

# Practical class 3

## **EXCRETORY SYSTEM**

### OBJECTIVES

By the time you have completed this practical, and any further necessary reading, you should be able to:

1. Recognise the structural and functional differences between male and female pelvises.
2. Describe the muscles which contribute to the pelvic diaphragm (floor) and the walls of the pelvis.
3. List the major organs of this system, their locations in the abdomen, pelvis and perineum, and comment on the most important function of each.
4. Describe the gross anatomy and relations of the two kidneys, ureters and the bladder.
5. Appreciate the arterial and autonomic nerve supply, venous and lymphatic drainage of the organs of the urinary system.
6. Name each structure in sequence, the mechanism by which it functions in the path of formation, collection and transport of urine to the bladder.
7. Describe the control mechanism of micturition.

### **Background reading**

Rogers: Chapter 42: The kidneys and ureters  
43: The lower urinary tract



# INTRODUCTION

The function of the excretory system is to maintain a constant internal environment, which involves removal from the cells and body fluids (a) carbon dioxide (b) nitrogenous waste (c) toxic materials (d) excess salts, water and heat.

These functions are carried out by several different bodily systems.

## 1. *Digestive tract, in particular the liver*

Part of the nitrogenous waste, salts and water from the broken down gut-lining and bile are eliminated with the faeces. Excretas is the collective name for the faeces and urine.

## 2. *Lungs*

CO<sub>2</sub> and considerable amounts of water and heat are lost via the lungs and respiratory passages.

## 3. *Skin*

The excess heat that is not lost through respiration is removed through the skin. Loss of heat is aided by sweating. The sweat removes some nitrogenous waste, salts and water.

## 4. *Urinary system as an excretory organ*

The urinary system is designed to eliminate nitrogenous and other toxic wastes, excess salts and water not removed in other ways. The function of the kidneys is the cleansing of the blood, adjustment of the salt, pH and control of overall volume of body fluid. The urine is formed in the kidney, then transported through ureters to be temporarily stored in the bladder and be finally passed through the urethra to the exterior on micturition.

In this section we will consider the skin briefly, and then concentrate on the urinary system.

# SWEAT GLANDS

These are simple tubular glands. Sweating extracts latent heat of evaporation from the skin and thus help to cool the body surface. Sweat glands are simple tubular glands and in humans there are two types: the eccrine producing watery fluid and apocrine producing a thicker secretion.

**Eccrine** glands concentrate in areas of profuse sweat production i.e. the axilla, groin, palms and soles.

**Apocrine** glands are found in the axillae, around the anal and genital regions, eyelids and areola.

They are closely associated with the hair after opening into the hair follicles.

Eccrine glands are modified to form the ceruminous wax of the middle ear. In the female the glands undergo involutional changes during the menstrual cycle.

# ORGANS OF THE URINARY SYSTEM

The entire urinary system lies in the abdominopelvic cavity, but not within the peritoneal cavity. The kidneys and ureters are retroperitoneal, while the bladder lies essentially inferior to the peritoneal cavity. Finally, the urethra lies in the pelvis and perineum. All of these organs are therefore closely related to the muscles which contribute to the walls of the cavity.

## *Pelvis*

### STRUCTURAL DIFFERENCES IN THE PELVIS BETWEEN THE SEXES

Revise the bony skeleton of the pelvis covered in the first practical class.

*With reference to the pelvis on display, texts and the demonstrators, complete the table below indicating the major structural differences between the male and female pelvises.*

| Structure             | Male     |
|-----------------------|----------|
| False pelvis          | Narrow   |
| True pelvis           |          |
| Obturator foramen     | Oval     |
| Greater sciatic notch | Narrow   |
| ASIS                  | Inverted |
| Pelvic inlet          |          |
| Pelvic outlet         |          |
| Iliac fossa           | Deep     |
| Pubic arch            | Steep    |

On available prosections, locate the following bony landmarks: **subpubic arch**, **ischiopubic ramus** and the tip of the **coccyx**.

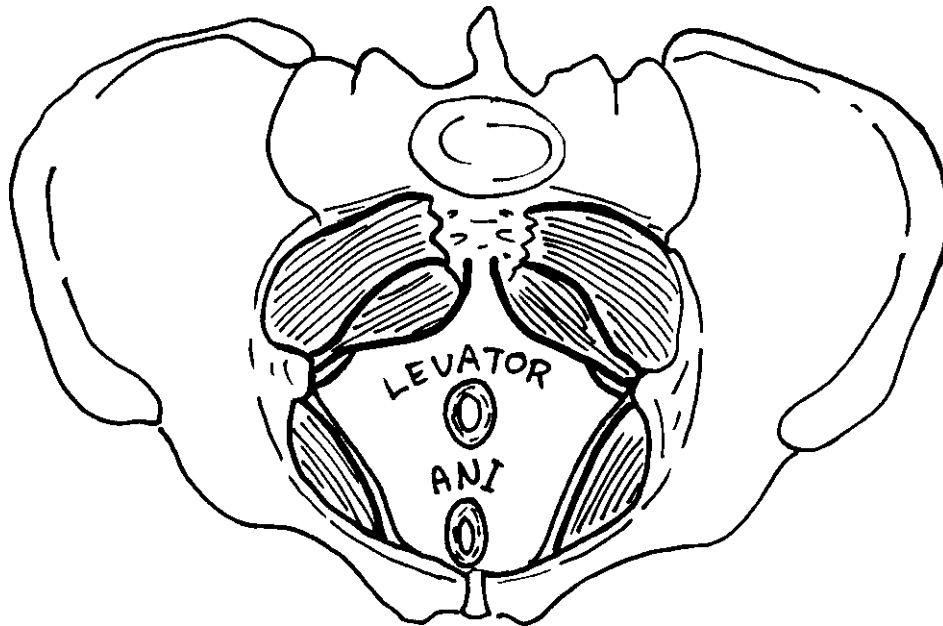
Look at the pelvis available and ensure that you can sexually differentiate them.

## *Muscles of the pelvic cavity*

At this point it would be useful to revise the muscles of the posterior body wall, and to consider those that make up the pelvic floor (that which divides the pelvis from the perineum).

The following diagram shows the muscles of the pelvic floor. These may be broadly divided into those which contribute to the pelvic walls: **obturator internus** and **piriformis**; and those which make up the pelvic diaphragm: **(ischio)coccygeus** and **levator ani**.

*Shade these on the following diagram.*



Levator ani has four parts; **levator prostatae/vaginae**, **puborectalis**, **pubococcygeus** and **iliococcygeus**. These subdivisions are very difficult to differentiate in prosected specimens, but you should appreciate their arrangement.

The pelvic diaphragm is shaped like an inverted pyramid with the rectum at its apex in the true pelvis. In the male, the bladder lies immediately in front of the rectum with no intervening structure between the two. In the female, the uterus intervenes between the two structures.

Revise the reflections of the peritoneum in the pelvis.

*What is the lowest extent of the peritoneal cavity in the male, and in the female?*

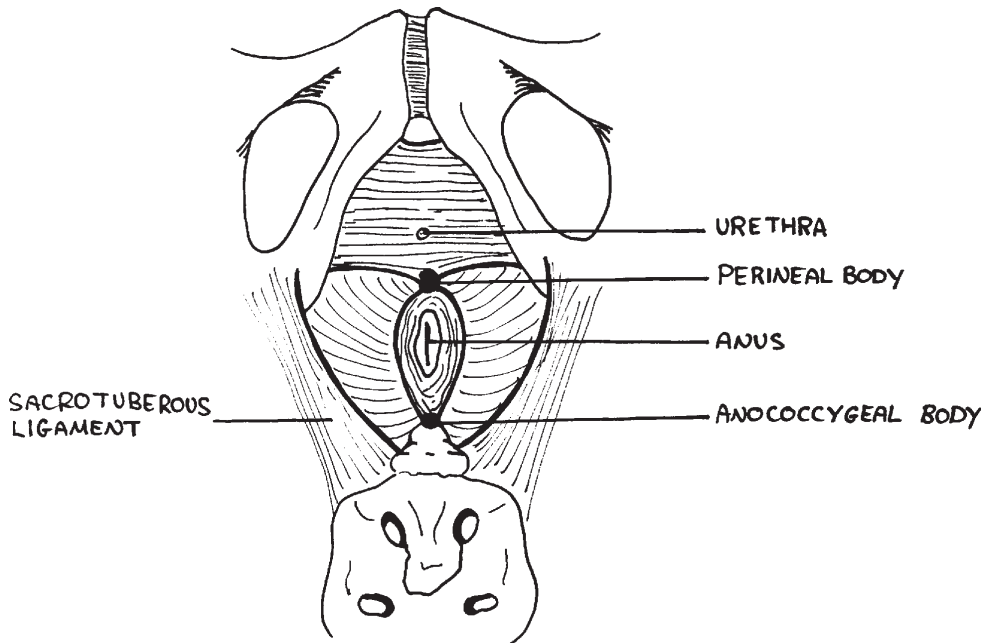
The pelvic diaphragm provides the major support to all pelvic viscera and its incompetence may lead to a prolapse

*What does the term 'prolapse' mean?*

The pelvic diaphragm and the associated fascia in women are particularly liable to damage in childbirth.

When viewed from below, the pelvic outlet can be divided into two regions: the **urogenital** and **anal triangles**. These are largely made up of the **urogenital diaphragm** and **levator ani** respectively.

*Draw these regions and label the two muscles mentioned on the following diagram .*



## KIDNEY

The nephron is the functional unit of the urinary system, and is therefore concerned with the regulation of water and salts in the internal environment, generally the emphasis is on retention.

The nephrons are located in the kidney. The kidney is bean-shaped, dark maroon in colour and has a firm consistency.

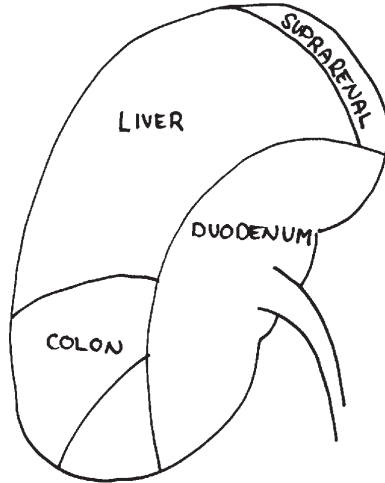
Locate the left and right kidneys which lie retroperitoneally (behind the parietal peritoneum) in the **paravertebral gutters** of the posterior abdominal wall.

*What are the paravertebral gutters?*

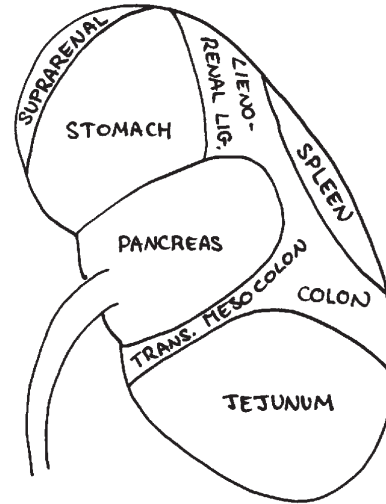
With the help of the following diagrams note that each kidney has certain important relationships:

*From your knowledge of the contents of the abdominal cavity, and the arrangement of the peritoneum: indicate on the diagrams which portions of the kidneys are peritonised.*

### **Anterior relations**



**Right**



**Left**

### *Posterior relations*

Each kidney lies on muscles. These muscles are: above, the **diaphragm**; medially, **psaos major**; laterally, the **quadratus lumborum**.

Revise the arrangement of the muscles of the posterior abdominal wall.

Beyond the muscles note the relationships of each kidney with the pleura and ribs.  
Identify the lower ribs by palpation through the posterior abdominal wall of the specimen.

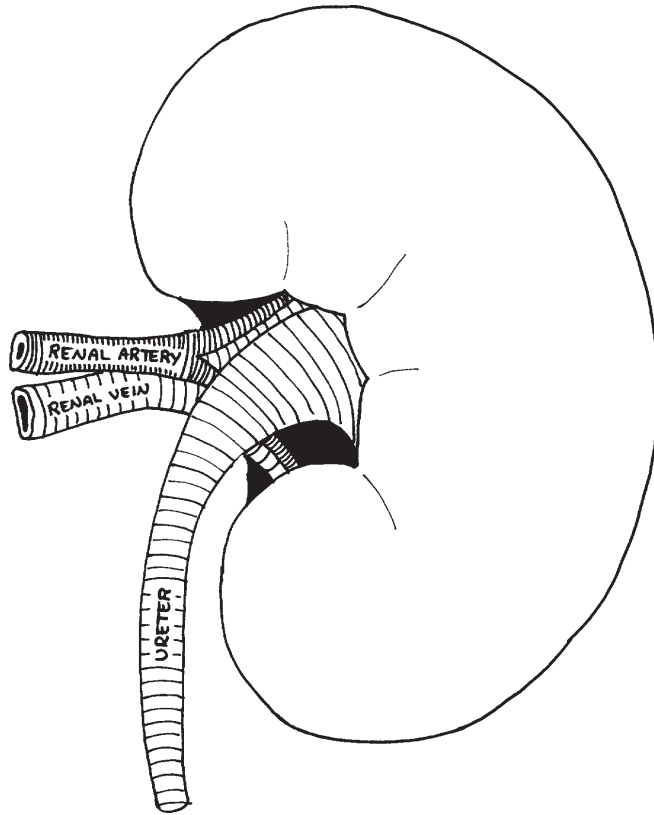
*On which ribs do the right and the left kidney lie?*

*What other structures (apart from muscles and bones) separate the upper poles of the kidneys from the skin of the back?*

Note on the dissections and the following diagram that from anterior to posterior the order of these structures is vein, artery (with its associated lymphatics and autonomic nerves) and ureter.

## Posterior view

Note also that the kidneys lie obliquely to the abdominal wall with the hilus lying anterior most and the lateral border posterior most.

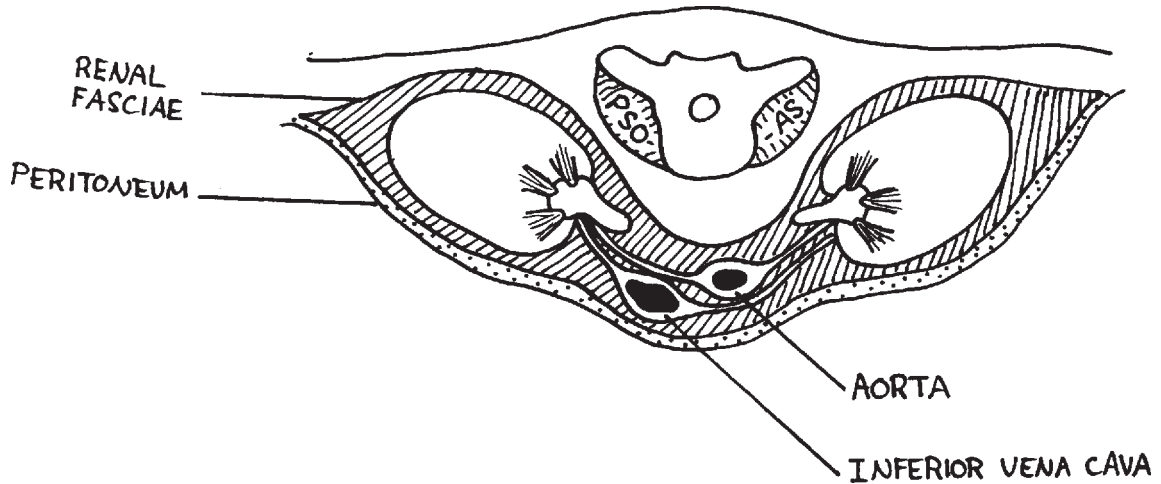


*Examine their position again, which pole lies more medially?*

Each kidney is immediately surrounded by a layer of **perinephric fat**, which is encapsulated together with the kidney by the renal fascia. This is in turn surrounded by another layer of fat, the **paranephric fat**.

The perinephric fat is firmer than normal adipose tissue and is in the shape of an inverted cone filling the hollow of the **paravertebral gutter**. It helps to restrain the kidney and to separate it from the suprarenal glands. Clinically it is important in restraining the spread of pus.

*Label these on the following diagram.*



### *Blood vessels of the kidney*

Identify the two **renal veins** entering into the **inferior vena cava** (IVC) and note that the right renal vein is short and passes directly to the IVC and does not receive venous drainage from any other organ. The left renal vein, on the other hand, is long (approx. 3") and crosses over the abdominal aorta and receives the veins from the left suprarenal gland and the left gonad.

Identify the two short renal arteries arising from the aorta. Note that the right renal artery runs behind the IVC.

### *Nerves and lymphatics*

The **renal plexus** of nerves consists of parasympathetic and sympathetic fibres passing from the **aortic plexus** along the renal artery to reach the kidney. The lymphatic channels follow the route of the renal vessels and enter the **aortic lymph nodes** around the IVC and abdominal aorta.

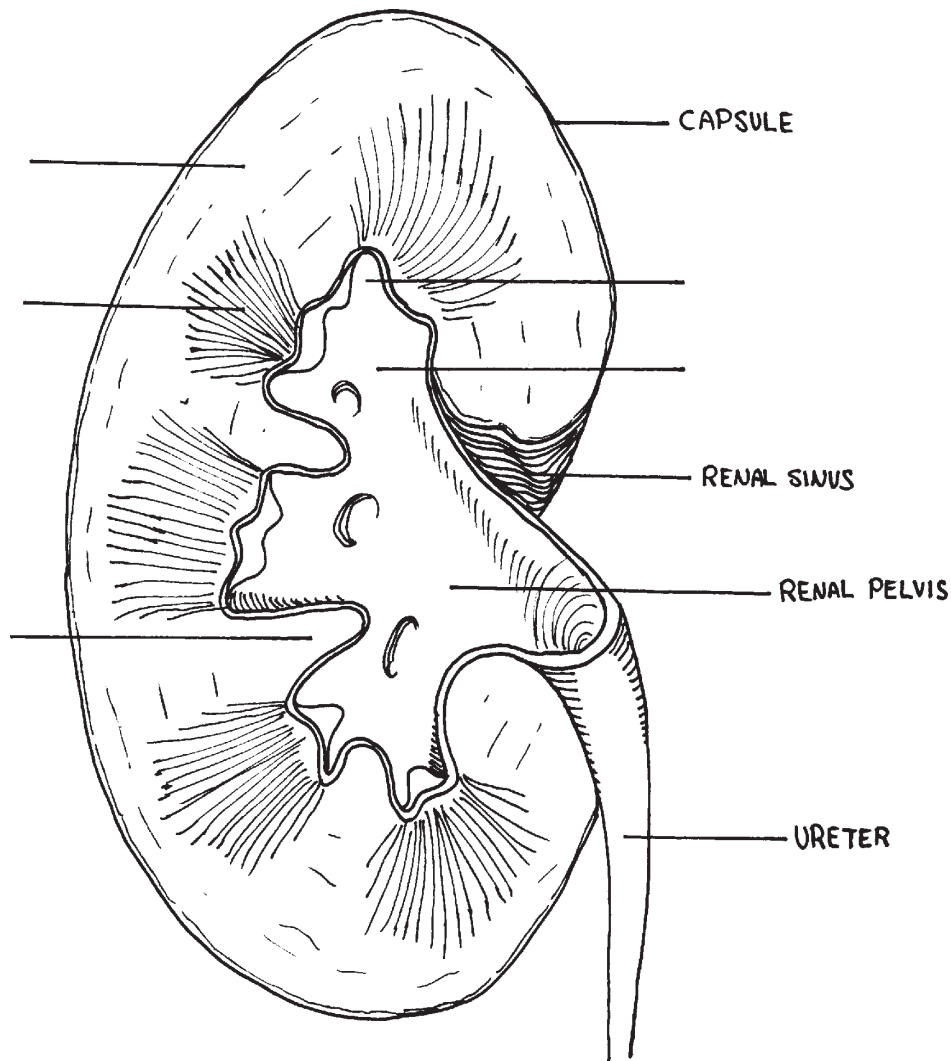
### *Fine structure of the kidney*

On a suitably coronally sectioned kidney it will be seen that the soft tissue is surrounded by a firm **fibrous capsule**. The **renal sinus** is a depression on the medial border and contains vessels and the upper expansion of the ureter - the **renal pelvis**.

*In which zone are the renal corpuscles located?*

*What structures collectively constitute a renal lobe?*

Complete the labelling in the following diagram.



## URETER

The ureter on each side is a narrow tube with thick muscular wall which runs from the renal pelvis to the bladder.

Identify the ureter on each side and follow it downward on the **psoas** muscle to the pelvic brim.

Note that at no time do the ureters enter the peritoneal cavity, but rather travel retroperitoneally throughout their course from kidney to bladder.

The gonadal vessels cross the ureters on both sides and on the left the **superior rectal vessel** crosses it at the pelvic brim. Establish the fact that the ureter crosses the bifurcation of the **common iliac artery** at the level of the **sacroiliac joint** and then follows to the side walls of the pelvis. At the level of the iliac spine it runs forward and medially in the fascia of the **pelvic floor** to reach the lateral angle of the bladder.

In the male, just prior to entering the bladder, the ureter is covered by the **vas (ductus) deferens** which loops round and downwards behind the bladder. In the female it is covered by the **uterine artery** at the base of the **broad ligament**.

Carefully study the relations of the ureters to the structures described.

Kidney stones commonly lodge at certain points of constrictions in the ureter.

*Where are these constrictions?*

## URINARY BLADDER

Locate the bladder immediately behind the pubic bones.

In the adult an empty bladder lies entirely within the pelvis but as it fills its superior wall bulges upwards into the hypogastric region of the abdomen, peeling the peritoneal covering from the lower part of the abdominal wall so that it is in direct contact with the anterior abdominal wall. Surgeons utilise this fact in carrying out an extraperitoneal incision into the bladder.

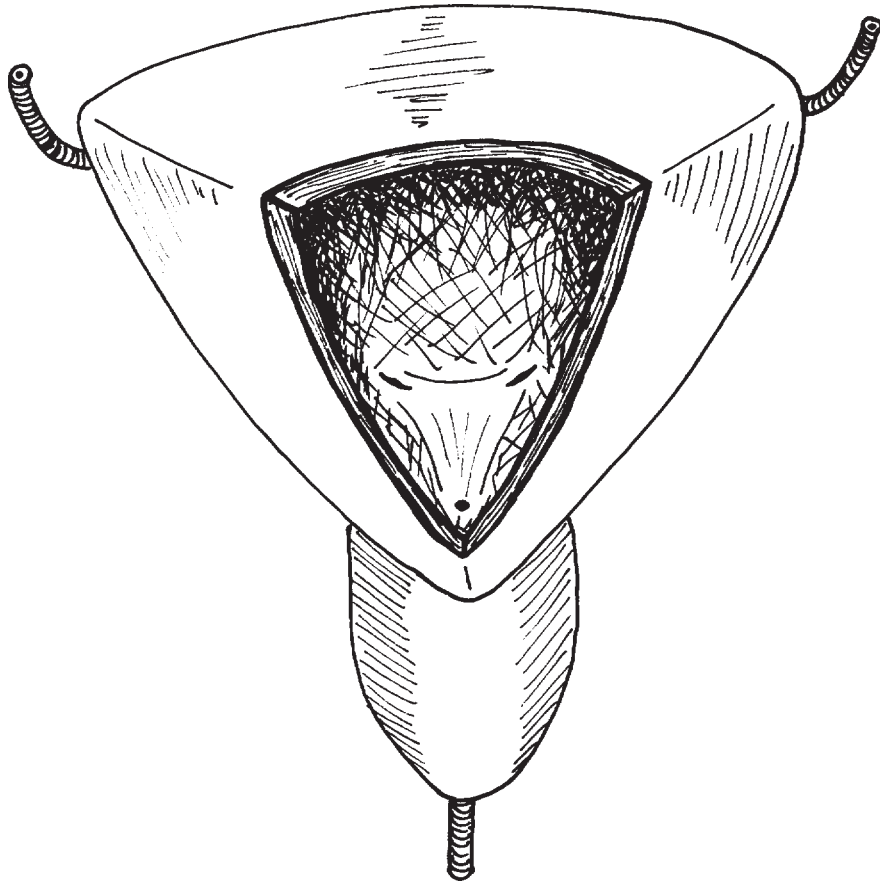
An empty bladder is a tetrahedron with an **apex**, **base**, a **superior** and two **infero-lateral** surfaces. It also has two **supero-lateral angles** - the sites for the entry of the two ureters and a **neck** which leads to the urethra.

*Sketch this shape below.*

Now examine the internal surface of the bladder in prosections of coronally sectioned bladders.

The **trigone** is the area on the posterior wall of the bladder lying between the two **ureteric orifices** and the **urethral orifice**. The rest of the internal surface of the bladder is convoluted into **rugae**.

*Label these structures on the following diagram.*



*What is the functional significance of the slit-like nature of the ureteric orifices?*

*How does the trigone differ from the rest of the internal surface of the bladder in appearance and function?*

The wall of the bladder has a thick striated muscular coat specialised for mass contraction required for micturition.

*What is the name of this muscle coat?*

This musculature is made up of smooth muscle fibres arranged in long interwoven groups whose circular arrangements predominate at the neck producing the autonomic **internal/preprostatic sphincter** or **sphincter vesicae**.

Further smooth bladder muscle fibres continue beyond the internal sphincter to attach to the **prostatic urethra** and extend up to the **external sphincter** or **sphincter urethrae**. The external sphincter is formed by the median portion of the **periurethral levator ani** muscle. This is under voluntary control and actively contracts during abdominal straining.

*Does the dimension of the base of the bladder or the trigone alter with distension?*

In the male, the trigone lies immediately above the prostate gland. Hypertrophy of the prostate can lead to an accumulation of tissue (**uvula vesicae**) immediately behind the bladder neck which interferes with the normal functions of the internal sphincter and may even occlude the urethral orifice.

Confirm the arrangement of bladder, trigone and prostate on the prosections.

### *Vascular supply to the bladder*

The main arteries supplying the bladder are branches of the internal iliac arteries. The **superior vesical** arteries supply the antero-superior part and the **inferior vesical** arteries supply to the base of the bladder. In the female the **uterine** and **vaginal** arteries also contribute to its blood supply.

The veins correspond to the arteries and form the vesical venous plexuses.

### *Lymphatics of the bladder*

Lymphatics of the bladder drain mainly into the external and internal lymph nodes.

### *Nerve supply to the bladder*

Nerve supply to the bladder is from the **pelvic splanchnic** nerves (parasympathetic). They are motor to the musculature and inhibitory to the internal sphincter. Hence when these fibres are stimulated by stretching; the bladder contracts and the internal sphincter relaxes, therefore urine flows out of the bladder.

The sympathetic fibres come from the T11-L2 and are probably inhibitory to the bladder.

Sensory fibres from the bladder are visceral and transmit sensations of pain and distension. The nerves supplying the bladder from the **vesical nerve plexus** consist of both sympathetic and parasympathetic fibres and are connected to the **inferior hypogastric plexus** of nerves in the pelvis.

Refer to the next section of the workbook for further details of the innervation of the pelvis.

*Describe the nervous control of micturition, which parts are voluntary, and which involuntary?*

## URETHRA

The urethra is the single muscular tube which conveys urine from the bladder to the exterior.

With the help of the following diagram, examine the whole length of the urethra in male prosections.

Note that it is 20cm long and in the normal flaccid condition of the penis it shows double curves in its course.

The first part, the **prostatic urethra** is 4cm long; it is also the widest and most dilatable urethral region in the living.

The second part, the **membranous urethra** is only 2cm long but narrow and rigid in the living, and together with the **bulbourethral glands** (Cowper's glands) it occupies the **deep perineal pouch**. It pierces the **perineal membrane** to enter the bulb of the penis (in the **superficial perineal pouch**).

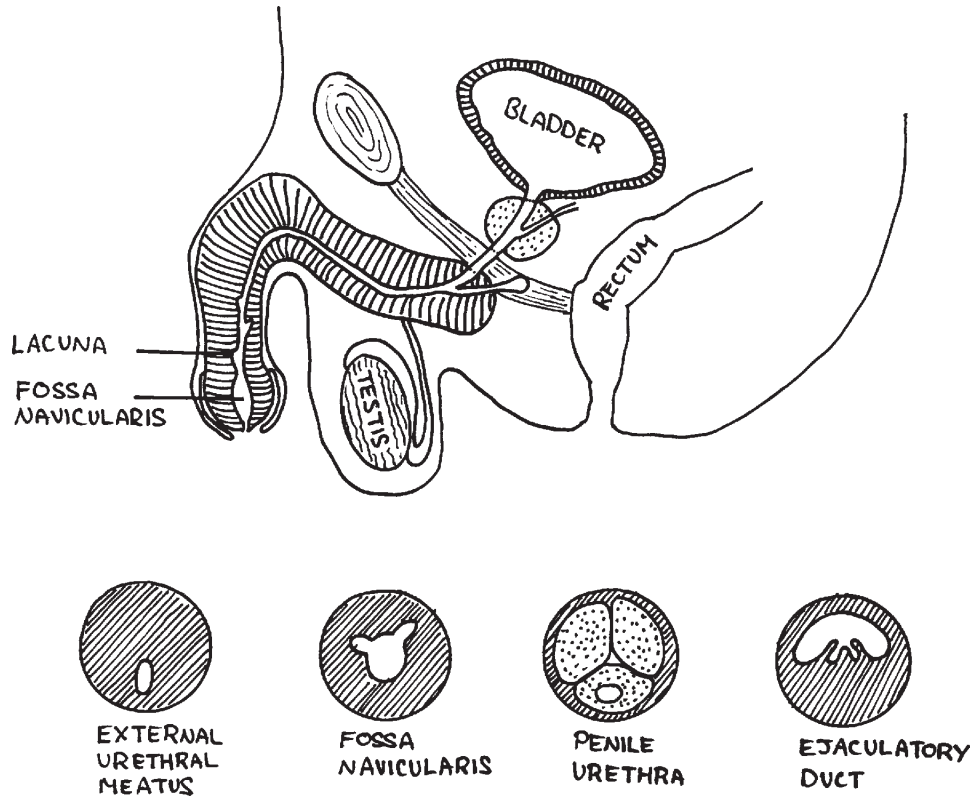
The third part, the **penile** or **spongy urethra** is 14cm long and invaginated before reaching a widened area, the **fossa navicularis** and ultimately terminating at the **meatal orifice** which is the narrowest point of the whole passage at the **glans penis**.

Note the difference in internal shape of the urethra along its course.

*Why are the above details relevant to an urologist who may wish to place a catheter into the bladder?*

The female urethra is short (4cm) and uncomplicated except for the presence of a number of mucous **periurethral glands**.

In the male the urethra is also the route for the expulsion of ejaculated semen. In the female the urethra does not have this shared function.



Consider the diagram, and indicate the three portions of the male urethra.

At the **deep perineal pouch**, the **external sphincter** of striped muscle surrounds the urethra that is very strong in the male but weak in the female.

Name three important clinical consequences of these anatomical differences between male and female urethrae.

a)

b)

c)

Interestingly, perhaps, with increasing age men are most likely to suffer from difficulty in micturition, while women are more likely to encounter stress incontinence.

Why is this the case?

Return to the objectives at the start of this section, and ensure that you can address them.

