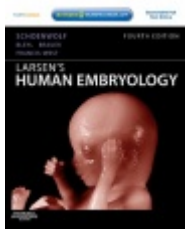
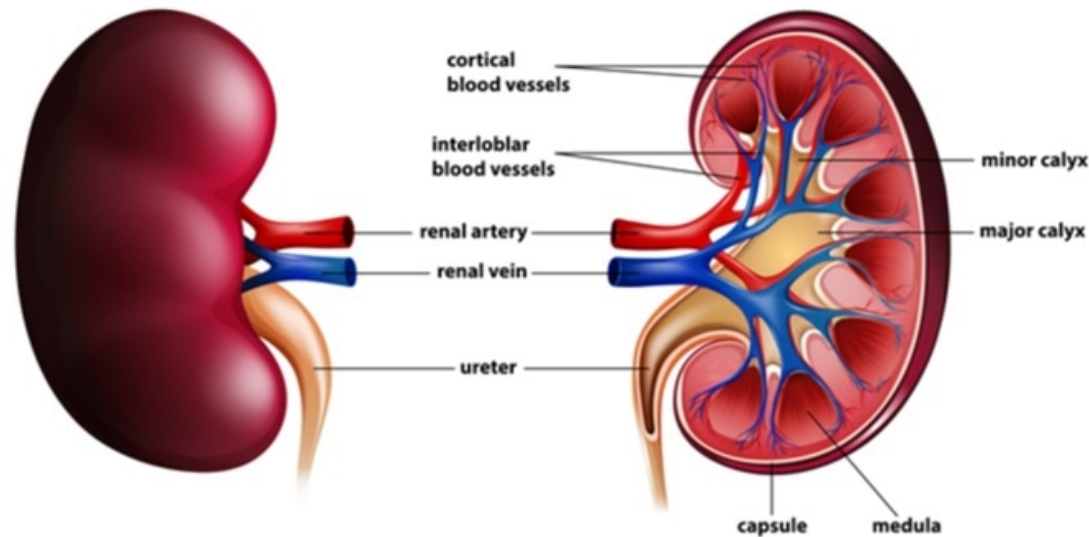
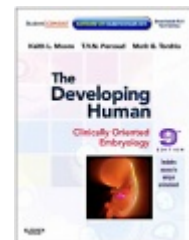


# Development of the Urinary System



Resources:  
<http://php.med.unsw.edu.au/embryology/>  
 Larsen's Human Embryology  
 The Developing Human: Clinically Oriented Embryology



Dr Annemiek Beverdam – School of Medical Sciences, UNSW  
 Wallace Wurth Building Room 234 – A.Beverdam@unsw.edu.au

# Development of the Urinary System

Anatomy of the Urinary System

Embryonic origins of Urinary System

Kidney Development

Nephrogenesis

Development of the Renal Vasculature

Development of the Urinary Bladder and Urethra

Congenital Abnormalities of the Urinary System

# Development of the Urinary System

## **Anatomy of the Urinary System**

Embryonic origins of Urinary System

Kidney Development

Nephrogenesis

Development of the Renal Vasculature

Development of the Urinary Bladder and Urethra

Congenital Abnormalities of the Urinary System

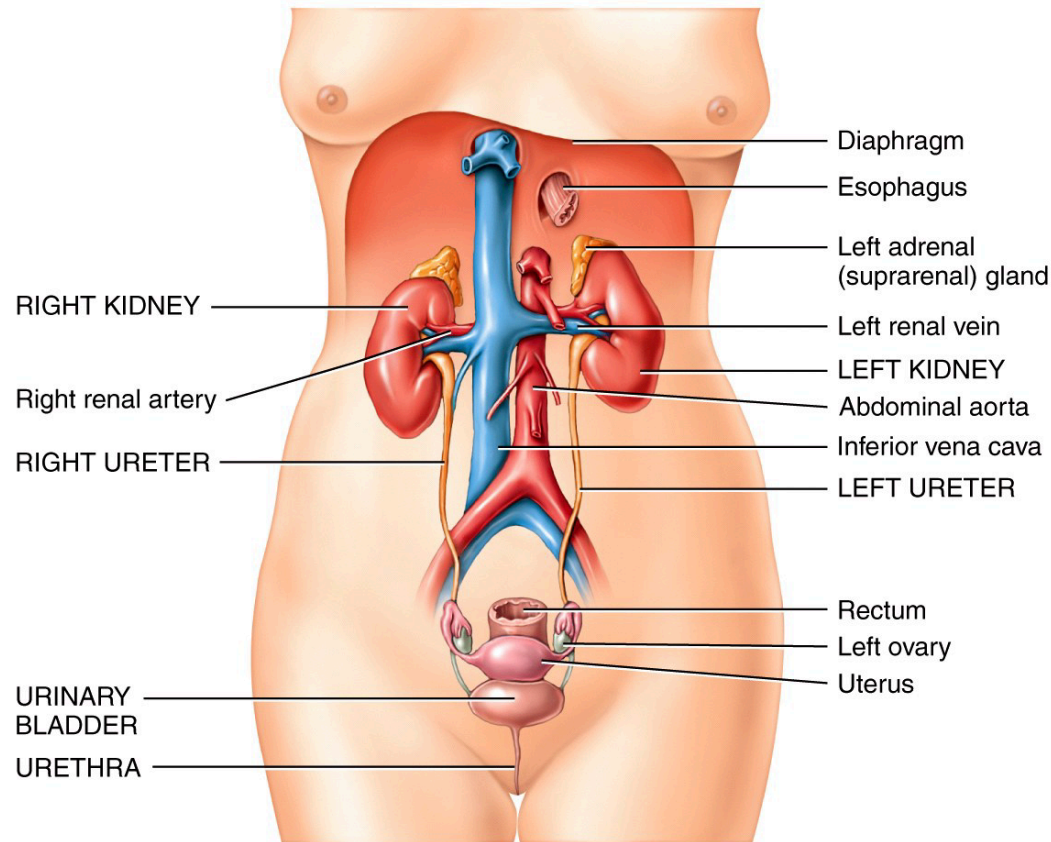
# Anatomy of the Urinary System

Consists of kidneys, ureters, urinary bladder and urethra

Blood filtration and control of body fluid homeostasis

Production of urine

Functional unit: nephron ( $\sim 10^6$ /kidney)

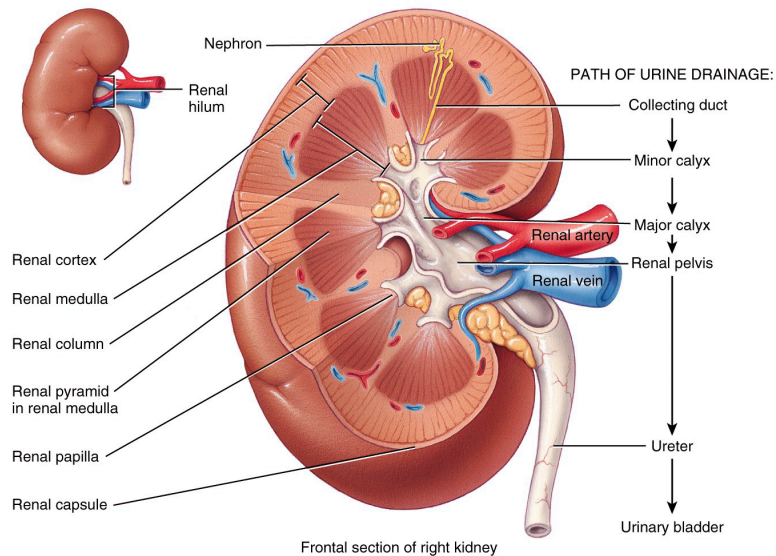


Anterior view



# Anatomy of the Urinary System

## kidneys



Copyright © John Wiley & Sons, Inc. All rights reserved.

Paired organs

Covered by renal capsule

Renal cortex

Renal medulla

Renal hilum (renal artery, vein, pelvis)

Nephrons: in renal pyramids and renal cortex

Renal pelvis

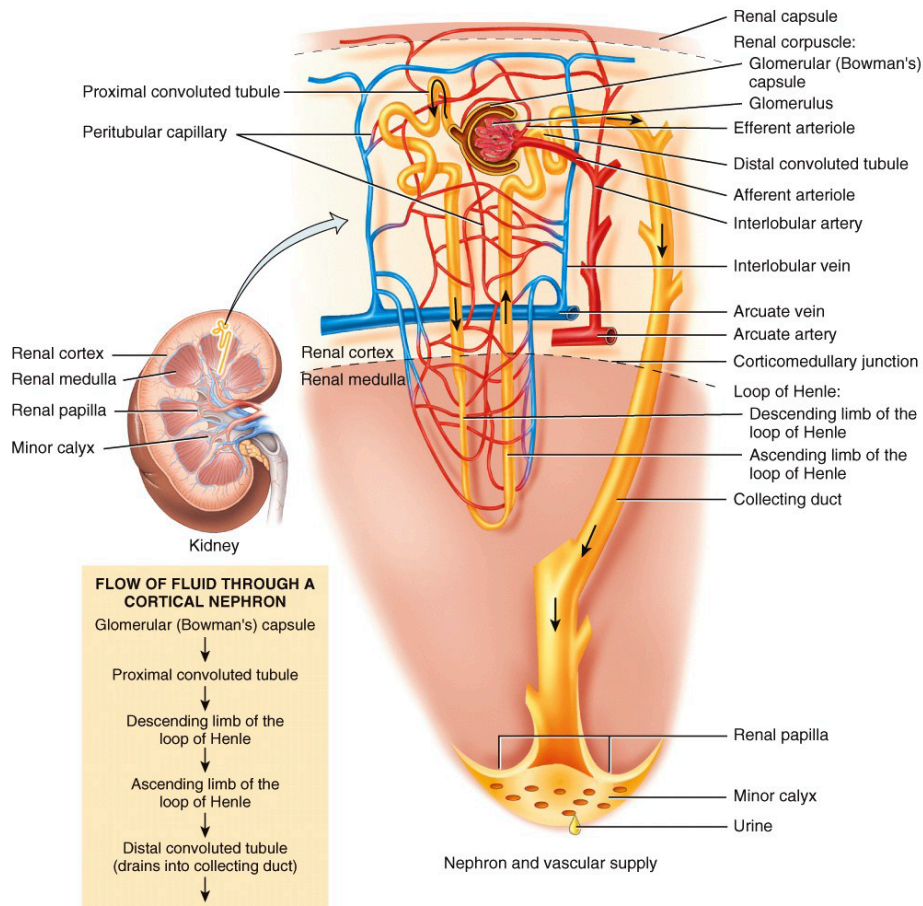
Ureter

Urinary bladder

Urethra

# Anatomy of the Urinary System

## nephrons



Nephrons: in renal pyramids and renal cortex

Nephrons consist of:

- Renal corpuscle (cortex):  
Bowman's capsule  
Afferent arteriole  
Glomerulus  
Efferent arteriole
- Renal tubules (cortex and medulla):  
Proximal convoluted tubule  
Loop of Henle  
Distal convoluted tubule  
Collecting duct

Renal pelvis

Ureter

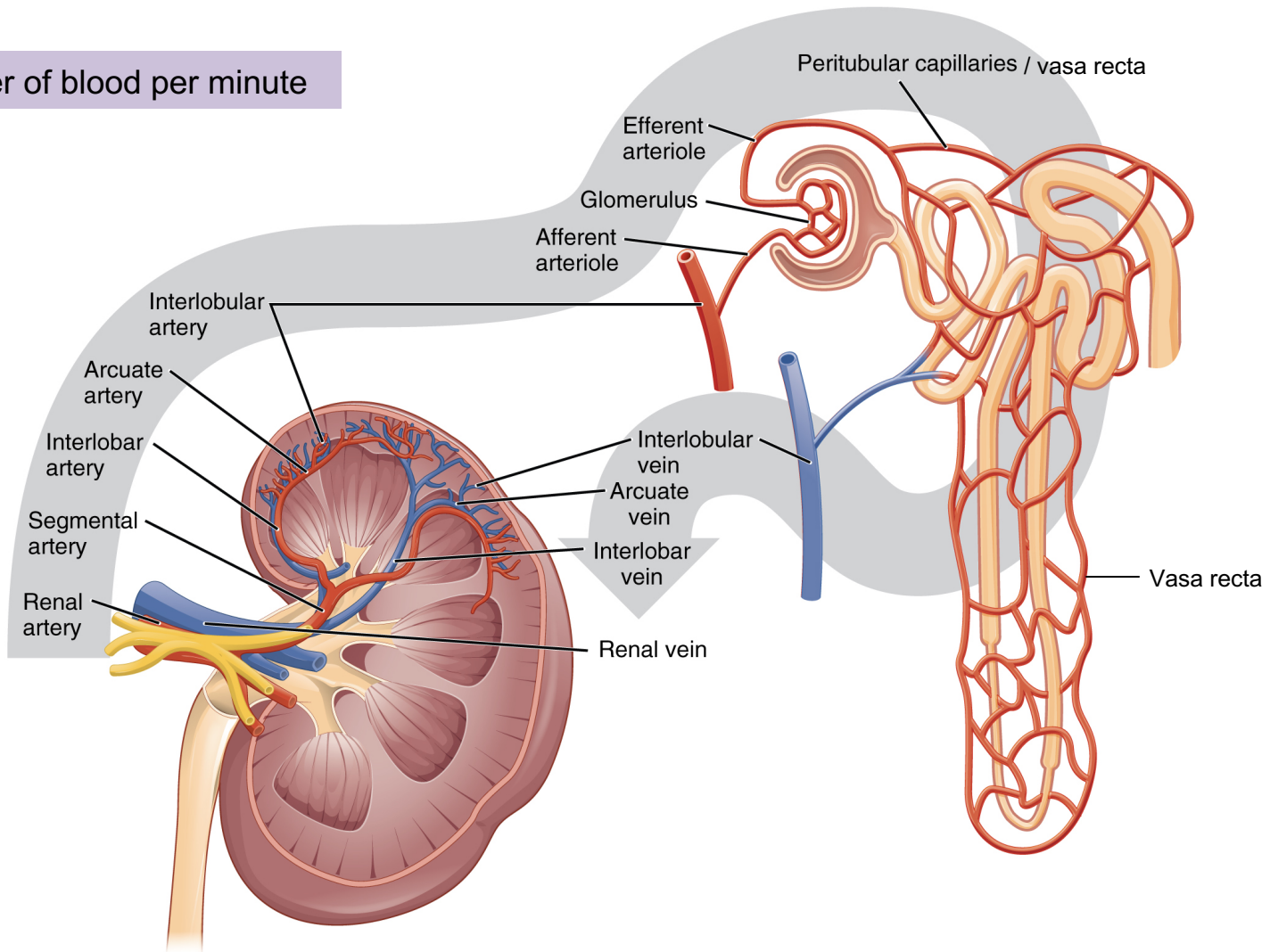
Urinary bladder

Urethra

# Anatomy of the Urinary System

## Renal blood circulation

1.2 liter of blood per minute



# Development of the Urinary System

Anatomy of the Urinary System

**Embryonic origins of Urinary System**

Kidney Development

Nephrogenesis

Development of the Renal Vasculature

Development of the Urinary Bladder and Urethra

Congenital Abnormalities of the Urinary System

# Trilaminar Embryo

## Ectoderm (Neural crest)

brain, spinal cord, eyes, *peripheral nervous system*  
epidermis of skin and associated structures,  
*melanocytes, cranial connective tissues (dermis)*

## Mesoderm

musculo-skeletal system  
limbs  
connective tissue of skin and organs  
**urogenital system**, heart, blood cells

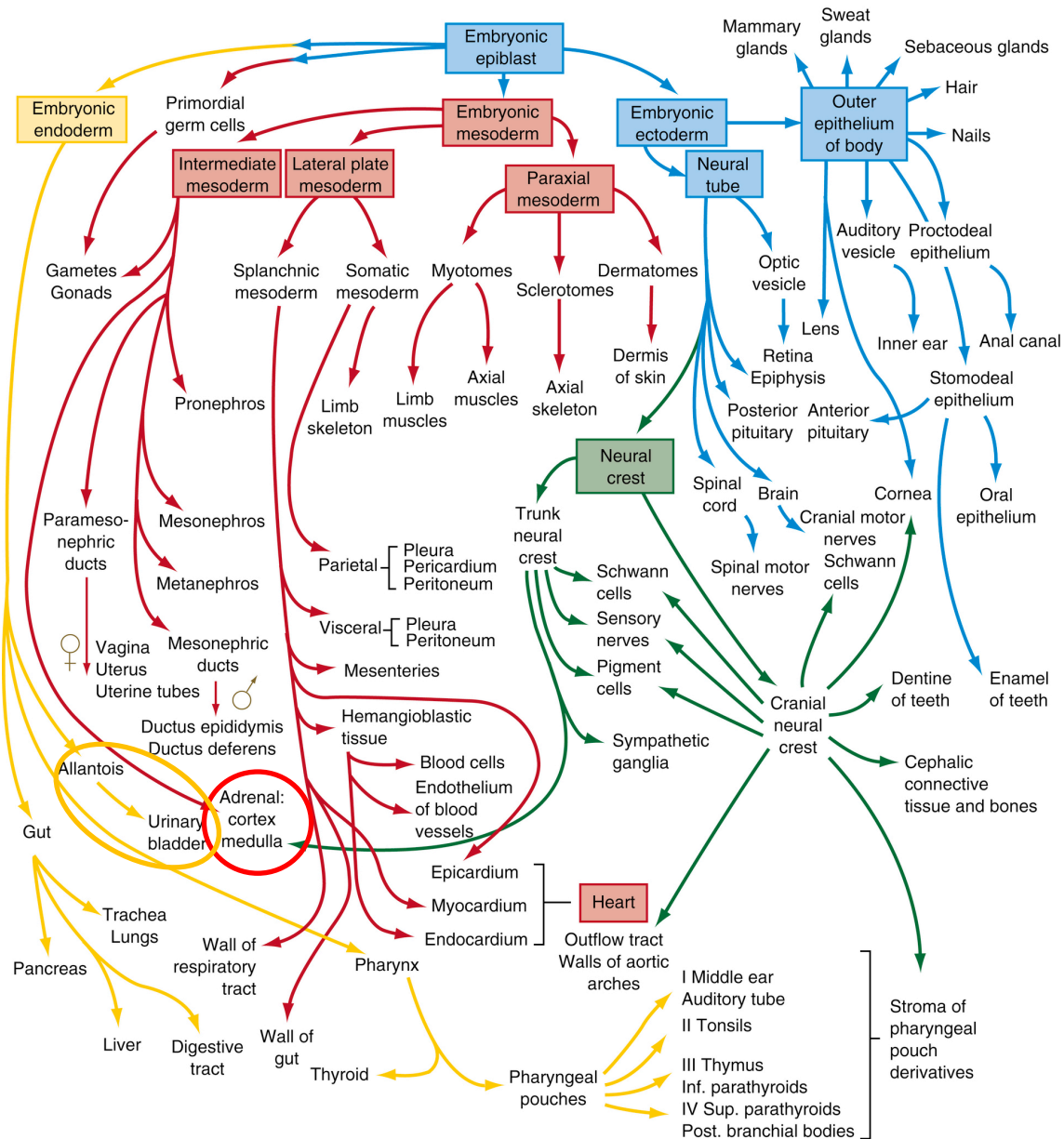
## Endoderm

epithelial linings of gastrointestinal and respiratory tracts,  
and of the **bladder and urethra**

# Embryonic origins of the Urinary System

Intermediate mesoderm: kidneys  
Endoderm: urinary bladder, urethra

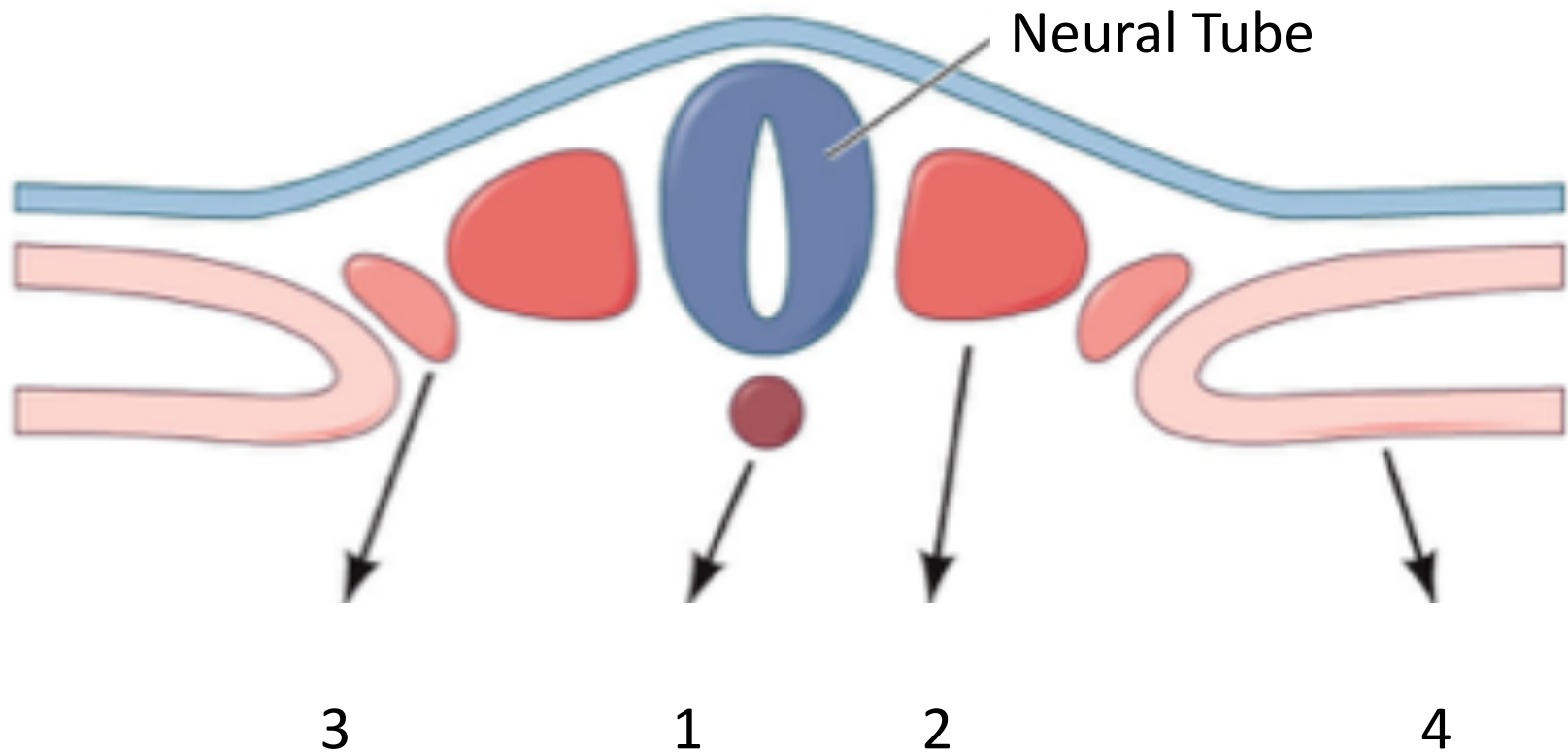
# Embryonic origins of the reproductive system



# Embryonic origins of the Urinary System

## Intermediate mesoderm

Intermediate mesoderm gives rise to the kidneys



3

1

2

4

1: notochord

2: paraxial mesoderm

**3: intermediate mesoderm**

4: lateral plate mesoderm



# Embryonic origins of the Urinary System

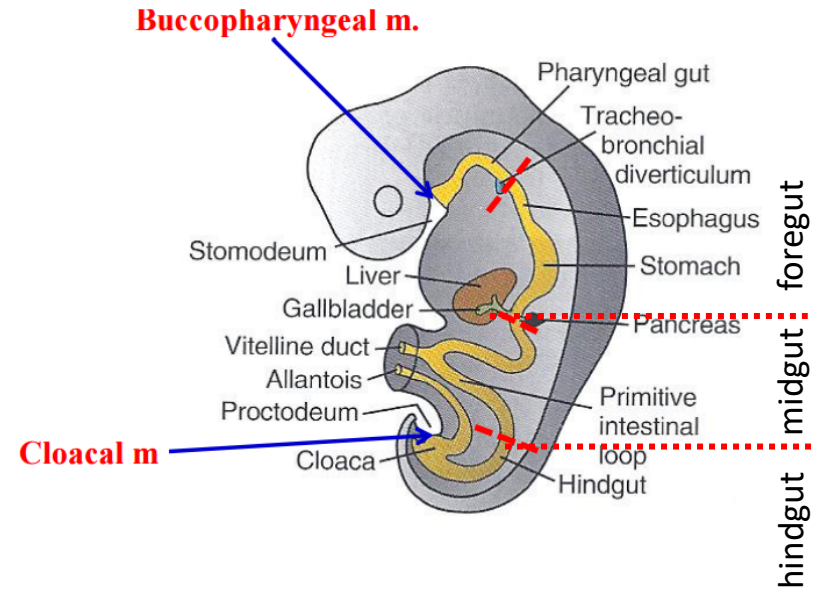
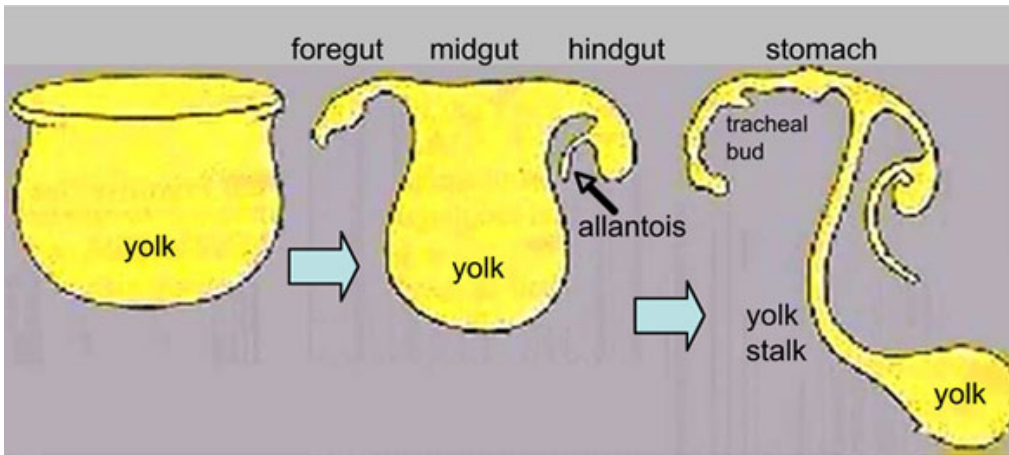
## Endoderm

Lining of the GI tract:

Primitive gut: foregut, midgut and hindgut

Oral cavity and cloaca

Cloaca/allantois will give rise to urinary bladder and urethra



# Development of the Urinary System

Anatomy of the Urinary System

Embryonic origins of Urinary System

**Kidney Development**

**Nephrogenesis**

Development of the Renal Vasculature

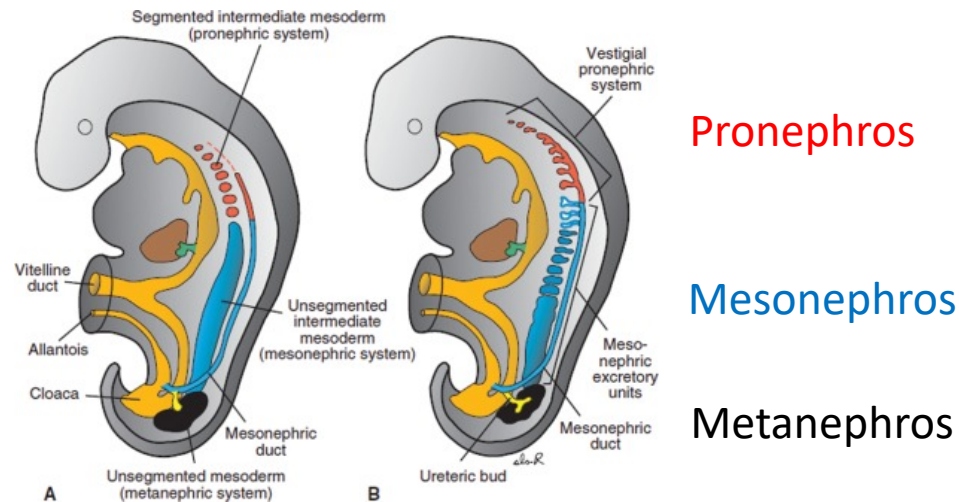
Development of the Urinary Bladder and Urethra

Congenital Abnormalities of the Urinary System

# Kidney development

3 nephric systems:

- Pronephros:
  - from segmented intermediate mesoderm
  - regresses
- Mesonephros:
  - embryonic kidney
  - reproductive system
  - Ureteric bud: collecting duct and tubules of the kidney
- Metanephros:
  - Adult kidney (capsule, glomeruli and nephron tubules)



# Kidney development

## Metanephros development

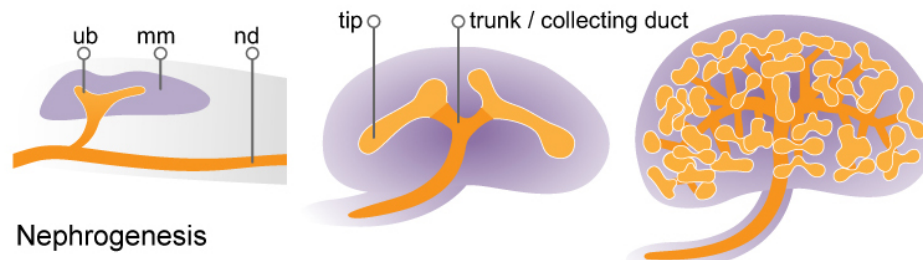
Proximal end of ureteric bud ends into mesonephric duct ( -> cloaca)

Ureteric bud grows out distally and branches out

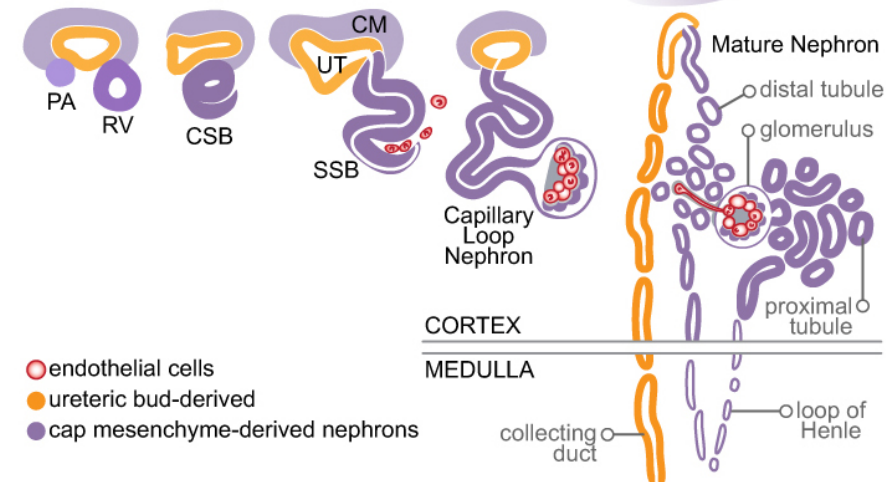
Ureteric bud gives rise to ureter, renal pelvis, collecting ducts

Metanephric mesenchyme gives rise to renal capsule and cortex, glomeruli and nephron tubules

### Ureteric Bud Formation & Branching



### Nephrogenesis



# Kidney development

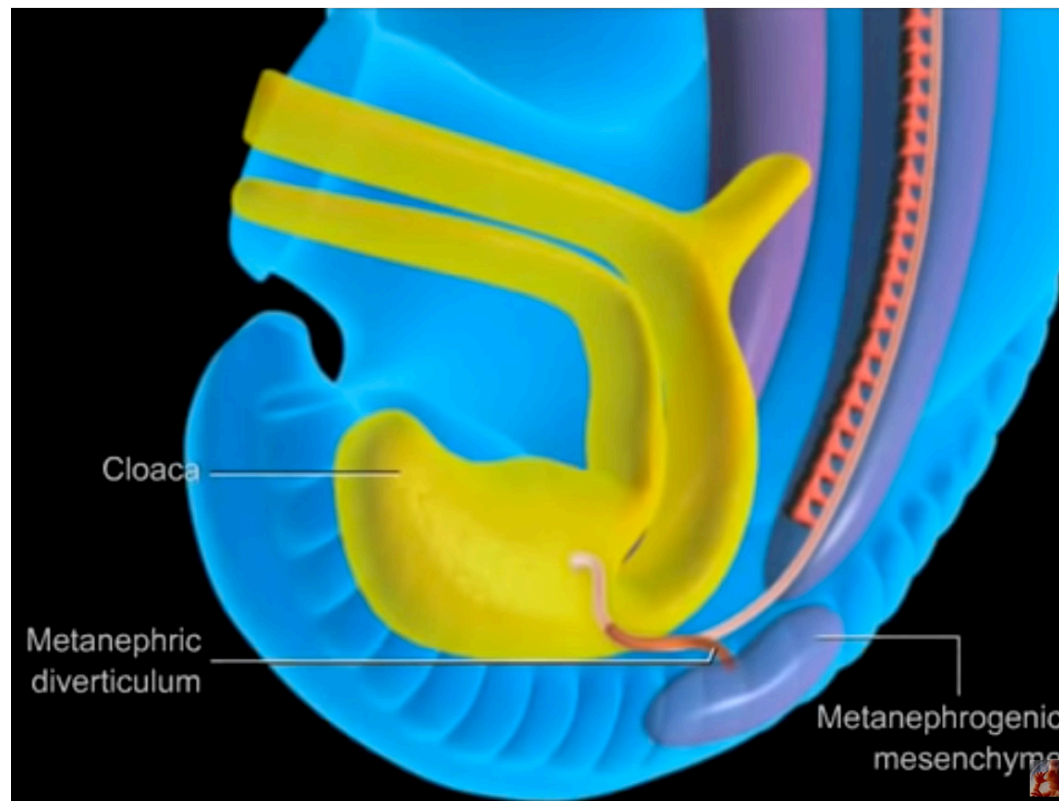
## Metanephros development

Proximal end of ureteric bud ends into mesonephric duct (cloaca)

Ureteric bud grows out distally and branches out

Ureteric bud gives rise to ureter, renal pelvis, collecting ducts

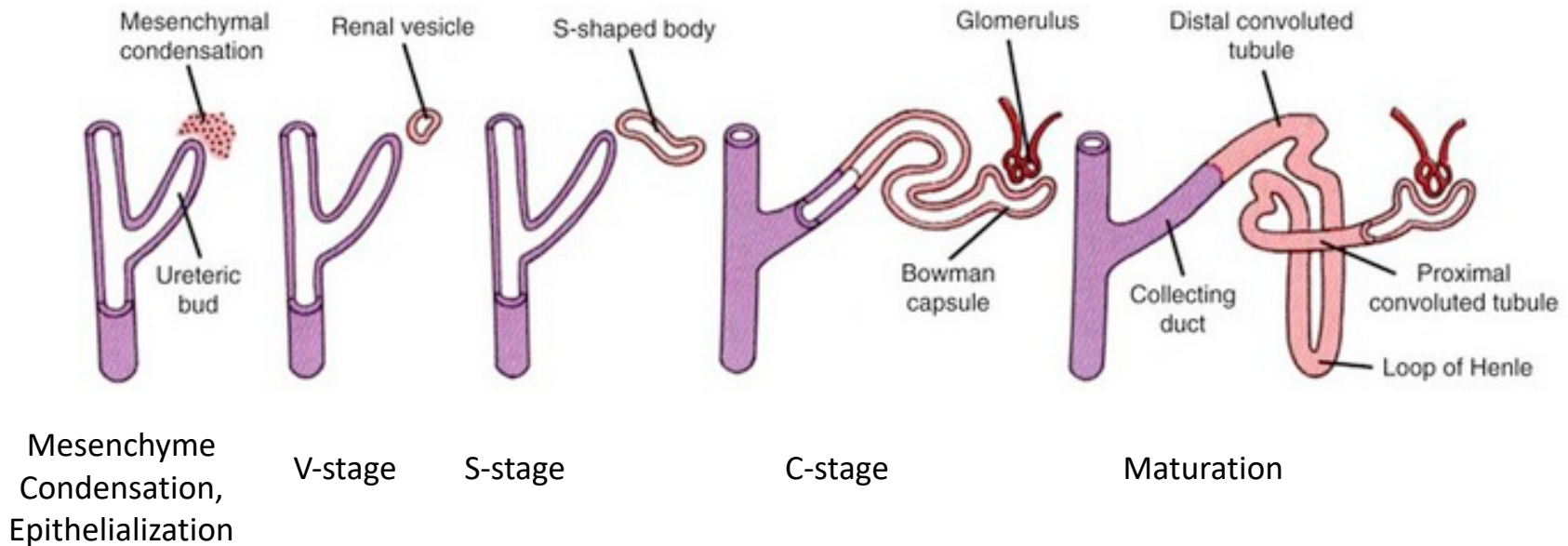
Metanephric mesenchyme gives rise to renal capsule and cortex, glomeruli and nephron tubules



# Nephrogenesis

Four developmental stages:

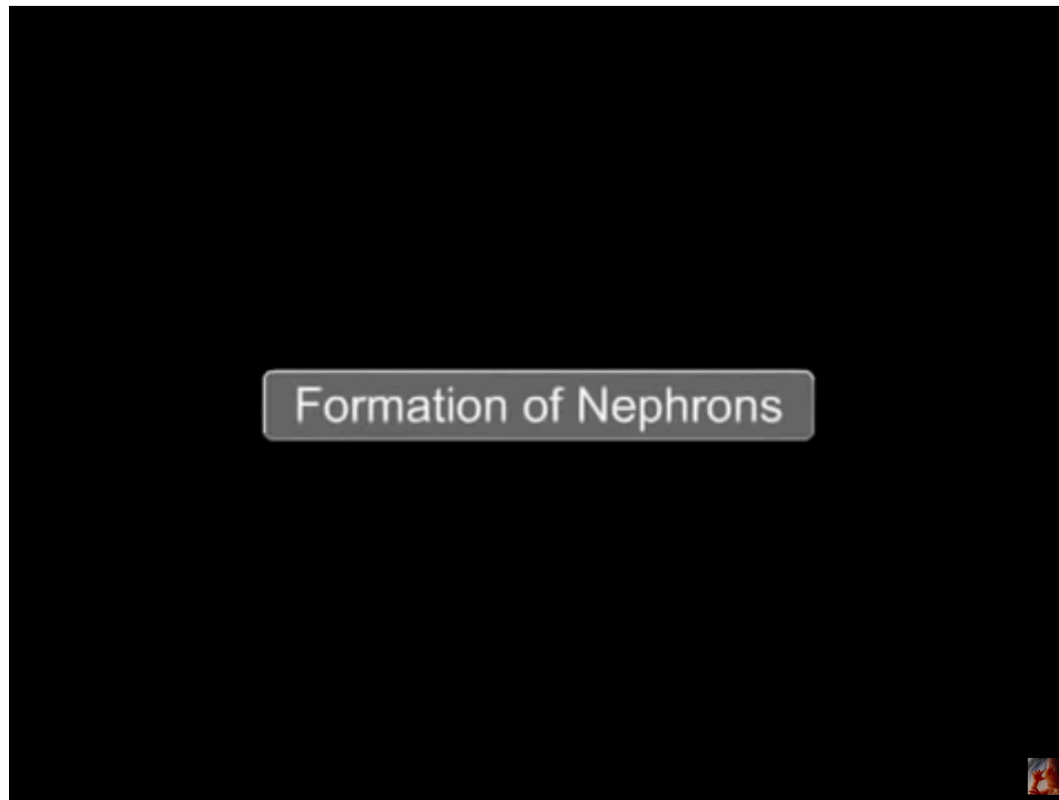
1. Vesicle (V) stage): 13-19 weeks: epithelialization and cyst formation
2. S-shaped body (S) stage: 2—24 weeks: invaginations of vesicle
3. Capillary loop (C) stage: 25-29 weeks: invasion of vasculature
4. Maturation (M) stage: infants up to 6 months



# Nephrogenesis

Four developmental stages:

1. Vesicle (V) stage): 13-19 weeks: epithelialization and cyst formation
2. S-shaped body (S) stage: 2—24 weeks: invaginations of vesicle
3. Capillary loop (C) stage: 25-29 weeks: invasion of vasculature
4. Maturation (M) stage: infants up to 6 months



# Development of the Urinary System

Anatomy of the Urinary System

Embryonic origins of Urinary System

Kidney Development

Nephrogenesis

**Development of the Renal Vasculature**

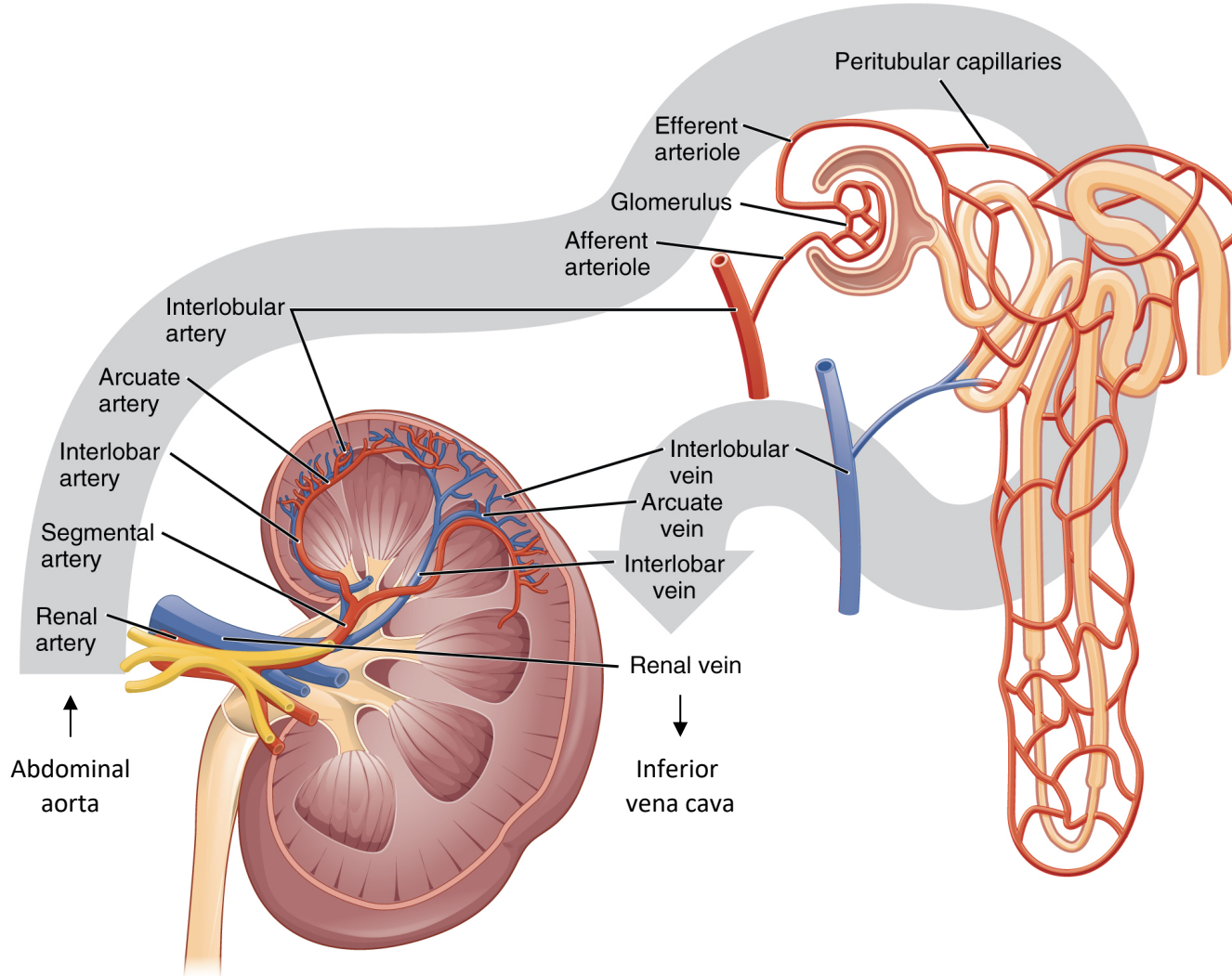
Development of the Urinary Bladder and Urethra

Congenital Abnormalities of the Urinary System



# Renal vasculature

## Anatomy



# Renal vasculature

## Development

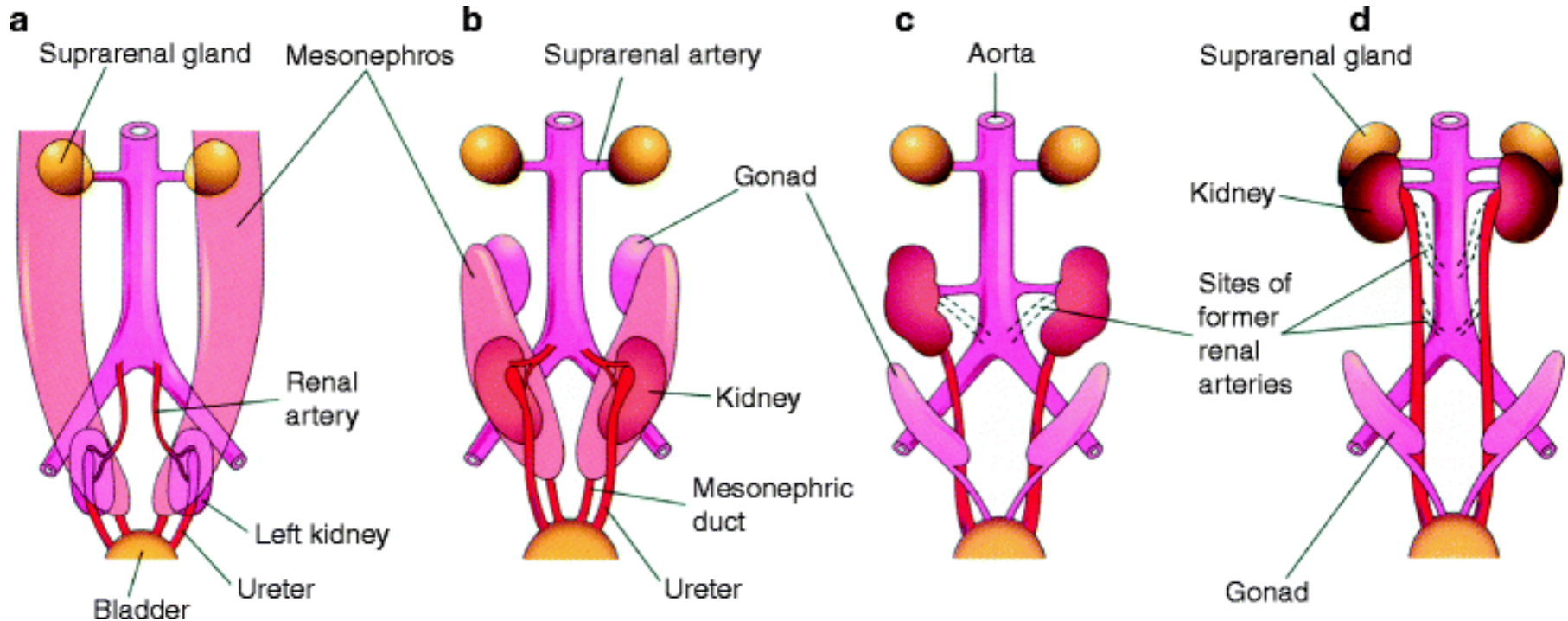
Renal artery sprouts into metanephros from dorsal aorta

From week 6: kidney ascent from pelvis to abdomen

Kidneys are supplied by arteries at successively higher levels during ascent

(25% of people have 2+ renal arteries per kidney)

Week 9: kidneys reach adrenal glands



# Renal vasculature

## Development

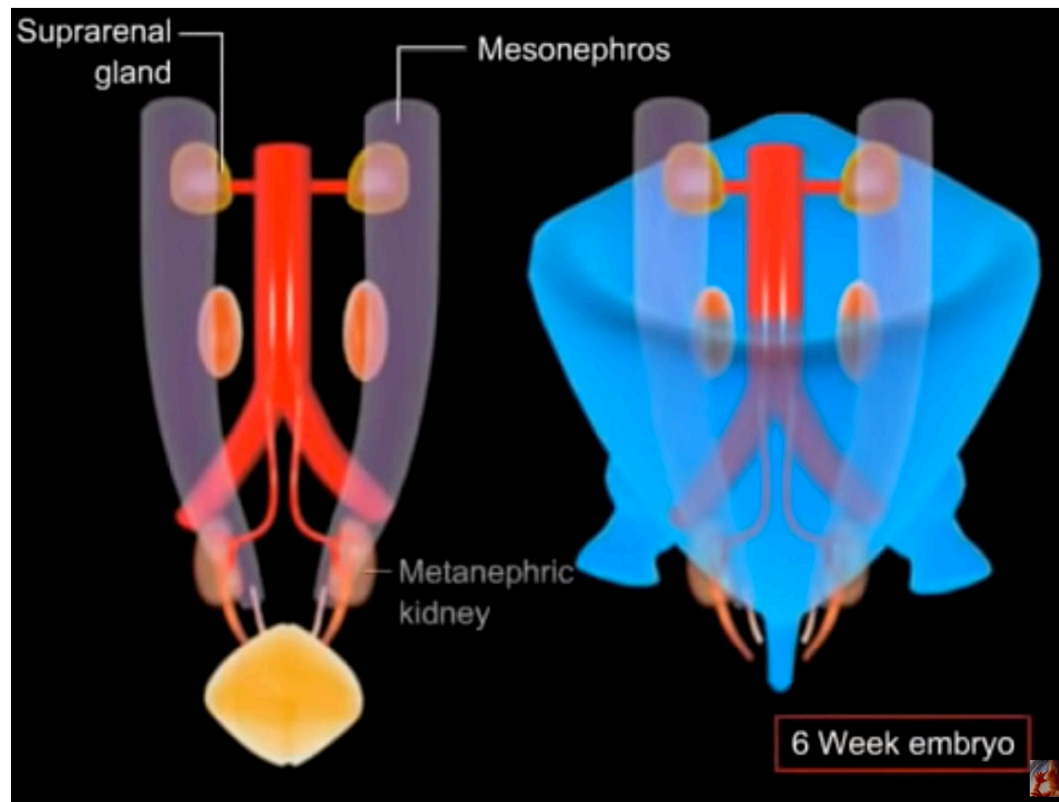
Renal artery sprouts into metanephros from dorsal aorta

From week 6: kidney ascent from pelvis to abdomen

Kidneys are supplied by arteries at successively higher levels during ascent

(25% of people have 2+ renal arteries per kidney)

Week 9: kidneys reach adrenal glands



# Development of the Urinary System

Anatomy of the Urinary System

Embryonic origins of Urinary System

Kidney Development

Nephrogenesis

Development of the Renal Vasculature

**Development of the Urinary Bladder and Urethra**

Congenital Abnormalities of the Urinary System

# Development of the Urinary Bladder and Urethra

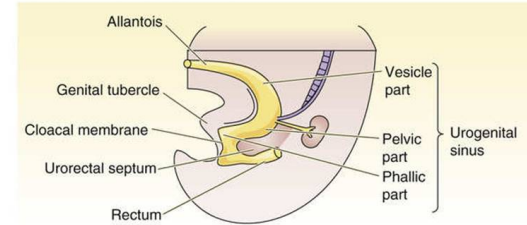
Cloaca is lined by endoderm-derived epithelium

Urorectal septum separates hindgut from urogenital sinus

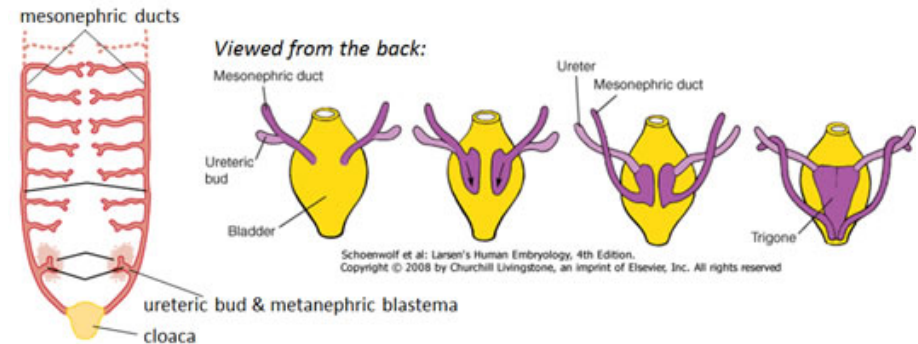
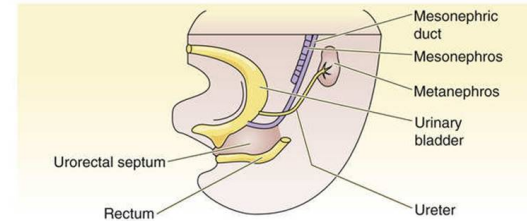
Ureters develop from ureteric buds  
Ureteric buds separate from mesonephric ducts,  
and end cranially in trigone of urogenital sinus

Urogenital sinus gives rise to  
bladder and urethra

A PARTITIONING OF CLOACA



B INDIFFERENT UROGENITAL SINUS



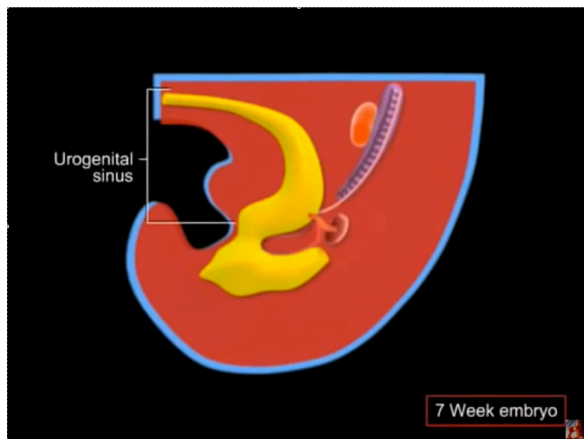
# Development of the Urinary Bladder and Urethra

Cloaca is lined by endoderm-derived epithelium

Urorectal septum separates hindgut from urogenital sinus

Ureters develop from ureteric buds  
Ureteric buds separate from mesonephric ducts,  
and end cranially in trigone of urogenital sinus

Urogenital sinus gives rise to  
bladder and urethra



# Development of the Urinary System

Anatomy of the Urinary System

Trilaminar Embryo

Embryonic origins of Urinary System

Kidney Development

Nephrogenesis

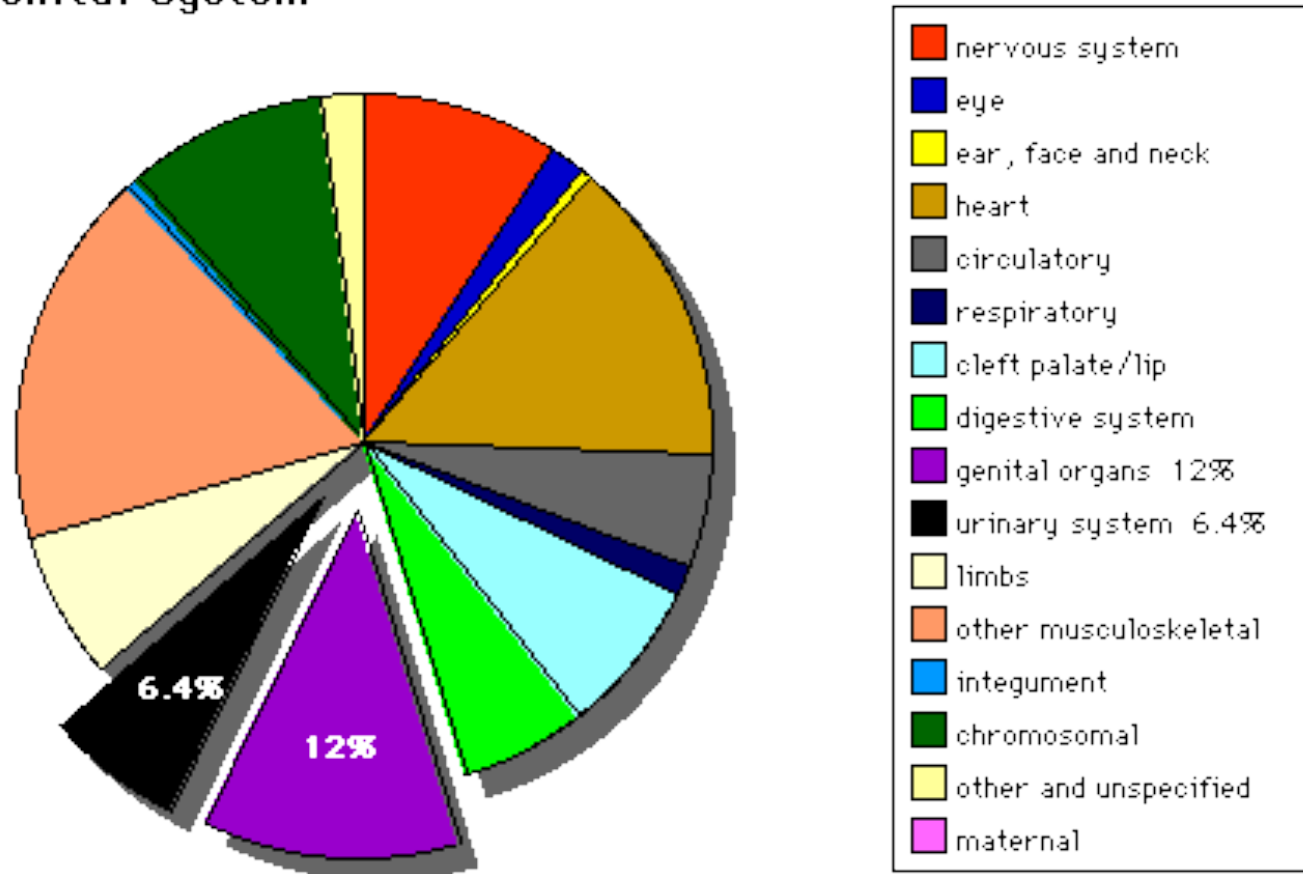
Development of the Renal Vasculature

Development of the Urinary Bladder and Urethra

**Congenital Abnormalities of the Urinary System**

# Congenital Abnormalities of the Urinary System

## Congenital Malformations by System 81-92 Urogenital System



Data source: Congenital Malformations Australia 1981-92

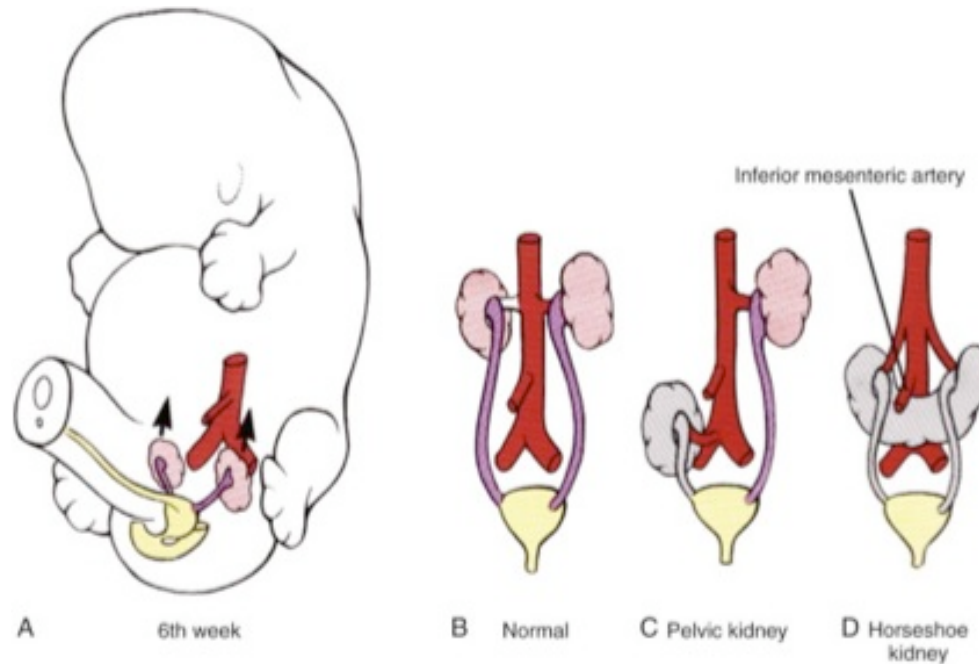


# Congenital Abnormalities of the Urinary System

## Horseshoe Kidney, Pelvic Kidney

Horseshoe kidney: during kidney ascent the two metanephric blastemas can come into contact, mainly at the lower pole, resulting in fusion.

Renal ectopia or pelvic kidney: kidney ascent failure



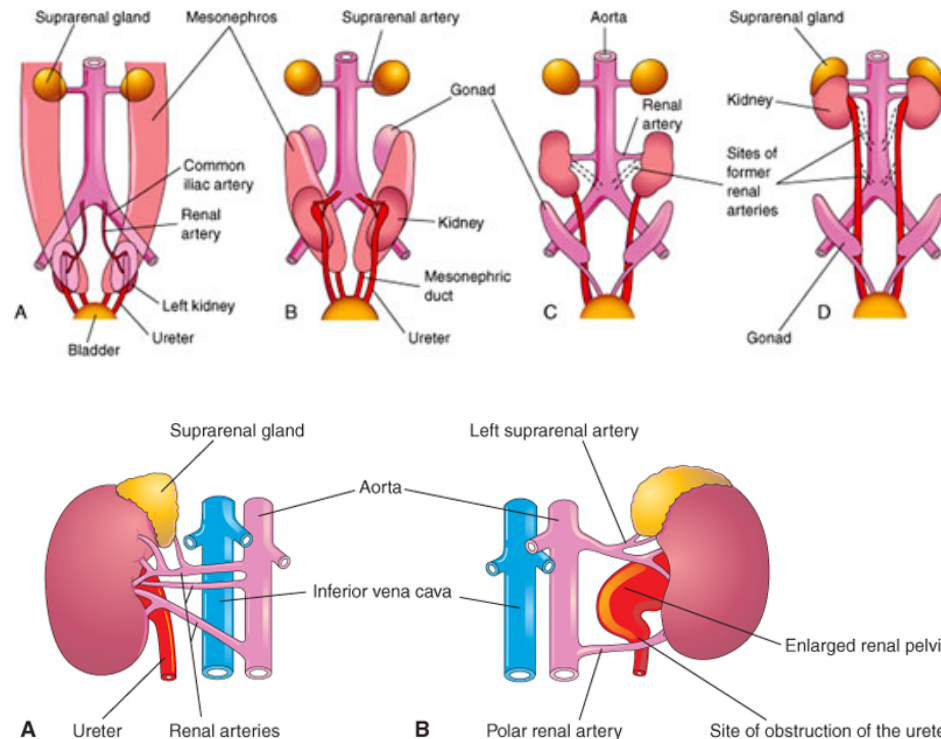
# Congenital Abnormalities of the Urinary System

## Supernumerary Renal Arteries

During kidney ascent, renal arteries form and degenerate at progressively anterior levels

Supernumerary/accessory renal arteries: failure of degeneration

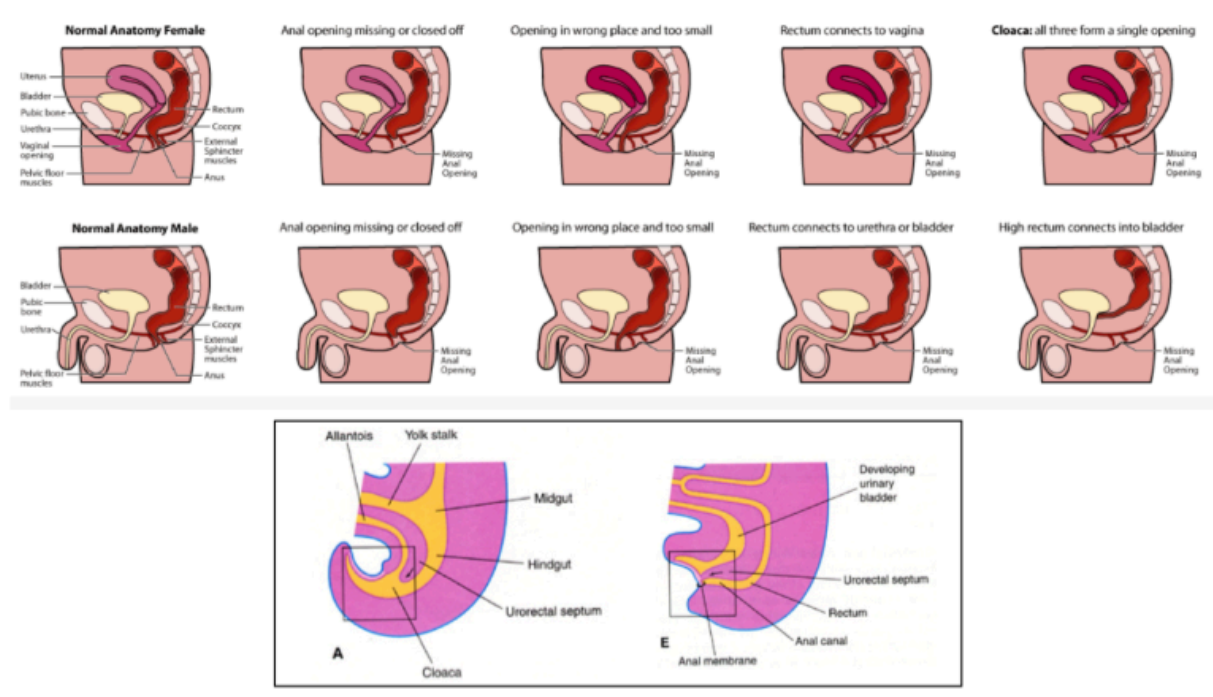
Occurs in 25% of population



# Congenital Abnormalities of the Urinary System

## Urorectal Septum Malformation

Problems with growth or position of urorectal septum results in anorectal anomalies:



# Development of the Urinary System

Anatomy of the Urinary System

Embryonic origins of Urinary System

Kidney Development

Nephrogenesis

Development of the Renal Vasculature

Development of the Urinary Bladder and Urethra

Congenital Abnormalities of the Urinary System