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THE AMERICAN BOARD OF PEDIATRICS®

CONTENT OUTLINE

Pediatric Nephrology

Subspecialty In-Training, Certification and Maintenance of Certification (MOC) Examinations
INTRODUCTION

This document was prepared by the American Board of Pediatrics Subboard of Pediatric Nephrology for the purpose of developing in-training, certification, and maintenance of certification examinations. The outline defines the body of knowledge from which the Subboard samples to prepare its examinations. The content specification statements located under each category of the outline are used by item writers to develop questions for the examinations; they broadly address the specific elements of knowledge within each section of the outline.
EXAM BLUEPRINT
Pediatric Nephrology

Each Pediatric Nephrology exam is built to the same specifications, also known as the blueprint. This blueprint is used to ensure that, for the initial certification and in-training exams, each exam measures the same depth and breadth of content knowledge. Similarly, the blueprint ensures that the same is true for each Maintenance of Certification exam form. The table below shows the percentage of questions from each of the content domains that will appear on an exam. Please note that the percentages are approximate; actual content may vary.

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<th>Maintenance of Certification (MOC)</th>
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<td>1. Fetal/Neonatal</td>
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<td>2. Fluids/Electrolytes/Acid-base</td>
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<td>3. Diagnostics</td>
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<td>4. Glomerular Disorders</td>
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<td>5. Acute Kidney Injury</td>
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<td>6. Cystic/Inherited/Tubular Disorders</td>
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<td>7. Urology/Urinary Tract Infection/Stone Disease</td>
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<td>8. Blood Pressure/Hypertension</td>
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<td>9. Chronic Kidney Disease</td>
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<td>10. Dialysis</td>
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<td>11. Transplantation</td>
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<tr>
<td>12. Basic Sciences and Research Methodology</td>
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<tr>
<td>13. Core Knowledge in Scholarly Activities</td>
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Nephrology

I. Fetal/Neonatal
   A. Embryonic development of the kidney
      1. Understand the different stages in the development of the urinary tract
      2. Know the embryologic development of the bladder, ureter, glomerulus, tubules, and renal vasculature
      3. Know that compensatory renal growth begins in utero
      4. Know the importance of fetal urine production in pulmonary development
      5. Understand the principles of branching morphogenesis in kidney development
      6. Understand the compartmental development of the kidney
      7. Understand the impact of the fetal environment on renal development
      8. Know the effects of maternal drugs on fetal renal development
      9. Know the effects of intrauterine growth retardation on nephrogenesis
   B. Normal function/basic physiology of the developing/mature kidney
      1. Renal circulation
         a. Know the changes in percentage of cardiac output perfusing the fetal, newborn and adult kidney
         b. Know the difference in intrarenal vascular resistance between newborn infants and adults
         c. Know the characteristics of autoregulation of renal blood flow across the developmental spectrum
      2. Glomerular filtration
         a. Know when the filtration of fluid through the glomerular capillary begins in the human fetus
         b. Know the factors controlling glomerular filtration rate
         c. Know the factors contributing to the increase in glomerular filtration rate after birth
      3. Renal Tubular Transport
         a. Sodium handling
            1. Understand the changes in proximal and distal sodium reabsorption during development
            2. Know about the differences between premature and term infants in their ability to handle sodium
            3. Understand the role of the renin-angiotensin-aldosterone system in contributing to sodium reabsorption during development
            4. Know about the effect of vasopressin, parathyroid hormone, calcitonin, prostaglandins, kallikrein-kinin system, ANP and other hormones on sodium reabsorption during renal maturation
            5. Understand the role of renal nerves and circulating catecholamines in influencing sodium reabsorption during development
            6. Understand the role of renal arterial or venous pressure, ureteral pressure, renal arteriolar resistance, and oncotic pressure in the control of sodium handling by the developing kidney
         b. Potassium handling
            1. Understand the changes in the ability of the kidney to excrete potassium during development
2. Understand the role of the renin-angiotensin-aldosterone system in contributing to potassium transport during development
3. Know the factors limiting potassium excretion in newborn infants
   c. Calcium, phosphate, and magnesium handling
      1. Know about the differences among neonates, infants, and young children in their plasma concentrations of inorganic phosphate and calcium
      2. Know about the factors influencing phosphate reabsorption during development
      3. Know about the factors influencing plasma calcium concentration during fetal and postnatal life
      4. Know the pathogenesis, diagnosis, and management of nephrocalcinosis in the neonate
d. Renal transport of organic substances and energy metabolism
      1. Know about changes in tubular reabsorption of glucose during development
      2. Understand handling of amino acids during development
      3. Know about changes in para-aminohippurate clearance and other organic acids during development
      4. Understand renal handling of uric acid in infancy
      5. Know the relationship between renal energy metabolism and solute transport
4. Concentrating and diluting mechanisms
   a. Delineate the factors contributing to the differences in urinary concentrating abilities in newborn compared to adult kidneys
   b. Know about vasopressin regulation in the newborn infant
   c. Know the changes in urine flow in the fetus and its contribution to amniotic fluid with increasing gestational age
5. Renal acidification mechanisms
   a. Know the factors limiting acid excretion in the newborn infant
   b. Understand the factors controlling bicarbonate reabsorption in the newborn infant
   c. Recognize the maturational changes in normal values of serum bicarbonate
6. Renal hormones during development
   a. Know about the changes in the hormonal activity of the renin-angiotensin-aldosterone system during development
   b. Know about the effects of prostaglandins and thromboxane on the developing kidney
   c. Know about the biosynthesis and metabolism of vitamin D during renal maturation
   d. Know about the effects of catecholamines, atrial natriuretic factor and other vasoactive substances (ie, endothelin, nitric oxide) during development

C. Clinical situations during the fetal and neonatal period
1. Renovascular accidents (renal vein thrombosis, renal artery thrombosis)
   a. Know the various etiologies of renal vein thrombosis in the neonate
   b. Know the various etiologies of renal artery thrombosis in the neonate
   c. Recognize the signs and symptoms of renal vein thrombosis in the neonate
   d. Recognize the signs and symptoms of renal artery thrombosis in the neonate
2. Edema and ascites
   a. Recognize the signs and symptoms of the different causes of edema (physiologic, cardiac, renal and miscellaneous) in the newborn infant
   b. Know how to diagnose and manage newborn infants with edema
c. Know how to manage newborn infants with hydrops fetalis
d. Know the different causes of ascites in the newborn period
e. Understand the pathogenesis of ascites in the newborn infant
f. Know how to manage newborn infants with ascites

3. Neonatal hypertension
   a. Understand the pathogenesis of hypertension during the newborn period
   b. Identify risk factors for the development of hypertension in premature infants
   c. Know how to diagnose and manage hypertension in the neonate
   d. Know about the natural history and prognosis of hypertension in the neonate

4. Micturition and GU
   a. Know the normal time range for first voiding in neonates
   b. Know the causes for delayed voiding in neonates
   c. Know how to evaluate and manage abnormalities of the urinary tract that are diagnosed in utero
   d. Know the issues concerning prenatal intervention for fetal urinary tract obstruction
   e. Know the developmental changes in normal voiding patterns

5. Neonatal urinary tract infection
   a. Know how to diagnose and manage renal infection in the newborn

6. Abnormal urinalysis in the newborn
   a. Be able to diagnose and manage the different conditions associated with hematuria during the newborn period
   b. Be able to diagnose and manage different conditions associated with other urinalysis abnormalities in the newborn

7. Neonatal renal impairment
   a. Understand the effect of hypoxia on the newborn kidney
   b. Know the major causes of decreased renal function in the neonatal period
   c. Know how to evaluate renal function in the neonatal period
   d. Know the relationship between maternal and newborn serum creatinine
   e. Know the gestational age-appropriate renal function indices for preterm and term infants
   f. Understand the effects of neonatal respiratory distress syndrome on renal function

8. Drugs and neonatal renal function
   a. Know the effects of drugs given to the mother before delivery upon renal function of the newborn infant
   b. Know the effects of drugs on neonatal renal function

II. Fluids/Electrolytes/Acid-base
   A. Parenteral fluid therapy
      1. Maintenance fluids
         a. Understand the concept of maintenance fluid therapy and its potential risks and complications
         b. Know the components of maintenance parenteral fluid therapy
      2. Replacement fluids
         a. Know the appropriate components of fluids to replace gastrointestinal losses
         b. Know the appropriate components of fluids to replace third space losses
         c. Know the appropriate components of fluids to replace abnormal renal losses
d. Know the appropriate components of fluids to replace other (e.g., CSF, sweat) extraordinary losses

B. Dehydration
1. Isotonic dehydration
   a. Know how to define isotonic dehydration
   b. Plan the appropriate therapy for isotonic dehydration
   c. Recognize the clinical presentation and severity of isotonic dehydration
2. Hypertonic dehydration
   a. Know how to define hypertonic dehydration
   b. Understand the pathophysiology of hypertonic dehydration
   c. Plan the appropriate therapy for hypertonic dehydration
   d. Recognize the clinical manifestations of hypertonic dehydration
3. Hypotonic dehydration
   a. Know how to define hypotonic dehydration
   b. Understand the pathophysiology of hypotonic dehydration
   c. Plan the appropriate therapy for hypotonic dehydration
   d. Recognize the clinical manifestations of hypotonic dehydration

C. Oral rehydration therapy
1. Know the indications for oral rehydration therapy
2. Know the physiologic principles on which oral rehydration therapy is based
3. Plan the appropriate therapy for dehydration, including knowing the appropriate composition of oral rehydration solutions

D. Electrolyte disorders
1. Hyponatremia
   a. Know the causes of hyponatremia
   b. Know the mechanism and causes of artifactual hyponatremia
   c. Plan the evaluation and treatment of hyponatremia
   d. Know the clinical manifestations of hyponatremia
   e. Know the complications of therapy for hyponatremia
2. Hypernatremia
   a. Know the causes of hypernatremia
   b. Plan the evaluation and treatment of hypernatremia
   c. Know the clinical manifestations of hypernatremia
   d. Know the complications of therapy for hypernatremia, including the pathophysiology
3. Hypokalemia
   a. Know the causes of hypokalemia
   b. Plan the evaluation and treatment of hypokalemia
   c. Know the clinical manifestations of hypokalemia
4. Hyperkalemia
   a. Know the causes of hyperkalemia
   b. Recognize the causes of artifactual hyperkalemia
   c. Plan the evaluation and treatment of hyperkalemia
   d. Know the clinical manifestations of hyperkalemia
5. Hypocalcemia
   a. Know the causes of hypocalcemia
b. Know the clinical manifestations of hypocalcemia
c. Recognize the causes of artifactual hypocalcemia
d. Plan the evaluation and treatment of hypocalcemia

6. Hypercalcemia
   a. Know the causes of hypercalcemia
   b. Know the clinical manifestations of hypercalcemia
   c. Plan the evaluation and treatment of hypercalcemia

7. Hyperosmolar syndromes
   a. Know the causes of hyperosmolar syndromes
   b. Recognize the laboratory artifacts of hyperosmolar syndromes

8. Hypomagnesemia
   a. Know the causes of hypomagnesemia
   b. Know the clinical manifestations of hypomagnesemia
   c. Plan the evaluation and treatment of hypomagnesemia

9. Hypermagnesemia
   a. Know the causes of hypermagnesemia
   b. Plan the evaluation and treatment of hypermagnesemia

10. Hyperphosphatemia
    a. Know the causes of hyperphosphatemia
    b. Know the clinical manifestations of hyperphosphatemia
    c. Plan the evaluation and treatment of hyperphosphatemia

11. Hypophosphatemia
    a. Know the causes of hypophosphatemia
    b. Know the clinical manifestations of hypophosphatemia
    c. Plan the evaluation and treatment of hypophosphatemia

E. Acid base disorders
1. Metabolic acidosis
   a. Know the causes of a metabolic acidosis
   b. Know how to use the anion gap and other laboratory tests to determine the etiology of a metabolic acidosis
   c. Know factors that increase or decrease the anion gap
   d. Know the clinical manifestations of acute and chronic metabolic acidosis
   e. Plan the evaluation and treatment of metabolic acidosis
   f. Know the complications of treatment of metabolic acidosis
2. Metabolic alkalosis
   a. Recognize the pathogenetic mechanisms responsible for the generation and maintenance of metabolic alkalosis
   b. Know the causes of metabolic alkalosis, including genetic renal transport defects
   c. Know the appropriate laboratory studies to evaluate potential causes of metabolic alkalosis
   d. Understand the concept of chloride-sensitive and chloride-resistant metabolic alkalosis
   e. Know the clinical manifestations and presentation of metabolic alkalosis
   f. Plan the evaluation and treatment of metabolic alkalosis
   g. Know the complications of treatment of metabolic alkalosis
3. Respiratory acidosis
a. Know the arterial blood gas and serum electrolyte findings in respiratory acidosis  
b. Know the causes of respiratory acidosis  
c. Know the clinical manifestations of respiratory acidosis  
d. Plan the evaluation and treatment of chronic respiratory acidosis  
e. Know the complications of treatment of respiratory acidosis  

4. Respiratory alkalosis  
a. Know the arterial blood gas and serum electrolyte findings in respiratory alkalosis  
b. Know the causes of respiratory alkalosis  
c. Know the clinical manifestations of respiratory alkalosis  
d. Plan the evaluation and treatment of chronic respiratory alkalosis  
e. Know the complications of treatment of respiratory alkalosis  

5. Blood gas interpretation  
a. Be able to differentiate respiratory from metabolic acid-base disorders  
b. Understand the concept of mixed acid-base disorders  

F. Edema  
1. Know causes and evaluation of edema  
2. Understand the pathophysiology of edema formation in heart failure  
3. Understand the pathophysiology of edema formation in cirrhosis  
4. Understand the pathophysiology of edema formation in glomerulonephritis and nephrotic syndrome  
5. Plan the evaluation of edema  
6. Plan the treatment of edema in glomerulonephritis  
7. Know the complications of treatment of edema  
8. Plan the treatment of edema in nephrotic syndrome  

III. Diagnostics  
A. Assessment of urinalysis and urine collections  
1. Understand the normal, abnormal, and artifactual feature of urine striptests and microscopic urinalysis  
2. Know the differential diagnosis of microscopic and gross hematuria, including differentiation of eumorphic versus dysmorphic erythrocytes  
3. Know the differential diagnosis of proteinuria  
4. Recognize various types of urinary crystals and their diagnostic implications  
5. Distinguish orthostatic from the various forms of persistent proteinuria  
6. Recognize pyuria and know its differential diagnosis  
7. Know the different types of casts in urine and their diagnostic implications  
8. Identify glycosuria and other reducing substances in urine  
9. Know the differential diagnosis of reducing substances in urine  
10. Identify ketonuria and know its differential diagnosis  
11. Know the causes of pigmenturia and their diagnostic implications  
12. Recognize eosinophiluria and know its implications  
B. Assessment of renal function/structure  
1. Know the clearance methods and their limitations for measuring renal blood flow, glomerular filtration rate and filtration fraction using endogenous and exogenous markers  
2. Know the utility and limitations of estimated glomerular filtration rate (eGFR) determinations
3. Know how to use urine osmolality, pH, electrolytes, and other constituents to assess renal tubular function under various circumstances
4. Assess timed and spot urine collections for determination of significant proteinuria and hypercalciuria
5. Be familiar with the methods for imaging of the urinary tract and recognize normal variations of each method
6. Know the indications for and limitations and complications of intravenous pyelography
7. Know the indications for and limitations of ultrasonography and Doppler study
8. Understand the indications for and complications of voiding cystourethrography
9. Understand the indications for and limitations of different radionuclide scans of the genitourinary system
10. Understand the indications, limitations, and complications of magnetic resonance imaging/angiography of the genitourinary system
11. Understand the indications, limitations, and complications of computed tomography of the genitourinary system
12. Understand the indications, limitations, and complications of renal arterial and venous angiography

C. Renal biopsy
1. Recognize indications for, risk factors, complications, and potential benefits of percutaneous and surgical renal biopsy
2. Assess the adequacy of biopsy specimens
3. Counsel a family regarding risk factors for a renal biopsy

D. Interpretation of anatomic and histopathology changes
1. Light microscopy
   a. Understand the contribution of specific histochemical stains in the evaluation of renal biopsies
   b. Identify minimal change disease on light microscopy
   c. Identify membranous nephropathy on light microscopy
   d. Identify mesangial proliferation on light microscopy
   e. Identify membranoproliferative lesions Types I, II, III on light microscopy
   f. Identify diffuse proliferation on light microscopy
   g. Identify extracapillary proliferation/crescents on light microscopy
   h. Identify chronic/sclerosing changes on light microscopy
   i. Identify focal and segmental sclerosis on light microscopy
   j. Identify focal necrotizing lesion/vasculitis on light microscopy
   k. Identify acute cell-mediated transplant rejection on light microscopy
   l. Identify acute antibody-mediated transplant rejection on light microscopy
   m. Recognize chronic glomerular and tubulointerstitial transplant injury on light microscopy
   n. Identify features of transplant kidney viral disease on light microscopy
   o. Identify tubulointerstitial nephritis on light microscopy
   p. Identify diabetic nephropathy on light microscopy
   q. Identify acute tubular necrosis on light microscopy
   r. Identify a normal kidney on light microscopy
   s. Identify renal dysplasia on light microscopy
t. Identify malignant hypertensive changes on light microscopy
u. Identify microthrombus on light microscopy
v. Identify oligomeganephronia on light microscopy
w. Recognize the nephrotoxic changes consistent with calcineurin inhibitors on light microscopy
x. Identify various forms of micro- and macrocystic disease on light microscopy

2. Electron microscopy
   a. Understand the limitations of electron microscopy
   b. Recognize effacement of epithelial foot processes on electron microscopy
c. Recognize intramembranous deposits on electron microscopy
d. Recognize epimembranous deposits on electron microscopy
e. Recognize reticulotubular particles on electron microscopy
f. Recognize fibrin deposits on electron microscopy
g. Recognize reticular/lattice lamination of basement membrane on electron microscopy
h. Recognize thinning/thickening/splitting of basement membrane on electron microscopy
i. Recognize finger print deposits on electron microscopy
j. Recognize lamellar bodies on electron microscopy
k. Recognize continuous deposits on electron microscopy
l. Recognize mesangial deposits on electron microscopy
m. Recognize subepithelial, subendothelial, and mesangial deposits in the same specimen
n. Recognize subendothelial deposits
   o. Recognize the presence of collagen bundles in the glomerular basement membrane of a patient with nail-patella syndrome
   p. Recognize viral inclusions on electron microscopy

3. Immunofluorescent microscopy
   a. Understand the methods of immunofluorescent microscopy
   b. Recognize linear glomerular or tubular basement membrane immunoglobulin and complement deposition on immunofluorescent microscopy
c. Recognize specific patterns of granular immunoglobulin and complement deposition on immunofluorescent microscopy
d. Recognize the specific pattern of mesangial immunoglobulin and complement deposition on immunofluorescent microscopy
e. Recognize specific patterns of trapped immunoglobulin deposits on immunofluorescent microscopy
   f. Recognize the pattern of fibrin deposition on immunofluorescent microscopy
g. Recognize the patterns of immunofluorescence staining seen in renal transplant rejection

4. Gross anatomy
   a. Recognize the pattern of changes and diagnostic criteria for autosomal dominant polycystic kidney disease
   b. Recognize the pattern of changes and diagnostic criteria for autosomal recessive polycystic kidney disease
c. Recognize the pattern of changes and diagnostic criteria for cystic dysplastic kidney
d. Recognize the pattern of changes and diagnostic criteria for nephronophthisis and medullary cystic kidney disease
e. Recognize the pattern of changes and diagnostic criteria for medullary sponge kidney disease
f. Recognize the pattern of changes and diagnostic criteria for renal abscess
g. Recognize the pattern of changes and diagnostic criteria for renal vein thrombosis
h. Recognize the pattern of changes and diagnostic criteria for reflux nephropathy
i. Recognize the pattern of changes and diagnostic criteria for Ask-Upmark kidney
j. Recognize the pattern of changes and diagnostic criteria for renal hypoplasia

E. Serologic studies
1. Know the biologic activities of complement components and their breakdown products
2. Understand the specificity and limitations of testing for antinuclear antibody
3. Understand the diagnostic use of total hemolytic complement and individual complement components
4. Know the clinical manifestations which frequently occur with congenital deficiency of C2 or C4
5. Be able to effectively utilize serologic tests to determine infections associated with streptococcus, varicella, cytomegalovirus human immunodeficiency virus, Epstein-Barr virus, etc
6. Understand the indications for performing and the clinical significance of anti-neutrophil cytoplasmic antibody test
7. Understand the differential diagnosis of low C3 and/or low C4
8. Know the indications for performing and the clinical significance of the antiglomerular basement membrane antibody test
9. Be able to effectively utilize polymerase chain reaction tests to diagnose infections associated with viral and bacterial pathogens

IV. Glomerular Disorders
A. Glomerulonephritis
1. Acute poststreptococcal and other post-infectious glomerulonephritides
   a. Know the systemic and renal manifestations of post-infectious glomerulonephritis
   b. Know the laboratory evaluation for the diagnosis and management of post-infectious glomerulonephritis
   c. Know the histopathology of post-infectious glomerulonephritis
   d. Know the differential diagnosis for the clinical presentation and histologic lesion of post-infectious glomerulonephritis
   e. Know the pathophysiology of post-infectious glomerulonephritis
   f. Know the natural history and epidemiology of post-infectious glomerulonephritis
   g. Know the therapeutic options and complications of treatment of post-infectious glomerulonephritis
2. Nephritis with systemic disease
   a. Henoch-Schoenlein purpura
      1. Know the systemic and renal manifestations of Henoch-Schoenlein purpura
2. Know the laboratory evaluation for the diagnosis and management of Henoch-Schoenlein purpura
3. Know the histopathology of Henoch-Schoenlein purpura
4. Know the differential diagnosis for the clinical presentation and histologic lesion of Henoch-Schoenlein purpura
5. Know the pathophysiology of Henoch-Schoenlein purpura
6. Know the natural history and epidemiology of Henoch-Schoenlein purpura
7. Know the therapeutic options and complications of treatment for Henoch-Schoenlein purpura

b. Systemic lupus erythematosus
1. Know the systemic and renal manifestations of systemic lupus erythematosus
2. Know the laboratory evaluation for the diagnosis and management of systemic lupus erythematosus
3. Know the histopathology of systemic lupus erythematosus
4. Know the differential diagnosis for the clinical presentation and histologic lesion of systemic lupus erythematosus
5. Know the pathophysiology of systemic lupus erythematosus
6. Know the natural history and epidemiology of systemic lupus erythematosus
7. Know the therapeutic options and complications of treatment for systemic lupus erythematosus
8. Know the genetic transmission of systemic lupus erythematosus and provide family counseling

c. Anti-phospholipid syndromes
1. Know the systemic and renal manifestations of anti-phospholipid syndrome
2. Know the laboratory evaluation for the diagnosis and management of anti-phospholipid syndrome
3. Formulate a differential diagnosis in a patient in whom anti-phospholipid syndrome is suspected
4. Know the therapeutic options and complications of treatment for anti-phospholipid syndrome

d. Granulomatosis with polyangiitis (Wegener granulomatosis and Churg-Strauss syndrome) and microscopic polyangiitis
1. Know the systemic and renal manifestations of granulomatosis with polyangiitis and microscopic polyangiitis
2. Know the laboratory evaluation for the diagnosis and management of granulomatosis with polyangiitis and microscopic polyangiitis
3. Know the histopathology of granulomatosis with polyangiitis and microscopic polyangiitis
4. Know the differential diagnosis for the clinical presentation and histologic lesion of granulomatosis with polyangiitis and microscopic polyangiitis
5. Know the pathophysiology of granulomatosis with polyangiitis and microscopic polyangiitis
6. Know the natural history and epidemiology of granulomatosis with polyangiitis and microscopic polyangiitis
7. Know the therapeutic options and complications of treatment for granulomatosis with polyangiitis and microscopic polyangiitis
e. Diabetic nephropathy
   1. Know the renal manifestations of diabetes mellitus
   2. Know the histopathology of diabetic nephropathy
   3. Know the pathophysiology of diabetic nephropathy, including mechanisms of progression
   4. Know the natural history and epidemiology of diabetic nephropathy
   5. Know the therapeutic options and complications of treatment for diabetic nephropathy

f. Hemoglobin S disease
   1. Know the renal manifestations of hemoglobin S disease
   2. Know the differential diagnosis for the clinical presentation and histologic lesions of hemoglobin S disease
   3. Know the pathophysiology of the renal manifestations of hemoglobin S disease
   4. Know the natural history and epidemiology of the renal manifestations of hemoglobin S disease
   5. Know the therapeutic options and complications of treatment for the renal manifestations of hemoglobin S disease

g. Mixed connective tissue disease
   1. Know the systemic and renal manifestations of mixed connective tissue disease
   2. Know the diagnostic tests for mixed connective tissue disease
   3. Know the natural history and epidemiology of the renal manifestations of mixed connective tissue disease
   4. Know the therapeutic options and complications of treatment for the renal manifestations of mixed connective tissue disease

h. Goodpasture syndrome
   1. Know the systemic and renal manifestations of Goodpasture syndrome
   2. Know the laboratory evaluation for the diagnosis and management of Goodpasture syndrome
   3. Know the histopathology of Goodpasture syndrome
   4. Know the differential diagnosis for the clinical presentation and histologic lesion of Goodpasture syndrome
   5. Know the pathophysiology of Goodpasture syndrome
   6. Know the natural history and epidemiology of Goodpasture syndrome
   7. Know the therapeutic options and complications of treatment for Goodpasture syndrome

i. Human immunodeficiency virus-associated nephropathy
   1. Know the renal manifestations of HIV infection
   2. Know the laboratory evaluation for the diagnosis and management of HIV-associated renal disease
   3. Know the renal histopathology of HIV infection
   4. Know the differential diagnosis of the presentation of HIV-associated renal disease
   5. Know the pathophysiology of HIV-associated renal disease
   6. Know the therapeutic options for HIV-associated renal disease, including the risks involved in transplantation

3. Hereditary glomerular disease
a. Alport syndrome
   1. Know the systemic and renal manifestations of Alport syndrome
   2. Know the laboratory evaluation for the diagnosis and management of Alport syndrome
   3. Know the histopathology of Alport syndrome
   4. Know the differential diagnosis for the clinical presentation and histologic lesion of Alport syndrome
   5. Know the pathophysiology of Alport syndrome, including the molecular basis of the disease
   6. Know the natural history and epidemiology of Alport syndrome
   7. Know the therapeutic options and complications of treatment for Alport syndrome, including the risk of anti-GBM disease following renal transplantation
   8. Know the genetic transmission of Alport syndrome
   9. Provide genetic counseling for parents of a child with Alport syndrome

b. Benign familial hematuria/thin basement membrane disease
   1. Know the systemic and renal manifestations of thin basement membrane disease
   2. Know the laboratory evaluation for the diagnosis and management of thin basement membrane disease
   3. Know the histopathology of thin basement membrane disease
   4. Know the differential diagnosis for the clinical presentation and histologic lesion of thin basement membrane disease
   5. Know the pathophysiology of thin basement membrane disease
   6. Know the natural history and epidemiology of thin basement membrane disease
   7. Know the therapeutic options and complications of treatment for thin basement membrane disease
   8. Know the genetic transmission of thin basement membrane disease
   9. Provide genetic counseling for parents of a child with thin basement membrane disease
  10. Know the gene mutations associated with thin basement membrane disease

c. Nail-patella syndrome
   1. Know the systemic and renal manifestations of nail-patella syndrome
   2. Know the laboratory evaluation for the diagnosis and management of nail-patella syndrome
   3. Know the histopathology of nail-patella syndrome
   4. Know the natural history and epidemiology of nail-patella syndrome
   5. Know the genetic transmission of nail-patella syndrome
   6. Know the gene affected in patients with nail-patella syndrome

d. Fabry disease
   1. Know the systemic and renal manifestations of Fabry disease
   2. Know the laboratory evaluation for the diagnosis and management of Fabry disease
   3. Know the histopathology of Fabry disease
   4. Know the differential diagnosis for the clinical presentation and histologic lesion of Fabry disease
5. Know the pathophysiology of Fabry disease
6. Know the natural history and epidemiology of Fabry disease
7. Know the therapeutic options and complications of treatment for Fabry disease
8. Know the genetic transmission of Fabry disease
9. Know the gene affected in patients with Fabry disease

4. IgA nephropathy
   a. Know the systemic and renal manifestations of IgA nephropathy
   b. Know the laboratory evaluation for the diagnosis and management of IgA nephropathy
   c. Know the histopathology of IgA nephropathy
   d. Know the differential diagnosis for the clinical presentation and histologic lesion of IgA nephropathy
   e. Know the pathophysiology of IgA nephropathy
   f. Know the natural history and epidemiology of IgA nephropathy
   g. Know the therapeutic options and complications of treatment for IgA nephropathy

5. Rapidly progressive glomerulonephritis/diffuse proliferative glomerulonephritis
   a. Know the systemic and renal manifestations of rapidly progressive glomerulonephritis
   b. Know the laboratory evaluation for the diagnosis and management of rapidly progressive glomerulonephritis
   c. Know the histopathology of rapidly progressive and diffuse proliferative glomerulonephritis
   d. Know the differential diagnosis for the clinical presentation and histologic lesion of rapidly progressive glomerulonephritis
   e. Know the pathophysiology of rapidly progressive glomerulonephritis
   f. Know the natural history and epidemiology of rapidly progressive glomerulonephritis
   g. Know the therapeutic options and complications of treatment for rapidly progressive glomerulonephritis

6. Nephritis with low serum complement concentrations
   a. Know which renal disorders in children are associated with low serum complement concentrations
   b. Be able to distinguish specific histologic lesions associated with low serum complement concentrations
   c. Understand the association of nephritis with inherited abnormalities in the complement system

7. Mesangial proliferative lesions
   a. Know the systemic and renal manifestations of mesangial proliferative lesions
   b. Know the laboratory evaluation for the diagnosis and management of mesangial proliferative lesions
   c. Know the histopathology of mesangial proliferative lesions
   d. Know the differential diagnosis for the clinical presentation and histologic lesion of mesangial proliferative lesions
   e. Know the immunopathogenesis and pathophysiology of mesangial proliferative lesions
   f. Know the natural history and epidemiology of mesangial proliferative lesions
g. Know the therapeutic options and complications of treatment for mesangial proliferative lesions

B. Nephrotic syndrome
   1. Infantile nephrotic syndrome
      a. Know the systemic and renal manifestations of infantile nephrotic syndrome
      b. Know the laboratory evaluation for the diagnosis and management of infantile nephrotic syndrome
      c. Know the histopathology of various etiologies of infantile nephrotic syndrome
      d. Know the differential diagnosis for the clinical presentation and histologic lesion of infantile nephrotic syndrome
      e. Know the pathophysiology of infantile nephrotic syndrome
      f. Know the natural history and epidemiology of infantile nephrotic syndrome
      g. Know the therapeutic options and complications of treatment for infantile nephrotic syndrome
      h. Know the genetic transmission of the different forms of infantile nephrotic syndrome
      i. Provide genetic counseling for parents of a child with infantile nephrotic syndrome
      j. Know the means of prenatal diagnosis of infantile nephrotic syndrome
      k. Know the genetic basis of the different forms of infantile nephrotic syndrome
   2. Primary nephrotic syndrome
      a. Minimal change disease
         1. Know the systemic and renal manifestations of minimal change disease
         2. Know the laboratory evaluation for the diagnosis and management of minimal change disease
         3. Know the histopathology of minimal change disease
         4. Know the differential diagnosis for the clinical presentation and histologic lesion of minimal change disease
         5. Know the pathophysiology of minimal change disease
         6. Know the natural history and epidemiology of minimal change disease
         7. Know the therapeutic options and complications of treatment for minimal change disease
      b. Membranous nephropathy
         1. Know the systemic and renal manifestations of membranous nephropathy
         2. Know the laboratory evaluation for the diagnosis and management of membranous nephropathy
         3. Know the histopathology of membranous nephropathy
         4. Know the differential diagnosis for the clinical presentation and histologic lesion of membranous nephropathy
         5. Know the pathophysiology of membranous nephropathy
         6. Know the natural history and epidemiology of membranous nephropathy
         7. Know the therapeutic options and complications of treatment for membranous nephropathy
      c. Focal and segmental glomerulosclerosis
         1. Know the systemic and renal manifestations of focal glomerulosclerosis
         2. Know the laboratory evaluation for the diagnosis and management of focal glomerulosclerosis
3. Know the histopathology of focal glomerulosclerosis
4. Know the differential diagnosis for the clinical presentation and histologic lesion of focal glomerulosclerosis
5. Know the pathophysiology of focal glomerulosclerosis
6. Know the natural history and epidemiology of focal glomerulosclerosis
7. Know the therapeutic options and complications of treatment for focal glomerulosclerosis
8. Know the secondary causes of focal segmental glomerulosclerosis
9. Know the genetic basis of the hereditary forms of focal segmental glomerulosclerosis
d. Membranoproliferative glomerulonephritis
   1. Distinguish among the types of membranoproliferative glomerulonephritides
   2. Know the systemic and renal manifestations of membranoproliferative glomerulonephritis
   3. Know the laboratory evaluation for the diagnosis and management of membranoproliferative glomerulonephritis, including hepatitis C serology
   4. Know the histopathology of membranoproliferative glomerulonephritis type I, dense deposit disease, and C3 glomerulonephritis
   5. Know the differential diagnosis for the clinical presentation and histologic lesion of membranoproliferative glomerulonephritis
   6. Know the pathophysiology of membranoproliferative glomerulonephritis, including the role of the complement system
   7. Know the natural history and epidemiology of membranoproliferative glomerulonephritis
   8. Know the therapeutic options, management, and complications of treatment for membranoproliferative glomerulonephritis
3. Generalized manifestations of nephrotic syndrome
   a. Know the abnormalities of lipid metabolism in nephrotic syndrome and their implications
   b. Understand the mechanisms which predispose children with nephrotic syndrome to bacterial infections
   c. Know the factors which contribute to the thromboembolic tendency in nephrotic syndrome
   d. Know the pathogenesis and consequences of hypoalbuminemia in nephrotic syndrome
   e. Recognize and treat fluid and electrolyte abnormalities associated with nephrotic syndrome
   f. Know how to identify, prevent, and manage patients with infectious or thrombotic complications of nephrotic syndrome
   g. Know how to alter drug dosing in children with nephrotic syndrome
C. Thrombotic microangiopathies (hemolytic uremic syndrome and thrombotic thrombocytopenic purpura)
   1. Know the systemic and renal manifestations of the thrombotic microangiopathies
   2. Know the laboratory evaluation for the diagnosis and management of the thrombotic microangiopathies
   3. Know the histopathology of the thrombotic microangiopathies
4. Know the differential diagnosis for the clinical presentation and histologic lesion of the thrombotic microangiopathies
5. Know the pathophysiology of the different causes of the thrombotic microangiopathies
6. Know the natural history and epidemiology of the different causes of the thrombotic microangiopathies
7. Know the therapeutic options and complications of treatment for the different causes of the thrombotic microangiopathies
8. Provide genetic counseling for parents of a child with atypical hemolytic uremic syndrome
9. Know the role of complement abnormalities in atypical hemolytic uremic syndrome
10. Know the risk of post-transplant recurrence in the different forms of the thrombotic microangiopathies

V. Acute Kidney Injury
   A. Diagnosis and Evaluation
      1. Oliguric and non-oliguric acute kidney injury
         a. Know current diagnostic criteria of acute kidney injury
         b. Know the natural history of oliguric and non-oliguric acute kidney injury
         c. Know the most common etiologies of oliguric and non-oliguric acute kidney injury
         d. Understand the epidemiologic significance of acute kidney injury definitions (pRIFLE and AKIN)
         e. Be able to use and interpret urinary indices, including fractional excretion of sodium and fractional excretion of urea, to distinguish among various causes of oliguria
         f. Be able to evaluate urinary sediment in various causes of oliguria
         g. Know the unique components of sepsis-associated acute kidney injury
         h. Know the causes and unique features of acute kidney injury in the newborn
         i. (1222) Know how to evaluate and manage acute kidney injury in newborns
      2. Volume depletion/diminished renal perfusion
         a. Understand the pathophysiologic response to volume depletion/diminished renal perfusion
         b. Recognize the common causes of volume depletion and diminished renal perfusion
         c. Understand the progression from decreased renal perfusion to ischemic kidney injury
      3. Acute ischemic/toxic/vasomotor kidney injury
         a. Recognize the clinical presentation and factors predisposing to ischemic, toxic, or vasomotor kidney injury
         b. Understand the pathophysiology and natural history of acute ischemic, toxic, or vasomotor kidney injury
      4. Urinary tract obstruction
         a. Recognize urinary tract obstruction as a cause of oliguria
         b. Know how to establish a diagnosis of urinary tract obstruction
         c. Understand the pathophysiology of urinary tract obstruction
         d. Know the appropriate intervention for urinary tract obstruction
      5. Cortical or medullary/papillary necrosis
         a. Recognize the clinical presentation and predisposing factors of cortical/medullary/papillary necrosis
b. Know the potential etiologic agents of cortical/medullary/papillary necrosis

c. Recognize the possible association of cortical/medullary/papillary necrosis with systemic conditions, including sickle-cell trait and disease

6. Vascular occlusion
   a. Renal artery
      1. Recognize the clinical presentation, predisposing factors, and systemic manifestations of an occluded renal artery
      2. Plan the appropriate evaluation of an occluded renal artery
      3. Know the current therapy/intervention for an occluded renal artery
   b. Renal vein
      1. Recognize the clinical presentation, predisposing factors, and systemic manifestations of an occluded renal vein
      2. Plan the appropriate evaluation of an occluded renal vein
      3. Know the current therapy/intervention for an occluded renal vein

7. Primary kidney disorders
   a. Recognize that certain primary kidney disorders (such as hemolytic-uremic syndrome, glomerular disorders, and tubulointerstitial nephritis) may present with acute kidney injury

8. Tumor lysis syndrome
   a. Understand the pathophysiology of tumor lysis syndrome
   b. Understand the management of tumor lysis syndrome
   c. Know the laboratory abnormalities associated with tumor lysis syndrome

B. General management of acute kidney injury
   1. Early goal-directed therapy
      a. Understand the risk factors associated with developing acute kidney injury
      b. Understand the importance of early diagnosis using validated definitions of acute kidney injury
      c. Know the common biomarkers used for acute kidney injury prediction, diagnosis, and prognosis
      d. Know that acute kidney injury is a predictor of chronic kidney disease, hypertension and proteinuria
   2. Fluid therapy
      a. Calculate the appropriate fluid therapy for an oliguric or non-oliguric patient with acute kidney injury
      b. Evaluate the clinical course and adequacy of fluid therapy for an oliguric patient
      c. Understand that fluid is a drug and may affect morbidity and mortality in acute kidney injury
   3. Serum electrolyte disorders
      a. Know the most common electrolyte disorders in acute kidney injury
      b. Recognize life-threatening electrolyte imbalance in acute kidney injury
      c. Plan the appropriate therapy for electrolyte disorders in acute kidney injury
   4. Nutrition
      a. Understand the metabolic state and the role of nutrition in care of a patient with acute kidney injury
      b. Know how to plan and evaluate enteral/parenteral nutrition support for acute kidney injury
c. Recognize the complications of nutritional support and associated systemic manifestations in acute kidney injury

5. Drugs
   a. Know the appropriate interventions to reduce the risk of developing acute kidney injury
   b. Understand the role of diuretics/vasoactive drugs in the treatment of acute kidney injury
   c. Recognize drugs that can delay recovery from or can worsen acute kidney injury
   d. Know how to modify drug dosages in patients with acute kidney injury

6. Dialysis/hemofiltration
   a. Know the absolute indications for dialysis or continuous renal replacement therapy in acute kidney injury
   b. Recognize the relative indications for dialysis or continuous renal replacement therapy in acute kidney injury
   c. Select the appropriate mode of dialysis or continuous renal replacement therapy for acute renal therapy
   d. Know how to modify drug doses in patients receiving renal replacement therapy
   e. Recognize that excessive ultrafiltration can delay recovery from acute kidney injury

C. Hepatorenal syndrome
   1. Know the definition of hepatorenal syndrome
   2. Recognize the patient at risk for hepatorenal syndrome
   3. Distinguish among hepatorenal syndrome and other causes of oliguria
   4. Understand ways of preventing and treating hepatorenal syndrome
   5. Know the limitations of creatinine measurement in hepatorenal syndrome

D. Nephrotoxins and drug interactions
   1. Know common nephrotoxins, their mechanisms of nephrotoxicity, and their clinical manifestations
   2. Know the natural history of kidney injury caused by common nephrotoxins
   3. Recognize drugs that potentiate nephrotoxicity
   4. Know the management of different types of nephrotoxicity

VI. Cystic/Inherited/Structural/Tubular Disorders
A. Specific cystic disorders
   1. Autosomal recessive polycystic kidney disease
      a. Know the renal and nonrenal features of autosomal recessive polycystic kidney disease
      b. Know the molecular and genetic basis for autosomal recessive polycystic kidney disease
      c. Know the laboratory and uroradiologic evaluation of autosomal recessive polycystic kidney disease including prenatal diagnosis
      d. Know the differential diagnosis of autosomal recessive polycystic kidney disease
      e. Know the natural history of autosomal recessive polycystic kidney disease, including prognosis in the neonatal period
      f. Know the treatment of autosomal recessive polycystic kidney disease including management of complications in the neonatal period
      g. Know the histomorphologic changes of autosomal recessive polycystic kidney disease
h. Know the spectrum of liver disease in autosomal recessive polycystic kidney disease, including long term complications

2. Autosomal dominant polycystic kidney disease
   a. Know the renal and nonrenal features of autosomal dominant polycystic kidney disease, including their frequency in children
   b. Know the molecular and genetic basis for autosomal dominant polycystic kidney disease
   c. Know the laboratory and uroradiologic evaluation of autosomal dominant polycystic kidney disease including prenatal diagnosis
   d. Know the differential diagnosis of autosomal dominant polycystic kidney disease
   e. Know the natural history of autosomal dominant polycystic kidney disease, including variability of clinical course within families
   f. Know the treatment of autosomal dominant polycystic kidney disease
   g. Understand the implications of screening asymptomatic children at risk for autosomal dominant polycystic kidney disease
   h. Know the histomorphologic changes of autosomal dominant polycystic kidney disease

3. Glomerulocystic disease
   a. Know the renal and nonrenal features of glomerulocystic disease
   b. Know molecular and genetic basis for glomerulocystic disease
   c. Know the laboratory and uroradiologic evaluation of glomerulocystic disease including prenatal diagnosis
   d. Know the differential diagnosis of glomerulocystic disease
   e. Know the natural history of glomerulocystic disease
   f. Know the treatment of glomerulocystic disease
   g. Know the histomorphologic changes of glomerulocystic disease

4. Multicystic renal dysplasia
   a. Know the renal features of multicystic renal dysplasia
   b. Know the laboratory and uroradiologic evaluation of multicystic renal dysplasia including prenatal diagnosis
   c. Know the differential diagnosis of multicystic renal dysplasia
   d. Know the natural history of multicystic renal dysplasia
   e. Know the management of multicystic renal dysplasia
   f. Know the histomorphologic changes of multicystic renal dysplasia

5. Acquired cystic kidney disease
   a. Know the renal features of acquired cystic kidney disease
   b. Know the differential diagnosis of acquired cystic kidney disease
   c. Know the natural history of acquired cystic kidney disease
   d. Know the treatment of acquired cystic kidney disease
   e. Know how to counsel parents regarding acquired cystic kidney disease
   f. Know the histomorphologic changes of acquired cystic kidney disease
   g. Recognize the risk for neoplasms in acquired cystic kidney disease
   h. Know the laboratory and uroradiologic evaluation of acquired cystic kidney disease
   i. Know the potential occurrence of acquired cystic renal disease in transplant recipients

6. Nephronophthisis
a. Know the renal and nonrenal features of nephronophthisis including infantile and syndromic forms
b. Know the molecular and genetic basis of nephronophthisis
c. Know the laboratory and uroradiologic evaluation of nephronophthisis including prenatal diagnosis
d. Know the differential diagnosis of small echogenic and/or cystic kidneys
e. Know the natural history of nephronophthisis
f. Know the treatment of nephronophthisis
g. Know the histomorphologic changes of nephronophthisis
h. Recognize nephronophthisis-related disorders, including Meckel syndrome, Joubert syndrome, and Senior-Loken syndrome

7. Medullary cystic disease
a. Know the renal and nonrenal features of medullary cystic disease
b. Know the molecular and genetic basis of medullary cystic disease
c. Know the laboratory and uroradiologic evaluation of medullary cystic disease
d. Know the natural history of medullary cystic disease
e. Know the treatment of medullary cystic disease
f. Know the histomorphologic changes of medullary cystic disease
g. Recognize related disorders such as familial juvenile hyperuricemic nephropathy and glomerular cystic disease

8. Medullary sponge kidney
a. Know the clinical features of medullary sponge kidney including extrarenal associations
b. Know the pattern of inheritance of medullary sponge kidney
c. Know the laboratory and uroradiologic evaluation of medullary sponge kidney
d. Know the differential diagnosis of medullary sponge kidney
e. Know the natural history of medullary sponge kidney
f. Know the treatment of medullary sponge kidney and complications of treatment
g. Know the histomorphologic changes of medullary sponge kidney

B. Isolated Structural Disorders
1. Solitary cysts
   a. Recognize a solitary renal cyst
   b. Know the appropriate management of a solitary renal cyst
   c. Know the incidence and differential diagnosis of a solitary renal cyst

2. Renal hypoplasia and dysplasia
   a. Recognize the presentation and histopathology of renal hypoplasia and dysplasia
   b. Know the management and prognosis of renal hypoplasia and dysplasia

3. Compensatory hypertrophy and adaptation
   a. Recognize the clinical features and histopathology of renal hypoplasia/oligomeganephronia
   b. Know the management and prognosis of renal hypoplasia/oligomeganephronia
   c. Plan appropriate diagnostic evaluation of renal hypoplasia/oligomeganephronia
   d. Be able to counsel parents about prognosis in renal hypoplasia/oligomeganephronia
   e. Know the incidences, causes and implications of unilateral renal agenesis
   f. Know the diagnosis and management of ectopic and horseshoe kidneys
   g. Know the diagnosis and management of duplicated collecting systems
h. Understand the clinical concept of compensatory renal hypertrophy

C. Multiple malformation syndromes

1. Tuberous sclerosis
   a. Recognize the renal and non-renal clinical manifestations of tuberous sclerosis
   b. Know the histologic appearance of kidneys from a patient with tuberous sclerosis
   c. Know the molecular and genetic basis for cystic disease related to tuberous sclerosis
   d. Know the natural history of renal disease associated with tuberous sclerosis
   e. Know the diagnosis, management and treatment of angiomyolipomata

2. Williams syndrome
   a. Recognize the renal and non-renal clinical manifestations of Williams syndrome
   b. Know the molecular and genetic basis for Williams syndrome
   c. Know the long-term renal and urologic issues anticipated in Williams syndrome

3. Bardet-Biedel syndrome
   a. Recognize the renal and nonrenal manifestations of Bardet-Biedel syndrome
   b. Understand the molecular and genetic basis for Bardet-Biedel syndrome

4. Beckwith-Wiedemann syndrome
   a. Recognize the renal and nonrenal manifestations of Beckwith-Wiedemann syndrome
   b. Know the complications of Beckwith-Wiedemann syndrome including malignancy and the role of monitoring

D. Tubular disorders

1. Glucosuria
   a. Understand the pathogenesis and biochemical features of each of the types of glucosuria (eg, maturity-onset diabetes of the young (MODY))
   b. Know the differential diagnosis of glucosuria
   c. Know the clinical and laboratory evaluation of renal glucosuria
   d. Know the appropriate therapy for renal glucosuria
   e. Know the molecular and genetic basis of renal glucosuria

2. Phosphate-wasting syndromes
   a. General
      1. Know the differential diagnosis of hypophosphatemia, with normal or abnormal serum calcium
      2. Know how to calculate and apply the tubular reabsorption of phosphorus (TRP) and TMP/GFR
   b. X-linked, autosomal dominant, and autosomal recessive forms of hypophosphatemic rickets
      1. Understand the pathogenesis and biochemical features of X-linked, autosomal dominant, and autosomal recessive hypophosphatemic rickets
      2. Recognize clinical features and natural history of X-linked autosomal dominant, and autosomal recessive hypophosphatemic rickets
      3. Know the laboratory evaluation of X-linked, autosomal dominant, and autosomal recessive hypophosphatemic rickets
      4. Know the appropriate therapy for X-linked, autosomal dominant, and autosomal recessive hypophosphatemic rickets
5. Know the complications of therapy for X-linked, autosomal dominant, and autosomal recessive hypophosphatemic rickets
6. Know the molecular and genetic basis of X-linked, autosomal dominant, and autosomal recessive forms of hypophosphatemic rickets

c. Hereditary hypophosphatemic rickets with hypercalciuria
   1. Understand the pathogenesis and biochemical features of hereditary hypophosphatemic rickets with hypercalciuria
   2. Recognize the clinical features and natural history of hereditary hypophosphatemic rickets with hypercalciuria
   3. Know the clinical and laboratory evaluation of hereditary hypophosphatemic rickets with hypercalciuria
   4. Know the treatment and complications of hereditary hypophosphatemic rickets with hypercalciuria
   5. Know the molecular and genetic basis of hereditary hypophosphatemic rickets with hypercalciuria

d. Tumor-induced osteomalacia
   1. Recognize the biochemical and clinical features and the natural history of tumor-induced osteomalacia
   2. Know the appropriate therapy for tumor-induced osteomalacia

e. Primary hyperparathyroidism
   1. Understand the pathogenesis and biochemical features of primary hyperparathyroidism
   2. Recognize clinical features and natural history of primary hyperparathyroidism
   3. Know the clinical and laboratory evaluation of primary hyperparathyroidism
   4. Know the appropriate therapy for primary hyperparathyroidism
   5. Know complications of therapy for primary hyperparathyroidism
   6. Know that hyperparathyroidism can be associated with other endocrine disorders

3. Renal tubular acidosis
   a. Distal renal tubular acidosis
      1. Understand the pathogenesis and biochemical features of distal renal tubular acidosis
      2. Recognize the clinical features, associated abnormalities, and natural history of distal renal tubular acidosis (eg, sensorineural deafness)
      3. Know the clinical and laboratory evaluation of distal renal tubular acidosis
      4. Know the appropriate therapy for distal renal tubular acidosis
      5. Know the complications of therapy for distal renal tubular acidosis
      6. Know the causes of distal renal tubular acidosis
      7. Know the methods for evaluating urinary acidification in distal renal tubular acidosis
      8. Know the molecular and genetic basis of inherited forms of distal renal tubular acidosis
   b. Proximal renal tubular acidosis
      1. Understand the pathogenesis and biochemical features of proximal renal tubular acidosis
2. Recognize the clinical features and natural history of proximal renal tubular acidosis
3. Know the clinical and laboratory evaluation of proximal renal tubular acidosis
4. Know the appropriate therapy for X-linked, autosomal dominant and autosomal recessive hypophosphatemic rickets
5. Know the appropriate therapy for proximal renal tubular acidosis
6. Know the complications of therapy for proximal renal tubular acidosis
7. Know the causes of proximal renal tubular acidosis
8. Know the methods for evaluating urinary acidification in proximal renal tubular acidosis
c. Renal tubular acidosis with hyperkalemia
   1. Understand the pathogenesis and biochemical features of renal tubular acidosis with hyperkalemia
   2. Recognize the clinical features and natural history of renal tubular acidosis with hyperkalemia
   3. Know the clinical and laboratory evaluation of renal tubular acidosis with hyperkalemia
   4. Know the appropriate therapy for renal tubular acidosis with hyperkalemia
   5. Know the complications of therapy for renal tubular acidosis with hyperkalemia
   6. Know the causes of renal tubular acidosis with hyperkalemia
   7. Know the methods for evaluating urinary acidification in renal tubular acidosis with hyperkalemia
4. Fanconi syndrome
   a. Know the genetic and acquired causes of Fanconi syndrome
   b. Understand the pathogenesis and biochemical features of genetic and acquired forms of Fanconi syndrome
   c. Know the general treatment of Fanconi syndrome
   d. Know the molecular and genetic basis for Dent disease
   e. Know the treatment, complications and long-term outcome of Dent disease
   f. Know the molecular and genetic basis for cystinosis
   g. Know the serologic and clinical features of cystinosis
   h. Know the treatment, complications and long-term outcomes of cystinosis
   i. Know the molecular and genetic basis for Lowe syndrome
   j. Know clinical features of Lowe syndrome
   k. Know the treatment, complications and long-term outcomes of Lowe syndrome
5. Hereditary disorders of sodium and potassium handling (see Fluids, section II)
   a. Bartter syndrome
      1. Know the clinical and laboratory features of the various forms of Bartter syndrome
      2. Know the molecular and genetic basis of the various forms of Bartter syndrome
      3. Understand the pathophysiology of the various forms of Bartter syndrome
      4. Know the treatment and the complications of treatment for the various forms of Bartter syndrome
      5. Know the natural history of the various forms of Bartter syndrome
   b. Gitelman syndrome
      1. Know the clinical and laboratory features of Gitelman syndrome
2. Know the molecular and genetic basis of Gitelman syndrome
3. Understand the pathophysiology of Gitelman syndrome
4. Know the treatment and the complications of treatment for Gitelman syndrome
5. Know the natural history of Gitelman syndrome
c. Pseudohypoaldosteronism type 1
   1. Know the clinical and laboratory features of pseudohypoaldosteronism type 1
   2. Know the molecular and genetic basis of pseudohypoaldosteronism type 1
   3. Understand the pathophysiology of pseudohypoaldosteronism type 1
   4. Know the treatment and the complications of treatment for pseudohypoaldosteronism type 1
d. Pseudohypoaldosteronism type 2
   1. Know the clinical and laboratory features of pseudohypoaldosteronism type 2
   2. Know the molecular and genetic basis of pseudohypoaldosteronism type 2
   3. Understand the pathophysiology of pseudohypoaldosteronism type 2
   4. Know the treatment and the complications of treatment for pseudohypoaldosteronism type 2
   5. Know the natural history of pseudohypoaldosteronism type 2
e. Liddle syndrome
   1. Know the clinical and laboratory features of Liddle syndrome
   2. Know the molecular genetic basis of Liddle syndrome
   3. Understand the pathophysiology of Liddle syndrome
   4. Know the treatment and the complications of treatment for Liddle syndrome
   5. Know the natural history of Liddle syndrome
f. Apparent mineralocorticoid excess (AME)
   1. Know the clinical and laboratory features of apparent mineralocorticoid excess
   2. Know the molecular genetic basis of apparent mineralocorticoid excess
   3. Understand the pathophysiology of apparent mineralocorticoid excess
   4. Know the treatment and the complications of treatment for apparent mineralocorticoid excess
   5. Know the natural history of apparent mineralocorticoid excess
6. Diabetes insipidus (DI)
   a. Be able to distinguish nephrogenic and central diabetes insipidus, including interpretation of the water deprivation test results
   b. Know the differential diagnosis of secondary nephrogenic diabetes insipidus
   c. Understand the pathogenesis and biochemical features of congenital and acquired nephrogenic diabetes insipidus
   d. Recognize the clinical and natural history of congenital and acquired nephrogenic diabetes insipidus
   e. Know the clinical and laboratory evaluation of congenital and acquired nephrogenic diabetes insipidus
   f. Know the appropriate therapy for congenital and acquired nephrogenic diabetes insipidus
   g. Know the complications of therapy for congenital and acquired nephrogenic diabetes insipidus
   h. Know the molecular and genetic basis for congenital nephrogenic diabetes insipidus
7. Disorders of vitamin D metabolism
   a. Vitamin D deficiency
      1. Understand the pathogenesis and biochemical features of vitamin D-deficient rickets
      2. Recognize clinical features and natural history of vitamin D-deficient rickets
      3. Know clinical and laboratory evaluation of vitamin D-deficient rickets
   b. Vitamin D-dependent rickets, types I and II
      1. Understand the pathogenesis and biochemical features of vitamin D-dependent rickets, types I and II
      2. Recognize clinical features and natural history of vitamin D-dependent rickets, types I and II
      3. Know the clinical and laboratory evaluation of vitamin D-dependent rickets, types I and II
      4. Know the molecular basis of types of vitamin D-dependent rickets, types I and II
   c. Chronic kidney disease - Mineral bone disorder (CKD-MBD) (see section IX.C.2)

E. Tubulo-interstitial nephritis
   1. Know the clinical and laboratory features of chronic tubulo-interstitial nephritis
   2. Know the clinical and laboratory features of acute tubulo-interstitial nephritis
   3. Know the histopathology of acute and chronic tubulo-interstitial nephritis
   4. Know the differential diagnosis for acute and chronic tubulointerstitial nephritis
   5. Know the immunopathogenesis and pathophysiology of acute and chronic tubulo-interstitial nephritis
   6. Know the natural history and epidemiology of acute and chronic tubulo-interstitial nephritis
   7. Know the therapeutic options and complications of therapy for acute and chronic tubulo-interstitial nephritis
   8. Know the drugs/chemicals most commonly known to cause acute tubulointerstitial nephritis
   9. Know the drugs/chemicals most commonly known to cause chronic tubulointerstitial nephritis

VII. Urology/Urinary Tract Infection/Stone Disease
   A. Urinary tract infection
      1. Know the definition and clinical manifestation of urinary tract infection as it occurs in infancy, childhood, and adolescence
      2. Understand the pathogenesis of urinary tract infection
      3. Know the spectrum of organisms causing urinary tract infection
      4. Know the methods for appropriate diagnosis of urinary tract infection
      5. Know the epidemiology of urinary tract infection in infancy, childhood, and adolescence
      6. Know the modes of therapy of urinary tract infection
      7. Know the appropriate follow-up of urinary tract infection
      8. Know the indications for radiologic evaluation of a boy or girl after a first and subsequent urinary tract infections
      9. Know the causes of sterile pyuria
     10. Know the definition and natural history of asymptomatic bacteruria
B. Urinary tract trauma
   1. Kidney trauma
      a. Recognize the physical and laboratory findings related to renal trauma
      b. Recognize the imaging findings of renal trauma
      c. Know factors enhancing susceptibility to renal trauma
      d. Know the consequences of renal trauma
   2. Ureteral trauma
      a. Recognize the physical, radiologic, and laboratory findings of a ruptured ureter
   3. Bladder and urethral trauma
      a. Recognize the physical and laboratory findings related to bladder and urethral trauma
      b. Recognize the imaging findings of bladder and urethral trauma
      c. Know factors predisposing to bladder and urethral trauma
   4. Vascular trauma
      a. Recognize the physical and laboratory findings related to trauma to urinary tract vasculature
      b. Recognize the imaging findings of trauma to urinary tract vasculature
   5. Diagnostic studies/management/sequelae
      a. Evaluate a child with hematuria following trauma
      b. Plan the management for a child with urinary tract trauma

C. Nephrolithiasis
   1. Causes
      a. Cystinuria
         1. Understand the pathogenesis and biochemical features of cystinuria
         2. Recognize clinical and natural history of cystinuria and excretion of di-basic amino acids
         3. Know the clinical and laboratory evaluation of cystinuria and di-basic amino acids
         4. Know the appropriate therapy for cystinuria
         5. Know the complications of therapy for cystinuria
         6. Know the genetic transmission of cystinuria
         7. Know the molecular genetic basis for the different forms of cystinuria
      b. Hypercalciuria
         1. Idiopathic hypercalciuria
            a. Recognize the clinical and natural history of idiopathic hypercalciuria
            b. Know the clinical and laboratory evaluation of idiopathic hypercalciuria
            c. Know the appropriate therapy for idiopathic hypercalciuria
            d. Know the complications of therapy for idiopathic hypercalciuria
            e. Know the causes of hypercalciuria with a normal serum calcium and with a high serum calcium
            f. Recognize hypercalciuria as a risk factor for calcium-containing stones and nephrocalcinosis
         2. Calcium oxalate and calcium phosphate nephrolithiasis
            a. Understand the pathogenesis and biochemical features of calcium oxalate, calcium phosphate and mixed calcium oxalate/phosphate nephrolithiasis
b. Recognize the clinical and natural history of calcium oxalate and calcium phosphate nephrolithiasis

c. Know the clinical and laboratory evaluation of calcium oxalate and calcium phosphate nephrolithiasis

d. Know the appropriate therapy for calcium oxalate and calcium phosphate nephrolithiasis

e. Know the complications of therapy for calcium oxalate and calcium phosphate nephrolithiasis

f. Know the familial and ethnic associations of calcium nephrolithiasis

g. Know the epidemiology of calcium nephrolithiasis

h. Know the importance of furosemide as a risk factor for neonatal calcium-containing stones and nephrocalcinosis

3. Hypocitraturia

   a. Understand the pathogenesis and biochemical features of hypocitraturia
   b. Know the clinical and natural history of hypocitraturia
   c. Know the appropriate therapy for hypocitraturia
   d. Know the complications of therapy for hypocitraturia
   e. Know the genetic transmission of hypocitraturia
   f. Recognize hypocitraturia as a risk factor for nephrolithiasis

c. Uric acid nephrolithiasis

   1. Understand the pathogenesis and biochemical features of uric acid nephrolithiasis
   2. Recognize the clinical and natural history of uric acid nephrolithiasis
   3. Know the clinical and laboratory evaluation of uric acid nephrolithiasis
   4. Know the appropriate therapy for uric acid nephrolithiasis
   5. Know the complications of therapy for uric acid nephrolithiasis
   6. Know the genetic transmission of uric acid nephrolithiasis

d. Struvite stones

   1. Understand the pathogenesis and biochemical features of struvite stones
   2. Recognize the clinical and natural history of struvite stones
   3. Know the clinical and laboratory evaluation of struvite stones
   4. Know the appropriate therapy for struvite stones
   5. Know the complications of therapy for struvite stones

e. Miscellaneous causes

   1. Know the clinical findings that suggest factitious renal stones
   2. Know the indications for different types of surgical stone removal

f. Extracorporeal shock wave lithotripsy

   1. Understand the principles of extracorporeal shock wave lithotripsy
   2. Know the indications of extracorporeal shock wave lithotripsy in different types of nephrolithiasis
   3. Know the complications of extracorporeal shock wave lithotripsy

2. Pathogenesis of stone formation

   a. Understand the chemical factors that promote urinary crystallization
   b. Understand the processes that prevent urinary crystallization
   c. Know that hypervitaminosis D is a cause of nephrolithiasis
   d. Know that concentrated urine is a risk factor for stone formation
3. Primary oxalosis
   a. Understand the pathogenesis and biochemical features of oxalosis
   b. Recognize the clinical features and natural history of oxalosis
   c. Know the clinical and laboratory evaluation of oxalosis
   d. Know the appropriate therapy for oxalosis
   e. Know the complications of therapy for oxalosis
   f. Know the genetic defect and transmission of oxalosis

D. Micturition and Enuresis
   1. Understand the normal physiologic phases of micturition
   2. Understand the maturation of bladder function
   3. Know the definition, incidence, and natural history of enuresis in children
   4. Understand the pathogenesis of different patterns of enuresis
   5. Know when and how to evaluate a child with enuresis
   6. Understand the therapeutic modalities for the treatment of enuresis

E. Anomalies of the urinary tract
   1. Know how to diagnose, evaluate and treat anomalies of the upper urinary tract
   2. Know how to diagnose, evaluate and treat anomalies of ureters and lower urinary tract
   3. Recognize clinical characteristics of prune-belly syndrome
   4. Be able to evaluate and treat prune-belly triad syndrome
   5. Know how to diagnose, evaluate and treat megacalyces

F. Vesicoureteral reflux
   1. Know the epidemiology and natural history of vesicoureteral reflux
   2. Know the indications for imaging studies for vesicoureteral reflux
   3. Know the clinical management and long-term follow-up of different grades of vesicoureteral reflux

G. Neurogenic bladder
   1. Understand the pathophysiology of the different types of neurogenic bladder, including non-neurogenic neurogenic bladder
   2. Know the etiologies of the different types of neurogenic bladder
   3. Know the treatment options and management plans for the different forms of neurogenic neurogenic and non-neurogenic bladder
   4. Know the complications and natural history of the different forms of neurogenic and non-neurogenic bladder

H. Intrinsic disorders of the bladder
   1. Know the potential for bladder injury from drugs and how to prevent bladder toxicity
   2. Understand chronic interstitial cystitis
   3. Recognize self-induced or factitious bladder injury
   4. Know how to diagnose and treat bladder diverticulum
   5. Know the complications of bladder diverticulum
   6. Know how to diagnose and treat ureteroceles
   7. Know the complications of ureteroceles and upper urinary tract abnormalities associated with ureteroceles

I. Renal tumors
   1. Nephroblastoma (Wilms tumor)
      a. Know the clinical features of nephroblastoma (Wilms tumor)
      b. Know how to evaluate and diagnose nephroblastoma (Wilms tumor)
c. Know the genetic implications and phenotypic abnormalities associated with nephroblastoma (Wilms tumor)
d. Know the cellular/molecular defect causing nephroblastoma (Wilms tumor)

2. Other genitourinary tumors
   a. Mesoblastic nephroma
      1. Know the clinical features and natural history of mesoblastic nephroma
      2. Know how to evaluate and diagnose mesoblastic nephroma
   b. Angiomyolipoma
      1. Know the clinical features and natural history of angiomyolipoma
      2. Know how to evaluate and diagnose angiomyolipoma
      3. Know the genetic implications and phenotypic abnormalities associated with angiomyolipoma

J. Urinary tract obstructive lesions
   1. Know how to diagnose and evaluate urethral valves and other anomalies of the urethra
   2. Know the prognosis and long term outcome of urethral valves
   3. Understand the pathophysiological consequences of urethral obstruction from urethral valves
   4. Know how to diagnose and evaluate obstructive lesions at the ureterovesicular junction and the ureteropelvic junction
   5. Understand the pathophysiological causes and consequences of obstruction at the ureterovesicular junction
   6. Understand the pathophysiological causes and consequences of obstruction at the ureteropelvic junction
   7. Understand the management options and follow-up for patients with urethral valves, ureterovesicular junction obstruction, and ureteropelvic junction obstruction
   8. Know the renal prognosis for patients with urethral valves, ureterovesicular junction obstruction, and ureteropelvic junction obstruction

VIII. Blood Pressure/Hypertension
   A. Normal vs abnormal blood pressure
      1. Know the possible role of prematurity and low birth weight in blood pressure throughout childhood
      2. Recognize and distinguish the factors involved in variability in blood pressure
      3. Understand and recognize the pitfalls in blood pressure measurement, eg, auscultatory, oscillometric, palpation, home blood pressure measurement
      4. Understand the concept and limitations of blood pressure tracking from childhood to adulthood
      5. Know the indications for ambulatory blood pressure monitoring
      6. Understand the definitions of hypertension in children as enumerated in the published guidelines (prehypertension, stage 1 and stage 2 hypertension)
      7. Know the meaning and implications of "white coat" hypertension
      8. Know the role of multiple blood pressure measurements in the diagnosis of hypertension
   B. Determinants of blood pressure
      1. Understand the hemodynamic factors (blood flow, cardiac output, etc.) and their role in the control of blood pressure
2. Recognize the contributions of humoral and hormonal factors to blood pressure regulation
3. Understand the contribution of diet, BMI, and exercise to blood pressure control

C. Evaluation of elevated blood pressure in childhood
   1. Know how to evaluate elevated blood pressure in childhood in a staged manner
   2. Know how to use laboratory tests and imaging techniques in the evaluation of hypertension
   3. Know the differential diagnosis of sustained hypertension
   4. Understand the relationship of age of onset of hypertension to etiology of hypertension

D. Acute hypertension
   1. Recognize acute hypertension and know the differential diagnosis of associated causes by age group
   2. Understand the pathophysiology of acute hypertension
   3. Recognize the iatrogenic causes of acute high blood pressure
   4. Know how to evaluate acute hypertension
   5. Know the clinical manifestations of acute hypertension by age group

E. Sustained hypertension
   1. Primary hypertension
      a. Understand the epidemiology of primary hypertension in childhood
      b. Understand the pathogenesis and pathophysiology of primary hypertension
      c. Know the clinical features of primary hypertension
      d. Know the role of obesity in primary hypertension
      e. Understand the contribution of heredity to primary hypertension
      f. Recognize low birth weight as a risk factor for primary hypertension
   2. Secondary Hypertension
      a. Know the pathophysiology of hypertension associated with chronic kidney disease
      b. Know the causes and pathophysiology of renovascular hypertension
      c. Know the pathophysiology of hypertension associated with coarctation of the aorta
      d. Know the monogenic disorders that cause hypertension
      e. Know the presentation and causes of neonatal hypertension
      f. Know the pathophysiology of hypertension associated with endocrinopathy
      g. Know the pathophysiology of hypertension associated with centrally mediated hypertension
      h. Recognize and evaluate hypertension in chronic dialysis patients
      i. Know the differential diagnosis and pathophysiology of hypertension associated with kidney and other forms of transplantation
      j. Recognize the iatrogenic causes of sustained hypertension
      k. Know complications of sustained hypertension

F. Therapy of hypertension
   1. Know how to use drugs to treat both essential and secondary hypertension
   2. Know how to treat hypertension secondary to monogenic disorders
   3. Know how to treat hypertension secondary to a pheochromocytoma and the strategies to optimize operative management
   4. Know how to use drugs to treat a hypertensive crisis
   5. Know the mechanisms of action, complications, specific indications and side effects of drugs used in treating hypertension in children
6. Know the role of nonpharmacologic therapy in the treatment of hypertension
7. Understand the role of interventional radiology and surgical therapy in the treatment of hypertension
8. Know the goal of therapy for acute hypertension
9. Know how the presence of chronic kidney disease affects the treatment of sustained hypertension
10. Know the issues related to treating hypertension in a patient with a solitary kidney

G. End Organ Effects of Hypertension
   1. Know the patterns and mechanisms of vascular reactivity to acute changes in blood pressure
   2. Know how changes in blood pressure affect organ perfusion including the concept of autoregulation of the kidneys, central nervous system, and splanchnic bed, and GFR and tubular handling of fluids and electrolytes
   3. Know the end-organ effects of hypertension on the cardiac, vascular, renal, and neurologic systems

IX. Chronic Kidney Disease
   A. Epidemiology and etiology
      1. Know the acquired and congenital causes of chronic kidney disease in children
      2. Know the demographics of end stage renal disease in children
      3. Know the incidence of end stage renal disease in children
   B. Pathogenesis
      1. Know the pathogenesis of uremic symptoms
      2. Be aware of clinical conditions that influence progression of chronic kidney disease
      3. Know the therapeutic interventions that slow the progression of chronic kidney disease
   C. Metabolic derangements
      1. Fluid and electrolyte (see Electrolyte disorders II.D.)
      2. Mineral metabolism
         a. Understand the interaction among, and regulation of, serum calcium and phosphorus, vitamin D, phosphatonin, parathyroid hormone and FGF-23 in normal physiology and in chronic kidney disease
         b. Recognize the clinical manifestations of abnormal mineral metabolism in chronic kidney disease including skeletal and cardiovascular pathology
         c. Understand the role of aluminum toxicity in the genesis of renal osteodystrophy
         d. Know the appropriate laboratory and radiologic evaluation of disorders of mineral metabolism in children with chronic kidney disease
         e. Know the appropriate therapy for derangements of mineral metabolism in chronic kidney disease
         f. Recognize the complications of therapy for abnormal mineral metabolism in chronic kidney disease
      3. Lipid metabolism
         a. Recognize the lipid abnormalities in chronic kidney disease in children
         b. Know the treatment of lipid abnormalities in chronic kidney disease in children
      4. Carbohydrate metabolism
         a. Understand the mechanisms and clinical abnormalities of carbohydrate metabolism in chronic kidney disease
      5. Growth and endocrine disturbances
a. Recognize the effect of chronic kidney disease on linear growth of children
b. Understand the endocrine abnormalities of children with chronic kidney disease
c. Know the pathologic factors in chronic kidney disease that negatively impact linear growth
d. Understand how to evaluate and manage growth patterns and changes in growth in children with chronic kidney disease
e. Know how to evaluate sexual maturation in children with chronic kidney disease
f. Know the importance of sodium supplementation in infants with renal dysplasia or obstructive nephropathy

6. Protein metabolism
   a. Know the alterations in protein metabolism and the clinically appropriate dietary manipulations in response to chronic kidney disease

7. Drug metabolism
   a. Recognize those drugs whose metabolism is altered in chronic kidney disease
   b. Know the principles of dosage adjustment of drugs in children with chronic kidney disease
   c. Recognize the drugs that are contraindicated in chronic kidney disease

D. Systemic derangements
1. Cardiovascular
   a. Know the signs, symptoms, diagnosis, and treatment of uremic pericarditis
   b. Know the abnormalities of myocardial function accompanying chronic kidney disease
   c. Know the relationship of chronic kidney disease in childhood to development of vascular disease and atherosclerosis

2. Gastrointestinal
   a. Know the abnormalities of the gastrointestinal system that accompany chronic kidney disease in children

3. Immunologic
   a. Know the immunologic abnormalities associated with chronic kidney disease
   b. Know the effect of chronic kidney disease on the response to vaccinations
   c. Know how to interpret hepatitis B serology

4. Neurologic
   a. Know the neurologic abnormalities associated with chronic kidney disease
   b. Know the etiology and treatment of seizures in children with chronic kidney disease
   c. Know the effects of uremia on cognitive development and function in children

5. Hematologic system
   a. Know the causes and principles of management of anemia in chronic kidney disease
   b.Know the prophylactic and therapeutic management options to reverse coagulation defects in chronic kidney disease
   c. Understand the pathophysiology of anemia that accompanies chronic kidney disease
   d. Know the therapeutic options and complications of drugs used for treatment of anemia that accompanies chronic kidney disease

X. Dialysis
A. Hemodialysis
1. Know the principles, advantages, and disadvantages of the different types of vascular access for hemodialysis in infants, children and adolescents
2. Know the differential diagnosis and management of inadequate or excessive blood or dialysate flow during hemodialysis
3. Understand the principles underlying the assessment of adequacy of a hemodialysis treatment, including the principles of kinetic modeling
4. Understand the principles of ultrafiltration during hemodialysis, including calculation of fluid removal using the ultrafiltration coefficient
5. Understand the pathophysiologic principles, strategies to prevent, and treatment of the dialysis disequilibrium syndrome
6. Understand the pathophysiologic principles behind hemodialysis-induced leukopenia
7. Recognize, understand, and treat hemodialysis induced hypoxemia
8. Know how to recognize, treat, and prevent hemodialysis-induced hypotension
9. Know how to prevent, diagnose and treat infections associated with vascular access for hemodialysis
10. Understand the use of heparin and other anticoagulation agents used during intermittent hemodialysis; understand the principles of heparin-free dialysis
11. Know how to prevent, diagnose, and treat anaphylactoid reactions during hemodialysis
12. Know how to recognize the complications of vascular access
13. Know the indications for the use of central venous catheters for acute hemodialysis
14. Know factors involved in the development of aneurysm or stenosis of an arteriovenous fistula
15. Understand the advantages and disadvantages of the different types of dialyzers
16. Know the potential mechanical and machine-related complications that can occur during a hemodialysis treatment
17. Know the role of hemodialysis in renal failure in newborns
18. Know the indications and principles of hemodialysis treatment of metabolic disorders in the newborn period
19. Be able to write the prescription for a hemodialysis treatment using the principles of kinetic modeling
20. Know the management of hypercalcemia in patients treated with maintenance dialysis

B. Continuous Renal Replacement Therapy
1. Know the advantages and disadvantages of continuous renal replacement therapies, including CAVH, CVVH, CAVH and CVVH with CAVH-D and CVVH-D, and SCUF
2. Understand the physical and working principles underlying continuous renal replacement therapies, including CAVH, CVVH, CAVH and CVVH with CAVH-D and CVVH-D, and SCUF
3. Be able to identify and treat the complications of continuous renal replacement therapies, including CAVH, CVVH, CAVH and CVVH with CAVH-D and CVVH-D, and SCUF
4. Know the renal complications of ECMO in the neonate
5. Understand the use of and complications of heparin, citrate, and other anticoagulation agents with CAVH-CVVH treatment
6. Know how to prevent and treat bradykinin release syndrome
C. Peritoneal dialysis
1. Know the composition of the dialysate solutions for peritoneal dialysis and how to alter standard solutions in different clinical situations
2. Know the indications, limitations, and contraindications of various modalities of peritoneal dialysis: continuous ambulatory peritoneal dialysis (CAPD), continuous cycling peritoneal dialysis (CCPD), and intermittent peritoneal dialysis (IPD)
3. Know how to adjust the variables of peritoneal dialysis treatment in intermittent peritoneal dialysis, continuous ambulatory peritoneal dialysis (CAPD), and continuous cycling peritoneal dialysis (CCPD) to achieve corrections of pathologic states in children
4. Know the principles and diagnostic tests that establish treatment adequacy in the various modes of chronic peritoneal dialysis in children
5. Know how to prevent, diagnose and treat infectious complications of peritoneal dialysis including exit site infection and peritonitis
6. Know the benefits, limitations and complications of peritoneal dialysis in infants and small children including diagnosis and management of ultrafiltration failure
7. Recognize the non-infectious and mechanical complications of peritoneal dialysis in children
8. Understand the circumstances under which peritoneal dialysis should be temporarily or permanently discontinued
9. Understand the diagnosis and management of a transdiaphragmatic leak in patients undergoing CAPD/CCPD
10. Understand the implications of changes in BUN and serum creatinine levels in patients undergoing peritoneal dialysis
11. Understand the management of metabolic alkalosis during peritoneal dialysis treatment
12. Know the nutritional management of infants treated with peritoneal dialysis, including the value of nasogastric or gastric tube feedings and potential complications
13. Understand the applications of the peritoneal equilibration test

D. Extracorporeal treatment of poisoning and intoxication
1. Know the indications for acute hemodialysis and/or CRRT in patients with poisonings or intoxications
2. Plan an appropriate dialysis regimen to treat poisoning or intoxication

E. Drug therapy and clearances
1. Know the methods for adjusting drug dosages to achieve appropriate drug levels in the child receiving renal replacement therapy
2. Know the impact of intraperitoneally administered antibiotics upon blood concentrations in the child receiving renal replacement therapy
3. Understand the importance of drug binding and partition characteristics upon their removal by dialysis

F. Psychosocial adaptation
1. Understand the psychological and behavioral adjustments of the child to chronic dialysis therapy
2. Understand the alterations in normal cognitive development of the child receiving chronic dialysis
3. Understand the changes in family dynamics that may occur when a child is begun or maintained on dialysis
4. Understand the psychosocial factors predisposing to nonadherence

G. Rehabilitation
1. Understand the problems imposed by the different forms of dialysis upon school attendance, performance and peer group activities
2. Understand the prevention and management of school- and work-related problems
3. Understand the psychosocial predisposing factors to poor school or work rehabilitation in the child or adolescent on dialysis

H. Ethical problems
1. Recognize the ethical issues mitigating for and against dialyzing children with severely impaired mental or physical status
2. Understand the management of the child and family when a decision is made not to begin or to desist from dialyzing a child with end-stage kidney disease
3. Understand the role of the nephrologist within the context of team decisions regarding indications for withholding acute or chronic dialysis or CRRT

I. Systemic complications of dialysis
1. Recognize the etiologic principles and management of the anemia in dialysis patients
2. Recognize the causes and treatment of the coagulation disorders seen in the child receiving dialysis
3. Recognize and know how to treat electrolyte abnormalities resulting from dialysis
4. Recognize and know how to treat iron overload and iron deficiency in children receiving dialysis
5. Understand the potential abnormal changes in cardiac function in response to hemodialysis and peritoneal dialysis
6. Recognize the clinical, laboratory, radiographic, electrocardiographic and echocardiographic changes indicative of pericarditis in the dialyzed child and know how to treat uremic pericarditis
7. Recognize the causes and know how to treat hypertension in a child receiving dialysis
8. Understand the principles of dietary management to meet the demands imposed by the different forms of dialysis
9. Understand the pathogenesis, diagnosis and treatment of seizure disorders associated with dialysis
10. Recognize the clinical presentation and possible pathophysiologic mechanisms of dialysis dementia
11. Recognize the clinical presentation and know the impact of dialysis upon peripheral nerve conduction time
12. Understand the impact of dialysis upon autonomic functions and the autonomic nervous system
13. Understand the significance, potential etiologies and appropriate diagnostic work-up of abnormalities of liver function tests in a child on dialysis

XI. Transplantation
A. Recipient selection and preparation
1. Know the absolute and relative conditions in a child that are contraindications to renal transplantation
2. Understand the potential benefits and risks of pre-transplant immunologic conditioning programs
3. Recognize the clinical situations in which multiple organ transplantation is indicated (ie, liver-kidney, kidney-pancreas, heart-kidney)
4. Know relative indications for nephrectomy of native kidneys
5. Know the work-up of a patient in preparation for renal transplantation
6. Know how to evaluate and manage urologic abnormalities prior to renal transplantation
7. Understand the unique management of children with primary oxalosis
8. Understand the unique management of children with atypical hemolytic uremic syndrome
9. Know the recipient factors which are associated with poor outcome post transplant

B. Donor selection
1. Know the age and donor health considerations when selecting a deceased organ donor for a child
2. Know the medical/surgical conditions that mitigate against using the organs of a potential donor
3. Know the advantages/disadvantages of living related versus deceased donors
4. Understand the concept of expanded donor criteria
5. Know the issues involved in management of the deceased donor prior to organ retrieval harvest
6. Know the indications and benefits of enrolling in donor exchange and chain protocols

C. Ethical considerations
1. Understand the concepts and criteria of brain death in children and adults, specifically in reference to transplantation
2. Recognize the ethical dilemmas involved in deceased donor kidney donation
3. Recognize the ethical issues involved in the use of living organ donors
4. Recognize the ethical dilemmas involved in altruistic kidney donation
5. Know the ethical issues which have been raised as a consequence of the shortage of donor organs
6. Identify the long-term medical and financial risks to the living donor
7. Understand the post-transplant dilemmas of choosing patient survival at the expense of graft survival

D. Access to transplantation
1. Understand the concept of the deceased donor renal transplant waiting list
2. Know the factors which affect the allocation of organs
3. Know the social and economic factors which affect access to transplantation
4. Know the factors that are considered in the prioritization of recipients on the deceased donor renal transplant list
5. Know the pros and cons of organ shipment and sharing

E. Financial Issues
1. Know the financial impact of transplantation
2. Understand the administrative aspects and the system for reimbursement of physicians and institutions for renal transplantation
3. Know the relative financial benefits of transplant vs dialysis
4. Know the Medicare coverage of immunosuppressive medications post transplant

F. Histocompatibility
1. Know the major and minor erythrocyte blood group compatibility requirements and exceptions for successful transplantation
2. Know the structure, function, and genetics of class 1 and 2 major histocompatibility complex antigens
3. Know the advantages, disadvantages, and theoretical considerations of HLA matching in renal transplantation
4. Understand the causes and measurement of transplant recipient presensitization
5. Interpret and know significance of pretransplant crossmatch tests
6. Understand the therapeutic approaches to transplant in the highly sensitized patient
7. Understand the contribution of the HLA laboratory to the pre- and post-transplant care

G. Surgical technique
1. Donor
   a. Understand the risks and benefits of laparoscopic organ retrieval
   b. Understand the risks of donor anatomic variations
2. Recipient
   a. Know the anatomy and surgical considerations for a renal transplant in an infant or child
   b. Understand the intraoperative fluid and inotropic drug support for the pediatric recipient of a renal transplant
   c. Understand the concepts of cold and warm ischemia and how they influence graft survival rates

H. Immunosuppression
1. Know the mechanism of action, metabolic pathways, indications for, and short-term side effects of immunosuppressive agents
2. Be aware of drugs that interact with immunosuppressive agents in renal transplantation
3. Understand the principles governing immunosuppressive drug dosages for children receiving renal transplants
4. Understand the principles and limitations of antibody-based immunosuppressive therapies
5. Recognize the option for lower doses of immunosuppression with HLA-identical sibling donor
6. Understand the concept of immunosuppressive dose reduction post transplant
7. Recognize the issues associated with use of generic immunosuppressive agents
8. Be aware of long term toxicities associated with immunosuppressive agents
9. Know how to monitor patients long-term for risks from immunosuppressive agents

I. Rejection
1. Know the differential diagnosis and manifestations of renal allograft rejection
2. Understand the principles of the humoral and cellular immunologic response to organ transplants
3. Understand the use of clinical, laboratory, pathologic and radiographic determinations in the differential diagnosis of renal allograft rejection
4. Know the mechanisms of action of the therapeutic modalities useful for reversing rejection episodes and their indications and adverse effects
5. Know when anti-rejection treatment should be withheld in the face of allograft dysfunction
6. Know the natural history of chronic progressive transplant injury
7. Recognize the histology of chronic progressive transplant injury
8. Understand the concept of immunologic tolerance
9. Understand the immunologic mechanisms that give rise to hyperacute, acute, and chronic rejection
10. Recognize the histology of acute cellular rejection
11. Recognize the clinical and histologic picture of acute and chronic antibody-mediated rejection

J. Complications
1. Be able to recognize and treat postoperative medical and surgical complications of renal transplantation
2. Recognize the causes and management of the child with a rapidly decreasing urine output following renal transplantation
3. Know the natural history of cystinosis following renal transplantation
4. Recognize the clinical presentation and natural history of diseases that recur after renal transplantation
5. Know the presentation and diagnostic characteristics of de novo membranous glomerulonephritis following renal transplantation
6. Be able to diagnose and manage viral infections including cytomegalovirus, EBV, varicella herpes and BK virus infections following renal transplantation
7. Be able to recognize and treat bacterial and fungal infections following renal transplantation
8. Know the types, causes, and potential treatments of hyperlipidemia following renal transplantation
9. Know the epidemiology, diagnosis, and associations of malignancy with renal transplantation
10. Know the biology and management of post-transplant lymphoproliferative disease (PTLD)
11. Know the causes of allograft dysfunction in both early and late post transplant period
12. Know indications for use of dialysis in treating acute graft dysfunction
13. Know the causes, clinical manifestations, and management of primary graft non-function
14. Know the causes and potential treatment of bone and mineral abnormalities following transplant
15. Recognize the causes and management of gross hematuria following renal transplant
16. Know the causes and treatment of hyperglycemia following renal transplant
17. Know the causes and treatment of hypertension following renal transplant
18. Know the risks and benefits of allograft nephrectomy

K. Growth/sexual maturation
1. Know the factors and mechanisms that retard growth following renal transplantation
2. Understand the ways to maximize growth in the child with a renal transplant
3. Understand the patterns of sexual development following renal transplantation
4. Know the natural history, complications to mother and offspring, and management of pregnancy in a renal transplant recipient

L. Rehabilitation and psychosocial adaptation
1. Understand the psychosocial and behavioral adaptations to renal transplantation
2. Understand the predictive factors, psychological processes, and management of medical non-adherence with the medication regimen following renal transplantation
3. Understand the principles present in the successful rehabilitation of the child or adolescent after renal transplantation
4. Be able to compare long-term quality of life outcomes in successful dialysis and renal transplantation in children and adolescents
5. Know the risks and optimal management of transitioning transplant patients from pediatric to adult care

M. Graft and patient outcome
1. Know the expected short- and long-term patient and allograft outcome in living-related and deceased donor renal transplantation
2. Know the differences in patient outcomes comparing the different forms of dialysis to the different types of renal transplantation
3. Recognize the factors affecting long-term morbidity and mortality in kidney transplant recipients

XII. Basic Sciences and Research Methodology
A. Immunology/mechanisms of immune injury
1. Mechanisms involving humoral immunity
   a. Describe the handling of circulating immune complexes by glomerular cells
   b. Know the role of antibodies against specific renal antigens in disease pathogenesis
   c. Know the immunoglobulin subclasses and their role in disease
2. Mechanisms involving cell-mediated immunity
   a. Know the function of lymphocyte subsets
   b. Know the relationship of T cells to B cells
   c. Know the role of monocytes in cell-mediated immunity
   d. Know the role(s) of effector cytokines in transplantation biology
   e. Understand the concept of Th1 and Th2 cellular subsets and their differential function and associated cytokines
   f. Know the mechanisms regulating cell-mediated immunity
3. Mediator systems in immune renal disease
   a. Know which C components are necessary for activation of the classical and alternative C pathways
   b. Differentiate the agents that activate the classical and alternative C pathways
   c. Understand the role of major complement components in renal disease
   d. Understand the role of the membrane attack complex in kidney disease and transplantation
   e. Describe the mechanisms of renal injury in disseminated intravascular coagulation
   f. Describe the mechanisms of renal injury mediated by polymorphonuclear cells, macrophages, and platelets
   g. Understand the role of chemokines in renal inflammation
   h. Know the mechanisms of action of immunosuppressive drugs used to treat kidney disease
4. HLA associations
   a. Know the association between major histocompatibility complex and certain renal diseases
b. Know the association between major histocompatibility complex antigens and rheumatoid diseases

5. Transplant immunology
   a. Know the cells involved in transplantation biology
   b. Understand the cellular and molecular basis of the acute rejection response
   c. Understand the theories of tolerance induction
   d. Know the role of the endothelium, complement, and the coagulation cascade in transplant rejection
   e. Know the mechanisms of action of commonly prescribed antirejection therapies

B. Mechanisms of disease pathogenesis
   1. Mechanisms of renal injury
      a. Understand the pathophysiology of obstructive nephropathy
      b. Understand the pathophysiology of toxic nephropathies
      c. Understand the pathophysiology of acute kidney injury
      d. Know the effects of hypoxia on cellular function and energy metabolism
      e. Know the events involved in ischemia-reperfusion injury
      f. Understand the concept of compensatory hypertrophy
      g. Know the role of cellular mechanisms of acute and chronic nephron loss (e.g., apoptosis)
      h. Understand the pathophysiology of pigment nephropathy
      i. Understand the pathophysiology of sepsis associated acute kidney injury
      j. Understand the mechanisms of glomerular injury and production of proteinuria in nephrotic syndrome and glomerulonephritis

   2. Mechanisms of progressive renal disease
      a. Know the physical factors contributing to progression of renal insufficiency
      b. Know the component parts of the renal extracellular matrix
      c. Know the association of growth factors (e.g., TGF-beta, PDGF, and bFGF) with progressive renal disease
      d. Know the role of angiotensin II and hypertrophy in progressive renal disease
      e. Know the effect of the balance between extracellular matrix synthesis and degradation in renal scarring
      f. Know the effect of lipids in progressive renal failure
      g. Know the role of inflammation in progressive renal nephron loss
      h. Know the role of tubulointerstitial injury in progressive renal disease
      i. Understand the role of chronic proteinuria in progressive renal disease
      j. Understand the role of glomerular hyperfiltration in progressive glomerular disease

C. Physiology
   1. Know the organization, regulation, and function of the renal circulation
   2. Understand the different effects of renal nerves on renal function
   3. Understand the concept of autoregulation of renal blood flow and glomerular filtration rate in each stage of renal development
   4. Know the effects of vasoconstrictors and vasodilators on renal hemodynamics, glomerular perfusion, and sodium reabsorption
   5. Know the determinants of glomerular ultrafiltration and changes in each determinant during renal maturation
6. Know the patterns and mechanisms of transport of water and electrolytes in the whole kidney and specific nephron segments during each stage of renal development
7. Understand the concept of glomerulotubular balance and know the changes which occur during renal development
8. Know about the role, localization, and inhibition of sodium-potassium-ATPase
9. Understand the relationship of oxygen consumption and sodium transport in the kidney
10. Understand the countercurrent multiplier system
11. Know the function, action, and metabolism of hormones/humoral factors produced in the kidney (renin-angiotensin, kinins, eicosanoids, nitric oxide)
12. Understand factors regulating renin release (baroreceptor mechanism, macula densa, sympathetic system, prostaglandins, extracellular ions hormones)
13. Know the function, physiologic regulation, and extrarenal effects of circulating natriuretic peptides
14. Know the mechanism of action, regulation, and renal and extrarenal effects of antidiuretic hormone
15. Know the mechanisms of action of commonly used diuretic drugs
16. Know the pattern and mechanisms of transport of organic anions and cations
17. Understand the effects of various drugs on the glomerulus (eg, NSAIDs), proximal tubule (eg, aminoglycosides), and distal tubule (eg, amphotericin)
18. Know the physiology of magnesium handling

D. Renal development
1. Know the patterns and mechanisms of renal tubular acidification in whole kidney and specific nephron segments during development
2. Understand the pharmacodynamics and pharmacokinetics of drugs during renal development
3. Understand the role of growth factors, hormones, and genes that influence kidney development
4. Understand the molecular basis of renal and urinary tract development
5. Know the role of apoptosis in renal development
6. Know the role and function of epithelial-mesenchymal interactions in renal embryology

E. Molecular and cellular biology
1. Know the features of intra- and intercellular communication
2. Know the principles of gene transcription and translation
3. Know the general principles of membrane transport and renal metabolism
4. Understand the interaction of cells and extracellular matrix
5. Understand intracellular signaling and second messenger function
6. Understand the role of regulation of cell structure in the development of renal disease
7. Understand the development of cell polarity
8. Understand the pathophysiology of disruption of cell polarity
9. Understand receptor-ligand interactions

F. Genetics in renal disease
1. Know the genetic basis of inherited renal diseases
2. Know the gene mutations resulting in renal or urinary tract developmental abnormalities
3. Know genetic risk factors for progressive renal disease

G. Experimental methods in renal research
   1. Be familiar with the basic methodologies of research used in molecular genetics
   2. Understand the research methods used in studies of gene and protein expression
   3. Understand the characteristics of the predominant experimental models of immune-mediated renal disease and their relevance to human disease
   4. Know the characteristics of the predominant experimental models of cystic kidney disease and understand their relevance to human disease
   5. Understand the potential roles of experimentally induced conditions in the progression of renal disease through chronic renal failure to end-stage renal disease
   6. Understand the requirements for the use of animals in renal research
   7. Understand the utility and limitations of cell culture methodology
   8. Understand the use of transgenic animals and homologous recombination, as well as the limitations of these techniques
   9. Know the characteristics of the predominant experimental models of acute kidney injury and toxic nephropathy and understand their relevance to human disease
  10. Know the limitations of knockout mouse models in renal research
  11. Know the use and limitations of molecular techniques to diagnose infectious renal diseases
  12. Understand the role and limitations of stem cell therapy and gene delivery techniques with respect to renal diseases
  13. Know the use and limitations of genome-wide association studies, exome sequencing, and copy number variant analysis
  14. Understand the applications of genomics, proteomics and metabolomics in the field of renal research
  15. Understand the role of bioinformatics with mass data handling

XIII. Core Knowledge in Scholarly Activities
   A. Principles of Use of Biostatistics in Research
      1. Types of variables
         a. Distinguish types of variables (eg, continuous, categorical, ordinal, nominal)
         b. Understand how the type of variable (eg, continuous, categorical, nominal) affects the choice of statistical test
      2. Distribution of data
         a. Understand how distribution of data affects the choice of statistical test
         b. Differentiate normal from skewed distribution of data
         c. Understand the appropriate use of the mean, median, and mode
         d. Understand the appropriate use of standard deviation
         e. Understand the appropriate use of standard error
      3. Hypothesis testing
         a. Distinguish the null hypothesis from an alternative hypothesis
         b. Interpret the results of hypothesis testing
      4. Statistical tests
         a. Understand the appropriate use of the chi-square test versus a t-test
         b. Understand the appropriate use of analysis of variance (ANOVA)
         c. Understand the appropriate use of parametric (eg, t-test, ANOVA) versus non-parametric (eg, Mann-Whitney U, Wilcoxon) statistical tests
d. Interpret the results of chi-square tests
e. Interpret the results of t-tests
f. Understand the appropriate use of a paired and non-paired t-test
g. Determine the appropriate use of a 1- versus 2-tailed test of significance
h. Interpret a p-value
i. Interpret a p-value when multiple comparisons have been made
j. Interpret a confidence interval
k. Identify a type I error
l. Identify a type II error

5. Measurement of association
   a. Differentiate relative risk reduction from absolute risk reduction
   b. Calculate and interpret a relative risk
c. Calculate and interpret an odds ratio
d. Interpret a hazard ratio
e. Understand the uses and limitations of a correlation coefficient

6. Regression
   a. Identify when to apply regression and analysis (eg, linear, logistic)
b. Interpret a regression analysis (eg, linear, logistic)
c. Identify when to apply survival analysis (eg, Kaplan-Meier)
d. Interpret a survival analysis (eg, Kaplan-Meier)

7. Diagnostic tests
   a. Recognize the importance of an independent "gold standard" in evaluating a diagnostic test
   b. Calculate and interpret sensitivity and specificity
c. Calculate and interpret positive and negative predictive values
d. Understand how disease prevalence affects the positive and negative predictive value of a test
e. Calculate and interpret likelihood ratios
f. Interpret a receiver operator characteristic curve
g. Interpret and apply a clinical prediction rule

8. Systematic reviews and meta-analysis
   a. Understand the purpose of a systematic review
   b. Understand the advantages of adding a meta-analysis to a systematic review
c. Interpret the results of a meta-analysis
d. Identify the limitations of a systematic review
e. Identify the limitations of a meta-analysis

B. Principles of Epidemiology and Clinical Research Design
1. Study types
   a. Distinguish between Phase I, II, III, and IV clinical trials
   b. Recognize a retrospective study
c. Understand the strengths and limitations of retrospective studies
d. Recognize a case series
e. Understand the strengths and limitations of case series
f. Recognize a cross-sectional study
g. Understand the strengths and limitations of cross-sectional studies
h. Recognize a case-control study
i. Understand the strengths and limitations of case-control studies
j. Recognize a longitudinal study
k. Understand the strengths and limitations of longitudinal studies
l. Recognize a cohort study
m. Understand the strengths and limitations of cohort studies
n. Recognize a randomized-controlled study
o. Understand the strengths and limitations of randomized-controlled studies
p. Recognize a before-after study
q. Understand the strengths and limitations of before-after studies
r. Recognize a crossover study
s. Understand the strengths and limitations of crossover studies
t. Recognize an open-label study
u. Understand the strengths and limitations of open-label studies
v. Recognize a post-hoc analysis
w. Understand the strengths and limitations of post-hoc analyses
x. Recognize a subgroup analysis
y. Understand the strengths and limitations of subgroup analyses

2. Bias and confounding
   a. Understand how bias affects the validity of results
   b. Understanding how confounding affects the validity of results
   c. Identify common strategies in study design to avoid or reduce bias
   d. Identify common strategies in study design to avoid or reduce confounding
   e. Understand how study results may differ between distinct sub-populations (effect modification)

3. Causation
   a. Understand the difference between association and causation
   b. Identify factors that strengthen causal inference in observational studies (eg, temporal sequence, dose response, repetition in a different population, consistency with other studies, biologic plausibility)

4. Incidence and prevalence
   a. Distinguish disease incidence from disease prevalence

5. Screening
   a. Understand factors that affect the rationale for screening for a condition or disease (eg, prevalence, test accuracy, risk-benefit, disease burden, presence of a presymptomatic state)

6. Decision analysis
   a. Understand the strengths and limitations of decision analyses
   b. Interpret a decision analysis

7. Cost-benefit, cost-effectiveness, and outcomes
   a. Differentiate cost-benefit from cost-effectiveness analysis
   b. Understand how quality-adjusted life years are used in cost analyses
   c. Understand the multiple perspectives (eg, of an individual, payor, society) that influence interpretation of cost-benefit and cost-effectiveness analyses

8. Sensitivity analysis
   a. Understand the strengths and limitations of sensitivity analysis
   b. Interpret the results of sensitivity analysis
9. Measurement
   a. Understand the types of validity that relate to measurement (e.g., face, construct, criterion, predictive, content)
   b. Distinguish validity from reliability
   c. Distinguish internal from external validity
   d. Distinguish accuracy from precision
   e. Interpret measurements of interobserver reliability (e.g., kappa)
   f. Understand and interpret Cronbach's alpha

C. Applying Research to Clinical Practice
   1. Assessment of study design, performance & analysis (internal validity)
      a. Recognize when appropriate control groups have been selected for a case-control study
      b. Recognize when appropriate control groups have been selected for a cohort study
      c. Recognize the use and limitations of surrogate endpoints
      d. Understand the use of intent-to-treat analysis
      e. Understand how sample size affects the power of a study
      f. Understand how sample size may limit the ability to detect adverse events
      g. Understand how to calculate an adequate sample size for a controlled trial (e.g., clinically meaningful difference, variability in measurement, choice of alpha and beta)
   2. Assessment of generalizability (external validity)
      a. Identify factors that contribute to or jeopardize generalizability
      b. Understand how non-representative samples can bias results
      c. Assess how the data source (e.g., diaries, billing data, discharge diagnostic code) may affect study results
   3. Application of information for patient care
      a. Estimate the post-test probability of a disease, given the pretest probability of the disease and the likelihood ratio for the test
      b. Calculate absolute risk reduction
      c. Calculate and interpret the number-needed-to-treat
      d. Distinguish statistical significance from clinical importance
   4. Using the medical literature
      a. Given the need for specific clinical information, identify a clear, structured, searchable clinical question
      b. Identify the study design most likely to yield valid information about the accuracy of a diagnostic test
      c. Identify the study design most likely to yield valid information about the benefits and/or harms of an intervention
      d. Identify the study design most likely to yield valid information about the prognosis of a condition

D. Principles of Teaching and Learning
   1. Educational theory
      a. Understand the basic principles of adult learning theory (e.g., adult learners are self-directed, goal-oriented, practical; need to feel respected, build on life experiences; learn best when learning is based on an existing framework)
      b. Understand the attributes of an effective learning environment
c. Understand the importance of "reflective practice" in teaching and learning
d. Identify strategies that motivate learners
e. Recognize the impact of the "hidden curriculum" on learning

2. Feedback and evaluation
   a. Identify components of effective feedback
   b. Distinguish between formative and summative feedback
   c. Distinguish between evaluation and feedback
   d. Understand the strengths and weaknesses of various methods to evaluate learners

3. Teaching methods
   a. Understand the strengths and weaknesses of various teaching methods (e.g., lecture, small group discussion, bedside teaching, simulation)
   b. Understand that individuals may learn more effectively with certain teaching methods (e.g., reading, hearing, doing) than with others

4. Educational planning
   a. Understand the role of needs assessment in educational planning
   b. Distinguish between goals and learning objectives
   c. Identify components of well-formulated learning objectives
   d. Recognize the strengths and weaknesses of various educational outcome measures (e.g., participant satisfaction, acquisition of knowledge and skills, behavioral change, patient outcomes)

E. Ethics in Research
   1. Conflicts of interest and commitment
      a. Evaluate whether an investigator has a conflict of interest during the course of a study
      b. Understand ways to manage a conflict of interest
      c. Understand what constitutes a conflict of commitment
   2. Professionalism and misconduct in research
      a. Identify forms of research misconduct (e.g., plagiarism, fabrication, falsification)
      b. Differentiate honest error and differences of opinion from research misconduct
      c. Understand the criteria for authorship of clinical research publications
   3. Principles of research with human subjects
      a. Understand and apply the three main principles of research ethics articulated in the Belmont Report (e.g., respect for persons, beneficence, and justice)
      b. Understand the role of analysis of risks and benefits in the ethical conduct of research
      c. Understand the federal regulatory definitions regarding which activities are considered research
      d. Understand the federal regulatory definitions regarding when research includes the use of human subjects
      e. Understand the federal regulatory definition of minimal risk
      f. Understand the functions of an Institutional Review Board
      g. Understand the rules that make a study involving children exempt from review by the Institutional Review Board
      h. Understand the functions of a Data Safety Monitoring Board
      i. Understand the importance of clinical equipoise in research with human subjects
j. Understand the impact of "therapeutic misconception" on clinical research with human subjects
k. Understand the ethical considerations of study design (eg, placebo, harm of intervention, deception, flawed design)
l. Understand the privacy rules regarding recruitment and participation of subjects in a research study and reporting the results of that study

4. Principles of consent and assent
   a. Understand what constitutes informed consent in research
   b. Understand when an exemption from review by the Institutional Review Board is permissible (eg, medical record review of de-identified data)
   c. Understand how undue influence can affect obtaining consent for research
   d. Understand how coercion can affect obtaining consent for research
   e. Understand the special ethical considerations related to research utilizing children because of their inability to give informed consent
   f. Distinguish among consent, assent, and permission in research involving children

5. Vulnerable populations
   a. Recognize that the definition of "children" is related to the underlying clinical intervention in the jurisdiction in which the child is located rather than a fixed nationwide notion of age
   b. Recognize the types of protections that might be accorded to vulnerable populations (eg, incarcerated individuals, pregnant women, fetuses, children, mentally disabled individuals, educationally or economically disadvantaged individuals)
   c. Understand the concept of minimal risk as it applies to research involving children
   d. Understand the circumstances under which research that involves children and that entails greater than minimal risk may be permissible