
بسم الله الرحمن
الرحيم

PHYSIOLOGICAL CHANGES DURING PREGNANCY

LEC1

DR. SAWSAN TALIB
ASSISTANT PROFESSOR IN
DEPARTMENT OF OBSTETRICS AND GYNECOLOGY
COLLEGE OF MEDICINE/
DIYALA UNIVERSITY

Objectives

- To make the student able to:

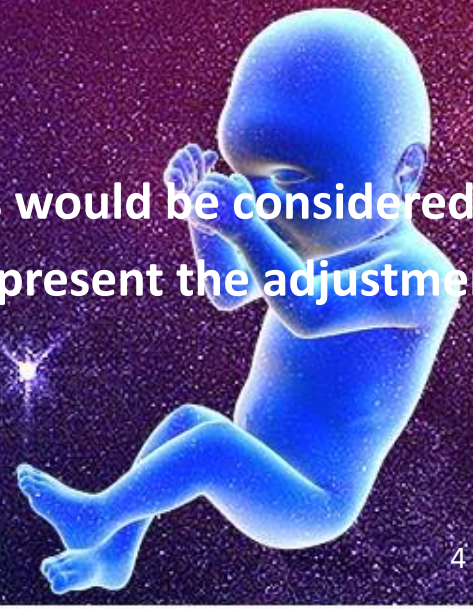
- interpret the reason for the maternal physiological changes
- Describe the changes involving CVS, respiratory, renal and other systems
- Specify the investigation in accordance with the physiological changes

- Maternal physiologic adjustment to pregnancy are designed to support the requirements of fetal homeostasis and growth.
- This is accomplished by remodeling maternal systems:

To deliver energy and growth substrates to the fetus

To remove inappropriate heat and waste products

- Those maternal adaptation maintain a healthy environment for the fetus.
- These changes are due to
- 1. Hormonal changes
- 2. Increasing size of uterus and fetus
- 3. Anatomical changes
- In a non-pregnant patient, many of these alterations would be considered pathologic rather than physiologic. This lecture will present the adjustments and alterations in maternal physiology."



PHYSIOLOGICAL CHANGES IN PREGNANCY

Nutrition
- Normal Wt. Gain - 20-30 lbs.
- Balanced Diet
  - ↑ Folic Acid & Iron
  - ↑ Caloric Intake by 300 cal/Day
- ↑ Need for H_2O

Respiratory
- ↑ Tidal Volume
- ↑ O_2 Consumption
- Elevated Diaphragm
- Nasal Stuffiness
- Epistaxis

Musculoskeletal
- ↑ Lumbosacral Curve
- Altered Center of Gravity
- Duck Waddling Gait

Breasts
- ↑ Breast Size
- Heaviness
- Tingling
- Fullness
- Darkening of Nipple
- Thin watery secretion

Cardiovascular
- ↑ Blood Volume
- ↑ HR
- ↑ Cardiac Palpitations
- ❤ Enlargement
- Murmurs
- Pseudoanemia

Gastrointestinal
- Pregnancy Gingivitis
- ↑ Saliva
- ↓ Gastric Acidity
- N & V
- ↓ Tone & Motility of Smooth Muscles
- Hemorrhoids & Constipation
- ↓ Emptying of the gallbladder

Urinary-Renal
- Frequency
- ↓ Bladder Tone
- ↓ Renal Threshold for Sugar
- ↑ Glomerular Filtration
- ↓ BUN, Creatinine, Uric Acid

Vagina
- Estrogen Influence
- Hypertrophy
- Hyperplasia of Lining
- ↑ Thick white secretions

Uterus
- ↑ Size
- ↑ Wt.
- ↑ Fibrous Connective Tissue
- Braxton Hicks
- Cervical Softening
- Mucus Plug

Integumentary
- ↑ Skin Pigmentation
- Facial Mask
- Acne Vulgaris
- Dermatitis
- Vascular Spider Nevi
- ABD - Stretch Marks
  Linea Nigra

Endocrine
- Placenta
  - Nutrients To → Fetus
  - Waste Away From ← Fetus
  - Produces - HCB, HPL
- Thyroid
  - ↑ Size & Activity
  - ↑ Basal Metabolic Rate
  - ↑ Parathyroid Activity
- Pituitary
  - Enlarges 9th Month
  - Produces FSH, LH, Thyrotropin Adrenotropin & Prolactin

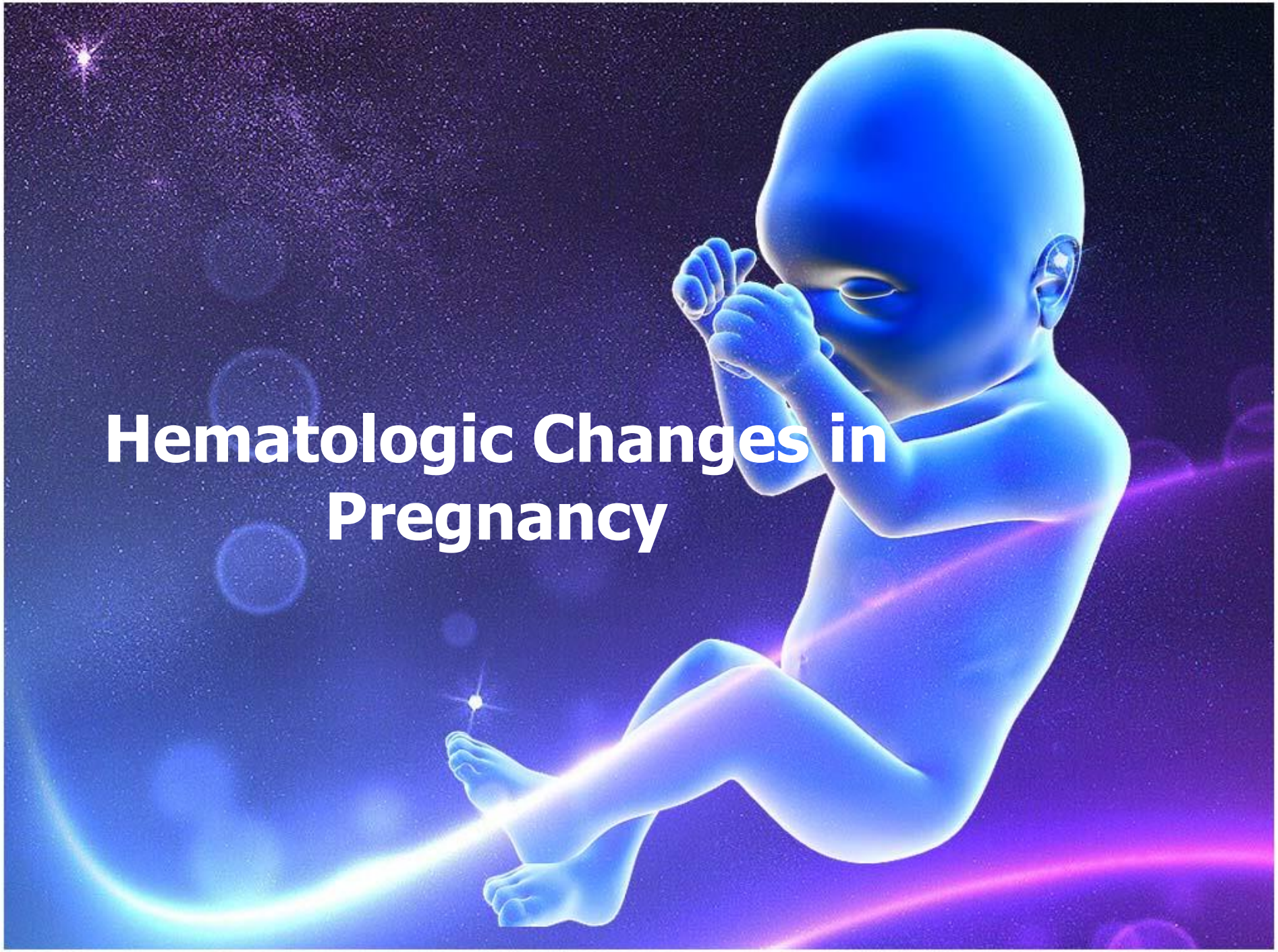

Hematologic Changes in Pregnancy

Table 5.1: Principal Blood Changes during Pregnancy				
Parameters	**Nonpregnant**	**Pregnancy Near Term**	**Total Increment**	**Change**
Blood volume (mL)	4000	5500	1500	+ 30–40%
Plasma volume (mL)	2500	3750	1250	+ 40–50%
Red Cell volume (mL)	1400	1750	350	+ 20–30%
Total Hb (g)	475	560	85	+ 18–20%
Hematocrit (whole body)	38%	32%		Diminished

- **BLOOD VOLUME** starts to increase from about 6th week, expands rapidly thereafter to maximum 40–50% above the nonpregnant level at 30–34 weeks. The level remains almost static till delivery.
- **PLASMA VOLUME**: It starts to increase by 6 weeks and it plateaus at 30 weeks of gestation The increase is greater in multigravida, in multiple pregnancy and with large baby.
- **RBC AND HEMOGLOBIN**: This increase is regulated by the increased demand of oxygen transport during pregnancy. RBC mass begins to increase at about 10 weeks and continues till term without plateauing.
- The disproportionate increase in plasma and RBC volume produces a state of hemodilution (fall in hematocrit) during pregnancy. Thus, even though the total hemoglobin mass increases during pregnancy to the extent of 18–20%, there is apparent fall in hemoglobin concentration

Why there is increase in the red cell volume?

Increase in total metabolism

↓

Increase in total oxygen consumption

↓

Demand for increase in total oxygen-carrying capacity of blood

↓

Increase in total red cell volume

PREGNANCY

↑ concentrations of estrogen & progesterone

Directly act on kidney

Causing release of renin

Activates aldosterone-renin-angiotensin mechanism

Renal sodium retention & in total body water

↑ Blood volume

↑ in plasma volume (45%)

hb → ht

Physiological anemia

- To allow adequate perfusion of vital organs including placenta and fetus and protect mother from erect and supine position
- To anticipate blood loss a/w delivery
- Diminished blood viscosity ensures optimum gaseous exchange between the maternal and fetal circulation

Table 5.3: Changes in Blood Coagulation Factors

Parameters	Nonpregnant	Pregnancy near term	Change
Platelets (mm^3)	1,60,000–2,00,000	Conflicting observation	Static or 15% reduction of the count
Fibrinogen (mg%)	200–400	300–600	+ 50%
Fibrinolytic activity	—	Depressed	—
Clotting time	—	Unaffected	—
ESR	10 mm/h	40 mm/h	Marked increase (4 times)

Hypercoagulable State

Increase in:

PROCOAGULANT FACTORS
- Factor VII
- Factor VIII
- Factor IX
- Factor X
- Factor XII
- Fibrinogen increase by 50%

- Activated Protein C resistance

↑ESR 4 times

Decrease till 15 min. after delivery in:

ANTICOAGULANT
- Protein S activity
- Antithrombin IIIa

Levels of coagulation factors normalize 2 weeks postpartum

Increased production of:

RBC mass (20%)

Due to increase in renal erythropoietin production

Supports higher metabolic requirement for O_2 during pregnancy

Platelet

but platelet consumption increase more

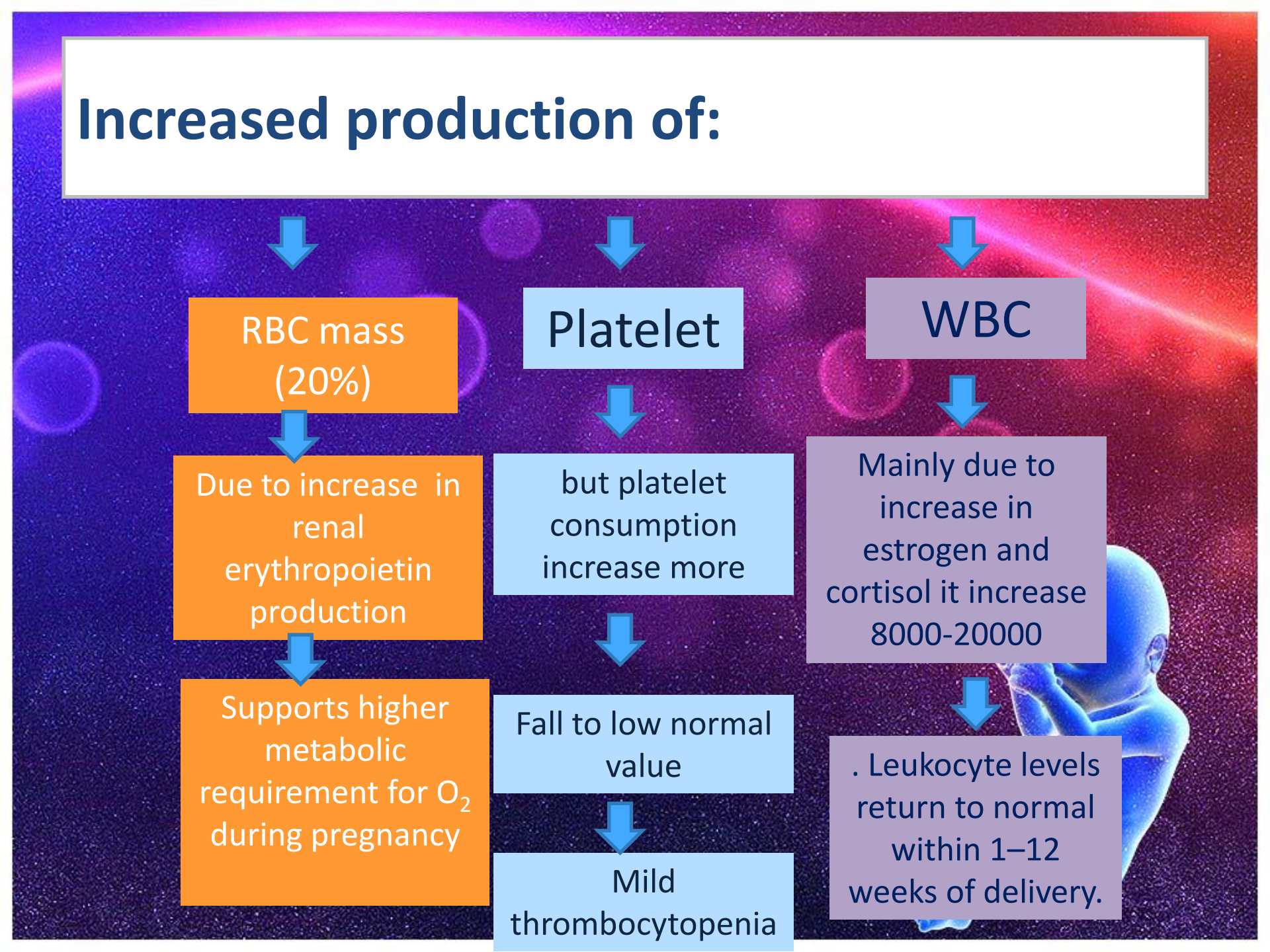
Fall to low normal value

Mild thrombocytopenia

WBC

Mainly due to increase in estrogen and cortisol it increase 8000-20000

. Leukocyte levels return to normal within 1–12 weeks of delivery.



Immunosuppresive State

Approximately 30% of women develop IgG abs against the inherited paternal human leukocyte Ag of fetus

↓

BUT, the role of these abs is UNCLEAR & there is no evidence of attack on fetus

↓

Lack of maternal immunity towards the fetus

↓

Due to reduced no of cytotoxic T cells (CD8+) during pregnancy

→

Potentially harmful T cell-mediated immune responses downregulated & components of innate immune system activated instead

Allowed fetal allograft to implant & develop

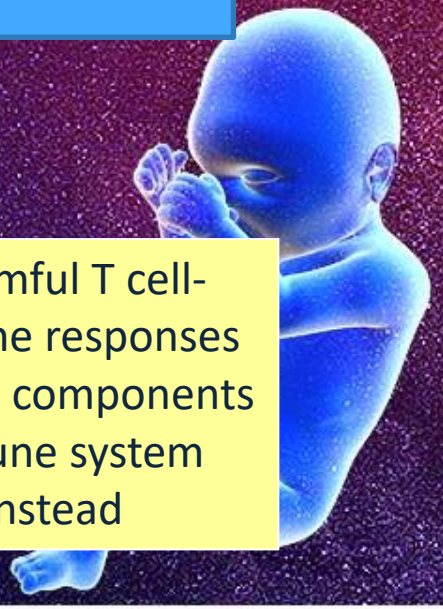


Table 5.6: Changes in Respiratory System

Parameters	Non-pregnant	Pregnancy near term	Change
Respiration rate/min	15	15	Unaffected
Vital capacity (mL)	3200	3300	Almost unaltered
Tidal volume (mL)	475	675	+ 40%
Residual volume (mL)	965	765	– 20%
Inspiratory capacity (IC)	2500	2650	+10%
Minute ventilation	7.5 L/min	10.5 L/min	+40%
Total lung capacity (mL)	4200	4000	–5%

Airway

Weight gain (neck, oropahyngeal tissue, breast, chest wall) and airway edema can compromise the airway → difficulty to visualize larynx during tracheal intubation

Increase vascularity of the respiratory tract and nasal mucosa → edema and prone to bleeding

Ventilation

Increase in ventilation

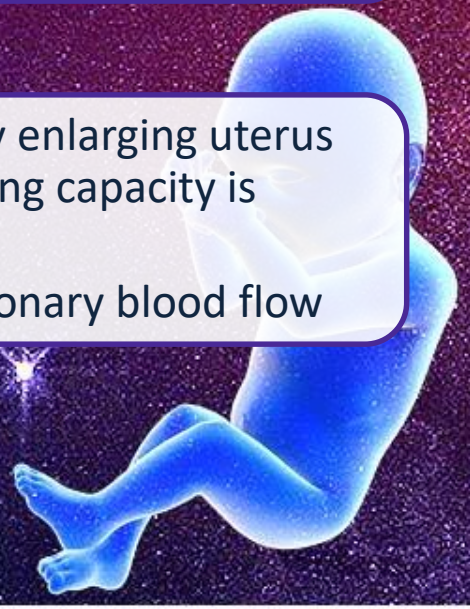
- Begins around 8th week of gestation
- Most likely in response to progesterone related sensitization of the respiratory centre to CO2 and increase in metabolic rate

Changes in mechanical aspects of ventilation

- Increase in tidal volume by 40% (from 500- 700 ml)
- Reduction in functional residual capacity

Thoracic anatomy changes

- Elevation of the diaphragm by about 4 cm by enlarging uterus and reconfiguration of the chest wall total lung capacity is reduced 5%due to it
- Change in lung volume and increase in pulmonary blood flow



Functional residual capacity (FRC) is our “air tank” for apnea.

www.picture-newsletter.com/scuba-diving/scuba... from Google images

Pregnant Mom has a smaller “air tank”.

Non-pregnant woman

This make mother more suscetable to effects of apnea (during intubation)

www.pyramydair.com/blog/images/scuba-web.jpg

Arterial Gases

Decrease in PCO2 (15-20%)

- Due to increase in progesterone which subsequently increases alveolar ventilation (through increase in tidal volume)

Increase in PO2

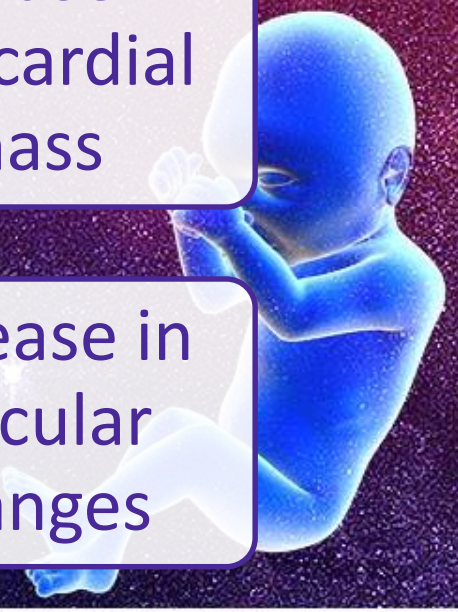
- Slightly increased
- These changes (O2 and CO2), facilitates gas transfer to the fetus

Acid- base balance

- ↓ in PCO2 activate compensatory buffering mechanism (carbonic anhydrase converts carbonic acid to HCO3, thus releasing H ions to restore Ph)

Anatomic Changes

- Heart rotates on its long axis → apex point left-upward
  - Uterine enlargement
  - Diaphragm elevation
- Heart size increase
  - Increase in myocardial mass
  - Increase in vascular changes



Cardiac Output

Increase ~40% during pregnancy (max at 30-34 weeks about 40-50%)

Increased

1. blood volume.

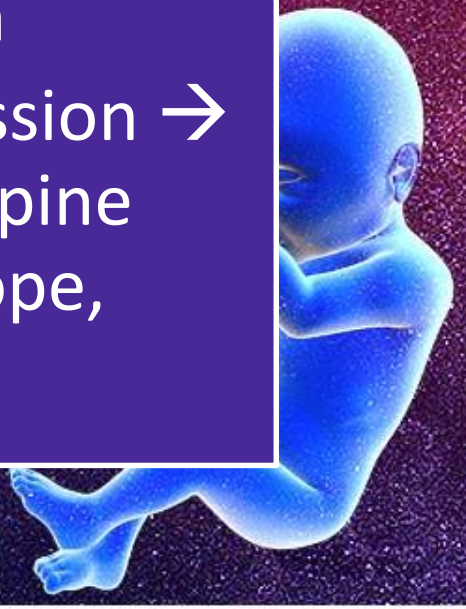
2. To meet the additional O2 required due to increased metabolic activity during pregnancy.

Resting maternal heart rate:

- Progressively increase over the course of gestation
- 15 beats more than non pregnant state

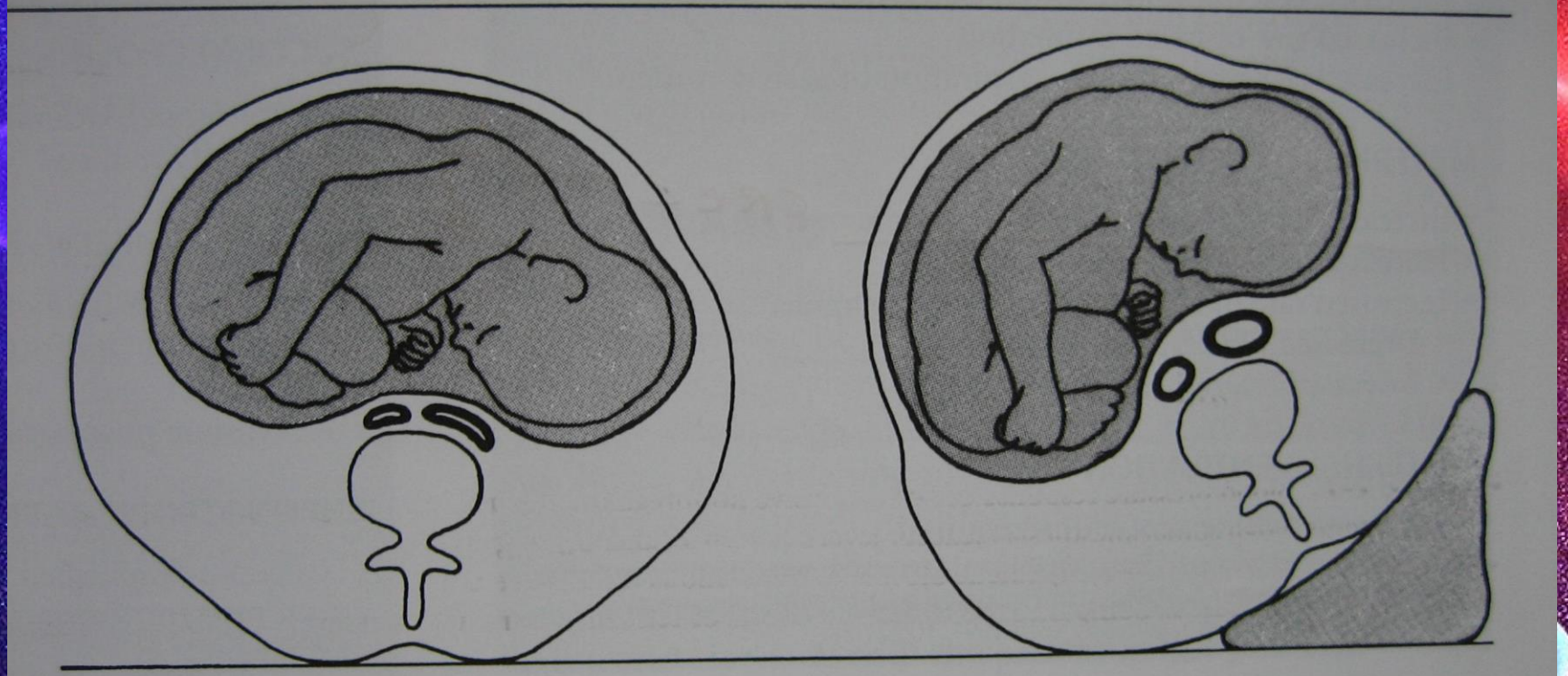
Stroke volume increase 25-30% :

- Sensitive to maternal position
- Supine → aortocaval compression → decrease stroke volume → supine hypotension syndrome (syncope, bradycardia, hypotension)



oplacental blood flow
ine position.[42]

Young[197] found the incidence of failed endotracheal intubation in obstetric patients to be 1:280 (i.e., 7 of 1980 cases),



Chestnut chap. 2

Blood Pressure

Pulse pressure widen → due to diastolic falls greater than systolic

Venous pressure → progressively increase in lower extremities

- Compression of vena cava by gravid uterus
- Will cause edema and varicosities

Peripheral vascular resistance → decrease

- Hormonal changes enhance local vasodilators such (nitric oxide, prostacyclin, adenosine)

Clinical findings in cardiovascular system examination

Systolic ejection murmur

- Results from increase cardiac output and decrease blood viscosity

Continuous murmur@bruit at left sternal edge → arise from internal thoracic artery mammary murmur".

Splitting of first heart sound

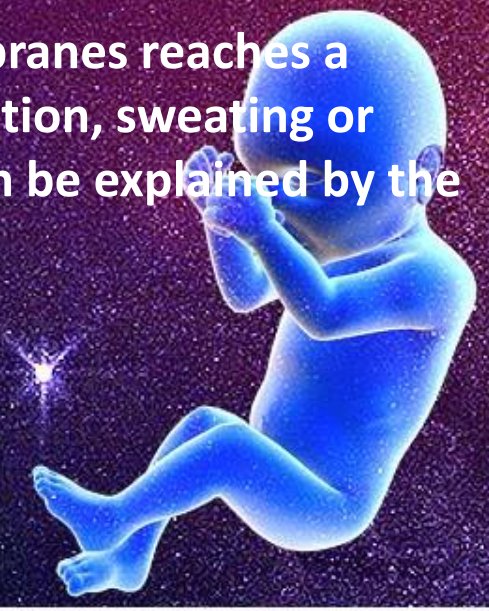
ECG

- Left axis deviation

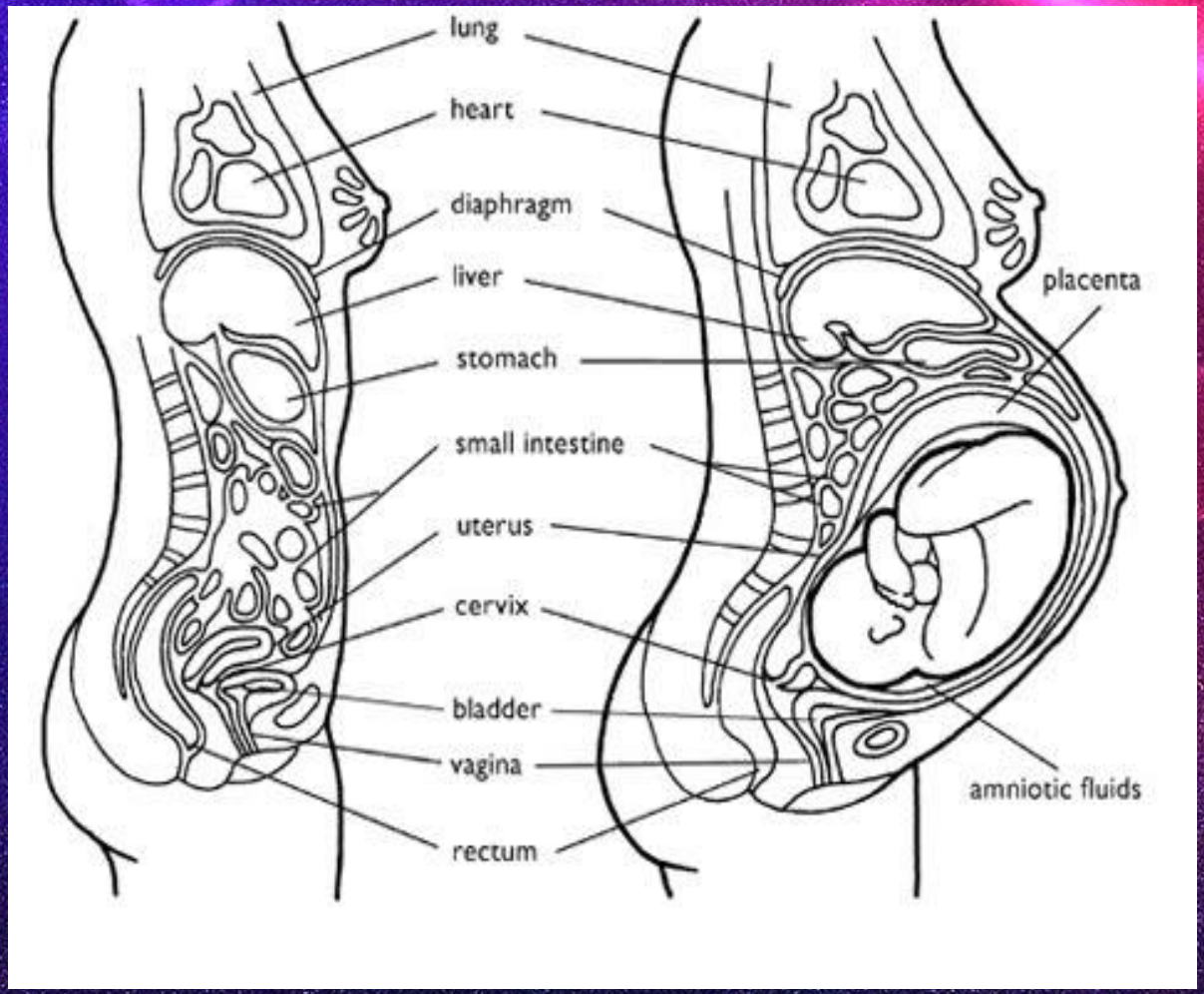
Parameter	Percentage of change	
Cardiac output	40–50%	Increase
Stroke volume	30%	Increase
Heart rate	15–25%	Increase
Intravascular volume	45%	Increase
Systemic vascular resistance	20%	Decrease
Systolic BP		Minimal
Diastolic BP	20%	Decrease at mid-pregnancy Pre-pregnant values at term
CVP		Unchanged
O_2 consumption	30–40%	Increase

REGIONAL DISTRIBUTION OF BLOOD FLOW

- Uterine blood flow is increased from 50 mL/min in nonpregnant state to about 750 mL near term.
- The increase is due to the combined effect of uteroplacental and fetoplacental vasodilatation
- The vasodilatation is due to the smooth muscle relaxing effects of progesterone, estrogen, nitric oxide (endothelium derived factor), prostaglandins and atrial natriuretic peptide (ANP).
- The blood flow through the skin and mucous membranes reaches a maximum of 500 mL/min by 36th week. Heat sensation, sweating or stuffy nose complained by the pregnant women can be explained by the increased blood flow.



Difference in Gastrointestinal tract in Pregnancy and Non pregnant state




As the baby grows, he/she pushes the woman's stomach up.

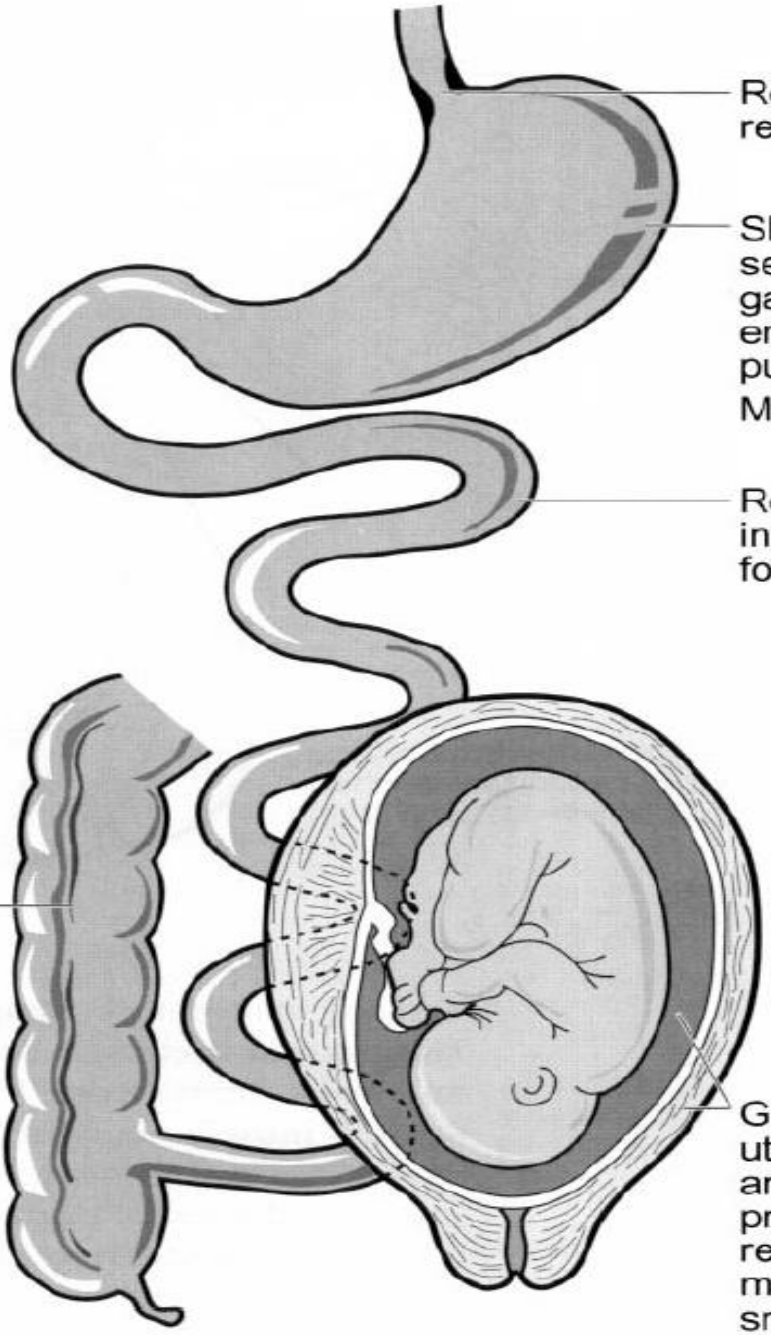
Gastro-intestinal changes

- *Increased salivation* (ptyalism)
- *Taste* is often altered very early in pregnancy
- Increase appetite & thirst → frequent small snacks
- *Heart burn* (reflux oesophagitis)

  relaxation of the cardiac sphincter due to progesterone and relaxin
- *Emesis gravidarum*, morning sickness in 50 %
- *Decreased gastric acidity*, which interfere with iron absorption
- *Constipation*

  reduced gut motility due to progesterone

  increased water and salt absorption



Relaxation of sphincter → regurgitation → heartburn

Slight reduction in gastric secretion and diminished gastric motility result in slow emptying → more efficient pulping of food.

May also cause nausea.

Reduced motility in small intestine – increases time for absorption.

Reduced motility of large intestine – increases time for water absorption but also tends to induce constipation.

Growth of conceptus and uterus – increases appetite and thirst. In late pregnancy pressure of the uterus reduces capacity for large meals → frequent small snacks.

Gastro-intestinal changes

- *Liver*

  - Hepatic synthesis of albumin, plasma globulin and fibrinogen increases

  - Total hepatic synthesis of globulin increases stimulated by estrogen

  - Hormone-binding globulins rise

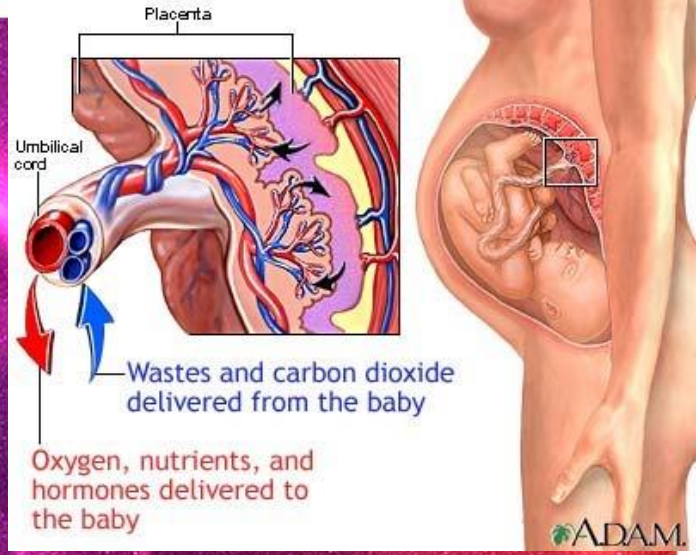
  - gall bladder increases in size and empties more slowly

  - relaxation of gall bladder increases the tendency of stone formation

  - cholestasis is almost physiological

  - secretion of bile is unchanged

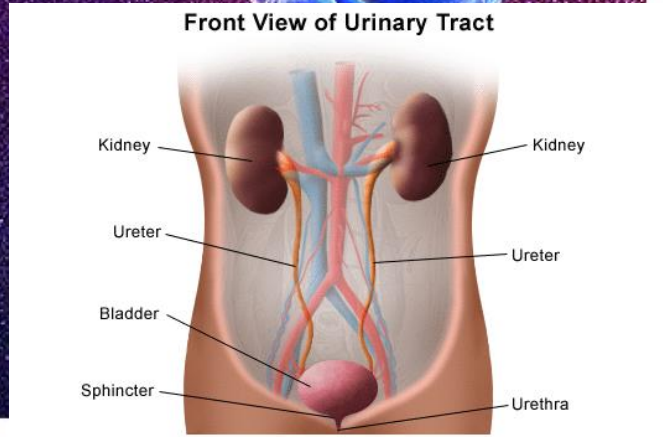
Urinary changes



- *Kidneys*
  - increase in size
  - hydronephrosis
  - effective renal plasma flow is increased

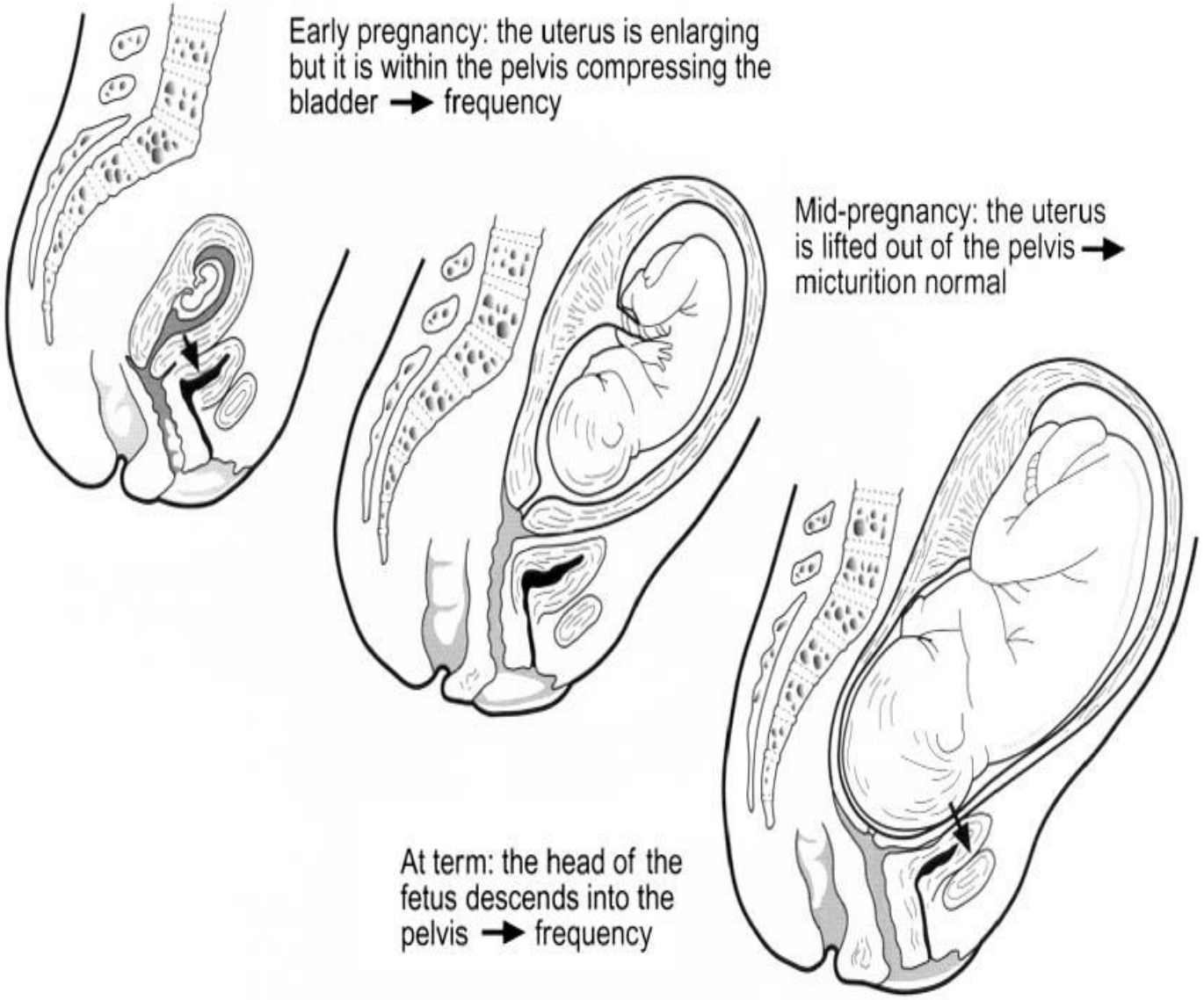
- *Dilatation of the ureters*
  - Atony of the ureteric muscles } caused by progesterone and relaxin
    hydro-ureter
  - vesico-ureteric reflux increased - pressure of the uterus on the ureter
    affects more the right ureter due to the dextro-rotation of the uterus

Changes in the ureter in pregnancy leads to urinary stasis and pyelitis



The urinary tract and renal function

- blood flow increase (60-70%).
- glomerular filtration increased (50%).
- clearance of most substances is enhanced.
- plasma creatinine ,urea,urate are reduced.
- glycoseuria is normal.


Early pregnancy: the uterus is enlarging but it is within the pelvis compressing the bladder → frequency
Mid-pregnancy: the uterus is lifted out of the pelvis → micturition normal
At term: the head of the fetus descends into the pelvis → frequency

Uterus

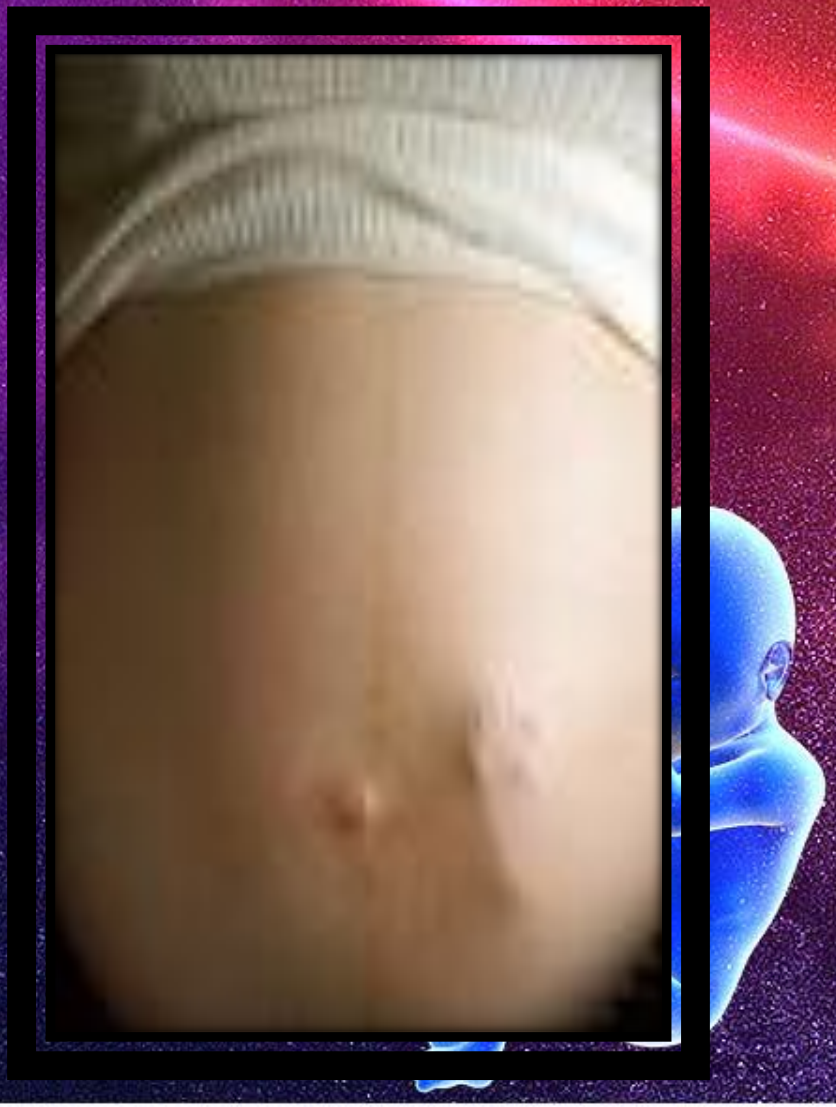
	Non Pregnant Uterus	Pregnant Uterus
Muscular Structure	Almost Solid	Relatively thin – walled (≤ 1.5 cm)
weight	60 g, and measures about 7.5 cm in length	weighs 900–1,000 g and measures 35 cm in length.
Volume	cavity of 5–10 mL	The capacity is increased by 500–1,000 times.

Mechanism Of Uterine Enlargement

Stretching & marked hypertrophy of muscle cells.

Considerable increase in elastic tissue

Accumulation of fibrous tissue, particularly in the external muscle layer.

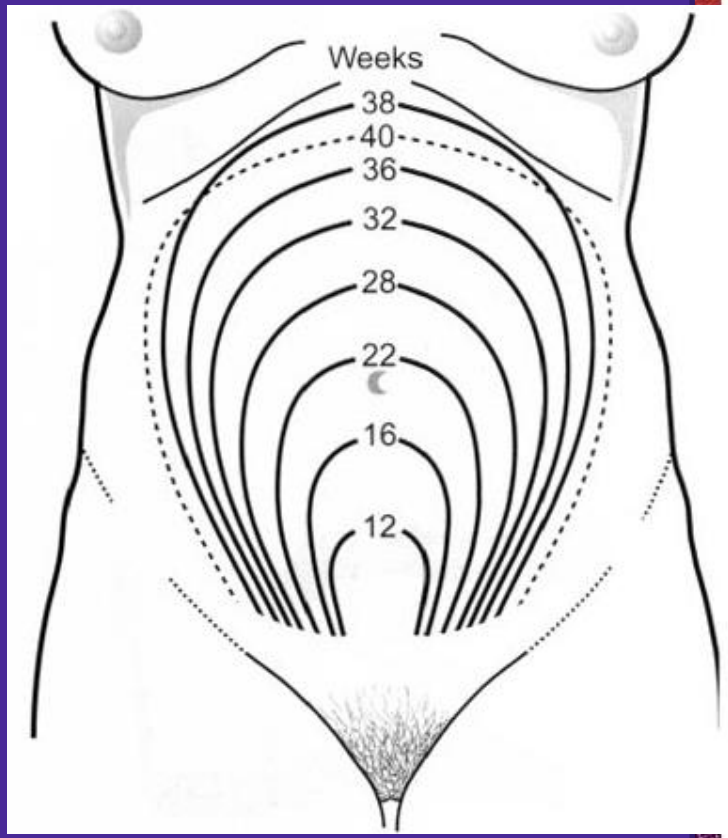


- **Arrangement of the muscle fibers**
- (1) Outer longitudinal—It follows a hood-like arrangement over the fundus
- (2) Inner circular—It is scanty and sphincter like arrangement around the tubal orifices and internal os
- (3) Intermediate—It is the thickest and strongest layer arranged in crisscross fashion through which the blood vessels run called the living ligature
- **Vascular system**—Whereas in the nonpregnant state, the blood supply to the uterus is mainly through the uterine and least through the ovarian but, in the pregnant state, the latter carries as much the blood as the former

Contractions (Braxton-Hicks):

- Uterine contraction in pregnancy has been named after Braxton- Hicks who first described its entity during pregnancy. From the very early weeks of pregnancy, the uterus undergoes spontaneous contraction. This can be felt during bimanual palpation in early weeks or
- during abdominal palpation when the uterus feels firmer at one moment and softer at another. Although spontaneous, the contractions may be excited by rubbing the uterus. The contractions are irregular, infrequent, spasmodic and painless without any effect on dilatation of the cervix. The patient is not conscious about the contractions. Intrauterine pressure remains below 8 mm Hg. Near term, the
- contractions become frequent with increase in intensity so as to produce some discomfort to the patient. Ultimately, it merges with the painful uterine contractions of labor. In abdominal pregnancy, Braxton-
- Hicks contraction is not felt.

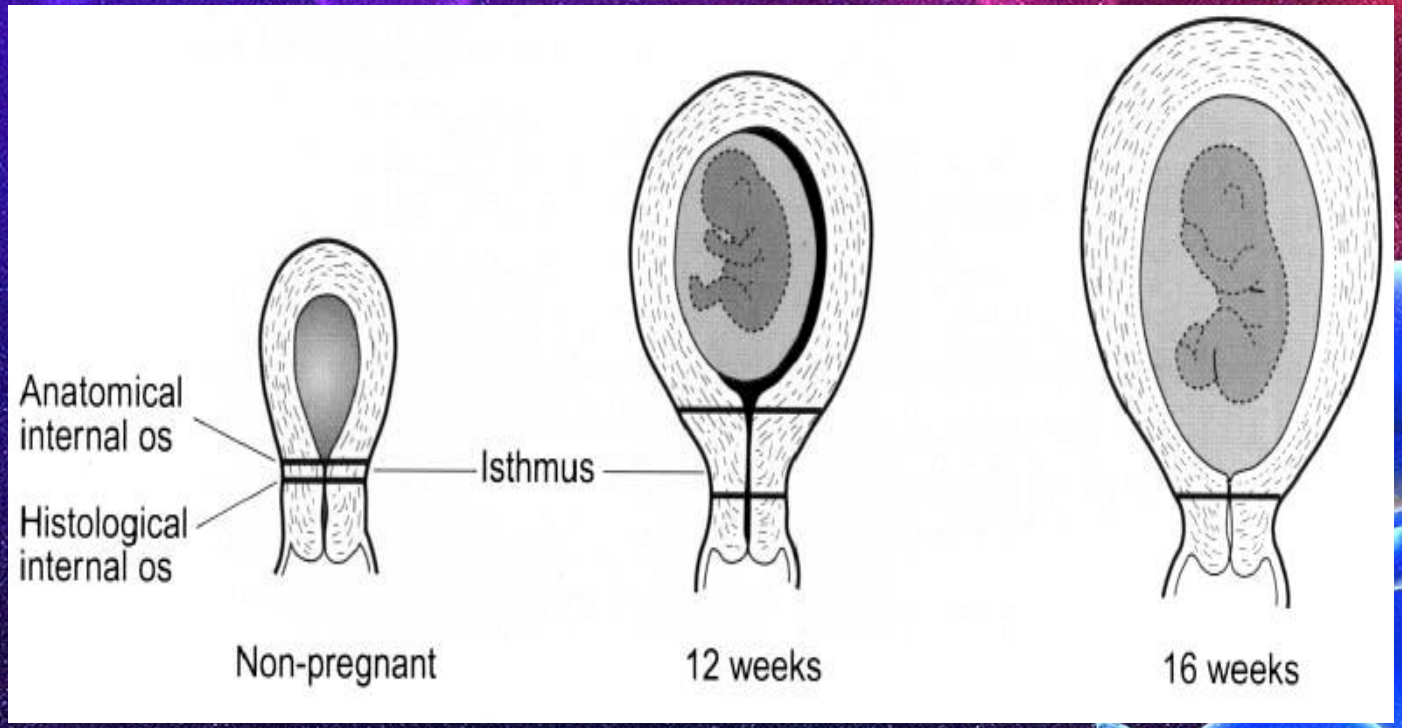
16 wks	3 finger widths above symphysis
20 wks	3 finger widths below umbilicus
24 wks	at umbilicus
28 wks	3 finger widths above umbilicus
32 wks	between umbilicus and xyphoid process
36 wks	at costal arch
40 wks	1-2 finger widths below costal arch



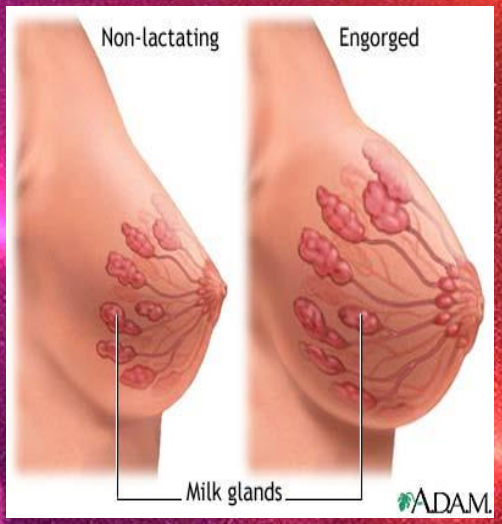
CERVIX

- Estradiol + progesterone → swollen and softer during pregnancy
- Estradiol → stimulates growth of columnar ep. of cervical canal → **ectropion** (visible on ectocervix) → prone to contact bleeding
- ↑ vascularity → look **bluer**
- Mucous glands → distended + ↑ complexity → ↑ secretion → mucus thickened → protective plug
- **PG** (remodelling of cervical collagen) + **collagenase** (from leukocytes) → **softening**

- Estrogen → **vaginal epithelium thicker** → ↑ desquamation rate → ↑ vaginal discharge → **> acidic** → protect against ascending infection
- Vagina become **more vascular**



BREAST



- **Deposition of fat** around the glandular tissue
- Estrogen → ↑ number of **glandular ducts**
- Progesterone + hPL → ↑ number **of gland alveoli**
- **hPL** → stimulate synthesis of **alveolar casein + lactoglobulin + lactalbumin**
- ↑ [**serum prolactin**] in pregnancy → antagonized by estrogen → no lactation

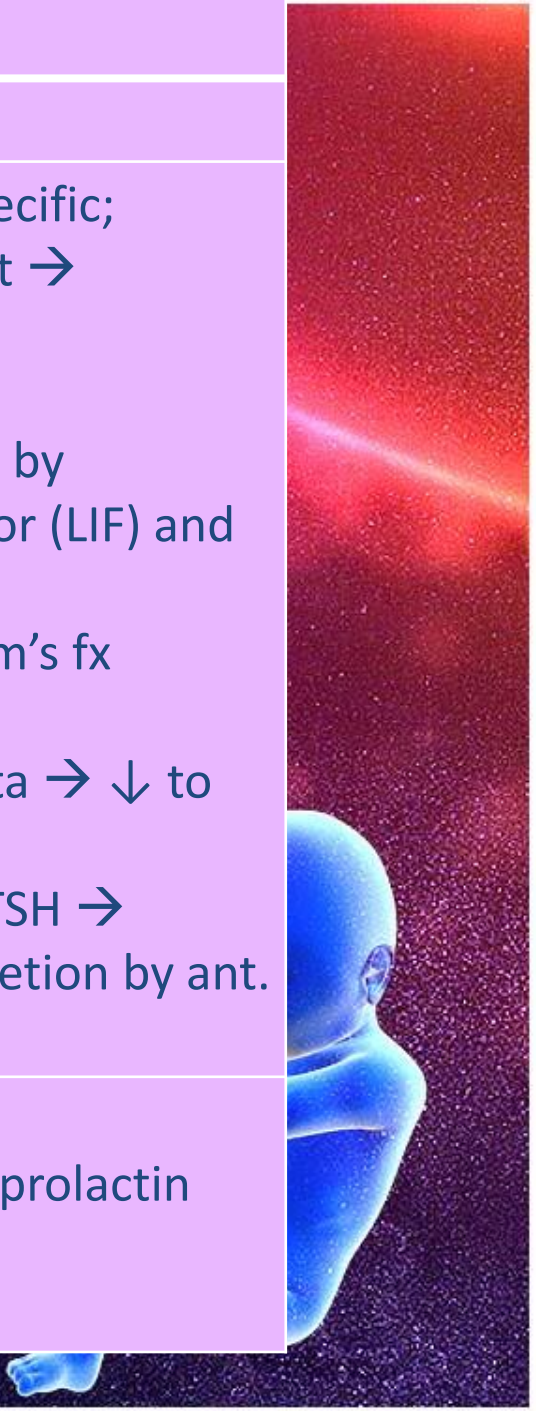
- **48 hours** after birth → rapid ↓ of [estrogen] → lactation
- End of pregnancy and early puerperium → **colostrum** produced (thick yellow secretion + ↑ immunoglobulin)
- **Early + frequent suckling** → stimulates ant. and post. Pituitary gland → prolactin + oxytocin → promotion of lactation
- **Stress + fear** → ↑ dopamine → ↓ synthesis and release of prolactin

- 2-3 days of puerperium → prolactin → alveoli distended by milk → **breast engorgement**
- oxytocin → **myoepithelial cells** surrounding alveoli and small ducts contract → squeezes milk into larger ducts and subareolar reservoirs
- Oxytocin → inhibit dopamine → ↑ prolactin → successful lactation

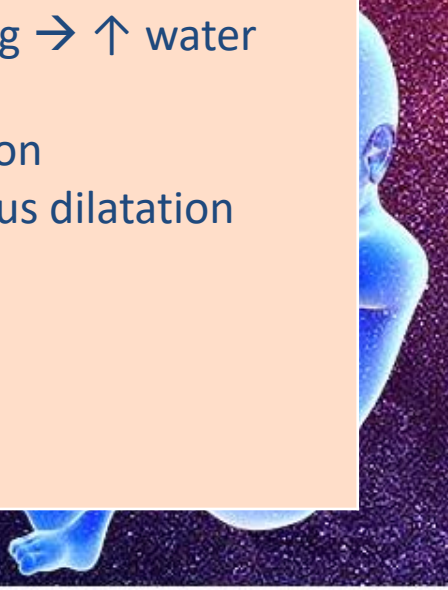
Suckling causes:
Afferent signals to posterior pituitary increasing oxytocin release, inducing myoepithelial cells to contract and express milk.
Afferent signals to anterior pituitary increasing prolactin release, thus increasing milk synthesis.

- Peptide and steroid hormones produced by
  - Non-pregnant: endocrine glands
  - Pregnant: intrauterine tissues

Hormones	
Pregnancy specific	
• Human chorionic gonadotrophin **(hCG)**	• α and β (pregnancy specific; produced by trophoblast → detectable w/in days of implantation) • production influenced by leukemia inhibitory factor (LIF) and isoform of GnRH • Maintain corpus luteum's fx • peak values @10w → progesterone by placenta → ↓ to plateau @>12w • α hCG ≈ α of LH, FSH, TSH → supress FSH and LH secretion by ant. pituitary
• Human placental lactogen **(hPL)**	• Produced by placenta • partial homology with prolactin and hGH



Hormones	
Steroids	• produced by placenta and fetus • Concentration ↑ earliest weeks of pregnancy → plateau •Effects upon myometrium and (+prolactin) breast tissue • effects on smooth muscle of vascular tree, GIT, GUT
• estrogen	• max ↑ 30-40mg/day (80% estriol) • encourages cellular hypertrophy (uterus, breast) •Alter chemical constitution of con. tissue • Water retention • Reduce sodium excretion
• progesterone	• reduce smooth muscle tone • ↓ stomach motility → nausea • ↓ colon activity → delayed emptying → ↑ water reabsorb → constipation • ↓ uterine tone → prevent contraction • ↓ vascular tone → diastolic P ↓ → venous dilatation • ↑ temperature • ↑ fat storage • Induce over-breathing • Induce development of breast



Hormones	
Pituitary related	
• Prolactin	• produced by lactotrophs of ant pituitary and cells of decidua • Rc in trophoblast cells and w/in amniotic fluid • Stimulated by estrogen and sleep •Inhibited by hPL and dopamine agonist • essential of lactation
•Human growth hormone (hGH)	• production by ant pituitary supressed in pregnancy • [hGH] ↓ • hPL supress hGH
•Adrenocorticotrophic hormone (ACTH)	• placental clock theory

Pituitary gland increase 30% in weight in first pregnancy (50% in next pregnancy) → can produce headache

Hormones	
Hypothalamus related	
• Gonadotrophin-releasing hormone (GnRH) • Corticotrophin-releasing factor (CRF)	CRF → placental clock theory
Other peptides	
• Insulin-like growth factor I and II (IGF) •1,25-Dihydroxycholecalciferol •Parathyroid hormone-related peptide •Renin •Angiotensin II	• IGF regulates fetal growth • IGF I and II: produced by fetal cells (in liver) and maternal cells (in uterus) • IGF II predominated in fetal circulation • 1,25-$(OH)_2$D3: ↑ calcium absorption

Endocrine

GLUCOSE METABOLISM

ensure continuous glucose supply to fetus

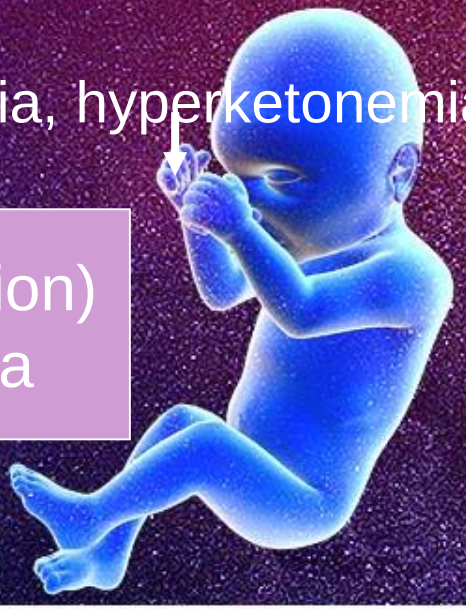
Estrogen, progesterone
Hpl, prolactin,
cortisol, FFA

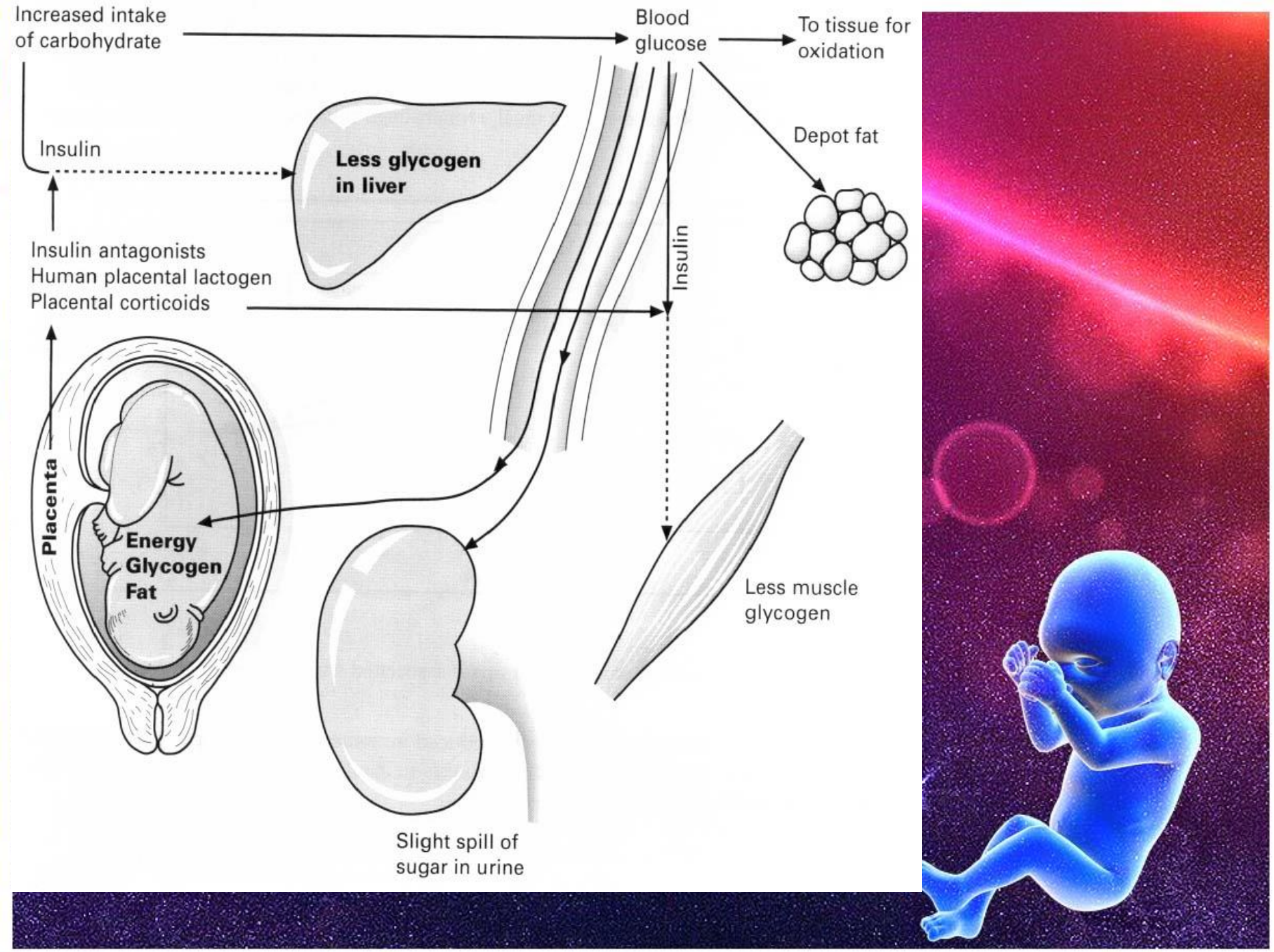
contrainsulin factors

hyperinsulinemia (resistance)

lipogenesis, hyperlipidemia, hyperketonemia

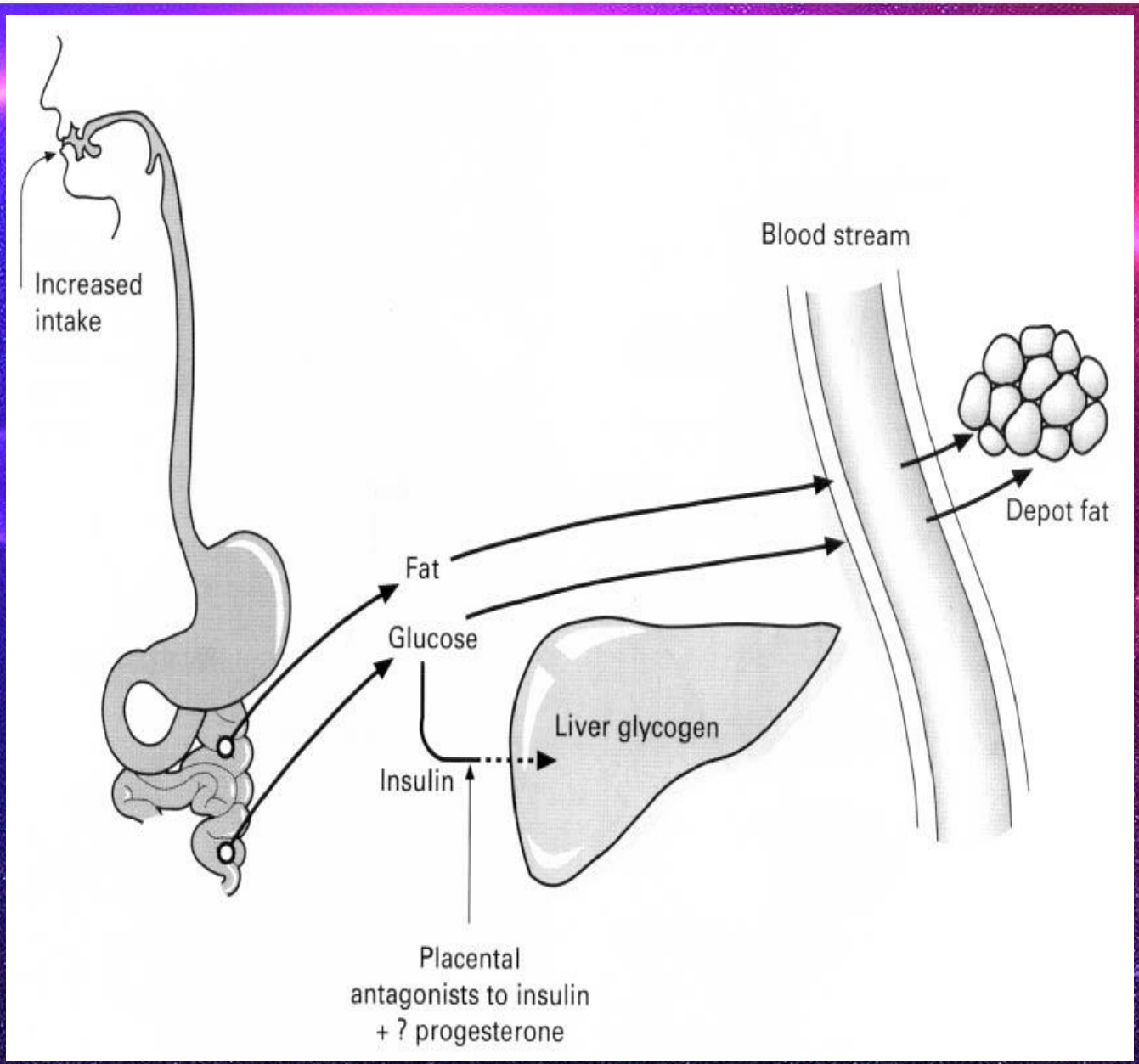
Fasting hypoglycemia (fetal consumption)
PP hyperglycemia& hyperinsulinemia




Increased intake of carbohydrate
Blood glucose
To tissue for oxidation
Insulin
Less glycogen in liver
Depot fat
Insulin antagonists
Human placental lactogen
Placental corticoids
Insulin
Placenta
Energy
Glycogen
Fat
Less muscle glycogen
Slight spill of sugar in urine

Fat metabolism

- **4kg fat** is stored by 30 weeks of gestation
- Mostly in form of depot **in abdominal wall, back and thighs.**
- Modest amount stored in **breast**
- Three points to be noted
  - Total metabolism and energy demand ↑
  - Glycogen stores are diminished
  - Although blood fat in greatly increase only a moderate amount stored


Increased intake
Blood stream
Depot fat
Fat
Glucose
Liver glycogen
Insulin
Placental antagonists to insulin + ? progesterone

Endocrinal changes

- *Pituitary*
  - anterior pituitary increases in size and activity
  - posterior pituitary releases oxytocin on the onset of labor

- *Thyroid*
  - increases in size and activity: *physiological goiter*
  - most pregnant women are euthyroid
  - thyroid binding globulin concentrations double (not other thyroid binding proteins)
  - total T3, T4 are increased (not the free T3 ,T4)

- *Parathyroid*

  increases in size and activity to regulate calcium metabolism

Adrenals

- *increases in size and activity*
- *total cortisol is increased (free cortisol unchanged)*

Skin changes

- *Pigmentation*

  due to increased melanocyte stimulating hormone:

  - linea nigra: pigmentation of the linea alba, more marked below the umbilicus
  - chloasma gravidarum: Butterfly pigmentation of the face (mask of pregnancy)

- *Striae gravidarum*

  - stretch of the abdominal wall

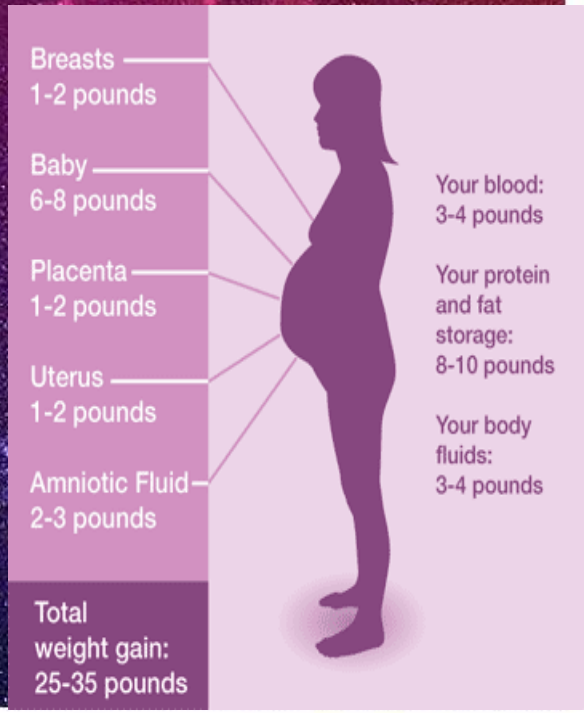
  ⇒ rupture of the subcutaneous elastic fibers

  ⇒ pink lines in flanks

  - become white after labor

Weight increase

- There is an increase weight of approximately 12.5 Kg at term
- The main increase occurs in the 2nd half of the pregnancy, 0.5 Kg/week
- Causes:
  - growth of the conceptus
  - enlargement of the maternal organs
  - maternal storage of fat
  - increase in maternal blood and interstitial fluid

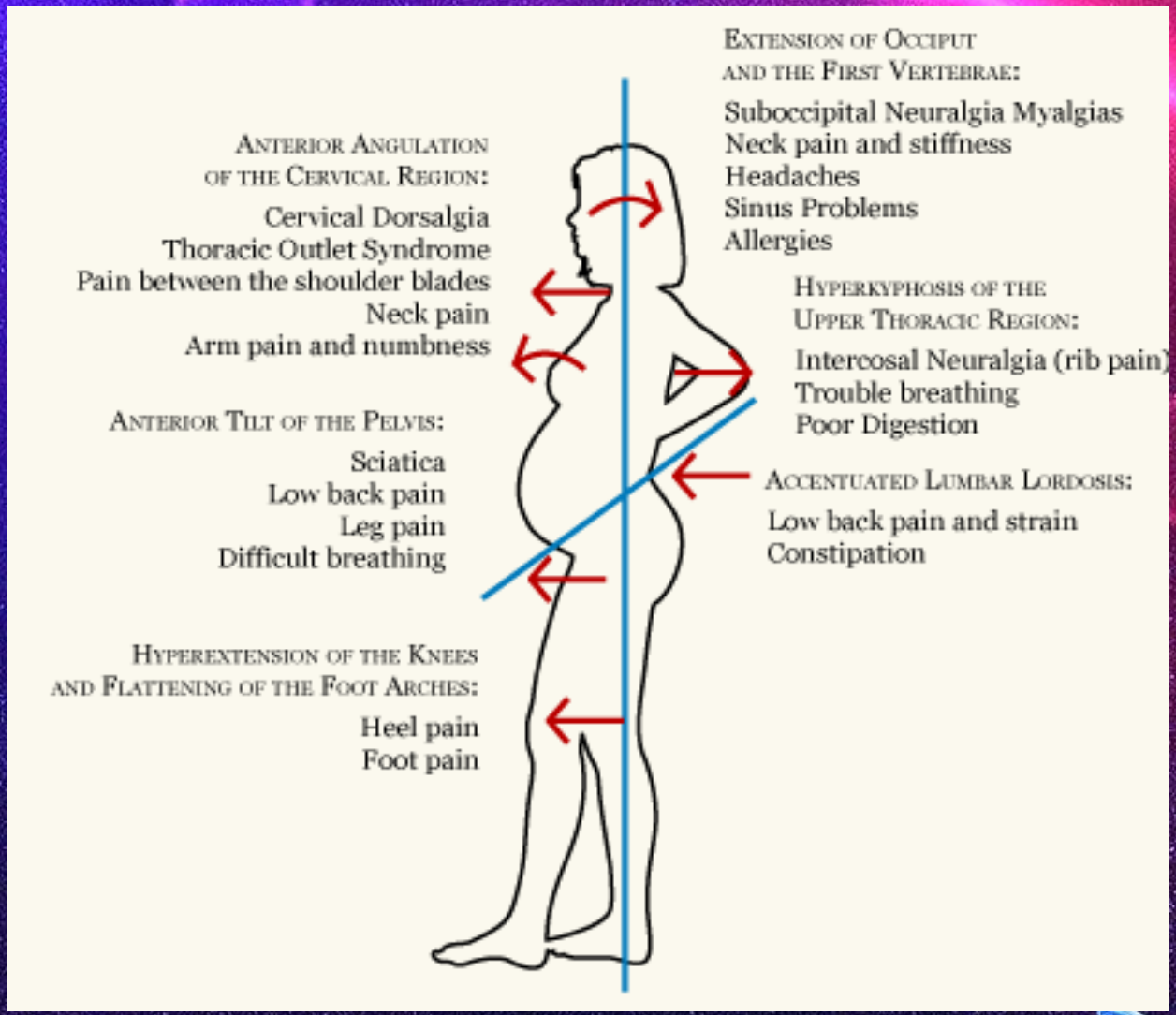


- Importance of weight checking: Single weight checking is of little value except to identify the overweight or underweight patient. Periodic and regular weight checking is of importance to detect abnormality.
- Rapid gain in weight of more than 0.5 kg (1 lb) a week or more than 2 kg (4 lb) a month in later months of pregnancy may be the early manifestation of preeclampsia and need for careful supervision.
- Stationary or falling weight may suggest intrauterine growth retardation or intrauterine death of fetus.
- Obese women are in increased risk of complications in pregnancy, labor and puerperium
- Ideally weight gain should depend on pre-pregnancy body mass index (BMI) level .
- Weight gain for a woman with normal BMI (20–26) is 11–16 kg. An obese woman (BMI > 30) should not
- gain more than 7 kg, whereas an underweight woman (BMI < 19) may be allowed to gain up to 18 kg

Skeletal changes

- Increased lumbar lordosis
- Relaxation of pelvic joints and ligaments due to progesterone and relaxin

Postural changes in pregnancy




Thank You!