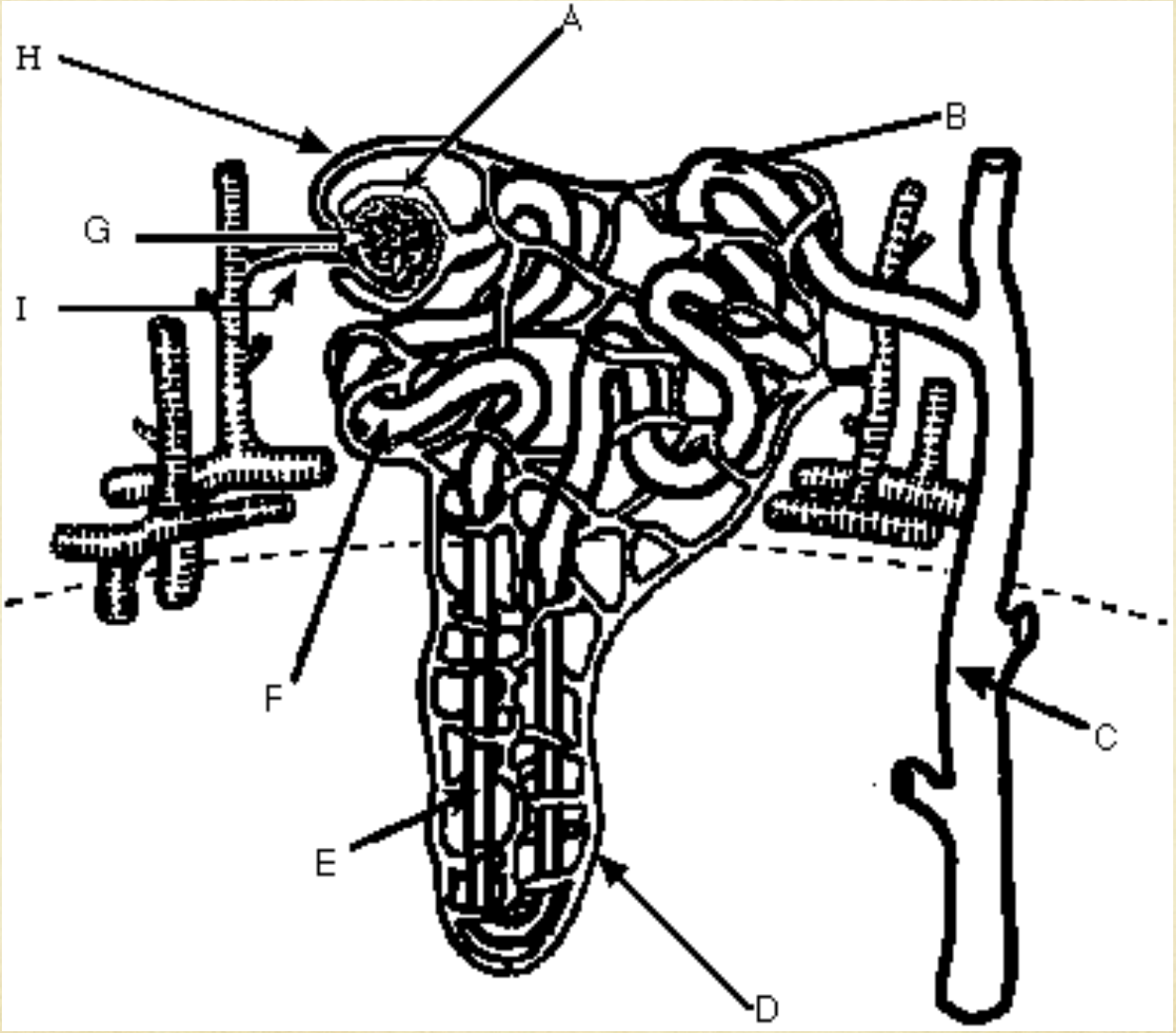
II. Nephron Structure and Function



A. Afferent arteriole (I)
   1. Blood vessel entering the glomerulus.
   2. Contains ‘normal’ blood.
   3. Blood pressure is higher here than in the efferent arteriole.

B. Efferent arteriole (H)
   1. Blood vessel leaving the glomerulus.
   2. Travels to the capillary network surrounding the nephron.
   3. Contains ‘thick’ blood with less plasma

C. Glomerulus capillary network (G)
   1. Where a large portion of the blood plasma filters from the blood vessels into the Bowman's capsule.

D. Bowman's capsule/glomerular capsule(A)

1. Cup-like end of nephron where plasma is forced out of the blood and into the nephron.
2. Collecting area for blood plasma from the glomerulus.
3. Blood is PRESSURE FILTERED.
    a. Large objects stay inside the glomerulus.
        i. Blood cells
        ii. Platelets
        iii. Proteins (globulins, enzymes, hormones)
    b. Small objects are squeezed out of the glomerulus into the Bowman's capsule.
        i. Urea
        ii. Nutrients
        iii. Salts
        iv. Water
    c. What ends up in the capsule is equivalent to blood plasma now called GLOMERULAR FILTRATE

E. Capillary network (D)

1. Nest of capillaries surrounding the nephron.
2. Reabsorb most of nutrients, H_2O etc.

F. Proximal convoluted tubule (F)

1. Active and passive SELECTIVE REABSORPTION occurs here.
2. Interior cells have microvilli and many mitochondria.
3. Sugars, amino acid, positive ions are ACTIVELY transported out of filtrate in the nephron and returned to the blood via capillary network.
4. Active transport uses ATP and O_2.
5. Specific carrier proteins in epithelial cells bind and transport specific molecules.
6. Negative ions (e.g. Cl^-) passively flow into the bloodstream due to attraction to the positive ions.
7. The filtrate is now less concentrated than the blood (hypotonic!), so water moves from the filtrate to the blood by osmosis.

G. Loop of Henle/Loop of the nephron (E)

1. Dips down into medulla, then back up into cortex.
2. Two sections
   a. Descending limb
   b. Ascending limb
3. Absorbs over 99% of the water in the original filtrate.
4. A hypertonic environment is maintained in the medulla tissue to aid loop functioning.
5. Function of descending limb:
   a. H_2O diffused out of descending limb because the medulla is more hypertonic compared to the loop.
   b. The deeper the filtrate travels into the medulla, the greater the osmotic gradient so this keeps the water flowing out of the descending limb.
   c. This water is picked up by the peritubular capillaries and returned to the bloodstream.

6. Function of the ascending limb:
    a. IMPERMEABLE to water.
    b. Na^+ and Cl^- diffuse passively out of the lower portion.
    c. They are actively PUMPED out at the top.
    d. This action makes the medulla "salty" (hypertonic)
7. This pattern is called countercurrent exchange.

H. Distal convoluted tubule (B)

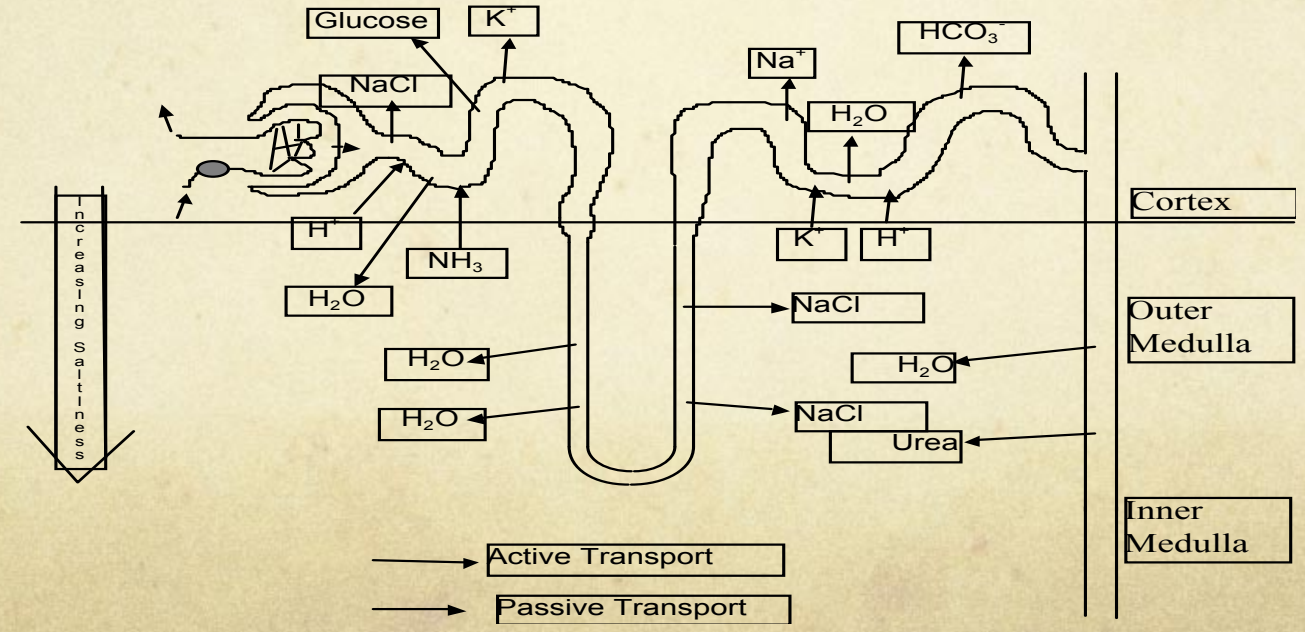
1. TUBULAR EXCRETION from the nephron tubule into the capillary network occurs here.
2. Materials that are actively excreted from blood into distal convoluted tubule:
    a. NH_4^+ and H^+ ions
    b. Penicillin
    c. Creatinine
    d. Histimine
    e. Blood pH can be regulated by this active excretion of H^+.

I. Collecting duct (C)

1. Many distal tubules feed into one collecting duct.
2. Filtrate that reaches here is isotonic to the blood, due to the reabsorption of water and salt in nephron but the collecting duct travels through same hypertonic medulla, so more water diffuses out of collecting duct, making urine more concentrated.

3. Collecting duct area is very important in regulating the overall water content of urine because ADH hormone acts here to regulate permeability to water.

A comparison of urine and plasma!	
URINE	**PLASMA**
WATER: 95%	WATER: 90-92%
UREA: ~2.5-3%	PROTEINS: 7-8%
CREATININE: .2%	SALTS: <1%
AMMONIA: ~.2%	
URIC ACID: ~.1%	
IONS: ~2%	URINE IS HYPERTONIC TO PLASMA
Na^+, Cl^-, K^+, SO_4^{-2} Mg^{+2}, PO_4^{-2}, Ca^{+2}	



O3: Blood in Renal Artery and Vein

I. Glucose

A. Renal Artery: 100 mg/L

B. Renal Vein: 98 mg/L

C. Glucose is 100% reabsorbed from the filtrate into the blood.

D. 2 mg/L drop results from use of sugar to make ATP to fuel all the active transport that is happening in the tubules.

II. Urea

A. Renal Artery: 30 mg/L

B. Renal Vein: 25 mg/L

C. Urea is lower in the renal vein because it is excreted in the filtrate.

D. Kidneys do not remove ALL the wastes from the blood; they remove enough to keep waste levels healthy.

O4-O5: ADH and Aldosterone

I. Blood Volume Regulation
   - A. Done by 2 hormones:
     1. ANTIDIURETIC HORMONE (ADH)
     2. ALDOSTERONE

II. ADH - Antidiuretic Hormone "Anti Pee"
   - A. Controls H_2O balance.
   - B. Secreted by the posterior pituitary gland.
   - C. Increases the permeability of the distal tubule and collecting duct so that more water can be reabsorbed back into the blood.
   - D. If ADH is secreted:
     1. Blood volume increases.
     2. Blood becomes more dilute.
     3. Urine becomes more concentrated.

E. ADH secretion is controlled by the water content of the blood.

1. Cells in hypothalamus detect low H_2O content of blood.
2. ADH released into blood, acts on distal convoluted tubule and collecting duct.
3. More H_2O reabsorbed so the volume of urine decreases.
4. Therefore, blood volume increases.
5. As blood becomes more dilute, this is detected by the hypothalamus, ADH secretion stops (a negative feedback loop!)

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F. Diuretics

1. Chemicals that increase urine output
2. Some examples and their mechanisms:

a. Diuretic drugs
   i. Prescribed for high blood pressure, inhibits ADH secretion.
   ii. Lower blood volume and thus blood pressure (cause increased urination).

b. Caffeine
   i. Increases blood pressure.
   ii. Increases filtration at glomerulus.
   iii. Lowers Na^+ reabsorption
   iv. Results in increased urine output.

c. Alcohol

i. Inhibits hypothalamus, and thus pituitary's secretion of ADH.

ii. Results in increased urine output.

iii. Person becomes dehydrated and that leads to a hangover!

iv. Beer and alcohol cannot quench your thirst! (you will urinate more!)

III. Aldosterone

A. Hormone secreted by adrenal cortex (outer layer of the adrenal gland on top of each of the kidneys).

B. Increases reabsorption of Na^+ back into blood.

C. This encourages water to be reabsorbed, which causes blood volume and pressure to rise.

D. Concentration of sodium in blood regulates secretion of aldosterone.

1. Triggered by low blood volume and/or low blood Na^+ concentrations cause more aldosterone to be produced.
2. High blood volume and/or high blood Na^+ concentrations cause less aldosterone to be produced. (Another negative feedback loop!)

IV. Atrial Natriuretic Hormone (ANH)

A. Secreted by heart atria.

B. High blood volume stretches the cardiac muscles to produce ANH.

C. ANH promotes the excretion of Na^+ ("natriuresis").

D. More Na^+ in urine causes more water to move into urine from blood so the blood volume and pressure drop.

E. ANH also inhibits aldosterone secretion!

V. Kidneys and Blood pH

A. Kidneys help maintain blood pH (H^+).

B. Nephrons vary the amount of H^+ and NH_3 that they excrete and the amount of HCO_3^- and Na^+ they reabsorb.

C. If the blood is acidic,

1. More H^+ and ammonia are excreted.
2. More sodium bicarbonate is reabsorbed.

D. Sodium bicarbonate neutralizes acid.

$Na^+HCO_3^- + HOH \dashrightarrow H_2CO_3 + NaOH$

E. If the blood is alkaline,

1. Less H^+ excreted.
2. Less Na^+ and HCO_3^- reabsorbed.

F. Reabsorption and excretion of ions (e.g. K+, Mg++) by kidneys maintains proper electrolyte balance of blood.