
Fetal membranes in amnions (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
    - 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 (lig. umbilicale medianum)
  - in placental mamals 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 arteris 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 fetoplacentar 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 fetoplacentar 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 cell 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 bloods 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)
  o hormone production
• HCG (human chorionic gonadotropin \(\rightarrow\) maintains the corpus luteum)
• HCS (human chorionic somatomamotropin, growth and diabetogenic hormone)
• HPL (placental lactogen)
• since week 12 the placenta takes the production of progesterone and estrogenic hormones \(\rightarrow\) maintains the pregnancy since the 2nd trimester
  - fetal hemoglobin (HbF)
    o has a greater affinity to oxygen
    o occurs in greater concentration than the adult Hb
    o \(\rightarrow\) fast saturation even in lower PaO\(_2\)
  - full term placenta
    o disc, 15-20×2-3 cm
    o mass of 500-600 g
  - function decreasing after week 40 (fibrinoid, microinfarction, hypoxia risk)
    o watch the post-term pregnancy > 42 weeks, Doppler USG of the umbilical arteries

**Placenta abnormalities**

- shape
  o placenta disseminata (succeuturiata) with separated cotyledons
  o placenta duplex (two almost detached parts)
- cord insertion (normal = central insertion)
  o paracentral
  o marginal
  o velamentus (into the chorion outside the placenta)
- localization
  o placenta praeavia (in lower uterine segment, may cause haemorrhage and cover the internal os)
- trophoblastic invasion into the uterine wall
  o p. accreta (trophoblast reaching the myometrium surface)
  o p. increta (trophoblast invading the myometrium)
  o p. percreta (trophoblast penetrates the myometrium)
- placental abruption = separation and bleeding, from asymptomatic to severe (\(\rightarrow\)maternal shock and fetal death)
- placental insufficiency \(\rightarrow\) growth retardation to abortion
- fetomaternal transfusion
- isoimmunization
  o especially the Rh antigen
  o maternal antibodies respond against fetal blood cells
  o hemolysis of the fetal RBC opsonized by the IgG
  o \(\rightarrow\) erythroblastosis fetalis = hemolytic disease
  o 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 = biamniati monochoriati
  - 18–30 % MZ twins have separate placetae and amnions = biamniati bichoriati
  - 1–2 % MZ twins have both common placenta and amnion = monoamniati monochoriati
- 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 placenta is possible, or anastomoses of the circulation
- twin defects
  - death – vanishing twin
  - placentar 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
  - $38 \times 7$ 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: $\text{CHL [cm]} = \text{month}^2$
  - lunar month 6-10: $\text{CHL [cm]} = \text{month} \times 5$

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
  - fontanels 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 al over, acrocyanosis, pink)
    - Pulse (<60, 60-100, >100)
    - Grimace – reflex irritability (no response, grimace, pulls away when stimulated)
    - Activity of muscles (0, weak flection, resists extension actively)
    - Respiratory effort (absent, gasping, strong/crying)
- $\Sigma = 8-10$: healthy baby
- 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 $\rightarrow$ 1100 g), blood perfusion (50 ml $\rightarrow$ 700 ml/min) and volume(10 ml $\rightarrow$ 5 l)
- when lying on back, major blood vessels (aorta, inferior vena cava) may be compressed by the uterus $\rightarrow$ 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