

Mammalogy Lecture 12 - Reproduction I: General Patterns

I. Obviously, reproduction is a very important aspect of biology and whole courses are dedicated to it.

It's also obvious that reproductive traits are subject to strong selection because of their direct effects on fitness. Therefore, reproductive traits tend to evolve rapidly.

II. Remember that there are three main types of reproduction among mammals.

Monotremes lay eggs (e.g., *Tachyglossus*).

Metatherians give birth to very altricial young after a short gestation period (shown are *Antechinus* and *Macropus*).

Eutherians give birth to more precocial young after a much longer gestation period (as we discussed earlier).

III. Placenta Formation - Let's look at formation of the placenta in Metatherians & Eutherians.

For both groups, at least initial embryonic growth is intrauterine.

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

1) A **single maternal layer** is the **endometrium**.

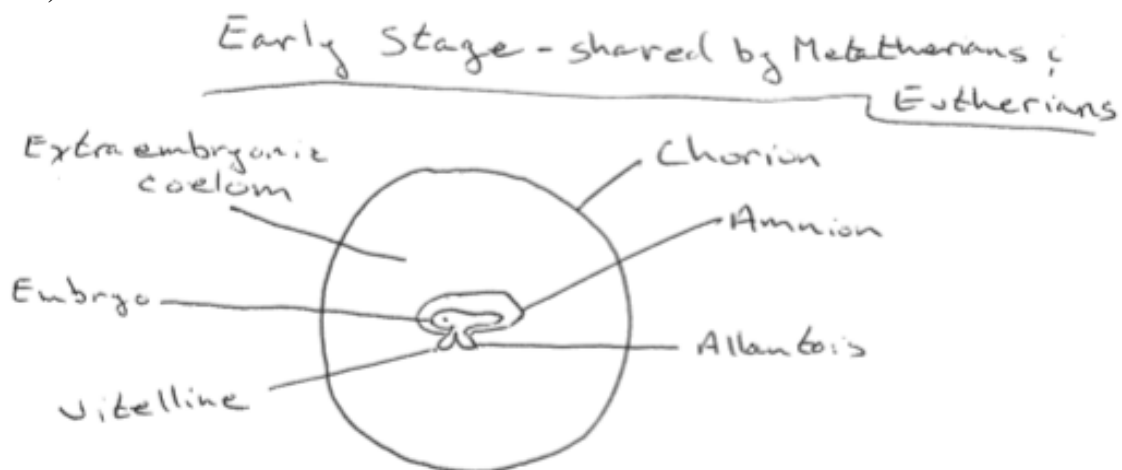
The inner lining of the uterus is highly vascularized, and this is what is shed during human menstruation.

2) **The chorion** is the **outer embryonic layer**, which is derived, in part, from the trophoblast.

3) An **inner embryonic layer** varies: There are two options.

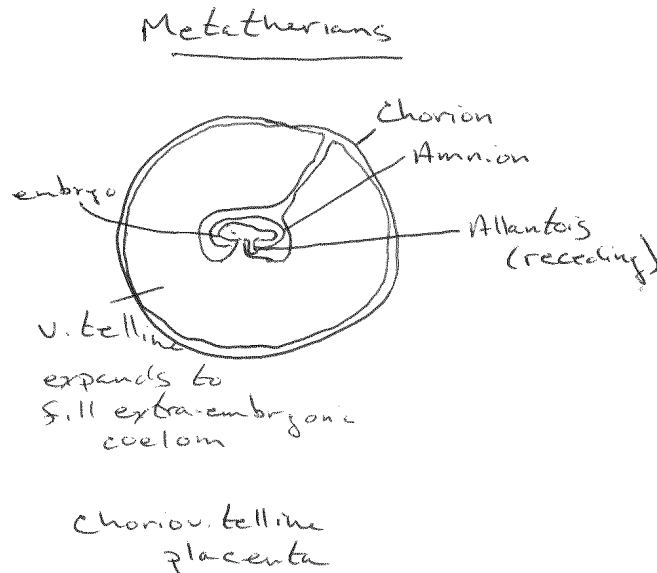
vitelline (yolk sac) in metatherians. **Choriovitelline placenta**
allantois in eutherians. **Chorioallantoic placenta**

A) **Early embryonic stage** is similar for both eutherians and metatherians (prior to reaching uterus).



B) 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**.

Once the zygote reaches the uterus, 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 nutritive 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.

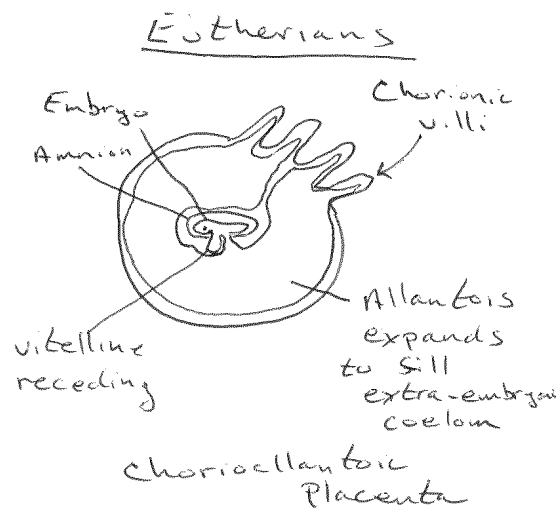
- In choriovitelline placentas there is no close contact between fetal and maternal circulation. Nutrient transfer is relatively inefficient; nutrients diffuse from the uterine milk.

- As we’ve discussed, young are born altricial, after a very short gestation and continue development in marsupium or at least anchored to the mammae.

C) In eutherians, As mentioned, the early stages of placentation are similar for eutherians & metatherians.

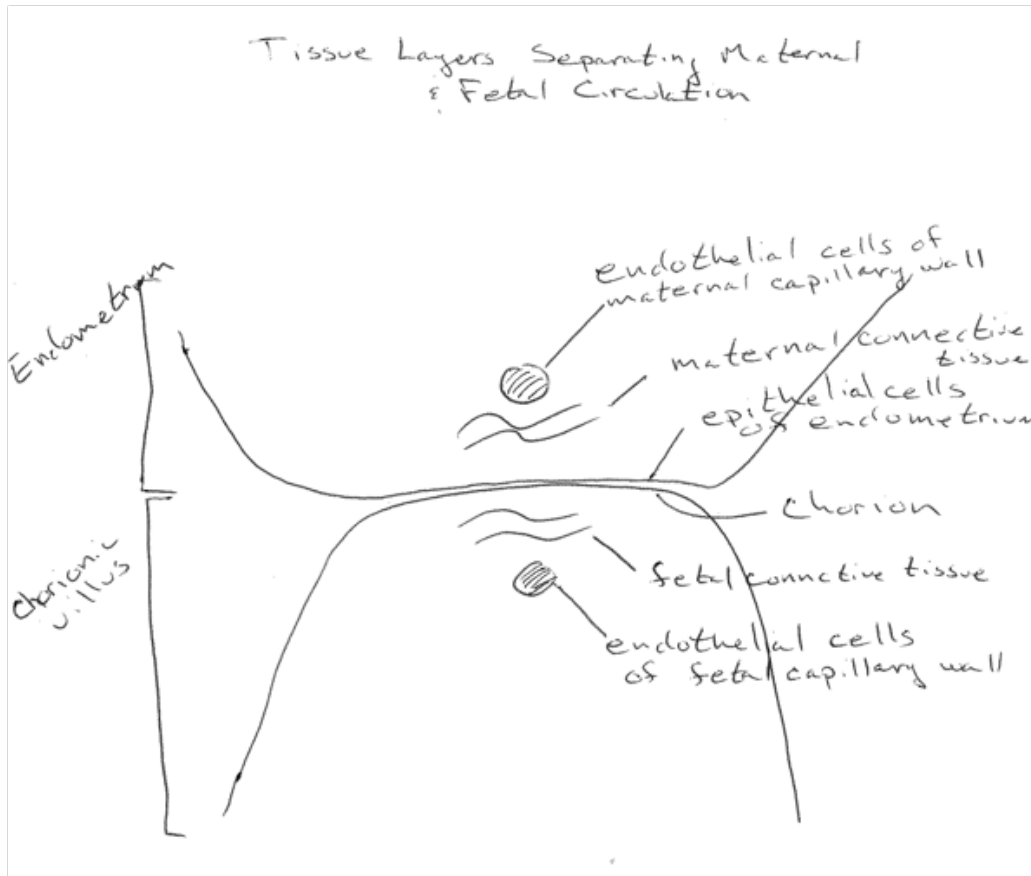
- **Chorioallantoic type** - There is much variation in how intimate the fetal/maternal contact is, but all eutherian placentas provide more intimate contact than the choriovitelline type.

- The vitelline functions very early in development to nourish the embryo, but it quickly recedes.
- This leads to greater efficiency of transport of maternal nutrients to the fetus.
- 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 chorion then develops **villi**, which further penetrate the endometrium. These villi serve to greatly increase the surface area for absorption and are highly vascularized.



- As implantation is occurring and the vitelline is receding, the allantois expands greatly to surround the developing embryo.
- There is a great deal of variation in the extent and distribution of the villi and placentae are often described by the pattern of chorionic villi.
- It's across the endometrium that nutrient transport takes from maternal to fetal circulation through the chorionic villi. This is possible because both the endometrium and the chorionic villi are highly vascularized. This leads to greater efficiency of transport of maternal nutrients to the fetus, compared to a choriovitelline placenta.
- As I said, there is a great deal of variation in eutherian placentae.
- One important axis of variation is the degree of endometrial erosion, and efficiency of nutrient transfer is directly related to this. The more erosion, the less tissue separating fetal circulation from maternal circulation. Three types of are typically recognized:

There are, at most, 6 layers of tissue that separate maternal and fetal circulation, three of which are maternal and three of which are fetal: maternal capillary walls (endothelial cells), maternal connective tissue, the epithelial cells of the endometrium, the chorion, fetal connective tissue, and fetal capillary walls (also endothelial cells).



Three types of eutherian placentae are named for the tissues that contact each other.

Epitheliochorial (epithelial cells of the endometrium contact the chorion)

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**).

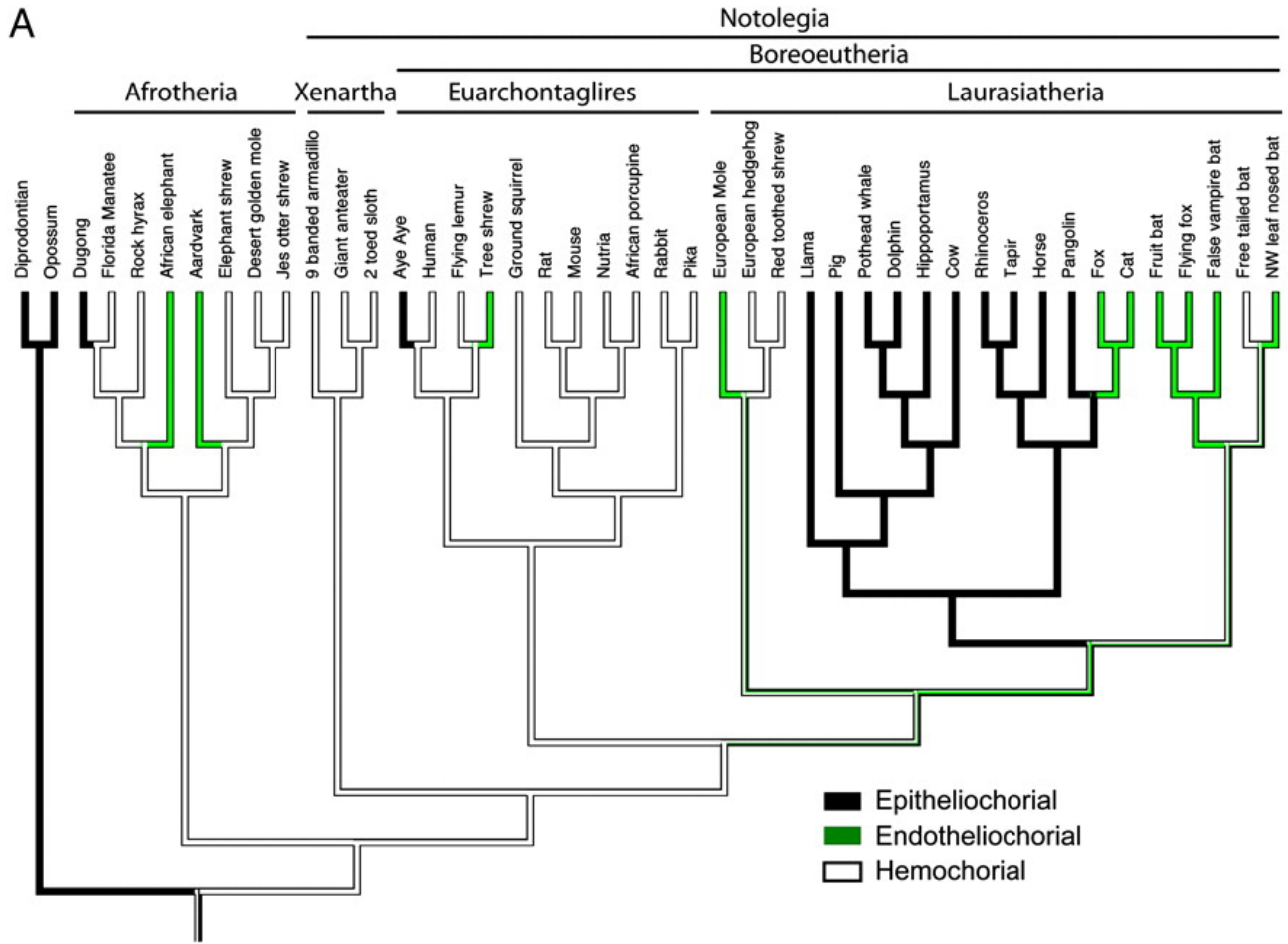
Endotheliochorial (endothelial cells of the maternal capillaries contact the chorion)

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

Hemochorial (maternal blood bathes the chorionic villi)

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

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



Wildman D. E. et.al. 2006. PNAS, 103:3203-3208

It appears that Hemochorial placentas were present in the ancestral eutherians, as a novel trait, and there have been multiple instances of independent evolution of less efficient Endothelio- and Epitheliochorial placentas

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 afterbirth, and its shedding results in lots of bleeding. This is called a deciduous placenta.

In those forms where there is little endometrial erosion, there is no maternal afterbirth shed, and therefore, little bleeding. This is called a non-deciduous placenta.

It's been suggested that the less efficient placentas evolved in response to this difference. If there is much bleeding, predators may be attracted (e.g., sharks, in the case of cetaceans), nest locality may be revealed, or the nest may be fouled leading, to bacterial infection.

Final note:

Peramelids (remember the bandicoots?) have a chorioallantoic placenta - these differ from those of eutherians in that they 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.