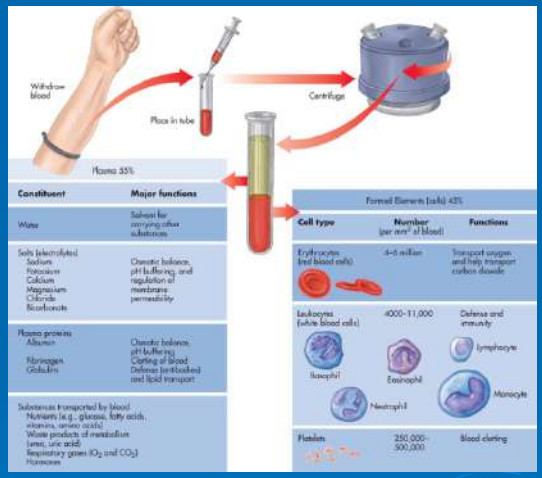
Anatomy, Physiology and Disease
Chapter 5
Basic Diagnostic Tests:
What Do The Tests Tell Us?



Introduction

- Diagnostic tests help to provide a more accurate view of patient's overall condition and disease state including diagnosis, progression, or improvement.
- Medical diagnostics are like advanced diagnostics for your car; tests can be used to verify the obvious or to discover where signs & symptoms are pointing.

Important things to keep in mind when interpreting test results

- Normal values for specific tests vary slightly from lab to lab
- Even perfectly healthy people will sometimes have abnormalities on diagnostic tests
- Test results must be interpreted in context of patient's overall medical history and physical exam; not every abnormal test is significant!!!

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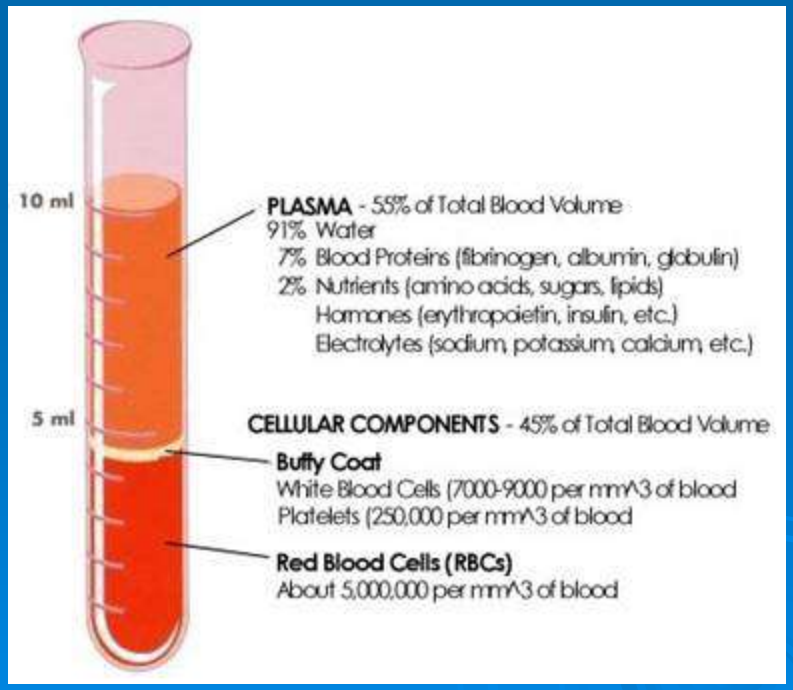
Blood Testing

Composition of blood

- Partly composed of liquid, partly cells
- Liquid portion called plasma
- Composed of about 90% water



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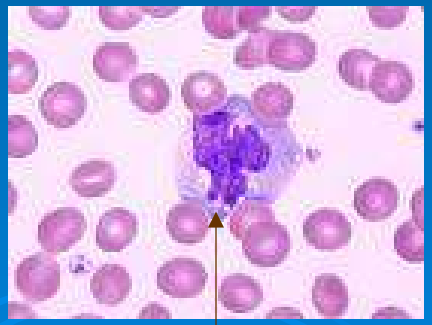
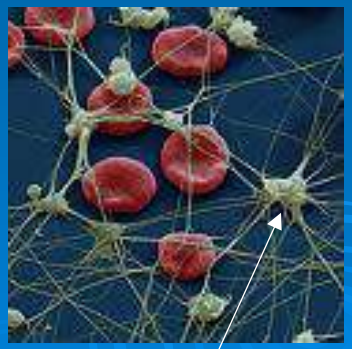
Several types of blood cells

- Erythrocytes (Red Blood Cells) medium-sized blood cell; Transports oxygen from lungs to body cells
- Leukocytes (White Blood Cells) large-sized blood cell; protects body from infection
- Thrombocytes (Platelets) small-sized blood cell; helps blood clot after cut or similar injury

Erythrocytes



Leukocytes



Thrombocytes

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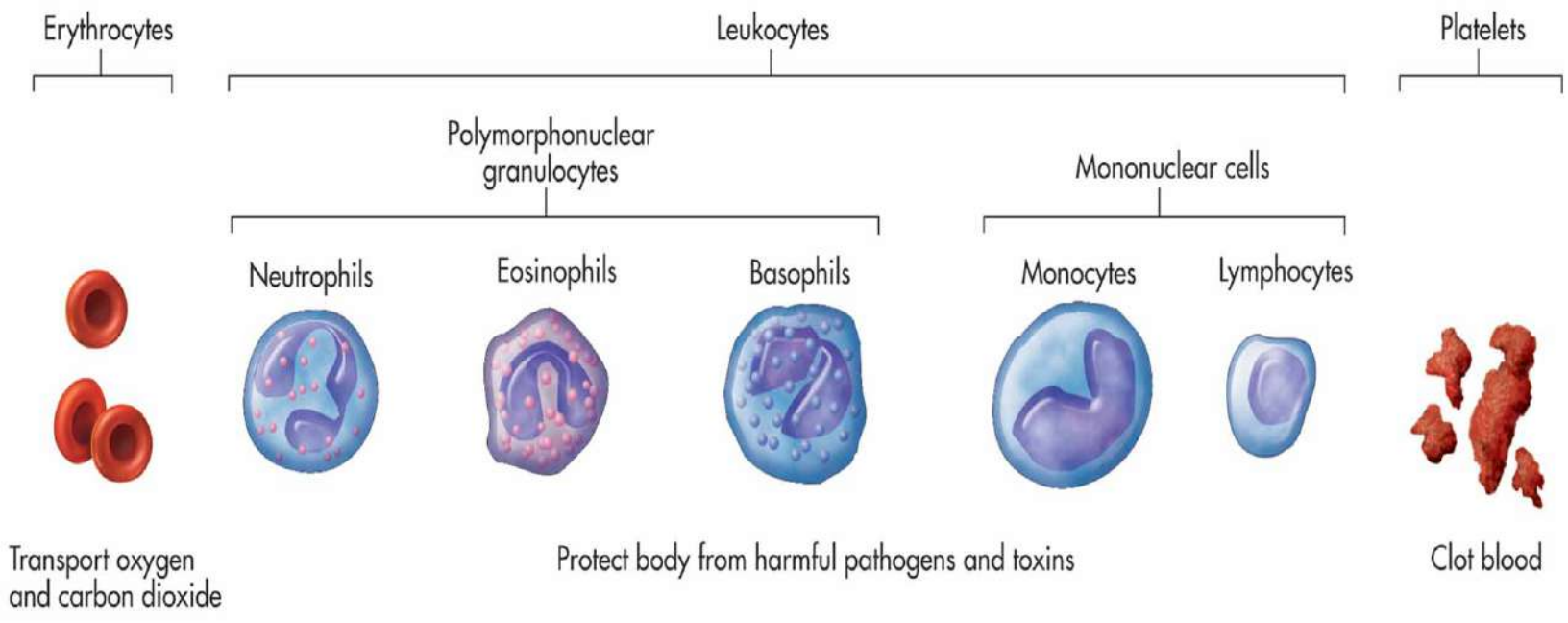
Types of Blood Cells



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Obtaining blood sample for testing

- Venous stick: bluish blood vessels visible through skin.
- Finger stick: pin prick to finger (which samples capillary blood); example: diabetics testing their own blood sugar.
- Arterial stick: to assess *oxygenation* of blood

Blood Tubes

Venous

Accucheck

Arterial

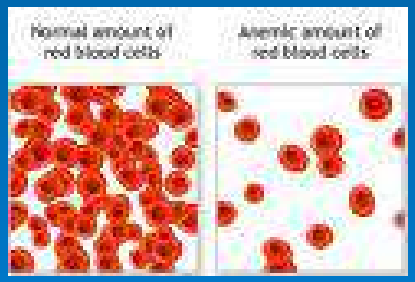
End Of Slide

Accu Check Machine for Blood Sugar Levels

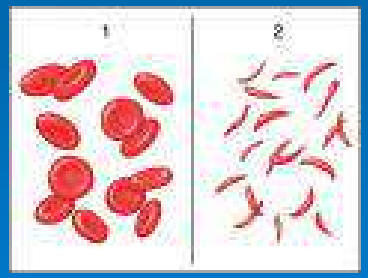
End Of Slide

Red Blood Cell Disorders

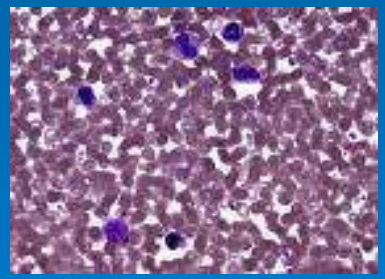
- Anemia: lower than normal amounts of RBCs; possible causes: hemorrhage, low RBC production, or RBC destruction.
- Polycythemia: higher than normal amounts of RBCs; possible cause: chronically low oxygen in blood.



Anemia



Sickle Cell



Polycythemia

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White Blood Cell Disorders

- Leukopenia: lower than normal amounts of WBCs
- Causes: Cancer, radiation & chemotherapy, antipsychotic medicines
- Leukocytosis: higher than normal amounts of WBCs; possible causes: infection or leukemia
- Causes: Massive infection

Platelet Disorders

- Thrombocytopenia: lower than normal number of platelets.

Causes:

- Vitamin B12 or Folic Acid deficiency
- Leukemia
- Sepsis (massive blood infection)
- Dengue fever

The Culprit

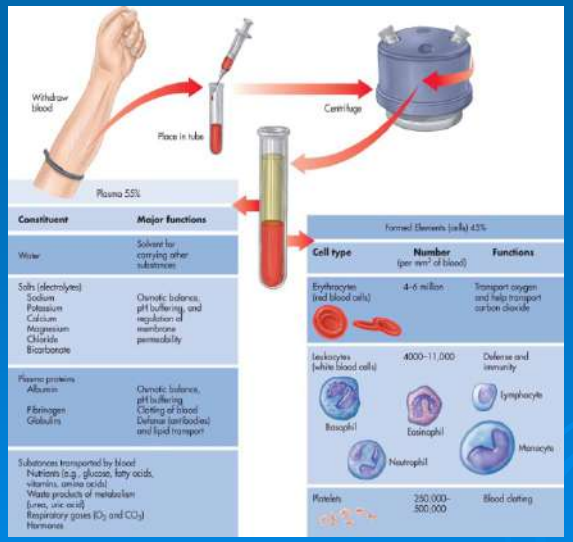
Typical Dengue Rash

Severe

End Of Slide

Centrifuged Blood

- Blood in tube spun to separate cells from plasma
- Formed elements: heavier cells forced to bottom of tube.
- Dissolved substances: upper level, lighter in weight & color, is plasma or liquid portion of blood.



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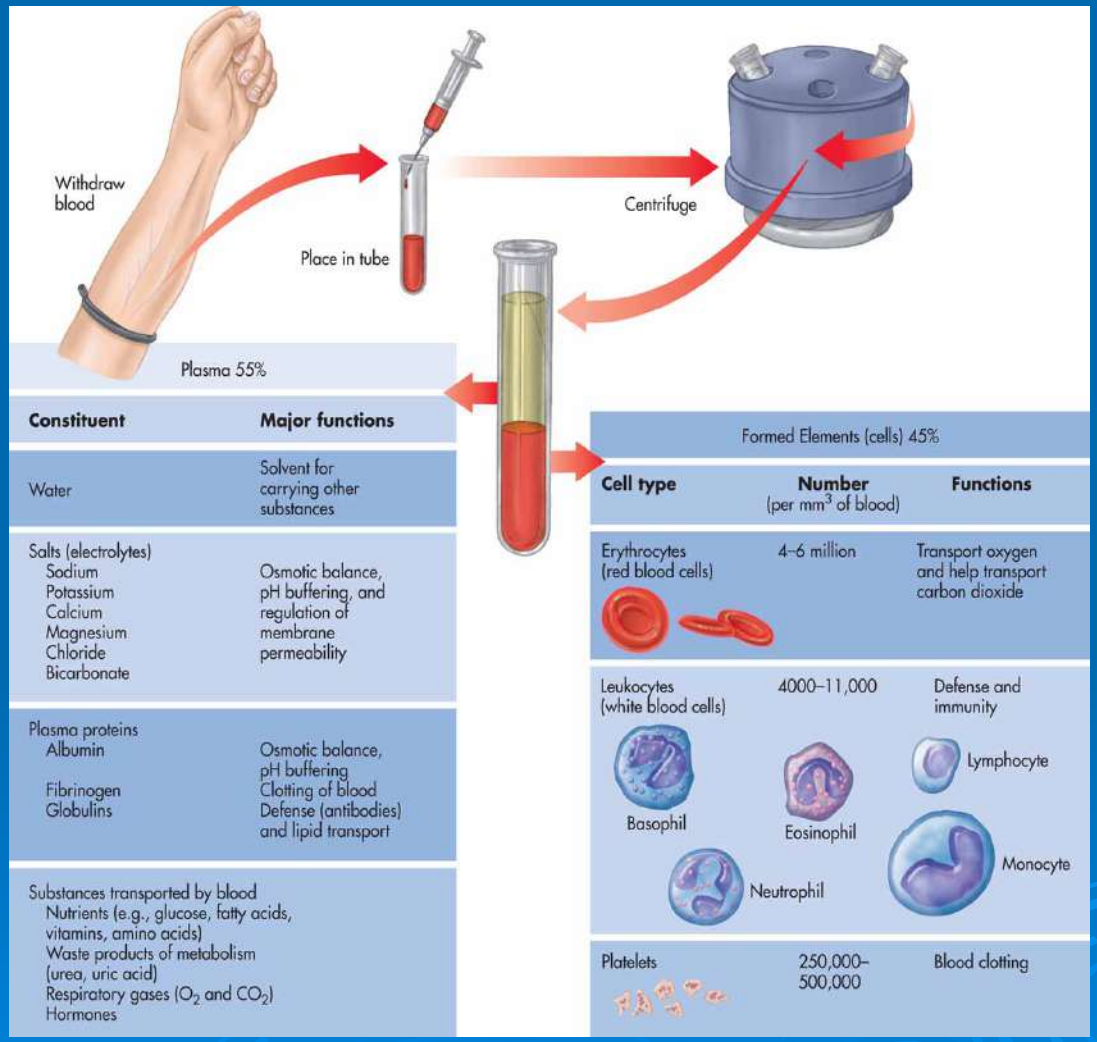
Centrifuged Blood



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Blood Testing

- Includes
  - RBC (red blood cell count) or (CBC)
  - Hct (hematocrit) "judging blood" the proportion of blood volume that is occupied by RBCs
  - Hgb (hemoglobin) "protein" 97% of dry content of the RBC…
  - WBC (white blood cell count)
  - Diff (differential white blood cell count)
  - Platelet count

Red Blood Cell Count(RBCs)

Quantity of RBCs in 1 cubic mm

Normal values: men: 4.6-6.2; women: 4.2-5.4

Decreased numbers Caused by

1. blood loss
2. dietary insufficiency (iron, folic acid, certain vitamins)
3. decreased RBC Production
4. increased RBC destruction

Red Blood Cell Count

Polycythemia: too many RBCs….

1. dehydration, diarrhea (severe)
2. high altitude
3. over production by bone marrow
4. Smoking
5. Adrenal gland illnesses

Hematocrit (Hct)

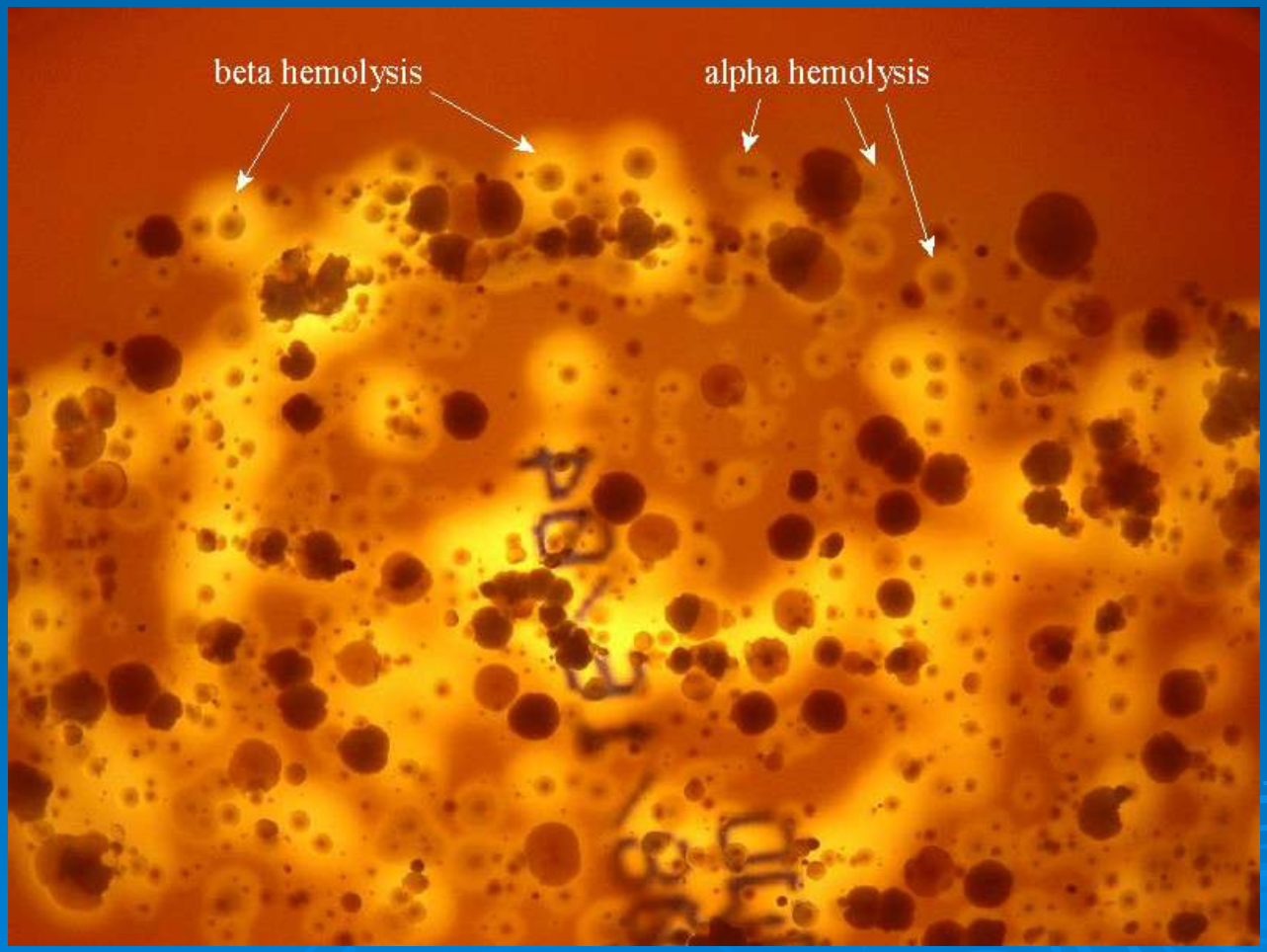
Determines what percent of the blood is composed of RBCs.

- Normal values: men: 40-54%; women: 38-47%
- Higher than normal Hct

  1. dehydration 2. shock
- Lower than normal Hct

  1. anemia 2. hemorrhage, 3. hemolytic reactions (blood cell destruction – such as what occurs when incompatible blood is transfused)

Hemolytic Reaction



Hemoglobin(Hgb)

- Measures protein in RBCs that carries oxygen
- Normal values: men: 13.5 – 17.5 g/dl; women: 12-16 g/dl; newborns: 14-16 g/dl
  - Decreased hemoglobin: anemia, excessive fluid intake, hemorrhage, pregnancy
  - Increased hemoglobin: COPD (which may result in chronically low blood oxygen), high altitude

White Blood Cell Count (WBCs)

- Measures total number of white blood cells $10^3/mm^3$
- Normal values: men: 4.5-11; women: 4.5-11
  - (leukopenia): Decreased WBCs diagnosed with WBC < 4,000
    - May be caused by alcoholism, viral infections, any chronic infection where body is so "worn out" that it cannot continue to produce enough WBCs
    - "panic value," WBC<500 is requires "STAT" attention.

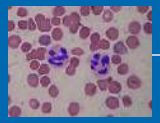
End Of Slide

White Blood Cell Count (WBCs) con't

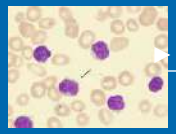
- (leukocytosis) Increased WBCs
  - Diagnosed with WBC > 10,000
  - Usually results from an increase in just one type of WBC
  - May be caused by infection, malignancy/leukemia, steroid therapy, hemorrhage, coma, stress (pain/excitement), menstruation.

Differential white blood cell count (Diff)

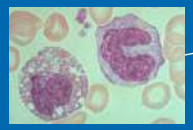
- Measures each different type of WBC
  - Types of WBCs



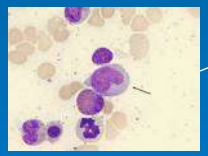
- Neutrophils: combat bacterial infection, inflammation and stress



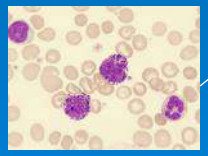
- Lymphocytes: fight viral infections



- Eosinophils: respond to allergic conditions and parasitic invasions



- Monocytes: respond to severe and chronic infections



- Basophils: respond to inflammation & blood disorders

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Platelet count

Determines number of platelets in blood

- Normal values: 150,000-350,000 / mm^3
- Thrombocytopenia: decreased platelets may be caused by blood transfusions, bone marrow lesions, cancer chemotherapy, infections/pneumonia, toxic drug effects
- Thrombocytosis: Increased platelets may be caused by splenectomy, heart disease, high altitude living, iron deficiency, trauma, tuberculosis, cancer

PT (Prothrombin Time, ProTime)

- Timed test that measures blood's ability to clot through use of the protein prothrombin produced by the liver.
- Prothrombin converts to thrombin
- Body needs Vit K to produce prothrombin
- Normal values: 10-14 sec

PT (Prothrombin Time, ProTime) con't

- Increased ProTime: suggests blood will not clot as quickly as normal; ex: patients on anti-coagulant therapy such as Coumadin
- Decreased ProTime: suggests increase in blood's ability to clot; may result from excessive consumption of green, leafy vegetables (which alters vitamin K levels, and therefore alters prothrombin levels or too much Vit K.
- Decreased ProTime may result in blood clots

PTT (Partial Thromboplastin Time)

- Timed test that measures blood's ability to clot through intrinsic thromboplastin system
- Used to monitor administration of Heparin
- Normal values: 30-45 sec
- Increased PTT: suggests blood will not clot as quickly as normal; ex: pts on anti-coagulant therapy such as heparin.

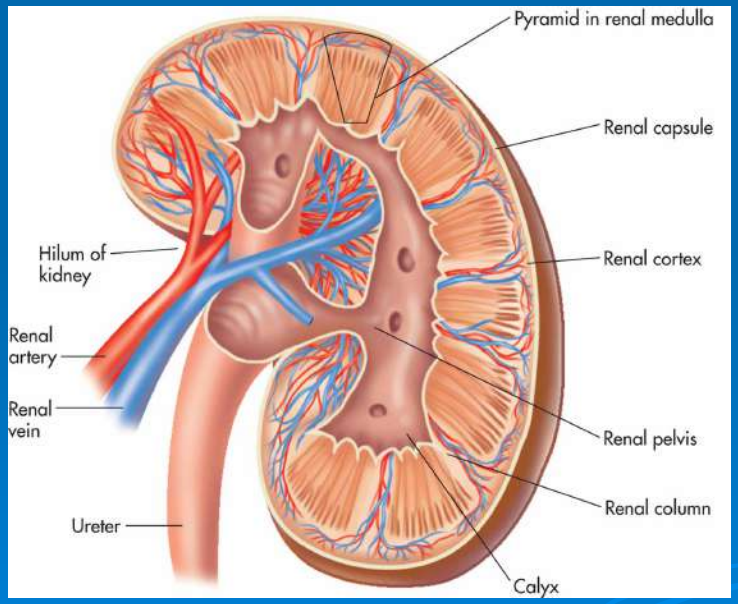
Blood Testing Results
Don't copy this!!! I will discuss this slide.

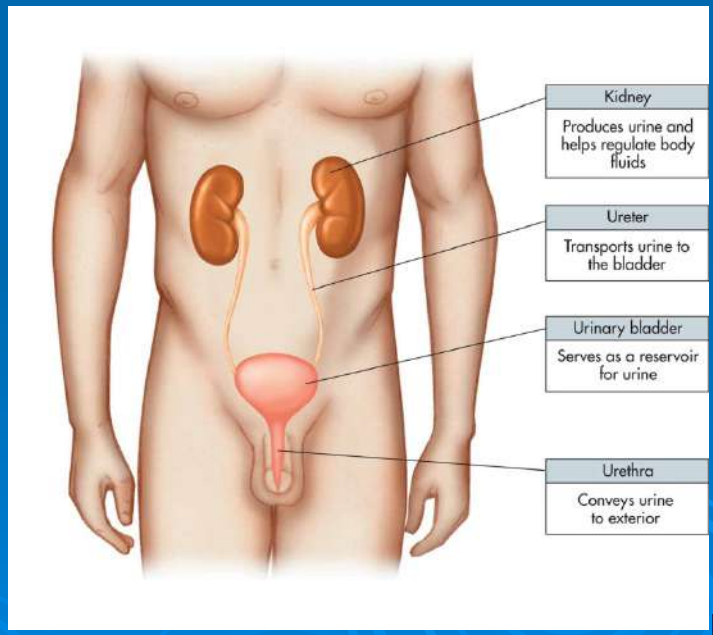
TABLE 5–1 Blood Testing Results

Abnormal Test Result(s)	Possible Causative Conditions / Situations
WBCs, decreased	Alcoholism, bone marrow depression, viral infections
WBCs, increased	Circulatory disease, coma, drugs (such as anesthetics, quinine), fever, hemorrhage, leukemia, malignancy, menstruation, moderate physical activity, newborns, serum sickness, severe electric shock, steroid therapy, stress (pain / excitement), tissue necrosis, toxins, trauma / tissue injury, uremia, allergies
RBCs, decreased	Blood loss, dietary insufficiency, decreased RBC production, increased RBC destruction, Hodgkin's disease, leukemia, multiple myeloma, pernicious anemia, rheumatic fever, Addison's disease
RBCs, increased	Dehydration, diarrhea (severe), exercise, high altitude, poisoning (acute), secondary polycythemia, pulmonary fibrosis
Hct, decreased	Anemia, cirrhosis, hemolytic reactions (incompatible transfusions, infections, drugs / chemicals, burns), hyperthyroidism, leukemia, massive hemorrhage
Hct, increased	Erythrocytosis, dehydration (severe), polycythemia, shock
Hgb, decreased	Anemia, cirrhosis of the liver, excessive fluid intake, hemolytic reactions, hemorrhage (severe), hyperthyroidism, pregnancy
Hgb, increased	Chronic obstructive pulmonary disease (COPD), congestive heart failure, high altitude living, conditions of hyperconcentration of blood
Platelet count, decreased	Allergic conditions, anemia, blood transfusions, bone marrow lesions, cancer chemotherapy, chemical exposures, toxic drug effects, infections, pneumonia
Platelet count, increased	Asphyxiation, anemia (post hemorrhagic) Cancer, cirrhosis, exercise/excitement, heart disease, high altitude living, iron deficiency, polycythemia vera, Rheumatoid arthritis, splenectomy, trauma, tuberculosis, Winter (!)

BUN (Blood Urea Nitrogen)

- Measurement of kidney's ability to eliminate urea (waste product) from blood
- Normal values: 7-18ml/dl or 2.5-6.3mmol/L





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BUN (Blood Urea Nitrogen) (cont'd)

- Increased BUN
  - May be caused by renal function impairment, non-renal causes (acute MI, chronic gout, diabetes, excessive protein consumption
  - Signs and symptoms of increased BUN: confusion, convulsions, Hypertension

Decreased BUN

- May be caused by

1. low protein diet/malnutrition,
2. fluid overload,
3. liver failure,
4. nephrotic syndrome

- S/S of edema

BUN Testing Results

TABLE 5-2 BUN Testing Results

ABNORMAL TEST RESULT(S)	POSSIBLE CAUSATIVE CONDITIONS / SITUATIONS,	SIGNS / SYMPTOMS (S/S)
Increased BUN	Acute myocardial infarction, chronic gout, dehydration, diabetes, drugs, excessive protein consumption / protein catabolism, GI hemorrhage, infection, pregnancy(late stage), renal function impairment, shock, tissue trauma(severe).	Confusion, convulsions, disorientation, many more.
Decreased BUN	Diet (low protein / high carbohydrate), drugs, fluid overload (as in intravenous therapy), liver failure, malnutrition, nephrotic syndrome, overhydration	Edema, many more disease specific

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Electrolytes

- Crucial for proper cellular function throughout body; body must maintain normal concentrations of various electrolytes
- Amount of water in body (too much or too little) can affect electrolyte concentrations

Electrolyte Testing Results

TABLE 5–3 Electrolyte Testing Results

ABNORMAL TEST RESULT(S)	POSSIBLE CAUSATIVE CONDITIONS / SITUATIONS,	SIGNS / SYMPTOMS (S/S)
Calcium increased	Diuretic therapy, excessive consumption of antacids or milk, hyperparathyroidism, malignant tumors, vitamin D intoxication	Anorexia, constipation, hyporeflexia, lethargy, mental deterioration, renal stones, weakness
Calcium decreased	Pregnancy, hypoparathyroidism, vitamin D deficiency	Convulsions, cramping of muscles, mental disturbances, paresthesia
Chloride increased	Renal tubular acidosis	Breathing rapid and deep, disorientation, weakness
Chloride decreased	Excessive vomiting	Breathing depressed, muscle hypertonicity, tetanus
Potassium increased	Muscle tissue damage, renal failure	Diarrhea, irritability, nausea, ventricular fibrillation, weakness
Potassium decreased	Chronic stress, diuretic therapy, diarrhea, endocrine disorder	Cardiac arrhythmias, hypotension, malaise, muscle weakness
Sodium increased	Dehydration	Dry mucous membranes, dry tongue, flushed skin, intense thirst
Sodium decreased	Burns, excessive water intake, loss of gastrointestinal secretions, excessive sweating	Abdominal cramping, confusion, muscle twitching, perfusion decrease, seizures, vasomotor collapse

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Calcium (Ca++)

- Normal values: 4.5-5.4 mEq/L
- Hypercalcimia: Increased Calcium
- Caused by hyperparathyroidism, malignant tumors, diuretic therapy, excessive calcium consumption (milk or antacids), vitamin D intoxication.
- S/S: anorexia, constipation, lethargy & weakness, hyporeflexia, mental deterioration, kidney stones

Calcium (Ca++) con't

- Hypocalcimia: Decreased calcium
- Caused by hypoparathyroidism, vitamin D deficiency, diuretic therapy, pregnancy
- S/S: muscle cramping, paresthesia, mental disturbances, convulsions
-

Chloride (Cl^-)

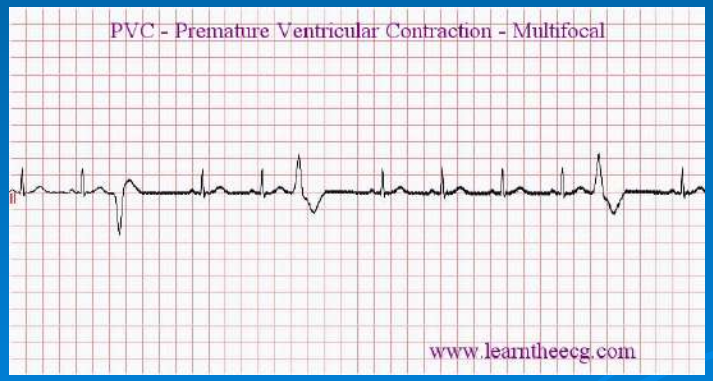
- Normal values: 95-103 mEq/L
- Decreased Chloride: caused by excessive vomiting, dehydration, burns.
- S/S: depressed breathing, muscle hypertonicity/tetanus

Potassium (K^+)

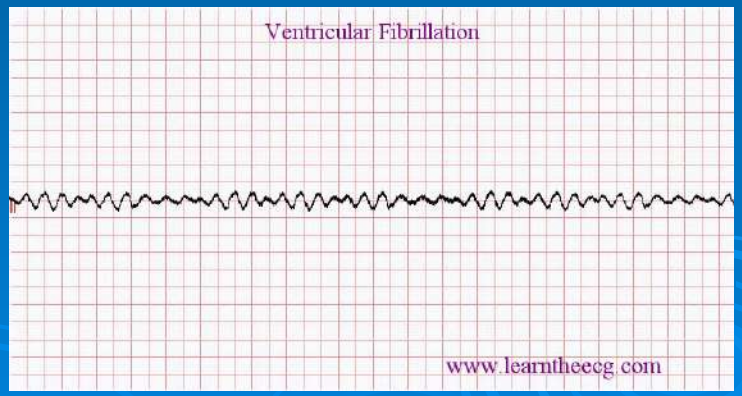
- Normal Values: 3.8-5.0 mEq/L
- Hyperkalemia-High potassium: caused by muscle tissue damage, renal failure
- S/S: diarrhea/nausea, ventricular fibrillation (heart dysrrhythmias), irritability, weakness. confusion.

Potassium (K^+)

- Hypokalemia: Decreased Potassium
- Caused by diuretic therapy, diarrhea, endocrine disorder, chronic stress
- S/S: cardiac arrhythmias, hypotension, muscle weakness, malaise



Dangerous



Cardiac Arrest

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Sodium (Na^+)

- Normal values: 136-142 mEq/L
- Hypernatremia: Increased sodium:
- Caused by dehydration
- S/S: dry mucous membranes & tongue, intense thirst, flushed skin

Sodium (Na^+) con't

- Hyponatremia: Low Sodium Level
- Etiology: excessive water intake, loss of GI secretions, excessive sweating, burns
- S/S: abdominal cramps, muscle twitching, confusion, seizures, vasomotor collapse

Enzymes

- Complex proteins that facilitate chemical changes
- Normally found inside body cells
- May be released into bloodstream following cell injury or death; example: cardiac enzymes are released into bloodstream when cardiac tissue dies during heart attack

Urine Testing

- Body makes 1-1.5 liters of urine every day
- Kidneys produce urine in order to:
  - Excrete waste
  - Regulate concentration of various substances in blood
- Morning urine is best for testing as it is the most concentrated.

Urine Testing (cont'd)

- Dipsticks: have several different areas impregnated with different reactive chemicals
  - Procedure: dipstick is dipped into urine and observed for color changes
  - Urine properties measured by dipstick: pH, bilirubin, ketones, glucose, leukocyte esterase, protein, hemoglobin, nitrite, urobilinogen

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Urine Testing

Specific gravity

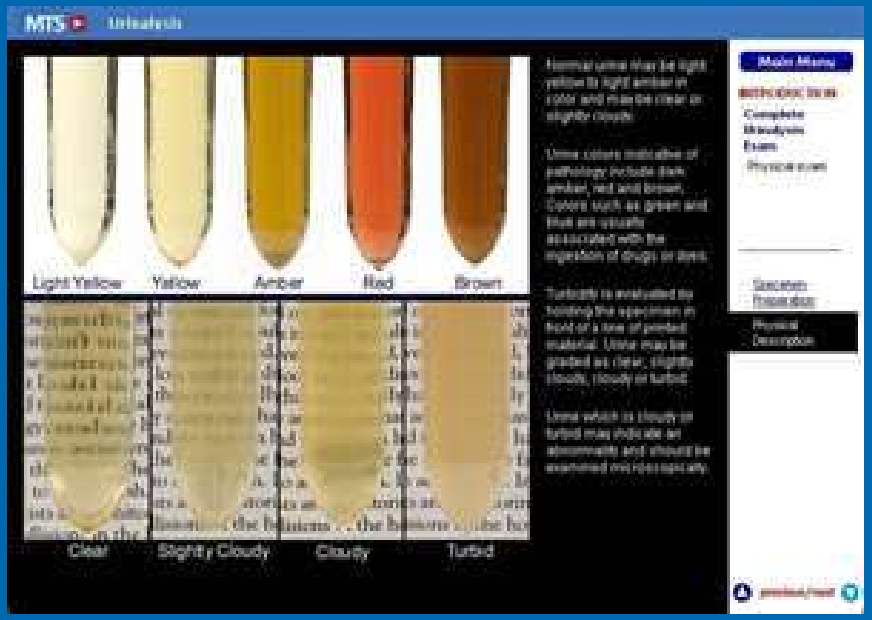
- Measurement of:

1. Kidney's ability to concentrate urine
2. Hydration of a patient
3. Amount of solids mixed in urine

- Normal values: 1.010-1.025
- Concentrated urine = 1.025-1.030+; suggests dehydration
- Diluted urine = 1.001-1.010; suggests overhydration or diuretic use

Factors that can interfere with urine test results

- Use of diuretics
- Hypercalcemia
- Potassium deficiency
- Liver, Bone & diseases



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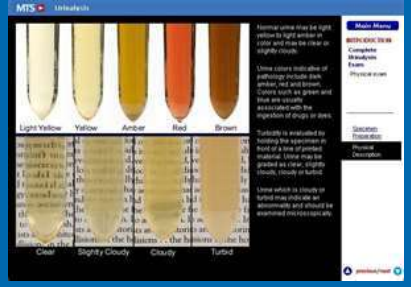
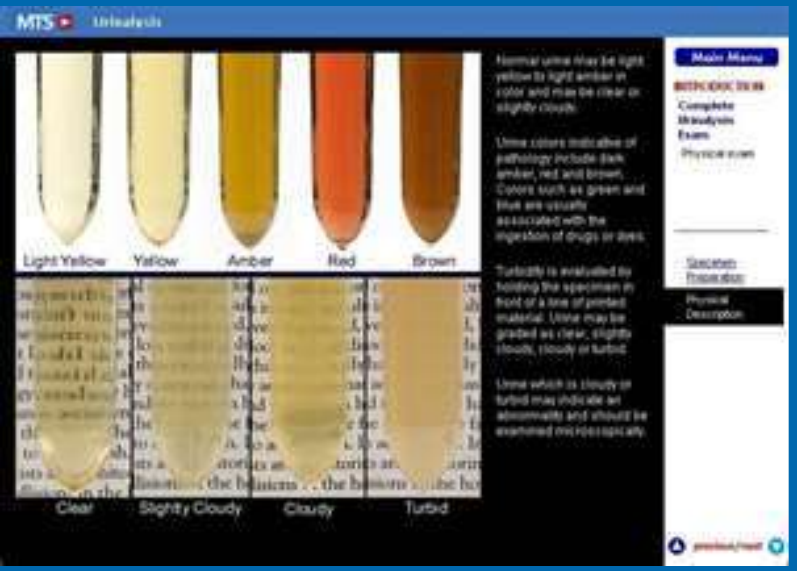
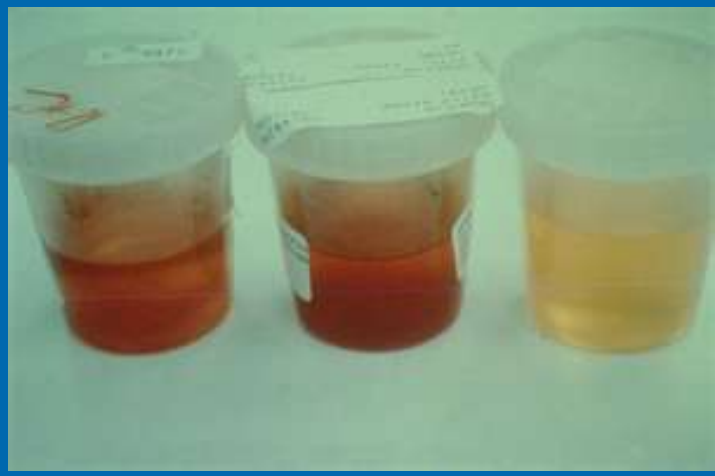
Urine Color

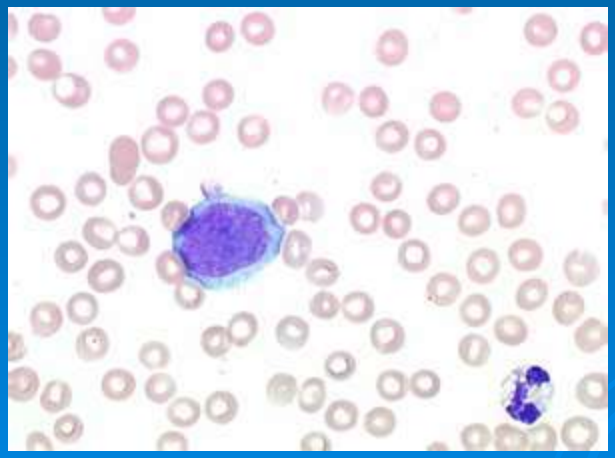


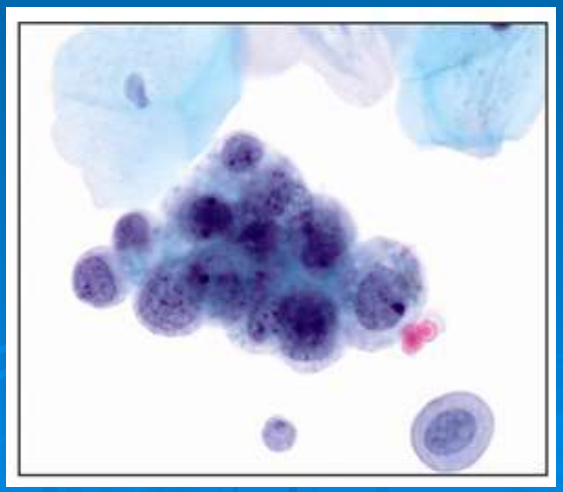
- **Normal values**: straw-amber color
- **Abnormal urine colors and their significance**
  Black: Lysol poisoning; alkaptonuria
- Brown: Addison's disease, drugs, melanotic tumor, bilirubin, rhubarb ingestion
- Clear/nearly clear: ETOH or other diuretic substances, large fluid intake, diabetes insipidus, chronic interstitial nephritis, untreated diabetes mellitus
- Orange: concentrated urine, decreased fluid intake, excessive sweating, drugs
- Red: (hematuria) blood/hemoglobin, beets, drugs

Urine….


MTS
Urinalysis
Light Yellow
Yellow
Amber
Red
Brown
Clear
Slightly Cloudy
Cloudy
Turbid
Main Menu
Complete Urinalysis Exam
Physical Exam
Physical Description







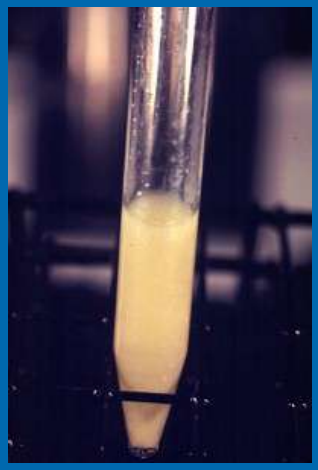
Urine odor

- Normal urine has distinct, but non-offensive aroma
- Unusual odors can suggest specific problems
  - Ammonia scent: stale urine with bacterial activity
  - General sweet smell: diabetic ketosis
  - Maple syrup scent: particular metabolic disorder

Urine pH (acidity)

- Controlled by kidneys to maintain homeostatic pH in body
- Normal values: pH of 4.6-8 (with average pH of 6)
- Excessively acidic urine may be due to respiratory acidosis (retention of CO_2 in lungs causes extra acid in blood, which kidneys try to eliminate), diarrhea/dehydration, high protein diets, starvation
- Excessively alkaline urine may be due to hyperventilation (body blows off too much CO_2 causing deficient acid in blood; kidneys try to correct blood pH by eliminating less acid into urine), chronic renal failure, renal tubular acidosis, urinary tract infection (UTI), salicylate (aspirin) intoxication

Urine turbidity



- Measure of how "cloudy" urine appears
- Normal values: clear to slightly hazy
- Cloudy urine may be caused by
  - Bacteria (infection)
  - Pus (lots of WBCs)
  - Red blood cells (hematuria)
  - Ingestion of certain foods (especially greasy/fatty foods)
  - Vaginal contamination (common occurrence when women give urine samples)

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Urine Sugar

- Glycosuria or Glucosuria

Caused by:

1. un-treated or inadequately treated DM
2. emotional stress
3. early Renal Failure

Urine protein (proteinuria)

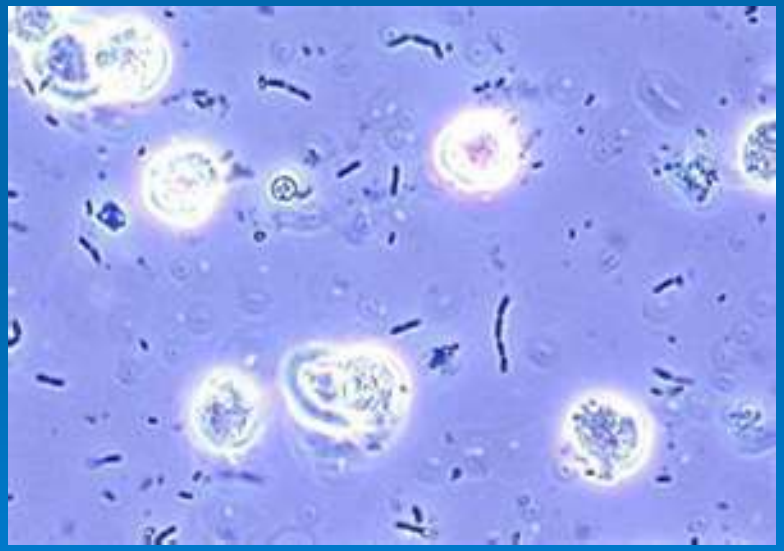
- Normal Values: 50-80mg /24 hours
- Causes of Proteinuria:
  - activities: bathing or swimming in cold water, eating large amounts of protein, violent/intense exercise, severe emotional stress
  - Renal disease: kidney stones, nephritis, nephrosis, polycystic kidney, tuberculosis or cancer of the kidney

Urine ketone bodies (acetone)

- Ketones released as result of metabolism of fatty acids; takes place when body runs out of carbohydrates to burn
- Normal values: negative
- Causes of Ketonuria: DM, anorexia/starvation/ fasting, diarrhea/prolonged vomiting, fever, drugs (i.e. insulin)

Urine Bacteria

- Normal values: negative
- Presence of bacteria in urine can suggest urinary tract infection (UTI)



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Fecal Matter

- Normal stool: 100-200 g/day, dark brown
- Color Abnormalities:
  - Yellow/yellow-green: breast fed infant, bowel sterilization due to antibiotics, severe diarrhea
  - Green: severe diarrhea, antibiotic therapy, ingestion of chlorophyll-rich vegetables
  - Tan/clay: common bile duct blockage, pancreatic insufficiency, excessive fat intake
  - Black: upper GI bleeding, ingestion of iron, high meat diet, ingestion of charcoal or bismuth
  - Red: bleeding from lower GI tract; if red streaking on outer surface of stool, consider hemorrhoids or anal pathology; if blood mixed through stool, consider problem higher up GI tract

Blood in stool

- Causes: gastritis, gastric ulcers, diverticulitis, ulcerative colitis, colon or gastric cancer, trauma.
- Conditions that cause false-positive occult blood tests: ingestion of red meat, large amounts of inorganic iron, and large doses of vitamin C

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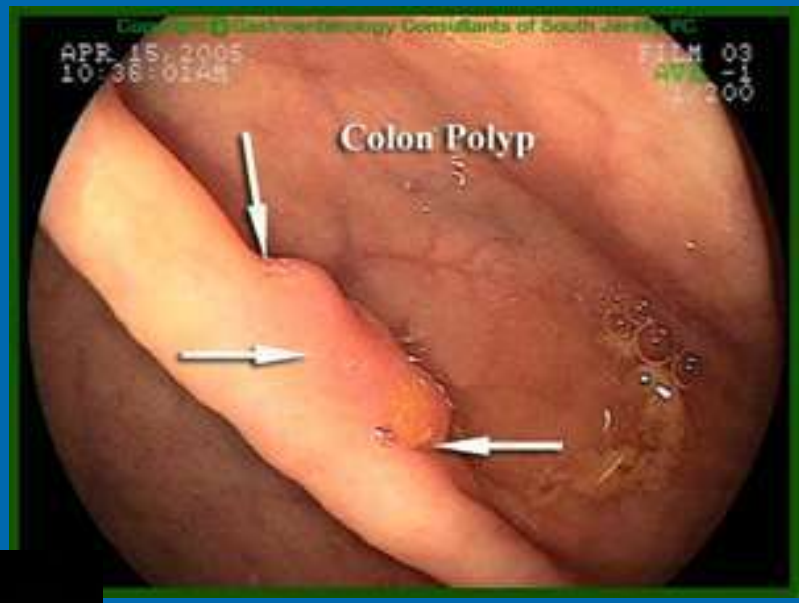
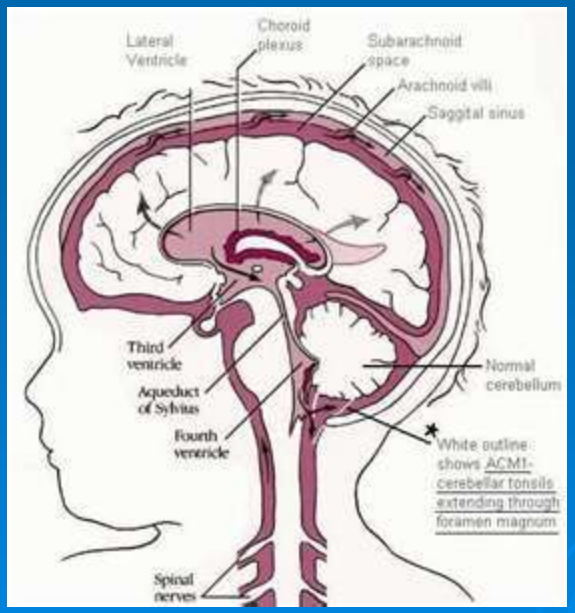
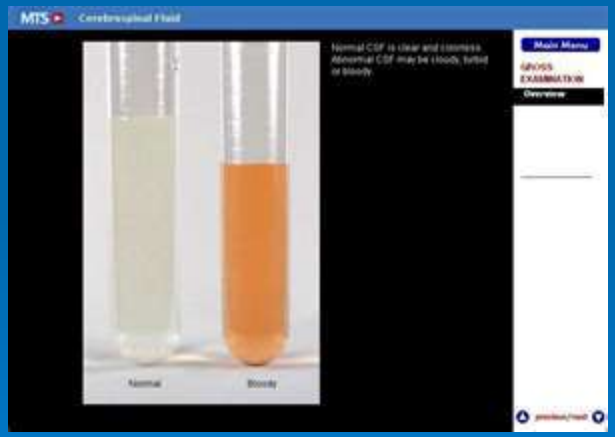
Pathology Conncection:
Colon Polyps



Cerebral Spinal Fluid (CSF)

- Clear and colorless fluid found in ventricles of the brain and central canal of the spinal cord
- Functions: acts as a shock absorber, helps regulate intracranial pressure, cranial glucose levels, leading to hunger sensations & eating behaviors.





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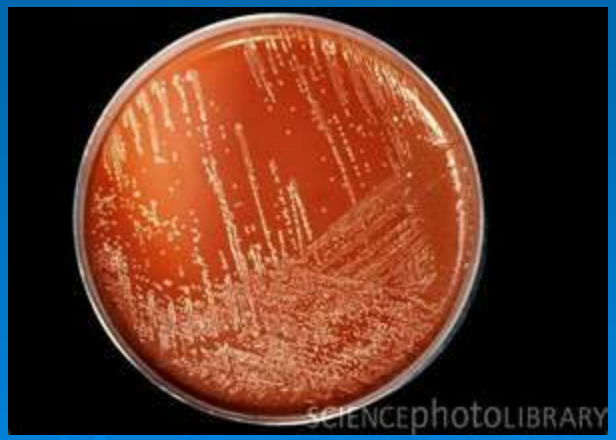
CSF Analysis

- Normal values
  - Normal daily production = 500ml
  - Normal circulation around brain and spinal cord = 150-200ml
  - Normal color = clear, colorless
  - Normal cell count = 0-5/microliters



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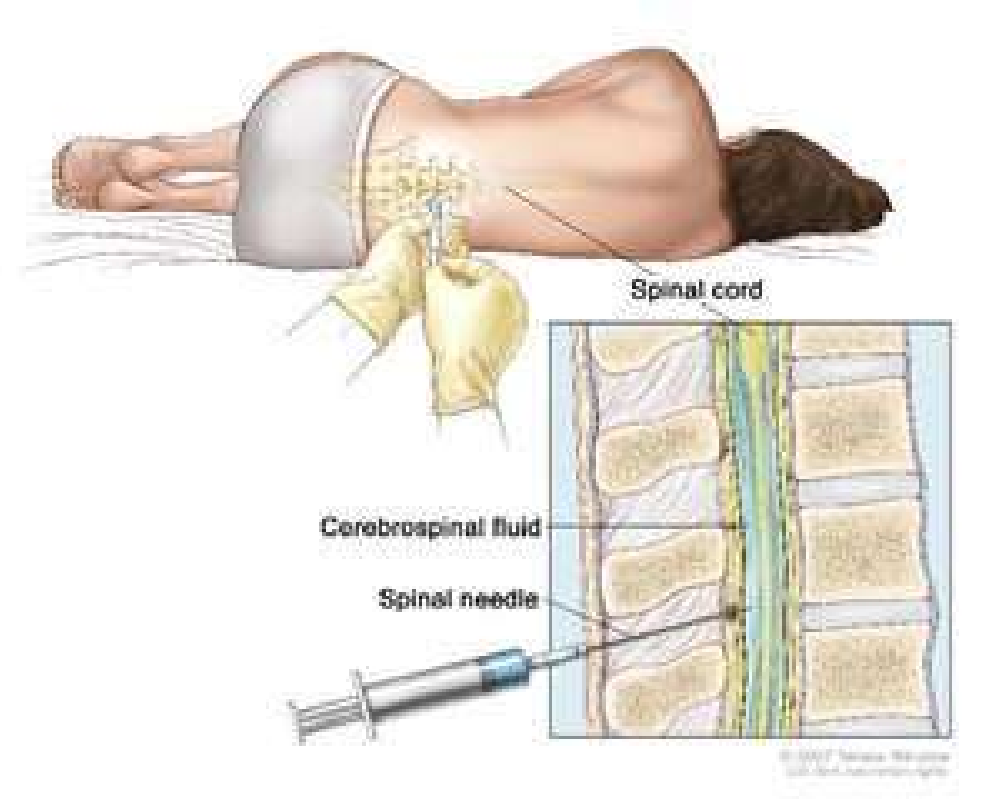
Adult Spinal Tap



CSF Abnormalities

- Abnormalities due to:
  - Hemorrhage
  - Micro-organisms
  - Tumors
  - Infections (like meningitis)
  - Trauma

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Culture and Sensitivity (C&S) Testing

- Purpose: to identify pathogen causing infection (culture) and which drug will most effectively kill pathogen (sensitivity)

- Important considerations
  - Culture may grow normal flora as well as pathogens
  - C&S results may be altered if patient is already on some kind of antibiotic

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