Intake:
Na^+ ~ 5-200 mmoles/day
K^+~ 50-300 "
H_20 ~ 0.5-3 L/day
H^+ ~ 50-100 mEq/day

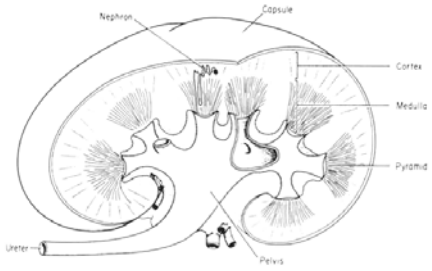
Air water ~ 3000 mOsm/Kg H_20

Extracellular Fluid
Volume ~ 1/3 body water; Osmol 290 mOsm/Kg H_20
Na^+ 142 mM; K^+ 4 mM; H^+ 40 nM (pH 7.40)

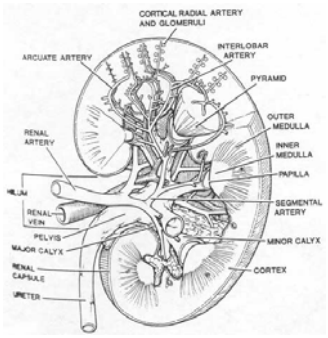
Cells

urine

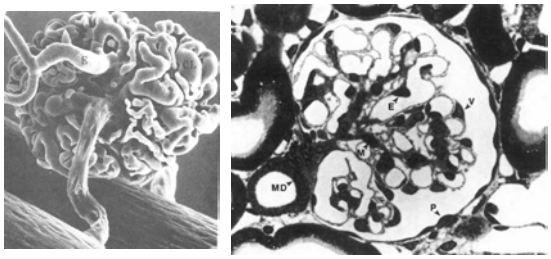
Kidney



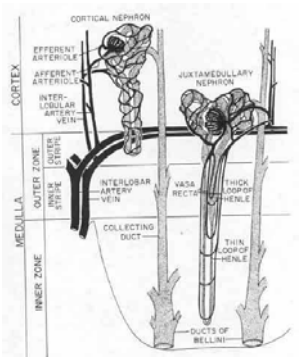
Kidney Vasculature



Glomerulus



Nephron Circulation

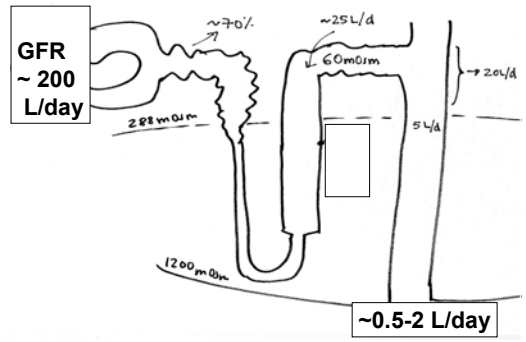


Blood Flow in Resting Human

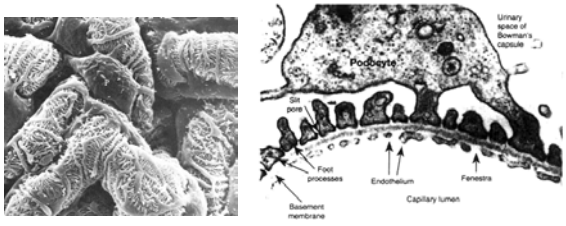
Organ	*Weight kg*	*Resting Blood Flow ml/min*	*Resting Blood Flow ml/min/100g*	*Cardiac Output %*
Brain	1.4	750	55	14
Heart	0.3	250	80	5
Kidneys	0.3	1,200 ★	400	22
Liver	1.5	1,300	85	23
Muscles	35.0	1,000	3	18
Skin	2.0	200	10	4
Bone, etc.	27.0	800	3	14

★ RPF ~ 600 m/mi = 36L/h = 864L/day

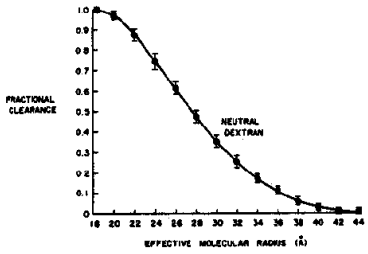
Volume of Urine



Glomerular Capillary Wall



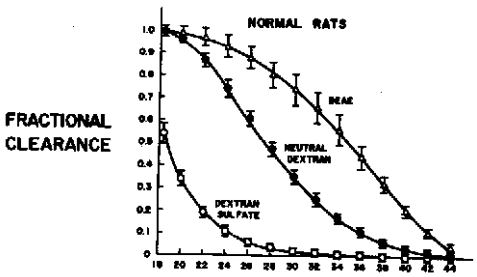
Fractional Clearance Across Glomerular Capillary



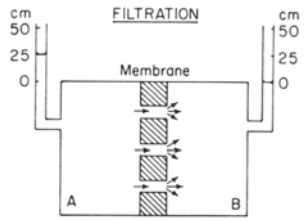
Glomerular "Sieve"

SUBSTANCE	MOL.WT. Grams	DIMENSIONS IN ANGSTROM UNITS: Radius from Diffusion Coefficient	Dimensions from X-Ray Diffraction	(FILTRATE)/(FILTRAND)
WATER	18	1.0 ·		1.0
UREA	60	1.6 ·		1.0
GLUCOSE	180	3.6 ·		1.0
SUCROSE	342	4.4 •		1.0
INULIN	5,500	14.8 •		0.98
MYOGLOBIN	17,000	19.5 ●	54 × 18	0.75
EGG ALBUMIN	43,500	28.5 ●	88 × 32	0.22
HEMOGLOBIN	68,000	32.5 ●	54 × 54 × 32	0.03
SERUM ALBUMIN	69,000	35.5 ●	150 × 36	<0.01

Electrical Charge Effect on Fractional Clearance Across Glomerular Capillary



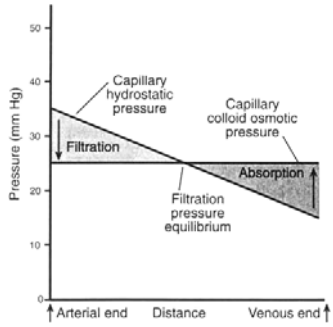
Forces Driving Filtration



$P_A > P_B$

$\dot{Q} = k_f \Delta P$

Filtration & Reabsorption In Systemic Capillary



Forces Determining GFR

Systemic capillary: F = Kf x [(Pc-Pi) - (Ac-Al)]

Glomerular capillary: GFR = Kf x [(Pgc-Pu) – (Agc-Au)]

Because Pu is unregulated and believed to be constant and AU = 0, then

$$GFR = Kf \times (\Delta P - Agc)$$

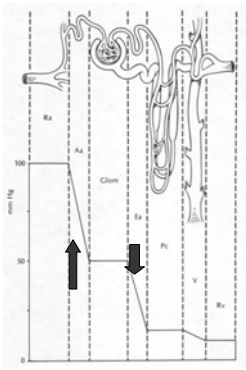
Permeability of Glomerular Capillary

Effective Hydraulic Permeability (k) of Various Capillaries

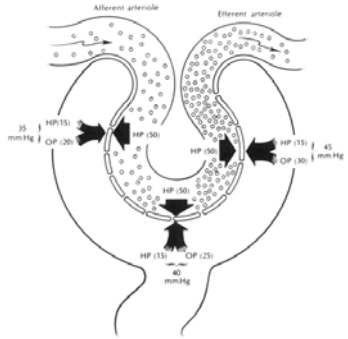
Capillary (Source)	*k* *nl/(sec-mm Hg-cm²)*
Renal	
Glomerular (rat)	**41**
Peritubular (rat)	**1.0**
Extrarenal	
Cremaster muscle (rat)	**0.9**
Mesentery (frog)	**0.65-1.0**
Omentum (rabbit)	**0.3-9.0**

***Glomerular Ultrafiltration,* W. M. Dean et al., 1974.**

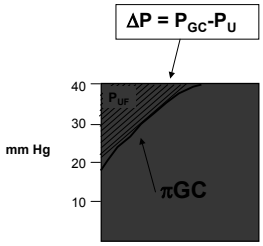
Pressures Inside the Renal Circulation



Filtration Pressures in Glomerular Capillary

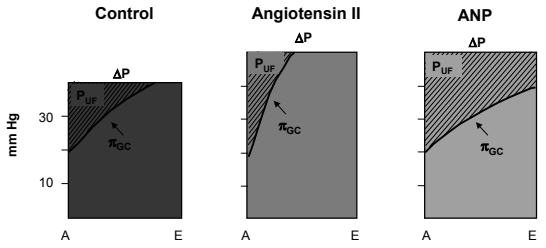


Filtration Pressures in Glomerular Capillary



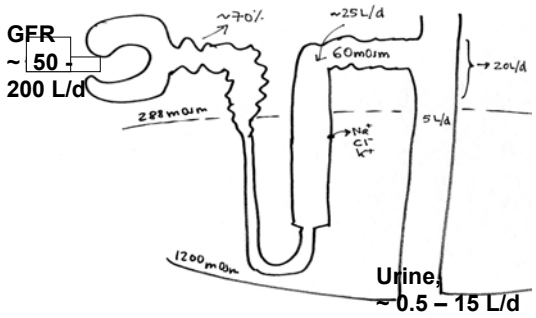
$$GFR = Kf \times (\Delta P - \pi GC) = Kf \times P_{UF}$$

Factors Regulating P_{GC}



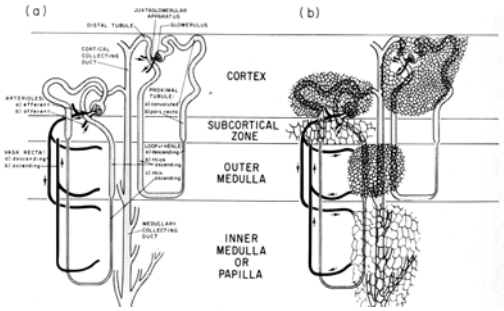
Distance Along Glomerular Capillary

Volume of Urine

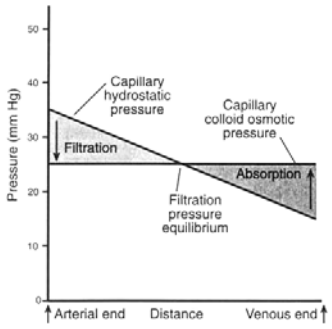


Urine:
~ 0.5 – 15 L/d

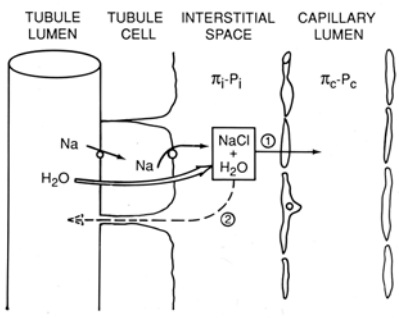
Nephron Capillaries



Filtration & Reabsorption In Systemic Capillary



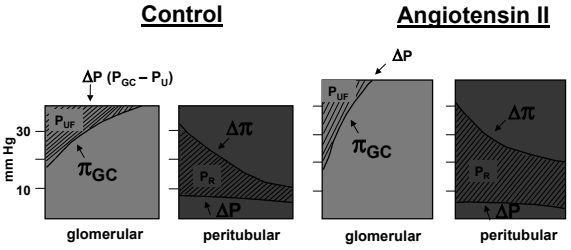
Starling's Forces in Peritubular Capillary



$P_R = Kf\,(B_C - B_i) - (P_C - P_i)$

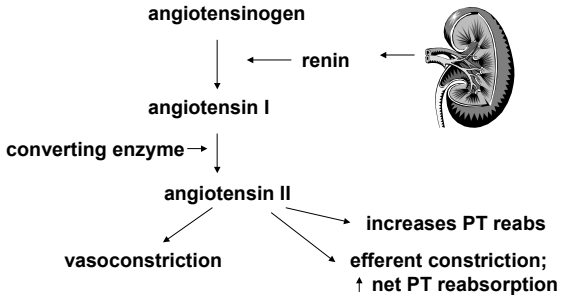
$P_R = Kf\,(\,)B - \,)P)$

Glomerular and Peritubular Starling Forces



Distance Along Capillary

Renin-Angiotensin System

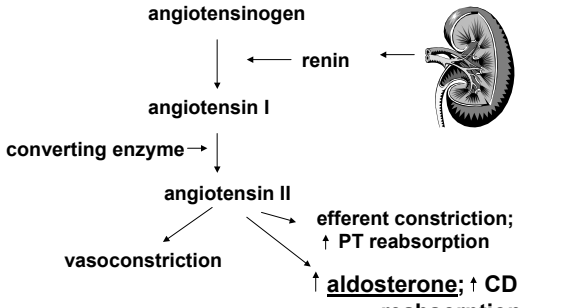


Angiotensin II Direct Effects on Kidney Function

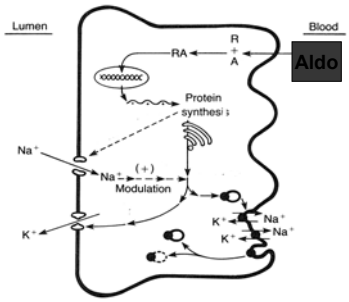
1 - constricts Efferent Arteriole: ↑P_{GC} and ↑A_{GC} ; does not change GFR but ↑ peritubular capillary A and, therefore, ↑ net Proximal Tubule sodium reabsorption

2- directly ↑Proximal Tubule Na^+ transport

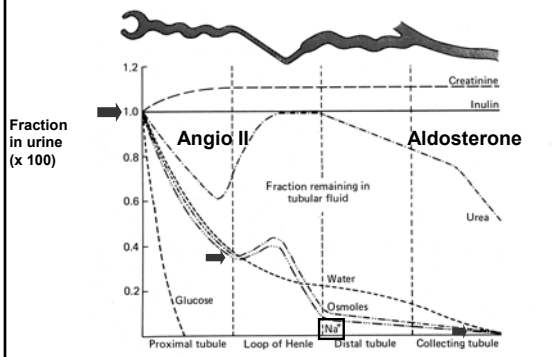
Renin-Angiotensin System



Aldosterone Effect on Na^+ and K^+ in the Collecting Duct



Fractional Na^+in Urine along the Nephron



Measurement of GFR

If a substance is freely filterable, then its rate of filtration is,

Plasma [x] x GFR vol/time

The rate of urinary excretion of any substance is,

Urine [x] x Urine volume/time

If all of x that is filtered appears in the final urine, then we have

$$P[x] \times GFR = U[x] \times V$$

and,

$$GFR = U[x] \times V / P[x]$$