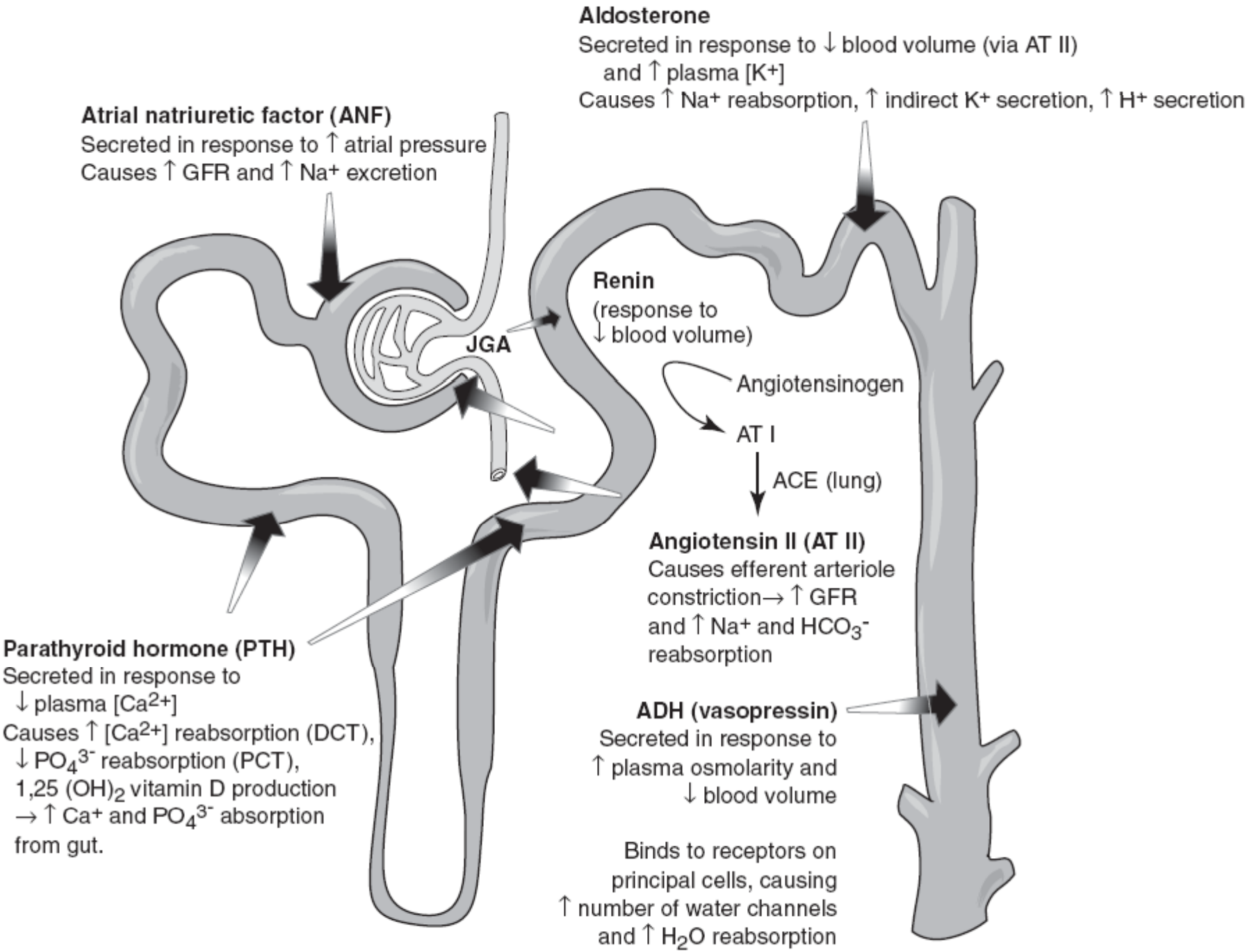
EXTRA RENAL MATERIAL

D.H

Hormones acting on kidney



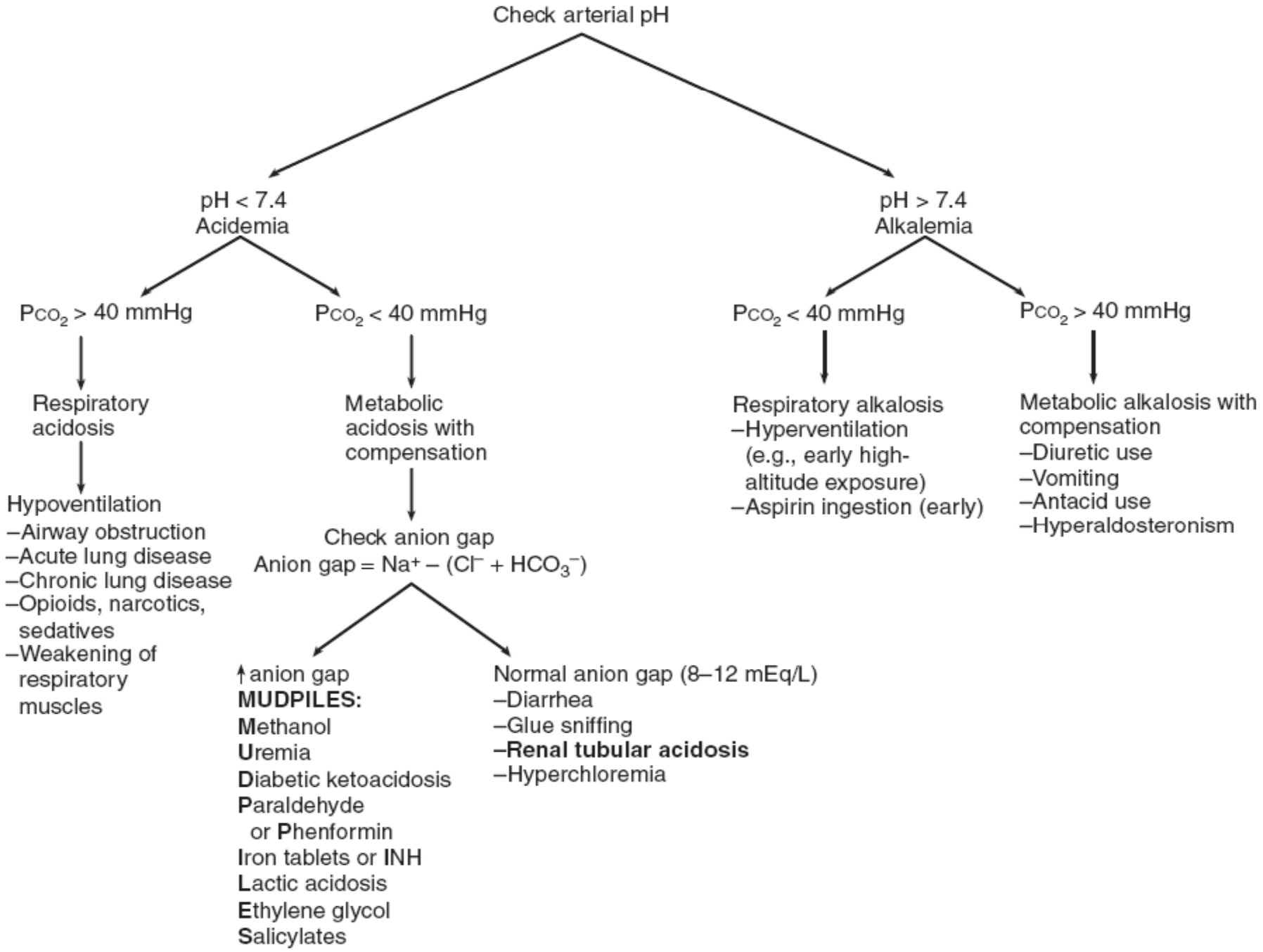
Acid-base physiology

	pH	P_{CO_2}	$[HCO_3^-]$	Compensatory response
Metabolic acidosis	↓	↓	**↓**	Hyperventilation
Metabolic alkalosis	↑	↑	**↑**	Hypoventilation
Respiratory acidosis	↓	**↑**	↑	↑ renal $[HCO_3^-]$ reabsorption
Respiratory alkalosis	↑	**↓**	↓	↓ renal $[HCO_3^-]$ reabsorption

Henderson-Hasselbalch equation: $pH = pKa + \log \frac{[HCO_3^-]}{0.03\ P_{CO_2}}$

Key: **↑ ↓** = 1° disturbance; ↓ ↑ = compensatory response.

Acidosis/alkalosis



Renal tubular acidosis	
Type 1	Defect in H^+ pump → failure to acidify urine.
Type 2	Renal loss of bicarbonate.
Type 4	Hypoaldosteronism → hypokalemia → inhibition of ammonia excretion.
Acid-base compensations	The following formulas give appropriate compensations for a single disorder. If the formula does not match the actual values, suspect a mixed disorder.
Metabolic acidosis	Winter's formula: $P_{CO_2} = 1.5\ (HCO_3^-) + 8 \pm 2$.
Metabolic alkalosis	P_{CO_2} ↑ 0.7 mmHg for every ↑ 1 mEq/L HCO_3^-.
Respiratory acidosis	Acute— ↑ 1 mEq/L HCO_3^- for every ↑ 10 mmHg P_{CO_2}.
	Chronic— ↑ 3.5 mEq/L HCO_3^- for every ↑ 10 mmHg P_{CO_2}.
Respiratory alkalosis	Acute— ↓ 2 mEq/L HCO_3^- for every ↓ 10 mmHg P_{CO_2}.
	Chronic— ↓ 5 mEq/L HCO_3^- for every ↓ 10 mmHg P_{CO_2}.

Casts

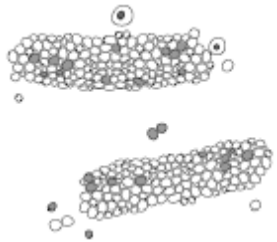
Casts in urine:

- RBC casts—glomerular inflammation (nephritic syndromes), ischemia, or malignant hypertension.
- WBC casts—tubulointerstitial disease, acute pyelonephritis, glomerular disorders.
- Granular ("muddy brown") casts—acute tubular necrosis.
- Waxy casts—advanced renal disease/CRF.
- Hyaline casts—nonspecific.

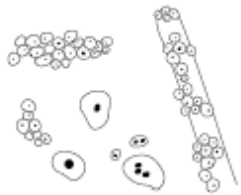
Presence of casts indicates that hematuria/pyuria is of renal origin.

Bladder cancer → RBCs, no casts.

Acute cystitis → WBCs, no casts.



Red blood cell casts



White blood cell casts

Hyaline casts

Granular casts

Electrolyte disturbances

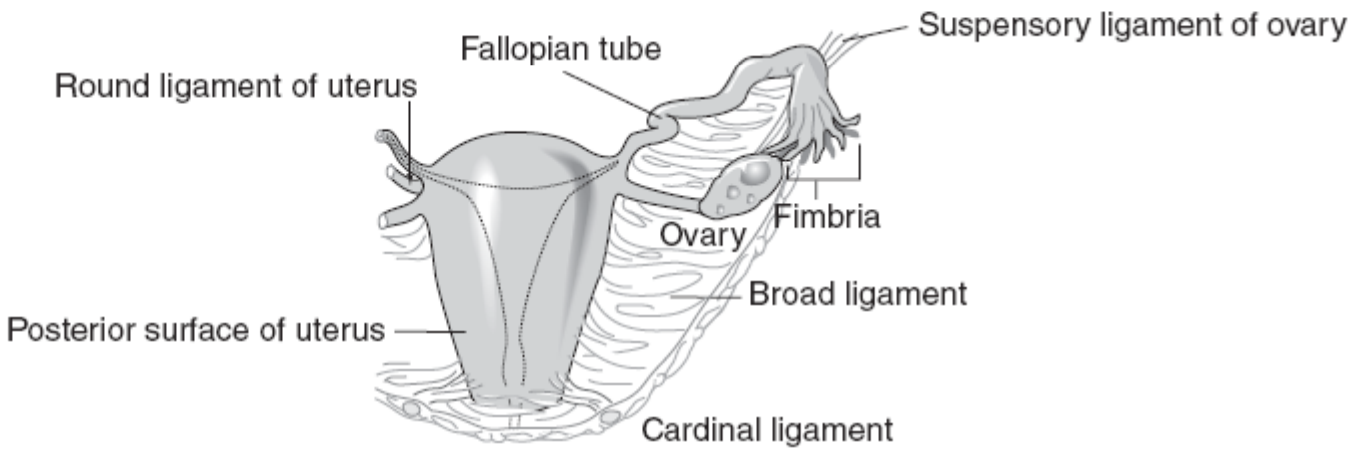
Electrolyte	Low serum concentration	High serum concentration
Na^+	Disorientation, stupor, coma	Neurologic: irritability, delirium, coma
Cl^-	2° to metabolic alkalosis, hypokalemia, hypovolemia, ↑ aldosterone	2° to non–anion gap acidosis
K^+	U waves on ECG, flattened T waves, arrhythmias, paralysis	Peaked T waves, wide QRS, arrhythmias
Ca^{2+}	Tetany, neuromuscular irritability	Delirium, renal stones, abdominal pain, not necessarily calciuria
Mg^{2+}	Neuromuscular irritability, arrhythmias	Delirium, ↓ DTRs, cardiopulmonary arrest
PO_4^{2-}	Low-mineral ion product causes bone loss, osteomalacia	High-mineral ion product causes metastatic calcification, renal stones, met calcifications

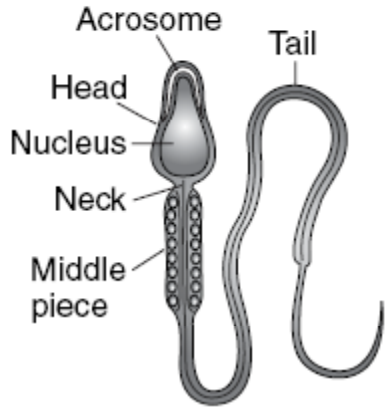
REPRODUCTIVE EXTRA

DH

Ligaments of the uterus

Suspensory ligament of ovaries	Contains the ovarian vessels.	
Transverse cervical (cardinal) ligament	Contains the uterine vessels.	
Round ligament of uterus	Contains no important structures. Travels through the inguinal canal and attaches distally to the labia majora.	**Round** like the number of structures it carries: 0.
Broad ligament	Contains the round ligaments of the uterus and ovaries and the fallopian tubes.	

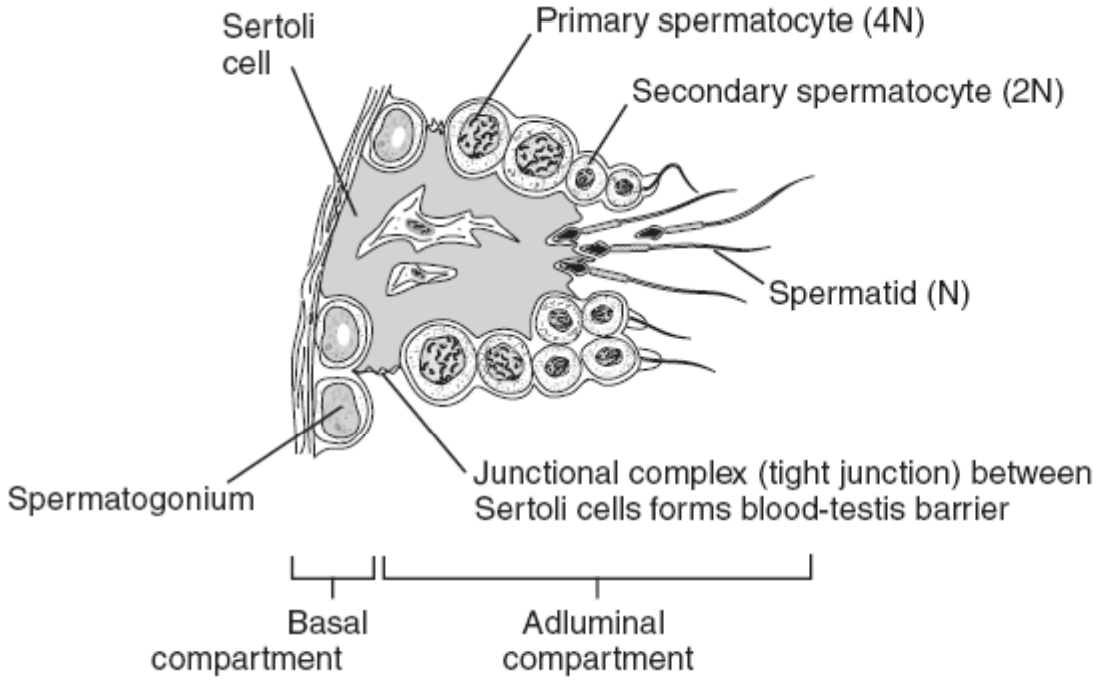


Autonomic innervation of the male sexual response	Erection is mediated by the Parasympathetic nervous system. Nitric oxide is vasodilator. Emission is mediated by the Sympathetic nervous system. Ejaculation is mediated by visceral and somatic nerves.	Point and Shoot.
Derivation of sperm parts	Acrosome is derived from the Golgi apparatus and flagellum (tail) from one of the centrioles. Middle piece (neck) has Mitochondria. Feeds on Fructose.	

Sperm development

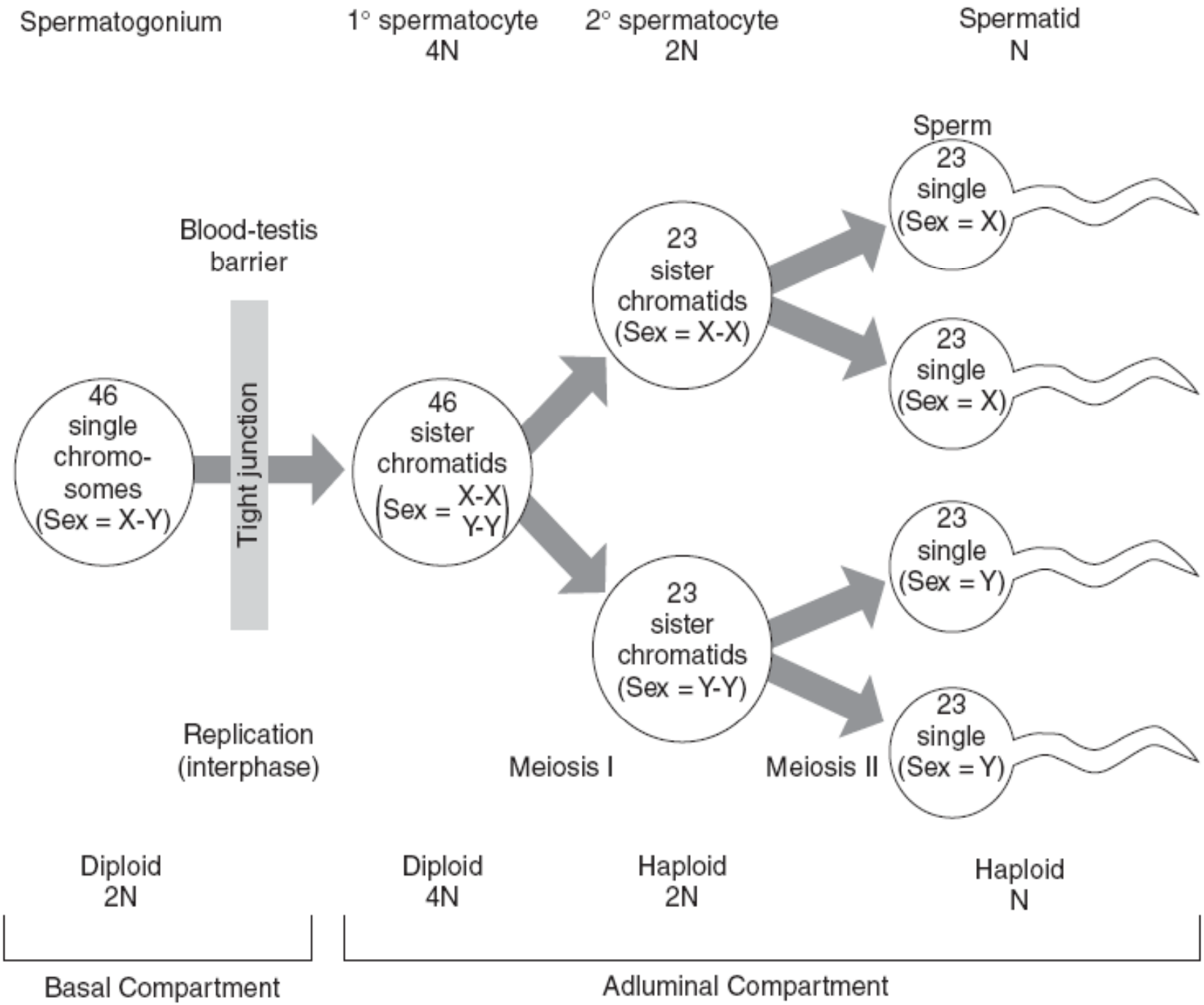
Spermatogenesis begins at puberty with spermatogonia (type A and type B). Full development takes 2 months. Spermatogenesis occurs in Seminiferous tubules.

Blood-testis barrier is a physical barrier in the testis between the tissues responsible for spermatogenesis and the bloodstream (to avoid autoimmune response).

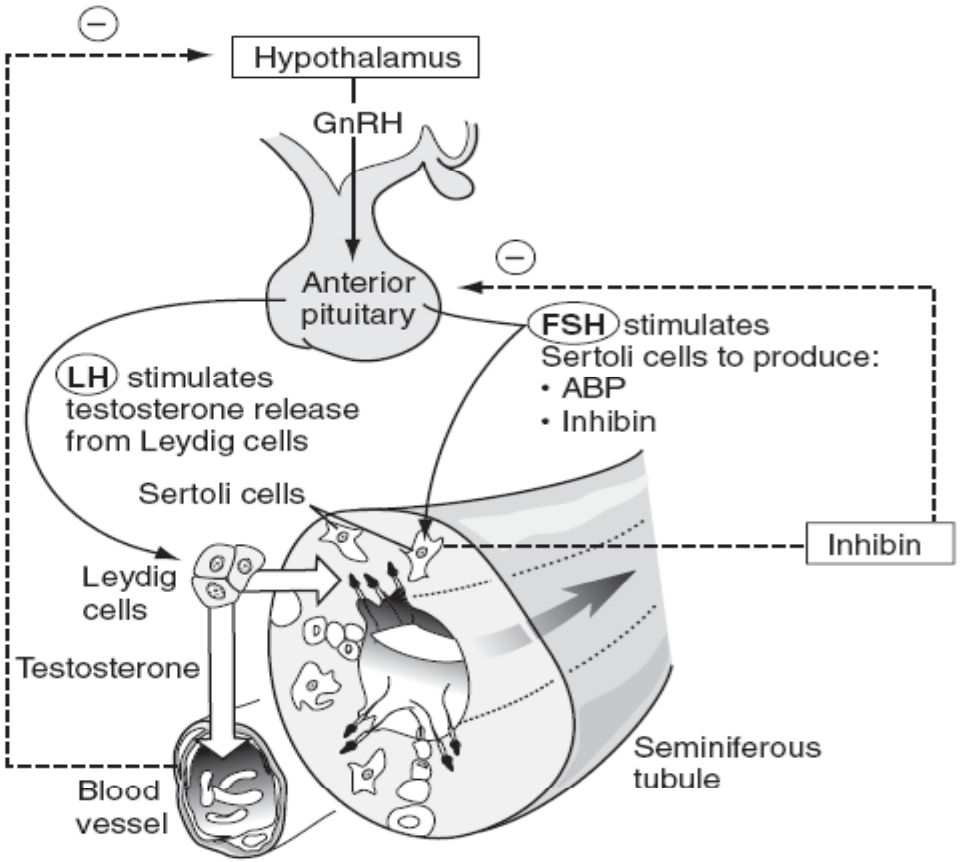


SEVEN UP:
- Seminiferous tubules
- Epididymis
- Vas deferens
- Ejaculatory ducts
- (Nothing)
- Urethra
- Penis

Sertoli cells
- Support Sperm
- Synthesis.


Spermatogonium
1° spermatocyte
4N
2° spermatocyte
2N
Spermatid
N
Sperm
23
single
(Sex = X)
Blood-testis
barrier
23
sister
chromatids
(Sex = X-X)
23
single
(Sex = X)
46
single
chromo-
somes
(Sex = X-Y)
Tight junction
46
sister
chromatids
(Sex = X-X
Y-Y)
23
single
(Sex = Y)
23
sister
chromatids
(Sex = Y-Y)
23
single
(Sex = Y)
Replication
(interphase)
Meiosis I
Meiosis II
Diploid
2N
Diploid
4N
Haploid
2N
Haploid
N
Basal Compartment
Adluminal Compartment

Male spermatogenesis



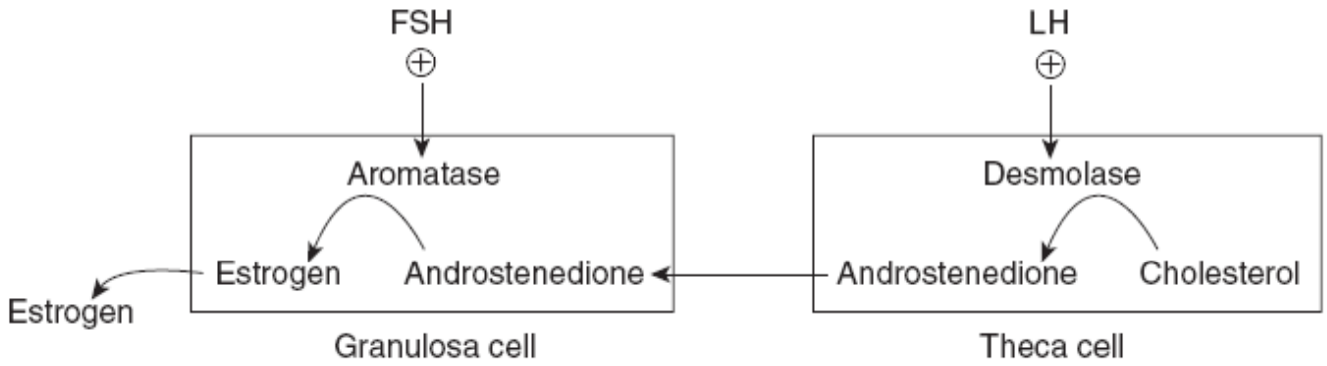
PRODUCTS	FUNCTIONS OF PRODUCTS
Androgen-binding protein (ABP)	Ensures that testosterone in seminiferous tubule is high
Inhibin	Inhibits FSH
Testosterone	Differentiates male genitalia, has anabolic effects on protein metabolism, maintains gametogenesis, maintains libido, inhibits GnRH, and fuses epiphyseal plates in bone

FSH → Sertoli cells → Sperm production
LH → Leydig cell → testosterone

Androgens	Testosterone, dihydrotestosterone (DHT), androstenedione.	
Source	DHT and testosterone (testis), androstenedione (adrenal).	Potency—DHT > testosterone > androstenedione.
Targets	Prostate, seminal vesicles, epididymis, liver, muscle, brain, skin.	Testosterone is converted to DHT by the enzyme 5α-reductase, which is inhibited by finasteride.
Function	1. Differentiation of wolffian duct system into internal gonadal structures 2. 2° sexual characteristics and growth spurt during puberty, close epiphyseal plates 3. Required for normal spermatogenesis 4. Anabolic effects— ↑ muscle size, ↑ RBC production 5. ↑ libido	Testosterone and androstenedione are converted to estrogen in adipose tissue and Sertoli cells by enzyme aromatase.

Estrogen

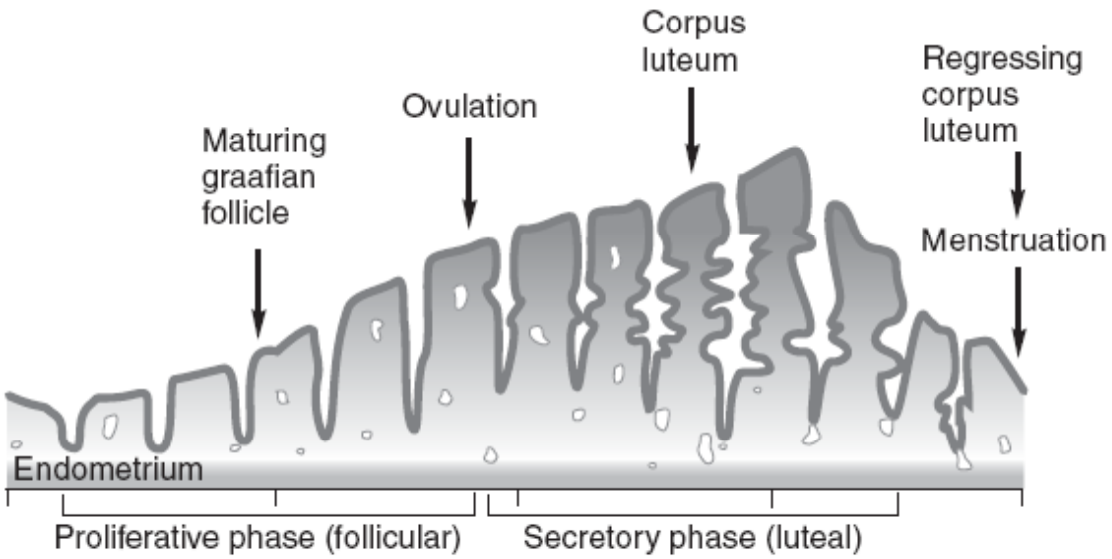
Source	Ovary (17β-estradiol), placenta (estriol), blood (aromatization).	Potency—estradiol > estrone > estriol.
Function	1. Growth of follicle 2. Endometrial proliferation 3. Development of genitalia 4. Stromal development of breast 5. Female fat distribution 6. Hepatic synthesis of transport proteins (↑ synthesis of sex hormone–binding globulin) 7. Feedback inhibition of FSH and LH 8. LH surge (estrogen negative feedback on LH secretion switches to positive from negative just before LH surge) 9. ↑ myometrial excitability 10. ↑ HDL, ↓ LDL	Pregnancy: 50-fold ↑ in estradiol and estrone 1000-fold ↑ in estriol (indicator of fetal well-being)



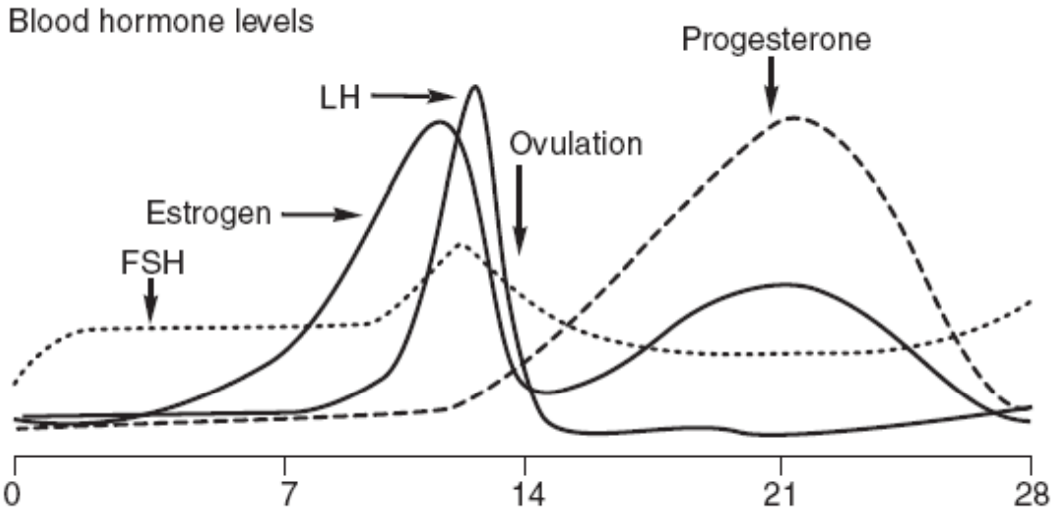
Progesterone

Source	Corpus luteum, placenta, adrenal cortex, testes.	Elevation of progesterone is indicative of ovulation.
Function	1. Stimulation of endometrial glandular secretions and spiral artery development 2. Maintenance of pregnancy 3. ↓ myometrial excitability 4. Production of thick cervical mucus, which inhibits sperm entry into the uterus 5. ↑ body temperature 6. Inhibition of gonadotropins (LH, FSH) 7. Uterine smooth muscle relaxation (preventing contractions)	Progesterone Prepares for Pregnancy.

Menstrual cycle

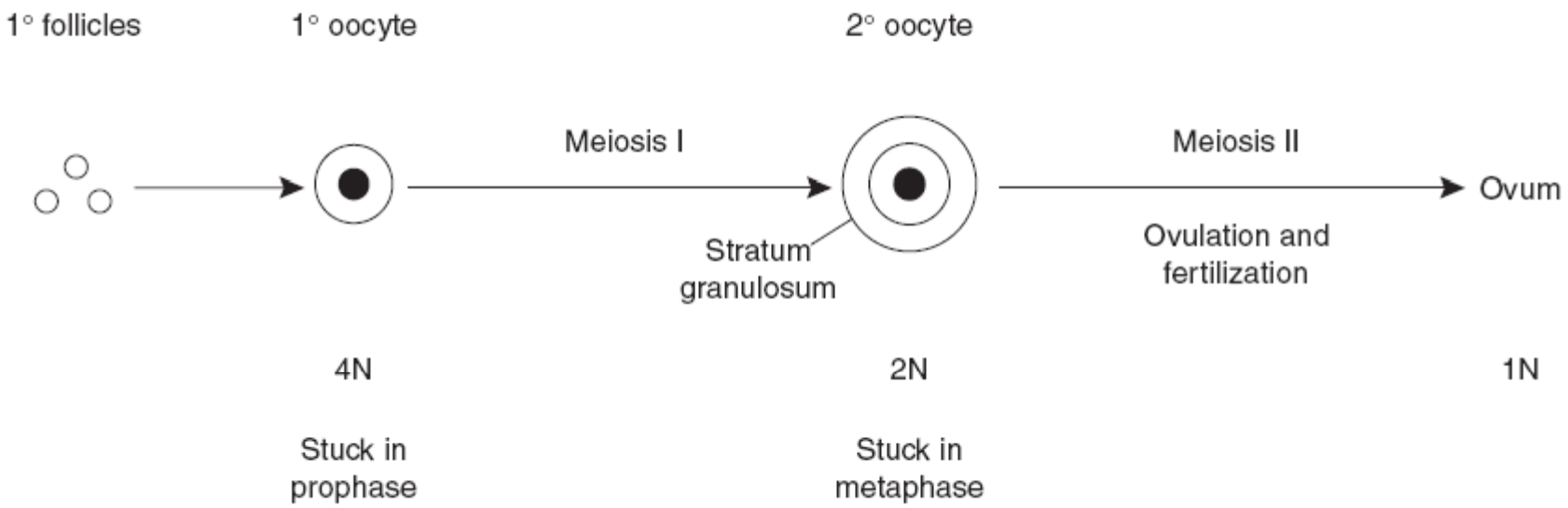


Follicular growth is fastest during 2nd week of proliferative phase.
Estrogen stimulates endometrial proliferation.
Progesterone maintains endometrium to support implantation.
↓ progesterone leads to ↓ fertility.
Follicular phase can vary in length. Luteal phase is usually a constant 14 days. Ovulation day = menstruation day 14.



Estrogen
↓
LH
↓
Ovulate
↓
Progesterone (from corpus luteum)
↓
Period

Ovulation	Estrogen surge day before ovulation. Stimulates LH, inhibits FSH. LH surge causes ovulation (rupture of follicle). ↑ temperature (progesterone induced). Ferning of cervical mucosa. Oral contraceptives prevent estrogen surge, LH surge → ovulation does not occur.	Mittelschmerz—blood from ruptured follicle causes peritoneal irritation that can mimic appendicitis.
Meiosis and ovulation	1° oocytes begin meiosis I during fetal life and complete meiosis I just prior to ovulation. Meiosis I is arrested in prOphase for years until Ovulation (1° oocytes). Meiosis II is arrested in METaphase until fertilization (2° oocytes).	An egg MET a sperm.



Pregnancy

Fertilization most commonly occurs in upper end of oviduct. Occurs within 1 day after ovulation.

Implantation occurs 6 days after fertilization. Trophoblasts secrete β-hCG, which is detectable in blood 1 week after conception and on home test in urine 2 weeks after conception.

↑ estrogen, progesterone, oxytocin, and prolactin at term (hCG peak is in 1st trimester).

Lactation—during pregnancy, estrogen inhibits prolactin and inhibits lactation. After labor, the ↓ in maternal estrogen induces lactation. Suckling is required to maintain milk production, since ↑ nerve stimulation ↑ oxytocin.

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hCG

Source: Syncytiotrophoblast of placenta.

Function:

1. Maintains the corpus luteum (and thus progesterone) for the 1st trimester by acting like LH (otherwise no luteal cell stimulation, and abortion results). In the 2nd and 3rd trimester, the placenta synthesizes its own estriol and progesterone and the corpus luteum degenerates.
2. Used to detect pregnancy because it appears early in the urine (see above).
3. Elevated hCG in women with hydatidiform moles or choriocarcinoma.

Menopause	Cessation of estrogen production with age-linked decline in number of ovarian follicles. Average age of onset is 51 years (earlier in smokers).	Hormonal changes: ↓ estrogen, ↑↑ FSH, ↑ LH (no surge), ↑ GnRH. Menopause causes HAVOC: Hot flashes, Atrophy of the Vagina, Osteoporosis, Coronary artery disease. Early menopause can indicate premature ovarian failure.

Hydatidiform mole

A pathologic ovum ("empty egg"—ovum with no DNA) resulting in cystic swelling of chorionic villi and proliferation of chorionic epithelium (trophoblast). Most common precursor of choriocarcinoma. High β-hCG. "Honeycombed uterus," "cluster of grapes" appearance. Genotype of a **complete** mole is 46,XX and is **completely** paternal in origin (no maternal chromosomes).

Complete moles have no associated fetus and commonly lead to an abnormally enlarged uterus. **PART**ial mole is made up of 3 or more **PARTS** (triploid or tetraploid); may contain fetal **PARTS**. Partial moles are less likely to be associated with excessive uterine size (see Color Image 74). Moles can lead to uterine rupture. Treat with dilatation and curettage and methotrexate. Monitor β-hCG.

Complete—2 sperm + empty egg.
Partial—2 sperm + 1 egg.

Pregnancy complications	**Abruptio placentae**—premature detachment of placenta from implantation site. **Painful** uterine bleeding (usually during 3rd trimester). Fetal death. May be associated with DIC. ↑ risk with smoking, hypertension, cocaine use.	Painful bleeding.
	Placenta accreta—defective decidual layer allows placenta to attach directly to myometrium. Predisposed by prior C-section or inflammation. May have massive hemorrhage after delivery.	Massive bleeding.
	Placenta previa—attachment of placenta to lower uterine segment. May occlude internal os. **Painless** bleeding in any trimester. Prior C-section predisposes.	Painless bleeding.
	Ectopic pregnancy—most often in fallopian tubes, predisposed by salpingitis (PID). Suspect with ↑ hCG and sudden lower abdominal pain; confirm with ultrasound. Often clinically mistaken for appendicitis.	Pain without bleeding.