Mammalogy Lecture 11 - Reproduction I: General Patterns

I. Obviously, reproduction is a very important aspect of biology and whole courses are dedicated to it. It’s easy to understand why reproductive traits would be subject to strong selection because of their direct effects on fitness.

II. As we might expect, there are three basic types of mammalian reproduction. These correspond to the three major groups of mammals.

Differences among these types reflect the degree of intimacy of fetal-maternal contact.

A. Monotreme Type - Retain the primitive amniote pattern, but add a period of lactation.

- Egg is very large at ovulation, about 3 mm. It moves down the oviduct where it is fertilized, then it’s coated with albumin, then a shell is laid down by a shell gland, and the shell is mineralized (with CaCO$_3$).

- Embryo spends 2-3 weeks in the uterus, then it’s laid. It’s large, 15 mm, when it’s laid.

- Embryo growth is supported entirely by the yolk that’s enclosed in the egg.

B. Metatherian type:

- In some superficial ways it’s similar to monotremes, in that metatherians retain a shell membrane around the fertilized egg; a shell gland is present in Müllerian ducts.

- However the shell is never mineralized and young are born live after only ca. 12 days, as we’ve seen, they are very altricial (poorly developed).

- Initial intrauterine growth is supported by maternally by a placenta.

- Metatherian placenta is the choriovitelline type - yolk-sac placenta (Eutherian placenta is called chorioallantoic placenta)

C. Placenta Formation - Let’s look at formation of the placenta in Meta- & Eutherians.

Placentas are formed from **three layers** in both groups.

A single maternal layer is the **endometrium**. The inner lining of the uterus is highly vascularized and this is what is shed during human menstruation.

The chorion is the **outer embryonic layer**, which is derived in part from the trophoblast. An **inner embryonic layer** varies: There are two options.

- **vitelline** (yolk sac) in metatherians.
- **allantois** in eutherians
Early embryonic stage is similar for both Eutherians and Metatherians

In metatherians, attachment of the embryo to the uterine wall is very superficial; it sinks into a shallow depression and there is almost no erosion of the uterine wall.

The vitelline expands greatly and surrounds the embryo, and the allantois shrinks. This results in the Choriovitelline placenta of metatherians.

- Maternal nutrients are taken up very indirectly.
  A fluid called “uterine milk” bathes the embryo and nutrients diffuse into the yolk sac. It’s not really milk at all, but a nutritive fluid secreted by the uterus.
  There may be some degree of wrinkling of the chorionic surface at the point of contact with the endometrium. This increases the surface area across which diffusion can take place, but only by a small amount.

- In this system then there is no direct contact between fetal and maternal circulation. Nutrient transfer is relatively inefficient; nutrients diffuse from the uterine milk.

- As we’ve mentioned, young are born altricial, after a very short gestation and continue development in marsupium or at least anchored to the mammae.
In eutherians, the vitelline layer always functions very early in development to nourish the embryo, but it quickly recedes.

- **Chorioallantoic type** - There is much variation in how intimate the fetal/maternal contact is, but all eutherians have more intimate contact than the choriovitelline type.

- This then leads to greater efficiency of transport of maternal nutrients to the fetus.

- This variation doesn’t seem to exhibit a strong correlation with phylogeny.

- As we mentioned, the early stages of placentation are similar for eutherians & metatherians.

- When the zygote contacts the endometrial lining, it sinks into the wall rather deeply. This is called **implantation**. It results from the **erosion of the endometrium**. In many species including humans, implantation is so deep that the endometrium entirely surrounds the embryo.

- The vitelline recedes and the allantois expands greatly to surround the developing embryo.

- The chorion then develops **villi**, which further penetrate the endometrium. These villi serve to greatly increase the surface area for absorption and are highly vascularized.

- There is also a great deal of variation in the extent of the villi.

- It’s across this endometrium that nutrient transport takes from maternal to fetal circulation place through the chorionic villi.

- Now as I said, there is a great deal of variation in eutherian placentae.

- One thing that varies is the degree of endometrial erosion, and efficiency of nutrient transfer is directly related to this. The more erosion, the less tissues separating fetal circulation from maternal circulation. There are a number of types that are recognized, we’ll use 4 examples:

Figure 9.14 - Is good description of a number of types of eutherian placentas.
There are, at most, 6 layers of tissue that separate maternal and fetal circulation.

**Epitheliochorial**
In some eutherians, there is relatively little endometrial erosion; it’s limited to a pocket around the chorionic villi. There are six thin layers of tissue separating maternal from fetal circulation. (Cetaceans, Suids, and Equids).

**Endotheliochorial**
There is more erosion of endometrium. The epithelium and connective tissue erode and the chorionic villi are in direct contact with maternal capillaries. (Common in Carnivora)

**Hemochorial**
All the maternal tissue erodes, including the maternal capillary walls. Pools of maternal blood then surround the villi. (Chiroptera, Insectivorans, some primates [including Homo])

**Hemoendothelial**
Much of the chorionic tissue also erodes and fetal capillaries are actually bathed in maternal blood. Fetal capillaries are actually bathed in blood because much of chorionic tissue also erodes. (Some Insectivora and Rodentia)

These provide much more efficient nutrient transfer; a hemoendothelial insectivoran placenta is 250 times more efficient than the epitheliochorial placenta of a suid.

**D. Deciduous vs. Non-deciduous Placentas**
In those forms where there is extensive endometrial erosion, the maternal portion of the placenta is shed after birth, along with the fetal portion. This is what is called the after-birth, and it results in lots of bleeding.

In those forms where there is little endometrial erosion, there is no maternal afterbirth - little blood - non-deciduous
It’s been suggested that the less efficient placentas are maintained by this difference. If there is much bleeding, predators may be attracted (i.e. sharks in the case of cetaceans), nest locality may be revealed, nest may be fouled leading to bacterial infection.

Peramelids have a chorioallantoic placenta - these differ from those of eutherians in that these lack chorionic villi. The surface area is increased only slightly by corrugations or slight folds.

The embryo is bathed in “uterine milk” as I indicated for metatherians earlier.