2.Kidney as a Filtration System

- The kidney is a complex organ that acts as a **filtration system** for the body.
- It **removes waste and excess fluid** from the bloodstream and maintains a **delicate balance of electrolytes, hormones, and other substances** that are critical for the body's normal functioning.
- The kidney also **plays an important role in regulating blood pressure** by secreting the hormone renin, which helps control the balance of fluid and electrolytes in the body.

- It also **regulates red blood cell production** and the **levels of various minerals** in the blood, such as calcium and phosphorus.
- Without the kidney, **waste and excess** fluid **would accumulate in the body,** leading to **serious health problems.**

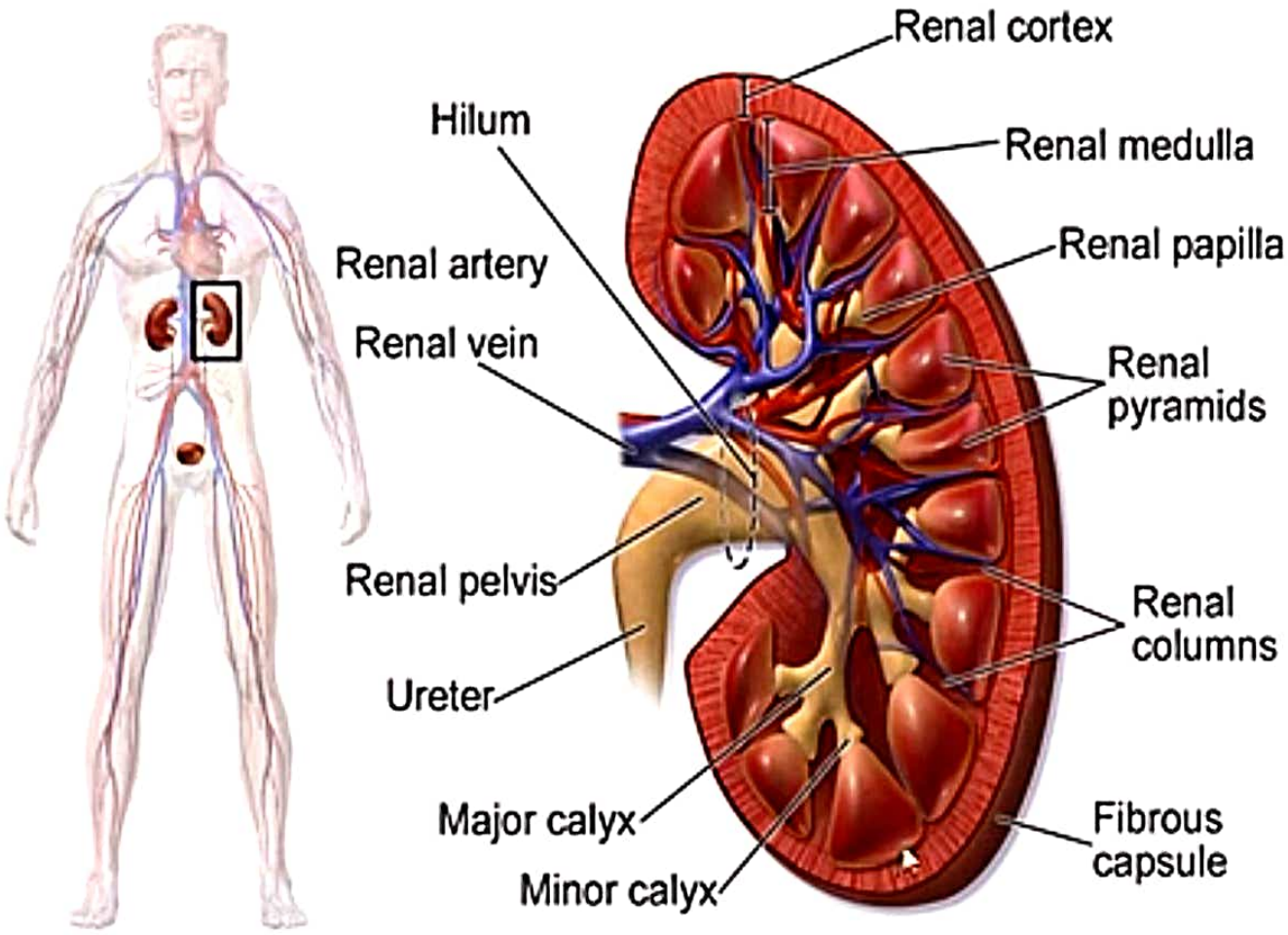


Figure 3.10: Anatomy of kidney

2.1 Architecture of Kidney

- The kidney is composed of **functional units** called **nephrons,** which are the basic structural and functional units of the kidney.
- Each kidney contains **approximately one million nephrons**, and each nephron performs the **functions of filtration, reabsorption, and secretion.**

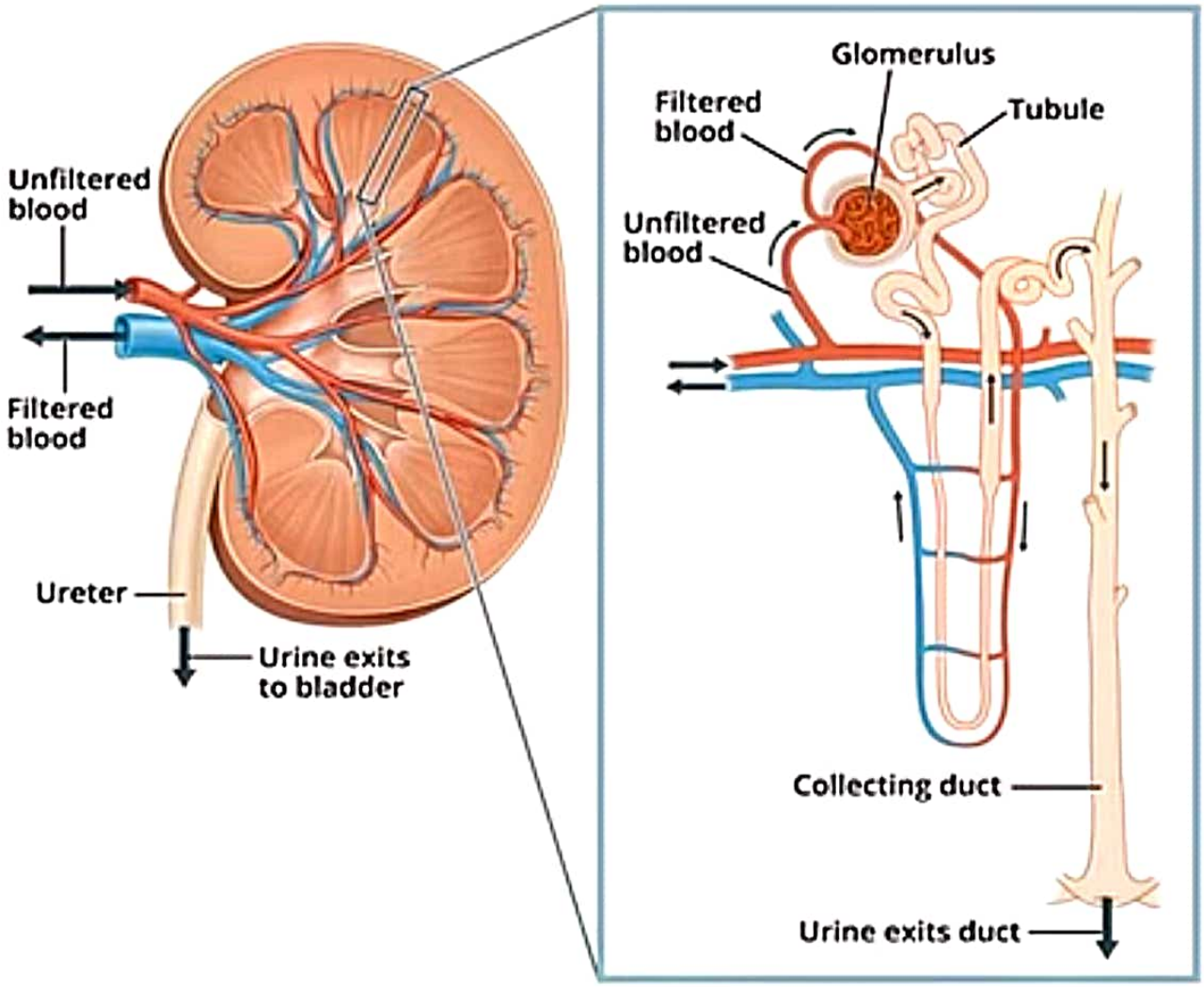


Figure 3.11: Representing kidney and nephron

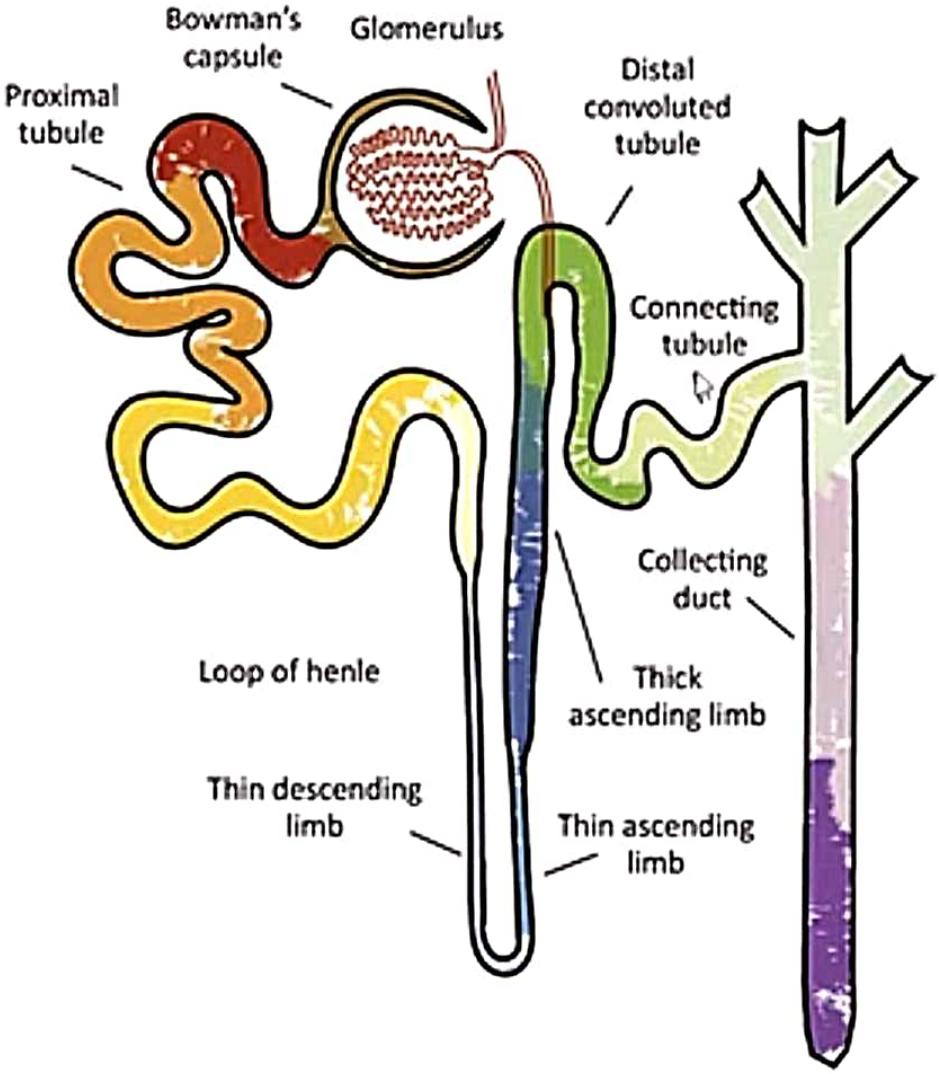


Figure 3.12: Representing the parts of nephron

- The nephron is comprised of several key structures:

1. **Bowman's capsule:** This is a cup-shaped structure that surrounds the glomerulus and filters waste and excess fluid from the bloodstream into the renal tubule.
2. **Glomerulus:** A network of tiny blood vessels within the Bowman's capsule that filters waste and excess fluid from the bloodstream.
3. **Proximal convoluted tubule:** A segment of the renal tubule that reabsorbs important substances, such as glucose, amino acids, and electrolytes, back into the bloodstream.

4. **X Loop of Henle:** A U-shaped segment of the renal tubule that is critical for the reabsorption of ions and water.
5. **Distal convoluted tubule:** A segment of the renal tubule that regulates the levels of electrolytes and other important substances in the bloodstream.
6. **Collecting duct:** A series of ducts that collect the filtrate from the renal tubules and transport it to the renal pelvis, where it drains into the ureter and eventually into the bladder.

2.2 Mechanism of Filtration – Urine Formation

- The **mechanism of filtration** in the kidneys is a complex process that involves multiple steps **to remove waste and excess fluids** from the bloodstream.
- The following is a summary of the steps involved in the filtration process:

1. **Blood enters the** kidney through the renal arteries and flows **into** tiny filtering units called glomeruli.
2. At the glomerulus, the pressure in the blood vessels causes a portion of the **plasma and dissolved substances to filter out** and **enter** a structure called Bowman's capsule.
3. In Bowman's capsule, the filtrate is then transferred into the renal tubules, which are the **main filtering units of the kidneys.**

4. In the renal tubules, the **filtrate passes through a series of specialized cells**, such as proximal tubular cells and distal tubular cells, which **reabsorb important substances such as glucose, amino acids, and electrolytes back into the bloodstream**.
5. **At the same time**, the renal tubules **secrete waste products**, such as **urea and creatinine**, back into the filtrate.
6. Finally, the filtered fluid, now known as **urine**, is transported **through the renal pelvis and ureters** to the **bladder**, where it is eventually eliminated from the body.

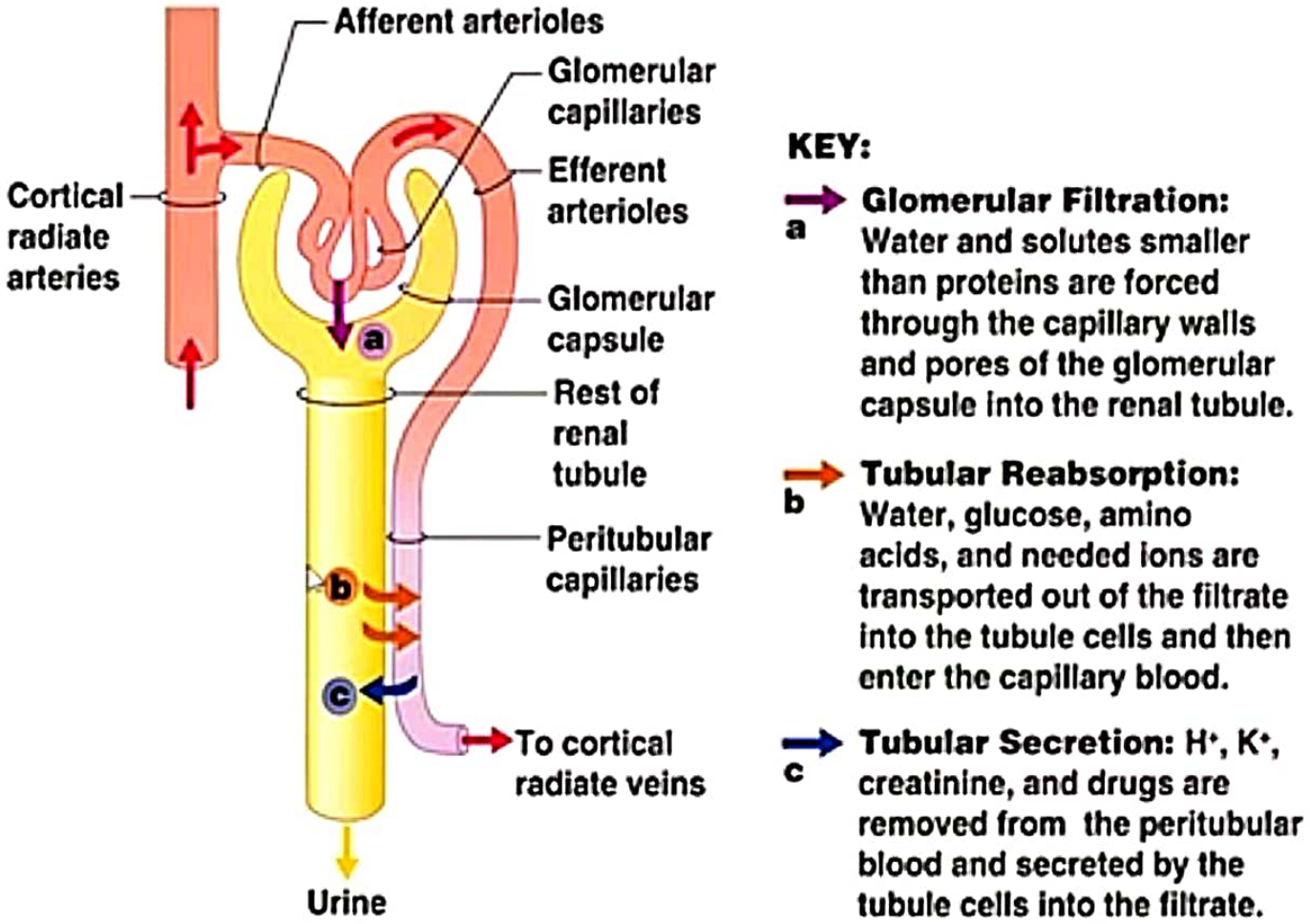


Figure 3.13: Schematic of mechanism of filtration in human kidney

- This process of **filtration, reabsorption, and secretion** helps to maintain the proper balance of fluids and electrolytes in the body, as well as to **remove waste and excess substances.**

2.3 Chronic Kidney Disease (CKD)

- CKD stands for Chronic Kidney Disease.
- It is a **long-term condition** in which the kidneys ***gradually become less able to function*** properly.
- It can be caused by a **variety of factors**, including **diabetes, high blood pressure, and other health problems** that damage the kidneys.

- Symptoms of CKD include fatigue, swelling in the legs and feet, trouble sleeping, and difficulty concentrating.
- As the disease progresses, it can lead to more serious complications, such as **anemia, nerve damage,** and an increased risk of **heart disease and stroke**

- Treatment for CKD may include **lifestyle changes**, such as **eating a healthy diet** and **exercising regularly**, as well as **medications** to manage symptoms and underlying health conditions.
- In severe cases, **kidney transplant or dialysis** may be necessary.
- It is important for individuals with risk factors for CKD to **get regular check-ups** and to talk to their doctor about **how to best manage their condition.**

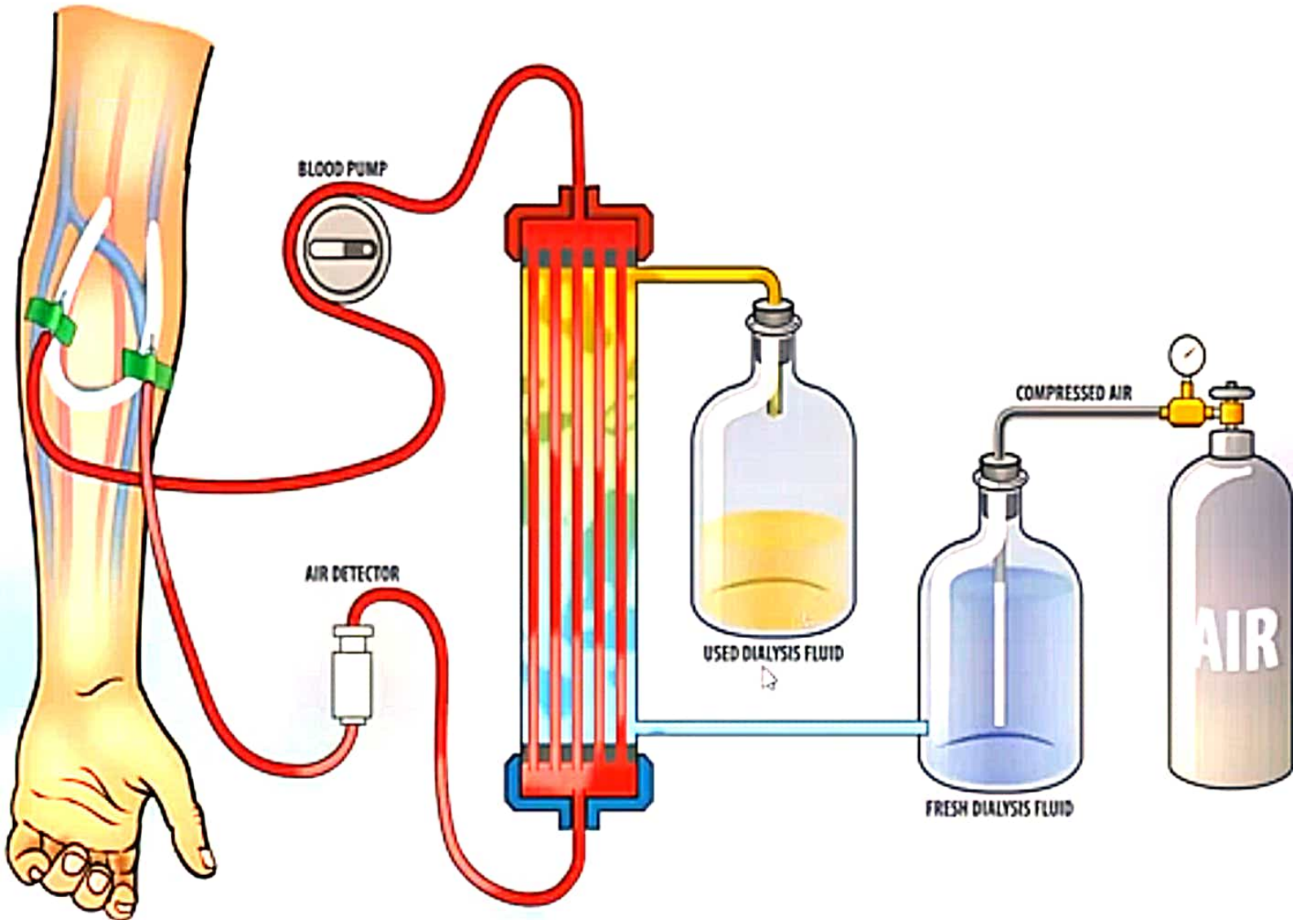
2.4 Dialysis Systems

- Dialysis is a medical treatment that **helps to filter waste and excess fluids** from the blood when the kidneys are unable to function properly.
- There are two main types of dialysis systems:

1. **Hemodialysis** and
2. **Peritoneal dialysis.**

1.Hemodialysis

- It uses a **machine to clean the blood.**
- During hemodialysis, **blood is removed** from the body, **passed through a dialysis machine** that filters out waste and excess fluids, and then returned to the body.
- Hemodialysis **typically takes place in a hospital or dialysis center**, and is typically performed **three times a week** for three to four hours at a time.


BLOOD PUMP
AIR DETECTOR
USED DIALYSIS FLUID
COMPRESSED AIR
AIR
FRESH DIALYSIS FLUID

2.Peritoneal dialysis

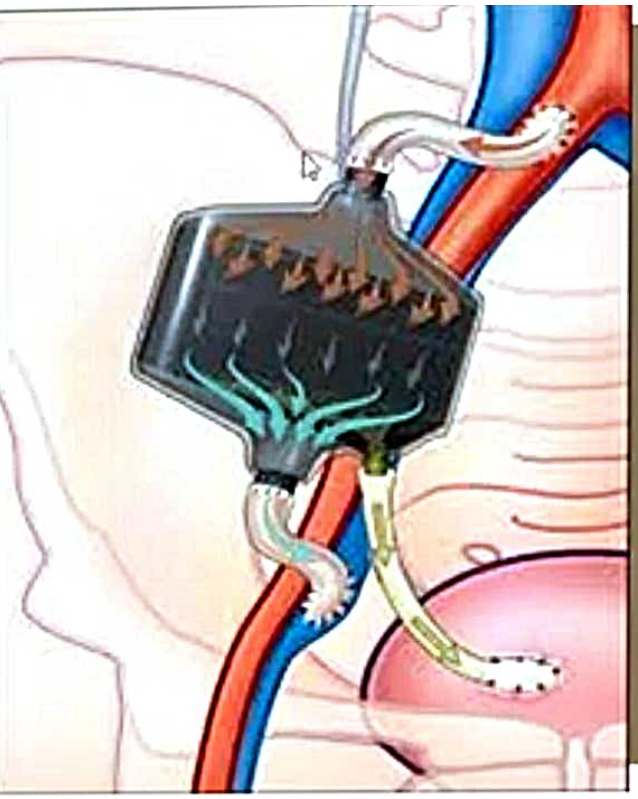
- A type of dialysis that **uses the lining of the abdomen,** called the **peritoneum**, to filter waste and excess fluids from the blood.
- A **sterile solution** is introduced into the abdomen, where **it absorbs waste and excess fluids**, and is then drained and replaced with fresh solution.
- Peritoneal dialysis **can be performed at home** and allows for more flexibility in scheduling.

- Both hemodialysis and peritoneal dialysis can effectively treat the symptoms of kidney failure, but each has its own **advantages and disadvantages.**
- The choice of dialysis system depends on various factors such as the **individual's overall health, lifestyle, and personal preferences**

2.5 Artificial Kidney

- While much progress has been made in developing an artificial kidney, **it is still in the experimental stage** and is not yet widely available.
- Further research and development is needed **to improve the efficiency and safety** of artificial kidney devices, and to ensure that they can be widely adopted as a treatment for chronic kidney disease.

- An artificial kidney is a device that is being developed **to mimic the functions** of the human kidney.
- The goal of an artificial kidney is **to provide a more effective and efficient** means of **treating patients** with chronic kidney disease, who currently rely on dialysis or kidney transplantation.



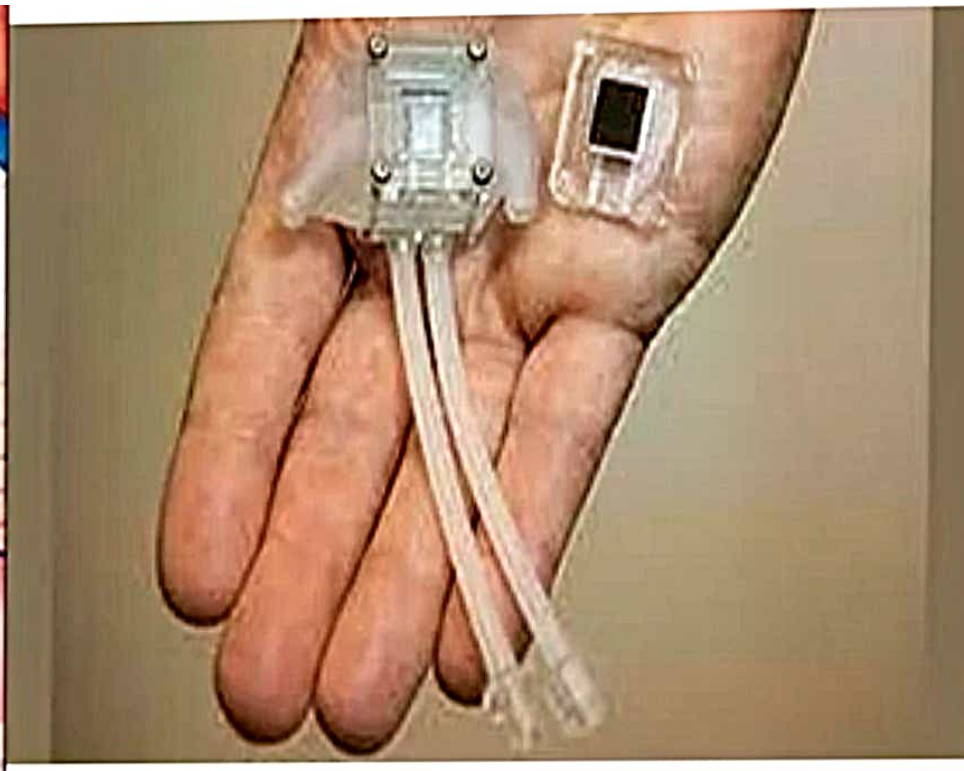


Figure 3.17: a) Schematic representation b) a prototype of artificial kidney

Approaches

- There are currently two main approaches to developing an artificial kidney: a biological approach and a technological approach.

1. **The biological approach** involves using living cells, such as **kidney cells or stem cells**, to create a functional, implantable artificial kidney.
2. **The technological approach** involves using synthetic materials, such as **silicon or polymer**, to create a dialysis device that can filter the blood and remove waste and excess fluids

- It's important to note that while the development of an artificial kidney holds great promise, it is **not a cure for chronic kidney disease** and patients with kidney failure will still need dialysis or kidney transplantation in the meantime