

Early development and bladder Ontology Feb 2015

TS17 10.5dpc (range 10-11.25 dpc)
 TS18 11dpc (range 10.5-11.25 dpc)
 TS19 11.5 dpc (range 11-12.25 dpc)
 TS20 12 dpc (range 11.5 – 13 dpc)
 TS21 13 dpc (range 12.5 – 14 dpc)
 TS22 14 dpc (range 13.5 – 15 dpc)
 TS23 15 dpc
 TS24 16 dpc
 TS25 17 dpc
 TS26 18 dpc
 TS27 newborn (range P0 - P3)
 TS28 P4 – Adult

Ontology trees – red text = new terms or modified terms

A number of terms have been merged with the Alt ID providing a reference to the secondary ID

Early development: TS17-18

Genitourinary system has been extended through to adult.

EMAPA:25765	TS01-TS28	mouse				
EMAPA:16103	TS11-TS28	└	organ system			
EMAPA:16245	TS12-TS28		└ visceral organ			
EMAPA:16367	TS13-TS28			└ genitourinary system (syn: urogenital system)		
EMAPA:16577	TS14-TS24				└ nephric duct (syn: mesonephric duct, Wolffian duct) (Alt ID: EMAPA:28425, 28429)	
EMAPA:16579	TS14-TS14				└ pronephros	
EMAPA:27602	TS14-TS14				└ nephric duct, pronephric portion (syn: mesonephric duct, pronephric portion Wolffian duct, pronephric portion)	
EMAPA:16744	TS15-TS18				└ mesonephros	
EMAPA:27591	TS15-TS18				└ nephric duct, mesonephric portion (syn: mesonephric duct, Wolffian duct, mesonephric portion)	
EMAPA:17379	TS18-TS18				└ urogenital sinus (Alt ID: EMAPA:17211)	
EMAPA:31509	TS18-TS18				└ epithelium of urogenital sinus (Alt ID: EMAPA:31520)	
EMAPA:31500	TS18-TS18				└ mesenchyme of urogenital sinus (Alt ID: EMAPA:31519)	
EMAPA:27573	TS17-TS20				└ cloaca (Alt ID: EMAPA:27638)	
EMAPA:27577	TS17-TS20				└ cloacal epithelium (syn: distal urethral epithelium) (syn: cloacal endoderm) (Alt ID: EMAPA:27640)	
EMAPA:27581	TS17-TS20				└ cloaca associated mesenchyme (Alt ID: EMAPA:27642)	
EMAPA:16832	TS17-TS20				└ cloacal membrane	
EMAPA:36070	TS17-TS20				└ cloacal epithelium of cloacal membrane	
EMAPA:36071	TS17-TS20				└ surface ectoderm of cloacal membrane	
EMAPA:17210	TS17-TS18	 	 	 	└ urogenital membrane	
EMAPA:17212	TS17-TS18				└ urorectal septum	

EMAPA:30074 TS17-TS18 | | | | genital swelling
 EMAPA:31578 TS17-TS18 | | | | L developing vasculature of genitourinary system

The nephric duct group terms and nephric duct term refer to the same structure and have been merged:

EMAPA:16577 TS14-TS16 | | | | nephric duct (syn: Wolffian duct)
 EMAPA:28425 G TS17-TS18 | | | | nephric duct group (syn: mesonephric duct;-Wolffian duct)
 EMAPA:28429 G TS19-TS19 | | | | nephric duct group (syn: mesonephric duct; Wolffian duct)

EMAPA:16577 TS14-**TS24** | | | | nephric duct (syn: mesonephric duct, Wolffian duct) (Alt ID: EMAPA:28425, 28429)
 EMAPA:27602 **TS14-TS14** | | | | nephric duct, pronephric portion (syn: mesonephric duct, pronephric portion Wolffian duct, pronephric portion)
 EMAPA:27591 **TS15**-TS18 | | | | nephric duct, mesonephric portion (syn: mesonephric duct, Wolffian duct, mesonephric portion)
 EMAPA:27599 TS17-TS18 | | | | nephric duct, metanephric portion (syn: mesonephric duct, metanephric portion, Wolffian duct, metanephric portion)
 EMAPA:36101 TS19-TS22 | | | | L common nephric duct (syn: common mesonephric duct, common Wolffian duct)

Cloaca (TS17-20)

cloaca (TS17-20): an epithelial lined cavity derived from endoderm, seen early in embryonic development located at the posterior end of the embryo. The cloaca undergoes septation to form the urogenital sinus (ventral) and hindgut (dorsal). This common cavity is referred to as the cloaca until the urorectal septum makes contact with the skin at the surface of the embryo, and completely septates the urogenital sinus from the hindgut at TS21. The cavity that remains, becomes part of the urogenital sinus and urethra. The cloaca is comprised of cloacal epithelium lining the lumen and the adjacent cloaca associated mesenchyme. Part of the cloacal epithelium forms the cloacal membrane.

cloacal epithelium (syn: cloacal endoderm) (TS17-20): the cloacal epithelium is derived from endoderm and lines the cloacal cavity. It is marked by Shh and Cdh1 and lines the cloacal lumen. The cloacal epithelium gives rise to the urogenital sinus epithelium, hindgut epithelium and the urethral plate epithelium.

cloacal membrane (TS17-20): part of the cloaca where the two different epithelia of the surface ectoderm (of the embryo) and cloacal epithelium are in direct contact with each other. Comprised of cloacal epithelium of cloacal membrane and surface ectoderm of cloacal membrane. Fgf8 marks the cloacal epithelium component. (Note: the cloacal membrane is distinct to the urogenital membrane, which is comprised of the regions of surface ectoderm and urethral plate epithelium in contact with each other and part of the genital tubercle.)

tailgut (TS19): a blind-ended, caudal/posterior epithelial extension from the cloacal epithelium.

Early development: after TS19, the urinary system

EMAPA:25765	TS01-TS28	mouse				
EMAPA:16103	TS11-TS28	└	organ system			
EMAPA:16245	TS12-TS28		└	visceral organ		
EMAPA:16367	TS13- TS28			└	genitourinary system (syn: urogenital system)	
EMAPA:17366	TS17 -TS28			└	urinary system	
EMAPA:17377	TS19- TS19				└	nephric duct, metanephric portion (syn: mesonephric duct, metanephric portion; Wolffian duct, metanephric portion)
EMAPA:xxxxxx	TS19-TS22					└ common nephric duct (syn: common mesonephric duct, common Wolffian duct)
EMAPA:17950	TS20-TS28				└	ureter
EMAPA:17381	TS16 -TS28			└	reproductive system	
EMAPA:27663	TS19-TS19				└	nephric duct, mesonephric portion
EMAPA:35591	TS20-TS23				└	nephric duct of male (syn: mesonephric duct of male Wolffian duct of male) (Alt ID: EMAPA:29173, EMAPA:17970)
EMAPA:29181	TS20 -TS23					└ epithelium of nephric duct of male
EMAPA:29177	TS20 -TS23					└ mesenchyme of nephric duct of male
EMAPA:35590	TS20- TS24					└ nephric duct of female (syn: mesonephric duct of female, Wolffian duct of female) (Alt ID: EMAPA:28945,28924)
EMAPA:28949	TS20 -TS23				└	epithelium of nephric duct of female
EMAPA:28953	TS20 -TS23				└	mesenchyme of nephric duct of female
EMAPA:27665	TS19-TS19				└	paramesonephric duct (syn: Mullerian duct)
EMAPA:35661	TS20- TS24				└	paramesonephric duct of male (syn: Mullerian duct of male)
EMAPA:35320	TS20 -TS23				└	epithelium of paramesonephric duct of male
EMAPA:35560	TS20 -TS23				└	mesenchyme of paramesonephric duct of male
EMAPA:35660	TS20-TS23				└	paramesonephric duct of female (syn: Mullerian duct of female) (Alt ID: EMAPA:35341)
EMAPA:35319	TS20 -TS23				└	epithelium of paramesonephric duct of female
EMAPA:35559	TS20 -TS23				└	mesenchyme of paramesonephric duct of female

nephric duct (syn: mesonephric duct, Wolffian duct) (TS14-TS24): paired epithelial ducts which develop early in development (TS14) in the cranial/anterior intermediate mesoderm and extend caudally down the rostro-caudal axis of the embryo to terminate at the cloaca. The nephric duct is subdivided along its anterior-posterior length, into the pronephric portion, mesonephric portion (part of the mesonephros) (located in mesonephros, anterior), metanephric portion (adjacent to the metanephros) and common nephric duct (posterior portion below the metanephros). These regions are stage-dependant, with the pronephric portion present at TS14 in the pronephros, the mesonephric portion from TS15 in the mesonephros and posterior to these, the metanephric portion from TS17. The regions are part of either the urinary or reproductive system. After the urogenital sinus extends from the cloaca, the nephric duct connects to the dorsal side of the caudal urogenital sinus at the urogenital sinus ridge. The ducts are marked by Cdh1 and Hoxb7. As the ontology becomes gender-specific, the nephric duct becomes the nephric duct of male/female (from TS20).

common nephric duct (syn: common mesonephric duct, common Wolffian duct) (TS19-22): the caudal portion of the paired epithelial nephric ducts, between the ureteric bud stalk/ureter attachment site (anterior/cranial end) and the site of insertion into the urogenital sinus at the urogenital sinus ridge (posterior/caudal end). Regresses after TS21 due to remodelling and apoptosis and at TS22 only a few cells are visible. Marked by Cdh1, Hoxb7 and Ret.

paramesonephric duct (syn: Mullerian duct) (TS19): paired epithelial ducts which develop laterally adjacent to the nephric ducts in the anterior mesonephros and extend caudally down the rostro-caudal length of the nephric ducts. Later, at TS21, they will terminate at the urogenital sinus/pelvic urethra. Part of the reproductive system. The ducts are marked by Cdh1 and Pax2. As the ontology becomes gender-specific, the paramesonephric duct becomes the paramesonephric duct of male/female (from TS20).

paramesonephric duct of male/female (TS20-23 in female, TS20-24 in males) (syn: Mullerian duct of male/female): paired epithelial ducts which develop laterally adjacent to the nephric ducts in the anterior mesonephros and extend caudally down the rostro-caudal length of the nephric ducts to terminate at the urogenital sinus/pelvic urethra. Part of the reproductive system. They connect at the caudal end, to the dorsal, anterior urogenital sinus (caudal urogenital sinus) at the urogenital sinus ridge at TS21, crossing over the nephric ducts, such that they connect to the urethra medially, with the nephric ducts located on either side. The ducts are marked by Cdh1 and Pax2. They are comprised of epithelium and mesenchyme of paramesonephric duct of female. The epithelium is marked by Cdh1 and Pax2. Derives from the paramesonephric duct (syn: Mullerian duct, TS19). In females from TS24, becomes part of the oviduct, ureterus, cervix, uterine horn and upper vagina. In males from TS22, the ducts begin to degenerate with only remnants of the ducts present at TS24 in males.

nephric duct of male/female (syn: mesonephric duct of male/female, Wolffian duct of male/female) (TS20-24 in females, TS20-23 in males): paired epithelial ducts which develop early in development in the cranial/anterior intermediate mesoderm and extend caudally down the rostro-caudal axis of the embryo to terminate at the urogenital sinus/pelvic urethra. Part of the reproductive system from TS20. Develops from the nephric duct (TS19), and is located in mesonephros (anterior) and then at its caudal end (posterior), connects to the dorsal, anterior urogenital sinus (caudal urogenital sinus) at the urogenital sinus ridge. Marked by Cdh1, Pax2 (also seen in the paramesonephric duct) and Hoxb7 (specific to the nephric duct). From TS20-24, is comprised of epithelium of nephric duct of male/female and mesenchyme of nephric duct of male/female (the mesenchyme surrounding the epithelial duct). In males, the nephric duct of male becomes seminal vesicle, ductus deferens and epididymis from TS24. In females, the nephric duct degenerates in a rostral to caudal wave beginning at TS22 and complete by TS25, with only remnants seen at TS24.

urorectal septum (TS19-27): the mesenchyme located between the hindgut (dorsal) and urogenital sinus (ventral) (TS19-21) and later the colon/rectum and bladder/urethra. Derived from mesoderm.

Urogenital sinus (TS19-21)

EMAPA:25765	TS01-TS28	mouse					
EMAPA:16103	TS11-TS28	└ organ system					
EMAPA:16245	TS12-TS28	└ visceral organ					
EMAPA:16367	TS13-TS28	└ genitourinary system (syn: urogenital system)					
EMAPA:17366	TS19-TS28	└ urinary system					
EMAPA:17379	TS19-TS26	└ urogenital sinus (Alt ID: EMAPA:17211)					
EMAPA:31509	TS19-TS26	└ epithelium of urogenital sinus (Alt ID: EMAPA:31520)					
EMAPA:31500	TS19-TS26	└ mesenchyme of urogenital sinus (Alt ID: EMAPA:31519)					
EMAPA:31532	TS20-TS21	└ developing vasculature of urogenital sinus					
EMAPA:31533	TS20-TS21	└ nerves of urogenital sinus					
EMAPA:31527	TS20-TS21	└ pelvic ganglion					
EMAPA:31528	TS20-TS21	└ nerve of urogenital sinus					
EMAPA:30870	TS19-TS21	└ primitive bladder (syn: cranial urogenital sinus)					
EMAPA:36096	TS19-TS21	└ primitive bladder-caudal urogenital sinus transition zone (syn: primitive bladder-caudal urogenital sinus junction)					
EMAPA:36097	TS19-TS21	└ epithelium of primitive bladder-caudal urogenital sinus transition zone					
EMAPA:36098	TS19-TS21	└ mesenchyme of primitive bladder-caudal urogenital sinus transition zone					
EMAPA:30879	TS19-TS20	└ caudal urogenital sinus (syn: primitive pelvic urethra) (previously called rest of urogenital sinus)					
EMAPA:30882	TS19-TS20	└ caudal urogenital sinus epithelium (previously called epithelial layer of rest of urogenital sinus)					
EMAPA:36099	TS19-TS20	└ urogenital sinus ridge (syn: sinus ridge)					
EMAPA:36100	TS19-TS20	└ rest of caudal urogenital sinus epithelium					
EMAPA:30885	TS19-TS20	└ caudal urogenital sinus mesenchyme (previously called mesenchymal layer of rest of urogenital sinus)					

Another tree layout for the urogenital sinus, TS19-21:

EMAPA:17379	TS19-TS26	└ urogenital sinus (Alt ID: EMAPA:17211)					
EMAPA:31509	TS19-TS26	└ epithelium of urogenital sinus (Alt ID: EMAPA:31520)					
EMAPA:30873	TS19-TS21	└ urothelium of primitive bladder					
EMAPA:36097	TS19-TS21	└ epithelium of primitive bladder-caudal urogenital sinus transition zone					
EMAPA:30882	TS19-TS20	└ caudal urogenital sinus epithelium					
EMAPA:36099	TS19-TS20	└ urogenital sinus ridge					
EMAPA:36100	TS19-TS20	└ rest of caudal urogenital sinus epithelium					
EMAPA:31500	TS19-TS26	└ mesenchyme of urogenital sinus (Alt ID: EMAPA:31519)					
EMAPA:30876	TS19-TS21	└ mesenchymal layer of primitive bladder					
EMAPA:36098	TS19-TS21	└ mesenchyme of primitive bladder-caudal urogenital sinus transition zone					
EMAPA:30885	TS19-TS20	└ caudal urogenital sinus mesenchyme					

urogenital sinus (TS19-28): the epithelial lined cavity seen extending from the anterior cloaca. The epithelium is derived from cloacal endoderm. At TS19, the paired nephric ducts are attached to its dorsolateral sides. Comprised of epithelium of urogenital sinus epithelium lining the lumen and the surrounding mesenchyme of urogenital sinus. The UGS is subdivided into the primitive bladder (cranial/anterior), the primitive bladder-caudal urogenital sinus transition zone, and caudal urogenital sinus (caudal/posterior), at the connection site of the common nephric ducts (which connect the nephric ducts to the UGS at the urogenital sinus ridge). From TS20 the UGS also includes developing

vasculature of urogenital sinus and nerves of urogenital sinus. The primitive bladder will develop into the bladder and the caudal urogenital sinus into the pelvic urethra. From TS19-21 is comprised of three major regions; primitive bladder, primitive bladder-caudal urogenital sinus transition zone and caudal urogenital sinus. From TS22-28 it is comprised of three major regions; bladder, bladder-urethra transition zone and pelvic urethra.

primitive bladder-caudal urogenital sinus transition zone (TS19-21) (syn: primitive bladder-caudal urogenital sinus junction): comprised of epithelium and mesenchyme of primitive bladder-caudal urogenital sinus transition zone. The zone or region where the primitive bladder meets the caudal urogenital sinus, marking the junction where these two different epithelia meet. It is similar to transitional zones in other organs, such as the female cervix and the Z-line in the oesophagus. In early developmental stages it is identified by the site of the common nephric duct/nephric duct attachment to the urogenital sinus. Part of the urogenital sinus. Use these terms to annotate expression in the epithelium or mesenchyme where the primitive bladder meets the caudal urogenital sinus/pelvic urethra, when the tissue cannot be identified as being either part of the bladder or part of the urethra.

epithelium of urogenital sinus: the epithelium lining the lumen, marked by Cdh1 (E-cadherin), Osr1 and Shh. Derived from cloacal endoderm. Subdivided into urothelium of primitive bladder (cranial/anterior), epithelium of primitive bladder-caudal urogenital sinus transition zone and caudal urogenital sinus epithelium (caudal/posterior).

mesenchyme of urogenital sinus: the mesenchyme surrounding the urogenital sinus epithelium. Marked by Gli1, Ptch1, Bmp4, Raldh2. Derived from mesoderm. Subdivided into mesenchymal layer of primitive bladder (rostral/anterior), mesenchyme of primitive bladder-caudal urogenital sinus transition zone and caudal urogenital sinus mesenchyme (caudal/posterior).

Caudal urogenital sinus (TS19-20)

caudal urogenital sinus (TS19-20) (syn: primitive pelvic urethra): the posterior/caudal part of the urogenital sinus including the urogenital sinus ridge where the common nephric ducts/nephric ducts join the urogenital sinus. Comprised of the urogenital sinus ridge, rest of caudal urogenital sinus epithelium and surrounded by the caudal urogenital sinus mesenchyme. Becomes the pelvic urethra at TS21, which together with the primitive bladder makes up the urogenital sinus.

urogenital sinus ridge (synonym: sinus ridge) part of the urogenital sinus (TS19-21), part of the caudal urogenital sinus (TS19-20), and then later part of pelvic urethra (TS21-23). The thickened and raised, dorsal portion of the urogenital sinus or epithelium of pelvic urethra located at the site where the common nephric duct/nephric duct or reproductive ducts join the urogenital sinus/pelvic urethra. From TS19-22 the urogenital sinus ridge surrounds the common nephric duct. Marked by Cdh1 (E-cadherin) and derived from cloacal endoderm. It is a signalling centre, important for regulating common nephric duct remodelling and apoptosis during ureter maturation and repositioning, and later in

development, may be a source of inductive signals regulating vaginal outgrowth. At TS24, it becomes the verumontanum in males and sinovaginal bulb in females, the protrusion of the pelvic urethra where the reproductive ducts join.

Primitive bladder (TS19-21)

primitive bladder (TS19-21) (syn: cranial urogenital sinus): The anterior/cranial part of the urogenital sinus, lined with urothelium, located anterior to the attachment point of the common nephric duct/nephric duct at the urogenital sinus ridge. At TS19 the primitive bladder is an epithelial lined cavity comprised of urothelium of primitive bladder (upbl, endoderm-derived epithelium) and the adjacent mesenchyme of primitive bladder (mpbl, mesoderm-derived). From TS20-21 it is also comprised of developing vasculature of primitive bladder (TS20-21), outer layer of primitive bladder (either serosa of primitive bladder (TS20-21) or adventitia of primitive bladder) and from TS21, muscle layer of primitive bladder. From TS20, the mesenchyme of primitive bladder is subdivided into inner and outer layers. Becomes bladder (TS22-28).

EMAPA:17379	TS19- TS21						urogenital sinus
EMAPA:30870	TS19 -TS21						primitive bladder (syn: cranial urogenital sinus)
EMAPA:30873	TS19 -TS21						urothelium of primitive bladder (syn: epithelial layer of primitive bladder, epithelium of primitive bladder)
EMAPA:xxxxxx	TS19 -TS20						undifferentiated epithelial cell of urothelium of primitive bladder (syn: undifferentiated endodermal cell of urothelium of primitive bladder)
EMAPA:xxxxxx	TS19 -TS21						P-0 cell of urothelium of primitive bladder
EMAPA:xxxxxx	TS21 -TS21						intermediate cell of urothelium of primitive bladder
EMAPA:30876	TS19 -TS21						mesenchymal layer of primitive bladder (syn: primitive bladder mesenchyme)
EMAPA:36088	TS20 -TS21						inner mesenchymal layer of primitive bladder (syn: suburothelial mesenchyme of primitive bladder)
EMAPA:36089	TS20 -TS21						outer mesenchymal layer of primitive bladder
EMAPA:36091	TS21 -TS21						smooth muscle cell of outer mesenchymal layer of primitive bladder
EMAPA:36092	TS21 -TS21						mesenchymal cell of outer mesenchymal layer of primitive bladder
EMAPA:31529	TS20 - TS21	 	 	 	 	 	mesenchymal layer of dorsal primitive bladder
EMAPA:31525	TS20 - TS21	 	 	 	 	 	mesenchymal layer of ventral primitive bladder
EMAPA:36090	TS21 -TS21						muscle layer of primitive bladder (syn: smooth muscle layer of primitive bladder)
EMAPA:36093	TS20 -TS21						outer layer of primitive bladder
EMAPA:36094	TS20 -TS21						serosa of primitive bladder
EMAPA:36095	TS20 -TS21						adventitia of primitive bladder
EMAPA:31539	TS20 -TS21					└	developing vasculature of primitive bladder

urothelium of primitive bladder (TS19-21) (synonym: epithelium of primitive bladder): the urothelial layer lining the lumen of the primitive bladder, comprised of a stratified epithelium of different epithelial cell types depending on stage, a subpopulation of which expresses Uroplakin. Derived from cloacal endoderm. At TS19-20 the upbl is comprised predominantly of P-0 cells and very few undifferentiated epithelial cells. At TS21 the upbl is comprised of P-0 cells (usually on the luminal surface) and intermediate cells. Becomes the urothelium of bladder at TS22.

P-0 cell of urothelium of primitive bladder (TS19-TS21) (synonym: transient urothelial progenitor cells): a transient embryonic urothelial cell type of the primitive bladder. P-0 cells are defined by their expression pattern and location in the urothelium. P-0 cells express Shh, Uroplakin, Trp63, Isl1 and Foxa2. P-cells do not express Krt5. They make up most of the TS19-20 urothelium and generally reside on the luminal surface of the urothelium at TS21. P-0 cells are the progenitors of intermediate cells and superficial cells of the urothelium of primitive bladder/bladder during embryonic development.

undifferentiated epithelial cell of urothelium of primitive bladder (TS19-TS20) (syn: endodermal epithelial cell of urothelium): a very small number of these cells are present in the early embryonic urothelium of primitive bladder from TS19-20. These cells are defined by their expression pattern and location in the urothelium. They express Foxa2, Trp63, Shh and Isl1. They do not express Uroplakin or Krt5. They are usually located at the luminal surface of the urothelium.

intermediate cell of urothelium of primitive bladder (TS21): are defined by their expression pattern and location in the urothelium. They are present from TS21, in the primitive bladder they are located below the luminal cells and they express Uroplakins, Trp63 and Shh (and do not express Foxa2, Isl1 or Krt5). Intermediate cells are present in the bladder (after TS21).

mesenchymal layer of primitive bladder (TS19-TS21) (syn: primitive bladder mesenchyme): the mesenchyme surrounding the urothelium of primitive bladder. At TS19-20, expresses Ptch1 and Gli1. From TS21, contains smooth muscle cells. The mesenchyme of primitive bladder (and later the bladder) is radially patterned due to differentiation of mesenchymal cells into smooth muscle cells. The layers are defined by their location, differing gene expression profiles and proliferation rates. From TS20-21 it is divided into inner mesenchyme of primitive bladder (TS20-21) and outer mesenchyme of primitive bladder (TS20-21).

inner mesenchymal layer of primitive bladder (TS20-21; syn: suburothelial mesenchyme of primitive bladder): the inner zone of mesenchyme of the primitive bladder, immediately adjacent to the urothelium of primitive bladder. From TS20 is marked by high levels of expression of Gli2 and Bmp4 and moderate levels of Gli1 and Ptch1 and from TS21 is marked by high levels of Gli1, Gli2, Ptch1 and Bmp4. Does not contain smooth muscle cells and therefore does not express smooth muscle actins (alpha-actin and gamma-actin) or smooth muscle myosins (myosin heavy chain). Becomes the lamina propria of bladder (TS22-28).

outer mesenchymal layer of primitive bladder (TS20-21; syn: peripheral mesenchyme of primitive bladder): the outer zone of the mesenchyme of the primitive bladder adjacent to the serosa/adventitia of primitive bladder. Inner mesenchymal zone markers Gli1, Gli2, Ptch1, Bmp4 are not expressed at high levels. From TS21, is marked by Gli3 and Myocd, which are absent in the inner layer and from TS21 contains smooth muscle cells (marked by smooth muscle actins and myosins such as smooth muscle alpha-actin, smooth muscle

gamma-actin, smooth muscle myosin heavy chain, and Tgfb1) and mesenchymal cells of outer mesenchymal layer of primitive bladder.

muscle layer of primitive bladder (TS21-21, syn: smooth muscle layer of primitive bladder), smooth muscle differentiation, marked by Myocd, is first seen at TS21 in the fundus or bladder dome which moves towards the bladder neck. Marked by smooth muscle actins and myosins such as smooth muscle alpha-actin, smooth muscle gamma-actin, smooth muscle myosin heavy chain, and Tgfb1. Differentiates into the detrusor muscle of bladder (TS22-28).

*Removed the subdivision of mesenchyme into dorsal and ventral from TS20.

outer layer of primitive bladder (TS20-21): the outermost layer of the bladder is comprised of either a serosa or an adventitia. The adventitia refers to the outer part of the primitive bladder that is not exposed to the peritoneal cavity but is a connective tissue layer that binds it to the adventitia of the adjacent organs. Most of the bladder will be covered by serosa, but early when the primitive bladder is not developed and later in some regions (i.e. closer toward the urethra) there will instead be an adventitia. As the organs develop, more of the bladder is covered by serosa and less by an adventitia.

adventitia of primitive bladder (TS20-21): the outermost layer of the bladder is comprised of either a serosa or an adventitia. The adventitia refers to the outer part of the primitive bladder that is not exposed to the peritoneal cavity but is a connective tissue layer that binds it to the adventitia of the adjacent organs. Most of the bladder will be covered by serosa, but early when the primitive bladder is not developed and later in some regions (i.e. closer toward the urethra) there will instead be an adventitia. As the organs develop, more of the bladder is covered by serosa and less by an adventitia.

serosa of primitive bladder (TS20-21): the outermost layer of the bladder is comprised of either a serosa or an adventitia. The serosa (or serous membrane) of the primitive bladder, where the outer surface is covered by simple epithelium. Most of the bladder will be covered by serosa, but early when the primitive bladder is not developed and later in some regions (i.e. closer toward the urethra) there will instead be an adventitia. As the organs develop, more of the bladder is covered by serosa and less by an adventitia.

developing vasculature of primitive bladder (TS20-21): the blood vessels (arteries, veins and capillaries) of the primitive bladder.

TS22-28, bladder

bladder (TS22-28): comprised of urothelium of bladder (subdivided into layers and cell types), lamina propria of bladder (subdivided into layers), detrusor muscle of bladder and surrounded by an outer layer of bladder (subdivided into serosa of bladder or adventitia of bladder). Also includes vasculature of bladder and nerve of bladder. Derived from primitive bladder (TS19-21). Bladder is also subdivided into regions; bladder fundus and

bladder neck (subdivided into bladder trigone and ventral bladder neck). Part of the urogenital sinus and part of the urinary system.

urothelium of bladder (TS22-28) (synonym: epithelium of bladder): the innermost layer of the bladder lining the bladder lumen, comprised of a stratified epithelium of three epithelial cell layers containing different epithelial cell types. Contains blood vessels and nerve of urothelium of bladder (TS22-28). Comprised of three cellular layers; superficial, intermediate and basal cell layers. Distinct epithelial cell types reside within the layers of urothelium and are stage dependant. It is possible to annotate urothelium cell layer without knowing the cell type. In the adult bladder, Krt5-expressing basal cells of bladder urothelium make up 90% of the mature urothelium, while intermediate and superficial cells of bladder urothelium each make up about 5%.

superficial cell layer of bladder urothelium (TS22-TS28) (syn: luminal cell layer of bladder urothelium): the epithelial layer of cells lining the bladder lumen, comprised of superficial cells and intermediate cells of bladder urothelium from TS22-28.

intermediate cell layer of bladder urothelium (TS22-TS28) (syn: suprabasal cell layer of bladder urothelium): the 1-2 cell epithelial layer located between the superficial layer and the basal layers, comprised of intermediate cells of bladder urothelium at TS22. From TS23-28 is comprised of intermediate cells and Krt5-expressing basal cells of bladder urothelium.

basal cell layer of bladder urothelium (TS22-TS28): the cell layer at the base of the urothelium adjacent to the basement membrane, comprised of different cell types dependant on stage. At TS22, is comprised solely of intermediate cells (prior to the identification of Krt5-expressing basal cells), from TS23-24 is comprised of intermediate and Krt5-expressing basal cells of bladder urothelium, and from TS25-28 is comprised solely of Krt5-expressing basal cells of bladder urothelium.

superficial cell of bladder urothelium (TS22-28) (TS22-25 synonym: immature umbrella cells of bladder urothelium, at TS26 synonym: umbrella cells of bladder urothelium): the urothelial cell type lining the bladder lumen. Part of the superficial cell layer from E14 (TS22) to adult (TS28). During development immature umbrella cells become multinucleated large and oval shaped as they mature. Superficial cells are specialised for the synthesise and transport of uroplakin proteins which make up the urothelial plaque. These cell express uroplakins (whereas genetic markers of other urothelial cell types including, Krt5, Trp63, Foxa2, Isl1 and Shh, are not expressed). At TS22, superficial cells of bladder urothelium are immature umbrella cells which are mononucleated and similar in size to the other urothelial cell types. By TS26 mature umbrella cells, are fully differentiated, they are multinucleated (polyploidy) and are enormous in size compared to the other urothelial cell types. Fully differentiated superficial cells uniquely express Krt20, from TS26. In the adult, they make up ~5% of the urothelium of bladder.

Intermediate cells of bladder urothelium (TS21-28): are present from E13 (TS21, where they are a part of the urothelium of primitive bladder). In the bladder (TS22-28), intermediate cells are predominantly present in the intermediate cell layer but are also

found in the basal cell layer (from TS22-24) and superficial cell layer (from TS22-28). They express uroplakins, Trp63 and Shh (do not express Isl1, Foxa2 or Krt5). In the adult, they make up ~5% of the urothelium of bladder.

Krt5-expressing basal cells of bladder urothelium (syn: K5-basal cells of bladder urothelium) (TS23-28): cells expressing Krt5, present in the basal and intermediate cell layers of the bladder urothelium. First detected between E14-E15, at TS23. They express Krt5, Trp63 and Shh (do not express Isl1, Foxa2 or uroplakins). From TS27 (P0), a subpopulation of these cells also express Krt14. In the adult, they make up ~90% of the urothelium of bladder.

EMAPA:18321	TS22-TS28						bladder
EMAPA:28601	TS22-TS28						urothelium of bladder (syn: epithelium of bladder)
EMAPA:32273	TS22-TS28						superficial cell layer of bladder urothelium
EMAPA:xxxxx	TS22-TS28						superficial cell of bladder urothelium (syn: immature umbrella cell TS22-TS25 and syn: umbrella cells TS26-TS28)
EMAPA:xxxxx	TS22-TS28						intermediate cell of bladder urothelium
EMAPA:36073	TS22-TS28						intermediate cell layer of bladder urothelium (syn: suprabasal cell layer of bladder urothelium)
EMAPA:xxxxx	TS22-TS28						intermediate cell of bladder urothelium
EMAPA:xxxxx	TS23-TS28						Krt5-expressing basal cell of bladder urothelium (syn: K5-basal cell of bladder urothelium)
EMAPA:32274	TS22-TS28						basal cell layer of bladder urothelium
EMAPA:xxxxx	TS22-TS24						intermediate cell of bladder urothelium
EMAPA:xxxxx	TS23-TS28						Krt5-expressing basal cell of bladder urothelium (syn: K5-basal cell of bladder urothelium)

lamina propria of bladder (TS22-28): the thick mesenchymal cell layer of the bladder located between the urothelium and the detrusor muscle of bladder. Contains loose to dense (depending on region) connective tissue (marked by pro-collagen) many small blood vessels and nerves and thin, discontinuous wisps of smooth muscle (marked by smooth muscle markers; smooth muscle actin, desmin and actin). Contains nerve of lamina propria of bladder and is subdivided into suburothelial lamina propria of bladder (syn: suburothelial stroma of bladder, suburothelial mesenchyme of bladder, inner lamina propria of bladder) and outer lamina propria of bladder (syn: muscularis mesenchyme of bladder). These layers differ in their gene expression profile, presence of smooth muscle cells, vascularisation density and proliferation rates. During development the lamina propria of bladder is radially patterned into these two layers due to differentiation of the outer mesenchyme into smooth muscle.

suburothelial lamina propria of bladder (syn: suburothelial stroma of bladder, suburothelial mesenchyme of bladder, inner lamina propria of bladder) (TS22-28): a thin layer of mesenchymal (or stromal) cells located immediately adjacent to the urothelium. Numerous blood vessels and an absence of smooth muscle cells are characteristic of this layer and therefore it does not express markers of smooth muscle (such as smooth muscle actins (alpha-actin and gamma-actin) or smooth muscle myosins (myosin heavy chain) or Tgfb1). At E14-16, the suburothelial lamina propria expresses higher levels of Ptch1, Gli1

and is marked by Snai1 at E17. Contains nerve of suburothelial lamina propria of bladder (TS22-28).

outer lamina propria of bladder (syn: muscularis mesenchyme of bladder) (TS22-28): the outer mesenchymal layer or outer lamina propria layer of the bladder located adjacent to the detrusor muscle of bladder. Contains loosely organised connective tissue, many small blood vessels and nerves, and discontinuous wisps of smooth muscle cells marked by smooth muscle alpha actin. At E14-E16 this layer is marked by Gli3 and Myocd (DeSouza et al 2013). Contains nerve of outer lamina propria of bladder (TS22-28).

EMAPA:30088 TS22-TS28 | | | | | lamina propria of bladder
EMAPA:36075 TS22-TS28 | | | | | suburothelial lamina propria of bladder (syn: suburothelial stroma of bladder, suburothelial mesenchyme of bladder, inner lamina propria of bladder)
EMAPA:36076 TS22-TS28 | | | | | outer lamina propria of bladder (syn: muscularis mesenchyme of bladder)

detrusor muscle of bladder (TS22-28) (syn: smooth muscle layer of bladder): a thick layer comprised of irregularly oriented smooth muscle fibre bundles adjacent to the outer layer of bladder (serosa/adventitia of bladder). Marked by smooth muscle markers including Tgfb1, smooth muscle actins (smooth muscle alpha actin, smooth muscle gamma actin) and smooth muscle myosins (eg. Myh11, smooth muscle myosin heavy chain), the major structural components of smooth muscle. Contains nerve of bladder detrusor muscle (TS22-28).

outer layer of bladder: the outermost layer of the bladder subdivided into serosa of bladder (TS22-28) and adventitia of bladder (TS22-28). Most of the bladder is covered by serosa, a serous-fluid-secreting outer epithelial surface of the bladder in contact with the coelomic cavity. The fundus (or dome) is surrounded by serosa, the rest of the bladder, in contact with the adjacent connective tissue, is covered by adventitia. The adventitia refers to the outer part of the bladder that is not exposed to the peritoneal cavity but is a connective tissue layer that binds it to the adventitia of adjacent organs. The proportion of the bladder covered by serosa and adventitia is stage dependant, with adventita covering more of the bladder early in development, and the majority covered by serosa later in development. Contains nerve of bladder serosa/adventitia (TS22-28).

EMAPA:36077 TS22-TS28 | | | | | outer layer of bladder
EMAPA:28661 TS22-TS28 | | | | | serosa of bladder
EMAPA:28826 TS22-TS28 | | | | | adventitia of bladder

vasculature of bladder (TS22-28) (syn: blood vessel of bladder): blood vessels (arteries, veins and capillaries) of the bladder. Contains nerve of bladder blood vessel (TS22-28).

nerve of bladder (TS22-28)

Bladder tissue layer ontology tree:

EMAPA:18321	TS22-TS28	- - -			bladder
EMAPA:28601	TS22-TS28	- - -			urothelium of bladder (syn: epithelium of bladder)
EMAPA:32273	TS22-TS28	- - -			superficial cell layer of bladder urothelium
EMAPA:xxxxx	TS22-TS28	- - -			superficial cell of bladder urothelium (syn: immature umbrella cell TS22-TS25 and syn: umbrella cell TS26-TS28)
EMAPA:xxxxx	TS22-TS28	- - -			intermediate cell of bladder urothelium
EMAPA:36073	TS22-TS28	- - -			intermediate cell layer of bladder urothelium (syn: suprabasal cell layer of bladder urothelium)
EMAPA:xxxxx	TS22-TS24	- - -			intermediate cell of bladder urothelium
EMAPA:xxxxx	TS23-TS28	- - -			Krt5-expressing basal cell of bladder urothelium (syn: K5-basal cell of bladder urothelium)
EMAPA:32274	TS22-TS28	- - -			basal cell layer of bladder urothelium
EMAPA:xxxxx	TS22-TS24	- - -			intermediate cell of bladder urothelium
EMAPA:xxxxx	TS23-TS28	- - -			Krt5-expressing basal cell of bladder urothelium (syn: K5-basal cell of bladder urothelium)
EMAPA:36343	TS22-TS28	- - -			nerve of urothelium of bladder
EMAPA:36347	TS22-TS28	- - -			nerve of urothelium of bladder fundus
EMAPA:36348	TS22-TS28	- - -			nerve of urothelium of bladder neck
EMAPA:36349	TS22-TS28	- - -			nerve of urothelium of bladder trigone
EMAPA:36350	TS22-TS28	- - -			nerve of urothelium of ventral bladder neck
EMAPA:30088	TS22-TS28	- - -			lamina propria of bladder
EMAPA:36075	TS22-TS28	- - -			suburothelial lamina propria of bladder (syn: suburothelial stroma of bladder, suburothelial mesenchyme of bladder, inner lamina propria of bladder)
EMAPA:36076	TS22-TS28	- - -			outer lamina propria of bladder (syn: muscularis mesenchyme of bladder)
EMAPA:36344	TS22-TS28	- - -			nerve of lamina propria of bladder
EMAPA:36351	TS22-TS28	- - -			nerve of lamina propria of bladder fundus
EMAPA:36356	TS22-TS28	- - -			nerve of outer lamina propria of bladder fundus
EMAPA:36355	TS22-TS28	- - -			nerve of suburothelial lamina propria of bladder
fundus					
EMAPA:36352	TS22-TS28	- - -			nerve of lamina propria of bladder neck
EMAPA:36357	TS22-TS28	- - -			nerve of lamina propria of bladder trigone
EMAPA:36358	TS22-TS28	- - -			nerve of lamina propria of ventral bladder neck
EMAPA:28637	TS22-TS28	- - -			detrusor muscle of bladder
EMAPA:36345	TS22-TS28	- - -			nerve of detrusor muscle of bladder
EMAPA:36365	TS22-TS28	- - -			nerve of detrusor muscle of bladder fundus
EMAPA:36366	TS22-TS28	- - -			nerve of detrusor muscle of bladder neck
EMAPA:36367	TS22-TS28	- - -			nerve of detrusor muscle of bladder trigone
EMAPA:36368	TS22-TS28	- - -			nerve of detrusor muscle of ventral bladder neck
EMAPA:36077	TS22-TS28	- - -			outer layer of bladder
EMAPA:28661	TS22-TS28	- - -			serosa of bladder
EMAPA:36375	TS22-TS28	- - -			nerve of serosa of bladder fundus
EMAPA:28826	TS22-TS28	- - -			adventitia of bladder
EMAPA:36376	TS22-TS28	- - -			nerve of adventitia of bladder neck
EMAPA:36377	TS22-TS28	- - -			nerve of adventitia of bladder trigone
EMAPA:36378	TS22-TS28	- - -			nerve of adventitia of ventral bladder neck
EMAPA:36346	TS22-TS28	- - -			nerve of outer layer of bladder
EMAPA:36375	TS22-TS28	- - -			nerve of serosa of bladder fundus
EMAPA:36376	TS22-TS28	- - -			nerve of adventitia of bladder neck
EMAPA:36377	TS22-TS28	- - -			nerve of adventitia of bladder trigone

EMAPA:36378	TS22-TS28	-	-	-			L nerve of adventitia of ventral bladder neck
EMAPA:28679	TS22-TS28						├ vasculature of bladder (syn: blood vessel of bladder)
EMAPA:31526	TS22-TS28						└ nerve of bladder

Fundus, neck and trigone regions of bladder

bladder fundus region (TS22-28) (syn: bladder dome): the rounded blind-end of the bladder. Comprised of urothelium, lamina propria, detrusor muscle and serosa of bladder fundus.

bladder neck (TS22-28): the narrow open end of the bladder, located between the ureter orifices and the opening of the pelvic urethra. Subdivided into bladder trigone and ventral bladder neck.

bladder trigone region (TS22-28): the triangular-shaped dorsal region of the bladder neck located between the ureters and the opening of the pelvic urethra. The ureter orifices form the base of the trigone and the urethra opening, the apex. The urothelium of bladder trigone has a smooth surface (as opposed to folded luminal surface of the urothelium of the bladder fundus). The morphology of the trigone changes from isosceles to equilateral triangle during development, as the distance between the ureters and pelvic urethra lengthens. Lineage analysis has shown that the urothelium derives from the urogenital sinus and the muscle derives from differentiates from the intersecting detrusor muscle and longitudinal urethral muscle fibres. Comprised of urothelium, lamina propria and detrusor muscle of bladder trigone, intercalated with ureteral smooth muscle of trigone. Also contains ureter junction of bladder trigone and urethra junction of bladder trigone.

ventral bladder neck (TS22-28): the ventral region of the narrow open end of the bladder, located between the ureter orifices and the opening of the pelvic urethra. (The dorsal region of the bladder neck is the bladder trigone.) Comprised of urothelium, lamina propria, detrusor muscle and adventitia of ventral bladder neck.

Bladder regions ontology tree:

EMAPA:18321	TS22-TS28						├ bladder
EMAPA:35173	TS22-TS28						├ bladder fundus
EMAPA:28607	TS22-TS28						├ urothelium of bladder fundus
EMAPA:30102	TS22-TS28						├ lamina propria of bladder fundus
EMAPA:28643	TS22-TS28						├ detrusor muscle of bladder fundus
EMAPA:28667	TS22-TS28						├ serosa of bladder fundus
EMAPA:36078	TS22-TS28						├ bladder neck
EMAPA:35174	TS22-TS28						├ bladder trigone (syn: dorsal bladder neck)
EMAPA:36080	TS22-TS28						├ ureter junction of bladder trigone
EMAPA:36081	TS22-TS28						├ urethra junction of bladder trigone
EMAPA:28613	TS22-TS28						├ urothelium of bladder trigone
EMAPA:30109	TS22-TS28						├ lamina propria of bladder trigone
EMAPA:28649	TS22-TS28						├ detrusor muscle of bladder trigone
EMAPA:28836	TS23-TS28						├ adventitia of bladder trigone

EMAPA:36082	TS22-TS28									└ ureteral smooth muscle of trigone
EMAPA:36079	TS22-TS28									└ ventral bladder neck
EMAPA:36083	TS22-TS28									└ fundus junction of ventral bladder neck
EMAPA:36084	TS22-TS28									└ urethra junction of ventral bladder neck
EMAPA:30081	TS22-TS28									└ urothelium of ventral bladder neck
EMAPA:30116	TS22-TS28									└ lamina propria of ventral bladder neck
EMAPA:30123	TS22-TS28									└ detrusor muscle of ventral bladder neck
EMAPA:30144	TS23-TS28									└ adventitia of ventral bladder neck

Bladder-urethra transition zone

bladder-urethra transition zone (TS22-28) (syn: bladder-urethra junction): comprised of epithelium and mesenchyme of bladder-urethra transition zone. The zone or region located where the bladder neck meets the pelvic urethra/urethra, marking the junction where these two different epithelia meet (urothelium of bladder and epithelium of pelvic urethra). It is similar to transitional zones in other organs, such as the female cervix and the Z-line in the oesophagus. It is located close to where the nephric duct attaches to the urogenital sinus. Part of the urogenital sinus (to TS26) and part of the urinary system. Use these terms to annotate expression in the epithelium or mesenchyme where the bladder meets the pelvic urethra, when the tissue cannot be identified as being either part of the bladder or part of the pelvic urethra.

EMAPA:17366	TS19-TS28									└ urinary system
EMAPA:17379	TS19- TS26									└ urogenital sinus
EMAPA:36332	TS22-TS28									└ bladder-urethra transition zone (syn: bladder urethra junction)
EMAPA:36333	TS22-TS28									└ epithelium of bladder-urethra transition zone
EMAPA:36334	TS22-TS28									└ mesenchyme of bladder-urethra transition zone

epithelium of bladder-urethra transition zone (TS22-28): the zone or region of the epithelium located where the bladder neck meets the pelvic urethra/urethra, marking the junction where these two different epithelia meet (urothelium of bladder and epithelium of pelvic urethra). It is similar to transitional zones in other organs, such as the female cervix and the Z-line in the oesophagus. It is located close to where the nephric duct attaches to the urogenital sinus. Part of the bladder-urethra transition zone and part of the urogenital sinus and part of the urinary system. Use this term to annotate expression in the epithelium where the bladder neck meets the pelvic urethra, when the tissue cannot be identified as being either part of the bladder or part of the pelvic urethra.

mesenchyme of bladder-urethra transition zone (TS22-28): the mesenchyme surrounding the epithelium in the zone or region of the where the bladder neck meets the pelvic urethra/urethra. It is similar to transitional zones in other organs, such as the female cervix and the Z-line in the oesophagus. It is located close to where the nephric duct attaches to the urogenital sinus. Part of the bladder-urethra transition zone and part of the urogenital sinus and part of the urinary system. Use this term to annotate expression in the mesenchyme where the bladder neck meets the pelvic urethra, when the tissue cannot be identified as being either part of the bladder or part of the pelvic urethra.

Bladder-urethra transition zone:

EMAPA:17366	TS19-TS28					urinary system
EMAPA:17379	TS19- TS26					urogenital sinus
EMAPA:18321	TS22-TS28					bladder
EMAPA:36332	TS22-TS28					bladder-urethra transition zone (syn: bladder urethra junction)
	TS21-TS22					urethra
	TS21-TS22					pelvic urethra
EMAPA:28747	TS23-TS28					urethra of female
EMAPA:28753	TS23-TS28					pelvic urethra of female (syn: cranial urethra, internal urethra)
EMAPA:18692	TS23-TS28					urethra of male
EMAPA:18995	TS23-TS28					pelvic urethra of male

Another tree layout for the urogenital sinus, TS22-26:

EMAPA:17379	TS19- TS26					urogenital sinus
EMAPA:31509	TS19- TS26					epithelium of urogenital sinus
EMAPA:30873	TS19-TS21					urothelium of primitive bladder
EMAPA:xxxxxx	TS19-TS21					epithelium of pimitive bladder-caudal urogenital sinus transition zone
EMAPA:xxxxxx	TS19-TS20					caudal urogenital sinus epithelium
EMAPA:xxxxxx	TS19-TS20					urogenital sinus ridge
EMAPA:xxxxxx	TS19-TS20					rest of caudal urogenital sinus epithelium
EMAPA:31500	TS19- TS26					mesenchyme of urogenital sinus
EMAPA:30876	TS19-TS21					mesenchymal layer of primitive bladder
EMAPA:xxxxxx	TS19-TS21					mesenchyme of primitive bladder-caudal urogenital sinus transition zone
EMAPA:xxxxxx	TS19-TS20					caudal urogenital sinus mesenchyme

Bladder terms no longer required, because these structures do not exist in the mouse bladder:

EMAPA:28619	TS22-TS28	 	 	 	 	muscularis mucosa of bladder
EMAPA:28625	TS22-TS28	 	 	 	 	muscularis mucosa of fundus
EMAPA:28631	TS22-TS28	 	 	 	 	muscularis mucosa of trigone
EMAPA:30137	TS22-TS28	 	 	 	 	muscularis mucosa of neck
EMAPA:32275	TS22-TS28	 	 	 	 	submucosa of bladder
EMAPA:32277	TS22-TS28	 	 	 	 	submucosa of fundus
EMAPA:32304	TS22-TS28	 	 	 	 	submucosa of trigone
EMAPA:32276	TS22-TS28	 	 	 	 	submucosa of neck
EMAPA:28673	TS22-TS28	 	 	 	 	serosa of trigone
EMAPA:30130	TS22-TS28	 	 	 	 	serosa of neck

Combined bladder ontology tree (tissue layers and regions):

EMAPA:18321	TS22-TS28	-	-	-		bladder
EMAPA:28601	TS22-TS28	-	-	-		urothelium of bladder (syn: epithelium of bladder)
EMAPA:32273	TS22-TS28	-	-	-		superficial cell layer of bladder urothelium
EMAPA:xxxxxx	TS22-TS28	-	-	-		superficial cell of bladder urothelium (syn: immature umbrella cell TS22-TS25 and syn: umbrella cell TS26-TS28)
EMAPA:xxxxxx	TS22-TS28	-	-	-		intermediate cell of bladder urothelium

EMAPA:36073	TS22-TS28	- - -			intermediate cell layer of bladder urothelium (syn: suprabasal cell layer of bladder urothelium)
EMAPA:xxxxxx	TS22-TS24	- - -			intermediate cell of bladder urothelium
EMAPA:xxxxxx	TS23-TS28	- - -			└ Krt5-expressing basal cell of bladder urothelium (syn: K5-basal cell of bladder urothelium)
EMAPA:32274	TS22-TS28	- - -			basal cell layer of bladder urothelium
EMAPA:xxxxxx	TS22-TS24	- - -			intermediate cell of bladder urothelium
EMAPA:xxxxxx	TS23-TS28	- - -			└ Krt5-expressing basal cell of bladder urothelium (syn: K5-basal cell of bladder urothelium)
EMAPA:28607	TS22-TS28	- - -			urothelium of bladder fundus
EMAPA:28613	TS22-TS28	- - -			urothelium of bladder trigone
EMAPA:30081	TS22-TS28	- - -			urothelium of ventral bladder neck
EMAPA:36343	TS22-TS28	- - -			└ nerve of urothelium of bladder
EMAPA:36347	TS22-TS28	- - -			└ nerve of urothelium of bladder fundus
EMAPA:36348	TS22-TS28	- - -			└ nerve of urothelium of bladder neck
EMAPA:36349	TS22-TS28	- - -			└ nerve of urothelium of bladder trigone
EMAPA:36350	TS22-TS28	- - -			└ nerve of urothelium of ventral bladder neck
EMAPA:30088	TS22-TS28	- - -			lamina propria of bladder
EMAPA:36075	TS22-TS28	- - -			suburothelial lamina propria of bladder (syn: suburothelial stroma of bladder, suburothelial mesenchyme of bladder, inner lamina propria of bladder)
EMAPA:36076	TS22-TS28	- - -			outer lamina propria of bladder (syn: muscularis mesenchyme of bladder)
EMAPA:30102	TS22-TS28	- - -			lamina propria of bladder fundus
EMAPA:30109	TS22-TS28	- - -			lamina propria of bladder trigone
EMAPA:30116	TS22-TS28	- - -			lamina propria of ventral bladder neck
EMAPA:36344	TS22-TS28	- - -			└ nerve of lamina propria of bladder
EMAPA:36351	TS22-TS28	- - -			└ nerve of lamina propria of bladder fundus
EMAPA:36356	TS22-TS28	- - -			└ nerve of outer lamina propria of bladder fundus
EMAPA:36355	TS22-TS28	- - -			└ nerve of suburothelial lamina propria of bladder fundus
EMAPA:36352	TS22-TS28	- - -			└ nerve of lamina propria of bladder neck
EMAPA:36357	TS22-TS28	- - -			└ nerve of lamina propria of bladder trigone
EMAPA:36358	TS22-TS28	- - -			└ nerve of lamina propria of ventral bladder neck
EMAPA:28637	TS22-TS28	- - -			detrusor muscle of bladder
EMAPA:28643	TS22-TS28	- - -			detrusor muscle of bladder fundus
EMAPA:28649	TS22-TS28	- - -			detrusor muscle of bladder trigone
EMAPA:30123	TS22-TS28	- - -			detrusor muscle of ventral bladder neck
EMAPA:36345	TS22-TS28	- - -			└ nerve of detrusor muscle of bladder
EMAPA:36365	TS22-TS28	- - -			└ nerve of detrusor muscle of bladder fundus
EMAPA:36366	TS22-TS28	- - -			└ nerve of detrusor muscle of bladder neck
EMAPA:36367	TS22-TS28	- - -			└ nerve of detrusor muscle of bladder trigone
EMAPA:36368	TS22-TS28	- - -			└ nerve of detrusor muscle of ventral bladder neck
EMAPA:36077	TS22-TS28	- - -			outer layer of bladder
EMAPA:28661	TS22-TS28	- - -			serosa of bladder
EMAPA:28667	TS22-TS28	- - -			serosa of bladder fundus
EMAPA:36375	TS22-TS28	- - -			└ nerve of serosa of bladder fundus
EMAPA:28826	TS22-TS28	- - -			adventitia of bladder
EMAPA:28836	TS23-TS28	- - -			adventitia of bladder trigone
EMAPA:30144	TS23-TS28	- - -			adventitia of ventral bladder neck
EMAPA:36376	TS22-TS28	- - -			└ nerve of adventitia of bladder neck
EMAPA:36377	TS22-TS28	- - -			└ nerve of adventitia of bladder trigone
EMAPA:36378	TS22-TS28	- - -			└ nerve of adventitia of ventral bladder neck

EMAPA:36346	TS22-TS28	-	-	-			└	nerve of outer layer of bladder
EMAPA:36375	TS22-TS28	-	-	-			└	nerve of serosa of bladder fundus
EMAPA:36376	TS22-TS28	-	-	-			└	nerve of adventitia of bladder neck
EMAPA:36377	TS22-TS28	-	-	-			└	nerve of adventitia of bladder trigone
EMAPA:36378	TS22-TS28	-	-	-			└	nerve of adventitia of ventral bladder neck
EMAPA:28679	TS22-TS28						└	vasculature of bladder (syn: blood vessel of bladder)
EMAPA:31526	TS22-TS28						└	nerve of bladder