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.”
Hematologic Changes in 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%)

Physiological anemia

hb

dht

Pregnancy

• To allow adequate perfusion of vital organs including placenta and fetus
• To anticipate blood loss a/w delivery
Hypercoagulable State

Increase in:
- Factor VII
- Factor VIII
- Factor IX
- Factor X
- Factor XII
- Fibrinogen

Decrease in:
- Antithrombin IIIa
- Protein S activity
- Activated Protein C resistance

ESR
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 no of PMN cells as early as 3 wks AOG
  - Neutrophilia
  - Difficult to differentiate with infection

Supports higher metabolic requirement for $O_2$ during pregnancy.
Patients without overt anemia & not given supplementation

<table>
<thead>
<tr>
<th></th>
<th>Non preg</th>
<th>1st Tri</th>
<th>2nd Tri</th>
<th>3rd Tri</th>
<th>deliv</th>
</tr>
</thead>
<tbody>
<tr>
<td>concentration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HB</td>
<td>13.0</td>
<td>12.2</td>
<td>10.9</td>
<td>11.0</td>
<td>12.4</td>
</tr>
<tr>
<td>Serum iron</td>
<td>90.0</td>
<td>106.5</td>
<td>75.3</td>
<td>56.0</td>
<td>57.1</td>
</tr>
<tr>
<td>Serum Ferritin</td>
<td>63.0</td>
<td>97.4</td>
<td>22.2</td>
<td>14.7</td>
<td>27.6</td>
</tr>
</tbody>
</table>

Wide standard deviation

Williams 21ed
Anaemia is a **serious problem** especially during pregnancy.

An estimated 136,000 maternal deaths per year in India.

- **Anaemic Mother**
  - Low Hemoglobin
  - Low Birth Weight Baby
  - **If Its a Girl?**
    - Even if baby Survives
    - prone to diseases
    - poor mental development
    - poor physical development
    - disability

- **Does not Survive**
- **Does not Survive**

High Infant Mortality Rate of around 60/1000 live births in India.
Immunosuppressive 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

Allowed fetal allograft to implant & develop

Potentially harmful T cell-mediated immune responses downregulated & components of innate immune system activated instead
Changes of the respiratory function in pregnancy

- Tidal Volume
- O2 Consumption
- Elevated Diaphragm
- Nasal Stuffiness
- Epistaxis

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

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

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

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

- Normal Wt. Gain - 20-30 lbs.
- Balanced Diet
  - Folic Acid & Iron
  - Caloric Intake by 300 cal/Day
- Need for H2O

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

- Blood Volume
- HR
- Cardiac Palpitations
- Enlargement
- Murmurs
- Pseudoanemia

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

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

- Placenta
  - Nutrients to Fetus
  - Produces - HCG, HPL

- Thyroid
  - Size & Activity
  - Basal Metabolic Rate
  - Parathyroid Activity

- Pituitary
  - Enlarges 8th Month
  - Produces FSH, LH, Thyrotropin Adrenotropin & Prolactin
Airway

Weight gain (neck, oropharyngeal 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 enlarging uterus and reconfiguration of the chest wall
- Change in lung volume and increase in pulmonary blood flow
Functional residual capacity (FRC) is our “air tank” for apnea.
Pregnant Mom has a smaller “air tank”.

Non-pregnant woman
**Oxygenation**

<table>
<thead>
<tr>
<th>Increase in 2-3 diphosphoglycerate (2,3-DPG)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Binds to deoxygenated Hb and promotes the release of O$_2$ from red cells at relatively lower levels of Hb saturation</td>
</tr>
<tr>
<td>• Increase</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Increase O$_2$ consumption (45ml/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Represents an increase of about 20% of O$_2$ consumption at rest (300 ml/min)</td>
</tr>
<tr>
<td>• 1/3 necessary for the metabolic demands of placenta and fetus</td>
</tr>
<tr>
<td>• Remainder is needed for extra metabolic work of the maternal organ</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Increase O$_2$ consumption + reduce in FRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Reduce maternal oxygen reserve</td>
</tr>
<tr>
<td>• Predisposes pregnant women to hypoxemia and hypocapnia</td>
</tr>
</tbody>
</table>
Arterial Gases

- Due to increase in progesterone which subsequently increases alveolar ventilation (through increase in tidal volume)
- Slightly increased
- These changes (O2 and CO2), facilitates gas transfer to the fetus
- Decrease in PCO2 (15-20%)
- Increase in PO2
- \( \text{HCO}_3^- \) in PCO2 activate compensatory buffering mechanism (carbonic anhydrase converts carbonic acid to HCO3, thus releasing H ions to restore pH)
- Acid-base balance
↑ Oestrogen → Nasal congestion and rhinitis → ↑ Upper airway resistance → ↑ Snoring and oxygen desaturation during pregnancy

↑ Progesterone → Respiratory stimulation → ↑ Diaphragmatic drive → ↑ Upper airway negative pressure

↑ Snoring and oxygen desaturation during pregnancy
Physiological Changes in Cardiovascular System

- Normal Weight Gain: 20-30 lbs.
- Balanced Diet
  - Folic Acid & Iron
  - Caloric Intake by 300 cal/Day
  - Need for H2O
- Lumbosacral Curve
- Altered Center of Gravity
- Duck Waddling Gait
- Blood Volume
- HR
- Cardiac Palpitations
- Enlargement
- Murmurs
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- Frequency
- Bladder Tone
- Renal Threshold for Sugar
- Glomerular Filtration
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Gastrointestinal
- Pregnancy Gingivitis
- Saliva
- Gastric Acidity
- N & V
- Tone & Motility of Smooth Muscles
- Hemorrhoids & Constipation
- Emptying of the gallbladder
- Estrogen Influence
- Hypertrophy
- Hyperplasia of Lining
- Thick white secretions

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

Respiratory
- Respiratory Changes
- Tidal Volume
- O2 Consumption
- Elevated Diaphragm
- Nasal Stuffy
- Epistaxis

Urinary-Renal
- Urinary Changes
- Vagina
- Bladder Tone
- Emptying of Bladder
- Light Urine Output
- Frequency
- Heavy Urine Output

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

Placenta
- Produces HCG, HPL

Thyroid
- Size & Activity
- Basal Metabolic Rate
- Parathyroid Activity

Enlarges 9th Month
- Produces PSH, LH, Thyrotropin
- Adrenotropin & Prolactin

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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 20-24 weeks)
- Results from hormonal changes
- Arteriovenous-shunt effect of uteroplacental circulation

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 $\rightarrow$ aortocaval compression $\rightarrow$ decrease stroke volume $\rightarrow$ supine hypotension syndrome (syncope, bradycardia, hypotension)
placental blood flow in the correct position. \textsuperscript{42} Young\textsuperscript{197} found the incidence of failed endotracheal intubation in obstetric patients to be 1:280 (i.e., 7 of 1980 cases),
Cardiac Output – Positional Effects

• Aorto-caval Compression
  - <23 wks - No change
  - 24-28 wks - Decrease by 8%
  - 29-32 wks - Decrease by 14%
  - 33-term - Decrease by 25%
**Blood Pressure**

- **Pulse pressure widen** → due to diastolic falls greater than systolic
  - Compression of vena cava by gravid uterus
  - Will cause edema and varicosities

- **Venous pressure** → progressively increase in lower extremities
  - Venous pressure will increase in lower extremities.

- **Peripheral vascular resistance** → decrease
  - Hormonal changes enhance local vasodilators such as (nitric oxide, prostacyclin, adenosine)

- **Venous pressure** → progressively increase in lower extremities

- **Peripheral vascular resistance** → decrease
  - Hormonal changes enhance local vasodilators such as (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

Splitting of first heart sound

ECG
- Left axis deviation
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Percentage of change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac output</td>
<td>40–50% Increase</td>
</tr>
<tr>
<td>Stroke volume</td>
<td>30% Increase</td>
</tr>
<tr>
<td>Heart rate</td>
<td>15–25% Increase</td>
</tr>
<tr>
<td>Intravascular volume</td>
<td>45% Increase</td>
</tr>
<tr>
<td>Systemic vascular resistance</td>
<td>20% Decrease</td>
</tr>
<tr>
<td>Systolic BP</td>
<td>Minimal</td>
</tr>
<tr>
<td>Diastolic BP</td>
<td>20% Decrease at mid-pregnancy</td>
</tr>
<tr>
<td></td>
<td>Pre-pregnant values at term</td>
</tr>
<tr>
<td>CVP</td>
<td>Unchanged</td>
</tr>
<tr>
<td>$O_2$ consumption</td>
<td>30–40% Increase</td>
</tr>
</tbody>
</table>
Gastrointestinal and Hepatobiliary

Respiratory
- ↑ Tidal Volume
- ↑ O2 Consumption
- Elevated Diaphragm
- Nasal Stiffness
- Epistaxis

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

Gastrointestinal
- Pregnancy Gingivitis
- Saliva
- Gastric Acidity
- N & V
- ↓ Tone & Motility of Smooth Muscles
- Hemorrhoids & Constipation
- ↓ Emptying of the gallbladder
  - Estrogen Influence
  - Hypertrophy
  - Hyperplasia of Lining
  - ↑ Thick white secretions

Cardiovascular
- Normal Wt. Gain - 20-30 lbs.
- Balanced Diet
  - Folic Acid & Iron
  - Caloric Intake by 300 cal/Day
  - ↑ Need for H2O

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

Urinary-Renal
- ↑ Blood Volume
- ↑ HR
- ↑ Cardiac Palpitations
- Enlargement
- Murmurs
- Pseudoanemia

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

Endocrine
- Placenta
  - ↑ Size & Activity
  - Basal Metabolic Rate
  - Parathyroid Activity
- Enlarges 9th Month
  - Produces PSH, LH, Thyrotropin
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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
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.
- glycosuria 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
Physiological changes in reproductive organs:

- **Respiratory**
  - ↑ Tidal Volume
  - ↑ O2 Consumption
  - Elevated Diaphragm
  - Nasal Stuffiness
  - Epistaxis

- **Nutrition**
  - Balanced Diet
  - ↑ Folic Acid & Iron
  - ↑ Caloric intake by 300 cal/day
  - ↑ Need for H2O

- **Musculoskeletal**
  - ↑ Lumbosacral Curve
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- **Cardiovascular**
  - ↑ Blood Volume
  - ↑ HR
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- **Breasts**
  - ↑ Breast Size
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  - Thin watery secretion

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

- **Placenta**
  - Nutrients to Fetus
  - Placenta - HCG, HPL
  -茸↑ Basal Metabolic Rate
  - Parathyroid Activity

- **Endocrine**
  - Enlarges 3rd Month
  - Produces PSH, LH, Thyrotropin
  - Adrenocorticin & Prolactin

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  - ↑ Skin Pigmentation
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- **Normal Wt. Gain** - 20-30 lbs.

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## Uterus

<table>
<thead>
<tr>
<th></th>
<th>Non Pregnant Uterus</th>
<th>Pregnant Uterus</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Muscular Structure</strong></td>
<td>Almost Solid</td>
<td>Relatively thin – walled (≤ 1.5 cm)</td>
</tr>
<tr>
<td><strong>weight</strong></td>
<td>≈ 70 gm</td>
<td>Approx. 1100 gm by the end of pregnancy</td>
</tr>
<tr>
<td><strong>Volume</strong></td>
<td>≤ 10 mL</td>
<td>≈ 5 L by the end of pregnancy</td>
</tr>
</tbody>
</table>
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.
• ↑ estradiol + progesterone → hyperplasia + hypertrophy of myometrial cells
• Uterus weight 50-60g → 1000g (at term)
• Early:
  • uterine growth independent of the growing fetus
  • Later on hypertrophy > hyperplasia
• Muscle fibres ↑ in length x15
• Uterine arteries undergo hypertrophy
<table>
<thead>
<tr>
<th>Weeks</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>16 wks</td>
<td>3 finger widths above symphysis</td>
</tr>
<tr>
<td>20 wks</td>
<td>3 finger widths below umbilicus</td>
</tr>
<tr>
<td>24 wks</td>
<td>at umbilicus</td>
</tr>
<tr>
<td>28 wks</td>
<td>3 finger widths above umbilicus</td>
</tr>
<tr>
<td>32 wks</td>
<td>between umbilicus and xyphoid process</td>
</tr>
<tr>
<td>36 wks</td>
<td>at costal arch</td>
</tr>
<tr>
<td>40 wks</td>
<td>1-2 finger widths below costal arch</td>
</tr>
</tbody>
</table>
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 $\rightarrow$ ↑ number of glandular ducts
- Progesterone + hPL $\rightarrow$ ↑ number of gland alveoli
- hPL $\rightarrow$ stimulate synthesis of alveolar casein + lactoglobulin + lactalbumin
- ↑ [serum prolactin] in pregnancy $\rightarrow$ antagonized by estrogen $\rightarrow$ 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 $\rightarrow$ prolactin $\rightarrow$ alveoli distended by milk $\rightarrow$ breast engorgement

• oxytocin $\rightarrow$ myoepithelial cells surrounding alveoli and small ducts contract $\rightarrow$ squeezes milk into larger ducts and subareolar reservoirs

• Oxytocin $\rightarrow$ inhibit dopamine $\rightarrow$ ↑ prolactin $\rightarrow$ 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.
Endocrinological Changes in Pregnancy

- **Respiratory**
  - ↑ Tidal Volume
  - ↑ O₂ Consumption
  - Elevated Diaphragm
  - Nasal Stuffiness
  - Epistaxis

- **Nutrition**
  - Balanced Diet
  - Folic Acid & Iron
  - Caloric intake by 300 cal/day
  - ↑ Need for H₂O

- **Musculoskeletal**
  - ↑ Lumbar Sacral Curve
  - Altered Center of Gravity
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  - Frequency
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- **Integumentary**
  - ↑ Skin Pigmentation
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- **Endocrine**
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  - Pituitary
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- **Endocrine**
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© 2007 Nursing Education Consultants, Inc.
- Peptide and steroid hormones produced by
  - Non-pregnant: endocrine glands
  - Pregnant: intrauterine tissues
<table>
<thead>
<tr>
<th>Hormones</th>
<th>Pregnancy specific</th>
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<tbody>
<tr>
<td></td>
<td><strong>• Human chorionic gonadotrophin (hCG)</strong></td>
</tr>
<tr>
<td></td>
<td>• α and β (pregnancy specific; produced by trophoblast → detectable w/in days of implantation)</td>
</tr>
<tr>
<td></td>
<td>• production influenced by leukemia inhibitory factor (LIF) and isoform of GnRH</td>
</tr>
<tr>
<td></td>
<td>• Maintain corpus luteum’s fx</td>
</tr>
<tr>
<td></td>
<td>• peak values @10w → progesterone by placenta → ↓ to plateau @&gt;12w</td>
</tr>
<tr>
<td></td>
<td>• α hCG ≈ α of LH, FSH, TSH → supress FSH and LH secretion by ant. pituitary</td>
</tr>
<tr>
<td></td>
<td><strong>• Human placental lactogen (hPL)</strong></td>
</tr>
<tr>
<td></td>
<td>• Produced by placenta</td>
</tr>
<tr>
<td></td>
<td>• partial homology with prolactin and hGH</td>
</tr>
<tr>
<td>Hormones</td>
<td>Steroids</td>
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<tr>
<td>----------</td>
<td>---------</td>
</tr>
<tr>
<td>• produced by placenta and fetus</td>
<td></td>
</tr>
<tr>
<td>• Concentration ↑ earliest weeks of pregnancy → plateau</td>
<td></td>
</tr>
<tr>
<td>• Effects upon myometrium and (+prolactin) breast tissue</td>
<td></td>
</tr>
<tr>
<td>• effects on smooth muscle of vascular tree, GIT, GUT</td>
<td></td>
</tr>
<tr>
<td>• estrogen</td>
<td>• max ↑ 30-40mg/day (80% estriol)</td>
</tr>
<tr>
<td></td>
<td>• encourages cellular hypertrophy (uterus, breast)</td>
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<tr>
<td></td>
<td>• Alter chemical constitution of con. tissue</td>
</tr>
<tr>
<td></td>
<td>• Water retention</td>
</tr>
<tr>
<td></td>
<td>• Reduce sodium excretion</td>
</tr>
<tr>
<td>• progesterone</td>
<td>• reduce smooth muscle tone</td>
</tr>
<tr>
<td></td>
<td>• ↓ stomach motility → nausea</td>
</tr>
<tr>
<td></td>
<td>• ↓ colon activity → delayed emptying → ↑ water reabsorb → constipation</td>
</tr>
<tr>
<td></td>
<td>• ↓ uterine tone → prevent contraction</td>
</tr>
<tr>
<td></td>
<td>• ↓ vascular tone → diastolic P ↓ → venous dilatation</td>
</tr>
<tr>
<td></td>
<td>• ↑ temperature</td>
</tr>
<tr>
<td></td>
<td>• ↑ fat storage</td>
</tr>
<tr>
<td></td>
<td>• Induce over-breathing</td>
</tr>
<tr>
<td></td>
<td>• Induce development of breast</td>
</tr>
<tr>
<td>Hormones</td>
<td>Pituitary related</td>
</tr>
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<td>----------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Pituitary related</strong></td>
<td></td>
</tr>
<tr>
<td>• Prolactin</td>
<td>• produced by lactotrophs of ant pituitary and cells of decidua</td>
</tr>
<tr>
<td>• Prolactin</td>
<td>• Rc in trophoblast cells and w/in amniotic fluid</td>
</tr>
<tr>
<td>• Prolactin</td>
<td>• Stimulated by estrogen and sleep</td>
</tr>
<tr>
<td>• Prolactin</td>
<td>• Inhibited by hPL and dopamine agonist</td>
</tr>
<tr>
<td>• Human growth hormone (hGH)</td>
<td>• essential of lactation</td>
</tr>
<tr>
<td>• Human growth hormone (hGH)</td>
<td></td>
</tr>
<tr>
<td>• Human growth hormone (hGH)</td>
<td>• production by ant pituitary supressed in pregnancy</td>
</tr>
<tr>
<td>• Human growth hormone (hGH)</td>
<td>• [hGH] ↓</td>
</tr>
<tr>
<td>• Adrenocorticotropic hormone (ACTH)</td>
<td>• hPL supress hGH</td>
</tr>
<tr>
<td>• Adrenocorticotropic hormone (ACTH)</td>
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</tbody>
</table>

Pituitary gland increase 30% in weight in first pregnancy (50% in next pregnancy) → can produce headache
<table>
<thead>
<tr>
<th>Hormones</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypothalamus related</strong></td>
<td></td>
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</tbody>
</table>
|  • 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)$_2$D$_3$: ↑ calcium absorption |
Endocrine

GLUCOSE METABOLISM

Estrogen, progesterone, Hpl, prolactin, cortisol, FFA

contrainsulin factors

hyperinsulinemia (resistance)

lipogenesis, hyperlipidemia, hyperketonemia

ensure continuous glucose supply to fetus

Fasting hypoglycemia (fetal consumption)
PP hyperglycemia& hyperinsulinemia
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

Fat
Glucose
Liver glycogen

Insulin

Depot fat

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

[Diagram showing weight gain components:]
- Breasts: 1-2 pounds
- Baby: 6-8 pounds
- Placenta: 1-2 pounds
- Uterus: 1-2 pounds
- Amniotic Fluid: 2-3 pounds
- Total weight gain: 25-35 pounds
- Your blood: 3-4 pounds
- Your protein and fat storage: 8-10 pounds
- Your body fluids: 3-4 pounds
Skeletal changes

- Increased lumbar lordosis
- Relaxation of pelvic joints and ligaments due to progesterone and relaxin
Postural changes in pregnancy

- **Anterior Angulation of the Cervical Region:**
  - Cervical Dorsalgia
  - Thoracic Outlet Syndrome
  - Pain between the shoulder blades
  - Neck pain
  - Arm pain and numbness

- **Extension of Occiput and the First Vertebrae:**
  - Suboccipital Neuralgia Myalgias
  - Neck pain and stiffness
  - Headaches
  - Sinus Problems
  - Allergies

- **Hyperkyphosis of the Upper Thoracic Region:**
  - Intercosal Neuralgia (rib pain)
  - Trouble breathing
  - Poor Digestion

- **Accentuated Lumbar Lordosis:**
  - Low back pain and strain
  - Constipation

- **Hyperextension of the Knees and Flattening of the Foot Arches:**
  - Heel pain
  - Foot pain
Thank You!