Part II

The Urinary System

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Renal Functions
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Tubular Secretion
Kidney Disease
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Transplantatio
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basic micturition reflex,
the functions of the kidneys
What are the three basic renal processes that lead to the formation of urine
Describe the forces that determine the magnitude of the GFR. What is a normal value of GFR
Diagram the sequence of events leading to micturition in infants and in adults.

Urinary System

The urinary system consists of two kidneys, two ureters the urinary bladder, and the urethra

The formation of urine is the function of the kidneys, and the rest of the system is responsible for eliminating the urine.

Body cells produce waste products such as urea, creatinine, and ammonia, which must be removed from the blood before they accumulate to toxic levels.

The Kidneys :-

Retroperitoneal on either side of the backbone in the upper abdominal cavity; partially protected by the lower rib cage.

Adipose tissue and the renal fascia cushion the kidneys and help hold them in place.

Hilus an indentation on the medial side that renal artery enters, renal vein and ureter emerge.

As the kidneys form urine to excrete these waste products, they also accomplish several other important functions:

1. Regulation of the volume of blood by excretion or conservation of water .

2. Regulation of the electrolyte content of the blood by the excretion or conservation of minerals .

3. Regulation of the acid–base balance of the blood by excretion or conservation of ions such as H_ ions or HCO3 ions .

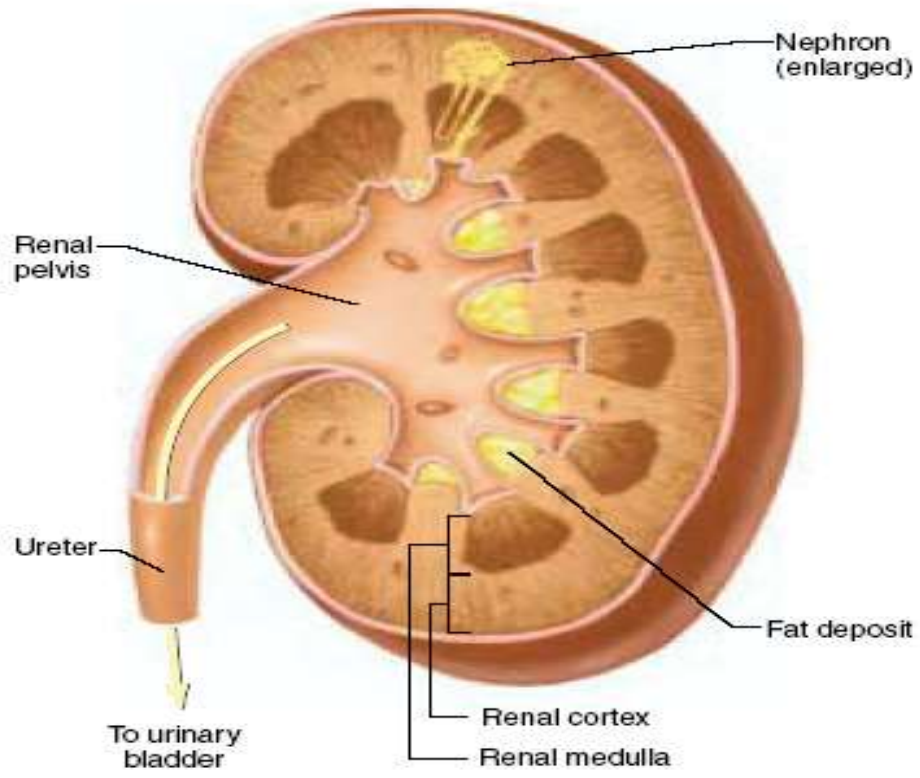
4. Regulation of all of the above in tissue fluid .

internal structure of Kidney :-

1- Renal cortex:- outer tissue layer, made of renal corpuscles and convoluted tubules.

2-Renal medulla (pyramids):- inner tissue layer, made of loops of Henle and collecting tubules.

3. Renal pelvis:- a cavity formed by the expanded end of the ureter within the kidney at the hilus; extensions around the papillae of the pyramids are called calyces, which collect urine.



The Nephron:-ABDUDTED

The nephron is the structural and functional unit of the kidney. Each kidney contains approximately 1 million nephrons. It is in the nephrons, with their associated blood vessels, that urine is formed.Each nephron has two major portions: a renal corpuscle and a renalTubule :-

1. **Renal corpuscle:-**

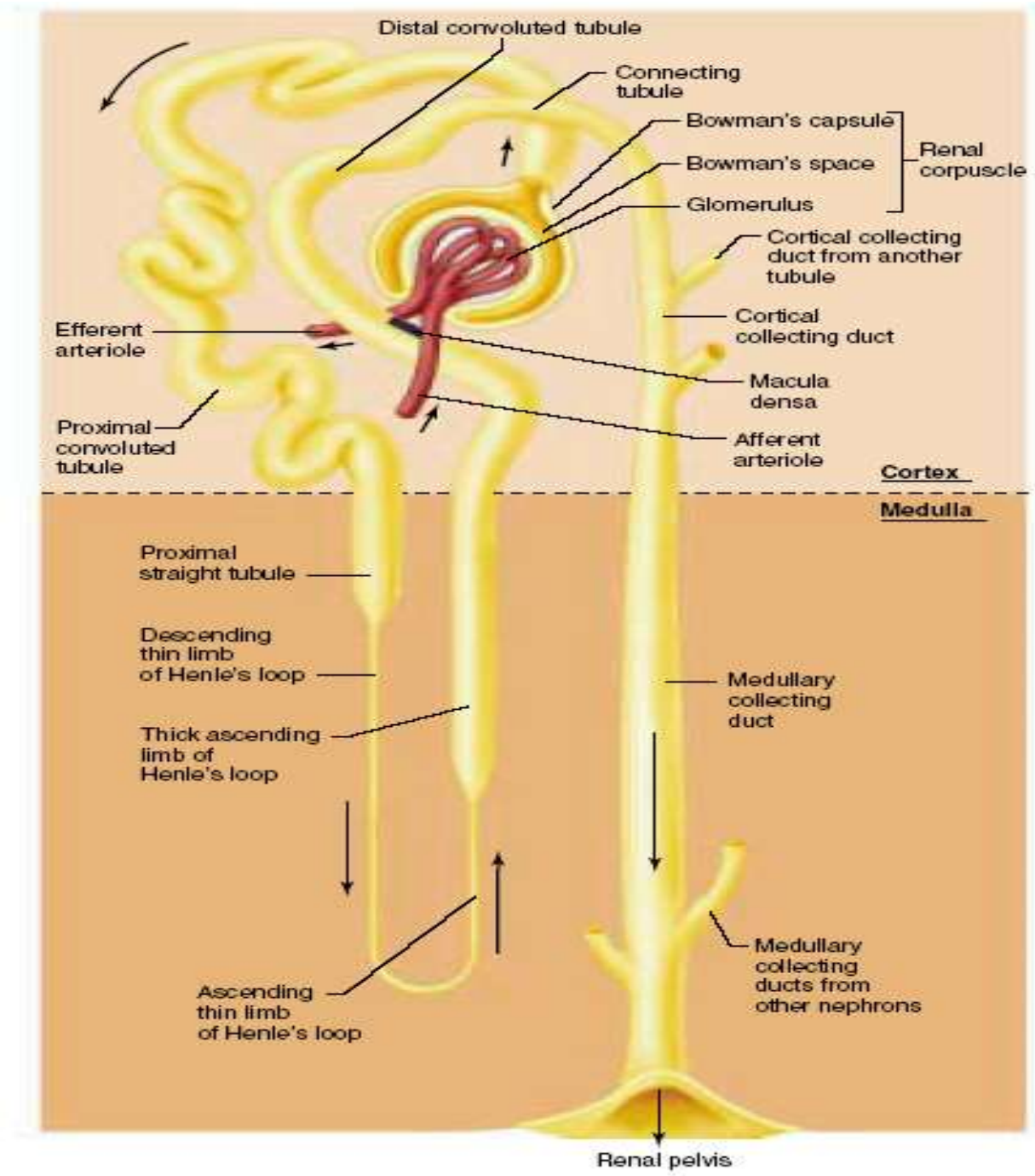
consists of a glomerulus surrounded by a Bowman's capsule.Glomerulus are capillary network between an afferent arteriole and an efferent arteriole.

Bowman's capsule it's the expanded end of a renal tubule that encloses the glomerulus, inner layer is made of podocytes, has pores, and is very permeable contains renal filtrate (potential urine).

2-Renal tubule:-

consists of the proximal convoluted tubule, loop of Henle, distal convoluted tubule, and collecting tubule. Collecting tubules unite to form papillary ducts that empty urine into the calyces of the renal pelvis.

Peritubular capillaries are arise from the efferent arteriole and surround all parts of the renal tubule



(Basic structure of a nephron.)

FORMATION OF URINE

The formation of urine involves three major processes ,The first is glomerular filtration, which takes place in the renal corpuscles. The second and third are tubular reabsorption and tubular secretion, which take place in the renal tubules.

1- GLOMERULAR FILTRATION :-

filtration is the process in which blood pressure forces plasma and dissolved material out of capillaries. In glomerular filtration, blood pressure forces plasma, dissolved substances, and small proteins out of the glomeruli and into Bowman's capsules, this fluid is no longer plasma but is called(renal filtrate).

The blood pressure in the glomeruli, compared with that in other capillaries, is relatively high, about 60 mmHg, the pressure in Bowman's capsule is very low, and its inner, podocyte layer is very permeable, so that approximately 20% to 25% of the blood that enters glomeruli becomes renal filtrate in Bowman's capsules.

The blood cells and larger proteins are too large to be forced out of the glomeruli, so they remain in the blood.

Waste products are dissolved in blood plasma, so they pass into the renal filtrate.

Useful materials such as nutrients and minerals are also dissolved in plasma and are also present in renal filtrate.

Renal filtrate is very much like blood plasma, except that there is far less protein and no blood cells are present.

The glomerular filtration rate (GFR) is the amount of renal filtrate formed by the kidneys in 1minute, and averages 100 to 125 mL per minute.

GFR may be altered if the rate of blood flow through the kidney changes.

If blood flow increases, the GFR increases, and more (filtrate is formed. If blood flow decreases the GFR decreases, less filtrate is formed, and urinary output decreases .

2- TUBULAR REABSORPTION :-

Reabsorption takes place from the filtrate in the renal tubules to the blood in the peritubular capillaries.

In a 24-hour period, the kidneys form 150 to 180 liters of filtrate, and normal urinary output in that time is 1 to 2 liters.

Approximately 99% of the filtrate is reabsorbed back into the blood in the peritubular capillaries, Only about 1% of the filtrate will enter the renal pelvis as urine.

Most reabsorption and secretion (about 65%) take place in the proximal convoluted tubules, whose cells have microvilli that greatly increase their surface area.

The distal convoluted tubules and collecting tubules are also important sites for the reabsorption of water

Tubular reabsorption is selective in terms of usefulness ,Nutrients such as glucose, amino acids, and vitamins are reabsorbed by active transport and

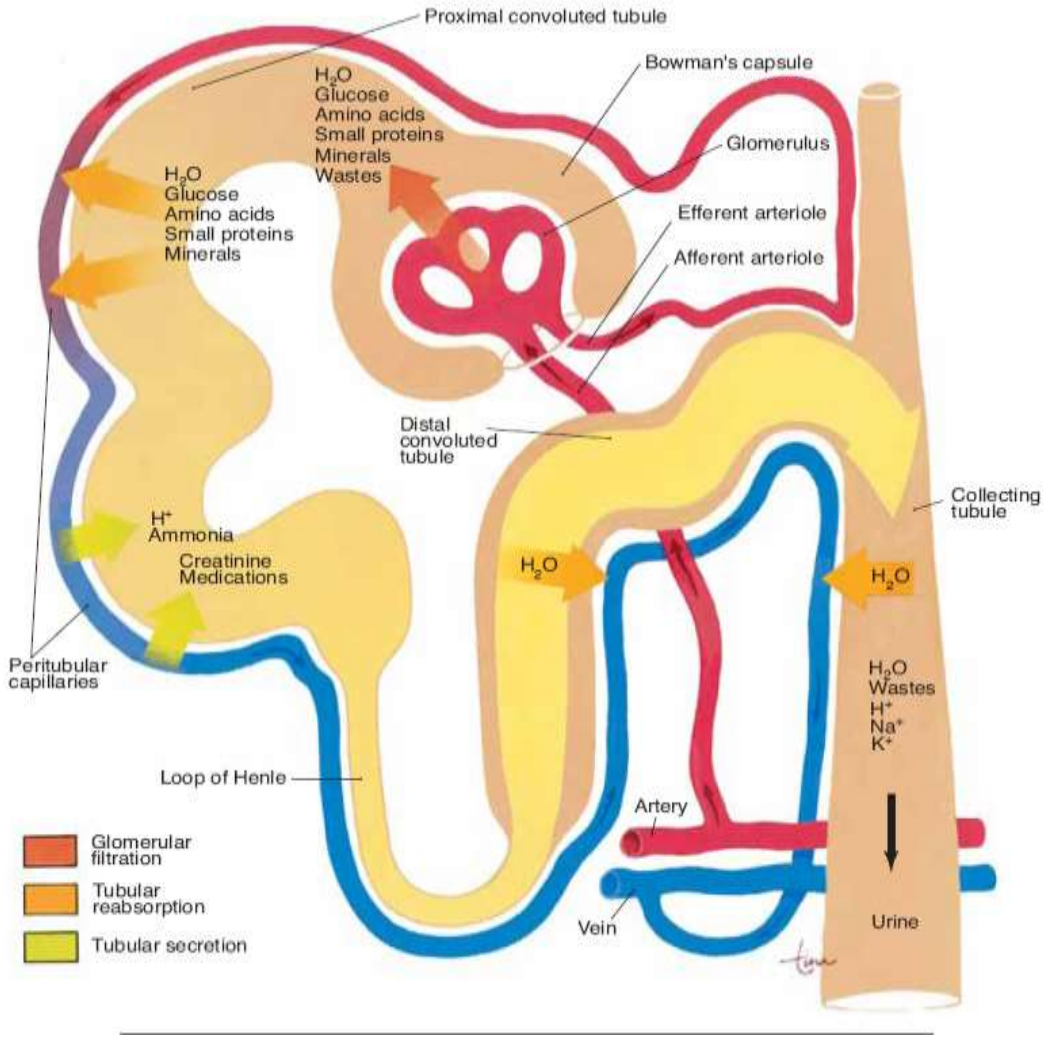
may have renal threshold levels.

Positive ions are reabsorbed by active transport and negative ions are reabsorbed most often by passive transport.

Water is reabsorbed by osmosis, and small proteins are reabsorbed by pinocytosis.

3- Tubular secretion:-

takes place from the blood in the peritubular capillaries to the filtrate in the renal tubule; creatinine and other waste products may be secreted into the filtrate to be excreted in urine; secretion of H_ ions helps maintain pH of blood .



representation of glomerular filtration, tubular reabsorption, and tubular secretion

Micturition :

When urine volume reaches 200 to 400 mL, the stretching is sufficient to generate sensory impulses that travel to the sacral spinal cord. Motor impulses return along parasympathetic nerves to the detrusor muscle, causing contraction, At the same time, the internal urethral sphincter relaxes.

If the external urethral sphincter is voluntarily relaxed

, urine flows into the urethra, and the bladder is emptied.

Urination can be prevented by voluntary contraction of the external urethral sphincter. However, if the bladder continues to fill and be stretched, voluntarycontrol is eventually no longer possible.

CHARACTERISTICS OF URINE and Urinalysis :-

The characteristics of urine include the physical and chemical aspects that are often evaluated as part of a urinalysis.

1- The Amount : 1–2 liters per 24 hours; highly variable depending on fluid intake and water loss through the skin and GI tract

2- the Color : typical yellow color of urine is often referred to as "straw" or "amber." Concentrated urine is a deeper yellow (amber) than is dilute urine; should be clear, not cloudy

3- Specific gravity :- it's the measure of the dissolved material in urine; thehigher the specific gravity number, the more dissolved material is present. the lower the value, the more dilute of urine , normal value 1.010–1.025 .

4- pH :- the pH range of urine is between 4.6 and 8.0, with an average value of 6.0. Diet has the greatest influence on urine pH.

5- the urine Composition :- 95% water which is the solvent for waste products and salts; 5% salts and waste products .

Nitrogenous wastes :-

Urea— from amino acid metabolism

Creatinine —from muscle metabolism

Uric acid —from nucleic acid metabolism

Other non-nitrogenous waste products :- include small amounts of urobilin from the hemoglobin of old RBCs and may include the metabolic products of medications .

(8)

Renal Failure and Hemodialysis

Renal failure, the inability of the kidneys to function properly, may be the result of three general causes, which may be called

a- prerenal, b- intrinsic renal c- postrenal.

a- "Prerenal" :- means that the problem is "before" the kidneys, that is, in the blood flow to the kidneys. Any condition that decreases blood flow tothe kidneys may result in renal damage and failure.Examples are severe hemorrhage or very low blood pressure following a heart attack (MI).

b- "Intrinsic renal" :- means that the problem is in the kidneys themselves. Diabetes and hypertension damage the blood vessels of the kidneys, and are the causes of 70% of all cases of end-stage renal failure. Bacterial infections of the kidneys or exposure to chemicals (certain antibiotics) may causedamage to the nephrons. Polycystic kidney disease is a genetic disorder in which the kidney tubules dilate and become nonfunctional. Severe damagemay not be apparent until age 40 to 60 years but may then progress to renal failure.

C:- "Postrenal" :- means that the problem is "after" the kidneys, somewhere in the rest of the urinary tract. Obstruction of urine flow may be caused by kidney stones, a twisted ureter, or prostatic hypertrophy. Treatment of renal failure involves correcting the specific cause, if possible. If not possible, and kidney damage is permanent, theperson is said to have chronicrenal failure. Hemodialysis is the use of anartificial kidney machine to do what the patient's

nephrons can no longer do. The patient's blood is passed through minute tubes surrounded by fluid (dialysate) with the same chemical composition as

plasma. Waste products and excess minerals diffuse out of the patient's blood into the fluid of the machine. (9)

Although hemodialysis does prolong life for those with chronic renal failure, it does not fully take the place of functioning kidneys. The increasing success

rate of kidney transplants, however, does indeed provide the possibility of a normal life for people with chronic renal failure.