

3. Fetal membranes. Placenta. Growth. Delivery.

Fetal membranes in amniots (reptiles, birds, mammals) – adaptation to terrestrial life

- **amnion** = extraembryonic mesoderm + amniotic ectoderm from the epiblast
 - the inner fetal membrane
 - surrounds the amniotic cavity filled with amniotic fluid
 - amniotic epithelium continues to the umbilical cord to the fetal epidermis
 - amniotic fluid
 - shock absorber
 - prevents adherence of the embryo to the amnion
 - allows for fetal movements
 - helps to dilate the cervical canal during birth
 - the amniotic fluid (AF)
 - week 10: 30 ml; week 20. 450 ml; week 37 800-1000 ml
 - replaced every 3 hours
 - from amniotic blood vessels
 - since month 5 the fetus urinates into AF and swallows the AF
 - polyhydramnios > 1500-2000 ml (GI atresia)
 - oligohydramnios < 400 ml (renal agenesis, polycystic kidney; amniotic bands → ring constrictions, deformations, limb amputation)
 - preterm rupture of the amnion → preterm birth, ascendant infection
- **allantois** = growing from the yolk sac towards the connecting stalk
 - surrounded by the primary mesoderm, where the extraembryonic umbilical circulation develops
 - urachus = a duct between the fetal urinary bladder and the yolk sac (→ median umbilical ligament)
 - in placental mammals its importance in gas exchange and handling waste products is lost
- **chorion** = syncytiotrophoblast + cytotrophoblast + primary (extraembryonic) mesoderm
 - chorion frondosum with villi: chorionic plate on the embryonic pole facing the decidua basalis
 - primary chorionic villi = syncytiotrophoblast + cytotrophoblast
 - secondary villi = syncytiotrophoblast + cytotrophoblast + extraembryonic mesenchyme
 - tertiary villi = syncytiotrophoblast + cytotrophoblast + extraembryonic mesenchyme + blood vessels
 - chorion laeve has no villi, on abembryonic pole facing the decidua capsularis
 - chorionic cavity = temporary space within the extraembryonic coelom
 - contains the yolk sac
 - disappears during the amniotic expansion → chorion grows together with the amnion → amniochorionic membrane

Umbilical cord

- primitive umbilical ring = amnioectodermal junction
- in week 5 it contains

- the connecting stalk: allantois, umbilical arteries and left umbilical vein (prehepatic right umbilical vein atrophies at week 6)
 - the omphaloenteric duct (yolk duct, vitelline duct) connecting the gut with the secondary yolk sac; accompanied by vitelline vessels
 - extraembryonic coelom cavity
- expanding amnion → amnion surrounds the connecting stalk and the vitelline duct → primitive umbilical cord
 - week 6-10: physiological umbilical hernia of the intestinal loops
 - since week 12: extraembryonic coelom, allantois and vitelline duct are obliterated
 - extraembryonic mesoderm → Wharton's jelly (rich in glycosaminoglycans)
 - at birth: 2 cm in diameter, 50-60 cm long; spiral umbilical vessels
 - Doppler USG for assessing fetoplacental circulation
 - abnormalities
 - too long → encircling the neck
 - too short → placental abruption at birth
 - missing umbilical artery is linked to cardiac defects

Placenta

- a feto-maternal interface
- a part of the fetoplacental unit
- fetal portion = chorion frondosum (chorionic plate and villi)
- maternal portion = decidua basalis and decidual plate (decidua = endometrium during pregnancy)
- intervillous space between the chorionic and decidual plates
 - up to 150 ml of maternal blood, replenished 3-4× per minute
 - lined with syncytiotrophoblast cells
- since month 4 decidual septa separate the placenta into 15-20 cotyledons
- cotyledons still retain vascular anastomoses
- placental villi
 - anchoring (attached to the decidual plate)
 - free (terminal villi, project to the intervillous space)
 - immature (proliferating trophoblast)
- placenta barrier is hemochorial
 - since week 4: syncytiotrophoblast + cytotrophoblast + primary mesoderm + endothelium
 - since month 4: direct contacts between the capillaries and syncytium (cytotrophoblast cells degenerate)
 - permeability of the placenta
 - nutrients, metabolites, gases, hormones
 - maternal IgG immunoglobulin (→ passive immunization)
 - pathogens (rubella, CMV, Coxsackie, varicella, measles, poliomyelitis virus)
- placental circulation
 - spiral arteries of the decidua → intervillous spaces in the cotyledons → maternal blood bathes the surface of the villi → the blood flows back to the endometrial veins
 - surface area 4 m² → 14 m² in full-term placenta

Function of the placenta

- exchange of gases and metabolic products
 - simple diffusion (mainly apolar and lipophilic molecules, steroids, CO₂, O₂)
 - osmosis – water through the aquaporin channels
 - simplified diffusion (glucose, lactate)
 - active transport (aminoacids)
 - vesicular transport (endo- exocytosis, transcytosis)
 - metabolic conversion and resynthesis (lipids)
- hormone production
 - HCG (human chorionic gonadotropin → maintains the corpus luteum)
 - HCS (human chorionic somatomammotropin, growth and diabetogenic hormone)
 - HPL (placental lactogen)
 - since week 12 the placenta takes the production of progesterone and estrogenic hormones → maintains the pregnancy since the 2nd trimester
- fetal hemoglobin (HbF)
 - has a greater affinity to oxygen
 - occurs in greater concentration than the adult Hb
 - → fast saturation even in lower PaO₂
- full term placenta
 - disc, 15-20×2-3 cm
 - mass of 500-600 g
- function decreasing after week 40 (fibrinoid, microinfarction, hypoxia risk)
 - watch the post-term pregnancy > 42 weeks, Doppler USG of the umbilical arteries

Placenta abnormalities

- shape
 - placenta disseminata (succenturiata) with separated cotyledons
 - placenta duplex (two almost detached parts)
- cord insertion (normal = central insertion)
 - paracentral
 - marginal
 - velamentous (into the chorion outside the placenta)
- localization
 - placenta praevia (in lower uterine segment, may cause haemorrhage and cover the internal os)
- trophoblastic invasion into the uterine wall
 - p. accreta (trophoblast reaching the myometrium surface)
 - p. increta (trophoblast invading the myometrium)
 - p. percreta (trophoblast penetrates the myometrium)
- placental abruption = separation and bleeding, from asymptomatic to severe (→maternal shock and fetal death)
- placental insufficiency → growth retardation to abortion
- fetomaternal transfusion
- isoimmunization
 - involves especially the Rh antigen
 - maternal antibodies respond against fetal blood cells

- hemolysis of the fetal RBC opsonized by the IgG
- → erythroblastosis fetalis = hemolytic disease
- prevented in Rh- mothers by screening for Ig and treating with anti-D-immunoglobulin

Twins

- monozygotic (MZ) twins: starting with a single genome; frequency 0.2-0.4 % births
 - splitting at the stage of
 - morula
 - embryoblast of an early blastocyst
 - bilaminar embryonic disc
 - approx. 1/3 of the twins × assisted reproduction twins
 - most MZ twins (60–70 %) have common placenta, but separate amnions = diamniati monochoriat
 - 18–30 % MZ twins have separate placentae and amnions = diamniati bichoriat
 - 1–2 % MZ twins have both common placenta and amnion = monoamniati monochoriat
- dizygotic (DZ) twins: two independent genomes; frequency 0.7-0.11 % births
 - = fraternal twins
 - more common in mothers over the age of 35
 - more common in some nations
 - separate placenta and amnion
 - secondary fusion of the placentae is possible, or anastomoses of the circulation
- twin defects
 - death – vanishing twin
 - placental anastomoses in monochorionic twins → twin transfusion syndrome, circulatory shunts, compromised blood flow → growth defects, death
 - preterm delivery, small at birth
 - conjoined (Siamese) twins
 - thoracopagus
 - pygopagus (lumbosacral region)
 - craniopagus

Embryonic and fetal growth

- progenesis: fertilization, cleavage, implantation gastrulation, approx.. until week 4; damage within this period leads to death
- embryonic period: organ systems are formed until the end of week 8; the embryo is sensitive and vulnerable to a number of teratogens
 - staging: Carnegie system of 23 embryonic stages until day 56
- fetal period: week 9 until birth; mainly the central nervous system and the urogenital system remains sensitive to teratogens
- measurement of anatomical landmarks using in utero sonography
 - CRL - crown-rump (sitting) length: valid mainly in week 7-14 → age estimation ± 3-5 days
 - CHL – crown-heel length
 - BPD - biparietal diameter: since week 12
 - FL - femur length: since week 14

- AC - abdominal circumference, HC - head circumference, OFD - occipitofrontal diameter, HL - humerus length

Duration of pregnancy

- 280 days after the onset of the last menstruation
 - $10 \times 28 = 40 \times 7$ days
 - used in gynaecology and obstetrics
- 266 days = after fertilization, used in embryology
 - 38×7 days
- estimated date of the birth = LMP (last menstrual period) + 1 year – 3 months + 7 days
- Hasse's approximation according to the crown-heel length
 - 3 months – 9 cm
 - 4 months – 16 cm
 - 5 months – 25 cm
 - 6 months – 30 cm
 - 7 months – 35 cm
 - 8 months – 40 cm
 - 9 months – 45 cm
 - 10 months – 50 cm (CRL 36 cm, weight 3000-3400 g)
- approximative formulae
 - lunar month 3-5: CHL [cm] = month²
 - lunar month 6-10: CHL [cm] = month*5

Neonatal maturity

- premature < week 38-41 (42) < postmature
- a mature newborn
 - HC 34 cm, m= 3-3.4 kg, CRL 36 cm, CHL 50 cm
 - outer genital organs differentiated
 - testis descended within the scrotum
 - greater labia covering the lesser labia
 - subcutaneous fat present
 - pink skin, may be remnants of lanugo
 - eyelashes, eyebrows, hair; nails reaching the fingertips
 - fontanelles are separated
- low birth weight
 - extremely low birth weight < 1000 g < very LBW < 1500 g < LBW < 2500 g
 - 500-1000 g may live if expert care provided, but neurological/respiratory disorders
 - IUGR – intrauterine growth restriction <10th percentile of their expected birth weight
 - SGA – small for gestational age
 - weight < 10% below pod the expected weight
 - associated with birth defects, worse adaptation to extrauterine life
 - common causes: chromosomal aberrations; intrauterine infection (rubeolla, CMV, Toxoplasma, syphilis); abuse of alcohol, smoking, drugs; untreated diabetes; placental insufficiency, twins
- Apgar score: does the baby require medical intervention?
 - scored 0-2 at 1, 5 and 10 minutes

- Appearance (blue/pale, acrocyanosis, pink)
- Pulse (<60, 60-100, >100)
- Grimace – reflex irritability (no response, grimace, pulls away when stimulated)
- Activity of muscles (0, weak flexion, resists extension actively)
- Respiratory effort (absent, gasping, strong/crying)
- $\Sigma = 8-10$: no intervention needed
- 5-7 points: watch carefully, may need assistance, but mostly temporarily
- <5: immediate intervention needed

Fetal position in utero

- fetal lie or situs: relation between the long axis of the fetus and the corpus of the uterus
 - longitudinal
 - transverse
 - oblique (unstable)
- fetal position: relationship between back of fetus and the uterus side
 - left = back to the left OR right = back to the right
- fetal attitude or habitus: relation among parts of the body
 - folded to an ovoid mass
- fetal praesentation: leading part of fetal body to the birth canal
 - head (vertex, occiput, face)
 - breech, legs
 - shoulder

Parturition (birth)

- stage 1
 - effacement (thinning and shortening) of the cervix, dilatation of the cervix (10 cm)
 - contractions 30-45 s with 10 min intervals
 - 8-12 hours
- stage 2 = delivery of the fetus
 - interval between the contractions < 1 min
 - 30-60 min
- stage 3 = delivery of the placenta and fetal membranes
 - 15-30 min
 - to be checked: is the placenta complete?

Some anatomical changes in pregnant women

- uterus increases in weight (70 g → 1100 g), blood perfusion (50 ml → 700 ml/min) and volume (10 ml → 5 l)
- when lying on back, major blood vessels (aorta, inferior vena cava) may be compressed by the uterus → a low venous return, hypotension, fainting
- retention of body fluids, increased blood perfusion of genital organs
- hyperpigmentation of the genitals and the nipples
- emphasized lumbar lordosis is balanced by straightening of the cervical lordosis and thoracic kyphosis
- increased flexibility and hypermobility of joints (sacroiliacal, sacrococcygeal, pubic symphysis) due to the relaxin
- displacement of the viscera due to the enlarged uterus