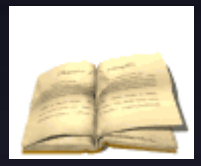
RENAL PHYSIOLOGY

RENAL CLEARANCE



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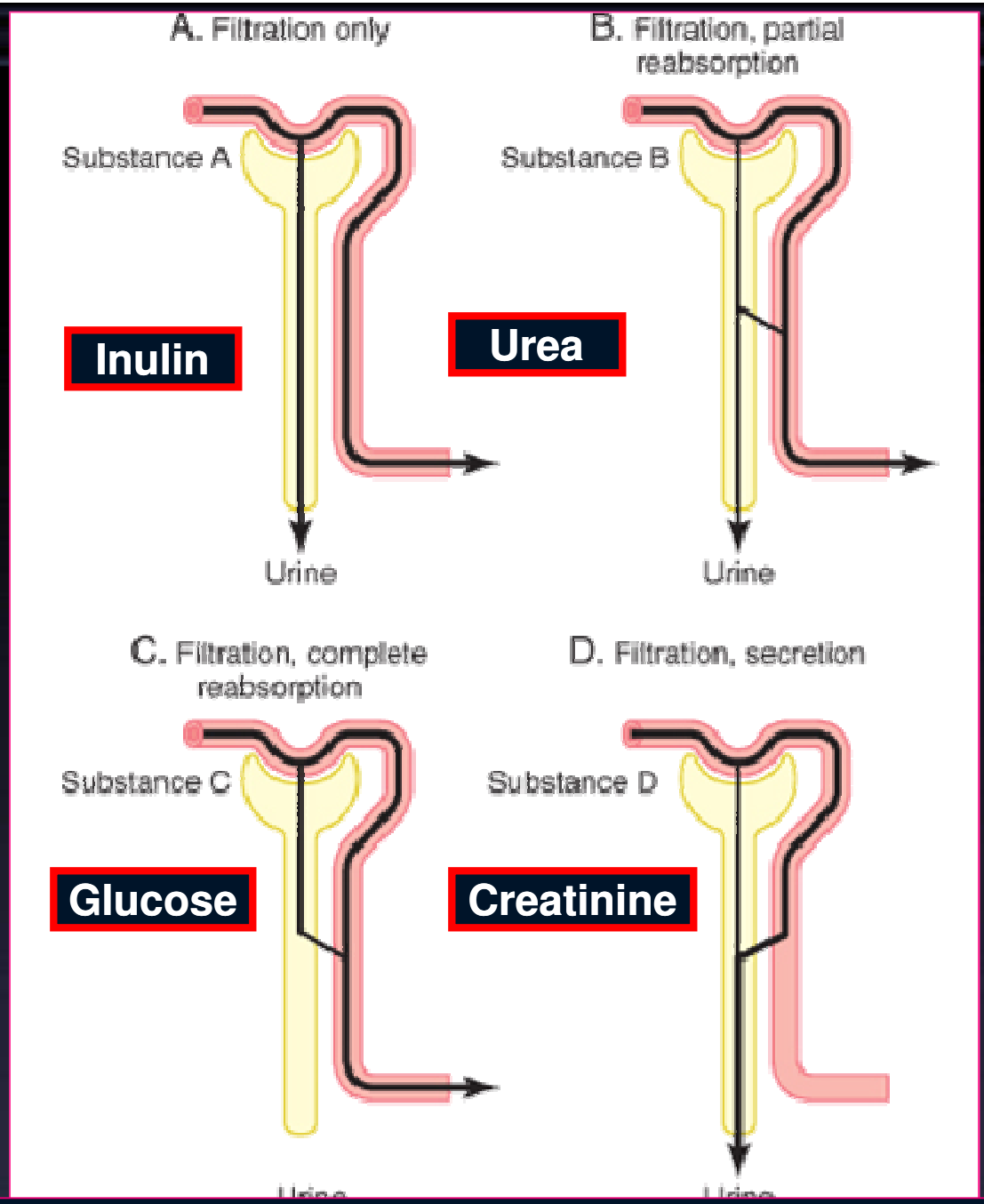
RENAL CLEARANCE

The Volume of Plasma that is completely cleared of any substance by the Kidneys per minute is called the clearance of that particular substance

AFTER A SUBSTANCE IS FREELY FILTERED THERE ARE FOUR POSSIBILITIES

1. **Neither reabsorbed Nor secreted**
2. **All is reabsorbed but it is not secreted**
3. **Partially reabsorbed and is not secreted**
4. **Not reabsorbed but it is secreted**



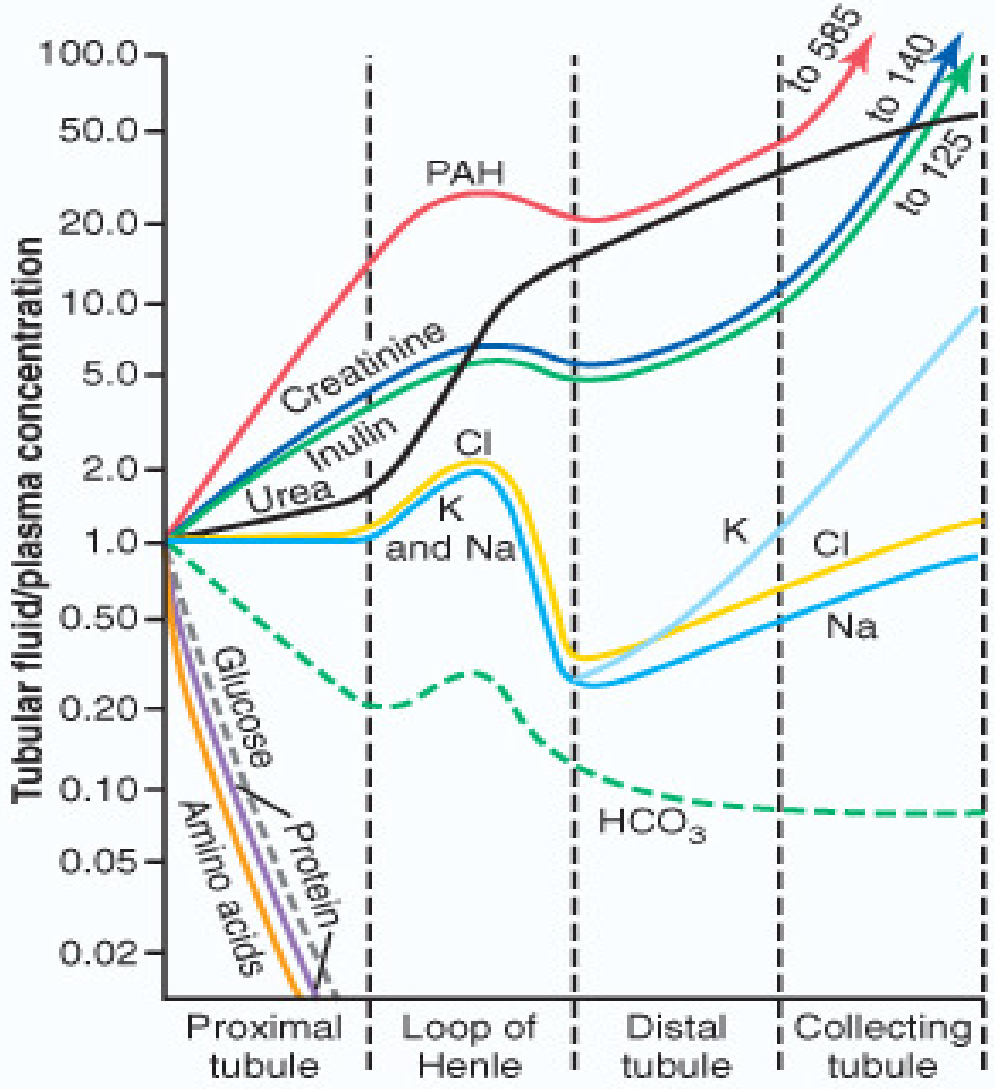
Urinary Excretion Rate = Filtration Rate – Reabsorption Rate + Secretion Rate

FILTRATE HANDLING

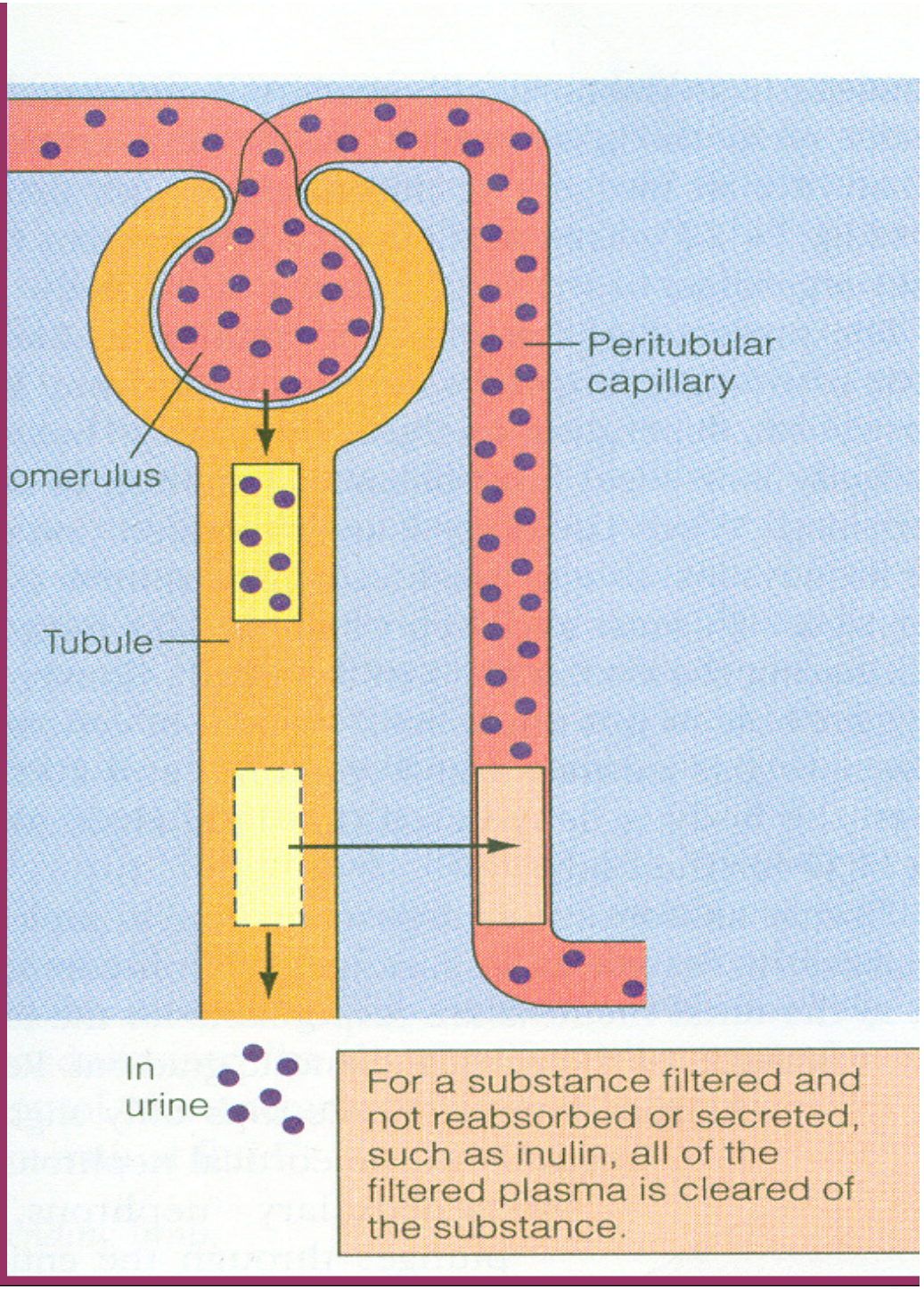
Relative Concentrations of Substances in the Plasma, Glomerular Filtrate, and Urine

Concentrations (mEq/1)			
Substance	***Plasma***	***Glomerular filtrate***	***Urine***
Sodium (Na^+)	142	142	128
Potassium (K^+)	5	5	60
Calcium (Ca^{+2})	4	4	5
Magnesium (Mg^{+2})	3	3	15
Chloride (Cl^-)	103	103	134
Bicarbonate (HCO_3^-)	27	27	14
Sulfate (SO_4^{-2})	1	1	33
Phosphate (PO_4^{-3})	2	2	40
Concentrations (mg/100ml)			
Substance	***Plasma***	***Glomerular filtrate***	***Urine***
Glucose	100	100	0
Urea	26	26	1820
Uric acid	4	4	53

	Amount Filtered	Amount Reabsorbed	Amount Excreted	% of Filtered Load Reabsorbed
Glucose (g/day)	180	180	0	100
Bicarbonate (mEq/day)	4,320	4,318	2	>99.9
Sodium (mEq/day)	25,560	25,410	150	99.4
Chloride (mEq/day)	19,440	19,260	180	99.1
Potassium (mEq/day)	756	664	92	87.8
Urea (g/day)	46.8	23.4	23.4	50
Creatinine (g/day)	1.8	0	1.8	0


Tubular fluid/plasma concentration
100.0
50.0
20.0
10.0
5.0
2.0
1.0
0.50
0.20
0.10
0.05
0.02
PAH
Creatinine
Inulin
Urea
Cl
K
and Na
to 585
to 140
to 125
K
Cl
Na
Glucose
Amino acids
Protein
HCO_3
Proximal tubule
Loop of Henle
Distal tubule
Collecting tubule

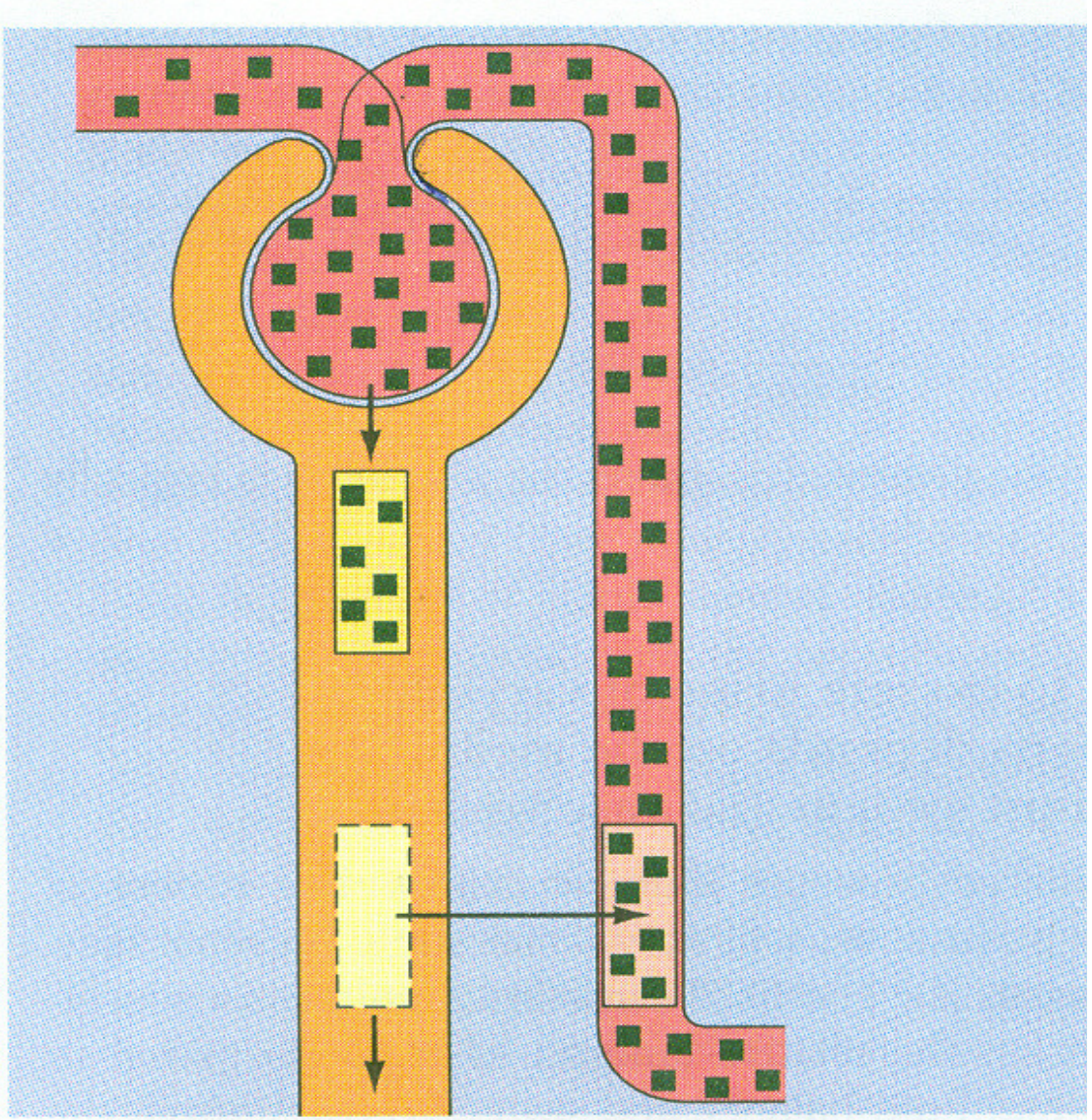
Freely filtered
Not Reabsorbed
Not Secreted



Freely filtered

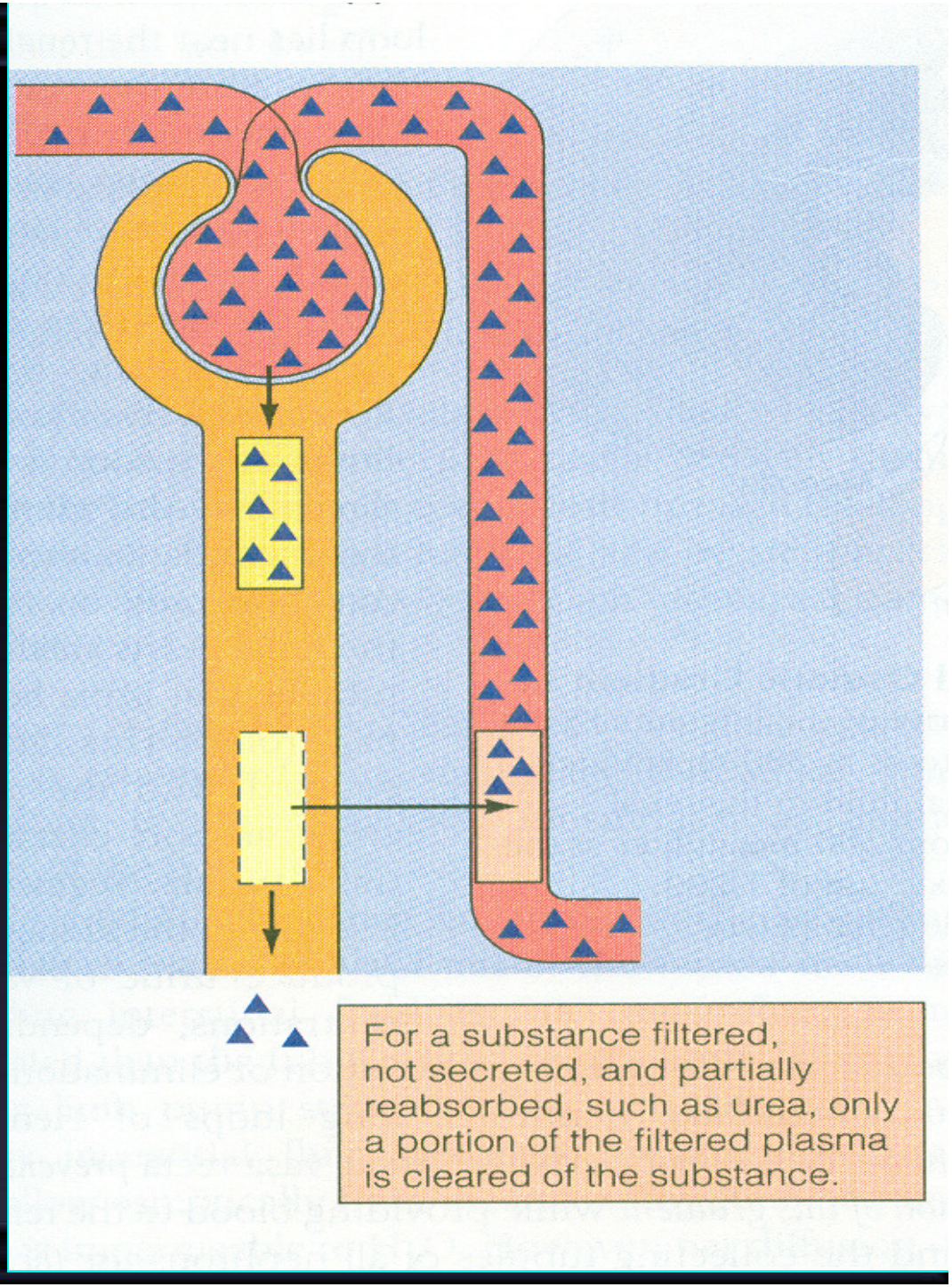
All Reabsorbed

Not Secreted



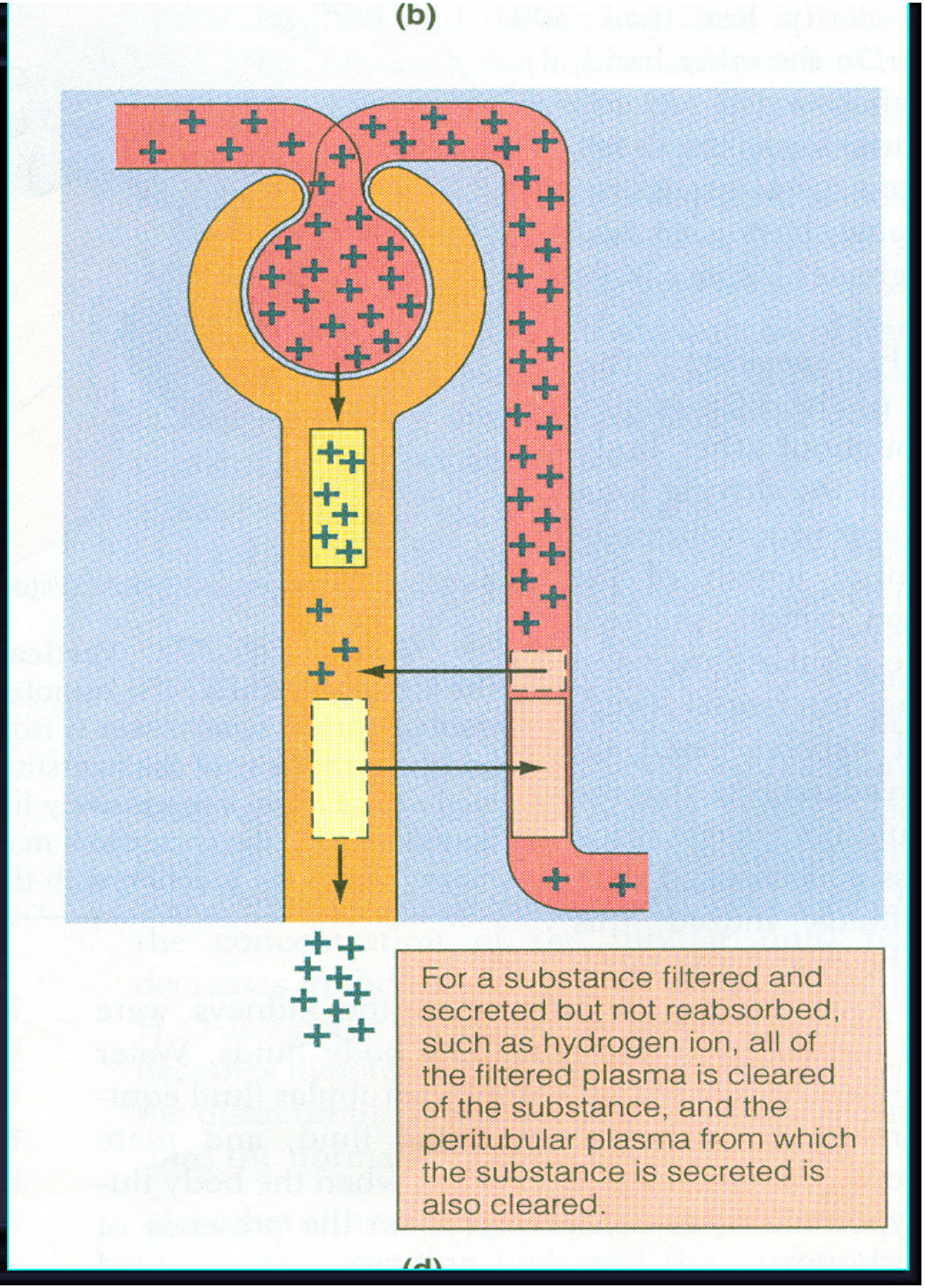
For a substance filtered, not secreted, and completely reabsorbed, such as glucose, none of the filtered plasma is cleared of the substance.

Freely filtered
Partially
Reabsorbed
Not Secreted



For a substance filtered, not secreted, and partially reabsorbed, such as urea, only a portion of the filtered plasma is cleared of the substance.

Freely filtered
Not Reabsorbed
Is Secreted



CLEARANCE FORMULA

$$Ps \times Cs = Us \times V$$

$$Cs = \frac{Us \times V}{Ps}$$

- **Cs** is the clearance rate of any substance
- **Ps** is the plasma concentration of the substance
- **Us** is the urine concentration of that substance
- **V** is the urine flow rate per minute

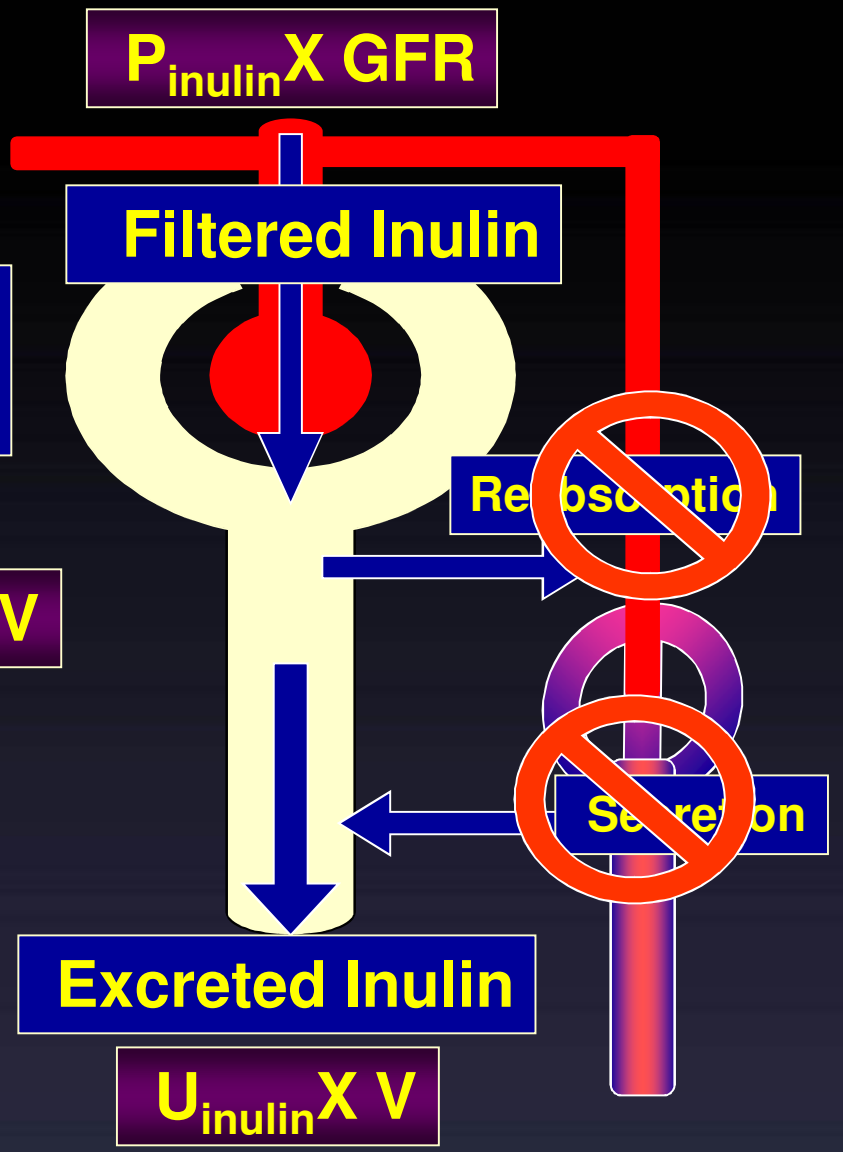
INULIN CLEARANCE

Filtered Inulin = Excreted Inulin

P_{inulin} X GFR = U_{inulin} X V

OR

$$GFR = \frac{U_{inulin} \times V}{P_{inulin}}$$



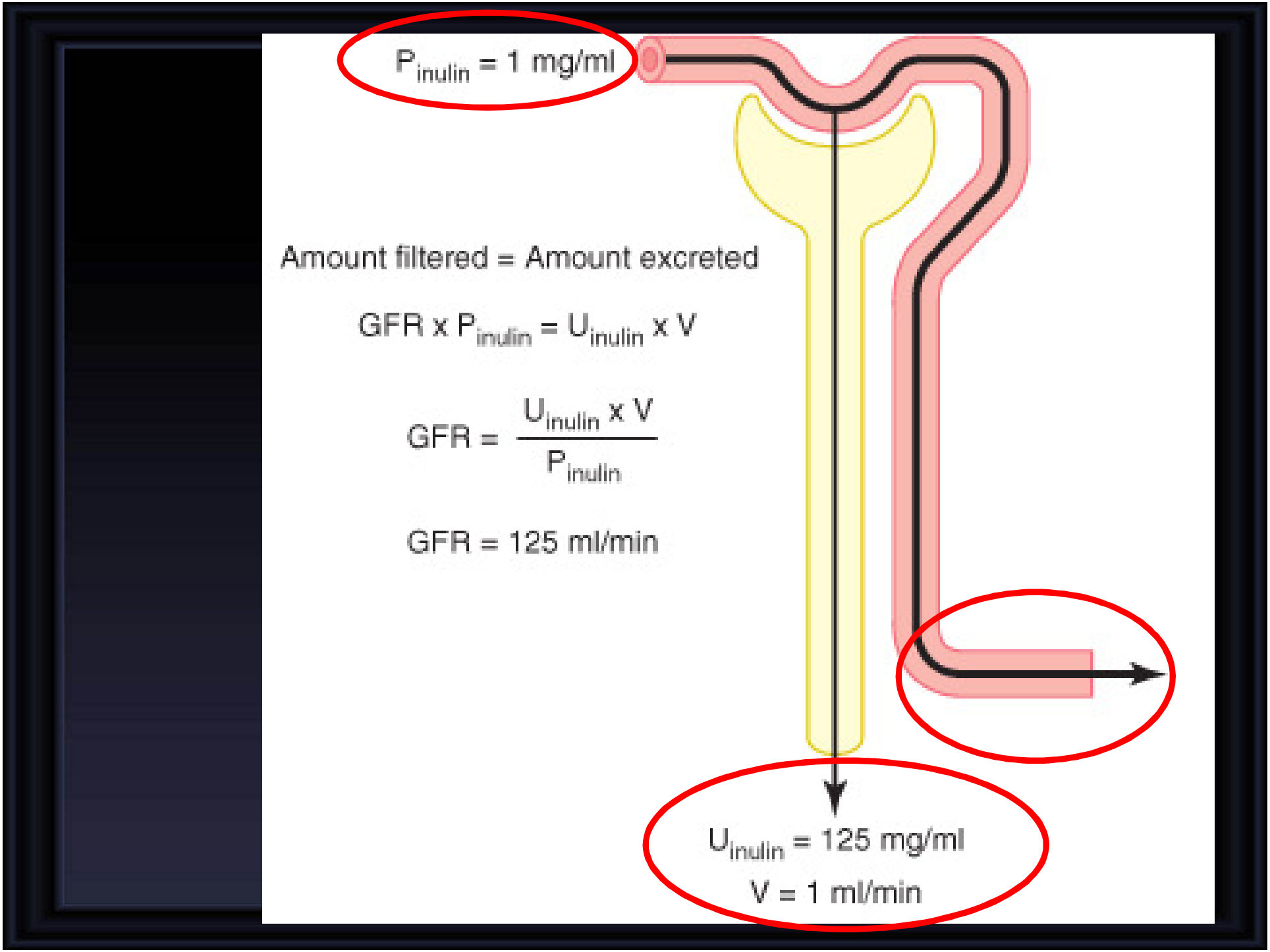
EXAMPLE

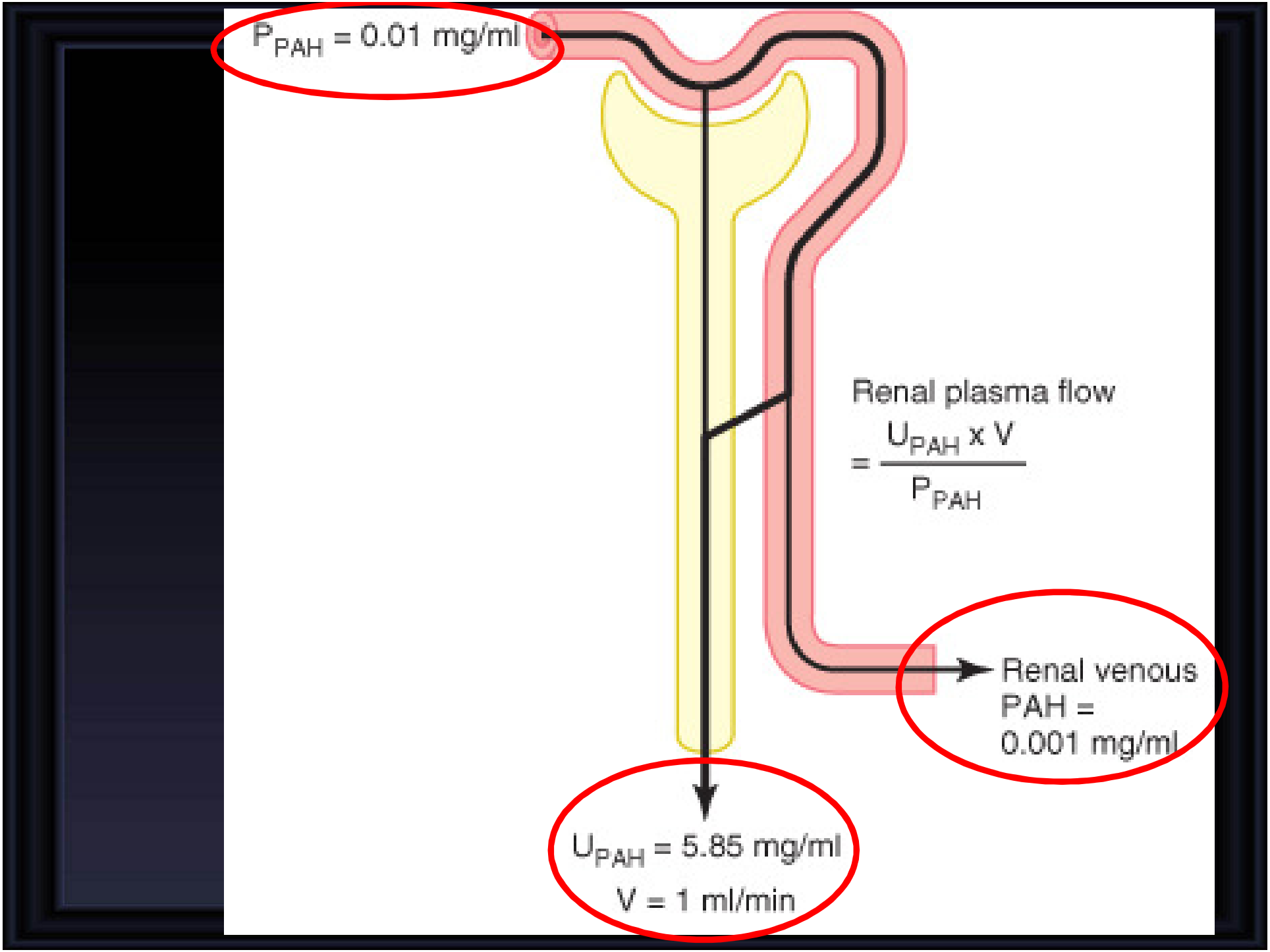
If

- Ps = 1 mg/ml
- Us = 1 mg/ml
- V = 1 ml/min

WHAT IS THE CLEARANCE OF THIS SUBSTANCE ?

CAN YOU CORRELATE IT TO GFR ?


P_{inulin} = 1 mg/ml
Amount filtered = Amount excreted
GFR x P_{inulin} = U_{inulin} x V
$GFR = \frac{U_{inulin} \times V}{P_{inulin}}$
GFR = 125 ml/min
U_{inulin} = 125 mg/ml
V = 1 ml/min

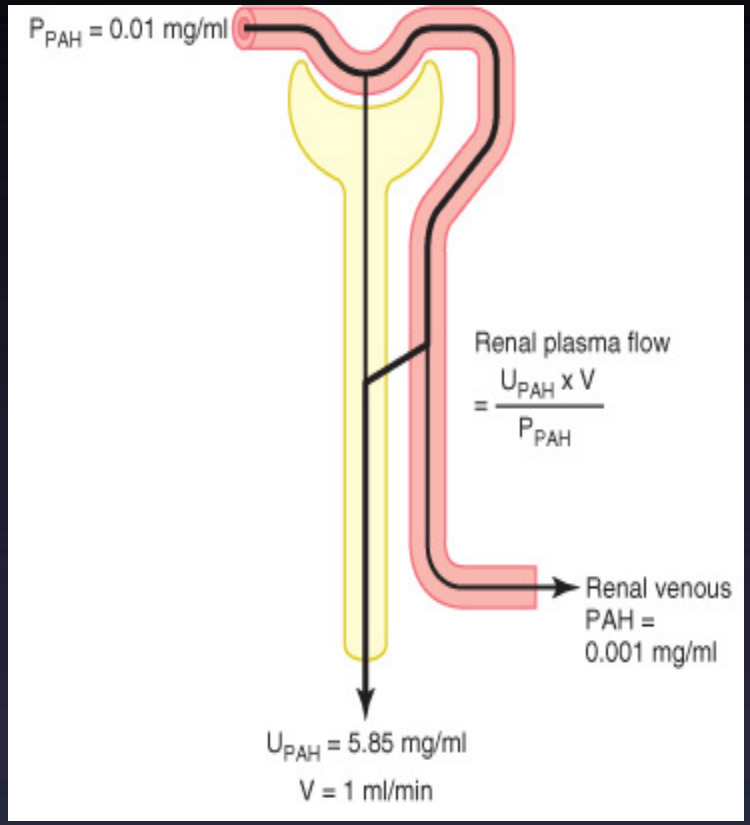

P_{PAH} = 0.01 mg/ml
Renal plasma flow
$= \frac{U_{PAH} \times V}{P_{PAH}}$
Renal venous
PAH =
0.001 mg/ml
U_{PAH} = 5.85 mg/ml
V = 1 ml/min

CAN YOU CORRELATE IT TO RENAL PLASMA FLOW ?

CPAH = UPAH x V/ PPAH
5.85 x 1 / 0.01 = 585
= ERPF

ARPF =
ERPF/ Extraction Ratio
= 585/0.9 = 650 ml/min

$$E_{PAH} = \frac{P_{PAH} - V_{PAH}}{P_{PAH}}$$



CAN YOU CALCULATE RENAL BLOOD FLOW NOW ?

Renal Blood Flow = RPF/ 1 - Hematocrit

650 / 1 – 0.45 = 1182 ml/min

EXAMPLE

Clearance = Urine Conc. x Vol of Urine/ Plasma Conc

FOR PAH

CPAH = UPAH x V/ PPAH
5.85 mg/ml x 1 ml/min/ 0.01 mg/ml = 585 ml/min
= ERPF

Actual Renal Plasma Flow = ERPF/ Extraction Ratio
= 585/0.9 = 650 ml/min

Extraction ratio (EPAH) is calculated as the difference between the renal arterial PAH (PPAH) and renal venous PAH (VPAH) concentrations, divided by the renal arterial PAH concentration

Substance	Clearance rate ml/min
Glucose	0
Sodium	0.9
Chloride	1.3
Potassium	12.0
Phosphate	25.0
Inulin	125.0
Creatinine	140.0

CREATININE CLEARANCE IS A TEST OF RENAL FUNCTION TO ESTIMATE GFR

Steady state for creatinine

Produced	=	Filtered	=	Excreted
1.8 g/day	=	10 mg/L × 180 L/day	=	1.8 g/day
1.8 g/day	=	20 mg/L × 90 L/day	=	1.8 g/day
1.8 g/day	=	40 mg/L × 45 L/day	=	1.8 g/day
1.8 g/day	=	80 mg/L × 22 L/day	=	1.8 g/day
1.8 g/day	=	160 mg/L × 11 L/day	=	1.8 g/day