

## Renal Hemodynamic and Glomerular Filtration

## Capillary Beds of the Nephron

- Every nephron has two capillary beds
  - Glomerulus
  - Peritubular capillaries
- Each glomerulus is:
  - Fed by an afferent arteriole
  - Drained by an efferent arteriole

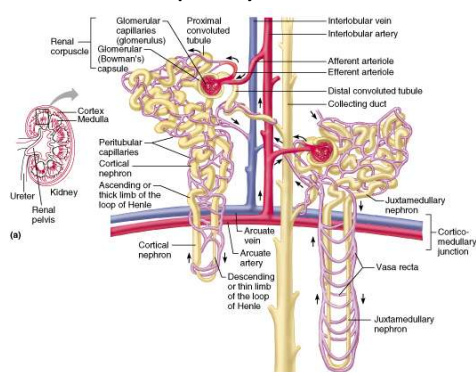
## Capillary Beds of the Nephron

- Blood pressure in the glomerulus is high because:
  - Arterioles are high-resistance vessels
  - Afferent arterioles have larger diameters than efferent arterioles
- Fluids and solutes are forced out of the blood throughout the entire length of the glomerulus

## Capillary Beds

- Peritubular beds are low-pressure, porous capillaries adapted for absorption which:
  - Arise from efferent arterioles
  - Cling to adjacent renal tubules
  - Empty into the renal venous system
- Vasa recta – long, straight efferent arterioles of juxtamedullary nephrons

## Capillary Beds



## Vascular Resistance in Microcirculation

- Afferent and efferent arterioles offer high resistance to blood flow
- Blood pressure declines from 95 mm Hg in renal arteries to 8 mm Hg in renal veins
- Resistance in afferent arterioles:
  - Protects glomeruli from fluctuations in systemic blood pressure
- Resistance in efferent arterioles:
  - Reinforces high glomerular pressure
  - Reduces hydrostatic pressure in peritubular capillaries

### Vascular Resistance in Microcirculation

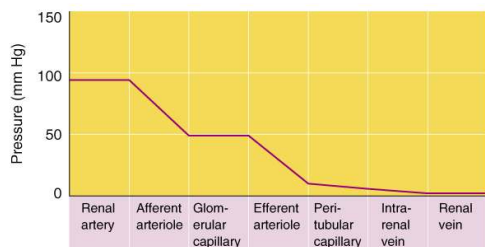


Figure 24.6

### Juxtaglomerular Apparatus (JGA)

- Where the distal tubule lies against the afferent (sometimes efferent) arteriole
- Arteriole walls have juxtaglomerular (JG) cells
  - Enlarged, smooth muscle cells
  - Have secretory granules containing renin
  - Act as mechanoreceptors

### Juxtaglomerular Apparatus (JGA)

- Macula densa
  - Tall, closely packed distal tubule cells
  - Lie adjacent to JG cells
  - Function as chemoreceptors or osmoreceptors
- Mesangial cells appear to control the glomerular filtration rate

### Juxtaglomerular Apparatus (JGA)

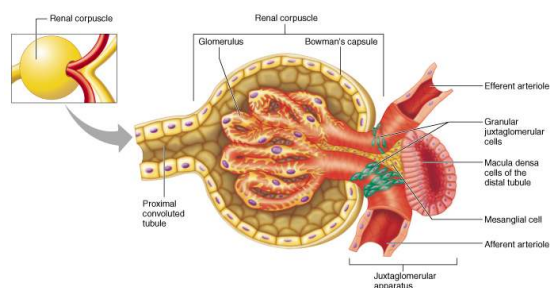


Figure 24.7

### Filtration Membrane

- Filter that lies between the blood and the interior of the glomerular capsule
- Composed of three layers
  - Fenestrated endothelium of the glomerular capillaries
  - Visceral membrane of the glomerular capsule (podocytes)
  - Basement membrane composed of fused basal laminas of the other layers

### Filtration Membrane

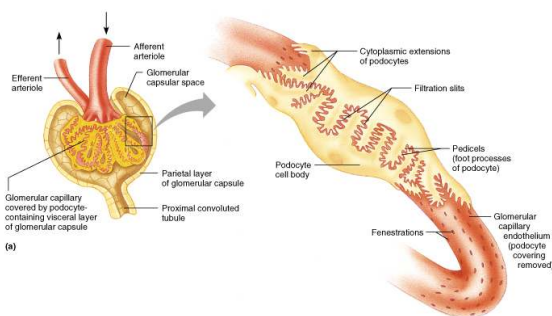


Figure 24.8a

## Filtration Membrane

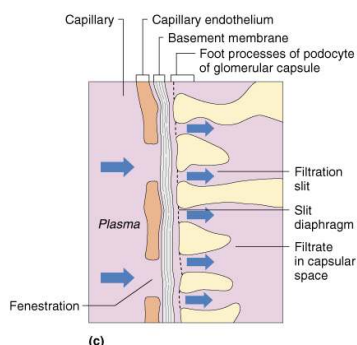


Figure 26.8c

## Mechanism of Urine Formation

- The kidneys filter the body's entire plasma volume 60 times each day
- The filtrate:
  - Contains all plasma components except protein
  - Loses water, nutrients, and essential ions to become urine
- The urine contains metabolic wastes and unneeded substances

## Mechanism of Urine Formation

- Urine formation and adjustment of blood composition involve three major processes
  - Glomerular filtration
  - Tubular reabsorption
  - Secretion

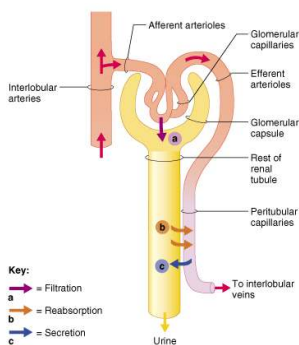


Figure 24.9

## Glomerular Filtration

- Principles of fluid dynamics that account for tissue fluid in all capillary beds apply to the glomerulus as well
- The glomerulus is more efficient than other capillary beds because:
  - Its filtration membrane is significantly more permeable
  - Glomerular blood pressure is higher
  - It has a higher net filtration pressure
- Plasma proteins are not filtered and are used to maintain oncotic pressure of the blood

## Net Filtration Pressure (NFP)

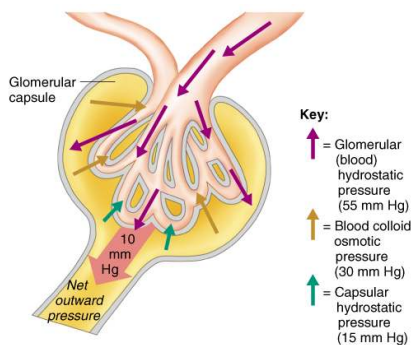
- The pressure responsible for filtrate formation
- NFP equals the glomerular hydrostatic pressure ( $HP_g$ ) minus the oncotic pressure of glomerular blood ( $OP_g$ ) combined with the capsular hydrostatic pressure ( $HP_c$ )

$$NFP = HP_g - (OP_g + HP_c)$$

## Glomerular Filtration Rate (GFR)

- The total amount of filtrate formed per minute by the kidneys
- Factors governing filtration rate at the capillary bed are:
  - Total surface area available for filtration
  - Filtration membrane permeability
  - Net filtration pressure
- GFR is directly proportional to the NFP
- Changes in GFR normally result from changes in glomerular blood pressure

## Glomerular Filtration Rate (GFR)



## Regulation of Glomerular Filtration

- If the GFR is too high:
  - Needed substances cannot be reabsorbed quickly enough and are lost in the urine
- If the GFR is too low:
  - Everything is reabsorbed, including wastes that are normally disposed of
- Three mechanisms control the GFR
  - Renal autoregulation (intrinsic system)
  - Neural controls
  - The renin-angiotensin system (hormonal mechanism)

## Intrinsic Controls

- Under normal conditions, renal autoregulation maintains a nearly constant glomerular filtration rate
- Autoregulation entails two types of control
  - Myogenic – responds to changes in pressure in the renal blood vessels
  - Tubuloglomerular feedback – senses changes in the juxtaglomerular apparatus

## Sympathetic Nervous System (SNS) Controls

- When the SNS is at rest:
  - Renal blood vessels are maximally dilated
  - Autoregulation mechanisms prevail
- Under stress:
  - Norepinephrine is released by the SNS
  - Epinephrine is released by the adrenal medulla
  - Efferent arterioles constrict and filtration is inhibited
- The SNS also stimulates the renin-angiotensin mechanism

## Renin-Angiotensin Mechanism

- Is triggered when the JG cells release renin
- Renin acts on angiotensinogen to release angiotensin I
- Angiotensin I is converted to angiotensin II
- Angiotensin II:
  - Causes mean arterial pressure to rise
  - Stimulates the adrenal cortex to release aldosterone
- As a result, both systemic and glomerular hydrostatic pressures rise