Placental formation, Growth and functions in domestic animals

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Placenta (Flat Cake)

Placenta is a flattened circular organ in the uterus of pregnant eutherian mammals, nourishing and maintaining the fetus through the umbilical cord.

Umbilical cord (Navel, omphalos) A flexible cordlike structure containing blood vessels and attaching a human or other mammalian fetus to the placenta during gestation.
Classification of Placenta

• THREE CLASSIFICATIONS

• Based on degree of tissue loss at parturition

• Based on shape or distribution of chorionic villi

• Based on tissue apposition
Based on Degree of Tissue Loss at Parturition

• Deciduate
  – Eccentric, interstitial
  – Rodent, human

• Indeciduate or Nondeciduate
  – Superficial
  – Farm animals

Partially deciduate
  Dogs, Cats
Shape or Distribution of Chorionic Villi

- Cotelydonary - cow, sheep
- Diffuse - pig, horse
- Zonary - dog, cat
- Discoid - human
Ruminant placenta

• Instead of having a single large area of contact between maternal and fetal vascular systems, these animals have numerous smaller placentae. The terminology used to describe ruminant placentation is cotyledonarry: Cotyledon: the fetal side of the placenta. Caruncle: the maternal side of the placenta. Placentome: a cotyledon and caruncle together
Chorion

Uterine Epithelium

Placental Attachment in Ruminant

Binucleate Cell

Migrate and fuse with uterine epithelium

Syncytium

Fusion of Binucleate cells and uterine epithelium

(multinucleate)

Capillary

Stroma
Binuclear Giant Cells

- 20% of fetal placenta
- Invade endometrium
- Source
  - Placental lactogen
  - Pregnancy specific protein B
Placental Lactogens (Protein Hormones)

Prolactin-like activity: Stimulates Milk Synthesis

**Not Present** in Pig and Mare

- May regulate maternal metabolism to facilitate fetal growth
- High levels in the last 1/3 of gestation.
- High levels facilitate higher milk production.
- Dairy cows have higher blood concentrations than beef cows
Placental Lactogens

• The bovine PL hormone is detected in maternal serum at about 4 months of gestation and remains low through parturation. In contrast, ovine placental lactogen is secreted in whopping quantities beginning at about day 50 and remains high through gestation. Placental lactogen also accumulates to high concentrations in the serum of fetal sheep
Pregnancy Specific Protein B

• Unique to ruminants
• Function uncertain
• Has been used to detect pregnancy
  – Cattle, sheep, deer
    • Can be used to detect pregnancy in cows after day 25

» Not early pregnancy factor!!!
ZONARY PLACENTA DOG
• The canine placenta looks very similar to that of cats. A feature usually seen in the placentae of both species is marginal hematomas (hematophagus zones). These are bands of maternal hemorrhage at the margins of the zonary placenta. The products of hemoglobin breakdown give them a distinctly green coloration due to uteroverdin in dogs, whereas in cats they are brownish and usually less obvious. The canine placenta is said to produce little if any quantity of steroid hormones. As with other species, maintenance of pregnancy is dependent on continued secretion of progesterone during gestation, but corpora lutea appear to be the exclusive source of progesterone in the bitch. Luteal secretion of progesterone is, in turn, dependent on secretion of luteinizing hormone and probably prolactin from the anterior pituitary. Removal of the ovaries at any time during canine gestation leads to termination of the pregnancy. Also, progesterone profiles in pregnant and pseudopregnant bitches are indistinguishable until late in gestation or diestrus.
Discoid Placenta (human)
Diffuse Placenta
Microcotelydons

- Microcotelydon (Fetal)
- Microcotelydon (Maternal)
- Epithelium
- Endometrial Glands
- Uterine Arteries
- Uterine Veins

Increase placental surface area
Endometrial Cups in Mare

- From both trophoblast and endometrium
- 5 to 10
- Form between days 35 to 60
- Produce equine chorionic gonadotropin (eCG, PMSG)
- Sloughed off after day 60
Endometrial cups develop from cells of the chorionic girdle, which can first be detected histologically at roughly 25 days of gestation. Initially, this structure is a narrow band of thickened trophoblast that develops circumferentially around the conceptus at a point where the membranes of the allantois and yolk sac meet.
Girdle cell invasion and proliferation result in formation of tightly packed mass of trophoblast-derived cells containing little stroma - these are the endometrial cups. Invasion of endometrial glands leads to destruction of their apical epithelium; deeper segments of those glands are spared, but their lumens are obstructed by cup cells and they become distended with secretions. Endometrial cups are destroyed by Day 100-140.

Immunological destruction of the endometrial cups appears to be a response to paternal class I MHC antigens, which are highly expressed on invading girdles cells. In conjunction with the cellular response is a vigorous humoral immune response to these antigens.
• Several interesting observations on endometrial cup biology have been made in inter-specific equine pregnancies. In mares carrying donkey conceptuses, the chorionic girdle fails to invade the endometrium, and endometrial cups do not develop. Most of these pregnancies are aborted between days 80 and 90, but the roughly 30% that survive and are carried to term do so in the absence of eCG. However, in donkeys carrying a hinny fetus, the cups develop to a much larger size and considerably higher concentrations of eCG are achieved than in donkeys carrying a donkey fetus.
## Histological Classification

<table>
<thead>
<tr>
<th>Tissues</th>
<th>epithelial-chorial</th>
<th>syndesmo-chorial</th>
<th>endothelial-chorial</th>
<th>hemo-chorial</th>
<th>hemo-endothelial</th>
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<tr>
<td>Maternal</td>
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<td>Fetal</td>
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<td>Species</td>
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<tr>
<td>pig</td>
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<td>horse</td>
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<td>*ruminant</td>
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<tr>
<td>dog</td>
<td></td>
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<tr>
<td>human</td>
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<tr>
<td>rat</td>
<td></td>
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<tr>
<td>rabbit</td>
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</tr>
</tbody>
</table>
Cell Layers Separating Maternal and Fetal Blood

Fetal

Capillary

Endothelium

Connective Tissue

Chorionic Epithelium

Maternal

Endometrial Epithelium

Connective Tissue

Capillary

Endothelium
Important!!!!

• In all cases, fetal and maternal blood does not mix.
<table>
<thead>
<tr>
<th>Type of Placenta</th>
<th>Common Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diffuse, epitheliochorial</td>
<td>Horses and pigs</td>
</tr>
<tr>
<td>Cotyledonary, epitheliochorial</td>
<td>Ruminants (cattle, sheep, goats, deer)</td>
</tr>
<tr>
<td>Discoid, hemochorial</td>
<td>Humans, apes, monkeys and rodents</td>
</tr>
<tr>
<td>Zonary, endotheliochorial</td>
<td>Carnivores (dog, cat, ferret)</td>
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</tbody>
</table>
# Gestation length in domestic animals

<table>
<thead>
<tr>
<th>Species</th>
<th>Gestation length (days)</th>
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</thead>
<tbody>
<tr>
<td>Dairy cows</td>
<td>270 – 280</td>
</tr>
<tr>
<td>Beef cows</td>
<td>280 – 290</td>
</tr>
<tr>
<td>Mare</td>
<td>340 - 390</td>
</tr>
<tr>
<td>Ass</td>
<td>365 – 375</td>
</tr>
<tr>
<td>Hinny (Stallion x Ass)</td>
<td>348 – 350</td>
</tr>
<tr>
<td>Mule (Jack x Mare)</td>
<td>355</td>
</tr>
<tr>
<td>Ewe</td>
<td>143 – 155</td>
</tr>
<tr>
<td>Goat</td>
<td>146 – 155</td>
</tr>
<tr>
<td>Pig</td>
<td>111 – 116</td>
</tr>
<tr>
<td>Bitch</td>
<td>59 – 68</td>
</tr>
<tr>
<td>Queen</td>
<td>56 – 65</td>
</tr>
<tr>
<td>Buffalo</td>
<td>310-320</td>
</tr>
<tr>
<td>Female Camel</td>
<td>370-380</td>
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</tbody>
</table>
Placental Functions

Placenta

Exchange
- Gas
- Nutrients
- Waste products

Endocrine
- Transient
- Estrogen
- Progesterone
- HCG
- eCG
- PL

Chemical Protection
- Immunosupression
- Prevents infiltration by maternal defenses
- Filters toxins

Physical Protection
- Shock Absorber
## Developmental Features

<table>
<thead>
<tr>
<th>Developmental Horizons</th>
<th>Mare</th>
<th>Cow</th>
<th>Ewe</th>
<th>Sow</th>
<th>Woman</th>
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</thead>
<tbody>
<tr>
<td>Germ layers</td>
<td>13-14</td>
<td>14</td>
<td>10-14</td>
<td>7-8</td>
<td>10-14</td>
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<tr>
<td>Open neural tube</td>
<td>20</td>
<td>15-21</td>
<td>13</td>
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<tr>
<td>Fusion of chorioamniontic folds</td>
<td>18</td>
<td>17</td>
<td>16</td>
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<tr>
<td>Heart beat apparent</td>
<td>24</td>
<td>21-22</td>
<td>20</td>
<td>16</td>
<td>25</td>
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<tr>
<td>Limb buds visible</td>
<td>24</td>
<td>25</td>
<td>28-35</td>
<td>17-18</td>
<td>28</td>
</tr>
<tr>
<td>Cotelydons first appear</td>
<td>30</td>
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<tr>
<td>Eye differentiation</td>
<td>40</td>
<td>30-45</td>
<td>42-49</td>
<td>21-28</td>
<td></td>
</tr>
<tr>
<td>Birth</td>
<td>340</td>
<td>280</td>
<td>147-155</td>
<td>112</td>
<td>266</td>
</tr>
</tbody>
</table>

### Critical Organ Systems Develop Early!
Estimates of Age

- Crown rump length
- Length femur, radius or tibia
- Circumference of head
Factors Influencing Fetal Growth

Genetics
- Species
- Breed
- Litter size
- Genotype

Environment
- Mother
  - Nutrition
  - Size, Parity
- Placenta
  - Blood flow
  - Size

Fetal Hormones
- Thyroid
- Insulin
- Growth hormone
Factors Influencing Fetal Growth

- Genetics
- Species
- Breed
- Litter size
- Genotype

Certain lines of animals may grow faster.
Factors Influencing Fetal Growth

- Fetal Hormones
  - Thyroid
  - Insulin
  - Growth hormone

Skeletal and muscular development

Increased energy substrate availability and stimulates placental growth

Stimulates fetal growth
Uterine Size Changes During Pregnancy

- **Hyperplasia**
  - Increase in the number of cells
- **Hypertrophy**
  - Increase in size of cells
- **Stretching**
Weeks of Gestation

Ovulation

Relative $P_4$ and $E_2$

Mare $P_4$ $E_2$

Weeks of Gestation

Ovulation
Weeks of Gestation

Ovulation

Relative P_4 and E_2

Mare

P_4

E_2

P
Progesterone is Essential To Maintain Pregnancy

Corpus Luteum

Placenta

<table>
<thead>
<tr>
<th>Species</th>
<th>Gestation Length</th>
<th>Placental Takeover</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sow</td>
<td>3.8 mo</td>
<td>3.8 mo (none)</td>
</tr>
<tr>
<td>Cow</td>
<td>9 mo</td>
<td>6 - 8 mo</td>
</tr>
<tr>
<td>Ewe</td>
<td>5 mo</td>
<td>50 d</td>
</tr>
<tr>
<td>Mare</td>
<td>11 mo</td>
<td>70 d</td>
</tr>
<tr>
<td>Human</td>
<td>9 mo</td>
<td>60-70 d</td>
</tr>
</tbody>
</table>
Other Species in Which Placenta Does not Take-over Progesterone Production

- Bitch
- Queen
- Alpaca, Llama, Camel
- Rabbit
- Goat
Thank You

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