The Mammalian Kidney

Kidneys maintain salt and water balance -
  maintain overall concentration of solutes
  maintain concentration of specific solutes
Kidneys filter blood to remove unwanted solutes
  removal of solutes requires some loss of water - the mammalian kidney allows solute removal with minimal water loss

Paired organs located in lower back region
Receives blood from renal artery, produces urine
Urine drains through ureter to urinary bladder
Adrenal gland produces several hormones
Internal structure of kidney
Mouth or ureter forms funnel-like renal pelvis
Cup-shaped extensions receive urine from renal tissue
Renal tissue composed of outer renal cortex and inner renal medulla
Functional unit is the **nephron**
each kidney contains one million nephrons
juxtamedullary nephrons have long loops that descend deep into medulla
cortical nephrons have shorter loops
Nephron has tubular and vascular components

The tubular components include Bowman’s capsule, the proximal convoluted tubule, the loop of Henle, the distal convoluted tubule, and the collecting duct.

The vascular component includes the afferent arteriole, glomerulus, peritubule capillaries, and efferent arteriole.
Afferent arteriole carries blood to capillary tuft called glomerulus. At the glomerulus, the blood is filtered - pressure forces fluid and small solutes blood through capillary walls into Bowman’s capsule - cells and large plasma proteins cannot pass through.

Filtrate travels through tubules of nephron. Each region plays a role in recovery of valuable solutes and water. Recovered water and solutes returned to circulatory system.
Large amounts of water and molecules form glomerular filtrate.
Filtrate enters first part of tubular component, Bowman's capsule.
Capsule surrounds glomerulus.
Capsule has pores through which fluid passes to nephron tubules.
Humans produce 180 l of glomerular filtrate each day - nearly all of the water is recovered.
Much of the water is recovered through the creation of an osmotic gradient.
Path of filtrate and tubule regions

- Bowman’s capsule
- Proximal convoluted tubule
- Descending loop of Henle
- Ascending loop of Henle
- Distal convoluted tubule
- Collecting duct
- Ureter
Filtrate first enters proximal convoluted tubule (PCT). 2/3 NaCl and water in capsule reabsorbed immediately. Most valuable solutes reabsorbed by active transport or diffusion. Na\(^+\) actively transported out of filtrate into blood vessels. Cl\(^-\) passively follows Na\(^+\) by electrical attraction. Water follows both because of osmosis. Filtrate is still isotonic to blood plasma.
1/3 of volume remains - ~60 l of fluid daily additional water must be reabsorbed occurs mostly across wall of collecting duct through osmosis renal medula is made hypertonic to filtrate in collecting duct by active transport of Na+ out of ascending Loop of Henle

water drawn out of collecting duct by osmosis remaining filtrate (urine) is hypertonic to blood
Reabsorption dependent on hypertonic renal medulla
  Steeper gradient will cause more water reabsorption
Loop of Henle creates hypertonic conditions in renal medulla
  Ascending limb of loop actively pumps Na+ out, Cl- follows
  Ascending limb not permeable to water
  so as Na+ exits, fluid in ascending limb gets more dilute,
  Surrounding tissue becomes more concentrated, hypertonic
NaCl remains in medulla because of
  vasa recta - an arrangement of
capillaries that creates a countercurrent
  multiplier system
As blood moves through capillaries, descending into medulla, the concentration of Na and Cl increases -

As blood ascends out of medulla - the Na and Cl it holds diffuses into blood descending into the medulla

The blood leaves the renal medulla with the same Na and Cl concentration it has when it entered.
Because of fluid in tissues of the medulla is hypertonic to the fluid in the collecting duct and in the descending loop of Henle, water can be drawn out of the filtrate and taken away by the circulatory system.

Some urea leaves the collecting duct by diffusion and contributes to osmotic gradient in medulla.

Remaining urea and other solutes leave in urine stream.