

Physiology of Pregnancy

- Maternal Physiology
- Fetal Physiology
- First Trimester
- Second Trimester
- Third Trimester
- Birth – Labor and Parturition
- Lactation

Maternal Physiology

- Basal metabolic rate increases 15%
- Cardiac output transiently increases 30-40%
- Blood volume increases 30%
- O₂ utilization increases 20%
- Ventilation increases 50%
- Renal tubule reabsorption increased 50%
- Glomerulus filtration rate increased 50%

Weight Gain and Pregnancy

- Average – 24 lbs, can be as much as 75lbs
- Fetus – 7 lbs
- Extraembryonic fluid/tissues – 4 lbs
- Uterus – 2 lbs
- Breasts – 2 lbs
- Body fluid – 6 lbs
- Fat accumulation – 3 lbs

Fetal Physiology - Circulation

Fetal heart rate (FHR) – beating at 5 weeks –
100 beats/min

8 weeks – 160 beats/min

15 weeks – 150 beats/min

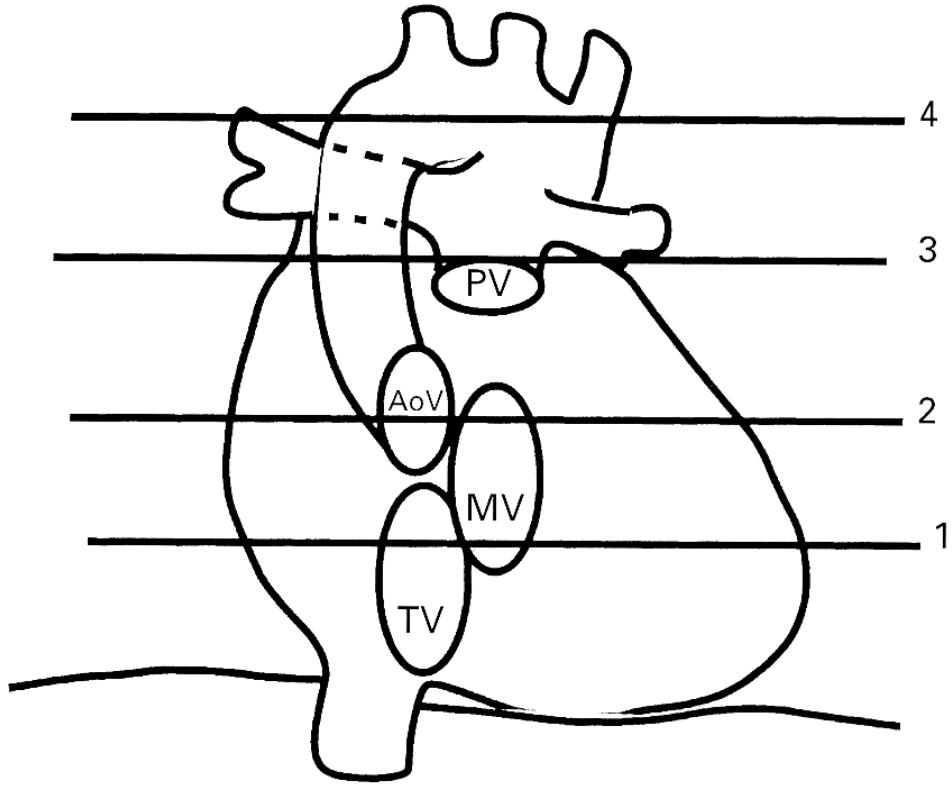
Birth – 130 beats/min

Bradycardia – slow pulse rate – very
dangerous to fetus

Blood flow – 40% to head/upperbody

30% to placenta

30% to lower body

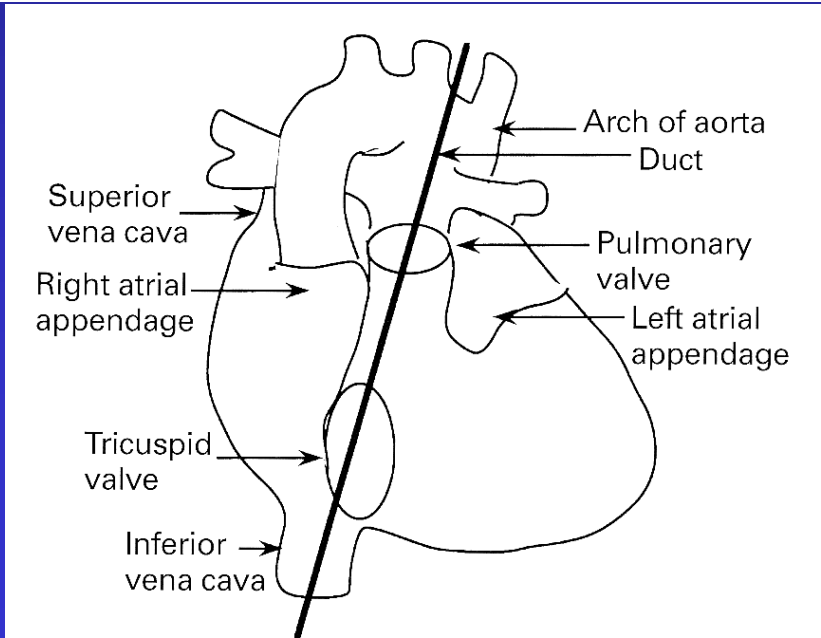
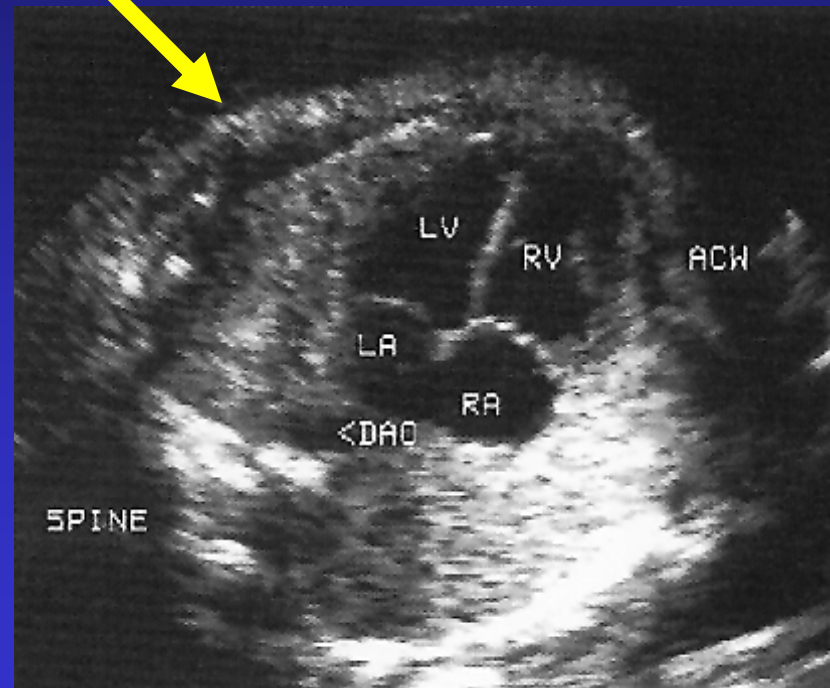


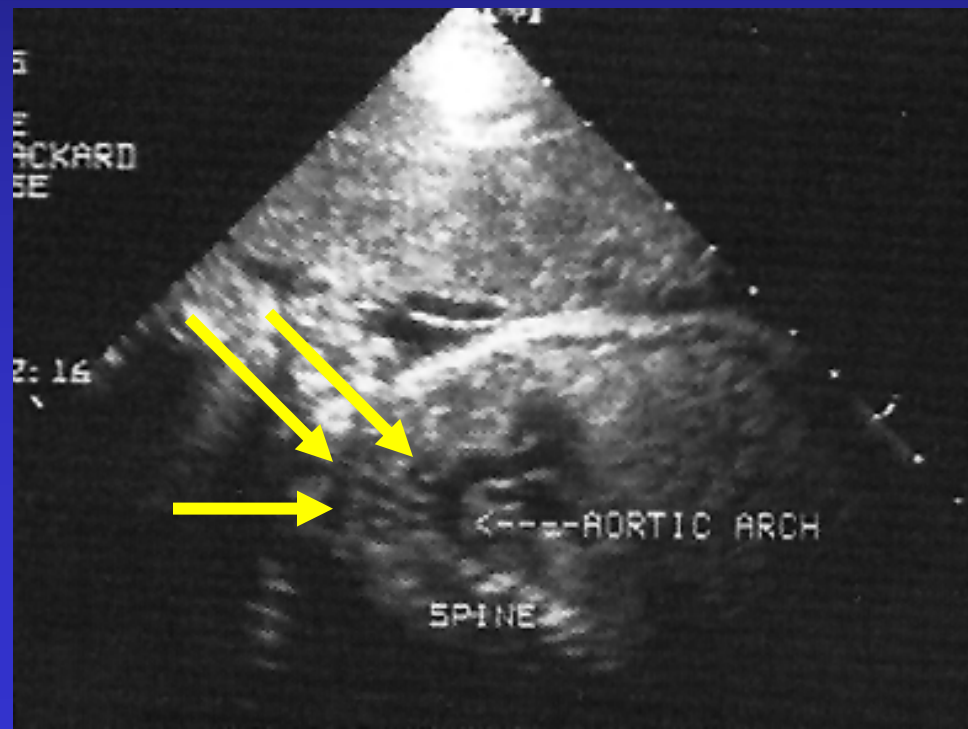
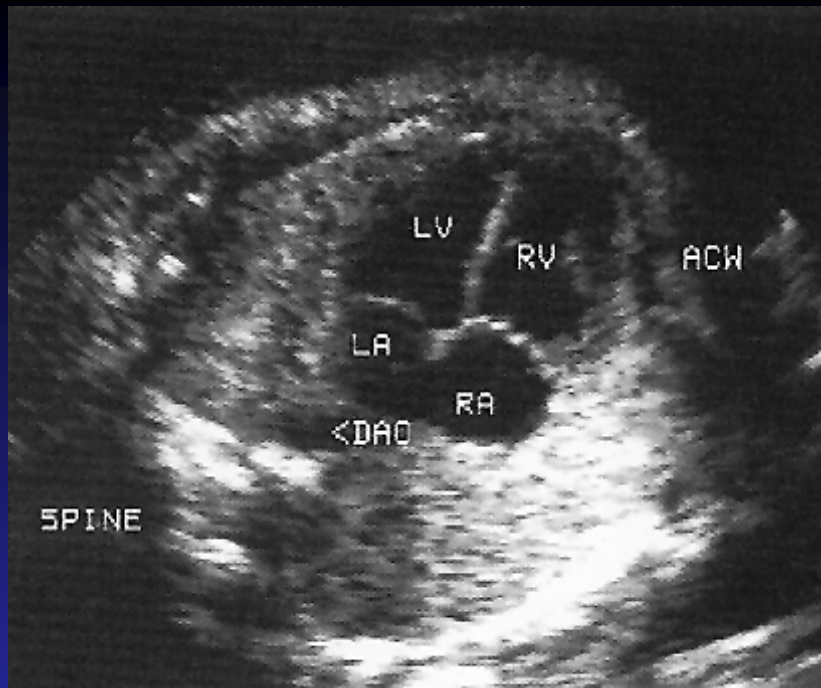
Crest of Aortic Arch view

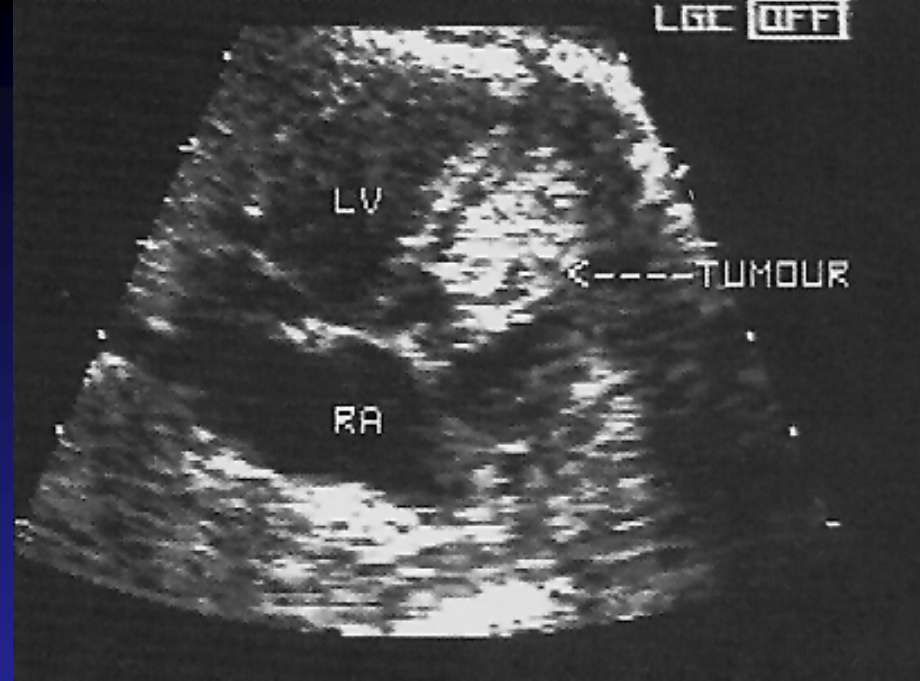
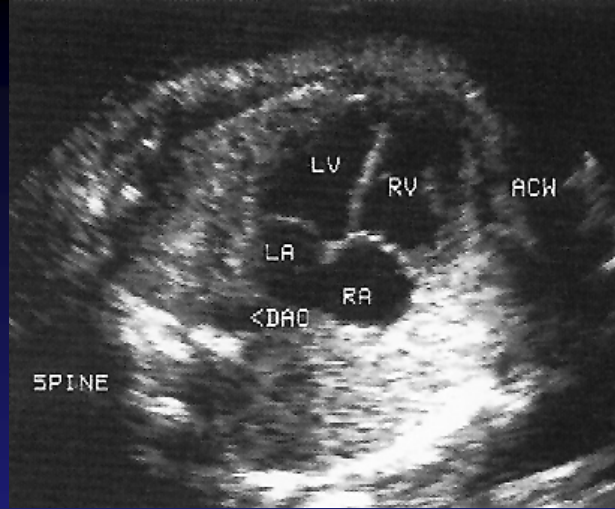
Pulmonary Artery & Duct view

Aortic Root view

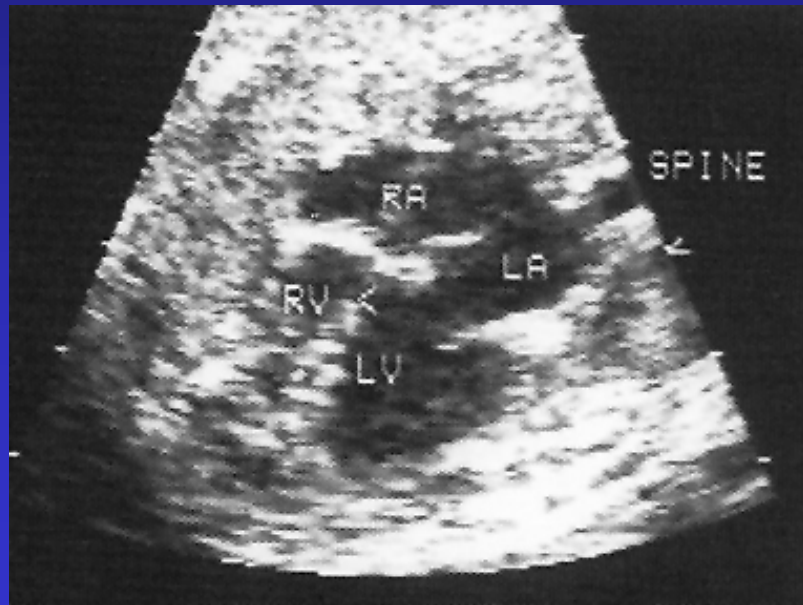
4-Chamber view







Right Ventricular tumor



Tricuspid Atresia

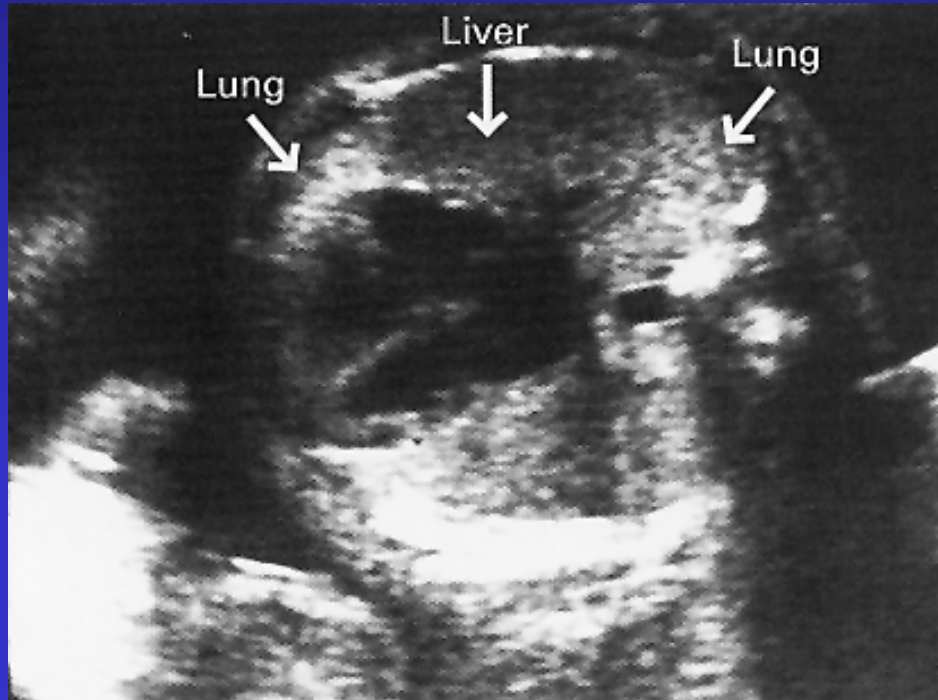


Atrioventricular septal defect

Fetal Physiology - Lungs

Lung development – limiting for survival of premature births
– record 23 weeks

Pulmonary hypoplasia – reduced lung volume



Fetal Physiology - Respiration

Gross breathing movements at 11 weeks

Rapid and irregular – associated with REM
(rapid eye movements)

Isolated slow movements – gasps

Apnea – periods of no breathing

Maternal eating → increases breathing rate

Maternal smoking → decreases breathing rate

Function of fetal breathing:

Stimulates growth of the lungs

Conditioning of muscles

Fetal Physiology - Respiration

Pulmonary surfactants – produced 24 weeks – phospholipids, proteins functions to reduce surface tension – prevents lung collapse; induced by glucocorticoids and thyroid hormone

Respiratory Distress Syndrome (RDS)

Common newborn health concern

Associated with low birth weight / Prematurity

Symptoms: rapid and labored breathing at birth

Cause: insufficient pulmonary surfactant

Fetal Behavior

Passive behavior

Early pregnancy – 7-15 weeks

All movement types present at 15 weeks

Diurnal pattern begins 20-23 weeks

peaks evening – maternal corticosteroid levels

Stimulated behavior

Vibro-acoustic stimulus (VAS) – broad band frequencies

Assay – FHR, fetal movements, breathing rate

Females – 28 weeks; Males – 30 weeks

Habituation (learning)

Cessation of response after repeated novel stimulation

Requires 10-50 stimuli

Discrimination of vowel sounds or parental voices

Table 23.1

The appearance of fetal movements in early pregnancy (adapted from Reference⁶)

| Movement | Gestation of first appearance |
|------------------------|--------------------------------------|
| Any movement | 7 |
| Startle | 8 |
| Generalized movements | 8 |
| Hiccups | 8 |
| Isolated arm movements | 9 |
| Head retroflexion | 9 |
| Hand-face contact | 10 |
| Breathing | 10 |
| Jaw opening | 10 |
| Stretching | 10 |
| Head anteflexion | 10 |
| Yawn | 11 |
| Suck and swallow | 12 |

Table 23.4**Biological/physiological factors which influence fetal behaviour (from Reference⁴⁰)**

| Behavioural characteristic | Biological variable and effect |
|-----------------------------------|---|
| Heart rate | <p>Advancing gestation produces: fall in baseline, increased correlation of accelerations and movements, faster rate of rise of accelerations, greater height of accelerations, differentiation of baseline variability with state development</p> <p>Ethnic differences exist</p> |
| Movement | <p>Diurnal variation in fetal activity from about 20–22 weeks</p> <p>Advancing gestation produces organization into rest/activity cycles and eventually behavioural states</p> |
| Respiratory | <p>Advancing gestation produces: proportion of time spent exhibiting:</p> <ul style="list-style-type: none">a) breathing movements are increased andb) hiccups is reduced <p>More breathing movements seen in active states</p> <p>Maternal glucose consumption increases fetal breathing activity</p> <p>Maternal caffeine consumption increases fetal breathing activity</p> |

Table 23.5
The effects of drugs on fetal behaviour

| Drug | Effects |
|--|--|
| Tranquillizers, narcotics, methadone, atropine, barbiturates, pancuronium, anticonvulsants | General depression <ul style="list-style-type: none">— reduced FHR variability— reduced movements— reduced breathing |
| Amphetamines | Increased PHR variability and movements |
| Magnesium sulphate | Reduced FHR variability, reduced movements and FHR response to VAS |
| Ethanol | Reduced FHR variability, movement and breathing |
| Indomethacin, terbutaline | Increased fetal movements and breathing |
| Prostaglandin E ₂ | Reduced fetal movements and breathing |

Digestive Tract

Development anticipates physiological function

Enzyme secreting cell differentiation begins at 11-12 weeks, but secretion is inhibited until after birth

Meconium – fetal poop – fills the lower digestive tract

Swallowing begins early, 11-12 weeks, and continues throughout development

Suckling response develops late – 32-36 weeks

First Trimester - Maternal

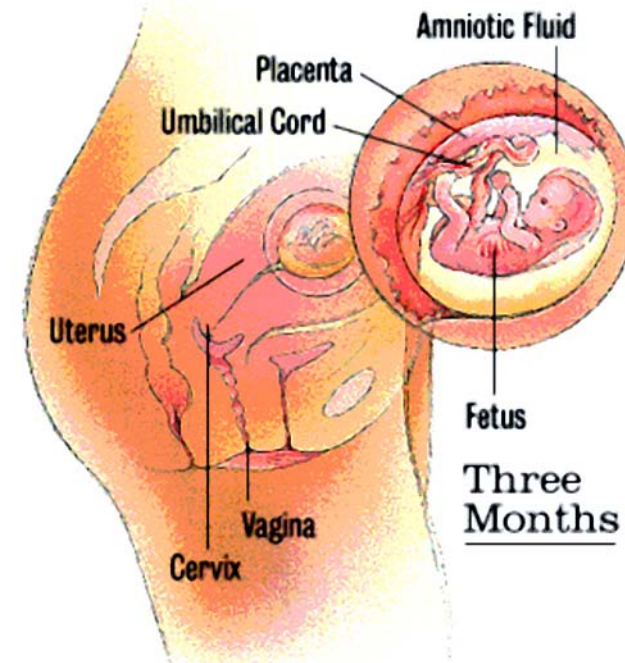
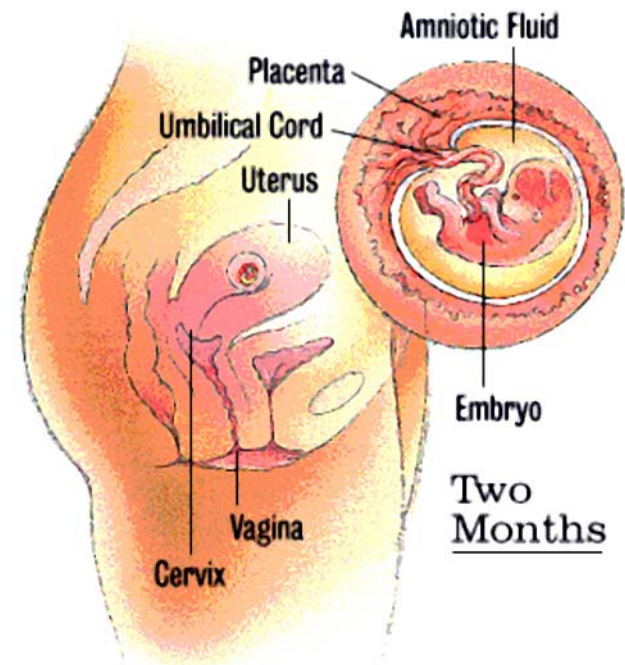
Morning Sickness (1st Trimester)

Sensitive / Sore Breast (1st Trimester), Breast
Growth (hormones)

Frequent Urination (Entire pregnancy,
enhanced 1st and 3rd trimester)

Constipation (hormones and pressure on the
rectum)

Fluctuating Emotions (moodiness)



Nausea and Vomiting during Pregnancy (NVP) (Morning Sickness)

- Peaks during the first Trimester
- Positive correlation with birth weight
- Negative correlation with spontaneous abortions
- Nausea – 50-70% of pregnant women
- Vomiting – 40-50% of pregnant women
- Less than 2% is solely in the morning

Nausea to continuous vomiting

1st trimester to entire pregnancy

Possible causes:

Elevated hCG

Elevated estrogen / progesterone

Bacterial (*Helicobacter pylori*)

Serotonin levels

Hyperemesis Gravidarum -- Severe

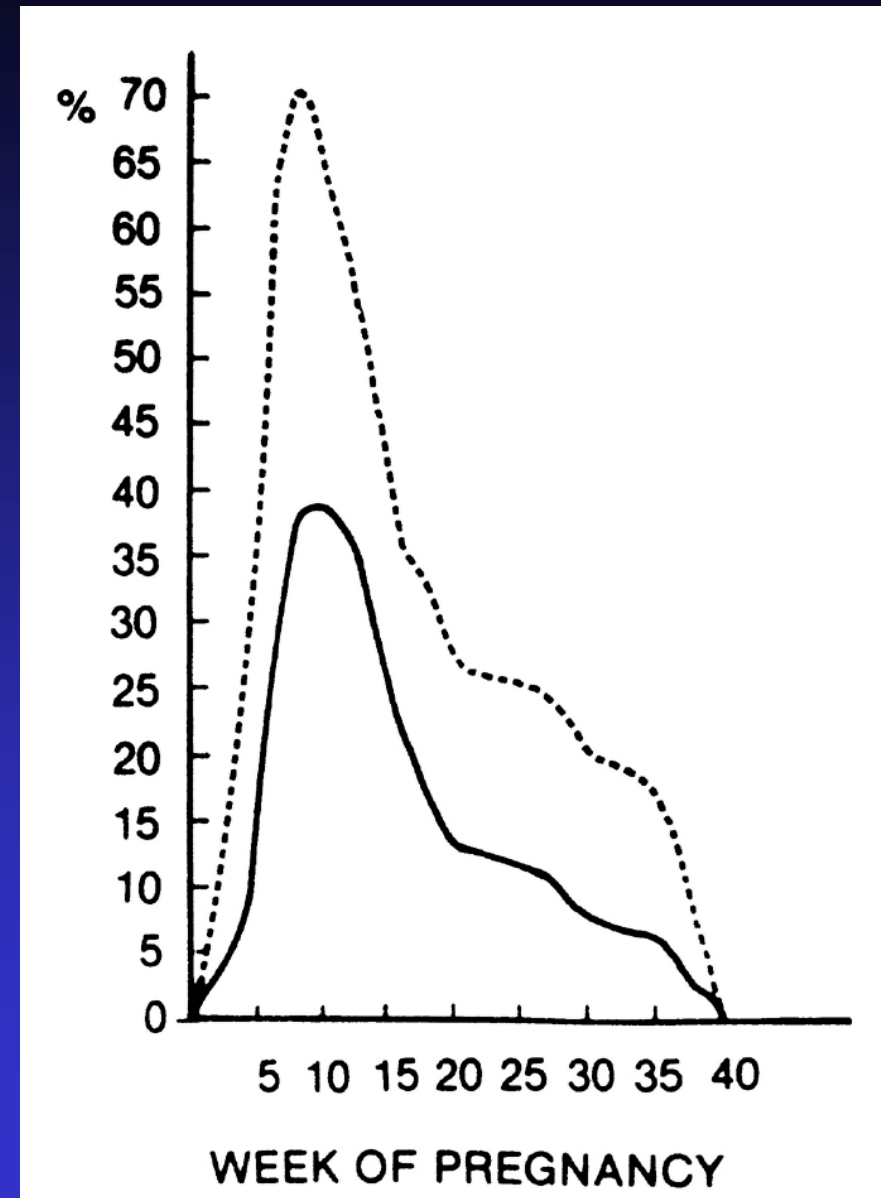
NVP (0.5-1.0%) - life threatening

– fetus and mother

– Dehydration, electrolyte

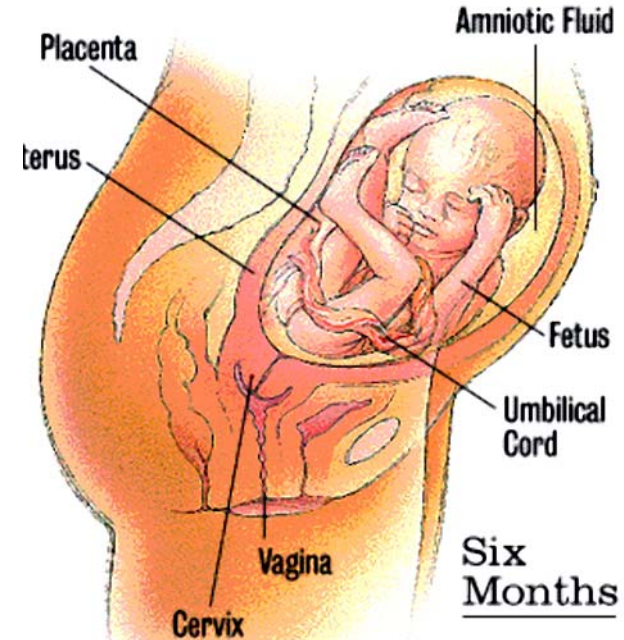
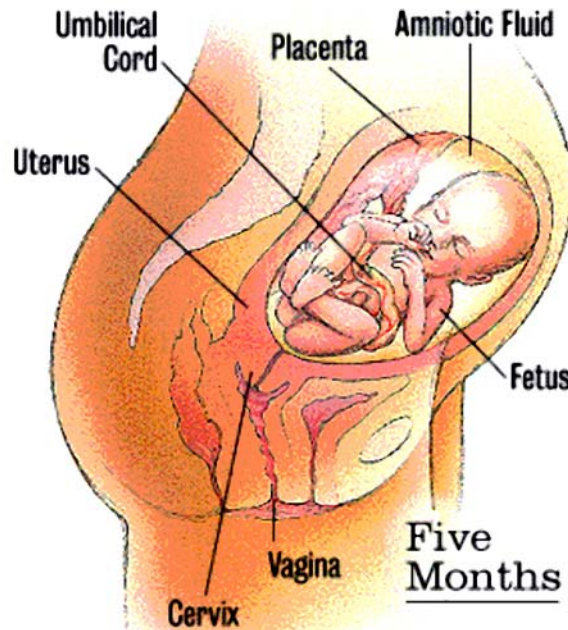
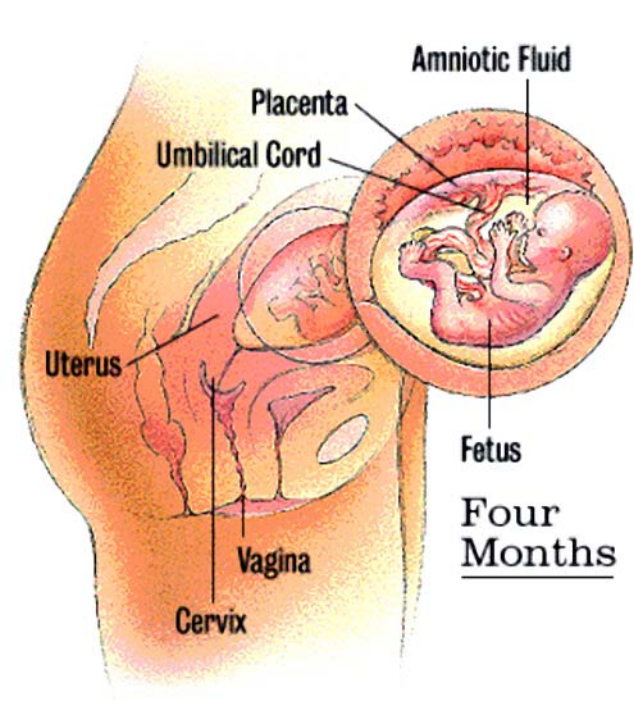
imbalance, nutritional deficiencies

Transcutaneous Acupoint electrical stimulation (ventral wrist where median nerve is close to the skin)



Second Trimester

Week 13-29



Frequent urination

Insomnia, Indigestion,
Muscle cramping

Pains associated with stretching uterus

Leukorrhea – vaginal discharge - increased secretion, vagina and cervix

Third Trimester

Week 29 to 40

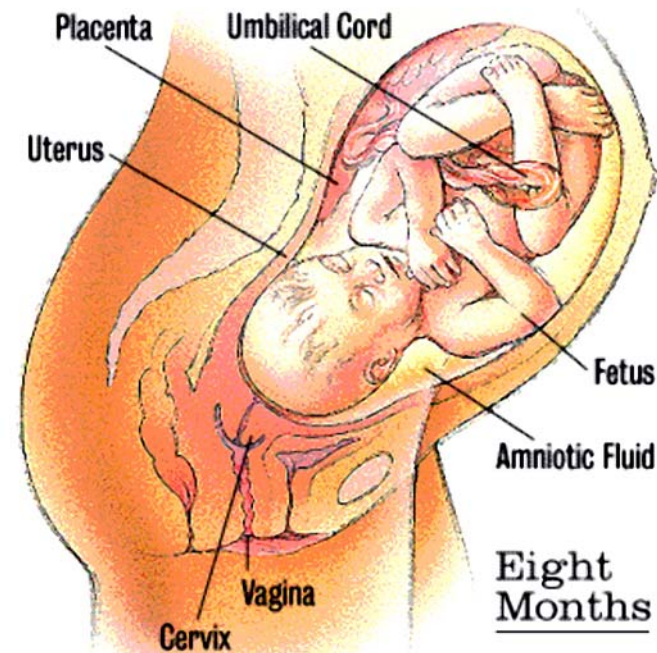
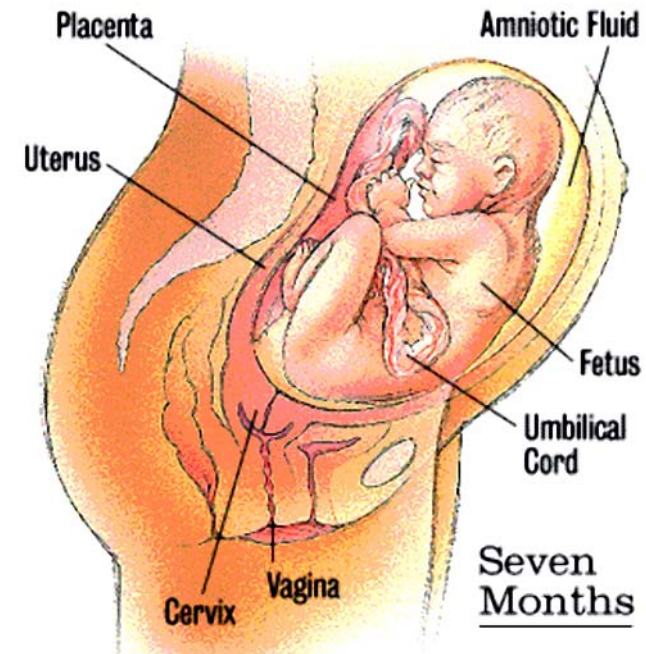
Pregnancy Blahs – 10% experience mild to moderate depression

Breathlessness – pressure on diaphragm

Edema – ankles, toes – pressure on vena cava and pelvic vein – restricts blood flow

Preclampsia – edema elsewhere – high blood pressure, protein in urine, incidence 4%, restricted blood flow to placenta

Eclampsia – seizure, 2nd leading cause of maternal death in US



Preclampsia or Toxemia of Pregnancy

Protein loss → buildup in glomerulus

Kidney function declines

salt and water retention

Increase blood pressure → Arterial spasms, kidney, brain,
liver

Two prevalent theories:

Hormones

Immune response to fetus

Symptoms disappear soon after birth

Eclampsia

Extreme degree of preclampsia

Vascular spasms throughout the body

Possible convulsions / coma

Decreased kidney output

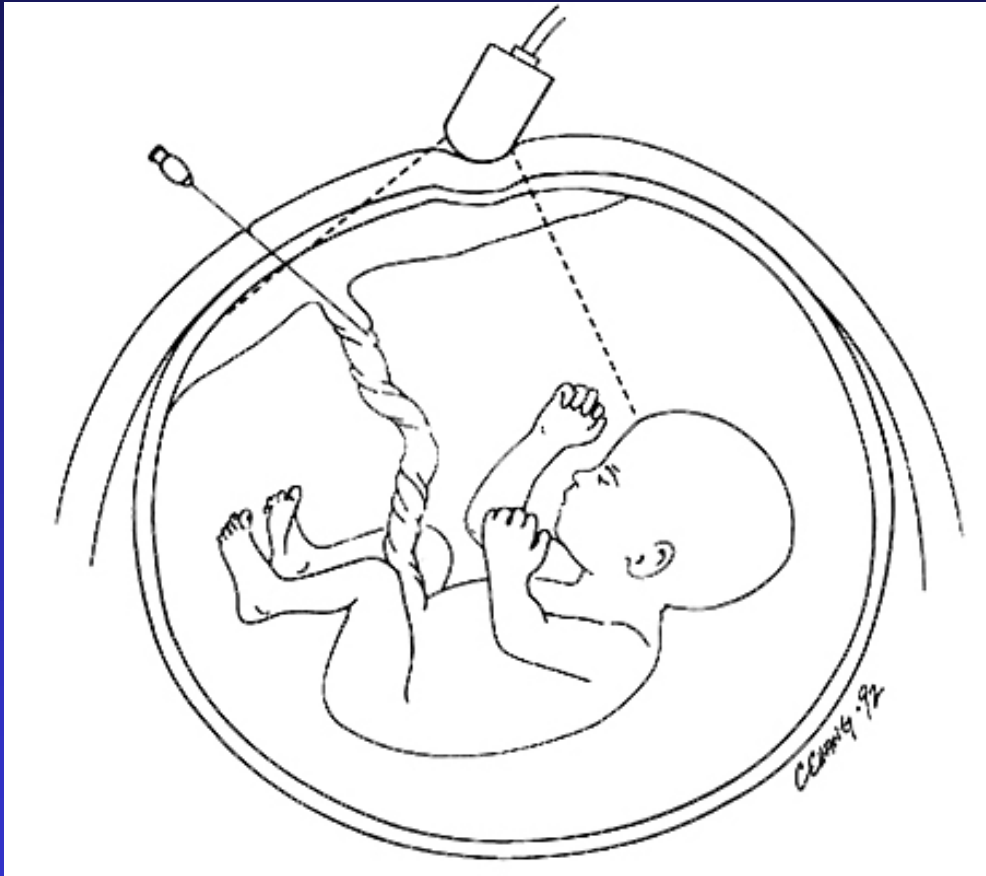
Liver malfunction

Extreme hypertension

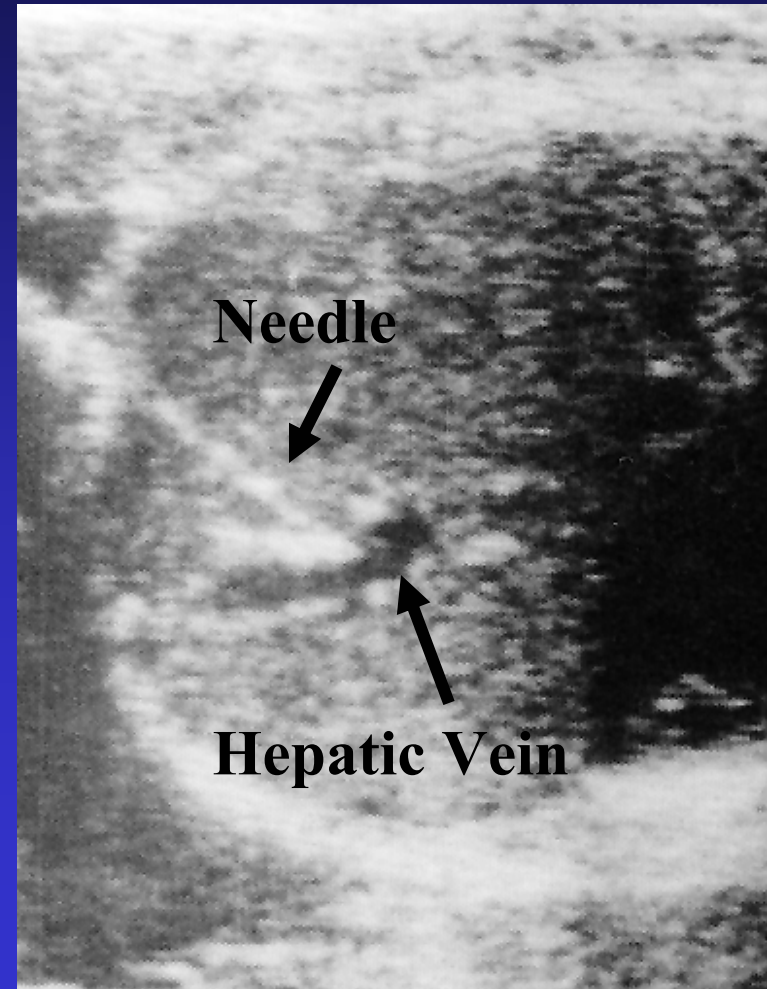
Lethal without treatment

Treatment: Vasodilators and cesarean section

Ultrasound Assisted – Intrauterine Therapy



Fetal Blood Sampling



Month Nine

Lightening – Fetus descends to pelvic cavity

Cervix – Dilation, Effacement (softening, thinning)

False Labor – Contractions initiate then diminish

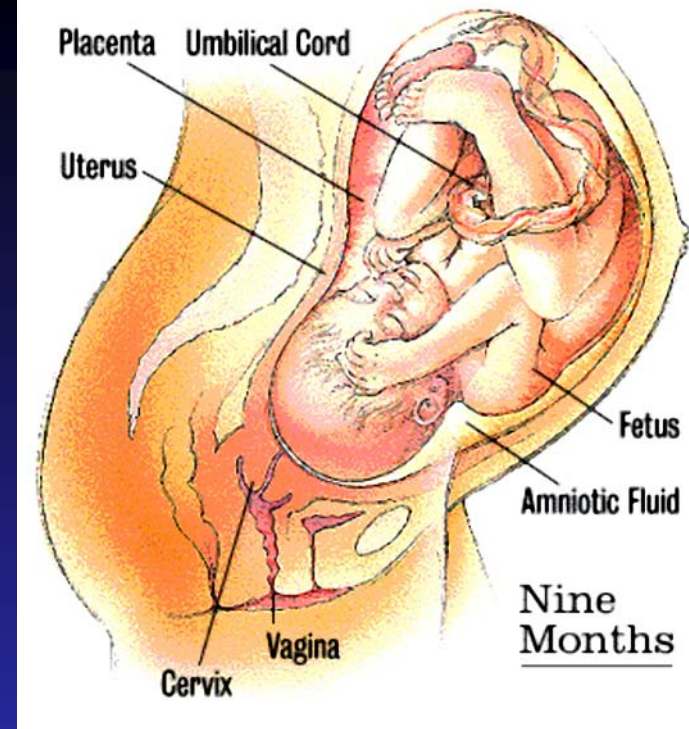
Labor:

Cervical effacement – dilation to 10 cm

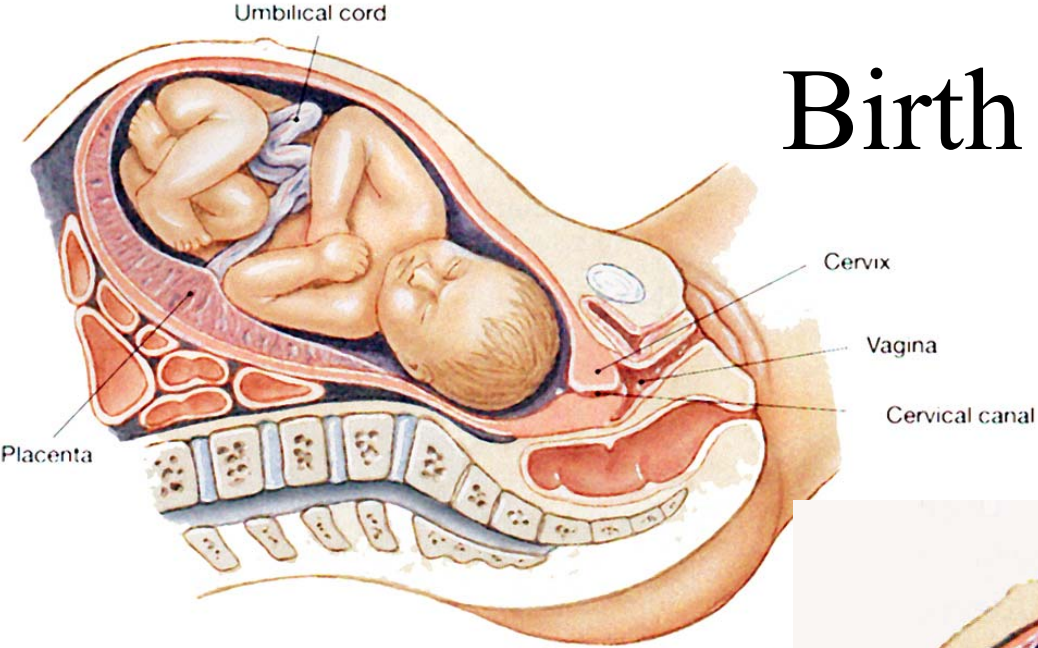
Bloody Show – mucus plug of the cervix – blood-colored

Breaking Water Bag – rupturing of the amnion

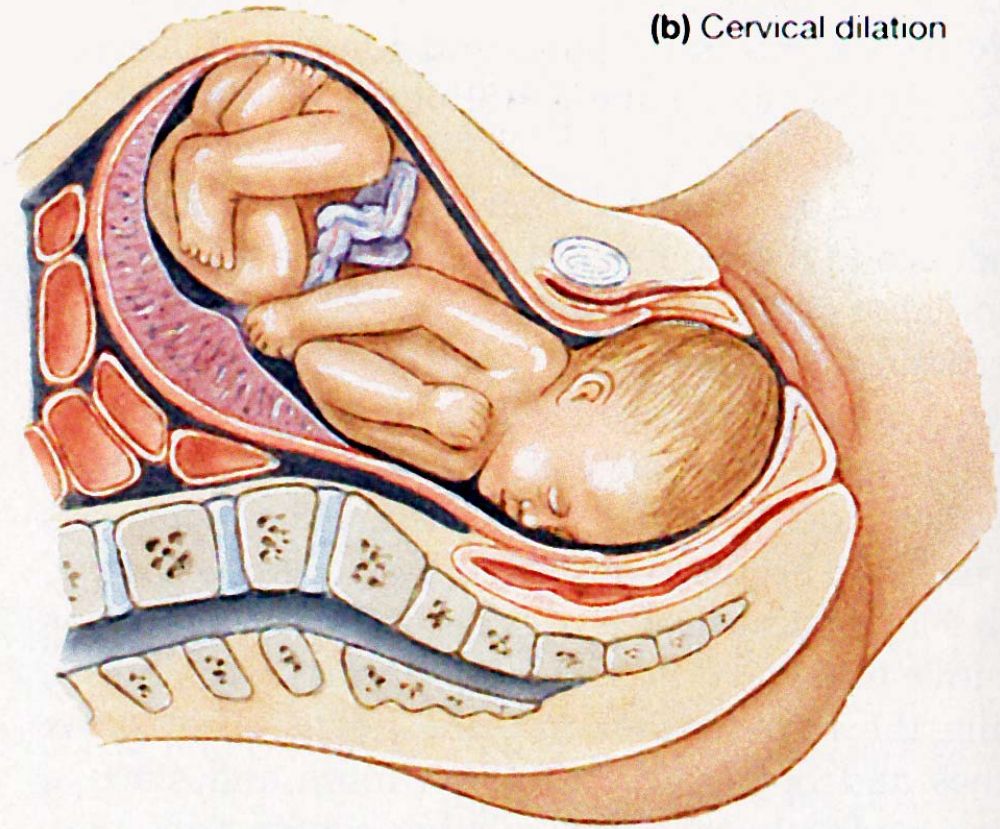
Contractions – shorter intervals, longer, stronger



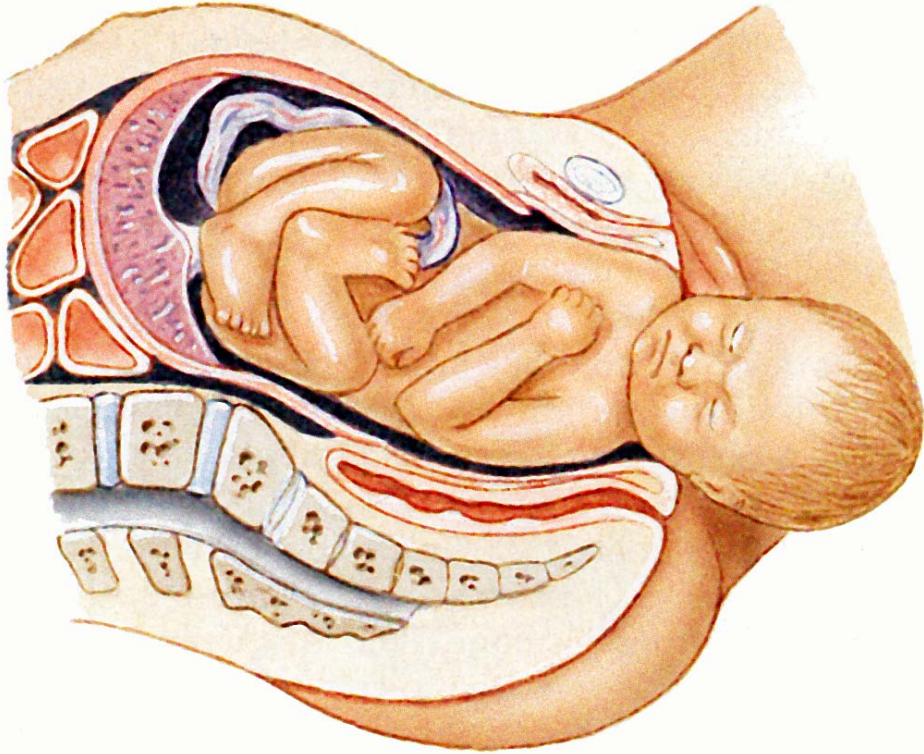
Birth



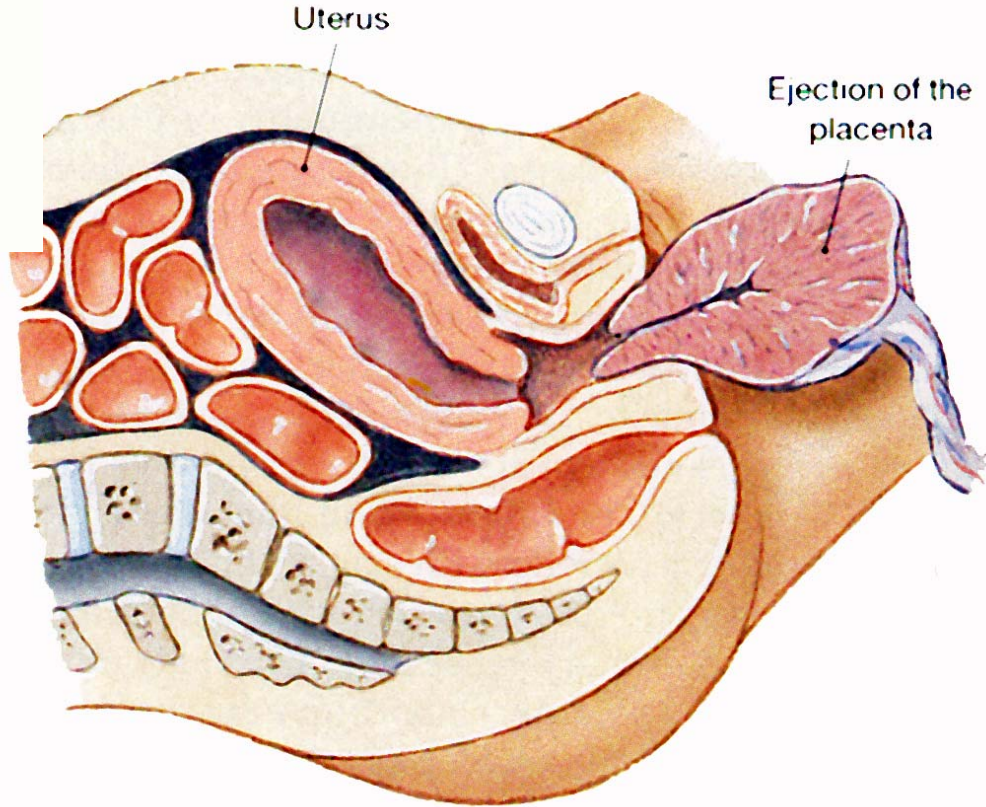
(b) Cervical dilation



(c) Delivery



(d) Expulsion of the placenta



Uterine Contraction

Uterine musculature becomes progressively more excitable

Estrogen/progesterone ratio changes increases excitability

Progesterone inhibits contraction

Estrogen increases gap junctional communication between smooth muscle cells → increases contractility

Oxytocin (maternal posterior pituitary gland) increases excitability

Mechanically stretching uterine smooth muscle increases contractility

Cervical stretching elicits uterine contractions

Fetal effects – glucocorticoids → placenta → inhibits progesterone

Fetal oxytocin is also produced

Labor and Parturition

Parturition: Process by which the baby is born

Labor: Strong uterine contractions, Cervix stretching, Forcing the fetus through the birth canal

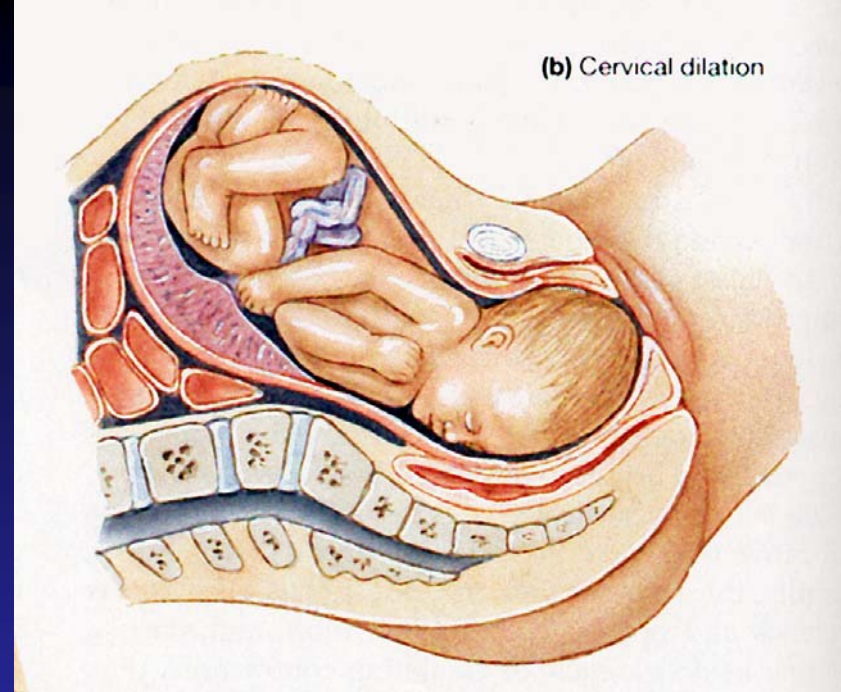
Rhythmic strong uterine contractions expel the fetus

Positive-Feedback regulation of labor

Contractions push baby → stretch cervix

Stretched cervix → Stronger uterine contraction

Cycles until parturition is complete



Labor and Parturition

Contractions: 30 minutes → 1-3 minutes

Contractions strongest at top of uterus – forcing baby toward cervix (25 lbs/contraction)

Continuous contractions (tetanus) can stop blood flow and lead to death of the baby

First stage of labor: cervical dilation (8-24 hours)

Second stage of labor: passage through birth canal (few minutes to half hour)

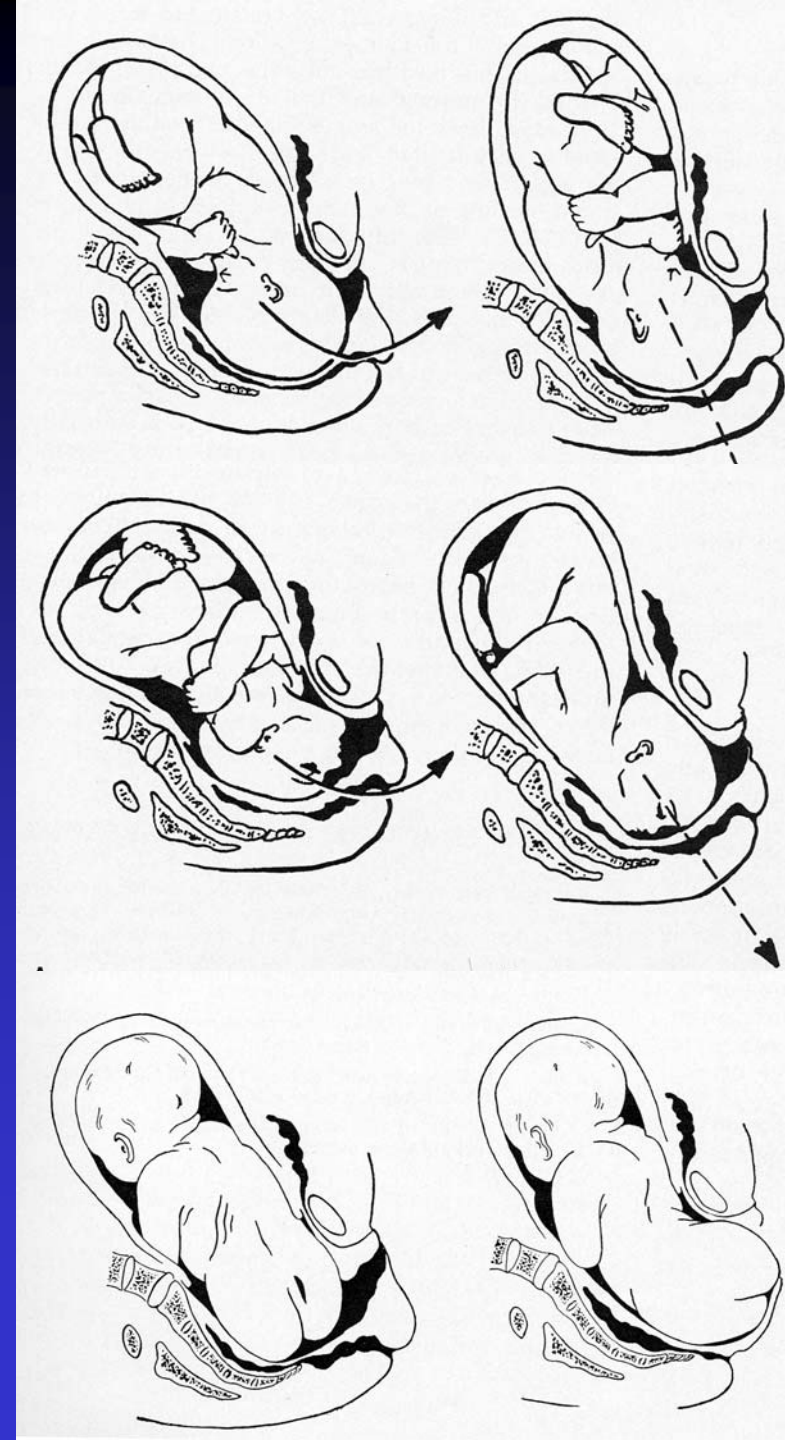
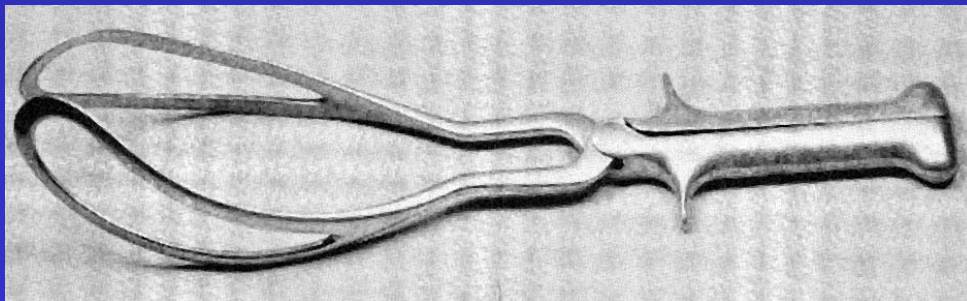
Third stage of labor: expulsion of the placenta

Labor and Parturition

Episiotomy – midline surgical incision just prior to delivery

Forceps aided delivery

Variable Presentations
95% head is inferior



Stage 3 - After Birth

10-45 minutes after parturition the placenta is delivered

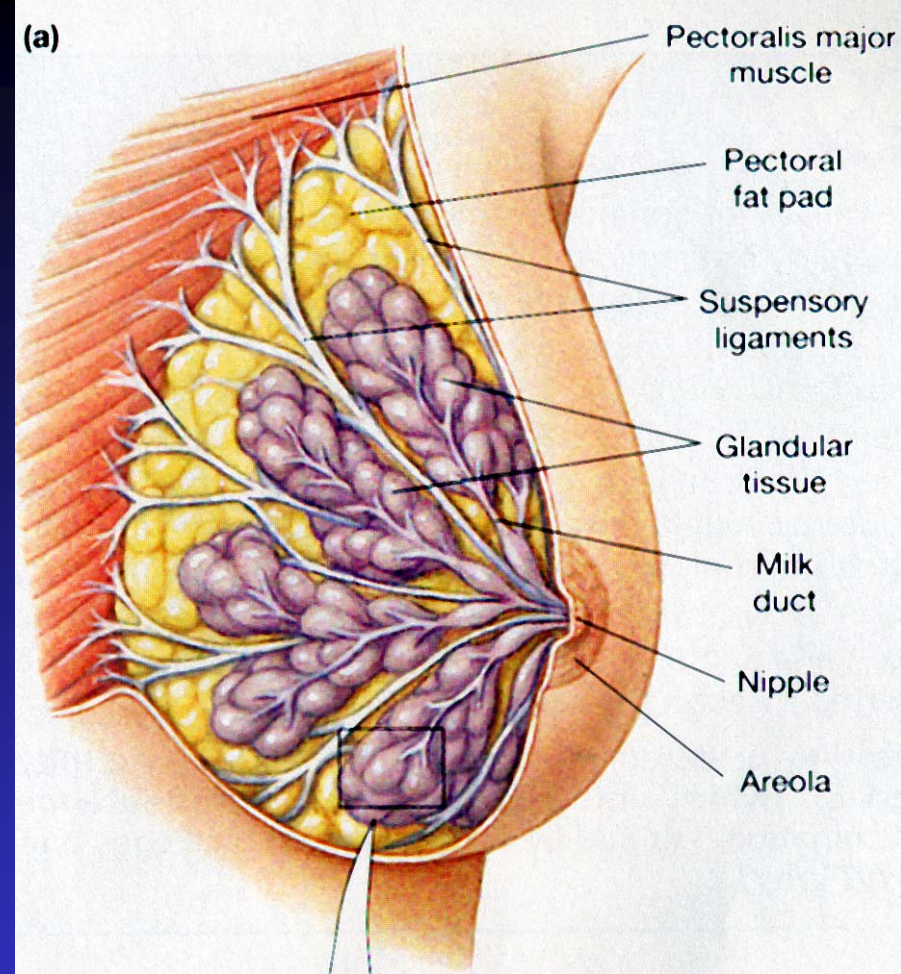
2 Phases – Separation and Expulsion

Separation - Uterine cavity reduces in size → shearing the placenta from the uterine wall

Limited bleeding – controlled by local production of vasoconstrictors (prostaglandins)

Expulsion is by uterine contraction

Breast Development Puberty



Estrogen-dependent growth
Fat deposition

Functional Breast Anatomy:

Nipple, areola glands (secretory, prevents chafing)

Lactiferous ducts – connects nipple to mammary gland lobes,
distal lactiferous sinus accumulates milk

Mammary gland - 15-20 lobes, each divided → lobules → terminal
alveoli (secretory sac)

Mammary ligaments to breast skin supports breast

Breast Development Pregnancy

Hormone-Dependent Growth

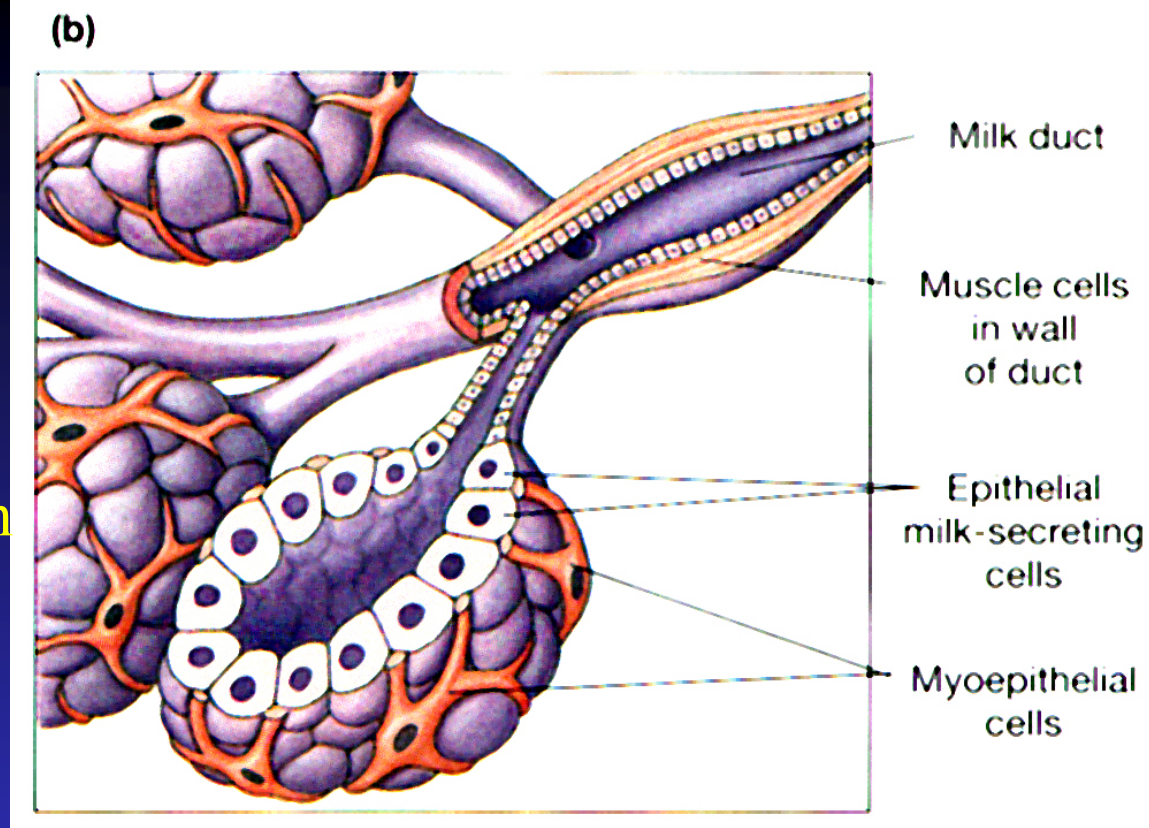
Estrogen

Growth Hormone

Prolactin

Adrenal glucocorticoid

Insulin



Growth and branching of the ductal system

Fat Deposition

Progesterone: Final stages – synergistic with other hormones – growth of lobules, budding of alveoli, secretory characteristics, but not secretion

Lactation

Estrogen and Progesterone
inhibit lactation

Prolactin:

Promotes milk secretion

Anterior pituitary

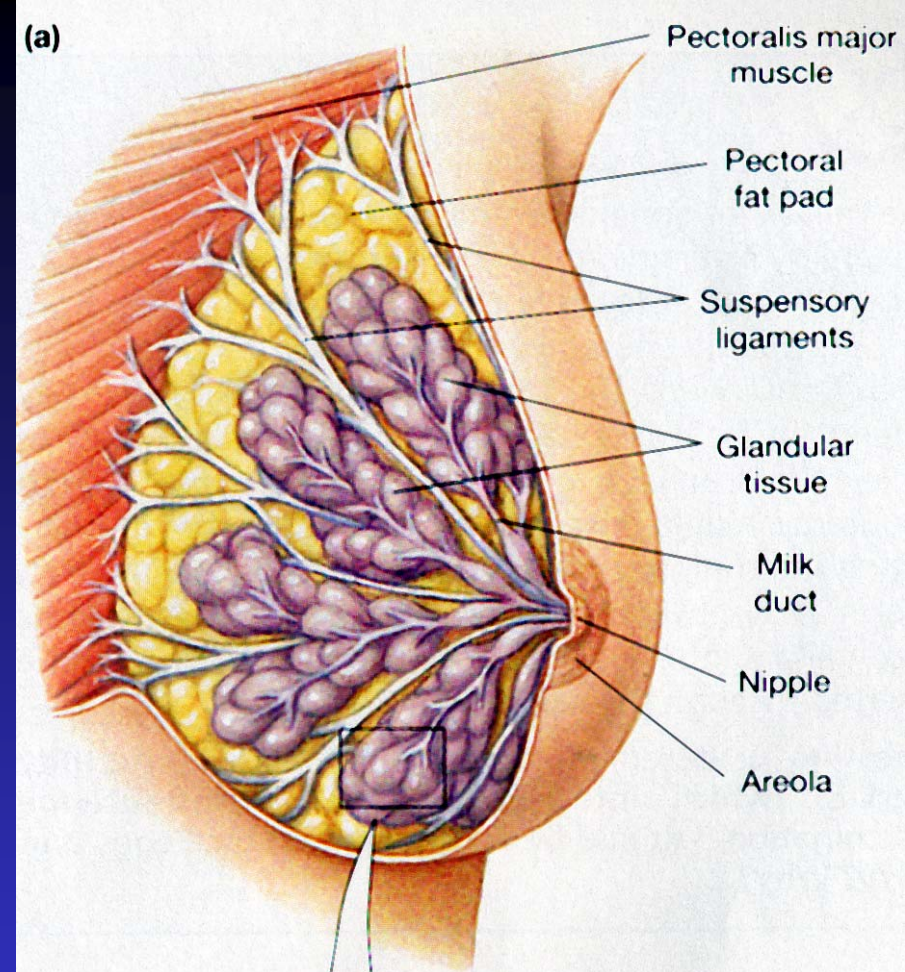
Hypothalamus (inhibition)

Steady rise week 5 - birth

Stimulates colostrum – low volume, no fat

Birth – sudden drop in Estrogen and Progesterone

1-7 days prolactin induces high milk production



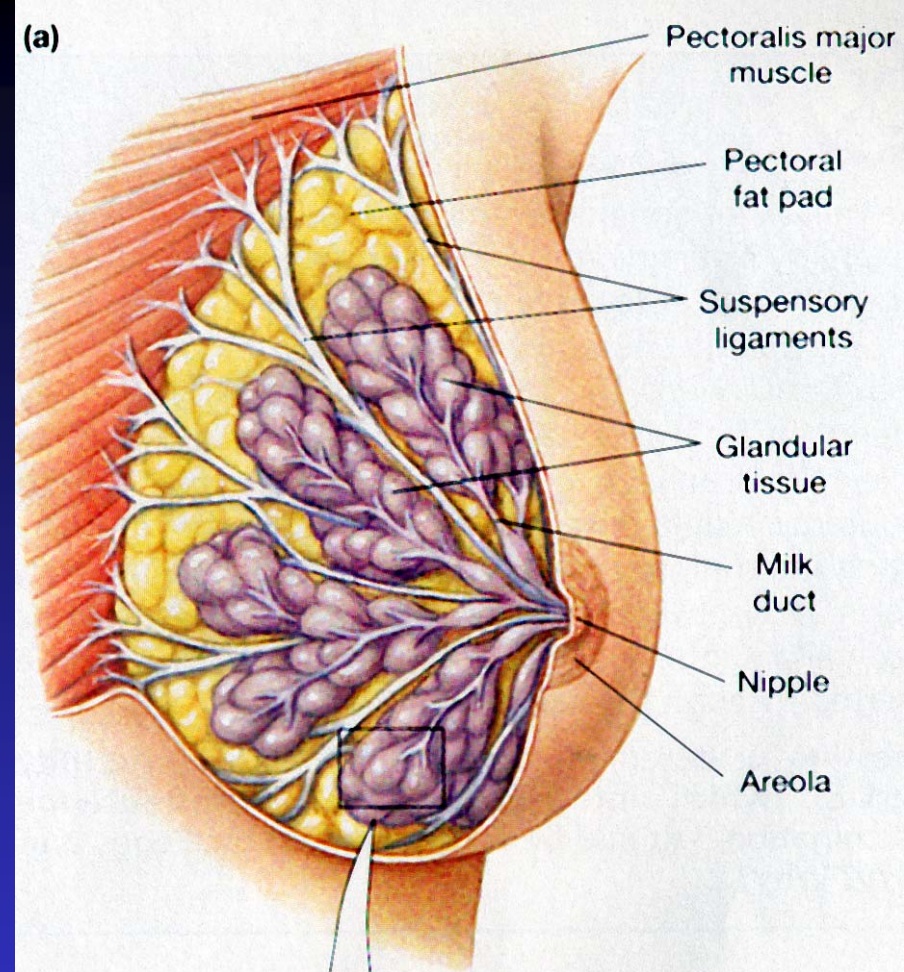
Lactation (cont.)

Other hormones are required:
growth hormone, cortisol,
parathyroid hormone

Prolactin production is
stimulated by signals from
the nipple to hypothalamus
(repression of prolactin-inhibiting hormone) → Anterior
Pituitary → 10-20x surge of prolactin

Nursing can continue for years

Once nursing stops - milk production declines within a week



Milk Letdown

Milk secreted into the alveoli of the breast, but must be ejected to the ductal system.

Oxytocin (posterior pituitary) stimulates this reflex

Oxytocin production controlled by hypothalamus (direct innervation of the posterior pituitary gland)

Oxytocin induces contraction of myoepithelial cells around the alveoli

Oxytocin induced by suckling and also crying

