and bronchioles. Define essential layers within a mucosa and why they are necessary for a mucosa to function.
3. Describe the detailed structure of the alveolar septa, the different cell types present, and the relationship of structure to gas exchange and alveolar defense.
4. Outline the construction of both the conduction system and alveolar septa in the following contexts: i.e. think about WHY the lung must have structural features that address the following functions:
   a.) Gas exchange (surface area and alveolar capillaries).
   b.) Congestion. c.) Infection.d.)
   Negative pressure. e.) Prevention of surface tension. f.) Prevention of drying.

Mediastinum and Pleura Diseases

1. Identify the anatomic relationships of the cardiovascular, respiratory, endocrine, and GI systems within the mediastinum and the compartments of the mediastinum.
2. Define the major symptoms and clinical syndromes associated with mediastinal diseases and how they relate to the mediastinal compartment.
3. List the types of masses found in the mediastinum including frequency and clinical evaluation of these masses.
4. List the diagnostic procedures used to evaluate abnormalities of the pleural space.
5. Identify the difference between transudative and exudative pleural effusions.
6. List the types of tumors found in the pleural space.

Myocardial Pathology

1. Name the most common benign cardiac neoplasm in adults and the most common location for this tumor.
2. Name the most common cardiac neoplasm of infancy/childhood and the cell of origin.
3. List examples of infectious causes of myocarditis, and describe the symptoms of this diagnosis.
4. Describe systemic auto-immune diseases that can involve the heart, and which parts of the heart may be affected.
5. Give examples of medications and other substances that have been reported to have a "toxic" effect on the myocardium.
6. Describe the classic description of amyloid with regards to protein structure, light microscopy, and special staining with Congo Red.
7. Differentiate between primary and secondary cardiomyopathies and give examples for each group.
8. Recognize the causes, functional problems and gross cardiac appearance of dilated cardiomyopathy, hypertrophic cardiomyopathy and restrictive cardiomyopathy.

Nephritic Syndrome

1. Recognize the clinical manifestations of nephritic syndromes.
2. Describe the basic mechanisms of injury and histologic patterns in the various nephritic syndromes.
3. Discuss the standard therapies used to treat the nephritic syndromes.

Nephritic Syndrome Pathology (No In-Class Lecture; Review Panopto Recording)

1. List the glomerular diseases caused by immune-complex deposition.
2. Define and recognize the 4 morphologic glomerular changes that accompany glomerular injury.
3. Explain the relationship of morphologic patterns of injury with clinical presentation.
4. Describe the role of immunofluorescence, serology and electron microscopy in the evaluation and diagnosis of glomerular disease.

Nephrotic Syndrome

1. Describe the anatomy and function of the glomerulus.
2. Discuss the pathogenesis of the nephrotic syndrome.
3. Identify and discuss the major causes and treatment of idiopathic nephrotic syndrome.

Nephrotic Syndrome Pathology (No In-Class Lecture; Review Panopto Recording)

1. Describe the pathophysiology, clinical manifestations and complications of nephrotic syndrome.
2. Describe the typical clinical manifestations, morphology, pathogenesis and prognosis of the common glomerular diseases summarized in the handout.

Occupational Lung Diseases/Exposures

1. Define the major determinants of site and severity of lung disease.
2. Identify the clinical tools/questions used in evaluation of occupational lung disease.
3. Discuss the two major categories of occupational/environmental lung diseases.
4. Define the four types of airways diseases and examples of each.
5. Describe the five types of interstitial lung diseases and examples of each.
6. Identify the exposures or causes for each of the nine occupational/environmental lung diseases.
7. Identify the mechanisms of disease for each of the nine occupational/environmental lung diseases.

Overview of Renal Physiology

1. Describe in a single sentence the role of the kidney in total body homeostasis.
2. State the volume of each of the major body compartments in a standard-sized, healthy, adult individual.
3. Describe the major components and volumes of daily water intake and loss.
4. Identify the processes of water intake and output that are regulated to achieve extracellular fluid homeostasis.
5. Identify the basic functional structures of the nephron.
6. Describe the basic glomerular and tubular processes and how they interact to achieve ECF homeostasis.
7. For a normal sized healthy individual, to state the magnitude of renal blood flow, renal plasma flow, glomerular filtration rate, filtration fraction, and urine flow rate.
8. Describe regulation of vascular resistance by angiotensin II via the baroreceptor-mediated renin/angiotensin axis.

Overview of the Pulmonary System/Lung Development

1. Describe the gross anatomy of the lung.
2. Define the major phases of lung development including association with approximate weeks of gestation and major structural and biochemical changes (i.e. surfactant secretion) and how this relates to survival of the premature infant.
3. Identify the major structural and functional differences between conducting and gas exchanging regions of the lung.

Pathology Lab: Infectious & Neoplastic Diseases (Required)

1. Name examples of infectious processes that can affect the lung, including bacterial, fungal, and viral.
2. Distinguish between infections seen in community-acquired pneumonia, hospital-acquired pneumonia, aspiration pneumonia and an immunocompromised patient.
3. Distinguish among bronchopneumonia, lobar pneumonia, abscess, and bronchiectasis.
4. Discuss role of immunosuppression with respect to increased vulnerability to new infections, recrudescence/recurrence of latent infection that had been held in check by immune system, viruses (herpes simplex/CMV) and parasites (toxoplasmosis).
5. Name major primary malignant lung neoplasm subtypes and distinguish key histologic features for subtypes, including non-small cell neoplasms (adenocarcinoma, squamous cell carcinoma, and large cell carcinoma) and small cell neoplasms (mesothelioma).
6. Distinguish location of non-small cell neoplasms (adenocarcinoma, squamous cell carcinoma, and large cell carcinoma) and small cell neoplasms (mesothelioma): proximal or peripheral location vs. pleural.
7. Name Key T/N/M features involved in staging primary lung neoplasms.
8. Discuss clinical and imaging/autopsy findings that would favor metastasis over primary carcinoma.
9. Name examples of neoplasms that might metastasize to lung, including lung neoplasms metastatic to ipsilateral and contralateral lung.

Pathology Lab: Ischemic Heart Disease (Required)

1. Define the histologic features and risk factors for arteriolosclerosis and atherosclerosis.
2. Define myocardial infarct (MI), including pathogenesis and laboratory documentation of MI including time frame during which enzyme levels (CK-MB, troponin) are elevated.
3. Describe the location of myocardial infarcts based on isolated involvement of the left anterior descending artery, left circumflex artery, and right coronary artery.
4. Distinguish between subendocardial infarct and transmural infarct.
5. Describe the histologic findings (acute, subacute, and chronic) in myocardial infarct.
6. Describe the three components of "Virchow's triad" of thrombosis, including: endothelial cell/vessel wall integrity (endothelial injury and collagen exposure-thrombosis); blood flow (stasis or reduced flow-thrombosis and turbulence of flow-thrombosis); and coagulation factors, platelets (hypercoagulability-thrombosis).
7. Distinguish phases of a myocardial infarct and the associated macroscopic (gross) and histopathologic findings (acute/subacute, chronic).
8. Name complications of myocardial ischemia/infarct with respect to electrical activity, myocardial injury, and pericardial injury.
9. Define and distinguish between "Cause of Death" and "Manner of Death," fill out a "Certificate of Death," distinguish "immediate" and "underlying" ("proximate") causes of death, identify relevant "Contributing" factors ("Other Significant Conditions"), and name the "Manners" of death.

Pathology Lab: Kidney & Urinary Tract Tumors (Required)

1. List the most common benign and malignant tumors of the kidney and describe their most important characteristics in regards to: incidence; clinical features; imaging features; urinary findings; gross pathology; microscopic pathology; and staging and prognosis.
2. Describe the basic genetic differences between spontaneous and familial renal tumors.
3. Describe the most important benign and malignant tumors of the urinary tract, calyx, pelvis, ureter, urinary bladder, and urethra.

Pathology Lab: Miscellaneous CV Diseases (Required)

1. Distinguish subtypes and etiologies of "non-ischemic" cardiomyopathy, including dilated, hypertrophic, and restrictive.
2. Describe clinical and histopathologic features of patients with genetic causes of cardiomyopathy.
3. Describe clinical and histopathologic features of systemic amyloidosis, including sources of protein which deposits in various organs, organs affected most commonly, and the effect on heart (restrictive cardiomyopathy).
4. Describe histologic criteria for "myocarditis" and name possible etiologies (infectious etiologies and immune etiologies).
5. Describe clinical and histopathologic features of left-sided congestive heart failure: (acute, chronic).
6. Describe "pericarditis" and distinguish among the processes that manifest as pericarditis (serous, purulent, hemorrhagic, caseous, malignant).
7. Describe the various features of aortic aneurysms, define aneurysm, and distinguish true aneurysm from false aneurysm/pseudoaneurysm.
8. Name the two critical etiologic processes in development of an aortic aneurysm (hypertension, atherosclerosis, and associated inflammation) and discuss possible outcomes of untreated (often undetected) aneurysms (rupture, thromboembolism).
9. Name examples of muscle-associated proteins which can be involved in a genetic-associated cardiomyopathy and describe possible clinical outcomes.
10. Describe the two main types of "true" aneurysms (fusiform variant and saccular/berry variant) and state possible locations of abdominal aortic aneurysms (infrarenal, suprarena, both).

Pathology Lab: Nephritic and Nephrotic Diseases (Required)

1. Define: mesangium (support/infrastructure, phagocytic properties); azotemia; proteinuria (nephrotic range >3.5 g/24 hours); proliferative changes (what cells are involved); membranous change (which "membrane" is involved); local vs. diffuse (proportion of total glomeruli involved); and segmental vs. global involvement (part or entire glomerulus involved).
2. Cite typical presentation, name key light, electron and immunofluorescence findings for IgA Nephropathy/Berger Disease/Focal Mesangial Proliferative Glomerulopathy.
3. Cite typical presentation, name key light, electron and immunofluorescence findings for Post-Infectious Rapidly Progressive Glomerulonephritis (GN) and distinguish that Group A strep can manifest with "Nephrogenic" strains (pharynx and skin infections) and "Rheumatologic"/"Rheumatic" strains (pharynx infection).
4. Cite typical presentation, name key light, electron and immunofluorescence findings for Diffuse Crescentic Proliferative Glomerulonephritis(GN)/Goodpasture Disease.
5. Cite typical presentation, name key light (none), electron and immunofluorescence (negative) findings for Minimal Change Disease/Nil Disease.
6. Cite typical presentation, name key light, electron (nothing specific) and immunofluorescence (negative) findings for Focal Segmental Glomerulosclerosis (FSGS): list a few diseases that can manifest with FSGS.
7. Cite typical presentation, name key light, electron and immunofluorescence findings on Membranous Glomerulonephritis (GN). Most cases are idiopathic: name a few possible causes in the ~15% of patients for whom an etiology is established.
8. Cite typical presentations and organ systems other than kidney that can be involved in patients with Lupus.
9. Recognize that various glomerular diseases can affect the kidney in patients with Lupus, including at different times during the course of the disease.
10. Recognize that there is a WHO Classification scheme: Class I - Class V.

Pathology Lab: Obstructive/Restrictive Lung Disease (Required)

1. Describe normal anatomy of lung, including the bronchi (cartilage)/bronchiole (no cartilage) and alveolus.
2. Distinguish between obstructive disease (increased resistance to air flow) and restrictive disease (reduced compliance - stiff lung).
3. Name examples and describe the histologic changes in the specific disease processes within alveolar airspace or bronchi and bronchioles (emphysema, bronchitis, asthma).
4. Describe major histologic changes in alveolar airspace vs. wall/septum in usual interstitial pneumonia (UIP)/idiopathic pulmonary fibrosis (IPF) and nonspecific interstitial pneumonia (NSIP).
5. Describe major histologic changes in airspace and wall/septum in the restrictive lung disease (acute lung injury (ALI)/acute respiratory distress syndrome (ARDS)/diffuse alveolar damage (DAD)).

Pathology Lab: Urinary Tract Infection-Chronic Renal Failure (Required)

1. Define pyelonephritis.
2. Describe microscopic changes in acute pyelonephritis.
3. Describe the appearance of the kidney in chronic pyelonephritis.
4. Name etiologic processes that can lead to urinary tract obstruction and predispose to pyelonephritis in the: renal pelvis; ureter; bladder, ureteropelvic junction; ureterovisiccular junction; and prostate (if present).
5. Distinguish among the various types of casts and their significance regarding renal disease: red blood cell casts; granular casts (coarse and fine); white blood cell casts, waxy casts; and hyaline casts (mostly benign).
6. Name the composition of several types of uroliths and state whether they can be recognized by X-ray (plain abdominal film ("KUB"), CT scan).
7. Name the type of nephrolith associated with Proteus and other bacterial urinary tract infections.
8. Name locations in the urinary tract where stones can form.
9. Describe clinical and pathologic findings in the setting of papillary necrosis of the renal medullary pyramids and name several disease processes that can present with this process.
10. In a poorly controlled diabetic patient, describe the changes seen in: glomerulus (blood vessel basement membrane, mesangium) and renal parenchymal arteries and arterioles.
11. Name the rounded mesangial structure that is characteristic of advanced, poorly-controlled diabetes.
12. Define hydronephrosis; hydroureter; pyelonephritis; xanthogranulomatous inflammation; kimmelstiel-Wilson body; diabetic arteriolsclerosis; Tamm-Horsfall protein; urolithiasis/nephrolithiasis/renal calculus/staghorn calculus; and papillary necrosis.

Pathology Lab: Valvular Disease (Required)

1. Describe anatomic features of bicuspid aortic valve compared to normal valve.
2. Describe possible long-term effects of bicuspid valve anatomy.
3. Describe gross pathology of Calcific Aortic Stenosis.
4. Describe pathophysiology of Calcific Aortic Stenosis.
5. State increased incidence in bicuspid vs. normal valve.
6. Describe possible long-term outcome (stenosis; regurgitation).
7. Describe possible treatment of calcific aortic stenosis.
8. For acute rheumatic heart disease: describe the pathophysiology, name involved areas (endocardium, myocardium, and epicardium), and recognize the name and describe the components seen histologically for the Aschoff body.
9. For chronic rheumatic heart disease: describe the gross pathology, list valves most commonly involved by rheumatic heart disease, describe changes in the leaflets and chordae tendinea of the mitral valve, and describe possible outcomes related to changes of chronic rheumatic heart disease (stenosis; regurgitation; increased risk of vegetation formation).
10. Describe the most common macroscopic finding in prolapse.
11. Describe possible adverse effects of prolapse (regurgitation).
12. List several possible symptoms of mitral valve prolapse (can be asymptomatic or symptomatic).
13. Describe gross and microscopic pathology of vegetations.
14. Distinguish between non-infective/sterile/marantic vegetations (non-bacterial thrombotic endocarditis) and infective (e.g. bacterial or fungal endocarditis = "Infective Endocarditis").
15. List disease processes which can predispose to development of vegetations: inflammatory disease (lupus - Libman-Sachs vegetations; rheumatic heart disease - acute and chronic); hypercoagulable state (in setting of solid neoplasm); and bacteremia (potential to involve normal or diseased valve).

Pathology of Valvular Disease

1. Explain some of the underlying causes of systemic hypertension, and which cause is most common.
2. Describe the effects of long-standing hypertension (systemic and pulmonary types) on the macroscopic and microscopic appearances of the heart.
3. Predict the action of all cardiac valves during systole and diastole, and the effects of stenosis or insufficiency in each valve.
4. Describe the prevalence of bicuspid aortic valves, and the sequelae of this diagnosis.
5. Describe the problems that can arise when cardiac valves do not function normally.
6. Describe the sequence for the development of rheumatic heart disease and the eventual anatomic and functional outcome of this diagnosis.
7. Describe the difference between rheumatic fever and rheumatic heart disease.
8. Describe the difference between infective and non-infective endocarditis, including pre-disposing factors for each, and sequelae of these diagnoses.

Pathophysiology of Sodium Handling

1. Understand the concept of effective arterial blood volume and the hormonal mechanisms involved in its maintenance. Must also under understand how these systems interact when one (or several) components are diseased.
2. Discuss the forces involved in edema formation and maintenance.
3. Identify the nephron site of action and discuss the potential side effects of diuretics.
4. Describe the “fate” of intravenous fluids containing different amounts of colloids, sodium, and glucose.

Pathophysiology of Water Handling

1. Recognize that hypo- and hypernatrimia refers to the concentration of sodium in serum and not to the absolute amount of sodium in the body.
2. Differentiate among the causes of hyponatremia.
3. Understand the physiologic mechanisms by which hyponatremia may be induced.
4. Know the differential diagnosis of hypernatremia.
5. Discuss the approach to the therapy of both hypo- and hypernatremia.

Pathophysiology Small Groups: Cases 1-7 (Required)

1. Discuss pathophysiology of lung diseases and diagnosis and treatment.

Pathophysiology Small Groups: Acid-Base Cases (Required)

1. Define simple and mixed acid-base disorders.
2. Define and discuss the utility of the serum and urine anion-gaps.
3. Discuss the concept (and rules) of compensation.
4. Discuss how to approach simple and mixed acid-base disorders.

Pathophysiology Small Groups: Acute Renal Failure (Required)

1. Logically evaluate a case of acute renal failure and "pigeon hole" the case based on clinical criteria into different diagnostic groups.
2. Evaluate findings on a history and physical examination that suggest one diagnosis or another.
3. Describe the physiologic differences between pre-renal azotemia and other causes of acute renal failure.
4. Identify the urinalysis findings that suggest ATN or other causes of acute renal failure.
5. Interpret urinary electrolytes and osmolality values, and use them in the differential diagnosis of acute renal failure.

Pathophysiology Small Groups: Arrhythmias (Required)

1. Recognize basic arrhythmias and explain their origin.

Pathophysiology Small Groups: Cases 14-19

1. Using clinical information from patients with obstructive or restrictive lung disease, diseases of the pulmonary circulation, etc., determine if the delivery of O2 to the tissues is adequate. Also determine the acid/base status of patients in various settings and determine if the compensatory efforts are adequate and if not, why not.

Pathophysiology Small Groups: Cases 20-24

1. Discuss lung cases.

Pathophysiology Small Groups: Cases 8-13 (Required)

1. Identify ventilation and perfusion relationships in health and disease and discuss how these lead to changes in gas exchange.

Pathophysiology Small Groups: Cases in Pathophysiology

1. Solve cases in pathophysiology.

Pathophysiology Small Groups: Chronic Kidney Disease-Dialysis and Transplant Cases (Required)

1. Identify the stages of chronic kidney disease and discuss the utility of this classification system.
2. Describe how balance is maintained for sodium, water, potassium and protons in chronic kidney disease.
3. Define the uremic syndrome and discuss the major theories of the pathogenesis of uremia.
4. Describe the pathogenesis of certain disorders that accompany chronic kidney disease, including anemia, hypertension, and mineral and bone disease.

Pathophysiology Small Groups: Congenital Heart Disease (Required)

1. Discuss cases of congenital heart disease.

Pathophysiology Small Groups: Heart Failure (Required)

1. Describe the pathophysiologic basis of the major signs, symptoms, and other findings in patients with heart failure.

Pathophysiology Small Groups: Ischemic Heart Disease (Required)

1. Discuss cases of ischemic heart disease.

Pathophysiology Small Groups: Myocarditis/Pericarditis Disease (Required)

1. Discuss cases of myocarditis and pericarditis.

Pathophysiology Small Groups: Peripheral Vascular Disease Cases (Required)

1. Discuss cases of ischemic heart disease and peripheral vascular disease cases.

Pathophysiology Small Groups: Potassium Regulation & Hypertension Cases (Required)

1. Identify the factors that influence potassium shifts between the intracellular and extracellular fluid spaces.
2. Identify how to diagnostically approach a case of hypokalemia.
3. Understand the physiologic effects of hypo- and hyperkalemia, particularly as they relate to excitable tissues.
4. Know how to diagnostically and therapeutically approach a case of hyperkalemia.

Pathophysiology Small Groups: Sodium Handling (Required)

1. Discuss the pathophysiology, diagnosis, and treatment options of sodium handling disorders.

Pathophysiology Small Groups: Valvular Disease Cases (Required)

1. Discuss diagnosis and treatment of valvular disease via clinical cases.

Pathophysiology Small Groups: Water Handling (Required)

1. Discuss the pathophysiology, diagnosis, and treatment options for water handling disorders.

Pediatric Kidney & Urinary Tract

1. List the common developmental defects encountered in the urinary tract, including appropriate terminology, embryologic origin, and clinical presentation.
2. Define the following terms: hydronephrosis, hydroureter, and megalocystis.
3. Describe the pathophysiologic events and consequences of urinary tract obstruction in the fetus.

Pediatric Lung Disease

1. Understand the differences between adult and pediatric pulmonary physiology.
2. Differentiate between mild and severe acute illnesses involving the upper airway.
3. Understand the pathophysiology of the most common causes of lower airway obstruction.
4. Define common pediatric pulmonary diseases including asthma, chronic lung disease of prematurity, and cystic fibrosis in terms of pulmonary pathophysiology, risk factors, and long-term sequelae.

Pericardial Disease

1. Describe the presenting symptoms and signs of, diagnostic approaches to and treatment for acute pericarditis.
2. Outline the clinical manifestations, diagnosis and treatment of cardiac tamponade.
3. Describe the clinical manifestations, diagnosis and treatment of constrictive pericarditis.

Peripheral Vascular Disease (Self-Study; No In-Class Lecture)

1. For aortic aneurysms and for aortic dissection, describe the etiology, pathogenesis, clinical presentation, diagnosis and treatment of this disease.
2. For aneurysms, describe how the risk of aneurysm rupture increases with aneurysm size, as predicted by Laplace's equation.
3. For peripheral atherosclerotic vascular disease, describe the etiology, pathogenesis, clinical presentation, diagnosis and treatment.
4. For peripheral atherosclerotic disease, describe the roles of (i) length of the stenosis, (ii) radius of the stenosis and (iii) blood viscosity in regard to how each contributes to a drop in pressure and flow across a stenosis (Poiseuille equation).
5. For peripheral atherosclerotic disease, describe the classic symptoms of exertional limb fatigue and pain known as claudication.
6. For acute arterial occlusion, describe the etiology, pathogenesis, clinical presentation, diagnosis and treatment of this disease.
7. Describe Raynaud's vasospasm phenomenon, and treatment.
8. Describe the clinical presentation, diagnosis and treatment of varicose veins, chronic venous insufficiency, and venous thromboembolism (including deep venous thrombosis and pulmonary embolism).
9. For venous thromboembolism, describe the components of Virchow's triad and mechanistically how each component contributes to thrombosis.
10. Describe the major sites of action of drugs that inhibit platelet function and coagulation with a focus on aspirin, clopidogrel, warfarin, heparin and factor Xa inhibitors (French content).

Pharmacology Issues in Renal Failure

1. Describe how the pathophysiological changes that occur in chronic kidney disease (CKD) can alter the pharmacokinetic disposition of, and the pharmacodynamic response to, drugs administered to CKD patients.
2. Describe changes in the pharmacotherapeutic regimen that may be necessary to manage changes in plasma drug levels and drug response that occur as a result of these alterations in pharmacokinetics and pharmacodynamics in CKD patients.
3. Relate the pathophysiological changes in CKD that result in anemia, renal osteodystrophy, and hyperkalemia TO the pharmacologic strategies that are used in their management.
4. For the drugs listed in the DRUG LIST, describe their: mechanism and site of action; pharmacokinetic factors (when clinically relevant); rational for use in CKD complications; and most common and most severe side effects/significant drug-drug interactions.

Pharmacotherapy of Ischemic Heart Disease

1. Describe the general mechanisms of platelet function, coagulation, and fibrinolysis, with special emphasis on the sites and targets for pharmacotherapeutic interventions in disorders of hemostasis.
2. For anticoagulants, thrombolytic agents, and antiplatelet agents utilized in the treatment of disorders of hemostasis: describe their mechanism of action and pharmacokinetics; list their uses, adverse reactions (plus treatment of overdosage if applicable), and drug-drug interactions; and disadvantages of drugs in each category.
3. Describe the general pathophysiology of angina (imbalance between cardiac oxygen supply and demand) and characteristics of the three major types.
4. Describe the rationale for using each of the three major pharmacological classes of antianginal agents and describe their mechanism(s) of action: nitrates, β-blockers, and Ca2+ channel blockers.
5. List the major side effects and pharmacokinetic profiles of nitrate/nitrate products.
6. List the side effects and relative cardiac vs. vascular action of Ca2+ channel blockers [dihydropyridine class (nifedipine) vs. diltiazem vs. verapamil].

Pharmacotherapy of the Upper Airway

1. List the major classes or generations of antihistamine (H1 antagonists) and describe their primary pharmacological actions, as well as the advantages and disadvantages (uses - side effects) of each.
2. For the following antihistamine drugs describe: mechanism and site of action (receptors and effector organs involved), pharmacokinetic factors (central vs peripheral activity, organ of elimination, duration of action - short vs long), major clinical uses, most common and most severe side effects, significant contraindications (Diphenhydramine/Chlorpheniramine/Brompheniramine, Meclizine/Dimenhydrinate, Loratadine/Fexofenadine/Cetirizine).
3. For the following various agents used in respiratory conditions (esp. colds and allergies) describe their: role in treating symptoms (MOA), relative efficacy, route of administration, side effects, relative advantages / disadvantages (Decongestants-sympathomimetics; Pseudoephedrine/Phenylephrine/Oxymetolazine; Antitussive agents-Codeine/Dextromethorphan; Expectorants-Guaifenesin; Mucolytics-N-Acetylcysteine).

PNA / Influenza

1. Define and discuss the features of pneumonia (PNA).
2. Describe pathogenesis of pneumonia.
3. Discuss pneumonia classifications or types.
4. Discuss a differential diagnosis of pneumonia (PNA).
5. Identify the main organisms associated with pneumonia (PNA) types.
6. Discuss the basics of pneumonia (PNA) treatment.

Primary Prevention of Cardiovascular Disease

1. Describe the primary goals in cardiovascular disease prevention.
2. Describe the public health benefits of blood pressure control.
3. Describe the barriers to cardiovascular disease risk reduction including adherence.
4. Describe the myths in cardiovascular disease prevention.
5. Describe public and community health approaches to cardiovascular disease prevention.

Psychiatry Small Groups: Patient Interview I - Mental Health (Required)

1. Describe symptoms/presentation of depression and grief particularly in medical settings and be able to differentiate depression from normal grief.
2. Describe the bi-directional relationship of depression and grief with medical illness such as cardiac, pulmonary, renal disease and describe the increased mortality in survivors.
3. Describe the etologies of depression, including risk factors, genetics, life experiences, and basic neurobiology.
4. Identify very basic psychotherapeutic and pharmacologic treatments of depression and grief.

Psychiatry Small Groups: Patient Interview II - Mental Health (Required)

1. Recognize symptoms/presentation of anxiety, primarily panic disorder, particularly in medical settings.
2. Describe the relationship of anxiety with depression.
3. Define basic etiologies of panic disorder, including risk factors and patient vulnerabilities, genetics, life experiences, stress, and basic neurobiology.
4. Identify very basic psychotherapeutic and pharmacologic treatments of panic disorder.

Psychiatry Small Groups: Patient Interview III - Mental Health (Required)

1. Recognize symptoms/presentation of suicide particularly in medical settings.
2. Describe the association of suicide with medical illness such as cardiac, pulmonary, and renal disease.
3. Define basic etiologies of suicide, including risk factors and patient vulnerabilities, genetics, life experiences, stress, and basic neurobiology.
4. Identify the very basic treatment of suicide.

Psychiatry Small Groups: Presentation of Psychiatric Illness (Required)

1. Sequence organization and expectations including the Interview Reviews.
2. Define psychiatric illness.
3. Describe how psychiatric illness is identified and assessed.
4. Recognize the Therapeutic 4-Part Assessment (Engage, Assess, Focus & Plan).

Pulmonary Circulation I

1. Describe the major functions of the pulmonary circulation.
2. Describe the major determinants of blood flow distribution in the lung.
3. Define the three physiologic zones of the lung.
4. Explain determinants of water and solute balance in the lung and types of pulmonary edema.

Pulmonary Circulation II

1. Define pulmonary hypertension and its causes.
2. Recognize the Dana-Point classification of pulmonary hypertension.
3. Describe the clinical presentation, diagnostic evaluation and treatment of acute pulmonary embolism.
4. Describe the therapeutic treatment options for PAH.

Pulmonary Defense Mechanisms

1. Describe the defense mechanisms of the lung.
2. Distinguish how the lung discriminates between harmful and harmless materials.
3. Explain the consequences of innate receptor signaling.
4. Describe the generation of an adaptive immune response in the lung.

Pulmonary Function Tests

1. Identify the three major components of routine pulmonary function tests and how they are performed/measured.
2. Identify components of and distinguish between volumes and capacities.
3. Define the determinants of Functional Residual Capacity (FRC) aka Thoracic Gas Volume (TGV).
4. Identify effort dependent and independent components to pulmonary function testing.
5. Distinguish between obstructive and restrictive patterns on pulmonary function tests.
6. Identify the three major factors contributing to the diffusing capacity of the lungs for carbon monoxide (DLCO).
7. Identify major disease processes by PFT patterns integrating airflow, lung volume, and gas exchange measurements.
8. Describe how pressure - volume curves are performed and assist in the interpretation of abnormal pulmonary function tests (specifically in emphysema, asthma, obesity and fibrotic lung disease) and define compliance and elastance.
9. Identify how bronchoprovocation testing and FeNO may be helpful in evaluating suspected asthma.

Pulmonary Manifestations of Systemic Disease

1. Recognize the pulmonary manifestations associated with various systemic diseases.
2. Identify whether the pulmonary manifestations of the systemic diseases are associated with obstructive or restrictive lung physiology.
3. Review approach to formulating a differential diagnosis and clinical decision making.

Pulmonary Pathology I

1. Recognize the components of the airways and the types of bronchitis and bronchiolitis.
2. Identify the main histologic changes that are associated with asthma.
3. Contrast and compare between acute, eosinophilic, and organizing pneumonia.
4. Identify the main forms of smoking-related lung disease.
5. Differentiate emphysema related to smoking from emphysema secondary to alpha-1-antitypsinase deficiency.
6. Recognize the main histologic features of acute lung injury/diffuse alveolar damage.

Pulmonary Pathology II

1. Identify the most common patterns of interstitial lung disease: UIP, NSIP and HP.
2. Recognize the histologic features seen in patients with pulmonary hypertension and thromboembolic disease.
3. Identify the main types of benign nodular processes in the lung: granulomas and pulmonary Langerhan's cell histiocytosis.
4. Recognize the appearance of neoplastic tumors in the lung and discuss how they are different from inflammatory nodules.

Regulation of Extracellular Sodium & Water

1. State the qualitative effects of adding and subtracting sodium from the ECF on ECF volume and the physicochemical bases for these changes.
2. Describe the physiological feedback loop involved in the homeostasis of sodium concentration in the ECF.
3. Describe the physiological feedback pathway for the regulation of water content in the ECF.
4. Identify the dominant pathway involved in water regulation during normal variations in volume and osmolarity.
5. Identify the dominant pathway involved in water regulation during severe hypovolemia.
6. Describe the pathways involved in the regulation of ECF volume in a hypervolemic state by atrial natriuretic factor.

Renal Regulation of ECF Potassium

1. Describe the cellular mechanisms for potassium reabsorption and secretion and their tubular location.
2. Describe the feedback pathways that regulate ECF potassium levels via potassium secretion.
3. Describe the effects of increased and decreased tubular flow on potassium secretion.
4. State the effects of acid/base imbalances on potassium levels.
5. Describe the cellular mechanisms by which acid/base abnormalities can cause hypokalemia and hyperkalemia.

Respiration in Stress and Disease

1. Describe how normal ventilation and perfusion changes related to positioning/gravity are relevant to the pathophysiology of lung diseases [such as emphysema, dust-inhalation diseases, hepatopulmonary syndrome (lung shunts in cirrhosis), and tuberculosis].
2. Describe how limitations of ventilation, gas exchange, and perfusion affect exertional tolerance in common lung diseases.
3. Using your knowledge from earlier in the block, understand the predictable disorders that happen with activities at high barometric pressure (diving).
4. Using your knowledge from earlier in the block, understand the predictable disorders that happen with activities at low barometric pressure (high altitude).
5. Give examples of how ventilation and perfusion changes related to positioning/gravity can be used during medical treatment.

Respiratory Failure and ARDS

1. Define the types and pathophysiology of respiratory failure.
2. Explain how you can use a blood gas to determine what type of respiratory failure your patient has and how ABG abnormalities can be fixed.
3. Identify ONLY FOUR mechanical ventilatory parameters and describe how one can use these to manage the majority of intubated and ventilated patients.
4. Discuss the basic definition and pathogenesis of ARDS and the conditions that predispose to its development.
5. Describe the management strategies that improve survival in ARDS.

Restrictive/Inflammatory Lung Disease

1. Define the primary physiologic abnormalities in restrictive lung disease.
2. Describe general mechanisms that lead to restrictive physiology (i.e. diseases and/or processes).
3. Determine how PFTs can distinguish between increased lung elastic recoil vs. increased chest wall resistance (i.e. differentiate between restrictive physiology and restrictive lung disease).
4. Determine how PFTs are interpreted in patients with mixed obstructive/restrictive lung disease.
5. Describe the diagnostic approach to interstitial lung diseases and review basic differences between different forms of ILD.

Role of the Kidneys in Acid/Base Balance

1. State the production rate of metabolic, nonvolatile acid in a healthy, average-sized individual.
2. State the major acid buffering mechanisms in the ECF.
3. Describe the chemical reaction scheme and role of bicarbonate in the buffering of nonvolatile acid.
4. State the role of the kidney in the maintenance of bicarbonate levels.
5. Describe the cellular mechanisms, tubular localization, and daily magnitude of bicarbonate reabsorption.
6. Describe the cellular mechanisms, tubular localization, and daily magnitude of bicarbonate synthesis.
7. Describe the renal responses to metabolic acidoses.
8. Describe the long term effects of primary changes in ECF potassium levels on plasma pH.

Secondary Causes of Hypertension

1. Define the prevalence of hypertension in the U.S.
2. Define the incidence of cardiovascular and renal complications of hypertension.
3. Discuss the pathophysiology of essential and secondary hypertension.
4. Discuss the role of non-pharmacological therapies in treating hypertension.
5. Recognize the JNC approach to pharmacologic therapy of hypertension.
6. Describe the mechanics of antihypertensive drug actions.

Secondary Prevention of Heart Disease

1. Describe the role of secondary prevention strategies in reducing recurrent cardiac events and mortality.
2. List the various risk factors that contribute to recurrent cardiac events.
3. Describe the guideline recommendations for both pharmacologic and lifestyle interventions to reduce cardiac risk, and which patients benefit from these recommendations.

Shock

1. Describe the cellular, tissue/organ, and circulatory defects that are underlie shock.
2. Describe the diagnostic features of 6 main types of shock (hypovolemic, distributive, cardiogenic, anaphylactic, neurogenic, dissociative).
3. Describe the basic treatments of each form of shock.

Sleep Disordered Breathing

1. Discuss the spectrum, epidemiology and complications of Sleep Disordered Breathing (SDB).
2. Discuss the clinical features and diagnostic approach to Sleep Apnea.
3. Describe the therapeutic approach to Sleep Apnea.
4. Understand the widespread problem of insomnia and some common ways to modify this.

Suicide

1. Recognize the medical, psychiatric, and psychosocial risk factors for suicide.
2. Describe the association of suicide with medical illness, including cardiac, pulmonary, and renal disease.
3. Describe the rationale for crisis psychiatric interventions.
4. Identify the very basic treatment of suicidal ideation and attempts.

TB - Worldwide Control, Testing

1. Identify individuals who should be targeted for turberculin skin testing to diagnose latent tuberculosis infection.
2. Identify the optimal pharmacologic regimen for treatment of latent tuberculous infection.
3. Discuss the public health implications of identifying and treating latent tuberculous infection.

Tobacco Prevention & Intervention

1. Describe pharmacology of nicotine.
2. List at least 3 indicators of Tobacco Use Disorder as defined by DSM-5.
3. List and describe 7 FDA approved cessation medications.
4. Describe common side effects of cessation medications.
5. List stages in the Transtheoretical Model of Change.
6. Define motivational interviewing (MI) and "open questions, affirmation, reflective listening, and summary reflections" (OARS).

Transplant

1. Describe the risks and benefits of undergoing kidney transplantation vs. dialysis.
2. Describe the role of the human HLA system in kidney transplantation.
3. Describe the main classes of immunosuppression utilized in clinical kidney transplantation.
4. Describe the basic approach to kidney transplant AKI.

Tubular Transport of NaCl and Water

1. State the magnitude and regulated range of NaCl and water handling by the kidneys.
2. Describe the major epithlelial transport mechanisms for NaCl and water reabsorption in each major tubular segment.
3. State the relative proportion of water and NaCl reabsorbed in each tubular segment.
4. Describe the overall role of each major tubular segment in the regulation of NaCl and water reabsorption.
5. Identify the major hormones that regulate tubular reabsorption of NaCl and water and their tubular and cellular site of action.
6. Describe the molecular mechanism of action of aldosterone and ADH/vasopressin with respect to NaCl and water transport.
7. State the Starling equation for the flow of solution from the renal interstitium to the peritubular capillaries.
8. Give values for each of the Starling forces and the net pressure driving the flow in (7).
9. Describe qualitatively the effects of increasing and decreasing tubular flow on water and sodium excretion.
10. Define "glomerulotubular balance" and "tubuloglomerular feedback" and describe the roles these processes play in the regulation of NaCl and water reabsorption.

Tumors of the Kidney

1. List the incidence, gross and microscopic features of the following benign renal tumors: Renal Papillary Adenoma, Angiomyolipoma, and Oncocytoma.
2. For renal cell carcinoma variants, including clear cell carcinoma, papillary carcinoma and chromophobe carcinoma, list their: a. Incidence / relative frequency, b. Clinical features, c. Imaging features, d. Gross pathology, e. Microscopic pathology
3. Describe the basic genetic differences between spontaneous and familial renal tumors.
4. Describe the gross and histologic findings of transitional cell carcinoma.

Upper Airways & Larynx

1. Describe the major anatomical and functional relationships of the upper airway.
2. Define the major symptom complexes that indicate disorders of the upper airway and larynx.
3. Define how the complex of symptoms called hoarseness is characterized and evaluated.
4. Define how speech is generated and the major categories of speech disorders.
5. Define the major infectious and non-infectious causes of hoarseness.

Urinalysis

1. Define the basic principles of urine collection.
2. Describe the different types of urinalysis and understand their corresponding clinical-pathological correlation, including macroscopic examination and chemical analysis (use and interpretation of dipstick for: glucose; bilirubin; specific gravity; blood; pH; protein; urobilinogen; nitrite; leukocyte esterase; microscopic examination; and cytology).
3. Interpret some of the most common chemical and cytological changes in urine samples in the most common inflammatory and neoplastic diseases of the kidney and the urinary tract.

Urinary Tract Infection/Interstitial Disease

1. Describe the pathogenesis of urinary tract infection in terms of routes of infection, organism virulence factors, host defense mechanisms, predisposing factors, clinical manifestations, and complications.
2. Compare and contrast the features and pathogenesis of the two major causes of chronic pyelonephritis (urinary tract obstruction and vesicoureteral reflux).
3. Describe the pathologic features of acute and chronic pyelonephritis.

Ventilation

1. Describe the mechanisms of ventilation (neural, chest wall, diaphragm and other muscles, airways).
2. Identify differences in ventilation throughout the lung related to anatomic location/gravity.
3. Identify the effects of dead space on ventilatory efficiency.
4. Identify fundamental lung pressure-volume relationships and understand lung compliance.
5. Describe structural features that affect airflow (both static and dynamic).
6. Describe the mechanisms of dynamic airflow resistance (and its inverse, conductance), and how resistance (conductance) and compliance determine ventilation.
7. Identify factors that affect ventilation in disease.