Urogenital System
Urinary System

Functionally , the urogenital system can be divided into two entirely different components: the **urinary system** and the **genital system**. Embryologically and anatomically, however, they are intimately interwoven. Both develop from a common mesodermal ridge **(intermediate mesoderm)** along the posterior wall of the abdominal cavity, and initially, the excretory ducts of both systems enter a common cavity, the cloaca.

URINARY SYSTEM

Kidney Systems

Three slightly overlapping kidney systems are formed in a cranial-to-caudal sequence during intrauterine life in humans: the **pronephros, mesonephros**, and **metanephros**. The first of these systems is rudimentary and nonfunctional; the second may function for a short time during the early fetal period; the third forms the permanent kidney.

Pronephros

At the beginning of the fourth week, the pronephros is represented by 7 to 10 solid cell groups in the cervical region. These groups form vestigial excretory units, nephrotomes, that regress before more caudal ones are formed. By the end of the fourth week, all indications of the pronephric system have disappeared.

Mesonephros

The mesonephros and mesonephric ducts are derived from intermediate mesoderm from upper thoracic to upper lumbar (L3) segments. Early in the fourth week of development, during regression of the pronephric system, the first excretory tubules of the mesonephros appear. They lengthen rapidly, form an S-shaped loop, and acquire a tuft of capillaries that will form a glomerulus at their medial extremity. Around the glomerulus, the tubules form **Bowman's capsule**, and together these structures constitute a **renal corpuscle**. Laterally, the tubule enters the longitudinal collecting duct known as the **mesonephric** or **wolffian duct**. In the middle of the second month, the mesonephros forms a large ovoid organ on each side of the midline. Since the developing gonad is on its medial side, the ridge formed by both organs is known as the **urogenital ridge**. While caudal tubules are still differentiating, cranial tubules and glomeruli show degenerative changes, and by the end of the second month, the majority have disappeared. In the male, a few of the caudal tubules and the mesonephric duct persist and participate in formation of the genital system, but they disappear in the female.

Metanephros: The Definitive Kidney

The third urinary organ, the **metanephros** or **permanent kidney**, appears in the fi fth week. Its excretory units develop from **metanephric mesoderm** in the same manner as in the mesonephric system. The development of the duct system differs from that of the other kidney systems. **Collecting System** Collecting ducts of the permanent kidney develop from the **ureteric bud**, an outgrowth of the mesonephric duct close to its entrance to the cloaca. The bud penetrates the metanephric tissue, which is molded over its distal end as a cap. Subsequently, the bud dilates,forming the primitive **renal pelvis**, and splits into cranial and caudal portions, the future **majorcalyces**. Each calyx forms two new buds while penetrating
the metanephric tissue. These buds continue to subdivide until 12 or more generations of tubules have formed. Meanwhile, at the periphery, more tubules form until the end of the fifth month. The tubules of the second order enlarge and absorb those of the third and fourth generations, forming the **minor calyces** of the renal pelvis. During further development, collecting tubules of the fifth and successive generations elongate considerably and converge on the minor calyx, forming the **renal pyramid**. **The ureteric bud gives rise to the ureter, the renal pelvis, the major and minor calyces, and approximately 1 to 3 million collecting tubules**.

Excretory System

Each newly formed collecting tubule is covered at its distal end by a **metanephric tissue cap**. Under the inductive infl uence of the tubule, cells of the tissue cap form small vesicles, the **renal vesicles**, which in turn give rise to small S-shaped tubules. Capillaries grow into the pocket at one end of the S and differentiate into **glomeruli**. These tubules, together with their glomeruli, form **nephrons**, or **excretory units**. The proximal end of each nephron forms **Bowman's capsule**, which is deeply indented by a glomerulus. The distal end forms an open connection with one of the collecting tubules, establishing a passageway from Bowman's capsule to the collecting unit. Continuous lengthening of the excretory tubule results in formation of the **proximal convoluted tubule, loop of Henle**, and **distal convoluted tubule**. Hence, the kidney develops from two sources:
(1) metanephric mesoderm, which provides excretory units and
(2) the ureteric bud, which gives rise to the collecting system.
Nephrons are formed until birth, at which time there are approximately 1 million in each kidney. Urine production begins early in gestation, soon after differentiation of the glomerular capillaries, which start to form by the 10th week. At birth, the kidneys have a lobulated appearance, but the lobulation disappears during infancy as a result of further growth of the nephrons, although there is no increase in their number.

POSITION OF THE KIDNEY

The kidney, initially in the pelvic region, later shifts to a more cranial position in the abdomen. This **ascent of the kidney** is caused by diminution of body curvature and by growth of the body in the lumbar and sacral regions. In the pelvis the metanephros receives its arterial supply from a pelvic branch of the aorta. During its ascent to the abdominal level, it is vascularized by arteries that originate from the aorta at continuously higher levels. The lower vessels usually degenerate, but some may remain.

FUNCTION OF THE KIDNEY

The definitive kidney formed from the metanephros becomes functional near the 12th week. Urine is passed into the amniotic cavity and mixes with the amniotic fluid. The fluid is swallowed by the fetus and recycles through the kidneys. During fetal life, the kidneys are not responsible for excretion of waste products, since the placenta serves this function.

BLADDER AND URETHRA

During the fourth to seventh weeks of development the **cloaca** divides into the **urogenital sinus** anteriorly and the **anal canal** posteriorly. The **urorectal septum** is a layer of mesoderm between the primitive anal canal and the urogenital sinus. The tip of the septum will form the **perineal body**. Three portions of the urogenital sinus can be distinguished: The upper and largest part is the **urinary bladder**. Initially the bladder is continuous with the allantois, but when the lumen of the allantois is obliterated, a thick fibrous cord, the **urachus,** remains and connects the apex of the bladder with the umbilicus. In the adult, it is known as the **median umbilical ligament.** The next part is a rather narrow canal, the **pelvic part of the urogenital sinus,** which in the male gives rise to the **prostatic** and **membranous** parts of the **urethra.** The last part is the **phallic part** of the urogenital sinus. It is flattened from side to side, and as the genital tubercle grows, this part of the sinus will be pulled ventrally. During differentiation of the cloaca, the caudal portions of the mesonephric ducts are absorbed into the wall of the urinary bladder. Consequently, the ureters, initially outgrowths from the mesonephric ducts, enter the bladder separately. As a result of ascent of the kidneys, the orifices of the ureters move farther cranially; those of the mesonephric ducts move close together to enter the prostatic urethra and in the male become the **ejaculatory ducts**. Since both the mesonephric ducts and ureters originate in the mesoderm, the mucosa of the bladder formed by incorporation of the ducts (the **trigone** of the bladder) is also mesodermal.With time the mesodermal lining of the trigone is replaced by endodermal epithelium, so that finally the inside of the bladder is completely lined with endodermal epithelium.

URETHRA

The epithelium of the urethra in both sexes originates in the endoderm; the surrounding connective and smooth muscle tissue is derived from splanchnic mesoderm. At the end of the third month, epithelium of the prostatic urethra begins to proliferate and forms a number of outgrowths that penetrate the surrounding mesenchyme. In the male, these buds form the **prostate gland**. In the female, the cranial part of the urethra gives rise to the **urethral** and **paraurethral glands.**