Nutrition During Pregnancy

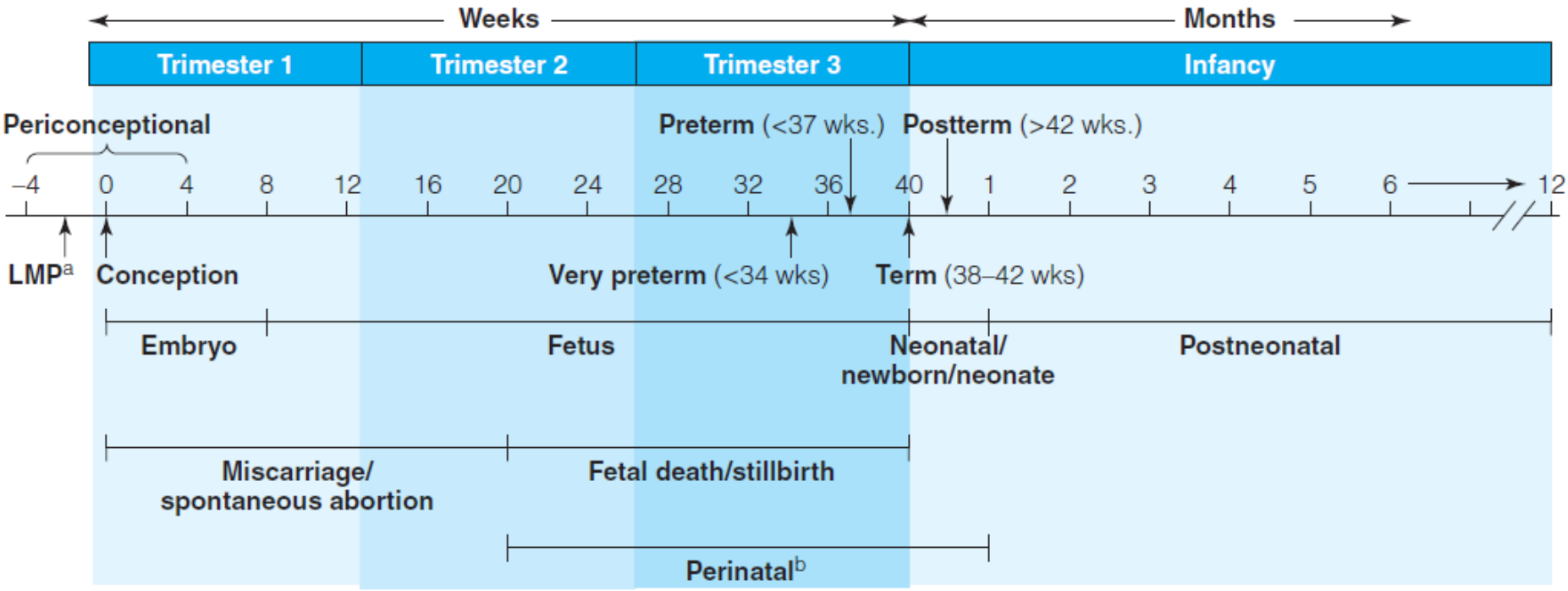
CHAPTER 4

Pregnancy and Nutrition

- The nine months of pregnancy represent the most intense period of growth and development humans ever experience.

- How well these processes go depends on many factors, most of which are modifiable. Of the factors affecting fetal growth and development that are within our control to change, nutritional status stands out.
- At no other time in life are the benefits of optimal nutritional status more obvious than during pregnancy.

Illustration 4.1 Time-related terms before, during, and after pregnancy.



[a]LMP = last menstrual period

[b]Perinatal definition varies from 20 to 24 weeks gestation to 7 to 28 days after birth.

low birth weight, preterm delivery, and infant mortality

- Infants born LBW or preterm are at significantly higher risk of dying in the 1st yr of life than are larger and older newborns
  - *Relationship between LBW and preterm infant → the shorter the pregnancy, the less newborns tend to weigh*

- *Population-wide improvements in social circumstances, infectious disease control, and availability of safe and nutritious foods → ↓ in infant mortality rates*

Reducing infant mortality and morbidity

- Improve birth weight of newborns
- Infants weighing 3.5-4.5Kg at birth are least likely to die within the 1st yr of life
  - They are less likely to develop heart disease, diabetes, lung disease, HTN… with age

Physiology of pregnancy

- **Pregnancy begins at conception** → occurs approximately 14 days before a woman's next menstrual period begins

- ***Gestational age:*** assessed from time of conception; pregnancy avgs 38 wks in length

- ***Menstrual age:*** measured from the date of the 1st day of the last menstrual period; pregnancy duration is given as 40 wks; most commonly used

Maternal physiology

- Changes in maternal body composition and functions occur in a specific sequence during pregnancy
  - *The order of the sequence is absolute because the successful completion of each change depends on the one before it*

- Because maternal physiological changes set the stage for fetal growth and development, they begin in within 1 wk after conception

Table 4.6 Sequence of tissue development and approximate gestational week of maximal rates of change in maternal systems, the placenta, and fetus during pregnancy[10]

Tissue	Sequence of Development	Gestational Week of Maximal Rate of Growth
Maternal plasma volume	1	20
Maternal nutrient stores	2	20
Placental weight	3	31
Uterine blood flow	4	37
Fetal weight	5	37

Volume: to provide the fetus with sufficient E, nutrients, and O_2 for growth

Nutrient stores: established in advance of the time they will be needed to support large gains in fetal weight

Placenta is fully prepared for the high level of functioning that will be needed as fetal weight increases most rapidly

Abnormalities in the development of any of these physiological systems can change subsequent fetal growth and development

Normal physiological changes during pregnancy

- **<u>Divided into:</u>**
  - *Maternal anabolic*- changes in 1st half: build the capacity of the mother's body to deliver relatively large quantities of blood, O_2, and nutrients to the fetus in the 2nd half of pregnancy; ~10% of fetal growth
  - *Maternal catabolic*- changes in 2nd half: Heightened capacity to deliver stored E and nutrients to the fetus predominates; 90% of growth

Table 4.7 Summary of maternal anabolic and catabolic phases of pregnancy[11–13]

Maternal Anabolic Phase 0–20 Weeks	Maternal Catabolic Phase 20+ Weeks
Blood volume expansion, increased cardiac output	Mobilization of fat and nutrient stores
Buildup of fat, nutrient, and liver glycogen stores	Increased production and blood levels of glucose, triglycerides, and fatty acids; decreased liver glycogen stores
Growth of some maternal organs	Accelerated fasting metabolism
Increased appetite, food intake (positive caloric balance)	Increased appetite and food intake decline somewhat near term
Decreased exercise tolerance	Increased levels of catabolic hormones
Increased levels of anabolic hormones	

- More blood (more RBCs) → increased by 50% → maintain the placenta

** pregnancy glow …

Normal changes in maternal physiology during pregnancy

Blood Volume Expansion
- Blood volume increases 20%
- Plasma volume increases 50%
- Edema (occurs in 60–75% of women)

Hemodilution
- Concentrations of most vitamins and minerals in blood decrease

Blood Lipid Levels
- Increased concentrations of cholesterol, LDL cholesterol, triglycerides, HDL cholesterol

Blood Glucose Levels
- Increased insulin resistance (increased plasma levels of glucose and insulin)

Maternal Organ and Tissue Enlargement
- Heart, thyroid, liver, kidneys, uterus, breasts, adipose tissue

Circulatory System
- Increased cardiac output through increased heart rate and stroke volume (30–50%)
- Increased heart rate (16% or 6 beats/min)
- Decreased blood pressure in the first half of pregnancy (−9%), followed by a return to nonpregnancy levels in the second half

Respiratory System
- Increased tidal volume, or the amount of air inhaled and exhaled (30–40%)
- Increased oxygen consumption (10%)

Food Intake
- Increased appetite and food intake; weight gain
- Taste and odor changes, modification in preference for some foods
- Increased thirst

Gastrointestinal Changes
- Relaxed gastrointestinal tract muscle tone
- Increased gastric and intestinal transit time
- Nausea (70%), vomiting (40%)
- Heartburn
- Constipation

Kidney Changes
- Increased glomerular filtration rate (50–60%)
- Increased sodium conservation
- Increased nutrient spillage into urine; protein is conserved
- Increased risk of urinary tract infection

Immune System
- Suppressed immunity
- Increased risk of urinary and reproductive tract infection

Basal metabolism
- Increased basal metabolic rate in second half of pregnancy
- Increased body temperature

Hormones
- Placental secretions of large amounts of hormones needed to support physiological changes of pregnancy

Body water changes

- A woman's body gains water during pregnancy, primarily due to increased volume of plasma and ECF, as well as amniotic fluid

- Range of increase 7-10L
  - About 2/3 of the expansion is IC (blood and body tissues)
  - 1/3 EC expansion

Body water changes

- Early pregnancy ↑↑ in plasma volume→ main reason that pregnant women feel tired and become exhausted easily when undertaking exercise performed routinely prior to pregnancy

- Fatigue associated with plasma-volume increases in the 2nd and 3rd months of pregnancy declines as other compensatory physiological adjustments are made

Body water changes

- Gains in body water vary among women during normal pregnancy

- High gains are associated with ↑ degrees of ***edema*** and wt gain
  - Edema generally reflects a healthy expansion of plasma volume if not accompanied by HTN

- *BW is strongly related to plasma volume: generally, the greater the expansion, the greater the newborn size*

Body water changes

- The increased volume of water in the blood is responsible for the "***dilution effect***" of pregnancy on blood [ ] of some vitamins and minerals
  - Blood levels of fat-soluble vitamins→ ↑
  - Levels of the water-soluble vitamins→ ↓
  - Vitamin supplement use to modify levels

Hormonal changes

- Modulated by hormones produced by the *placenta*
  - Supplier of many other hormones needed to support the physiological changes of pregnancy

Table 4.9 Key placental hormones and examples of their roles in pregnancy[13,16]

Human chorionic gonadotropin (hCG)

Maintains early pregnancy by stimulating the corpus luteum to produce estrogen and progesterone. It stimulates growth of the endometrium. The placenta produces estrogen and progesterone after the first 2 months of pregnancy

Progesterone

Maintains the implant; stimulates growth of the endometrium and its secretion of nutrients; relaxes smooth muscles of the uterine blood vessels and gastrointestinal tract; stimulates breast development; promotes lipid deposition

Estrogen

Increases lipid formation and storage, protein synthesis, and uterine blood flow; prompts uterine and breast duct development; promotes ligament flexibility

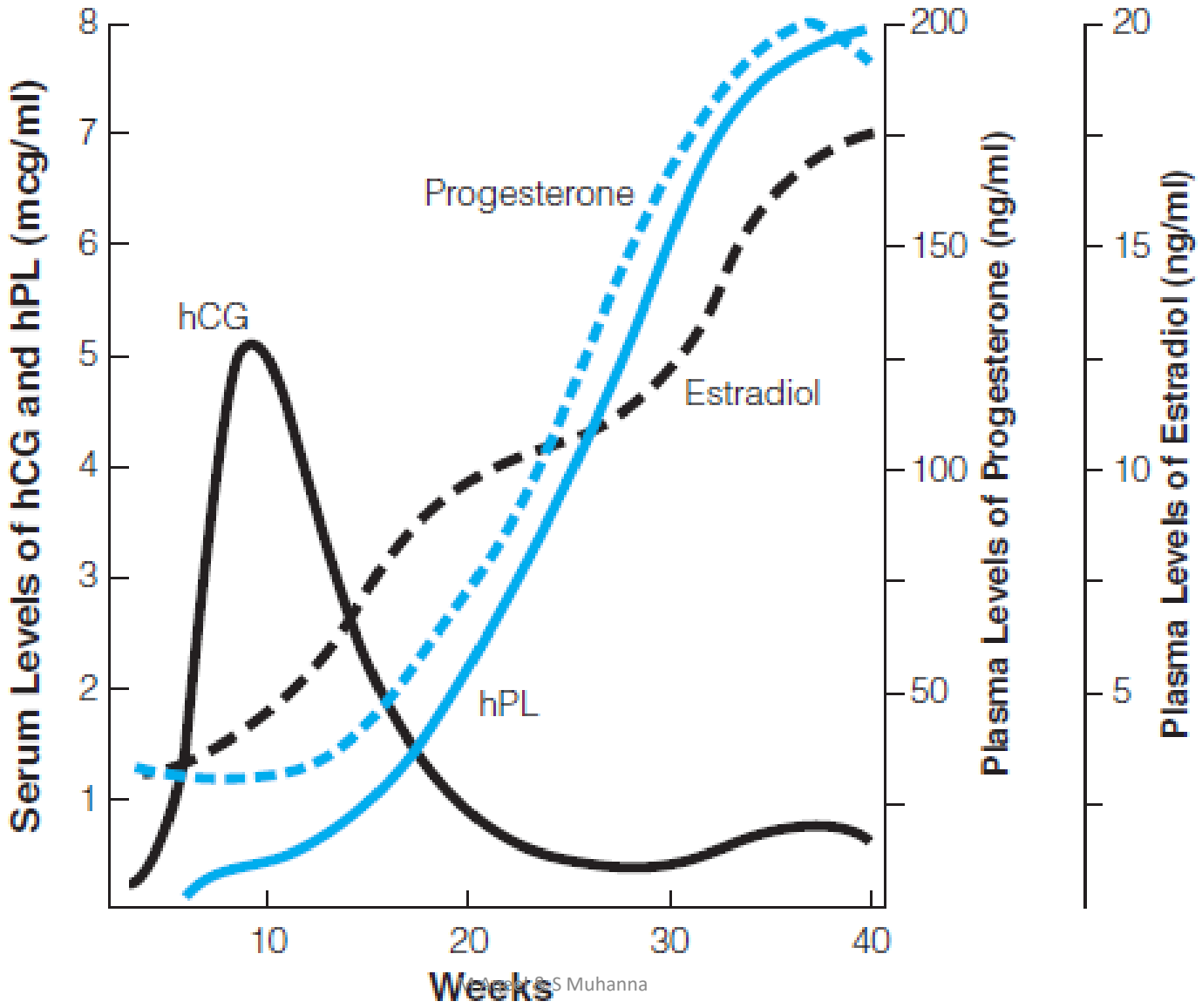
Human chorionic somatotropin (hCS)

Increases maternal insulin resistance to maintain glucose availability for fetal use; promotes protein synthesis and the breakdown of fat for energy for maternal use

Leptin

May participate in the regulation of appetite and lipid metabolism, weight gain, and utilization of fat stores

Illustration 4.3 Changes in maternal plasma concentration of hormones during pregnancy.



Maternal nutrient metabolism

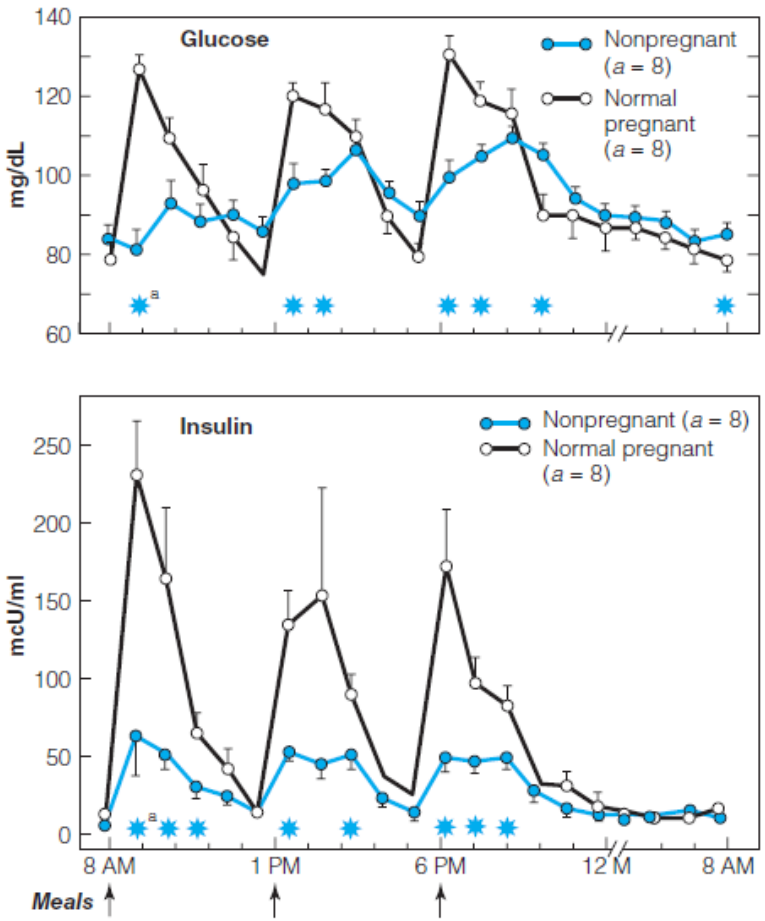
- The amount and types of nutrients required depend on the type and amount of nutrients needed for specific metabolic pathways to function and for fetal structures to develop

- Because normal fetal tissue growth and development are genetically timed→ nutrients must be available at the same time that genes controlling fetal growth and development are expressed

Carbohydrate metabolism

- Adjustments to promote the availability of glucose to the fetus
  - Glucose is the fetus's preferred fuel
    - Fats can be utilized for E
- Metabolic changes that promote maternal IR- "*diabetogenic effect*" of pregnancy
  - Make normal pregnant women slightly carb intolerant in 3rd trimester of pregnancy

Illustration 4.4 Plasma glucose and insulin levels in nonpregnant women and in women near term.



Constant supply of glucose for fetus

- *1st half of pregnancy*: carb metabolism is characterized by estrogen and progesterone- stimulated ↑ in insulin production
  - Glucose → glycogen and fat

- *2nd half:*
  - Rising levels of **hCS** and **prolactin** from the mother's pituitary gland **inhibit** the conversion of glucose to glycogen and fat; increased liver production of glucose
  - Insulin Resistance
    - **Increase reliance on fats for E in mother**
    - **Lowered maternal utilization of glucose**

Carbohydrate metabolism

- Fasting maternal blood glucose levels decline in the 3rd trimester due to increased utilization of glucose by the rapidly growing fetus
  - Post-meal blood glucose [ ] are elevated and remain higher longer than before pregnancy

Accelerated fasting metabolism

- Maternal metabolism is rapidly converted toward *gluconeogenic AA* utilization *(e.g., alanine, glutamate→ glucose)*, fat oxidation, and increased production of ketones with fasts that last> 12 hrs

- Decreased levels of plasma glucose and insulin; increased levels of TG, FFA, and ketones are seen hrs before they occur in non-pregnant fasting women

Accelerated fasting metabolism

- Rapid switch to fasting metabolism allows pregnant women to use stored fat for E; spare glucose and AA for fetus
  - Metabolic adaptations help ensure a constant fetal supply of glucose

- Fasting eventually ↑ the dependence of the fetus on ketone bodies for E
  - Prolonged fetal utilization of ketones → reduced growth and impaired intellectual development of the baby

Protein metabolism

- N_2 and protein are needed in increased amounts during pregnancy for synthesis of new maternal and fetal tissues

- Increased need→
  - reduction in level of N_2 excretion;
  - conservation of AA for protein tissue synthesis

- Maternal and fetal needs for protein are primarily fulfilled by the mother's intake of protein during pregnancy

Fat metabolism

- Accumulation of maternal fat stores in the 1st half; enhanced fat mobilization in the 2nd half
- Increased maternal reliance on fat stores for E as pregnancy progresses
- Blood levels of many lipoproteins increase
  - Plasma TG levels ↑- reach 3x non-pregnant levels by term
  - Cholesterol-containing lipoproteins, phospholipids, and FAs increase but<< TG increases

Fat metabolism

- ↑ cholesterol supply is used by the:
  - Placenta for steroid hormone synthesis
  - Fetus for nerve and cell membrane formation

- High [cholesterol and TG] observed during pregnancy do not promote the development of atherosclerosis- like the case in adults
  - 3rd trimester→ most women an atherogenic lipid profile→ *normal- screening not recommended during pregnancy*

- Small increases in HDL- C in pregnancy seem to decline within a yr postpartum and remain lower than pre-pregnancy levels
  - Declines in HDL- C after pregnancy may contribute to an ↑ risk of heart disease in women

- Other changes in serum lipids appear to return to pre-pregnancy levels postpartum

Mineral metabolism

- Elevated levels of body water and tissue synthesis during pregnancy are accompanied by increased reqs for Na
  - Accumulation of Na in mother, placenta, and fetus→ through increase in aldosterone → Na retention

- Normal change in pregnancy→ it is ineffective and harmful to try to prevent or treat HTN in pregnancy by reducing Na intake
  - Restriction may overstress mechanisms that work to conserve Na; lead to functional and growth impairments due to Na depletion

The placenta

- Develops from embryonic tissue and is larger than the fetus for most of pregnancy- precedes fetal development/ attaches the uterine wall

- **Functions of the placenta include:**
  - Hormone and enzyme production
  - Control the rate of passage of nutrients and other substances into and out of the fetal circulation
  - Acts as a barrier to some harmful compounds
    →But Alcohol, drugs, excessive amounts of some vitamins can pass through

- Barrier to the passage of maternal RBCs, bacteria, and many large proteins

- It prevents the mixing of fetal and maternal blood until delivery, when ruptures in blood vessels may occur


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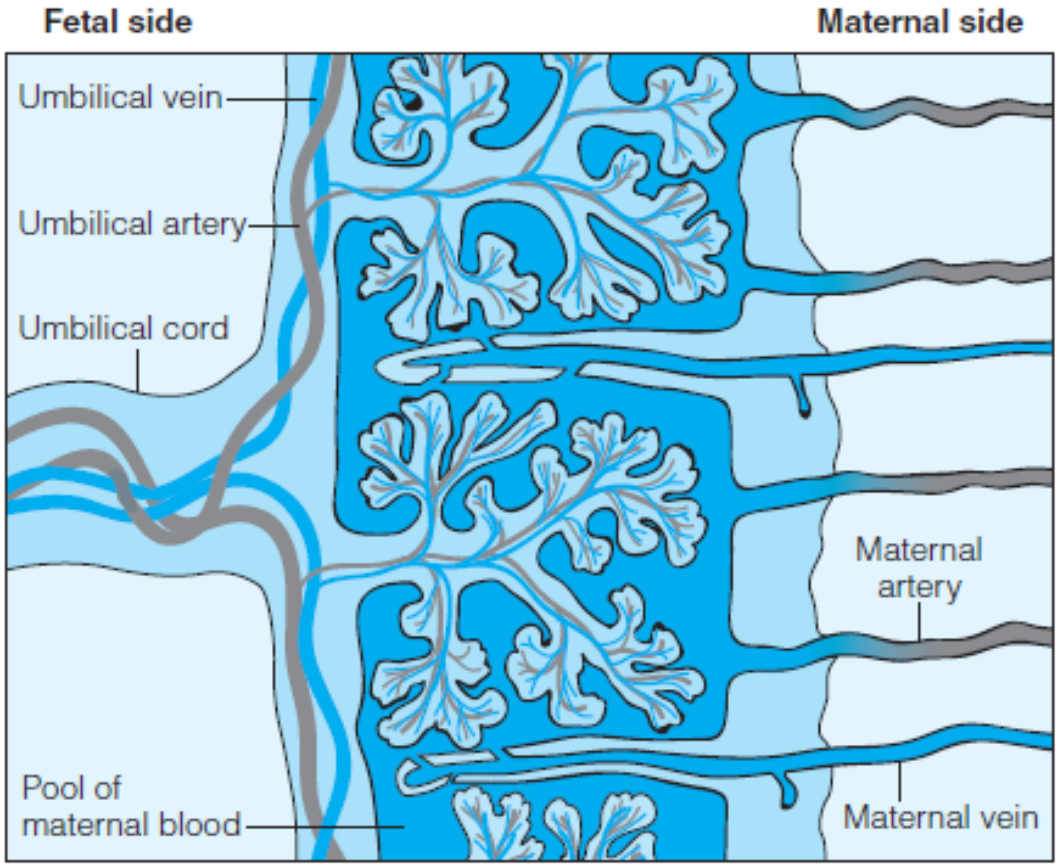
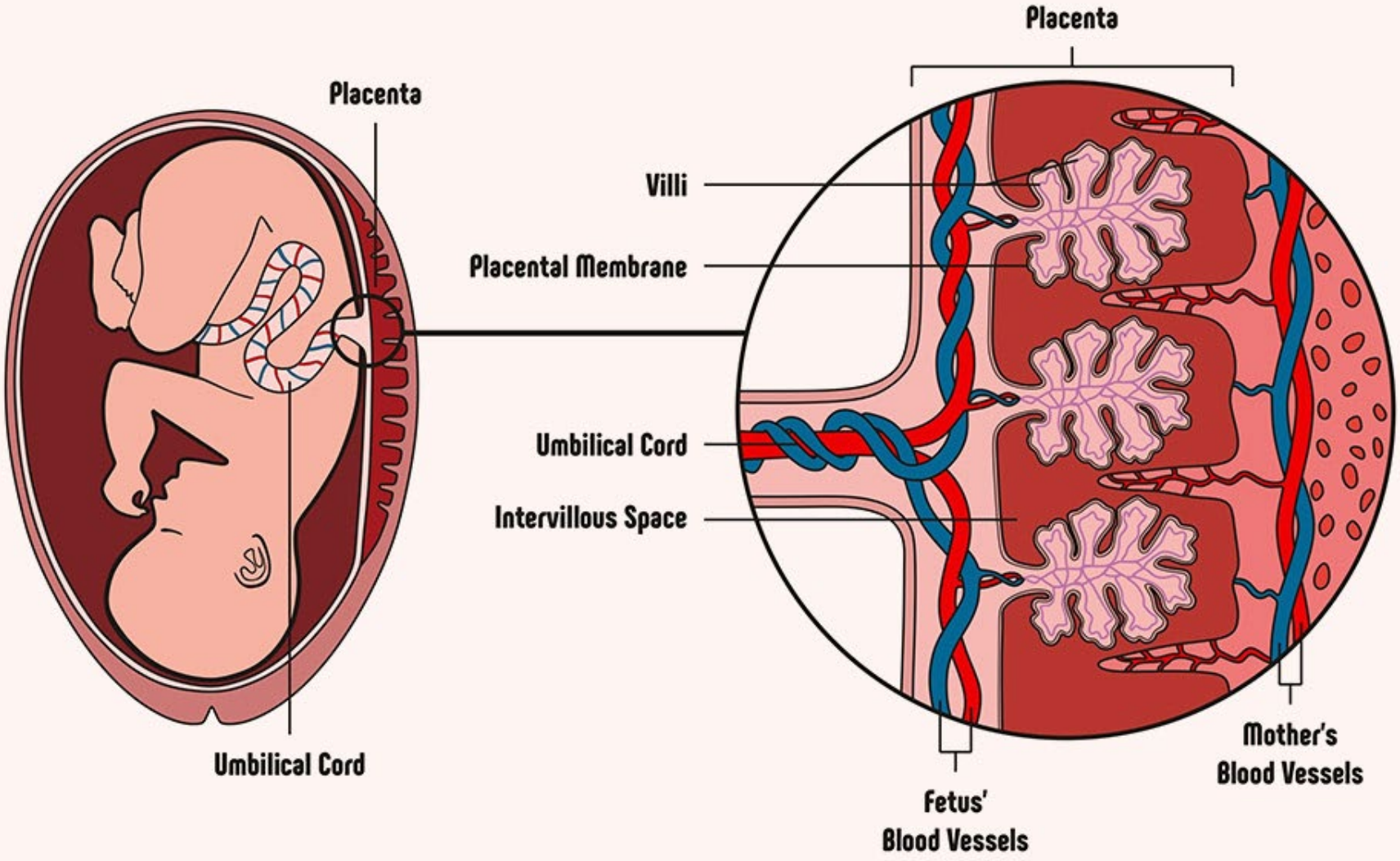
Illustration 4.6 Structure of the placenta. Maternal arteries and veins are part of the maternal circulation, whereas umbilical arteries and veins are part of the fetal circulation. Blood enters the fetus through umbilical veins and exits through umbilical arteries.



- Umbilical artery carries deoxygenated blood/ waste from fetus to placenta
- Umbilical vein carries oxygenated blood and nutrients from placenta to the fetus
- Umbilical cord develops from the placenta; connects mother and baby


Placenta
Placenta
Villi
Placental Membrane
Umbilical Cord
Intervillous Space
Umbilical Cord
Fetus'
Blood Vessels
Mother's
Blood Vessels

Nutrient transfer

- Placenta uses 30-40% of the glucose delivered by the maternal circulation
  - If nutrient supplies are too little to meet placental needs, functioning of the placenta is compromised to sustain the nutrient supply and health of the mother

- Nutrient exchange between the mother and fetus is unregulated for some nutrients, O_2 and CO_2

Nutrient transfer

- Nutrient transfer across the placenta depends on a number of factors, including:
  - The size and the charge of molecules available for transport
    - Small molecules with little or no charge (e.g., water) and lipids (cholesterol and ketones) pass through the placenta easily
    - Large molecules (e.g., insulin and enzymes) are not transferred at all
  - Lipid solubility of the particles being transported
  - The concentration of nutrients in maternal and fetal blood
- Three primary mechanisms regulate nutrient transfer:
  - Facilitated diffusion: attach to carrier protein
  - Active transport: need E; Na^+/K^+ ATPase
  - Endocytosis (or pinocytosis)

Table 4.11 Mechanisms of nutrient transport across the placenta[13,26]

Mechanism	Examples of Nutrients
Passive diffusion (also called *simple diffusion*) Nutrients transferred from blood with higher concentration levels to blood with lower concentration levels	Water, some amino acids and glucose, free fatty acids, ketones, vitamins E and K,[a] some minerals (sodium, chloride), gases
Facilitated diffusion Receptors ("carriers") on cell membranes increase the rate of nutrient transfer	Some glucose, iron, vitamins A and D
Active transport Energy (from ATP) and cell membrane receptors	Water-soluble vitamins, some minerals (calcium, zinc, iron, potassium) and amino acids
Endocytosis (also called *pinocytosis*) Nutrients and other molecules are engulfed by placenta membrane and released into fetal blood supply	Immunoglobulins, albumin

[a]Vitamin K crosses the placenta slowly and to a limited degree.

Nutrient transfer

- The fetus receives small amounts of water and other nutrients from ingestion of ***amniotic fluid (practice use of digestive system and kidneys)***
  - By the 2nd half of pregnancy, the fetus is able to swallow and absorb H_2O, minerals, nitrogenous waste products, and other substances in amniotic fluid

The fetus is not a parasite !!

- When maternal nutrient intakes fall below optimum levels, fetal growth and development are compromised more than maternal health

- **In general, nutrients will first be used to support maternal nutrient needs for her health and physiological changes, and next for placental development, before they become available at optimal levels to the fetus.**

- Examples:
  - underweight women gaining the same amount of wt as normal-wt women tend to deliver smaller infants and to retain more of the wt gained during pregnancy at the expense of fetal growth

  - Vitamin and mineral deficiencies and toxicities in newborns have been observed in women who showed no signs of deficiency or toxicity diseases during pregnancy

Embryonic and fetal growth and development

Highest rate of growth during gestation

Table 4.12 Notes on normal embryonic and fetal growth and development[13,29]

Day 1	Conception; one cell called the zygote exists.	Week 9	Embryo now considered a fetus.
Day 2–3	Eight cells have formed (called the morula) and enter the uterine cavity.	Month 3	Weighs 1 oz; primitive egg and sperm cells developed, hard palate fuses, breathes in amniotic fluid.
Day 6–8	The morula becomes fluid-filled and is renamed the blastocyst. The blastocyst is comprised of 250 cells, and cell differentiation begins.	Month 4	Weighs about 6 oz; placenta diameter is 3 inches.
Day 10	Embryo implants into the uterine wall, where glycogen is accumulating.	Month 5	Weighs about 1 lb, 11 inches long; skeleton begins to calcify, hair grows.
Day 12	Embryo is composed of thousands of cells; differentiation well under way. Utero placental circulation being formed.	Month 6	14 inches long; fat accumulation begins, permanent teeth buds form; lungs, gastrointestinal tract, and kidneys formed but are not fully functional.
Week 4 (21–28 days)	¼ inch long; rudimentary head, trunk, arms; heart "practices" beating; spinal cord and two major brain lobes present.		
Week 5 (28–35 days)	Rudimentary kidney, liver, circulatory system, eyes, ears, mouth, hands, arms, and gastrointestinal tract; heart beats 65 times per minute, circulating its own newly formed blood.	Month 7	Gains ½–1 oz per day.
		Months 8 and 9	Gains about 1 oz per day; stores fat, glycogen, iron, folate, B_6 and B_{12}, riboflavin, calcium, magnesium, vitamins A, E, D; functions of organs continue to develop. Growth rate declines near term. Placenta weighs 500 – 650 g (1–1½ lb) at term.
Week 7 (49–56 days)	½ inch long, weighs 2–3 g (less than a teaspoon of sugar); brain sends impulses, gastrointestinal tract produces enzymes, kidney eliminates some waste products, liver produces red blood cells, muscles work. (Approximately 25% of blastocysts and embryos will be lost before 7 weeks.)		

Critical periods of growth and development

- CP: **Preprogrammed time periods during embryonic and fetal development when specific cells, organs, and tissues are formed and integrated, or functional levels established. Also called *sensitive periods.***

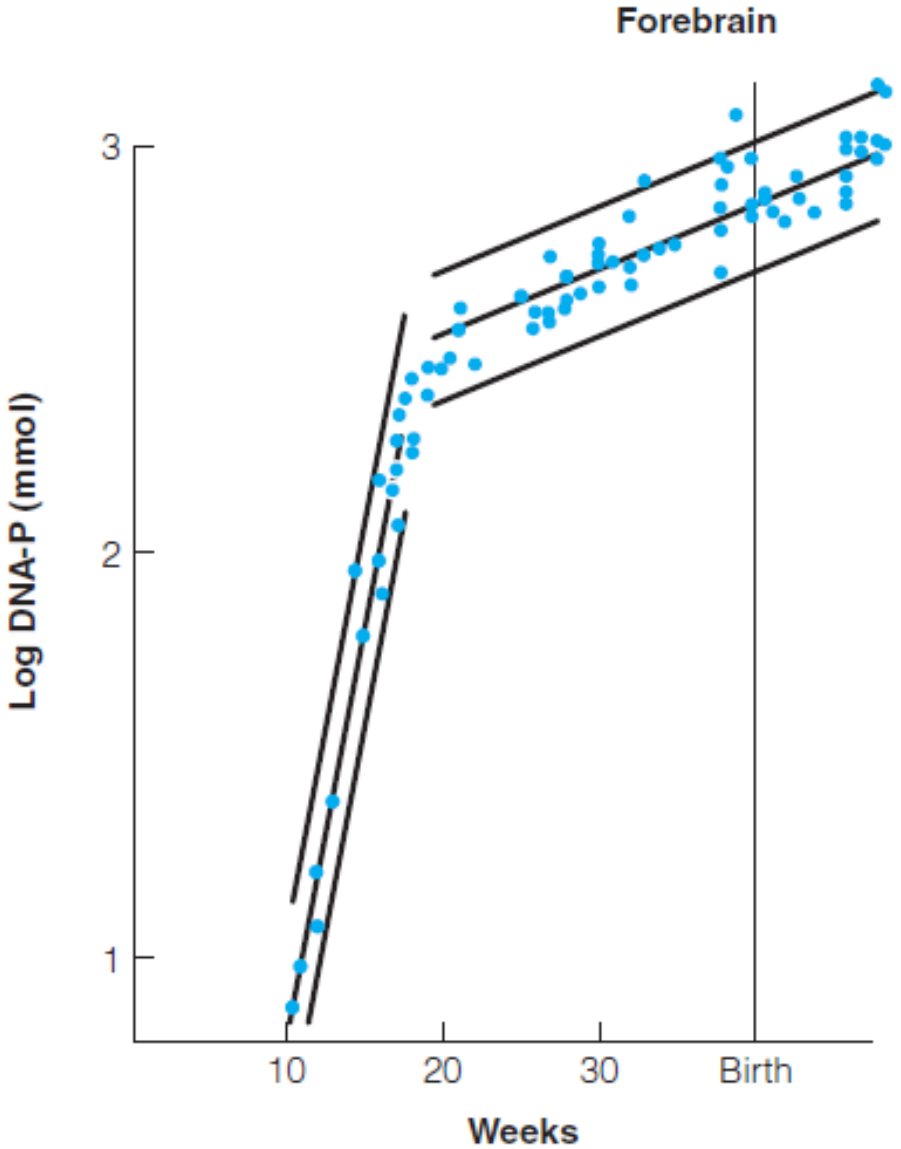
  - CP- most intense during the first 2months after conception- majority of organs and tissues form
  - It is not possible to reverse errors in growth or development that occur during a previous CP
    - deficits can lead to lifelong defects

  - Folate deficiency during first 3-4 wks after conception will lead to NTDs

Hyperplasia

- Increase in cell multiplication
- Human cells have specific amount of DNA→ we can determine period of hyperplasia when DNA content of certain organs sharply increases
- **Brain (CNS)** is the 1st organ that develops during gestation→ priority for nutrients over other organs
  - Heart and adrenal gland are next in line
- Hyperplasia can occur after birth
  - CNS cells multiply up to 2 yrs after birth- at a much slower pace
  - Skeletal and muscle cells increase in # during the adolescent growth spurt

Illustration 4.7 The critical period of cell multiplication of the forebrain. Growth in cell numbers is indicated by increases in DNA content of a given amount of tissue.



SOURCE: From J. Dobbing and J. Sands, "Quantitative Growth and Development of Human Brain," in *Archives of Disease of Children*, 48(10):757–767. © 1973 BMJ Publishing Group. Reprinted with permission.

Hypertrophy and maturation

Hypertrophy

- **Cell size** ↑ mainly due to an accumulation of protein and lipids inside cells
- Periods of hyperplasia-hypertrophy are followed by hypertrophy only
- Hyperplasia → hyperplasia and hypertrophy→ hypertrophy→ maturation
- reduction in cell size due to unfavorable nutrient environments are associated with deficits in organ function
  - e.g., reduced mental capabilities or declines in muscular coordination- these functional changes can often be reduced or reversed later if deficits are corrected

Maturation

- Last phase of growth and development
- Stabilization of cell number and size

Fetal body composition and variation in fetal growth

- Variations are mainly due to environmental factors including nutrient, E and O_2 availability and to conditions that interfere with genetically programmed growth and development

  - Pre-pregnancy underwt, low wt gain during pregnancy, poor dietary intakes, smoking, drug abuse, and certain clinical complications of pregnancy are associated with reduced fetal growth

FETAL GROWTH

- Insulin-like growth factor-1 (IGF-1) is the primary growth stimulator of the fetus → ***promotes uptake of nutrients & inhibits fetal tissue breakdown***
- Levels of IGF-1 are sensitive to maternal nutrition- *lower levels with under-nutrition*

- ↓ levels of IGF-1 → ↓ muscle and skeletal mass and produce asymmetrical growth

IUGR

Risk of illness and death varies with size at birth-

*it is high for newborns who experience **intrauterine growth restriction (IUGR)***

- *To decide on IUGR→ assessment of size for gestational age using a reference standard*
- Infants are generally considered likely to have experienced IUGR if their wt for gestational age or length is low

- **Small for gestational age**:

wt ≤ 10th percentile for gestational age

- **Appropriate for Gestational Age (AGA)**

Weight, length, and head circumference are between the 10th and 90th percentiles for gestational age.

Table 4.14 Percentiles of weight in grams for newborn gestational age

Gestational Age (wk)	5th Pctl	10th Pctl	50th Pctl	90th Pctl	95th Pctl
20	249	275	412	772	912
21	280	314	433	790	957
22	330	376	496	826	1023
23	385	440	582	882	1107
24	435	498	674	977	1223
25	480	558	779	1138	1397
26	529	625	899	1362	1640
27	591	702	1035	1635	1927
28	670	798	1196	1977	2237
29	772	925	1394	2361	2553
30	910	1085	1637	2710	2847
31	1088	1278	1918	2986	3108
32	1294	1495	2203	3200	3338
33	1513	1725	2458	3370	3536
34	1735	1950	2667	3502	3697
35	1950	2159	2831	3596	3812
36	2156	2354	2974	3668	3888
37	2357	2541	3117	3755	3956
38	2543	2714	3263	3867	4027
39	2685	2852	3400	3980	4107
40	2761	2929	3495	4060	4185
41	2777	2948	3527	4094	4217
42	2764	2935	3522	4098	4213
43	2741	2907	3505	4096	4178
44	2724	2885	3491	4096	4122

Disproportionately small for gestational age:

- wt ≤ 10th percentile of wt for gestational age; normal length &HC
- Skinny, wasted, and wrinkly
- Small abdominal area- lack of glycogen stores in liver and little body fat due to malnutrition in the 3rd trimester
- Smaller organ sizes but same # of cells in tissues
- Risk of developing hypo Ca, Mg, hypoglycemia and hypothermia;
- Higher risk of HTN, diabetes, heart disease
- If period of undernutrition is short they can catch up

Proportionately small for gestational age:

- Wt, length, and HC ≤ 10th percentile for gestational age
- Small but well proportioned
- Due to long-term malnutrition in utero/ pre-pregnancy underwt, low rate of maternal wt gain, inadequate dietary intake; chronic alcohol consumption
- Insults exist during CPs→ reduced # of cells in organs and tissues
- Catch up is poorer than dSGA even with nutritional rehabilitation
- They remain shorter, lighter and have small HC than appropriate for gestational age and large for gestational age babies

AP Images/Eleoi Correa/Agencia Estado

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Large for gestational age (Macrosomic)

- wt for gestational >90th percentile for gestational age;
- birth wt> 4.5kg

- **Related to** pre-pregnancy obesity, poorly controlled diabetes in pregnancy, excessive wt gain in pregnancy (>20 kg)
- Lower illness and death rates than SGA
- Delivery and postpartum complication

in mothers are higher-

postpartum hemorrhage, **shoulder dystocia**

Nutrition, miscarriage and preterm delivery

Miscarriage

- Thought to be primarily caused by :
  - genetic, uterine, or hormonal abnormalities, reproductive tract infections or tissue rejection due to immune system disorders
  - Underweight women→ higher risk than normal or OW women
- Vitamin D and E deficiency
- Elevated levels of cholesterol (>230mg/dL);
- TG> 140mg/dL
- high levels of markers of inflammation in 1st half of pregnancy
  - → increased risk of miscarriage

Miscarriage

Use of multivitamins→ decreased risk \\ not clear whether due to vitamins or healthy diets in women

Nausea and vomiting→ low risk of miscarriage because they indicate healthy changes in hormonal levels

Preterm delivery

- Infants are at higher risk of death, neurological problems, congenital malformations, chronic health problems including cerebral palsy
  - CP: a group of disorders characterized by impaired muscle activity and coordination present at birth or developed during early childhood

Etiology of preterm delivery is unknown

- A portion appears to be related to:
  - Genital tract infections
  - Insufficient uterine-placental blood flow
  - Placental abruption (bleeding into the uterus)
  - Pre-pregnancy underweight
  - Low weight gain in pregnancy
  - Short inter-pregnancy interval (<6 months)
  - High levels of psychological or social stress

Preterm delivery

- Infants born very preterm (<34 weeks):
  - Growth, digestion, respiration problems due to immaturity
  - Low stores of fat, glycogen, Ca, Fe, Zn→ interfere with growth and health after delivery

- Underweight and < recommended wt gain during pregnancy in mother→ high risk for preterm delivery
  - Risk in obese women is present but less than underweight

Preterm delivery

- Research findings: *elevated levels of cholesterol, TG , or FFA, markers of inflammation and oxidative stress in the 1st half of pregnancy in women delivering preterm*
  - Women with high levels of lipids coming into pregnancy are at increased risk of preterm delivery
  - Chronic inflammation and oxidative stress may be involved in the development of physiological conditions that favor preterm delivery

Prenatal care improvements can decrease risk of preterm delivery

- Close supervision
- Nutritional counseling
- Encouragement of adequate weight gain in underweight and normal-weight women

Pregnancy weight gain

- Wt gain during pregnancy is an indicator of plasma volume expansion and +ve calorie balance; it also provides an indication of dietary adequacy

- Newborn weight and health status increase as wt gain increases

- Rates of LBW are higher in women gaining too little wt during pregnancy

Pregnancy weight gain

- Because underweight women tend to **retain some of the weight gained in pregnancy for their own needs**, they need to gain more weight in pregnancy than do other women

- Overweight and obese women are able to use a portion of their E stores to support fetal growth, so they need to gain less

Pregnancy weight gain

- Current recommendations for wt gain in pregnancy are based mainly on gains associated with the birth of healthy-sized newborns (~3.5–4.5Kg)

Table 4.17 Pregnancy weight gain recommendations[75]

Prepregnancy Weight Status Body Mass Index	Recommended Weight Gain
Underweight, <18.5 kg/m^2	28–40 lb (12.7–18.2 kg)
Normal weight, 18.5–24.9 kg/m^2	25–35 lb (11.4–15.9 kg)
Overweight, 25–29.9 kg/m^2	15–25 lb (6.8–11.4 kg)
Obese, 30 kg/m^2 or higher	11–20 lb (5.0–9.1 kg)
Twin pregnancy	25–54 lb (11.4–24.5 kg)

Other influencers on birth weight

- Duration of gestation
- Smoking
- Maternal health status
- Gravida: # of pregnancies a woman has experienced regardless of the outcomes
- Parity: # of previous births a woman has had

→ *Due to the above possible influencers, gaining a certain amount of wt during pregnancy does not guarantee that newborns will be a healthy size but it improves the chances*

- Women who gain within the recommended ranges are approximately half as likely to deliver LBW or SGA babies as are women who gain less

- When pregnancy wt gain exceeds that recommended the following tend to be higher
  - Rates of LGA newborns
  - C-section deliveries
  - Postpartum wt retention

→IR may be related to excessive wt gain during pregnancy

- Low wt gain is not recommended- related to increased
  - Infant death
  - LBW
  - Possibility of developing type II diabetes, HTN and heart disease later in life

Rate of weight gain

- As important to newborn outcomes as total weight gain

- *1st trimester: ~1.5-1.8kg; might lose wt; should be followed by gradual wt gain*
- *2nd trimester: ~ 6kg*
- *3rd trimester: ~ 4.5kg*

- Rate of wt gain is generally highest around mid-pregnancy-which is prior to the time the fetus gains most of its wt

- For underwt and normal wt women, rates of gain:
  - < 0.25 kg/wk- 2nd half of pregnancy and
  - <0.37 kg/wk- 3rd trimester

  →double the risk of preterm delivery and SGA newborns

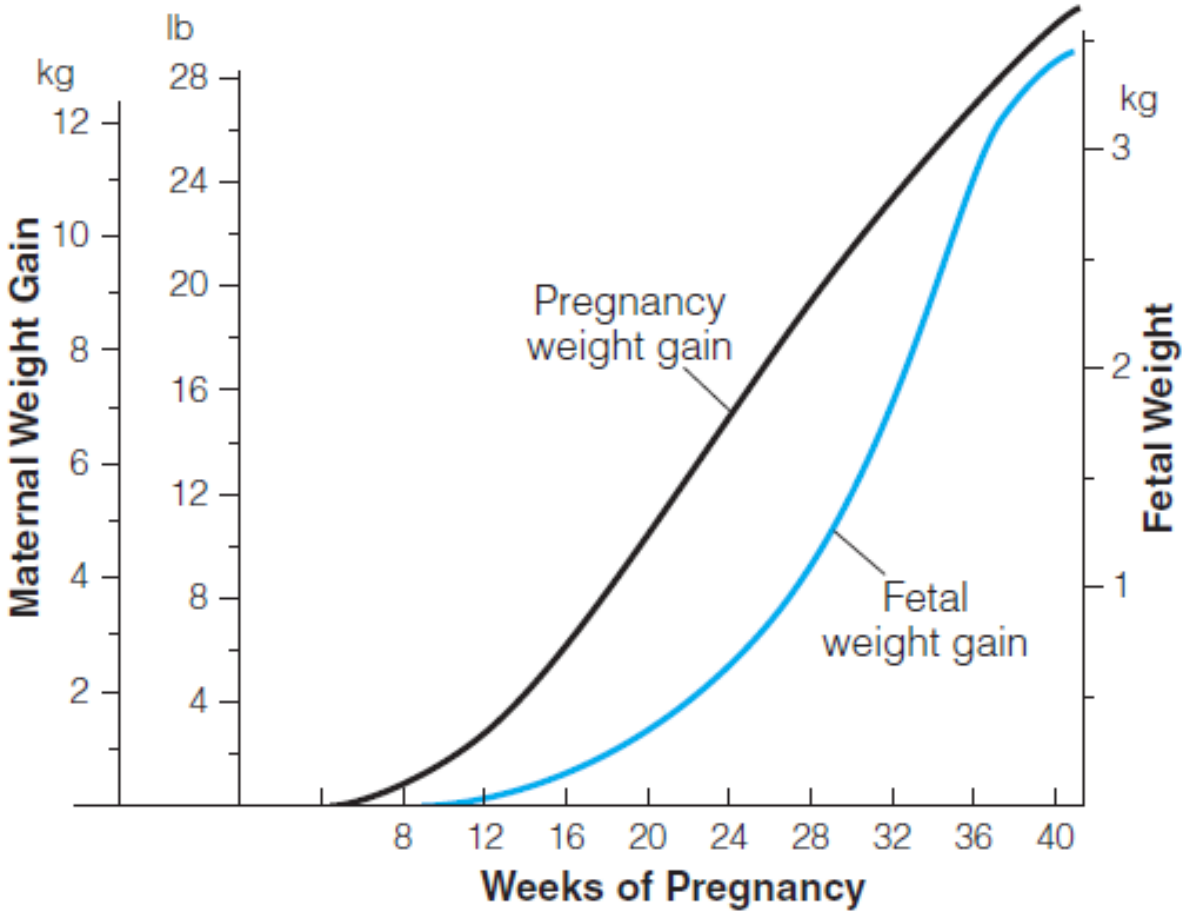
- For overwt and obese women, rates of gain of < 0.25kg/wk in 3rd trimester doubles the risk of preterm birth

- 3rd trimester wt gains exceeding ~0.7 kg/wk add little to birth wt in normal-wt and heavier women, and may ↑ postpartum wt retention

- The rate of wt gain often slows a bit a few wks prior to delivery

- Wt should not be lost until after delivery

Illustration 4.11 Rates of maternal and fetal weight gain during pregnancy.



Composition of weight gain in pregnancy

- The fetus comprises only about 1/3 of the total wt gained during pregnancy in women who enter pregnancy at normal wt or underwt

Table 4.18 Components of weight gain during pregnancy for healthy, normal-weight women delivering a 3500-g (about 8-lb) infant at term[10,12,13,36]

	Weight Gain, Grams			
Component	10 Weeks	20 Weeks	30 Weeks	40 Weeks
Fetus	5	300	1500	3550
Placenta	20	170	430	670
Uterus	140	320	600	1120
Amniotic fluid	30	350	750	896
Breasts	45	180	360	448
Blood supply	100	600	1300	1344
Extracellular fluid	0	265	803	3200
Maternal fat stores	315	2135	3640	3500
Total weight gain at term = 14.7 kg or 32 lb				

Body fat changes

- Fat stored to meet need of mother and fetus and to prepare for lactation
- Fat stores increase the most between 10- 20 weeks of pregnancy, or **before fetal E requirements are highest**
- Levels of stored fat tend to decrease before the end of pregnancy
- Only 0.5kg of the approximately 3.5 kg of fat stored during pregnancy is deposited in the fetus

Postpartum weight retention

- Increased wt after pregnancy appears to be related to a variety of factors, including:
  - Excessively high wt gain in pregnancy (>20 kg)
  - Weight gain after delivery
  - Low activity levels
  - High blood levels of insulin and leptin early in pregnancy- related to increased wt gain during pregnancy

Postpartum weight retention

- Women tend to lose about 7kg the day of delivery; subsequent weight loss is highly variable
- On avg, women who gain within the recommended ranges are ~1kg heavier 1 yr after delivery than they were before pregnancy
- Postpartum wt retention tends to be slightly less in women who breastfeed for at least 6 months after pregnancy

Nutrition and pregnancy outcome

skip

Nutrient needs during pregnancy

- Needs vary based on:
  - Pre-pregnancy stores
  - Body size
  - Composition
  - PA levels
- Diet quality during pregnancy affects health status of newborn

Need for energy

- Approximately:
  - 1/3 of the increased calorie need in pregnancy is related to increased work of the heart
  - 1/3→ for respiration and deposit of breast tissue, uterine muscles, and the placenta
  - 1/3→ for meeting the needs of the fetus

Need for energy

- The DRIs for E intake for pregnancy are (rough estimate- does not apply to every woman):
  - +340 kcal/day for the 2nd trimester
  - +452 kcal/day for the 3rd trimester

- Additional E requirements 210-570kcal may be needed- *depends on whether mother is active or not and level of activity*

- Adequacy of caloric intake is most easily assessed by pregnancy wt gain

Need for carbohydrates

- 50-60% of total caloric intake
  - Consume 175g carbs to meet fetus brain needs for glucose

- Carbs that do not contain added sugars and fat are less E-dense than those that do- help women manage pregnancy wt gain

Artificial sweeteners

- There is no evidence that consumption of aspartame (Nutrasweet) or acesulfame K (Sunette) is harmful in pregnancy

- Diet soft drinks and other artificially sweetened beverages and foods are often poor sources of nutrients-> may displace other more nutrient-dense foods in the diet

Need for protein

- Around 71g/day or **1.1g/kg BW** (for females>14yrs)
- *Shift*: less protein used for E and more of it is used for protein synthesis
- Protein reqs ↑ mainly due to :
  - protein tissue accumulation- mostly in fetus,
  - increase in maternal blood volume, used by uterus, accumulates in placenta
- Protein supplements do not benefit the course or outcome of pregnancy in well-nourished women

Vegetarian diets in pregnancy

- Protein sources should complement each other
  - Legumes (such as lentils, chickpeas, black-eyed peas, black beans, and lima beans) and grains (corn, rice, bulgur, and barley)
- Reqs may be 30% higher than for non-vegetarians- low digestibility of protein in plant based foods
- Diets may be low in- B12 and VD, Ca, Fe, Zn, and omega-3 fatty acids
  - Fortified juice, soymilks, breakfast cereal, and meat substitutes are available-> vitamins B12 and D and Ca

Table 4.21 Vegetarian food guide adapted for pregnant women[110–112]

Food Group	Servings per Day
A. Grains	
Whole-grain bread, 1 slice	6–11
Cooked grains, ½ c	
Fortified cold cereal, 1 oz	
Fortified cooked cereal, ½ c	
Corn, ½ c	
Pasta, ½ c	
Tortilla, 1 small	
Crackers, 4 small	
B. Legumes, Nuts, Seeds, Dairy	5–7
Dried beans, cooked, ½ c	
Peas, ½ c	
Soy products, ½ c or 2–3 oz	
Soynuts, ¼ c	
Nut and seed butter, 2 Tbsp	
Nuts and seeds, ¼ c	
Eggs, 1	
Cow's milk, 1 c	
Cheese, 1 oz	
Yogurt, ½ c	
Fortified soymilk, 1 c	
C. Vegetables	4
Cooked vegetables, ½ c	
Raw vegetables, 1 c	
Vegetable juice, ½ c	
D. Fruits	2
Medium-sized fruit, 1	
Cut-up raw or cooked, ½ c	
Fruit juice, ½ c	
Dried fruit, ¼ c	
E. Fats, Oils, and Sweets	2+ depending on caloric need
Mayonaise, oil, margarine, 1 Tbsp	
Honey, syrup, jams, jellies, sugar, 1 Tbsp	

Need for fat

- Fat in diet is used as :
  - an E source for fetal growth and development
  - source of fat soluble vitamins

- Recommendations for EFA
  - 13g/d of linoleic acid (omega 6): corn, sunflower and soy oil
  - 1.4g/d of alpha linolenic acid (omega 3): walnuts, canola oil, green leafy veggies, fish

- Both are structural components of brain, retina and other fetal tissues

Alpha linolenic acid

- Transported to placenta- [ ] becomes higher in fetal blood than maternal in 3rd trimester- maternal stores may become depleted during pregnancy

- **Derivatives of EPA**: reduce inflammation, dilate blood vessels, and reduce clotting

- **DHA**: structural component of phospholipids in cell membrane in CNS and retinal photoreceptors

- Adequate intake of both- higher level of intelligence, better vision and more mature CNS functioning

- In pregnancy: adequate intake >250mg/d; safe level 500mg/d; Should not exceed 3g/d
  - Prenatal supplements→ provide DHA, EPA or both

- Fish are good sources of these- recommendation of no more than 340g/wk (for pregnant and lactating women)- mercury and other contaminants
  - Choice of fish should be low in these (avoid- tuna, swordfish, and tilefish)
  - Fish oil supplements-> beneficial

Need for water

- Increases and so does thirst
- Avg consumption- 9cups/day
- PA-> increases need
- Urine should be light colored and normal in volume

Alcohol and pregnancy outcome

- Alcohol ingested by a pregnant woman readily passes through the placenta to the fetus- *effect normal growth and development (esp mental)*

- There is no clearly defined safe level of alcohol intake during pregnancy
  - It is strongly advised that women who are pregnant do not drink
  - It is recommended that women who may become pregnant not drink alcohol
    - In utero alcohol exposure during **the first critical months** of pregnancy may impair organ development

Need for vitamins and minerals

- Requirement increases- demand increases
- Maternal physiological changes-
  - changes in absorption and utilization in response to changing needs

Folic acid

- Inadequate intake-
  - anemia in pregnancy and reduced fetal growth
  - Congenital abnormalities
  - Clinical complications during pregnancy
- Polyglutamate- dietary folate- 50% bioavailability
- Monoglutamate- folate (fortified foods and supplements)
  - 100% bioavailable in supplements on empty stomach
  - 85% with food or from fortified food

Functions of folate

- Cofactor in many metabolic rxns involved in DNA synthesis, gene expression & regulation
  - *Deficiency- abnormal cell division and tissue formation*

Homocysteine ---Methionine synthase---→ methionine	Folate B12 Betaine B6

- Deficiency of folate- **homocysteine builds up**: increase risk of placenta rupture, stillbirth and pre-term delivery, preeclampsia, congenital defects and reduced birth wt

- Supplement of 500-600µg/d in 2nd and 3rd trimesters decrease homocysteine levels and improves pregnancy outcome

Neural tube defects

- NTDs- malformations of the spinal cord and brain

- *There are 3 major types of NTDs:*
  - **Spina bifida**: when bones of the spine do not form properly around part of the baby's spinal cord; paralysis below the gap in the spinal cord occurs in severe cases
  - **Anencephaly:** absence of a major portion of the brain, skull and scalp – occurs when head end of the neural tube fails to close
  -
  - **Encephalocele:** characterized by sac-like protrusion of the brain and the membranes that cover it through openings in the skull


Spina Bifida (Open Defect)
Vertebra
Dura Mater
Spinal Cord
Spinal Fluid

- Inadequate availability of folate between 21- 27 days after conception can interrupt normal cell differentiation and cause NTDs

- NTDs are among the most preventable types of congenital abnormalities that exist
  - ~70% of cases of NTDs can be prevented by consumption of adequate folate before and during very early pregnancy

Table 4.23 Food sources of folate

	Amount	Folic Acid (mcg)
A. Foods		
Orange	1	40
Orange juice	6 oz	82
Pineapple juice	6 oz	44
Papaya juice	6 oz	40
Dried beans	½ c	50
B. Fortified Foods		
Highly fortified breakfast cereal[a]	1 c or 1 oz	400
Breakfast cereal	1 c or 1 oz	100
Bread, roll	1 slice or 1 oz	40
Pasta	½ c	30
Rice	½ c	30

Dietary folate equivalents

- Due to variation in folate bioavailability, the DRI for folate takes into consideration a measure *called dietary folate equivalents (DFE)*

- *1 DFE equals any of the following:*
  - 1 µg food folate
  - 0.6 µg folate consumed in fortified foods or a supplement taken with food
  - 0.5µg of folate taken as a supplement on an empty stomach

- **Recommendation:**
  - 600µg DFE of folate/day during pregnancy
    - 400µg folic acid from fortified foods or supplements
    - 200µg DFE from vegetables and fruits/ fortified foods

Folate intake : upper limit

- UL for intake of folic acid from fortified foods and supplements is set at 1000µg/day
  - 1000µg/d level of folate may mask the neurological signs of vitamin B12 deficiency

- There is no UL for folate consumed in its naturally occurring form in foods

Choline

- A B-complex vitamin- can be produced in our body but not in enough amounts to meet needs when dietary intake is very limited
- Eggs, meat-> major sources

- Need increases during pregnancy:
  - Component of phospholipids in cell membranes
  - A precursor of intracellular messengers
  - Converted to betaine- neural tube and brain development

- Large amounts of choline are transported to the fetus during pregnancy

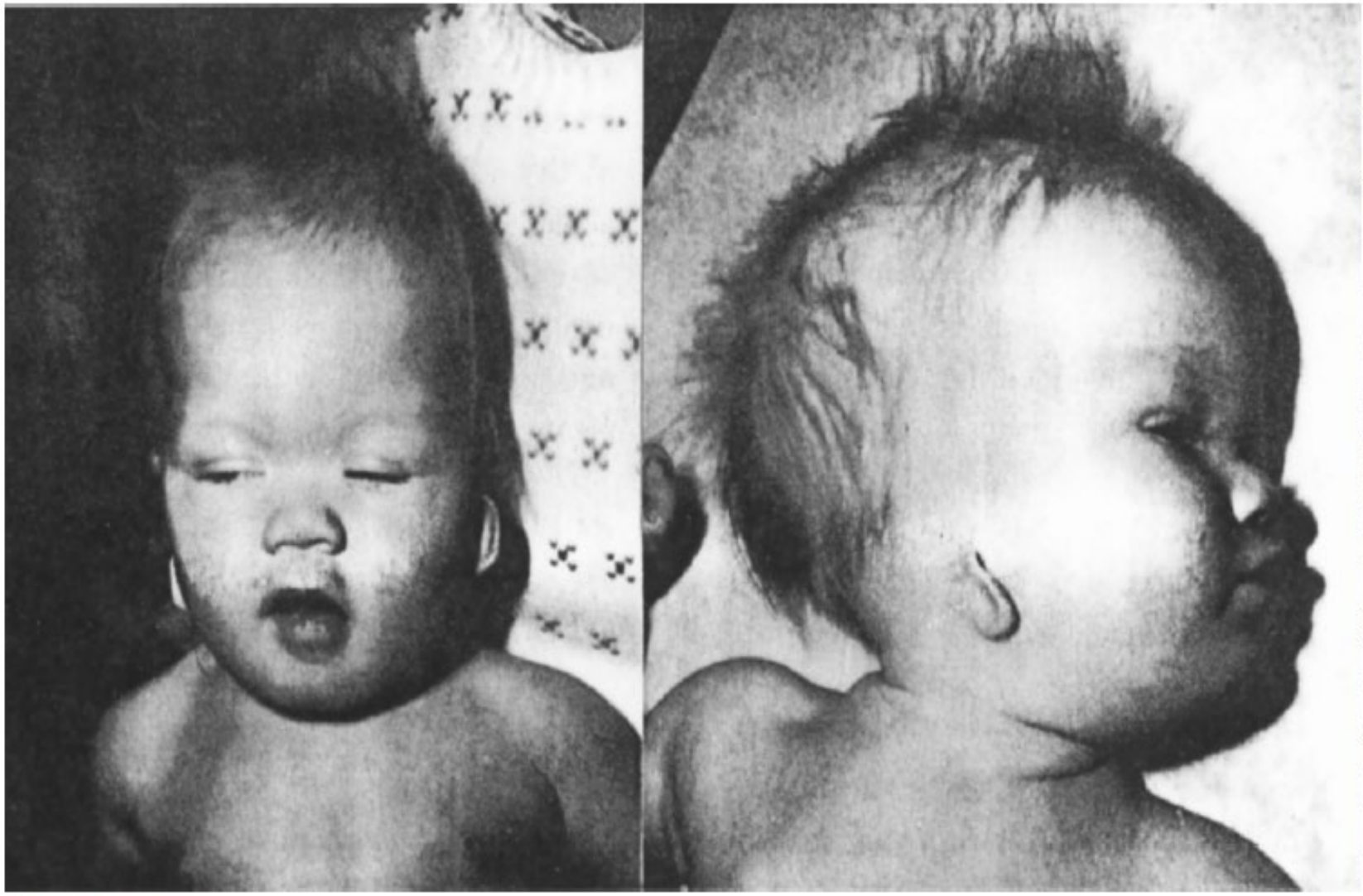
- The RDA for choline in pregnancy is 450mg/day

Vitamin A

- Role in rxns involved in cell differentiation
- Deficiency is a problem in developing countries
  - Def early in pregnancy- malformations in fetal lungs, heart, and urinary tract

- Excessive intake of Vitamin A (in form of retinoic acid> 10,000IU/d or in medications- Accutane)
  - **Retinoic acid syndrome-** small or no ears, missing ear canals, heart defects, heart malformations

- Due to the potential toxicity of retinol, it is recommended that pregnant women take ≤5,000 IU as retinol from supplements
  - **Most supplements now contain B-carotene instead of retinol**



Used by permission of Harcourt Health Sciences, Inc. Lott IT et al., Fetal hydrocephalus and ear abnormalities associated with maternal use of isotretinoin. J Pediatr 1984;105(4):597–600

ILLUSTRATION 4.20 ◗ An 8-month-old infant exposed to high levels of retinoic acid *in utero*. Note the high forehead, flat nasal bridge, and malformed ear.

Vitamin D

- Recommendation: intake of 10µg (400IU) vitaminD/day
  - Addition of Ca to bone, teeth, enamel- lack compromises bone development
  - Supports normal function of immune system; inhibits inflammation
- Poor vitamin D status->
  - infant- smaller than avg;
  - hypocalcemia at birth;
  - poorly calcified bone and abnormal enamel;
  - higher susceptibility to dental caries in childhood

Table 4.24 Risk factors for vitamin D inadequacy during pregnancy

Vegan diet
Consumption of small amounts of vitamin D–fortified milk or of raw milk
Limited exposure of the skin to the direct rays of the sun
Consistent use of sun block
Dark skin
Obesity ?

Calcium

- Skeletal mineralization and maintenance of maternal bone health
- Around 30g of Ca is transferred from mother to fetus during pregnancy- fetal needs increase in 3rd trimester when bone mineralization rate is highest
- Ca metabolism changes during pregnancy- absorption ↑and excretion ↓
- Additional req for Ca in the last quarter of pregnancy- ~300 mg/d; may be obtained by increased absorption and by release of Ca from bone (bone resorption)
  - Replaced after pregnancy with intake of Ca and vitamin D

Inadequate Ca intake

- Inadequate Ca intake has been related to:
  - ↓ bone remineralization
  - ↓breast milk [Ca]
  - ↑ BP during pregnancy
  - ↑ BP of infant

Fluoride

- Limited amount of fluoride is transferred from mother to child
  - Major gains in fluoride composition of enamel occur in years after birth
- Same level of dental carries in children of fluoride supplemented pregnant women vs. no supplement

Iodine

- Needed for thyroid hormone function
- E production
- Fetal brain development

- *Deficiency of iodine early in pregnancy is associated with:*
  - An increased occurrence of spontaneous abortions, stillbirths and congenital abnormalities, and perinatal and infant mortality
  - Hypothyroidism and cretinism (congenital hypothyroidism) in the offspring

- Recommended: 200µg/day
- One tsp of iodized salt contains 400 µg iodine

Sodium

- Maintain water balance
- Need increase- due to volume expansion

- *Do not restrict to prevent edema of HTN related to pregnancy*

Iron

- Pregnant women require an additional 1000mg of Fe during pregnancy:
  - 450 mg is used to increase RBC mass
  - 300 mg is used by the fetus and placenta
  - 250 mg is lost at delivery

- Focus on iron intake and maternal stores

Iron Deficiency

- **Iron Deficiency (ID):**
  - A condition marked by **depleted iron stores**
  - Characterized by: weakness, fatigue, short attention span, poor appetite, increased susceptibility to infection, and irritability

- **Iron-Deficiency Anemia (IDA):**
  - A condition often marked by **low hemoglobin levels**
  - Characterized by the signs of iron deficiency plus paleness, exhaustion, and a rapid heart rate

→Iron deficiency is more common than IDA

Stages of iron deficiency

Stage	Descriptive term
1st	Depleted iron stores
2nd	Iron deficiency
3rd	Iron-deficiency anemia

IDA in pregnancy

- IDA at the beginning of pregnancy :
  - ↑ the risk of preterm delivery and LBW infants by 2-3 times

- ID during pregnancy is related to:
  - Lower scores on intelligence, language, gross motor, and attention tests in affected children at the age of 5 yrs

- *The mechanisms underlying these effects are unknown, but they may be related to:*
  - Decreased O_2 delivery to the placenta and fetus
  - Increased rates of infection
  - Adverse effects of Fe deficiency on brain development

ID in pregnancy

- ID often occurs toward the end of pregnancy even among women who enter pregnancy with some iron stores

- ID and IDA are related to reduced Fe stores in newborns

- A fetus from a well-nourished mother is able to store a 6 to 8 month supply of Fe during the last 2 months *in utero*
  - Preterm infants are at risk for Fe deficiency in infancy

Assessment of iron status

- RBC mass ↑ by 30% and plasma volume ↑ by ~50% during pregnancy- because of this, it appears that hemoglobin, ferritin.. levels are low but they are not **(dilution effect)**

- Due to the dilution effects- changes in hemoglobin levels tend to be more indicative of plasma volume expansion than of iron status
  - Low hemoglobin or ferritin-> hypervolemia: larger than in hypovolemia
  - High hemoglobin or ferritin-> hypovolemia: reduced fetal growth

Table 4.26 CDC's gestational age-specific cutoffs for anemia in pregnancy[178]

Gestational Weeks	Hemoglobin (g/dL) Indicating Anemia[a]
12	<11.0
16	<10.6
20	<10.5
24	<10.5
28	<10.7
32	<11.0
36	<11.4
40	<11.9

- By trimester, hemoglobin levels indicative of iron deficiency anemia are
  - <11.0 g/dL in the first and third trimesters
  - <10.5 g/dL in the second trimester

Serum ferritin cut-points indicative of iron-deficiency anemia in pregnancy have also been developed:[178]

	Serum Ferritin, ng/mL
Normal	>35
Depleted Stores	<20
Iron Deficiency	≤15

Iron absorption

- Absorption (FROM FOODS AND SUPPLEMENT) of iron depends on body stores:
  - Adequate Fe stores→ absorb about 10% of total iron ingested
  - Low stores absorb ~20% of the Fe consumed
  - IDA - 40% absorption

- Iron absorption is enhanced in women with low Fe stores during pregnancy→ absorption ↑ as pregnancy progresses

- Maternal Fe depletion in pregnancy can lead to:
  - Decreases in fetal Fe stores
  - Increased risk that infants will develop ID
  - Development of maternal postpartum depression

Iron supplementation

- Amount of iron absorbed from supplement depends on woman's needs and the amount of the mineral in the supplement
  - The higher the Fe dose in supp- the lower the absorption
- Supplementation use is sometimes associated with: nausea, cramps, gas, and constipation
- Overload of Fe>60mg per day- oxidative stress & inflammation

Recommendation of Fe supplementation and intake during pregnancy

- RDA during pregnancy: 27mg/day (assuming 20% of iron consumed is absorbed)
- 30mg iron supplement when hemoglobin levels are <11 g/dL or if serum ferritin levels are <30ng/mL
- *The total need for absorbed iron during pregnancy is 5.5mg/d*
  - Women usually take 18mg/day-1.8 mg absorbed
  - Increased need for Fe can be met by intakes that lead to an additional 3.7 mg absorbed Fe/d

Bioactive components of food

- *Antioxidants*
  - Pregnancy: pro- oxidative state
  - Protect fetus from DNA damage
  - Reduce maternal tissue associated with inflammation and oxidation
  - Vitamin E and C containing foods

- *Caffeine*
  - Avoidance of caffeine and coffee during pregnancy does not appear to improve pregnancy outcomes or infant birth weight
  - Intake of <200mg/d caffeine= ~1.5 cups of coffee

Pica

- Eating disorder- compulsion to eat substances that are not food
- Nonfood items most commonly craved and consumed by pregnant women with pica include:
  - Ice or freezer frost (pagophagia)
  - Laundry starch or cornstarch (amylophagia)
  - Baking soda and powder, and clay or dirt (geophagia)
- Anemia, or iron deficiency, may be the underlying cause of pica in pregnant women
- It can complicate control of gestational diabetes if starch is eaten
- Can cause lead poisoning, intestinal obstruction, and parasitic infestation of the GIT

Assessment of nutritional status during pregnancy

- *Includes an evaluation of:*
  - Dietary intake and weight status
  - Nutritional biomarkers
  - Dietary supplement use
  - Food preferences and resources
  - Previous pregnancies
  - Health history

Dietary assessment

- *Includes an assessment of:*
  - Usual dietary intake
  - Dietary supplement use
  - Weight-gain progress

TABLE 4.30 Recommended amounts of food from the food groups that correspond to various levels of calorie need during pregnancy, and amounts of food in each food group that count as a cup, ounce (oz), or teaspoon (tsp)[a]

CALORIE NEED	GRAINS	VEGETABLES	FRUITS	DAIRY	PROTEIN FOODS	OILS
2000	6 oz	2½ cup	2 cup	3 cup	5½ oz	6 tsp
2200	7 oz	3 cup	2 cup	3 cup	6 oz	6 tsp
2400	8 oz	3 cup	2 cup	3 cup	6½ oz	7 tsp
2600	9 oz	3½ cup	2 cup	3 cup	6½ oz	8 tsp

FOOD GROUP	EQUIVALENTS
Grains, 1 oz (make half of your servings whole grain)	1 slice bread ½ cup cooked pasta, cereal, rice 1 tortilla (6″) 1 pancake (5″) 1 oz ready-to-eat cereal
Vegetables, 1 cup (vary your veggies, choose colourful ones)	1 cup raw or cooked vegetables 1 cup 100% vegetable juice 2 cup leafy salad greens
Fruit, 1 cup	1 cup raw or cooked fruit 1 cup 100% fruit juice ½ cup dried fruit 1 large banana (8″–9″) 1 large grapefruit, peach, pear, orange, mango 3 medium plums

[a]SOURCE: ChooseMyPlate.gov, accessed May 20, 2015.

Dietary supplements during pregnancy

- Dietary supplements used by pregnant women primarily include vitamins, minerals, and herbs

- Clinicians in general support the use of certain dietary supplements (multivitamin and minerals)

Multivitamin and mineral prenatal supplements

- **Well balanced diet during pregnancy should provide all- except for iron**
- Food is best because it also includes fiber, antioxidants..
- Multivitamin and mineral prenatal supplements may benefit women who:
  - Do not ordinarily consume an adequate diet
  - Have multifetal pregnancy
  - Smoke, drink, or use drugs
  - Are vegans
  - Have IDA
  - Have a diagnosed nutrient deficiency

Multivitamin and mineral prenatal supplements

- Must pay attention to amount provided by supplement
- Nutrition counselling is important
- Supplements should contain the essential nutrients most likely to be lacking in pregnant women's diets:
    - Vitamin B6
    - folate
    - VD
    - Fe
    - I_2
    - and EPA +DHA

Nutrition biomarker assessment

Table 4.33 Reference values for nutrition biomarkers during normal pregnancy in healthy women[a, 158,178,179,202]

Nutrient	Weeks Gestation	Reference Values
Calcium, mmol/L	7–17	2.18–2.53
	24–28	2.04–2.40
	34–38	2.04–2.41
Chloride, mmol/L	7–17	100–107
	24–28	99–108
	34–38	97–109
Ferritin, μg/L	7–17	7.1–106.4
	24–28	3.8–49.8
	34–38	4.8–43.5
Hemoglobin, g/dL	0–14	>11.0
	14–26	>10.5
	26–40	>110.0
Hematocrit, %	0–14	>33.0
	14–26	>32.0
	26–40	>33.0
Iodin, urinary, μg/L	0–40	150–249
Iron, μmol/L	7–17	8.7–37.0
	24–28	8.0–50.0
	34–38	7.6–34.5
Magnesium, mmol/L	7–17	0.70–0.96
	24–28	0.63–0.91
	34–38	0.57–0.87
Potassium, mmol/L	7–17	3.24–4.86
	24–28	3.27–4.62
	34–38	3.32–5.09
Sodium, mmol/L	7–17	133.2–140.5
	24–28	129.2–139.3
	34–38	127.0–140.2
Transferrin, g/L	7–17	1.92–3.85
	24–28	2.72–4.36
	34–38	2.88–5.12
Triglycerides, mmol/L	7–17	0.55–3.08
	24–28	1.09–3.63
	34–38	1.62–5.12
Vitamin D, nmol/L (25-hydroxyvitamin D)	0–40	≥80 (optimum) <35 (deficient)

Exercise and pregnancy outcome

- There is no evidence that moderate or vigorous exercise undertaken by healthy women consuming high-quality diets and gaining appropriate amounts of weight is harmful to mother or fetus

- Most research-> exercise benefits both mother and fetus

Exercise and pregnancy outcome

- Women who exercise regularly during pregnancy reduce their risk of:
  - Developing gestational diabetes
  - Pregnancy-induced HTN
  - Low back pain
  - Excessive weight gain
  - Blood clots

- Focus on maintaining hydration status

→ *Exercise during pregnancy can reduce fetal growth in women who are poorly nourished and gain little weight in pregnancy*

- It is safe to begin an exercise regimen while pregnant-> beneficial to mother and fetus
  - Improves fetal growth

- Recommendation: 3-5x/week 20–30 minutes

Food safety issues during pregnancy

- Increased progesterone --> decrease pregnant women's ability to resist infectious diseases--> more susceptible to the effects of foodborne infections

Food safety issues during pregnancy

- ***L. Monocytogenes*- Listeria:** a foodborne bacterial infection that can lead to preterm delivery and stillbirth
  - Commonly associated with the ingestion of soft cheeses, unpasteurized milk, ready-to-eat deli meats, and hot dogs

  →Placenta does not protect fetus from this bacteria

- ***T. Gondii*-Toxoplasmosis:** a parasitic infection that can impair fetal brain development; blindness, seizures, and death
  - Source of the infection→ hands contaminated with soil or the contents of a cat litter; surface of fruits and vegetables; raw or partially cooked pork, lamb, or venison

Mercury contamination

- Mercury passes from mother to fetus→ Hg is a fetal neurotoxin that can produce mild to severe effects on fetal brain development
- Fetuses exposed to high amounts of Hg can develop mental retardation, hearing loss, numbness, and seizures
- Pregnant women are generally only slightly affected by the mercury overload but Hg can accumulate in the mother's tissues and may increase fetal exposure during pregnancy and lactation
- High levels of mercury-> fish such as sharks, swordfish, tilefish, albacore tuna, walleye, pickerel, and bass

Common health problems during pregnancy

Nausea and vomiting

- Nausea: symptoms generally begin around wk 6 of gestation and usually disappear by wk 12
- Vomiting- less common than nausea

→Causes of these symptoms are unknown- may be related to ↑ levels of HCG, progesterone, estrogen, or other hormones early in pregnancy

→associated with a reduction in risk of miscarriage

Hyperemesis Gravidarum

- **Hyperemesis Gravidarum (1-2% of pregnant women):** characterized by severe nausea and vomiting that last throughout much of pregnancy

- Frequent vomiting can lead to wt loss, electrolyte imbalances, and dehydration

- Women with hyperemesis who gain wt normally during pregnancy (~14kg) are not at increased risk of delivering small infants, but women who gain less (~5kg) are

Management of nausea and vomiting

- Avoid odors and foods that trigger nausea (spicy/ hot foods)
- Select foods that are well tolerated- varies between women
- Continue to gain weight
- **Separate liquid and solid food intake**

→Women with hyperemesis may require **rehydration** therapy to restore fluids and electrolyte balance

Management of nausea and vomiting

- 3 types of **supplements** have been found to decrease the symptoms of nausea and vomiting in pregnancy:
  1. Vitamin B6 (pyridoxine) supplements given in a 10–25 mg dose every 8hrs reduce the severity of nausea in many women

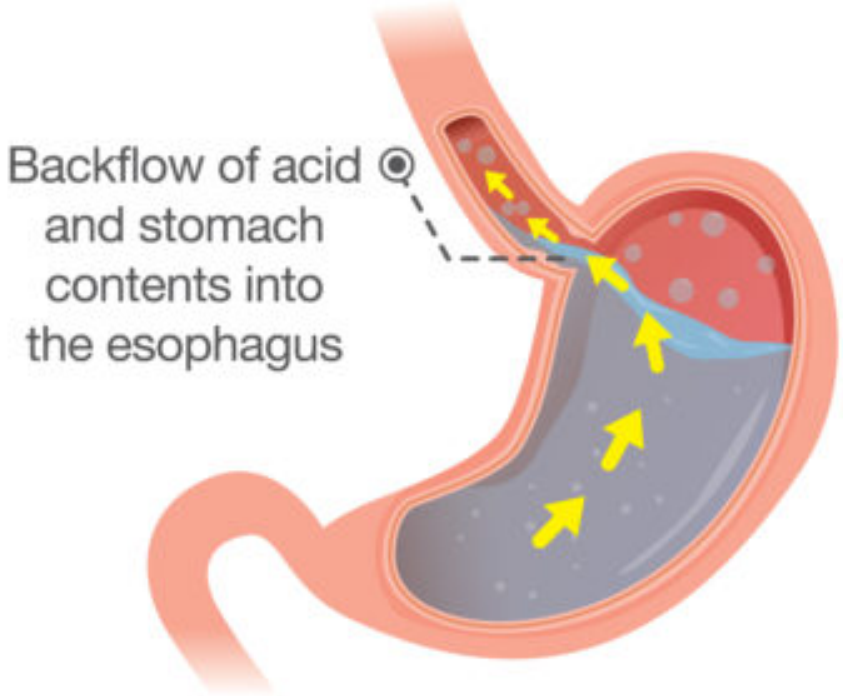
  2. Multivitamin supplements taken prior to and early in pregnancy may decrease the occurrence of nausea and vomiting

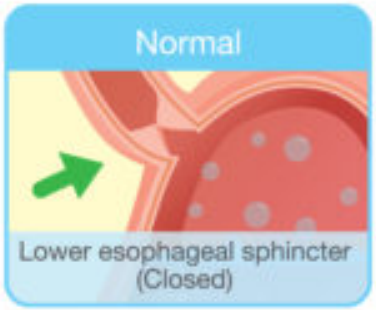
  3. Ginger in doses of 1g/d for 4 days may decrease nausea and vomiting

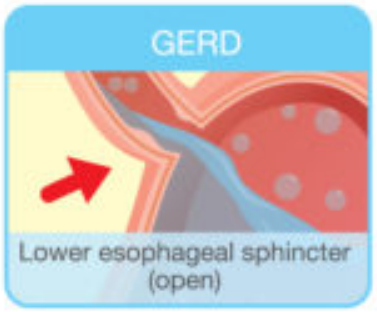
Heartburn

- Pregnancy is accompanied by relaxation of GIT muscles- mainly due to **progesterone levels**

- The loose upper valve may allow stomach contents to be pushed back into the esophagus


Backflow of acid and stomach contents into the esophagus


Normal
Lower esophageal sphincter (Closed)


GERD
Lower esophageal sphincter (open)

Management of heartburn

- Ingest small meals frequently
- Do not go to bed with a full stomach
- Avoid foods that seem to make heartburn worse

- Elevating the upper body during sleep, and not bending down so your head is below your waist-> reduce gastric reflux

- Antacid tablets, which act locally in the stomach, are recommended

Constipation

- Relaxed GI muscle tone-> primarily responsible for the increased incidence of constipation and hemorrhoids in pregnancy
- Prevention: consume 30g of dietary fiber/d
- Laxative pills are not recommended for use by pregnant women, but soluble fiber in products such as Metamucil, are considered safe and effective for the prevention and treatment of constipation
  - Women should drink a cup or more of water along with the fiber supplement