Session Plan

- Pregnancy and Development
- The embryonic period
- The Foetal period
- Prenatal diagnostic tests
- Maternal changes during pregnancy
- Labour
- Adjustments of the infant at birth
- Physiology of lactation
Pregnancy and Development

- Normal foetal development and inheritance: determines homeostasis of a developing embryo and foetus and the subsequent birth of a healthy child.

- Pregnancy: a sequence of events that begins with fertilization; proceeds to implantation, embryonic development, and foetal development; and ideally ends with birth about 38 or 40 weeks after the last menstrual period.
Pregnancy and Development

- **Gestation period**: fertilization to birth (38 weeks)

- **Prenatal period**: before birth
  - **Embryonic development**: From fertilization to 8 weeks (embryo)
  - **Fetal development**: from 9 weeks until birth (fetus)

- **Neonatal period**: first 42 days after birth
The embryonic period

- **Embryonic Period**: Development from fertilization to 8 weeks (embryo).

- The most critical stage of development, during which the rudiments of all the major organ systems appear.

- The developing embryo is the most vulnerable to the effects of drugs, radiation, and microbes.
Fertilization

- **Fertilization**: Genetic material from the haploid (n) sperm and haploid (n) ovum merges to form a single diploid (2n) zygote, the first embryonic stage.
  - Usually occurs in the uterine tube
  - Usually within 12 to 24 hours after ovulation.
  - Oocyte otherwise usually dies in 24 hours.
Events Before Fertilization

- Secondary oocyte transport towards the uterus
  - Peristalsis of uterine tube
  - Movement of cilia
  - Oocyte releases chemical attractants

- Sperm swim towards the oocyte
  - Flagella
  - Prostaglandins (within the semen) stimulate uterine contractions that help propel sperm

- Capacitation of sperm within the female reproductive tract
  - Acrosomal membrane becomes fragile
Events of Fertilization

**PATH OF SPERM CELL:**
- Corona radiata
- Zona pellucida
- Plasma membrane of secondary oocyte
- Cytoplasm of secondary oocyte

**Sperm penetrate secondary oocyte**
- Once sperm penetrate the secondary oocyte’s corona radiata, they enter the area of the zona pellucida.
- A glycoprotein in the zona pellucida binds to sperm and triggers the release of digesting enzymes.
- These enzymes help to digest a path for the sperm to reach the plasma membrane of the secondary oocyte.
- The first sperm to penetrate the entire zona pellucida fuses with the secondary oocyte (syngamy).
- Polyspermy is prevented by changes in the membrane of the secondary oocyte triggered by syngamy.
Events of Fertilization

- **Meiosis II of secondary oocyte completes** once a sperm cell enters the secondary oocyte.
  - A larger ovum (mature egg) and a smaller second polar body are formed
    - Second polar body fragments and disintegrates
- **Single diploid nucleus** is formed by fusion of the male and female pronuclei.
- **Zygote: A Fertilized ovum (2n)**
  - Surrounded by Zona Pellucida
Cleavage of the Zygote

- **Cleavage of the Zygote**: the rapid mitotic division of the zygote, starting the first week of development
- **Blastomeres**: progressively smaller cells produced by cleavage.

(a) Cleavage of zygote, two-cell stage (day 1)
Morula and Blastocyst

- **Morula**: a solid mass of cells produced by successive cleavages after 3-4 days of fertilization
  - Enters the uterine cavity
- **Blastocyst**: a hollow ball of cells developed from morula a day later.
  - **Trophoblast**: the future outer chorionic sac
  - **Embryoblast**: the future embryo
  - **Blastocoel**: Blastocyst cavity
Implantation

- **Implantation:** The attachment of the blastocyst to the endometrium 6–7 days after fertilization
  - Blastocyst contains two distinct cell types:
  - Trophoblast and Embryoblast

(a) External view of blastocyst, about 6 days after fertilization
(b) Frontal section through endometrium of uterus and blastocyst, about 6 days after fertilization
From Fertilization to Implantation

- **The decidua**: The modified portion of the endometrium after implantation

1. **Fertilization** (occurs within 12–24 hours after ovulation)
2. **Cleavage** (first cleavage completed about 30 hours after fertilization)
3. **Morula** (3–4 days after fertilization)
4. **Blastocyst** (4½–5 days after fertilization)
5. **Implantation** (occurs about 6 days after fertilization)
Development of Trophoblast & Embryoblast

- The trophoblast: develops the chorion
- Secrete hCG that helps the corpus luteum maintain the uterine lining.
Development of Embryoblast

- **The Embryoblast**: differentiates into two cell types
  - Hypoblast (primitive endoderm)
  - Epiblast (primitive ectoderm)

- This forms the Embryonic disc that eventually forms the Amnion and Amnionic Sac.
Extraembryonic Membranes

- **Amnion**: the innermost - forms a protecting “bag of waters” (amniotic cavity) around the embryo
- **Yolk sac**: becomes the site of early blood formation
- **Allantois**: helps form the umbilical cord and development of the urinary bladder
- **Chorion**: is the outermost - it forms the fetal portion of the placenta and takes over production of hCG which saves the corpus luteum from degeneration and sustains its secretion of progesterone and estrogens
Extraembryonic Membranes

(c) Frontal section through endometrium of uterus showing blastocyst, about 12 days after fertilization
Gastrulation

- **Gastrulation** involves the formation of the three tissue types that will eventually form most tissue and organs.
- Occurs 15 days after fertilization.
- Consists of **three primary germ layers**:
  - **Endoderm** → epithelial lining of GI and respiratory systems
  - **Mesoderm** → muscle, bone and other connective tissues
  - **Ectoderm** → epidermis of skin and nervous system
Gastrulation

Trilaminar embryonic disc
Neurulation

- **Neural tube:** develop into primary and secondary brain vesicles.

### TABLE 14.1

<table>
<thead>
<tr>
<th>Development of the Brain</th>
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<tbody>
<tr>
<td><strong>Three primary brain vesicles</strong></td>
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<tr>
<td>Wall</td>
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<tr>
<td>PROSENCEPHALON (FOREBRAIN)</td>
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<tr>
<td>MESENCEPHALON (MIDBRAIN)</td>
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<tr>
<td>RHOMBENCEPHALON (HINDBRAIN)</td>
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<td><strong>Five secondary brain vesicles</strong></td>
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<tr>
<td>Wall</td>
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<tr>
<td>Cavity</td>
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<td>TELENCEPHALON</td>
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<td>DIENCEPHALON</td>
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<td>MESENCEPHALON</td>
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<td>METENCEPHALON</td>
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<td>MYELENCEPHALON</td>
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<td><strong>Adult structures derived from:</strong></td>
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<tr>
<td>Walls</td>
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<tr>
<td>Cavities</td>
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<tr>
<td>Cerebrum</td>
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<tr>
<td>Thalamus, hypothalamus, and epithalamus</td>
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<tr>
<td>Midbrain</td>
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<tr>
<td>Pons</td>
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<tr>
<td>Cerebellum</td>
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<td>Medulla oblongata</td>
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<td>Lateral ventricles</td>
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<tr>
<td>Third ventricle</td>
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<tr>
<td>Aqueduct of the midbrain</td>
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<tr>
<td>Upper part of fourth ventricle</td>
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<tr>
<td>Lower part of fourth ventricle</td>
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<tr>
<td>Five-week embryo</td>
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Angiogenesis

- **Angiogenesis**: Blood vessel formation,
  - begins in mesodermal cells called angioblasts.
- **The heart**: forms from mesodermal cells called the cardiogenic area.
  - By the end of the third week, theprimitive heart beats and circulates blood.
Organogenesis

- **Organogenesis**: Formation of body organs and systems
  - mainly occurs during fourth through eighth weeks of embryonic development

- **During fourth week**: embryonic folding, The primitive gut, pharyngeal arches, and limb buds develop, Eyes and ears begin to develop, tail forms, and body systems begin to form.

- **During the fifth week**: rapid brain development and considerable head growth.
Organogenesis

- **During the sixth week**: the head grows even larger in relation to the trunk, substantial limb growth, the neck and trunk begin to straighten, and the heart becomes four-chambered.

- **During the seventh week**: regions of the limbs become distinct and the digits appear.

- **By the end of the eighth week**: all regions of the limbs are apparent, the digits are distinct, the eyelids come together, the tail disappears, and the external genitals begin to differentiate.
Organogenesis

(b) Four-week embryo showing development of free limb buds

(c) Six-week embryo showing development of hand and foot plates

(d) Seven-week embryo showing development of arm, forearm, and hand in free upper limb bud and thigh, leg, and foot in free lower limb bud

(e) Eight-week embryo in which free limb buds have developed into free upper and lower limbs

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Fetal Period

- **The fetal period**: From the ninth week until birth
- **Growth and differentiation** of tissues and organs developed during the embryonic period.
- **Very few new structures appear**;
  - The foetus is less vulnerable to the damaging effect of drugs, radiation, and microbes
- **Remarkable foetal growth**: half of the full-term weight is added during just the last 2.5 months of intrauterine life.
- By week 34 the foetus usually assumes an upside-down position in preparation for labour and delivery
Stages of Development

Fetal development

DEVELOPMENTAL STAGES

During gestation, developmental processes change a single celled zygote to a six to eight pound, 20 inch baby.
Chorionic villi, Umbilical cord and Placenta

- **Chorionic villi:** projections of the chorion, connect to the embryonic heart so that maternal and foetal blood vessels are brought into close proximity, allowing the exchange of nutrients and wastes between maternal and foetal blood.

- **Umbilical cord:** The actual connection between the placenta and embryo, and later the foetus.
  - consists of two umbilical arteries, and one umbilical vein

- **Placenta:** formed by the beginning of 12th week
  - The foetal portion: formed by the chorionic villi of the chorion
  - The maternal portion: formed by the decidua basalis of the endometrium
Chorionic villi, Umbilical cord and Placenta
Chorionic villi, Umbilical cord and Placenta

- Functions of placenta:
  - **Site of exchange of nutrients** and wastes between the mother and foetus.
  - **Produces hormones** needed to sustain the pregnancy.
  - **Stores nutrients** such as carbohydrates, proteins, calcium, and iron.
  - **Protective barrier**
    - But AIDS, German measles, chickenpox, measles, encephalitis, and poliomyelitis, Teratogens (Many drugs, alcohol) can cross.
Hormones of Pregnancy

Chorionic hormone:

- **Human chorionic gonadotropin (hCG):**
  - Secreted from day 8 until 4 months secretes hCG
  - Stimulate the corpus luteum for oestrogens and progesterone secretion
  - During the fourth and fifth months the hCG level decreases sharply
    - Placenta takes over the hormonal secretion of the corpus luteum.
Hormones of Pregnancy

Placental Hormones:

- **Progesterone and oestrogen**: by 4th month
  - corpus luteum is no longer important

- **Relaxin**: Produced first by the corpus luteum of the ovary and later by the placenta

- **Human chorionic somatomammotropin (hCS) or human placental lactogen (hPL)**: Reaching maximum levels after 32 weeks

- **Corticotropin-releasing hormone (CRH)**: Begins at about 12 weeks and increases enormously toward the end of pregnancy
Hormones of Pregnancy

- **Human chorionic gonadotropin (hCG)**: Rescues corpus luteum from degeneration until the 3rd or 4th month of pregnancy.
  - Maintains endometrium of uterus during pregnancy
  - Helps prepare mammary glands for lactation
  - Prepares mother's body for birth of baby

- **Relaxin**: Increases flexibility of pubic symphysis.
  - Helps dilate uterine cervix during labor

- **Human chorionic somatomammotropin (hCS)**: Helps prepare mammary glands for lactation.
  - Enhances growth by increasing protein synthesis
  - Decreases glucose use and increases fatty acid use for ATP production

- **Corticotropin-releasing hormone**: Establishes the timing of birth.
  - Increases secretion of cortisol

(a) Sources and functions of hormones
Anatomical and Physiological Changes During Pregnancy

- Many women suffer morning sickness during the first few months of pregnancy, until their systems adapt to elevated levels of oestrogen and progesterone.

- The uterus continuously enlarges, filling first the pelvic and then the abdominal cavity, displacing and compressing a number of structures.

- Heartburn often results from the displacement of the oesophagus, and constipation may result due to the decreased motility of the digestive tract.
Anatomical and Physiological Changes During Pregnancy

- Pressure on bladder causing changes in frequency and urgency.

- Compression of vena cava causing varicose veins and oedema in the legs.

- Compression of renal vessels causing renal hypertension.

- Vital capacity and respiratory rate increases, but there is a decrease in residual volume, and many women suffer from difficult breathing, or dyspnoea.
Anatomical and Physiological Changes During Pregnancy

- **Blood volume increases** to accommodate the needs of the foetus, so blood pressure and **heart rate rise**, increasing cardiac output.

- The kidneys produce **more urine**, since there is additional foetal metabolic waste.

- Skin may display **increased pigmentation**.

- **Weight gain**; increased protein, fat, and mineral storage; marked breast enlargement; and **lower back pain**.
Labour

- **Labour/Parturition**: is the process of giving birth, and usually occurs within 15 days of the calculated due date, which is 280 days from the last menstrual period.

- **Puerperium**: a period of time after delivery of the baby and placenta
  - about six weeks after delivery
  - reproductive organs and maternal physiology return to the prepregnancy state
  - uterus undergoes involution
  - uterine discharge (lochia) of blood and serous fluid for two to four weeks after delivery.
Initiation of Labour

- **Oestrogen levels peak**: stimulate uterus to form abundant oxytocin receptors, antagonizing the quieting effect of progesterone on uterine muscle.

- **Oxytocin production by foetal cells**: promotes the release of prostaglandins from the placenta, and further stimulates uterine contraction.

- **Increasing emotional and physical stresses**: activate the mother’s hypothalamus, which signals the release of oxytocin.
Initiation of Labour

Marieb, & Hoehn, 2011
Labor

- **Labour** begins when uterine contractions occur at regular intervals, usually producing pain.
  - dilation of the cervix
  - “show” (discharge of blood-containing mucus from the cervical canal)
  - other signs include localization of pain in the back, which in intensified by walking
Stages of Labor

- **Dilation**
  - 6 to 12 hours
  - regular contractions of the uterus
  - rupture of amniotic sac and dilation of cervix (10cm)
Stages of Labour

- Expulsion
  - 10 minutes to several hours
  - baby moves through birth canal
Stages of Labor

- **Placental**
  - 30 minutes
  - afterbirth is expelled by uterine contractions
  - constrict blood vessels that were torn
  - reduce the possibility of hemorrhage
Adjustments of the Infant at Birth

- Respiratory System:
  - After cord is cut, increased CO$_2$ levels in blood
  - Respiratory center in the medulla is stimulated
  - Causes muscular contractions and first breath
  - Breathing rate begins at 45 per minute for the first 2 weeks and declines to reach normal rate
Fetal Cardiovascular changes at Birth

(a) Fetal circulation

(b) Circulation at birth

Oxygenated blood
Mixed oxygenated and deoxygenated blood
Deoxygenated blood
Adjustments of the Infant at Birth

- **Cardiovascular System**
  - **Foramen ovale**: closes and converted the fossa ovalis at the moment of birth
    - diverts deoxygenated blood to the lungs for the first time.
  - **Ductus arteriosus** closes and converted to ligamentum arteriosum
  - **Umbilical vein** closes and converted to ligamentum venosum
  - **Pulse rate** slows down (120 to 160 bpm at birth)
Adjustments of the Infant at Birth

- **Cardiovascular System**
  - The greater need for oxygen stimulates an increase in the rate of erythrocyte and hemoglobin production. This increase usually lasts for only a few days.

- The white blood cell count at birth is very high, sometimes
  - 45,000 cells per cubic millimeter, but this decreases rapidly by the seventh day.
Physiology of Lactation

- **Lactation** = production and release of milk
- **Prolactin** from anterior pituitary increases during pregnancy
  - progesterone inhibits effect of prolactin until delivery
  - After delivery, progesterone levels drop
- Suckling increases the release of prolactin and oxytocin (milk ejection reflex)
  - Nursing causes neural feedback to the hypothalamus and the anterior pituitary gland → stimulates the production of PRF (prolactin releasing factor) and PRL → mammary glands prepare for the next nursing period.
- If suckling stops, milk secretion stops
Milk Ejection Reflex

- Oxytocin cause release of milk into mammary ducts
- Stimulation of touching nipple causes hypothalamus to release oxytocin
- Oxytocin causes contraction of myoepithelial cells
- Milk moved from alveoli into mammary ducts
- Oxytocin release by other stimuli
  - hearing a baby’s cry or touching the genitals

Positive feedback: milk availability encourages continued suckling, so touch sensations on nipple and oxytocin release continue
Physiology of Lactation

- During late pregnancy and the first few days after birth, the mammary glands secrete a cloudy fluid called colostrum.
  - not as nutritious as true milk but serves adequately until the appearance of true milk on about the fourth postpartum day.
- Colostrum and maternal milk contain antibodies that protect the infant during the first few months of life.
- Milk secretion can continue for several years if the child continues to suckle.
Benefits of Breast-feeding

- **To mother:**
  - Prevents the occurrence of female ovarian cycles for the first few months following delivery if the frequency of nursing is about 8-10 times a day. However, there is no guarantee of contraception.
  
  - Stimulates the release of oxytocin and helps promote expulsion of the placenta and the uterus to regain its smaller size.
Benefits of Breast-feeding

- To infant:
  - Faster and better absorption of the “right” nutrients
  - Beneficial cells
    - neutrophils help ingest bacteria in baby’s gut
    - macrophages produce lysozymes
    - plasma cells provides antibodies prevent gastroenteritis
  - Decreased incidence of diseases later in life
    - reduction in allergies, respiratory and GI infections, ear infections and diarrhea
  - Parent-child bonding
Readings and Resources

- Harris, P, Nagy, S & Vardaxis, N 2010, Mosby’s Dictionary of Medicine, Nursing and Health Professions, 2nd edn, Mosby Elsevier.
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