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Edited by HELEN BICKERSTAFF and LOUISE C KENNY

GYNAECOLOGY

20th EDITION

by Ten Teachers

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Dedication

This book is dedicated to the first and best teachers we ever had:

My Dad, Frank (HB)
My Mum, Elizabeth (LCK)

Contents

Preface

Gynaecology by Ten Teachers was first published in 1919 as 'Diseases of Women' and is one of the oldest, most respected and accessible texts on the subject. *Gynaecology by Ten Teachers* has informed generations of gynaecologists, and now has a wide international audience. There is great responsibility in revising this landmark 20th edition, to ensure its accessibility and relevance are maintained into the next century.

The 20th edition has been almost entirely rewritten to reflect both changing undergraduate medical curricula and changing diagnostic and management protocols in gynaecology. The 'Ten Teachers' are all internationally renowned experts in their fields and all actively involved in the delivery of undergraduate and postgraduate teaching in the UK. This volume has been edited carefully to ensure consistency of structure, style and level of detail, in common with those of its sister text *Obstetrics by Ten Teachers*. The books can therefore be used together or independently as required. New self assessment sections are presented consistently throughout, with detailed clinical scenarios for each subject in a structure similar to those used in most medical schools.

The global status of women's and girls' sexual and reproductive health and rights is disturbing. Millions of women have no access to contraception, undergo female genital mutilation and receive no gynaecological care. It is fitting, therefore, that the 20th edition, published almost 100 years after the first, maintains a global aspect throughout.

The aim of the text now, as it was a century ago, is to prepare students for their undergraduate examinations, and to continue to be useful afterwards in postgraduate studies and clinical practice. It is a text that the editors used as students, which inspired us to practice and teach in the specialty, and which we still enjoy reading because it is concise yet comprehensive. We hope that in addition to supporting medical students throughout their studies, general practitioners, trainees and allied health care professionals will find it useful in their work.

It has been a privilege and an honour to be the editors of this textbook as it approaches this important milestone; we echo a century of previous editors in hoping that this book will enthuse a new generation of doctors to become gynaecologists and work to improve the health and the safety of women through all reproductive ages.

Helen Bickerstaff
Louise C Kenny

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Abbreviations

AFC	antral follicle count
AFP	α-fetoprotein
AIDS	acquired immune deficiency syndrome
ALO	actimomyces-like organism
AMH	anti-Müllerian hormone
APS	antiphospholipid syndrome
ART	assisted reproductive treatment
AUB	abnormal uterine bleeding
AUC	area under the curve
AZF	azoospermic factor
BBV	blood-borne virus
BEO	bleeding of endometrial origin
BEP	bleomycin, etoposide and cisplatin
BMD	bone mineral density
BMI	body mass index
BNF	British National Formulary
BOT	borderline ovarian tumour
BRCA	breast ovarian cancer syndrome
BSO	bilateral salpingo-oophorectomy
BV	bacterial vaginosis
CAH	congenital adrenal hyperplasia
CAIS	complete androgen insensitivity syndrome
CBT	cognitive-behavioural therapy
CGIN	cervical glandular intraepithelial neoplasia
CHC	combined hormonal contraception
CIN	cervical intraepithelial neoplasia
CL	corpus luteum
CLIA	chemiluminescence immunoassay
CNS	central nervous system
COCP	combined oral contraceptive pill
COX	cyclooxygenase
CPP	chronic pelvic pain
CRP	C-reactive protein
CT	computed tomography
Cu-IUD	copper intrauterine device
CVD	cardiovascular disease
D&C	dilatation and curettage
DHEA	dehydroepiandrosterone
DHT	dihydrotestosterone
DNA	deoxyribonucleic acid
DO	detrusor overactivity
DSD	disorders of sexual development
DUB	dysfunctional uterine bleeding
EB	endometrial biopsy
EC	emergency contraception
ECG	electrocardiography
EGF	epidermal growth factor
EIA	enzyme immunoassay
EP	ectopic pregnancy
EVA	electrical vacuum aspiration
FAB	fertility awareness-based method
FBC	full blood count
FGF	fibroblast growth factor
FGM	female genital mutilation
FH	fetal heartbeat
FIGO	International Federation of Gynecology and Obstetrics
FSH	follicle-stimulating hormone
GFR	glomerular filtration rate
GnRH	gonadotrophin-releasing hormone
GP	general practitioner
GTA	gynaecology teaching associate
GTD	gestational trophoblastic disease
HAART	highly active retroviral therapy
(β) hCG	(beta-) human chorionic gonadotrophin
HDL	high-density lipoprotein
HFEA	Human Fertilisation and Embryo Authority
HIV	human immunodeficiency virus
HMB	heavy menstrual bleeding
HNPCC	hereditary non-polyposis colorectal cancer
HPO	hypothalamo–pituitary–ovarian (axis)

HPV	human papilloma virus
HRT	hormone replacement therapy
HSG	hysterosalpingography
HSIL	high-grade squamous intraepithelial (lesion)
HSV	herpes simplex virus
HVS	high vaginal swab
HyCoSy	hysterocontrast synography
ICSI	intracytoplasmic sperm injection
Ig	immunoglobulin
IGF	insulin-like growth factor
IMB	intermenstrual bleeding
ISD	intrinsic sphincter deficiency
IUD	intrauterine device
IUI	intrauterine insemination
IUS	intrauterine releasing system
IVF	in-vitro fertilization
LARC	long-acting reversible methods of contraception
LAVH	laparoscopic-aided vaginal hysterectomy
LBC	liquid-based cytology
LDL	low-density lipoprotein
LH	luteinizing hormone
LLETZ	large loop excision of transformation zone
LMP	last menstrual period
LMWH	low-molecular weight heparin
LNG-IUS	levonorgestrel intrauterine system
LOD	laparoscopic ovarian drilling
MAS	minimal access surgery
MBL	mean blood loss
MDT	multidisciplinary team
MEC	medical eligibility criteria
MRI	magnetic resonance imaging
MRKH	Mayer–Rokitansky–Kuster–Hauser syndrome
MSU	midstream urine sample
MTCT	mother-to-child transmission
MVA	manual vacuum aspiration
NAAT	nucleic acid amplification test
NICE	National Institute for Health and Care Excellence
NSAID	non-steroidal anti-inflammatory drug
OAB	overactive bladder
OCP	oral contraceptive pill
17-OHP	17-hydroxyprogesterone
OHSS	ovarian hyperstimulation syndrome
OI	ovulation induction
OPH	outpatient hysteroscopy
PAC	preassessment clinic
PAF	platelet activating factor
PCB	postcoital bleeding
PCOS	polycystic ovary syndrome
PCR	polymerase chain reaction
PG	prostaglandin
PGD	preimplantation genetic diagnosis
PGI	prostacyclin
PID	pelvic inflammatory disease
PMB	postmenopausal bleeding
PMS	premenstrual syndrome
POCT	point of care test
POF	premature ovarian failure
POI	premature ovarian insufficiency
POP	progestogen-only pill
PPC	primary peritoneal carcinoma
PPH	postpartum haemorrhage
PUL	pregnancy of unknown location
REM	rapid eye movement
RCOG	Royal College of Obstetricians and Gynaecologists
RMI	Risk of Malignancy Index
RNA	ribonucleic acid
RPOC	retained products of conception
RPR	rapid plasma reagin
RR	relative risk
SCJ	squamocolumnar junction
SERM	selective oestrogen receptor modulator
SFA	semen fluid analysis
SHBG	sex hormone-binding globulin
SIS	saline instillation sonography
SPRM	selective progesterone receptor modulator
SSR	surgical sperm retrieval
SSRI	selective serotonin-reuptake inhibitor
STI	sexually-transmitted infection
STIC	serous tubal intraepithelial carcinoma
STOP	surgical termination of pregnancy

TAUSS	transabdominal ultrasound scan
TCRF	transcervical resection of fibroid
TED	thromboembolic stocking
TGF	transforming growth factor
TLH	total laparoscopic hysterectomy
TOT	transobturator tape
TPHA	*T. pallidum* haemagglutination assay
TPPA	*T. pallidum* particle assay
TV	*Trichomonas vaginalis*
TVT	tension-free vaginal tape
TVUSS	transvaginal ultrasound scan
TZ	transformation zone
UAE	umbilical/uterine artery embolization
UPA	ulipristal acetate
UPT	urinary pregnancy test
USS	ultrasound scan
VaIN	vaginal intraepithelial neoplasia
VDRL	Venereal Disease Reference Laboratory
VEGF	vascular endothelial growth factor
VIN	vulval intraepithelial neoplasia
VTE	venous thromboembolism
WCC	white cell count
WHI	Women's Health Initiative
WHO	World Health Organization

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Chapter 11 Benign conditions of the ovary and pelvis

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Chapter 12 Benign conditions of the uterus, cervix and endometrium

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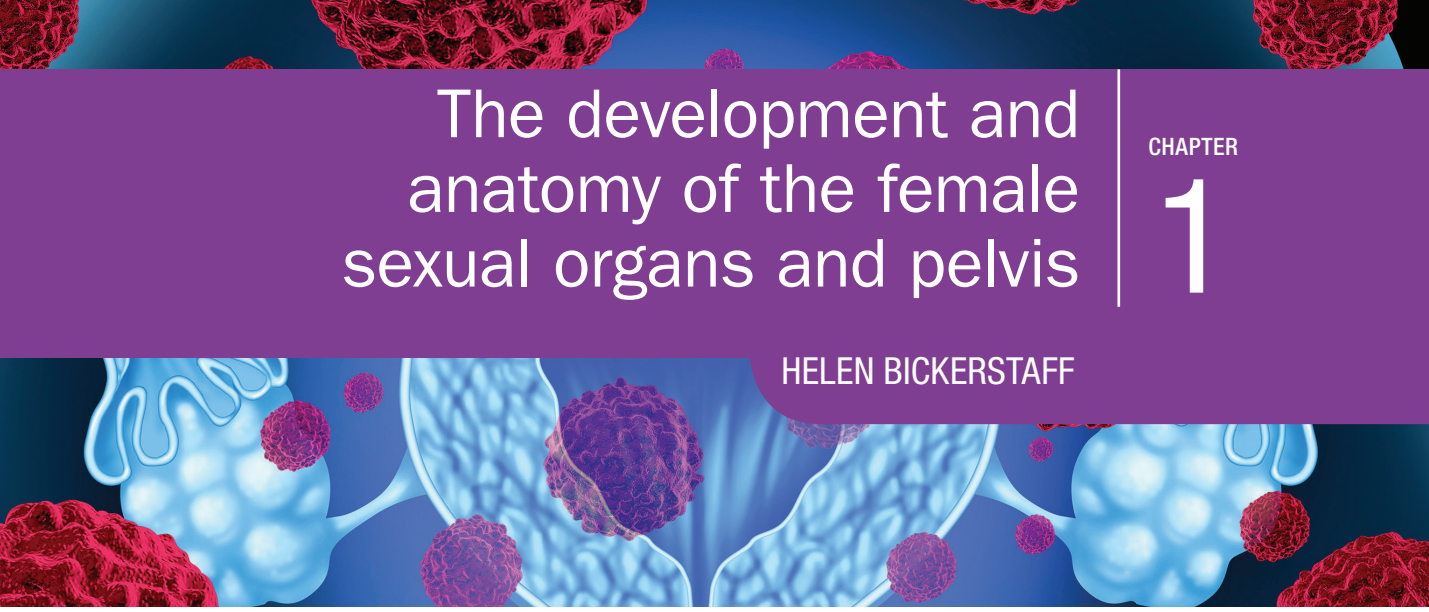

The development and anatomy of the female sexual organs and pelvis

CHAPTER 1

HELEN BICKERSTAFF

LEARNING OBJECTIVES

- Understand that sexual differentiation and development begin in early embryonic life.
- Understand the embryonic development and the anatomy of the perineum, the vagina, cervix and uterus, the adnexa and ovary and the bladder and ureters.
- Describe the blood supply and lymphatics of the perineum and pelvis.
- Understand the innervation of the perineum and pelvis.
- Understand the vulnerability of certain structures in gynaecological surgery.
- Describe the structural anomalies resulting from Müllerian tract disorders.

Sexual differentiation of the fetus and development of sexual organs

The gonadal rudiments appear as the 'genital ridge' overlying the embryonic kidney in the intermediate mesoderm during the fourth week of embryonic life, and they remain sexually indifferent until the seventh (**Figure 1.1**). The undifferentiated gonad has the potential to become either a testis or an ovary, and hence is termed bipotential, and the chromosomal complement of the zygote determines whether the gonad becomes a testis or an ovary. The development of either the testis or ovary is an active gene-directed process. In the male the activity of the SRY gene (sex-determining region of the Y chromosome) causes the gonad to begin development into a testis. In the past, ovarian development was considered a 'default' development due solely to the absence of SRY, but in the last 10 years ovarian-determining genes have also been found that actively lead to the development of a female gonad.

The fetus has two sets of structures called the Müllerian (or paramesonephric) ducts and Wolffian (or mesonephric) ducts, which have the potential to develop into male or female internal and external genitalia respectively.

Development of the male sexual organs

As the gonad develops into a testis, it differentiates into two cell types. The Sertoli cells produce

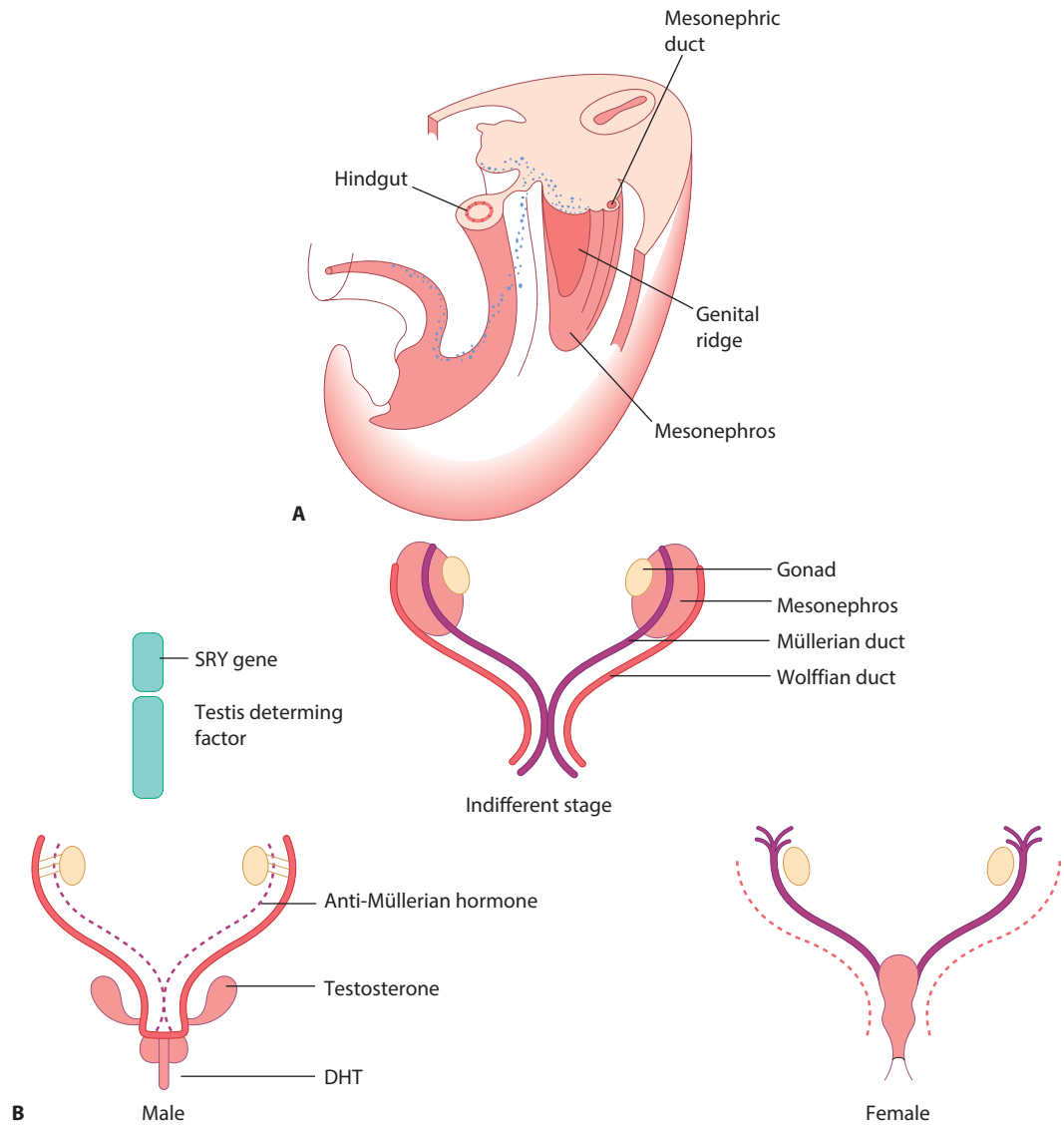

Figure 1.1 **A**: Cross-section diagram of the posterior abdominal wall showing the genital ridge; **B**: diagrammatic representation of the embryological pathways of male and female development. (DHT: dihydrotestosterone.)

anti-Müllerian hormone (AMH) and the Leydig cells produce testosterone. AMH suppresses further development of the Müllerian ducts whereas testosterone stimulates the Wolffian ducts to develop into the vas deferens, epididymis and seminal vesicles. In addition, in the external genital skin, testosterone is converted by the enzyme 5-alpha-reductase into dihydrotestosterone (DHT). This acts to virilize the external genitalia. The genital tubercle becomes the penis and the labioscrotal folds fuse to form the scrotum. The urogenital folds fuse along the ventral surface of the penis and enclose the urethra so that it opens at the tip of the penis.

Development of the female sexual organs

In the primitive ovary granulosa cells, derived from the proliferating coelomic epithelium, surround the germ cells and form primordial follicles.

Each primordial follicle consists of an oocyte within a single layer of granulosa cells. Theca cells develop from the proliferating coelomic epithelium and are separated from the granulosa cells by a basal lamina. The maximum number of primordial follicles is reached at 20 weeks' gestation when there are six to seven million primordial follicles present. The numbers of these reduce by atresia and at birth only 1–2 million remain. Atresia continues throughout life and by menarche only 300,000–400,000 are present, and by menopause none.

The development of an oocyte within a primordial follicle is arrested at the prophase of its first meiotic division. It remains in that state until it undergoes atresia or enters the meiotic process preceding ovulation.

In the female, the absence of testicular AMH allows the Müllerian structures to develop and the female reproductive tract develops from these paired ducts. The proximal two-thirds of the vagina develop from the paired Müllerian ducts, which grow in a caudal and medial direction and fuse in the midline. The midline fusion of these structures produces the uterus, cervix and upper vagina, and the unfused caudal segments form the Fallopian tubes, as shown in **Figure 1.2**.

Cells proliferate from the upper portion of the urogenital sinus to form structures called the 'sinovaginal bulbs'. The caudal extension of the Müllerian ducts projects into the posterior wall of the urogenital sinus as the Müllerian tubercle. The Müllerian tubercles and the urogenital sinus fuse to form the vaginal plate, which extends from the Müllerian ducts to the urogenital sinus. This plate begins to canalize, starting at the hymen and proceeding upwards to the cervix in the sixth embryonic month.

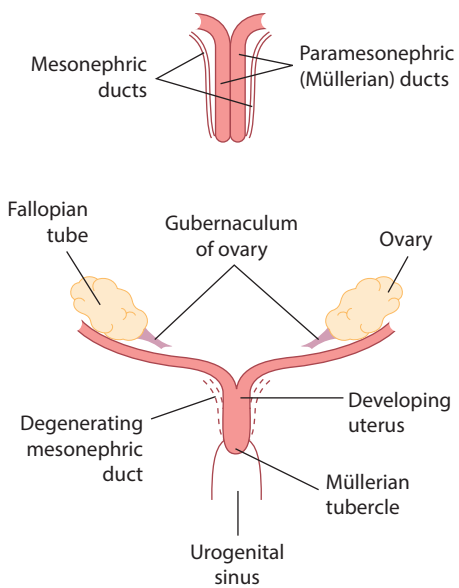

Figure 1.2 Caudal parts of the paramesonephric ducts (top) fuse to form the uterus and Fallopian tubes.

External female genitalia

The external genitalia do not virilize in the absence of testosterone. Between the fifth and seventh weeks of life, the cloacal folds, which are a pair of swellings adjacent to the cloacal membrane, fuse anteriorly to become the genital tubercle. This will become the clitoris. The perineum develops and divides the cloacal membrane into an anterior urogenital membrane and a posterior anal membrane. The cloacal folds anteriorly are called the urethral folds, which form the labia minora. Another pair of folds within the cloacal membrane form the labioscrotal folds that eventually become the labia majora. The urogenital sinus becomes the vestibule of the vagina. The external genitalia are recognizably female by the end of the twelfth embryonic week.

KEY LEARNING POINTS

- The primitive gonad is first evident at 5 weeks of embryonic life and forms on the medial aspect of the mesonephric ridge.
- The undifferentiated gonad has the potential to become either a testis or an ovary.
- The paramesonephric duct, which later forms the Müllerian system, is the precursor of female genital development.
- The lower end of the Müllerian ducts fuse in the midline to form the uterus and upper vagina.
- Most of the upper vagina is of Müllerian origin, while the lower vagina forms from the sinovaginal bulbs.
- Primordial follicles contain an oocyte arrested in prophase surrounded by granulosa cells separated by a basement membrane from Leydig cells.
- The maximum number of primordial follicles is reached at 20 weeks' gestation. These reduce by atresia throughout childhood and adult life.

Female anatomy

External genitalia

The external genitalia are commonly called the vulva and include the mons pubis, labia majora and minora, the vaginal vestibule, the clitoris and the greater vestibular glands. The mons pubis is a fibrofatty pad covered by hair-bearing skin that covers the bony pubic ramus.

The labia majora are two folds of skin with underlying adipose tissue lying either side of the vaginal opening. They contain sebaceous and sweat glands and a few specialized apocrine glands. In the deepest part of each labium is a core of fatty tissue continuous with that of the inguinal canal and the fibres of the round ligament, which terminate here.

The labia minora are two thin folds of skin that lie between the labia majora. These vary in size and may protrude beyond the labia major where they are visible, but may also be concealed by the labia majora. Anteriorly, they divide in two to form the prepuce and frenulum of the clitoris (clitoral hood). Posteriorly, they divide to form a fold of skin called the fourchette at the back of the vagina introitus. They contain sebaceous glands, but have no adipose tissue. They are not well developed before puberty and atrophy after the menopause. Both the labia minora and labia majora become engorged during sexual arousal.

The clitoris is an erectile structure measuring approximately 0.5–3.5 cm in length. The body of the clitoris is the main part of the visible clitoris and is made up of paired columns of erectile tissue and vascular tissue called the 'corpora cavernosa'. These become the crura at the bottom of the clitoris and run deeper and laterally. The vestibule is the cleft between the labia minora. It contains openings of the urethra, the Bartholin's glands and the vagina. The vagina is surrounded by two bulbs of erectile and vascular tissue that are extensive and almost completely cover the distal vaginal wall. These have traditionally been named the bulb of the vaginal vestibule, although recent work on both dissection and magnetic resonance imaging (MRI) suggests that they may be part of the clitoris and should be renamed 'clitoral bulbs'. Their function is unknown but they probably add support to the distal vaginal wall to enhance its rigidity during penetration.

The Bartholin's glands are bilateral and about the size of a pea. They open via a 2 cm duct into the vestibule below the hymen and contribute to lubrication during intercourse.

The hymen is a thin covering of mucous membrane across the entrance to the vagina. It is usually perforated, which allows menstruation. The hymen is ruptured during intercourse and any remaining tags are called 'carunculae myrtiformes'.

Internal reproductive organs (Figure 1.3)

The vagina

The vagina is a fibromuscular canal lined with stratified squamous epithelium that leads from the uterus to the vulva. It is longer in the posterior wall (approximately 9 cm) than in the anterior wall (approximately 7 cm). The vaginal walls are normally in apposition, except at the vault where they are separated by the cervix. The vault of the vagina is divided into four fornices: posterior, anterior and two lateral.

The midvagina is a transverse slit while the lower vagina is an H-shape in transverse section. The vaginal walls are lined with transverse folds. The vagina has no glands and is kept moist by secretions from the uterine and cervical glands and by transudation from its epithelial lining. The epithelium is thick and rich in glycogen, which increases in the postovulatory phase of the cycle. However, before puberty and after the menopause, the vagina is devoid of glycogen due to the lack of oestrogen. Doderlein's bacillus is a normal commensal of the vaginal flora and breaks down glycogen to form lactic acid, producing a pH of around 4.5. This has a protective role for the vagina in decreasing the growth of pathogenic bacteria.

The upper posterior wall forms the anterior peritoneal reflection of the pouch of Douglas. The middle third is separated from the rectum by pelvic fascia and the lower third abuts the perineal body. Anteriorly, the vagina is in direct contact with the base of the bladder, while the urethra runs down the lower half in the midline to open into the vestibule. Its muscles fuse with the anterior

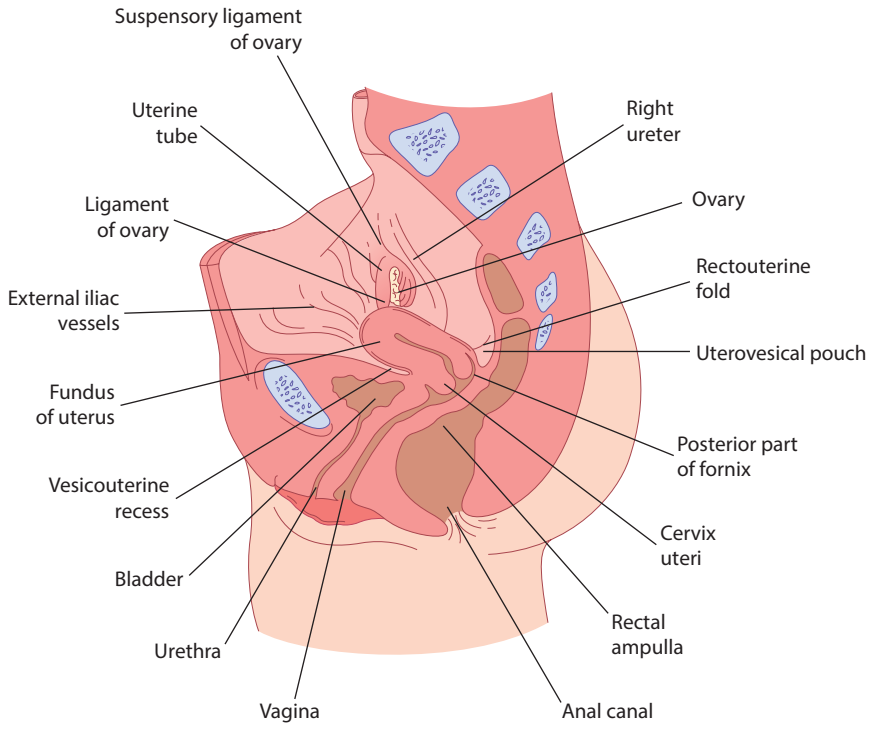

Figure 1.3 Sagittal section of the female pelvis.

vagina wall. Laterally, at the fornices, the vagina is related to the cardinal ligaments. Below this are the levator ani muscles and the ischiorectal fossae. The cardinal ligaments and the uterosacral ligaments, which form posteriorly from the parametrium, support the upper part of the vagina.

At birth, the vagina is under the influence of maternal oestrogens so the epithelium is well developed. After a couple of weeks, the effects of the oestrogen disappear and the pH rises to 7 and the epithelium atrophies. At puberty, the reverse occurs and finally at the menopause the vagina tends to shrink and the epithelium atrophies once again.

The uterus

The uterus is shaped like an inverted pear tapering inferiorly to the cervix and in its non-pregnant state is situated entirely within the pelvis. It is hollow and has thick, muscular walls. Its maximum external dimensions are approximately 7.5 cm long, 5 cm wide and 3 cm thick. An adult uterus weighs approximately 70 g. In the upper part, the uterus is termed the body or 'corpus'. The area of insertion of each Fallopian tube is termed the 'cornu' and that part of the body above the cornu is called the 'fundus'. The uterus tapers to a small constricted area, the isthmus, and below this is the cervix, which projects obliquely into the vagina. The longitudinal axis of the uterus is approximately at right angles to the vagina and normally tilts forward. This is called 'anteversion'. In addition, the long axis of the cervix is rarely the same as the long axis of the uterus. The uterus is also usually flexed forward on itself at the isthmus – antiflexion. However, in around 20% of women, the uterus is tilted backwards – retroversion and retroflexion. This has no pathological significance in most women, although retroversion that is fixed and immobile may be associated with endometriosis. This has relevance in gynaecological surgery and is referred to again in Chapter 2, Gynaecological history, examination and investigations.

The cavity of the uterus is the shape of an inverted triangle and when sectioned coronally the Fallopian tubes open at lateral angles The constriction at the isthmus where the corpus joins the cervix is the anatomical os. Seen microscopically, the site

of the histological internal os is where the mucous membrane of the isthmus becomes that of the cervix.

The uterus consists of three layers: the outer serous layer (peritoneum), the middle muscular layer (myometrium) and the inner mucous layer (endometrium). The peritoneum covers the body of the uterus and posteriorly it covers the supravaginal part of the cervix. The peritoneum is intimately attached to a subserous fibrous layer, except laterally where it spreads out to form the leaves of the broad ligament.

The muscular myometrium forms the main bulk of the uterus and is made up of interlacing smooth muscle fibres intermingling with areolar tissue, blood vessels, nerves and lymphatics. Externally, the muscle fibres are mostly longitudinal, but the thicker intermediate layer has interlacing longitudinal, oblique and transverse fibres. Internally, they are mainly longitudinal and circular.

The inner endometrial layer has tubular glands that dip into the myometrium. The endometrial layer is covered by a single layer of columnar epithelium. Ciliated prior to puberty, this epithelium is mostly lost due to the effects of pregnancy and menstruation. The endometrium undergoes cyclical changes during menstruation, as described in Chapter 3, Hormonal control of the menstrual cycle and hormonal disorders, and varies in thickness.

The cervix

The cervix is narrower than the body of the uterus and is approximately 2.5 cm in length. Lateral to the cervix lies cellular connective tissue called the parametrium. The ureter runs about 1 cm laterally to the supravaginal cervix within the parametrium. The posterior aspect of the cervix is covered by the peritoneum of the pouch of Douglas.

The upper part of the cervix mostly consists of involuntary muscle, whereas the lower part is mainly fibrous connective tissue. The mucous membrane of the cervical canal (endocervix) has anterior and posterior columns from which folds radiate out, the 'arbour vitae'. It has numerous deep glandular follicles that secrete clear alkaline mucus, the main component of physiological vaginal discharge. The epithelium of the endocervix is columnar and is also ciliated in its upper two-thirds. This changes to stratified squamous epithelium around the region of the external os and the junction of these two types of epithelium is called the 'squamocolumnar junction'.

Age changes to anatomy

The disappearance of maternal oestrogens from the circulation after birth causes the uterus to decrease in length by around one-third and in weight by around one-half. The cervix is then twice the length of the uterus. During childhood, the uterus grows slowly in length, in parallel with height and age. The average longitudinal diameter ranges from 2.5 cm at the age of 2 years, to 3.5 cm at 10 years. After the onset of puberty, the anteroposterior and transverse diameters of the uterus start to increase, leading to a sharper rise in the volume of the uterus. The increase in uterine volume continues well after menarche and the uterus reaches its adult size and configuration by the late teenage years. After the menopause, the uterus atrophies, the mucosa becomes very thin, the glands almost disappear and the wall becomes relatively less muscular.

The Fallopian tubes

The Fallopian tube extends outwards from the uterine cornu to end near the ovary. At the abdominal ostium, the tube opens into the peritoneal cavity, which is therefore in communication with the exterior of the body via the uterus and the vagina. This is essential to allow the sperm and egg to meet. The Fallopian tubes convey the ovum from the ovary towards the uterus and promote oxygenation and nutrition for sperm, ovum and zygote should fertilization occur.

The Fallopian tube runs in the upper margin of the broad ligament, known as the mesosalpinx, which encloses the tube so that it is completely covered with peritoneum, except for a narrow strip along this inferior aspect. Each tube is about 10 cm long and is described in four parts:

- The interstitial portion.
- The isthmus.
- The ampulla.
- The infundibulum or fimbrial portion.

The interstitial portion lies within the wall of the uterus, while the isthmus is the narrow portion adjoining the uterus. This passes into the widest and longest portion, the ampulla. This, in turn, terminates in the extremity known as the 'infundibulum'. The opening of the tube into the peritoneal cavity is surrounded by finger-like processes, known as

fimbria, into which the muscle coat does not extend. The inner surfaces of the fimbriae are covered by ciliated epithelium that is similar to the lining of the Fallopian tube itself. One of these fimbriae is longer than the others and extends to, and partially embraces, the ovary. The muscular fibres of the wall of the tube are arranged in an inner circular and an outer longitudinal layer.

The tubal epithelium forms a number of branched folds or plicae that run longitudinally; the lumen of the ampulla is almost filled with these folds. The folds have a cellular stroma, but at their bases the epithelium is only separated from the muscle by a very scanty amount of stroma. There is no submucosa and there are no glands. The epithelium of the Fallopian tubes contains two functioning cell types: the ciliated cells, which act to produce constant current of fluid in the direction of the uterus, and the secretory cells, which contribute to the volume of tubal fluid. Changes occur under the influence of the menstrual cycle, but there is no cell shedding during menstruation.

The ovaries

The size and appearance of the ovaries depends on both age and stage of the menstrual cycle. In a child, the ovaries are small structures approximately 1.5 cm long; however, they increase to adult size in puberty due to proliferation of stromal cells and commencing maturation of the ovarian follicles. In the young adult, they are almond-shaped and measure approximately 3 cm long, 1.5 cm wide and 1 cm thick. After the menopause, no active follicles are present and the ovary becomes smaller with a wrinkled surface. The ovary is the only intra-abdominal structure not to be covered by peritoneum. Each ovary is attached to the cornu of the uterus by the ovarian ligament and at the hilum to the broad ligament by the mesovarium, which contains its supply of nerves and blood vessels. Laterally, each ovary is attached to the suspensory ligament of the ovary with folds of peritoneum that becomes continuous with that of the overlying psoas major.

Anterior to the ovaries lie the Fallopian tubes, the superior portion of the bladder and the uterovesical pouch. Posterior to the ovary lies the ureter where it runs downwards and forwards in front of the internal iliac artery.

Structure of the ovary

The ovary has a central vascular medulla consisting of loose connective tissue containing many elastin fibres and non-striated muscle cells. It has an outer thicker cortex, denser than the medulla, consisting of networks of reticular fibres and fusiform cells, although there is no clear-cut demarcation between the two. The surface of the ovaries is covered by a single layer of cuboidal cells, the germinal epithelium. Beneath this is an ill-defined layer of condensed connective tissue called the 'tunica albuginea', which increases in density with age. At birth, numerous primordial follicles are found, mostly in the cortex, but some are found in the medulla. With puberty, some form each month into the graafian follicles under gonadotrophic control, to ovulate and subsequently form corpus lutea and ultimately the atretic follicles, the corpora albicans.

The bladder, urethra and ureter

The bladder

The bladder wall is made of involuntary muscle arranged in an inner longitudinal layer, a middle circular layer and an outer longitudinal layer. It is lined with transitional epithelium and has an average capacity of 400 ml.

The ureters open into the base of the bladder after running medially for about 1 cm through the bladder wall. The urethra leaves the bladder below the ureteric orifices. The triangular area lying between the ureteric orifices and the internal meatus of the urethra is known as the 'trigone'. At the internal meatus, the middle layer of muscle forms anterior and posterior loops round the neck of the bladder, some fibres of the loops being continuous with the circular muscle of the urethra.

The base of the bladder is adjacent to the cervix, with only a thin layer of tissue intervening. It is separated from the anterior vaginal wall below by the pubocervical fascia that stretches from the pubis to the cervix.

The urethra

The female urethra is about 3.5 cm long and is lined with transitional epithelium. It has a slight posterior angulation at the junction of its lower and middle thirds. The smooth muscle of its wall

is arranged in outer longitudinal and inner circular layers. As the urethra passes through the two layers of the urogenital diaphragm, it is embraced by the striated fibres of the deep transverse perineal muscle (also known as the compressor urethrae) and some of the striated fibres of this muscle form a loop on the urethra. Between the muscular coat and the epithelium is a plexus of veins. There are a number of tubular mucous glands and in the lower part a number of crypts that occasionally become infected. In its upper two-thirds, the urethra is separated from the symphysis by loose connective tissue, but in its lower third it is attached to the pubic ramus on each side by strong bands of fibrous tissue called the 'pubourethral tissue'. Posteriorly, it is firmly attached in its lower two-thirds to the anterior vaginal wall. This means that the upper part of the urethra is mobile, but the lower part is relatively fixed.

Medial fibres of the pubococcygeus of the levator ani muscles are inserted into the urethra and vaginal wall. When they contract, they pull the anterior vaginal wall and the upper part of the urethra forwards forming an angle of about 100° between the posterior wall of the urethra and the bladder base. On voluntary voiding of urine, the base of the bladder and the upper part of the urethra descend and the posterior angle disappears so that the base of the bladder and the posterior wall of the urethra come to lie in a straight line.

The ureter

As the ureter crosses the pelvic brim, it lies in front of the bifurcation of the common iliac artery. It runs downwards and forwards on the lateral wall of the pelvis to reach the pelvic floor and then passes inwards and forwards attached to the peritoneum of the back of the broad ligament to pass beneath the uterine artery. It next passes forward through a fibrous tunnel, the ureteric canal, in the upper part of the cardinal ligament. Finally, it runs close to the lateral vaginal fornix to enter the trigone of the bladder.

Its blood supply is derived from small branches of the ovarian artery, from a small vessel arising near the iliac bifurcation, from a branch of the uterine artery where it crosses beneath it and from small branches of the vesical artery.

Box 1.1 Ureteric damage during hysterectomy

Because of its close relationship to the cervix, the vault of the vagina and the uterine artery, the ureter may be damaged during hysterectomy. Apart from being cut or tied, in radical procedures, the ureter may undergo necrosis because of interference with its blood supply. It may be displaced by scar tissue or by fibromyomata or cysts that are growing between the layers of the broad ligament and may suffer injury if its position is not noticed at surgery.

The rectum

The rectum extends from the level of the third sacral vertebra to a point about 2.5 cm in front of the coccyx where it passes through the pelvic floor to become continuous with the anal canal. Its direction follows the curve of the sacrum and is about 11 cm in length. The front and sides are covered by the peritoneum of the rectovaginal pouch. In the middle third only the front is covered by peritoneum. In the lower third there is no peritoneal covering and the rectum is separated from the posterior wall of the vagina by the rectovaginal fascial septum. Lateral to the rectum are the uterosacral ligaments, beside which run some of the lymphatics draining the cervix and vagina.

The pelvic muscles, ligaments and fascia

The pelvic diaphragm (Figure 1.4)

The pelvic diaphragm is formed by the levator ani muscles, which are broad, flat muscles the fibres of which pass downwards and inwards. The two muscles, one on either side, constitute the pelvic diaphragm. The muscles arise by linear origin from the following points:

- The lower part of the body of the os pubis.
- The internal surface of the parietal pelvic fascia along the white line.
- The pelvic surface of the ischial spine.

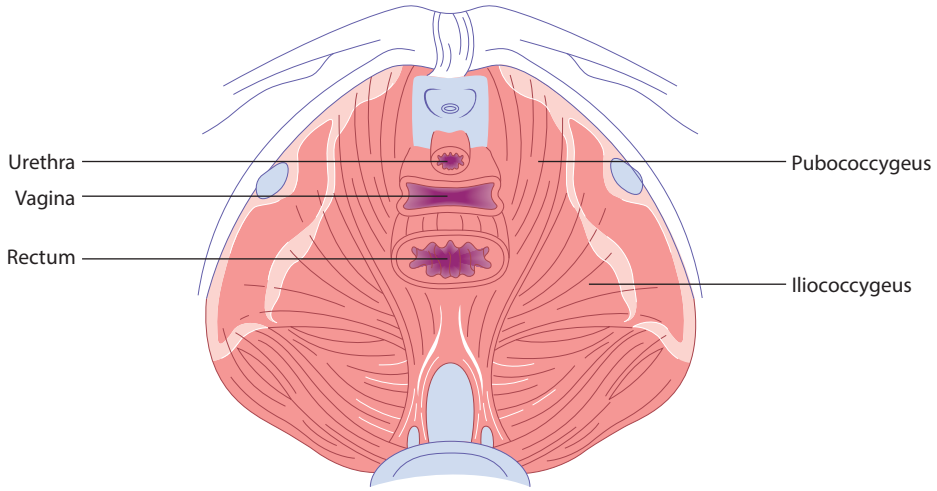

Figure 1.4 Pelvic floor musculature.

The levator ani muscles are inserted into the following points:

- The preanal raphe and the central point of the perineum, where one muscle meets the other on the opposite side.
- The wall of the anal canal, where the fibres blend with the deep external sphincter muscle.
- The postanal or anococcygeal raphe, where again one muscle meets the other on the opposite side.
- The lower part of the coccyx.

The muscle is described in two parts:

- The pubococcygeus, which arises from the pubic bone and the anterior part of the tendinous arch of the pelvic fascia (the 'white line').
- The iliococcygeus, which arises from the posterior part of the tendinous arch and the ischial spine.

The medial borders of the pubococcygeus muscle pass on either side from the pubic bone to the preanal raphe. They thus embrace the vagina and on contraction have some sphincteric action. The nerve supply is from the third and fourth sacral nerves. The pubococcygeus muscles support the pelvic and abdominal viscera, including the bladder. The medial edge passes beneath the bladder and runs laterally to the urethra, into which some of its fibres are inserted. Together with the fibres from the opposite muscle, they form a loop that maintains the angle between the posterior aspect of the urethra and the bladder base. During micturition, this loop relaxes to allow the bladder neck and upper urethra to open and descend.

Urogenital diaphragm

The urogenital diaphragm (also known as the triangular ligament) is made up of two layers of pelvic fascia that fill the gap between the descending pubic rami and lies beneath the levator ani muscles. The deep transverse perineal muscles (compressor urethrae) lie between the two layers and the diaphragm is pierced by the urethra and vagina.

The perineal body

This is a mass of muscular tissue that lies between the anal canal and the lower third of the vagina. Its apex is at the lower end of the rectovaginal septum at the point where the rectum and posterior vaginal walls come into contact. Its base is covered with skin and extends from the fourchette to the anus. It is the point of insertion of the superficial perineal muscles and is bounded above by the levator ani muscles where they come into contact in the midline between the posterior vaginal wall and the rectum.

The pelvic peritoneum

The peritoneum is reflected from the lateral borders of the uterus to form, on either side, a double fold of peritoneum – the broad ligament. Despite the name, this is not a ligament but a peritoneal fold and it does not support the uterus. The Fallopian tube runs in