Chemical reactions produce wastes that must be removed from cells and from your body. Many of these wastes are small, water-soluble molecules that become dissolved in your blood along with other small molecules that are not wastes. Your body must separate and excrete waste products of Metabolism?

**EXCRETION:** is the process that rids body of **METABOLIC WASTES.** (especially **Nitrogenous** wastes)

- Excretion is performed by:
  - **KIDNEYS:** excrete **Nitrogenous Wastes** (Ammonia, Urea, Uric Acid, Creatinine)
  - **LIVER:** excrete **Bile Pigments**
  - **LUNGS:** excrete **CO₂**
  - **SKIN:** **Sweat**
- Excretion is **not the same** as **DEFECATION,** which is the process which rids the body of **UNDIGESTED, UNABSORBED** food remains.
Nitrogenous Wastes End Products: what are they?

- **AMMONIA = NH₃**: from amino groups of amino acids. **VERY TOXIC** to tissues, so in land mammals NH₃ converted to **UREA** in liver.

  Structure Of Urea
  
  ![Urea Structure](image)

- Urea is **water-soluble** - excreted in **URINE**

**Other Excreted Substances (besides Nitrogenous wastes)**

- Kidneys also excrete **HCO₃⁻** (bicarbonate ion)
- **IONS**: Salts K⁺, Na⁺, Ca²⁺, Mg²⁺, Fe⁺
- **WATER**: metabolic end product, maintains blood pressure, consumed with food
- **UROCHROME** from breakdown of heme, gives urine its **yellow** colour.
- **URINE** is composed mainly of **UREA** (~3%), **SALTS** ~2%, **H₂O** (95%).

**Urinary System consists of these parts!**

- **RENAL VEIN**: carries blood from kidneys back to hearty
- **RENAL ARTERY**: carries blood to kidneys
- **URETER**: muscular tubes, move urine from kidneys to bladder via peristalsis
- **BLADDER**: holds up to 600 ml to 1000 ml urine, can expand/contract. Has stretch receptors that indicate when it is full, notifies the brain.
- **URETHRA**: tube connecting bladder to outside.
- The urethra of a man is about 6 inches long (extends through penis). In the man, the urethra also transports **semen** (not at the same time). For women, the urethra is only ~1 inch (which is why get more **infections** here).
  - **KIDNEYS**: Excrete urine, regulate blood volume, **pH**.
KIDNEYS - the main organ of excretion

- Structurally, kidneys have 3 major divisions: **CORTEX** (outer layer), **MEDULLA** (middle, striated), **PELVIS** (inner cavity).

Polycystic Kidneys ~18lbs
- **NEPHRONS** - are the *functional units* of the kidney. They *filter wastes* from the blood, and *retain water* and other needed materials. There are about *1 million* nephrons per kidney.
**STRUCTURE OF THE NEPHRON**

- **BOWMAN'S CAPSULE** - Cup-like end of nephron where wastes are forced out of the blood and into the nephron. The blood enters a capillary tuft called the **GLOMERULUS**.
- **AFFERENT ARTERIOLE** - carries blood to glomerulus
- **EFFERENT ARTERIOLE** - carries blood from glomerulus
- From capsule, nephron narrows into **PROXIMAL CONVOLUTED TUBULE**, which makes a turn to **FORM LOOP OF HENLE**, which is surrounded by the **PERITUBULAR CAPILLARY NETWORK**. Loop leads to the **DISTAL CONVOLUTED TUBULE**, which finally enters a **COLLECTING DUCT**.
URINE FORMATION: YOU MAKE ABOUT 1 mL OF URINE PER MINUTE!

Urine formation consists of 3 STEPS

1. **PRESSURE FILTRATION**: occurs inside Bowman's capsule as molecules are forced through the glomerulus.
   - High blood pressure in GLOMERULUS (~60 mm Hg) forces SMALL MOLECULES (*H₂O, nitrogenous wastes, *nutrients, *ions (salts)) into BOWMAN'S CAPSULE.
   - Large molecules are unable to pass (i.e. blood cells, platelets, proteins). The molecules that are forced into Bowman's capsule form FILTRATE.
   - **high blood pressure is necessary** for filtration.

2. **SELECTIVE REABSORPTION**: occurs in the **proximal convoluted tubule** (Na⁺, Cl⁻, H₂O)

3. **URINE CONCENTRATION**: Occurs in the loop of Henle

4. **TUBULAR EXCRETION**: occurs in **distal convoluted tubule**
2. **SELECTIVE REABSORPTION**

- the molecules that are reabsorbed move from the proximal convoluted tubule to the peritubular capillary network (i.e. back into the blood).
- **WHAT GETS REABSORBED?**: most H$_2$O, nutrients, some salts (Na$^+$, Cl$^-$)
- **WHAT DOESN’T GET REABSORBED**: some H$_2$O, wastes, excess salts
- Reabsorption of nutrients is both **ACTIVE**
Active reabsorption of salt at the **Loop of Henle** results in the passive transport of water at both the **Loop of Henle** and **Collecting Duct** and thus urine concentration.
3. **TUBULAR EXCRETION (=TUBULAR SECRETION)**

- This is an **ACTIVE PROCESS** by which other **non-filterable wastes** can be added to the tubular fluid so that these wastes will also be excreted in the urine.
- Occurs in the **DISTAL CONVOLUTED TUBULE**: secreted substances include some chemicals (e.g. **penicillin, histamine**) H⁺ ions, NH₃

- The tubular fluid, which we can now call **URINE** passes from duct into **pelvis** of kidney, and enters **ureter** for transport to **bladder**.
REGULATORY FUNCTION OF KIDNEYS: the kidneys do much more than just filter the blood!

REGULATE VOLUME OF BLOOD (i.e. water volume). This is done by two HORMONES: ADH and ALDOSTERONE.

**ADH (ANTIDIURETIC HORMONE):** Hormone released by pituitary gland promotes reabsorption of water from collecting duct and distal convoluted tubule

Here is how ADH does it's job:
1. cells in hypothalamus detect low H₂O content of blood
2. ADH (made in the hypothalamus and released by the posterior pituitary) released into blood, acts on DISTAL CONVOLUTED TUBULE and COLLECTING DUCT
3. more H₂O reabsorbed, volume of urine decreases
4. therefore, blood volume increases

**DIURETIC DRUGS, inhibits ADH cause increased urination**

**ALCOHOL also inhibits ADH therefore causes increased urination**
ALDOSTERONE
- this is a hormone released by ADRENAL CORTEX (adrenal glands sit on top of kidneys). Aldosterone acts on kidney to RETAIN Na+ and EXCRETE K+.
- [Na+] in blood results in kidneys ability to reabsorb H₂O
- if [Na+] in blood too low, too little H₂O is reabsorbed, results in **HYPOTENSION**.
- if [Na+] in blood too high, results in **HYPERTENSION**