Preconception Nutrition Chapter 2

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Successful reproduction is a product of

- An optimal state of health
- Product of an interrelation between genetic, biological, environmental, and behavioral factors
- Conception that happens with poor nutritional status→ ↑chance that fetal growth and development and the health status of the mother will be compromised

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Preconception related terms

- **Fertility:** ability to reproduce an offspring
- **Infertility:** absence of production of children- biological inability to bear children
- **Fecundity:** biological ability to bear children/ potential capacity for reproduction
- **Infecundity: ….**

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- Healthy couples having regular, unprotected intercourse have a 20 to 25% chance of a diagnosed pregnancy within a given menstrual cycle

- Many more conceptions occur:
  - Studies show that:
    - 30–50% of conceptions are lost by resorption into the uterine wall within the first 6 wks after conception
    - 9% are lost by **miscarriage** in the first 20 wks of pregnancy

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Reproductive Physiology

- Reproductive systems begin developing in the 1st months after conception and continue to grow through puberty

- Ability to reproduce occurs during **puberty**→ hormonal changes cause the maturation of the reproductive system over a period of 3- 5yrs

Puberty- the period in life during which humans become biologically capable of reproduction

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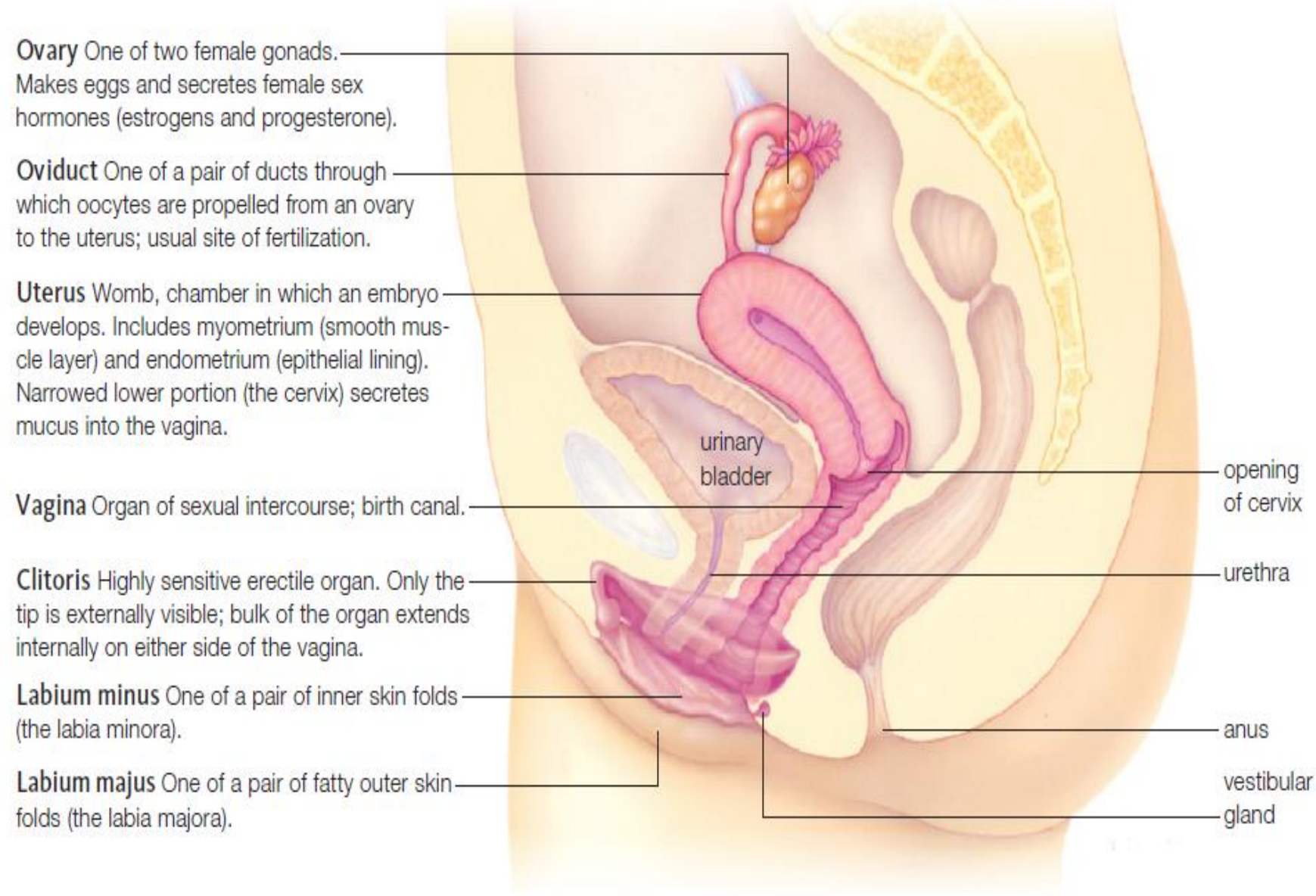

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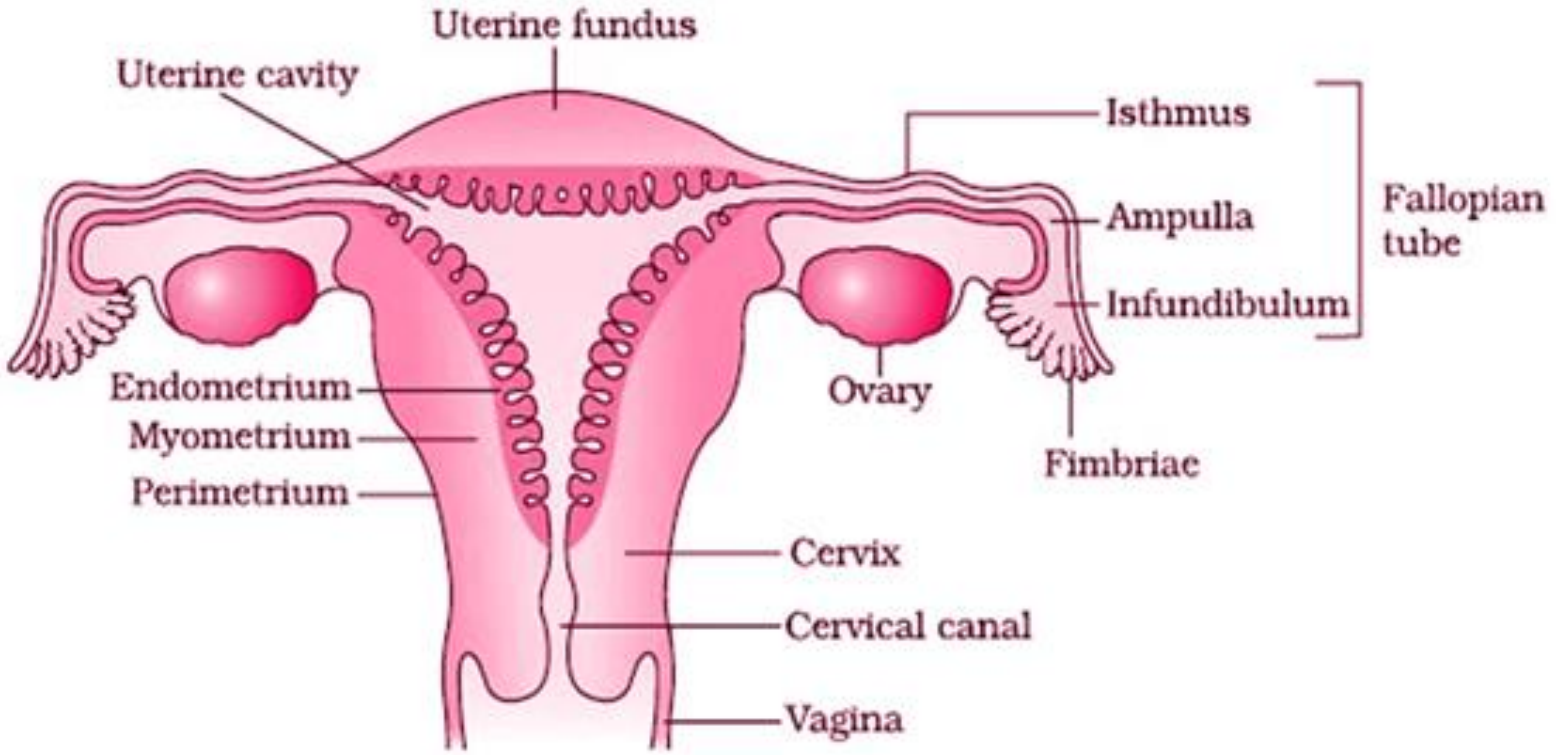

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Females

- At puberty, women have ~ ½ million ova
  - **Ova:** eggs of the female produced and stored within the ovaries
- During a woman's fertile years→ 400–500 ova will mature and be released for possible fertilization
- Very few ova remain by **menopause**

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Female reproductive system

- During puberty females develop monthly menstrual cycles
  - Purpose: to prepare an ovum for fertilization by sperm and the uterus for implantation of a fertilized egg

- Menstrual cycles (avg 28 days long) result from complex interactions among hormones secreted by the hypothalamus, the pituitary gland, and the ovary

The 1st half of the cycle is called the **follicular phase**
The 2nd half od the cycle is called the **luteal phase**

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Hormonal effects during the menstrual cycle

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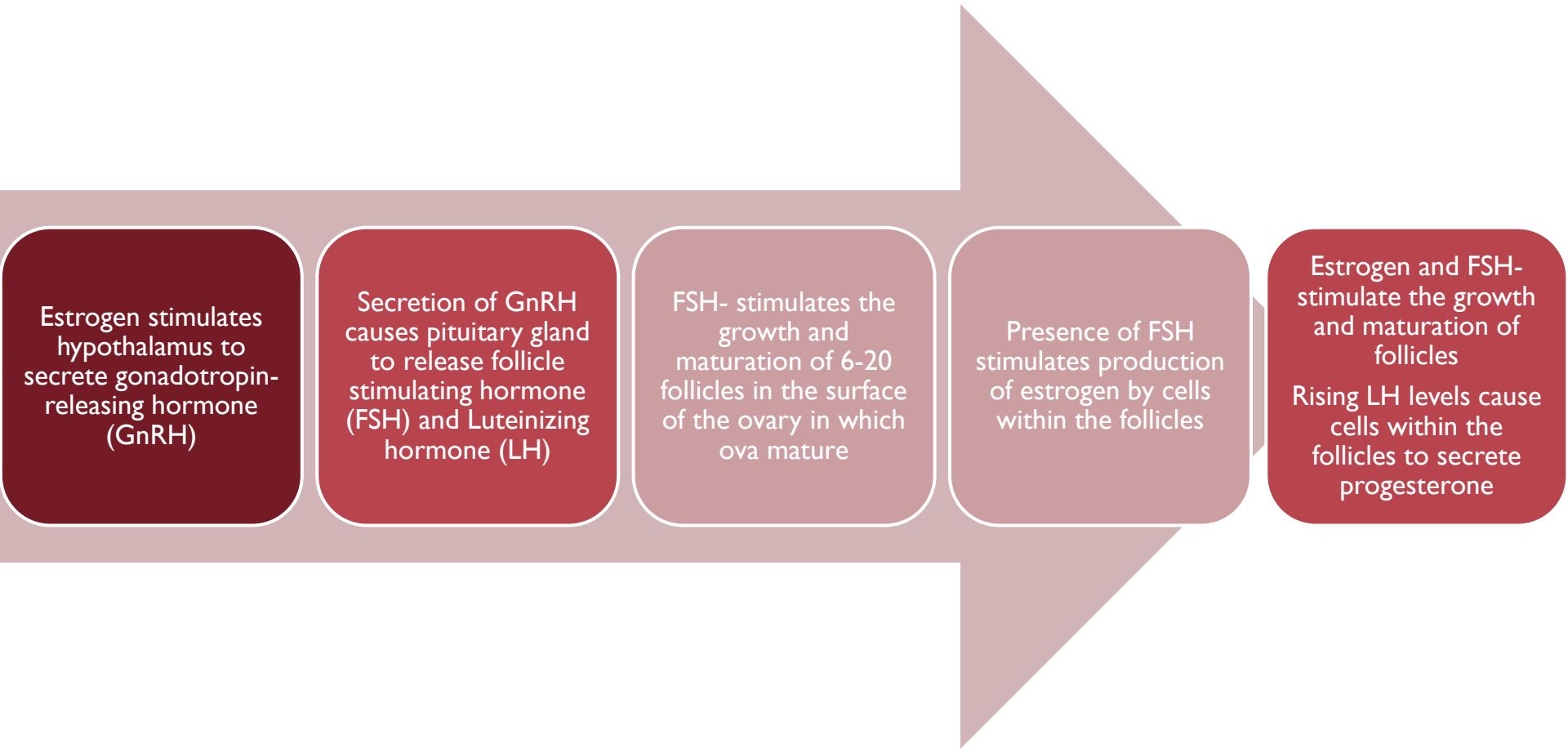
1st half- Follicular Phase



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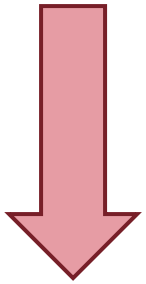
- Estrogen and progesterone prompt the uterine wall to store glycogen and other nutrients and to expand the growth of blood vessels and connective tissue



These changes prepare the uterus for nourishing a embryo after implantation

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- Blood levels of FSH and LH peak just prior to ovulation
- The surge in LH level results in the release of an ovum from a follicle, and **ovulation** occurs
- Without sufficient FSH and LH, ova within follicles do not mature and are not released (This is also how estrogen and progesterone in some birth control pills inhibit ova maturation and release.)

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2nd half- Luteal Phase

- Begins after ovulation
- Corpus luteum, *tissue formed from the follicle that contained the ovum prior to its release*, secretes estrogen and progesterone
- Estrogen and progesterone:
  - Inhibit the production of GnRH and hence the secretion of FSH and LH
  - Stimulate the development of the endometrium (uterine wall)

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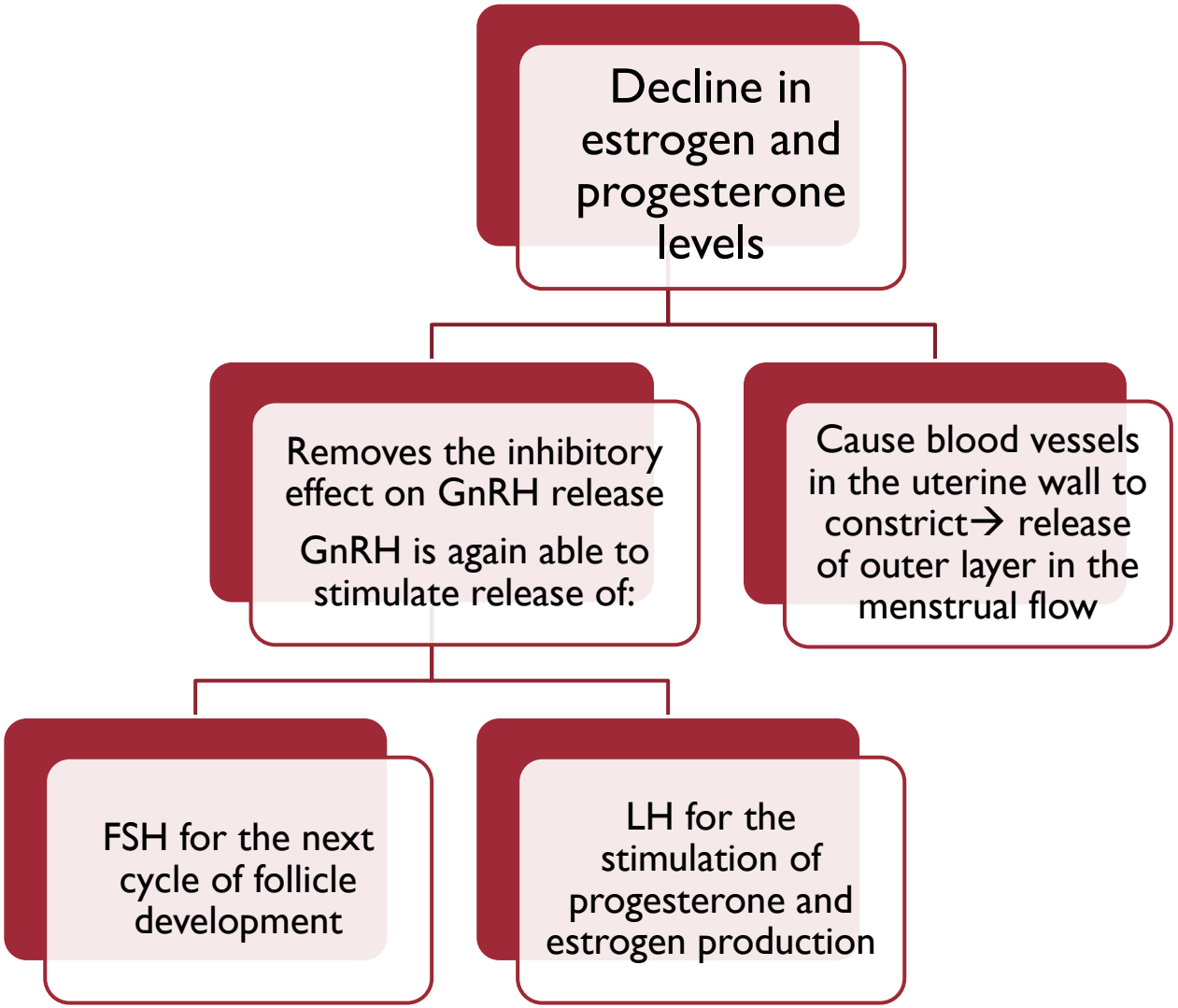
No fertilization→ production of hormones by the corpus luteum declines, and blood levels of progesterone and estrogen fall



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If fertilization of the ovum occurs:

- After implantation (8-10 days), the body starts producing the pregnancy hormone, *human chorionic gonadotrophin (hCG)*, which keeps the corpus luteum active
  - It continues to produce estrogen and progesterone to:
    - Maintain the nutrient and blood vessel supply in the endometrium
    - Prevent the lining of the uterus from being shed, until the placenta is mature enough to maintain the pregnancy

- The corpus luteum ceases to function within the first few months of pregnancy→ when it is no longer needed for hormone production

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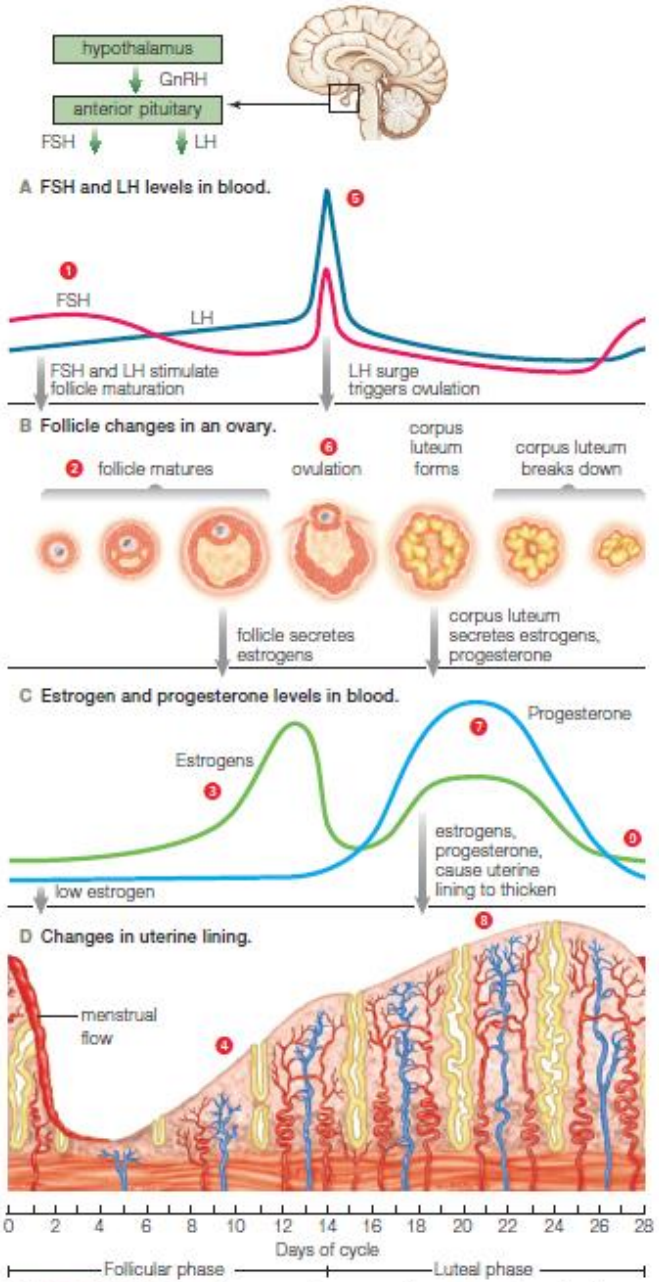

ILLUSTRATION 2.2 ▸ Changes in the ovary and uterus, correlated with changing hormone levels during the follicular and luteal phases of the menstrual cycle.

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Table 2.2 Hormones that affect reproduction

Hormone	Abbreviation	Source	Action
Gonadotropin-releasing hormone	GnRH	Hypothalamus	Stimulates release of FSH and LH
Follicle-stimulating hormone	FSH	Pituitary	Stimulates the maturation of ova and sperm
Luteinizing hormone	LH	Pituitary	Stimulates secretion of estrogen, progesterone, and testosterone and growth of the corpus luteum
Estrogen (most abundant form is estradiol)		Ovaries, testes, fat cells, corpus luteum, and placenta (during pregnancy)	Stimulates release of GnRH in follicular phase and inhibits in luteal phase; stimulates thickening of uterine wall during menstrual cycle
Progesterone (progestin, progestogen, and gestagon are similar)		Ovaries and placenta	"Progestational": prepares uterus for fertilized ovum and to maintain a pregnancy; stimulates uterine lining buildup during menstrual cycle; helps stimulate cell division of fertilized ova; inhibits action of testosterone
Testosterone		Mostly by testes	Stimulates maturation of male sex organs and sperm, formation of muscle tissue, and other functions

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Males

- Sperm are produced from puberty onward
- Sperm numbers and viability decrease somewhat after ~35 yrs of age

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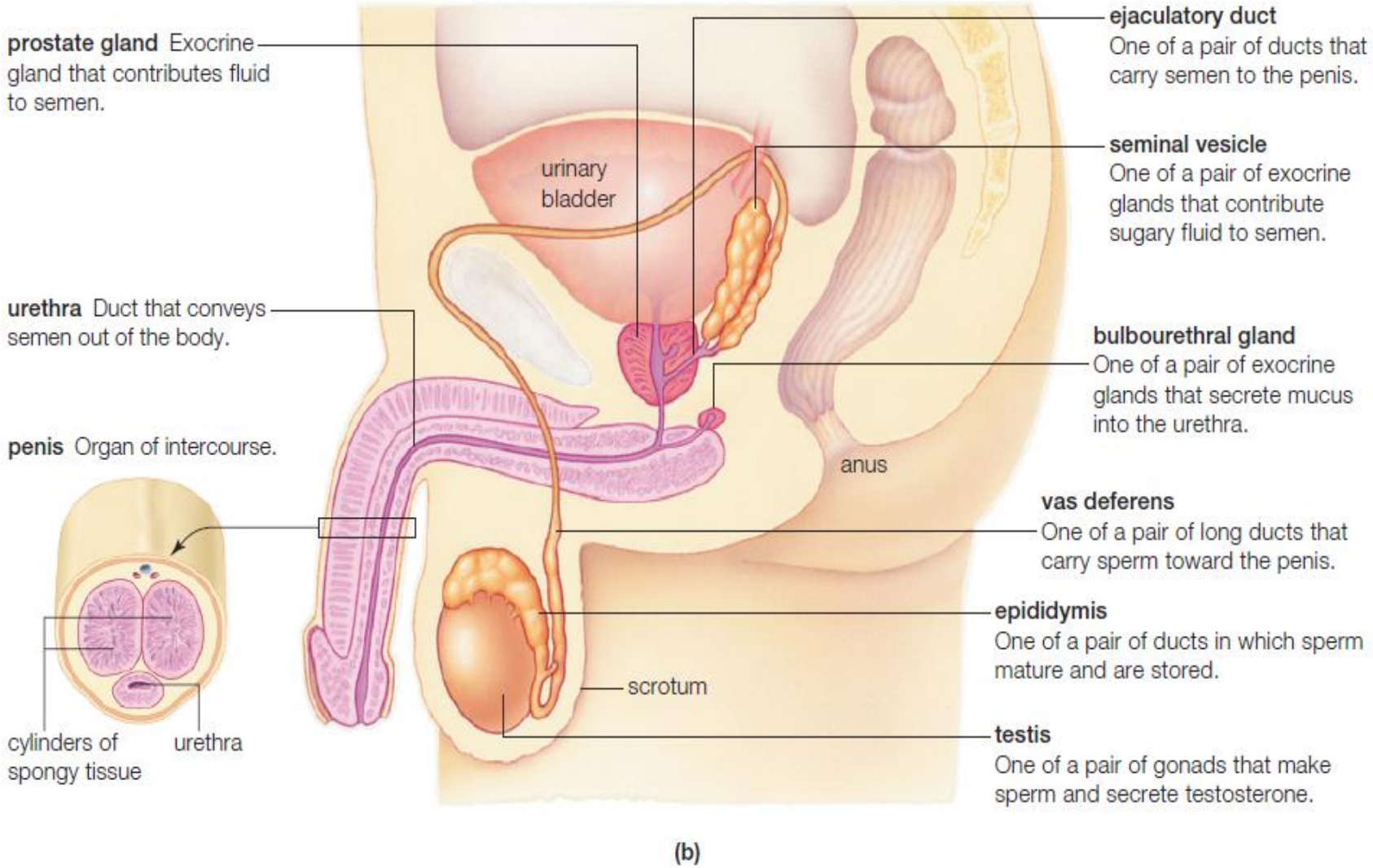

ILLUSTRATION 2.1 ▸ Mature (a) female and (b) male reproductive systems.

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Male reproductive system

- Reproductive capacity in males is established by complex interactions among the hypothalamus, pituitary gland, and testes
  - **Testes (testicles/testis)**: male reproductive glands located in the scrotum/ produce testosterone

- The process in males is ongoing rather than cyclic

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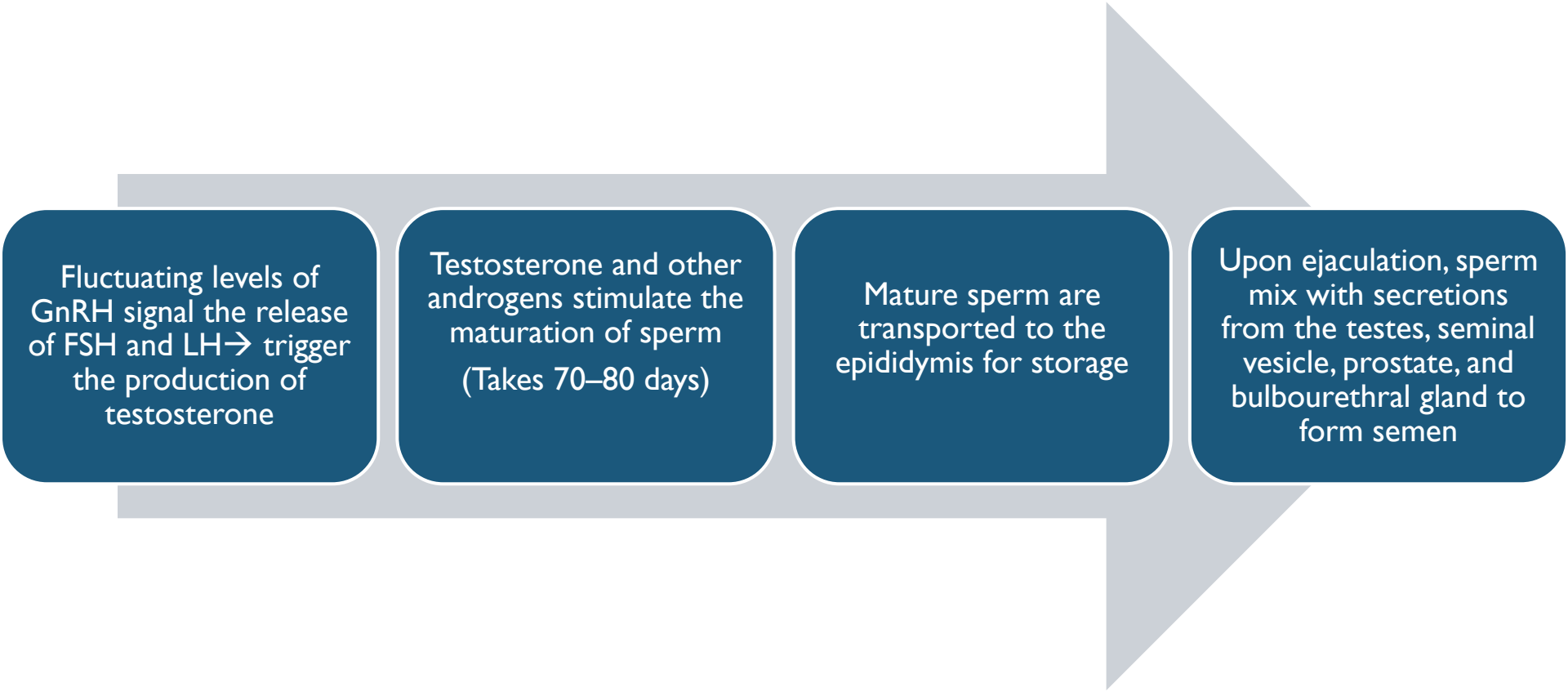

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Sources of disruption in fertility

- Adverse nutritional exposures
- Severe stress
- Infection
- Tubal damage and other structural problems
- Chromosomal abnormalities

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Table 2.3 Factors related to altered fertility in women and men

Females and Males	Females	Males
• Weight loss >10 to 15% of normal weight • Inadequate antioxidant status (selenium, vitamins C and E) • Inadequate body fat • Excessive body fat, especially central fat • Extreme levels of exercise • High alcohol intake • Endocrine disorders (e.g., hypothyroidism, Cushing's disease) • Structural abnormalities of the reproductive tract • Chromosomal abnormalities in sperm and eggs • Celiac disease • Oxidative stress • Severe psychological stress • Infection (sexually transmitted diseases) • Diabetes, cancer, other disorders • Some medications	• Recent oral contraceptive use (within 2 months) • Anorexia nervosa, bulimia nervosa • Vegan diets • Age >35 years • Metabolic syndrome • Pelvic inflammatory disease (PID) • Endometriosis • Polycystic ovary syndrome • Poor iron stores	• Inadequate zinc status • Heavy metal exposure (lead, mercury, cadmium, manganese) • Halogen (in some pesticides) and glycol (in antifreeze, de-icers) exposure • Estrogen exposure (in DDT, PCBs) • Sperm defects (quality, motility) • Excessive heat to testes • Steroid abuse • High intake of soy foods

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Nutrition related disruptions in fertility

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NUTRITION FACTORS

- Under nutrition
- Body fat
  - Adequate
  - Inadequate
- Nutrients status
  - Antioxidants
  - Zinc
  - Soy
  - Iron
  - Caffeine
  - Alcohol
  - Heavy metals
- Physical activity

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- Nutrient intake from food & dietary supplements and body fat, affect fertility primarily by:
  - Altering the environment in which eggs and sperm develop
  - Modifying levels of hormones involved in reproductive processes

- Nutrient intake and body fat level *before conception* affect the mother's health during pregnancy and the growth and development of the fetus
  - Nutritional factors generally exert only **temporary** influence on fertility→ normal fertility returns once the problem is corrected

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Under nutrition

- Under nutrition among previously well-nourished women is associated with a dramatic decline in fertility that recovers when food intake does

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Under nutrition

- Famine in Holland during World War II led to calorie intakes of about 1000/ day among women. One out of two women in famine-affected areas stopped menstruating, and the birthrate dropped by 53%.

- Fertility status improved within 4 months after the end of the famine, but for many women it took as long as a year for their menstrual cycles to return to normal.

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Body fat and fertility

- **Excessive** and **inadequate** levels of body fat are related to declines in fertility in women and men
  - Primarily related to changes in hormone concentrations

- Fat cells produce estrogen, androgens, and leptin→ the availability of these hormones changes with body fat content
  - This interferes with reproductive processes including *follicular development, ovulation, and sperm production & maturation*

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Body fat and fertility

- **Leptin**: a protein secreted by adipose tissue; binds to specific receptor sites in the hypothalamus which leads to:
  - decreases in appetite
  - increases EE
  - **stimulates gonadotropin secretion**
- leptin levels are elevated by high levels of fat; reduced by low levels of body fat

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Excessive body fat and infertility

- Obesity (BMI> 30 kg/m^2)→ ↑ levels of oxidative stress & exposure of eggs and sperm to oxidative damage
- Most obese women and men are not infertile- *more likely to experience delays in the time it takes to become pregnant*
- Hormonal changes in obese women can lead to the development of:
  - Menstrual-cycle irregularities
  - Ovulatory failure
  - Anovulatory cycles
  - Amenorrhea

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Excessive body fat and infertility

- Obesity in men is associated with:
  - ↓↓ testosterone levels (why??)
  - ↑↑ estrogen and leptin levels

- These changes are related to reduced sperm production

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- Infertility treatments are less effective in obese than in normal-weight women

- Loss of body fat is related to:
  - Improvements in hormone levels
  - Reduced oxidative stress,
  - Improved conception rates in both men and women

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Inadequate body fat and fertility

- A specific level of body fat (BMI> 20 kg/m^2) is needed to trigger and sustain normal reproductive functions in women

- **Low levels of body fat during adolescence** is related to delays in the age of onset of menstruation and to reduced fertility later in life

- Underweight and low levels of body fat in men→ lowered libido and reduced sperm production

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Weight loss and fertility in normal- weight women and men

- In normal-weight women, loss> ~10–15% of usual wt decreases levels of estrogen, LH, and FSH
  - Consequences include amenorrhea, anovulatory cycles, and short or absent luteal phases
- Hormone levels tend to return to normal when wt is restored to within 95% of previous wt
- Wt gain is the recommended first-line of treatment for amenorrhea related to low BW
  - Use of drugs and hormones might be less effective/ small for gestational age infants

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Oxidative stress, antioxidant nutrient status, and fertility

- Research findings: intake of ***antioxidants*** such as vit E, vit C, Se→ important role in fertility in women and men
- Antioxidants & protection from damage by oxidative stress
- Oxidative stress: ROS> antioxidants defenses in the body

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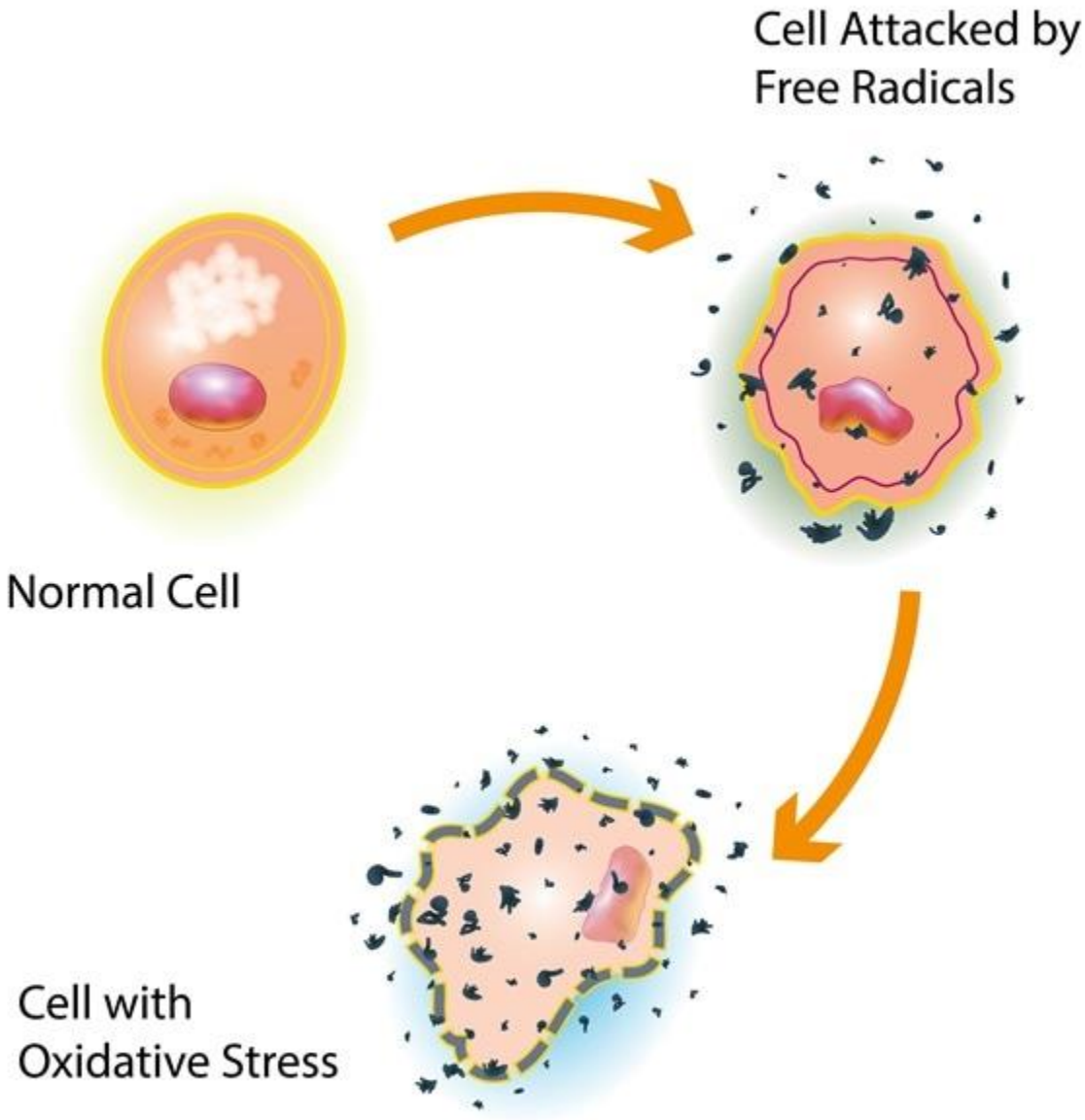

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Oxidative stress

- ***In women:*** ROS can harm egg and follicular development and can interfere with corpus luteum function and implantation of the egg in the uterine wall

- ***In men:*** ROS attack PUFAs in sperm membranes→ decreases sperm motility and reduces the ability of sperm to fuse with an egg
  - Enter sperm cell and damage DNA- defective DNA
  - Oxidative stress is observed in approximately half of all infertile men

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Effect of antioxidant intake on fertility

- Research findings: *intake of antioxidants is lower in infertile men and women compared with fertile individuals*

- ↑↑ avg intakes of antioxidants (can be in supplement form) are associated with:
  - Infertile women→ improvements in levels of oxidative stress
  - Infertile men → improvements in sperm maturation, motility, [ ], and reduction of DNA and chromosome damage

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Plant foods and fertility

- Women who regularly consume plant-based, low-fat diets are more likely to have irregular menstrual cycles than omnivores
  - Diets providing < 20% of Kcal from fat→ lengthen menstrual cycles among women in general

- Regular intake of soy foods such as tofu and soymilk is shown to be related to↓ sperm count in men
  - Effects of high plant- and soy-food diets on fertility may be related to the influence of certain phytochemicals in plant foods on hormone levels

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Preconception Fe status

- Fe status prior to pregnancy is related to fertility and pregnancy outcomes
  - Results of a large prospective study of nurses indicate that infertility due to a lack of ovulation is related to Fe intake
  - No established mechanism yet !
- Fe deficiency preconception has been shown to:
  - ↑ risk that IDA will occur during pregnancy and that infants will be born with low Fe stores
  - increased rates of preterm delivery

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- Improve Fe status by:
  - Taking iron supplements (18 mg/ day)
  - Regular consumption of lean meats
  - Iron fortified cereals
  - Vit C–rich fruits and vegetables along with plant sources of Fe

  - **It is easier and more efficient to build up Fe stores before pregnancy than during pregnancy**

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Caffeine and fertility

- Inconsistent findings
- Study findings: intake of >300 mg of caffeine daily ↓ the chance of conceiving by 27% / cycle compared to negligible caffeine intake
- Other studies→ no effect of caffeine intake prior to pregnancy on the amount of time it takes to become pregnant, on ovulatory infertility, or on indicators of ovarian function

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Alcohol and fertility

- Alcohol may influence fertility by decreasing estrogen and testosterone levels and by disrupting menstrual cycles and testicular functions

- Inconsistent findings
  - Not all studies show an effect and some show effects only in women and men with very high intakes of alcohol

- it is recommended that women restrict their alcohol intake while attempting pregnancy to avoid the possibility of alcohol-related harm to the developing fetus

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Heavy metal exposure

- Exposure to high levels of lead is related to decreased sperm production and abnormal sperm motility and shape
  - Inhaled or ingested Pb is transported to the pituitary gland→ appears to disrupt hormonal communications with the testes

- Exposure to excess levels of mercury, cadmium, molybdenum, manganese, boron, cobalt, copper, nickel, silver, or tin may also affect male fertility

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Multivitamin supplement, folate intake, and fertility

- multivitamin intake by preconceptional women has been associated with a lower risk of ovulatory infertility
  - Intake of supplemental folate appears to account for much of the decline in ovulatory infertility observed

- Folate status may affect **male fertility**: higher levels of folate intake in healthy men have been related to the presence of fewer chromosomally abnormal sperm than identified among men with lower intake of folate

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Folate status prior to conception and neural tube defects (NTDs)

- Inadequate folate very early in pregnancy can cause NTDs
- These defects develop within 21 days after conception
- Efforts are focused on encouraging women to consume folic acid
  - FDA→ refined grain products including white bread, crackers, rice, and pasta fortified with folate
- Women can get enough folate by consuming a good basic diet and a fully fortified breakfast cereal or a regular breakfast cereal and 6- 8 servings of refined grain products/ day
- Folic acid supplements: 400 mcg/ day: can also be taken

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- It is recommended that women who may become pregnant:
  - Consume 400 mcg of folate from fortified grain products, vegetables, fruits, or supplements
  - Take no more than 5000 IU of vitamin A from supplements daily
  - Limit or omit alcohol-containing beverages

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Other preconception nutrition concerns

Table 2.7 Nutritional exposures before and very early in pregnancy that disrupt fetal growth and development

Weight Status

- Being underweight increases the risk of maternal complications during pregnancy and the delivery of small and early newborns.
- Obesity increases the risk of clinical complications during pregnancy and delivery of newborns with neural tube defects or excessive body fat.

Nutrient Status

- Insufficient folate intake increases the risk of embryonic development of neural tube defects.
- Excessive vitamin A intake (retinol, retinoic acid) increases the risk the fetus will develop facial and heart abnormalities.
- High maternal blood levels of lead increase the risk of mental retardation in the offspring.
- Iodine deficiency early in pregnancy increases the risk that children will experience impaired mental and physical development.
- Iron deficiency increases the risk of early delivery and development of iron deficiency in the child within the first few years of life.

Alcohol

- Regular intake of alcohol increases the risk of *fetal alcohol syndrome* and *fetal alcohol effects*, both of which include impaired mental and physical development.

Diabetes

- Poorly controlled blood glucose levels early in pregnancy increase the risk of fetal malformations, excessive infant size at birth, and the development of diabetes in the offspring later in life.

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