Regional Circulation II
(renal, fetal)

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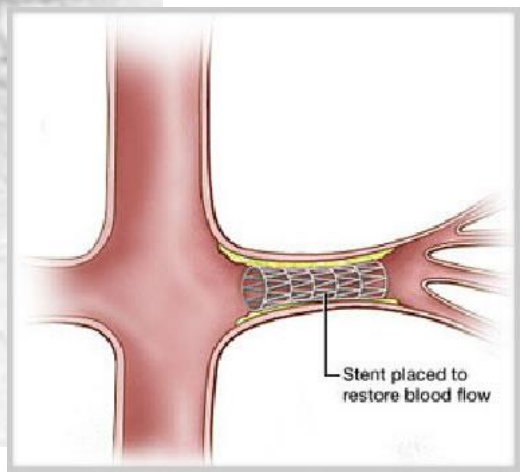
This presentation includes only the most important terms and facts. Its content by itself is not a sufficient source of information required to pass the Physiology exam.

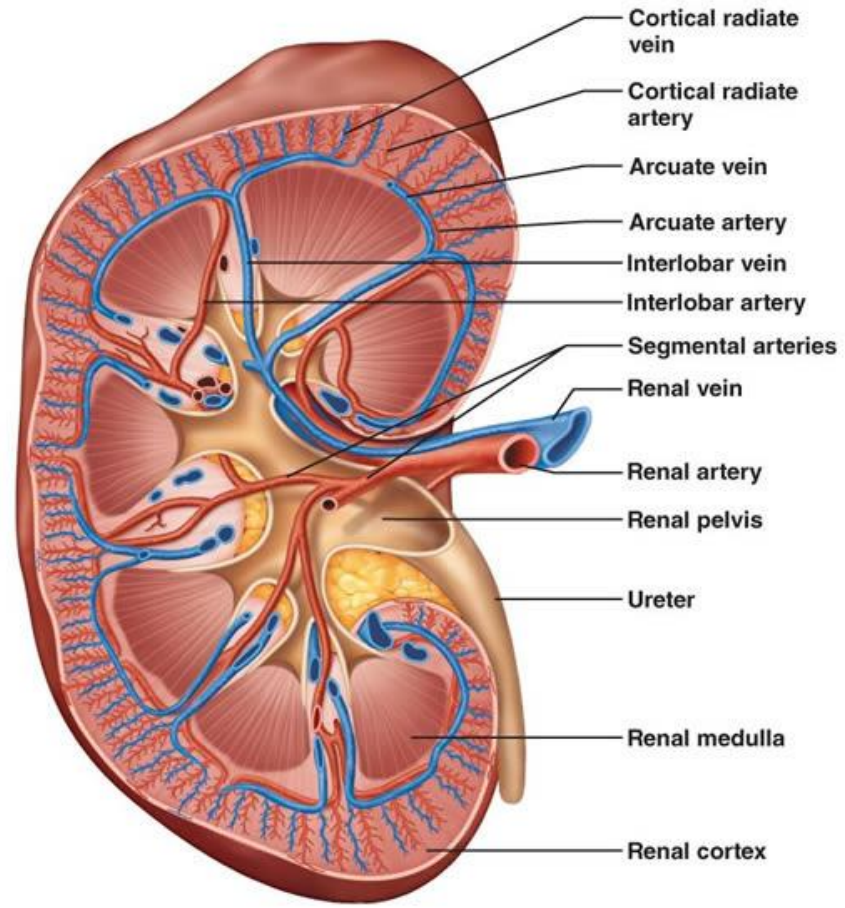
Renal Circulation



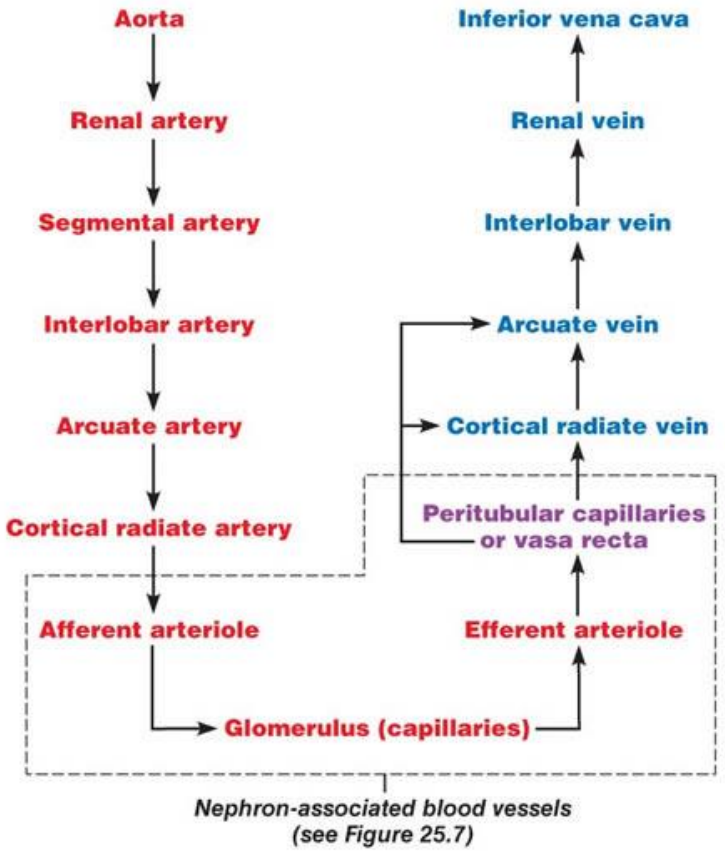
Renal Circulation

- main functions of kidneys – control of composition and volume of extracellular fluid, detoxification
- High filtration rate requires an adequate blood supply!
  - kidneys form only ~0.4 % of the body weight
  - blood flow 1.2 l/min, ~25% of cardiac output
- distribution of blood flow is irregular, the most flows through cortex (glomeruli – filtration)
  - cortex: 5.3 ml/g/min
  - medulla - outer zone: 1.4 ml/g/min
  - medulla - inner zone: 0.4 ml/g/min

Renal Circulation

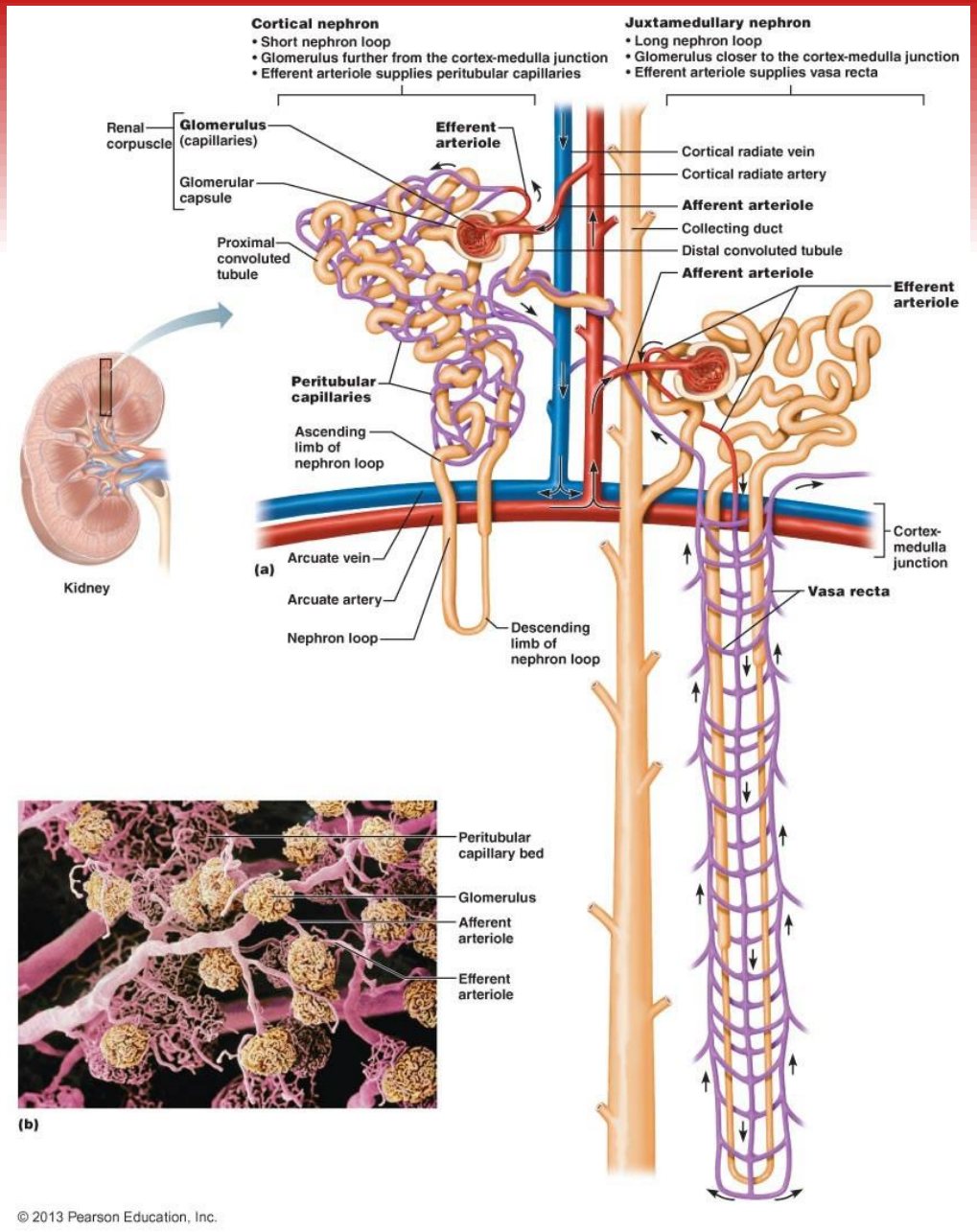


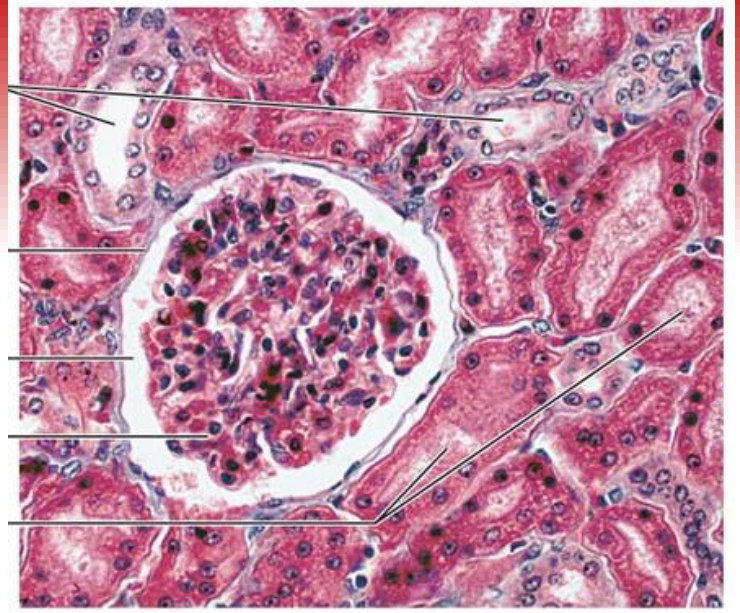
(a) Frontal section illustrating major blood vessels



(b) Path of blood flow through renal blood vessels

http://classes.midlandstech.edu/carterp/Courses/bio211/chap25/chap25.htm

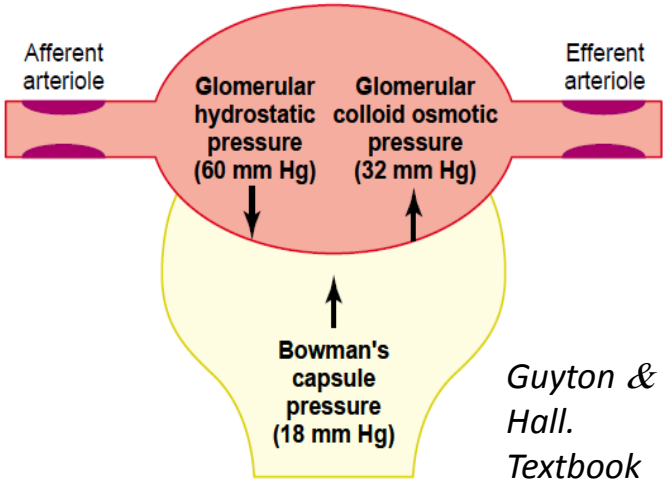




renal cortical tissue (180×)

http://classes.midlandstech.edu/carterp/Courses/bio211/chap25/chap25.htm

Renal Circul



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- *v. aff., v. eff.*
- entry/exit of high pressure glomerular capillary system
- glomerular blood flow $= \dfrac{P_{v.a.} - P_{v.e.}}{R_{v.a.} + R_{v.e.} + \cancel{R_{g.k.}}}$
- ↑ resistance in *vas aff.* or *vas eff.* → ↓ the renal blood flow (if the arterial pressure is stable)
- regulate the glomerular filtration pressure:

constriction of *vas aff*. → ↓ glomerular pressure → ↓ filtration

constriction of *vas eff*. → ↑ glomerular pressure → ↑ filtration

Renal Circulation

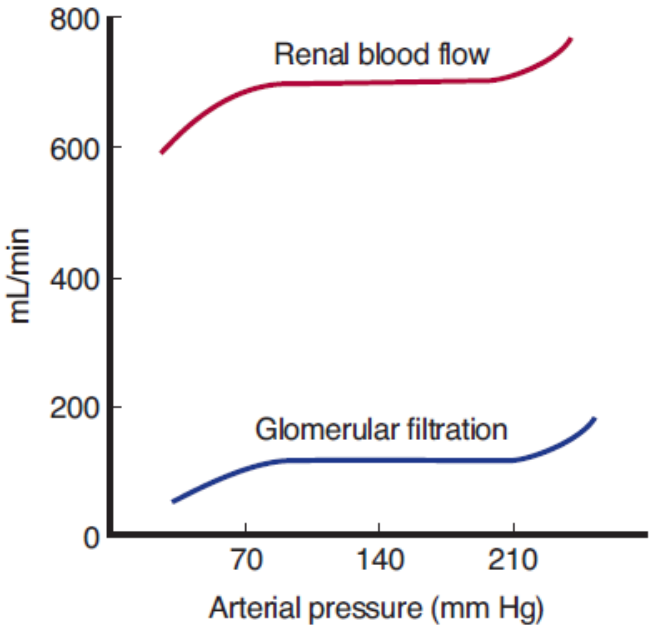
- **Regulation of renal blood flow:**
  1) Myogenic autoregulation
  2) Neural regulation
  3) Humoral regulation

Renal Circulation

- **Regulation of renal blood flow:**

1) Myogenic autoregulation

- dominates
- provides stable renal activity by maintaining stable blood flow at varying systemic pressure (stable glomerular pressure and, thus, also stable glomerular filtration rate)



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Renal Circulation

- **Regulation of renal blood flow:**

  2) Neural regulation

  - conformed to demands of systemic circulation
  - renal blood flow forms 25% of the cardiac output, thus, it considerably influence BP
  - **sympathetic system - norepinephrine**

    light exertion (both emotional and physical) + upright body posture → ↑ sympathetic tone → ↑ tone of *v. aff.* and *eff.* → ↓ renal blood flow but without ↓ GFR (↑ FF)

    higher ↑ of sympathetic tone - during anesthesia and pain - GFR may already ↓

Renal Circulation

- **Regulation of renal blood flow:**

  3) Humoral Regulation

  - contribute to regulation of systemic BP and regulation of body fluids
  - **norepinephrine, epinephrine** (from adrenal medulla)

    $\rightarrow$ constriction of aff. and eff. arterioles $\rightarrow \downarrow$ renal blood flow and GFR

    in agreement with $\uparrow$ activity of sympathetic system (small impact with the exception of serious conditions, for example serious bleeding)

Renal Circulation

- **Regulation of renal blood flow:**

  3) Humoral Regulation

  - contribute to regulation of systemic BP and regulation of body fluids

  - **endothelin**

    constriction of aff. and eff. arterioles → ↓ renal blood flow and GFR

    released locally from the impaired endothel (physiological impact - hemostasis; pathologically increased levels at the toxemia of pregnancy, acute renal failure, chronic uremia)

Renal Circulation

- **Regulation of renal blood flow:**

  3) Humoral Regulation

  - contribute to regulation of systemic BP and regulation of body fluids
  - **NO** (from the endothel)

    continual basal production → vasodilation in the kidney → stable renal blood flow and GFR
  - **prostanglandins (PGE_2, PGI_2), bradykinin**

    → vasodilation – minor impact under physiol. cond.

    decrease the effect of vasoconstrictive substances which reduce marked ↓ of renal blood flow and GFR

    non-steroidal anti-inflammatory agents during stress (surgery, ↓ fluid volume) may → notably ↓ GFR

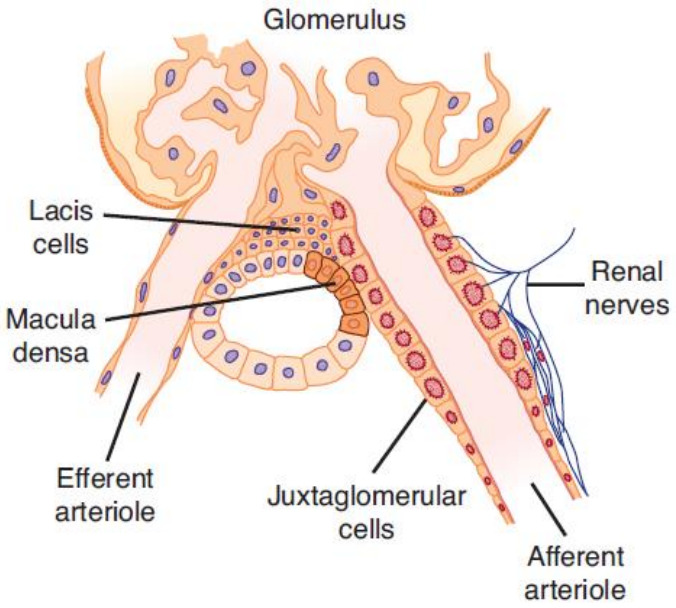
Renal Circulation

- **Regulation of renal blood flow:**

  3) Humoral Regulation

  - contribute to regulation of systemic BP and regulation of body fluids

  - **Renin-angiotensine system**



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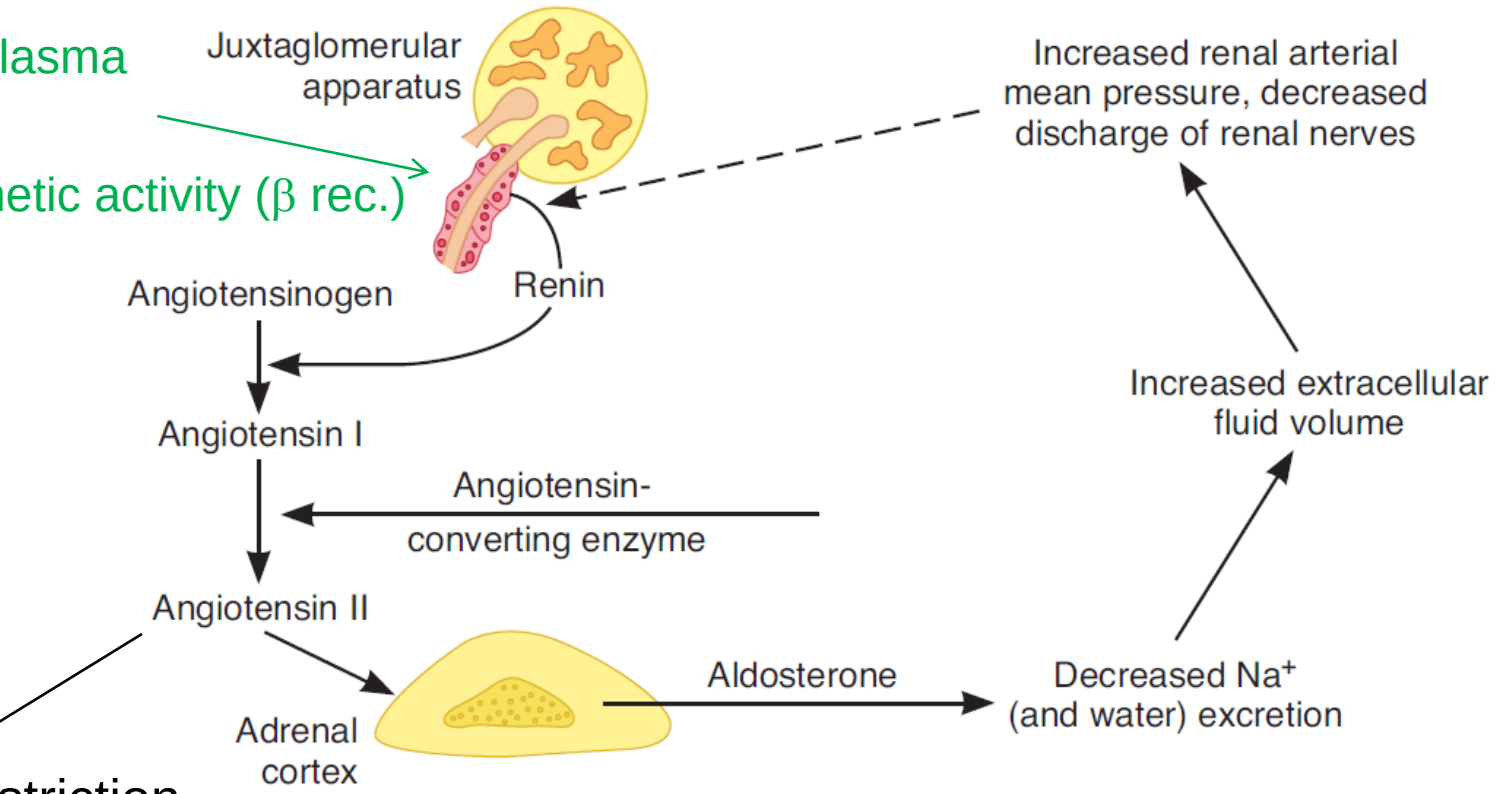
Renal Circulation

Renin-angiotensine system

↓ Na^+ in plasma
↓ BP
↑ sympathetic activity (β rec.)



vasoconstriction

thirst, ADH

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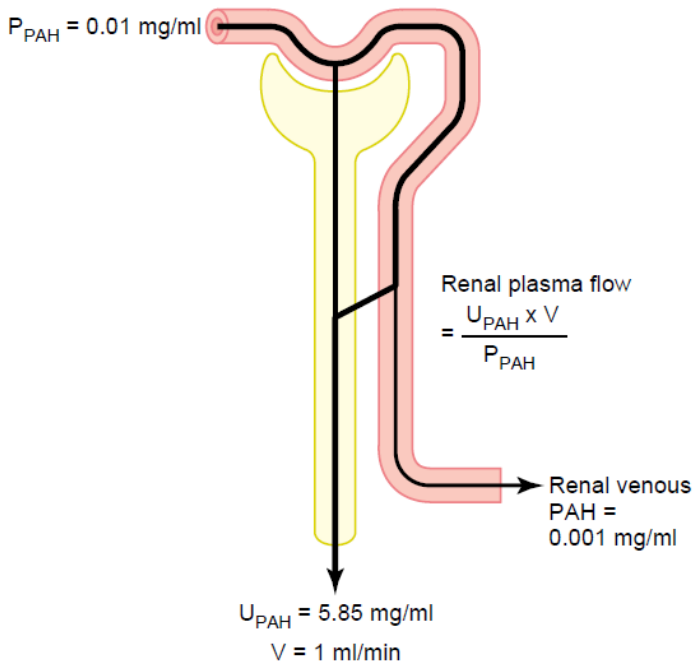
Renal Circulation

Determination of renal plasma flow velocity (RPF)

Clearance of a substance which is fully cleared from plasma in glomerulotubular apparatus.

PAH (paraaminohippuric acid) cleared by 90%

$$RPF = \frac{5.85 \times 1 \text{ mg/min}}{0.01 \text{ mg/ml}} = 585 \text{ ml/min}$$



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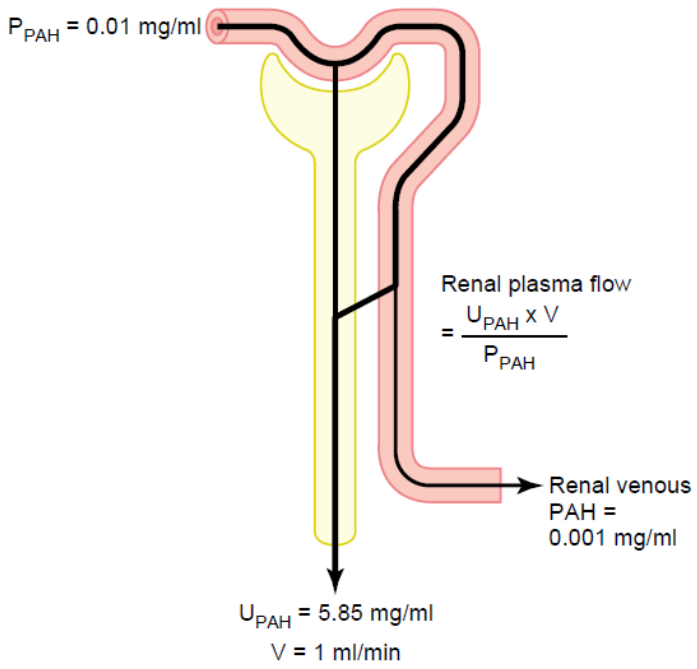
(in juxtamedullar nephrons, *vasa recta* additionally originate from *v. efferens* – not in contact with proximal and distal tubuli → no excretion of substances)

Renal Circulation

Determination of renal plasma flow velocity (RPF)

Clearance of a substance which is fully cleared from plasma in glomerulotubular apparatus.

PAH (paraaminohippuric acid) cleared by 90%



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$$RPF = \frac{5.85 \times 1 \text{ mg/min}}{0.01 \text{ mg/ml}} = 585 \text{ ml/min}$$

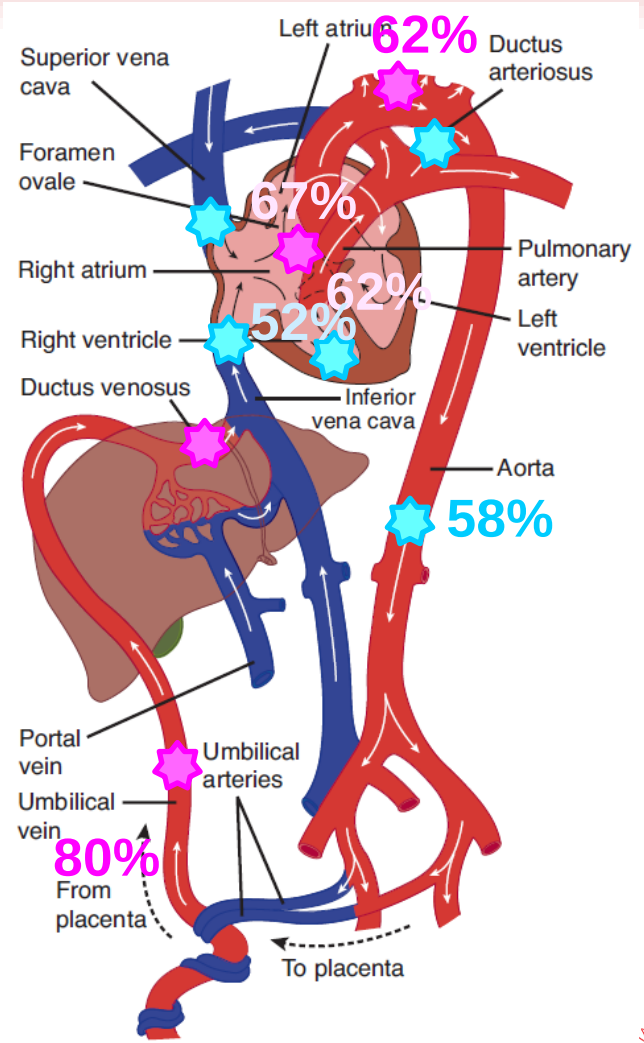
Correction to the extraction ratio of PAH (E_{PAH}):

$$E_{PAH} = \frac{P_{PAH} - V_{PAH}}{P_{PAH}} = 0.9 \longrightarrow RPF = \frac{585 \text{ ml/min}}{0.9} = 650 \text{ ml/min}$$

Fetal Circulation

Fetal Circulation

- placenta, umbilical vein
- liver, *ductus venosus*
- *crista dividens, foramen ovale*
- blood supply of the head and upper limbs
- *v. cava superior and inferior*
- the right ventricle
- *ductus arteriosus*
- aorta – the blood supply of the lower part of body + 60% of the cardiac output is directed to placenta



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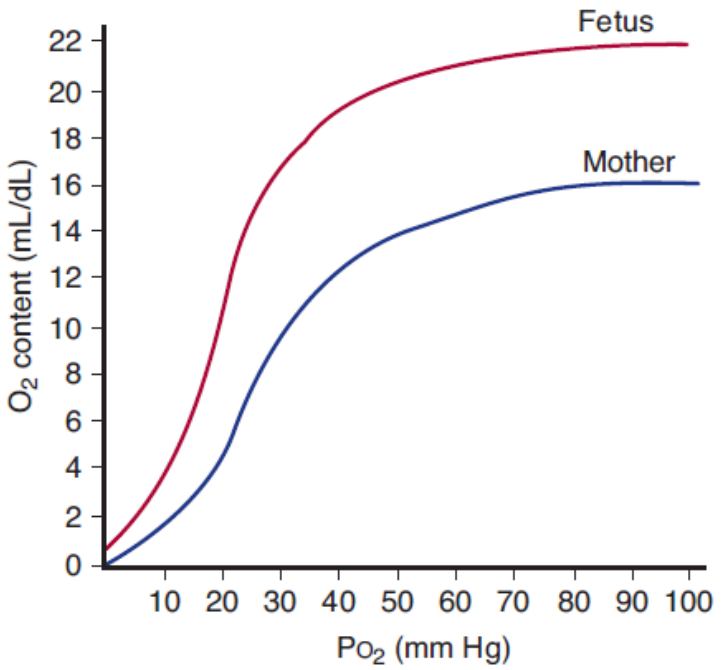
Fetal Circulation

- fetal haemoglobin (higher affinity to oxygen)

- short-period hypoxia
- longer hypoxia

- thick muscle wall of umbilical vessels
  (sensitive contractile reaction to many stimuli – injury, hypoxia, sympathomimetics, *etc.*)



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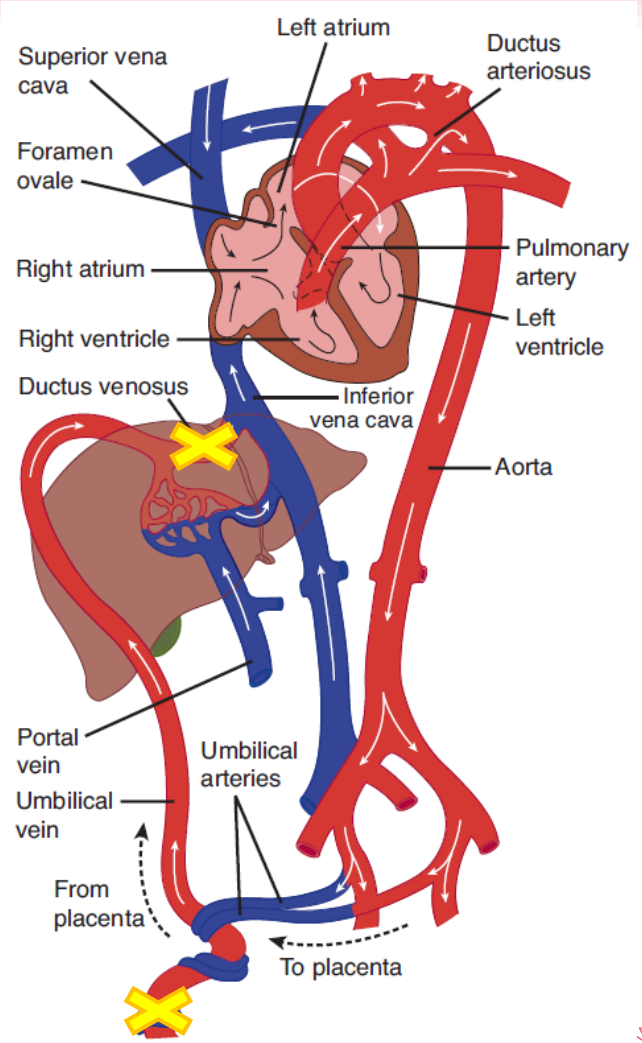
Fetal Circulation

- **Changes after birth**
- **Closure of umbilical vein**
  - sudden ↑ of peripheral resistance and blood pressure
  - contraction of musculature of *ductus venosus* and its closure
- **The first inspiration** (due to asphyxia and cooling of the body)
  - ↓ resistance of the lung bloodstream
  - much more blood into lungs



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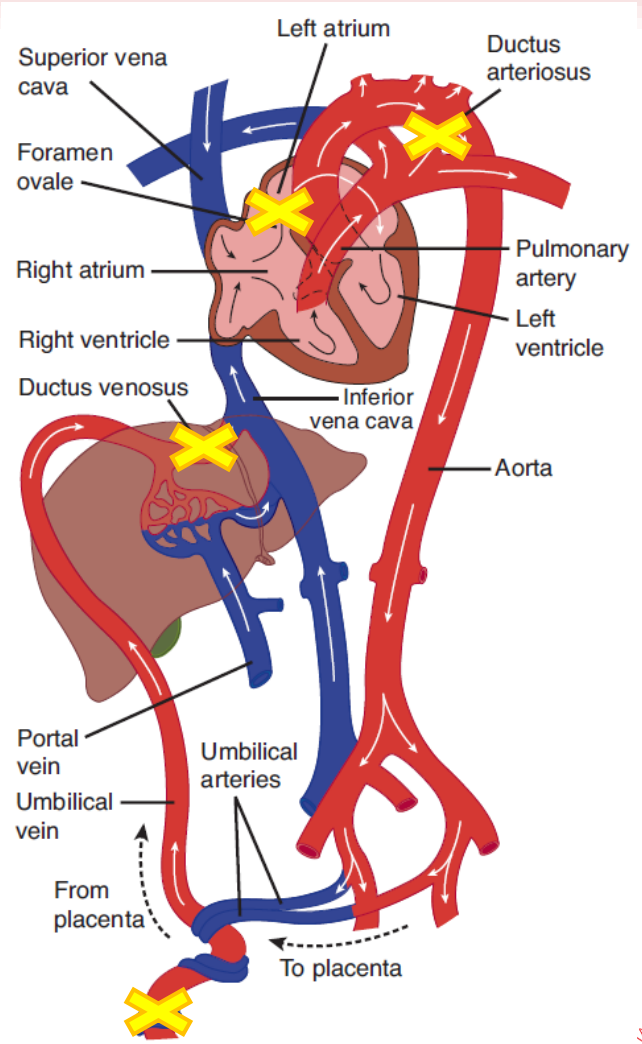
Fetal Circulation

- **Changes after birth**
- **Decrease of pressure in right atrium and its increase in left atrium** due to:
  - ↑ filling of left atrium by the blood from lungs
  - ↓ venous return to right atrium due to closure of umbilical vein
  - left ventricle works against ↑ pressure in aorta
- **Closure of *formanen ovale***
- **Closure of *ductus arteriosus***



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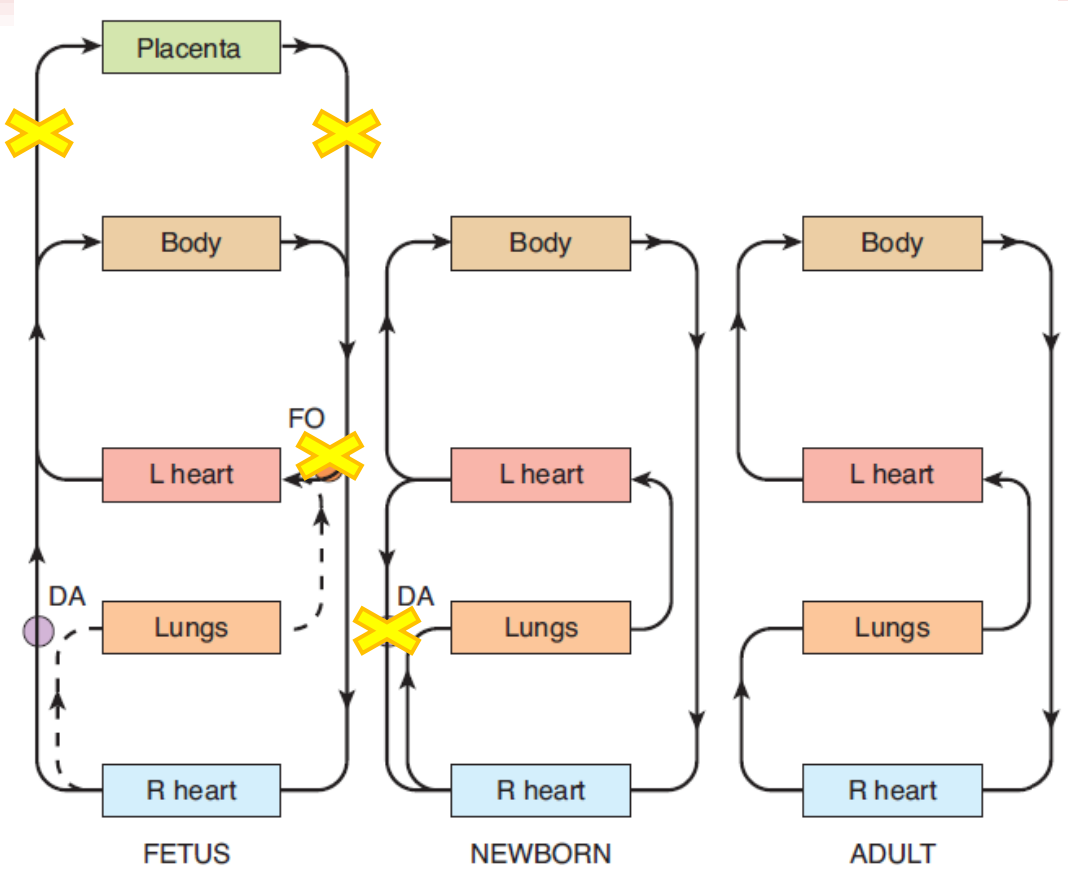
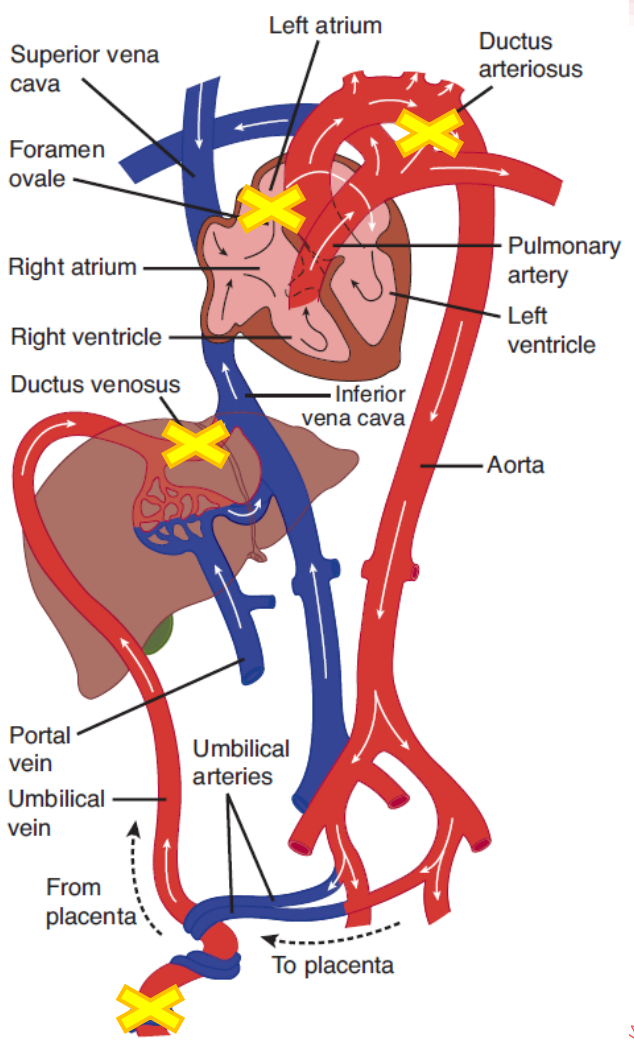
Fetal Circulation



left and right heart work in parallel

all connected in series



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