Monotremes (Prototheria)

Marsupials (Metatheria)

The higher taxonomy of extant mammals relates to striking differences in their reproductive biology

Class Mammalia

Subclass Prototheria

Subclass Theria

Infraclass Metatheria

Infraclass Eutheria

Placentals (Eutheria)

Monotremes

1) Lay eggs (meroblastic: lots of yolk; “like” cleidoic: enclosed in membrane, semi-permeable shell)
2) Cloaca (oviducts open into common urogenital sinus; monotreme = “single opening” for urogenital and alimentary systems)
3) No nipples

Some features of Monotreme reproduction

- Ovaries larger (relative to body size) than other mammals; eggs also larger, greater amount of yolk
- Oviducts open into common urogenital sinus, similar to reptile cloaca
- Milk secreted by glands in skin, licked from tufts of fur at concentrations of glands
- Young have “egg tooth” like birds to help break out of egg
- Platypus: 1-2 eggs
- Echidna: 1 egg

Typical platypus reproduction:

Egg is fertilized in fallopian tubes before entry to uterus, eventually coated with leathery mineralized shell before being laid.

But first, egg initially receives mucoid (membrane) coating that is semi-permeable and can expand. Uterine wall secretes nutritious secretions which are absorbed by fertilized egg, which grows in size (about 3X).

Egg at fertilization = 4 mm, when laid = 12-15 mm.

Egg retained in uterus about 28 days while development proceeds. THEN shell added, egg laid, 10 more days of external incubation. (Eggs sticky, female cradles between stomach and tail.)

Lactation about 3-4 months.

- Testes of male monotremes lie within body cavity, no external scrotum
- Penis in preputial sac in floor of urogenital sinus (cloaca)

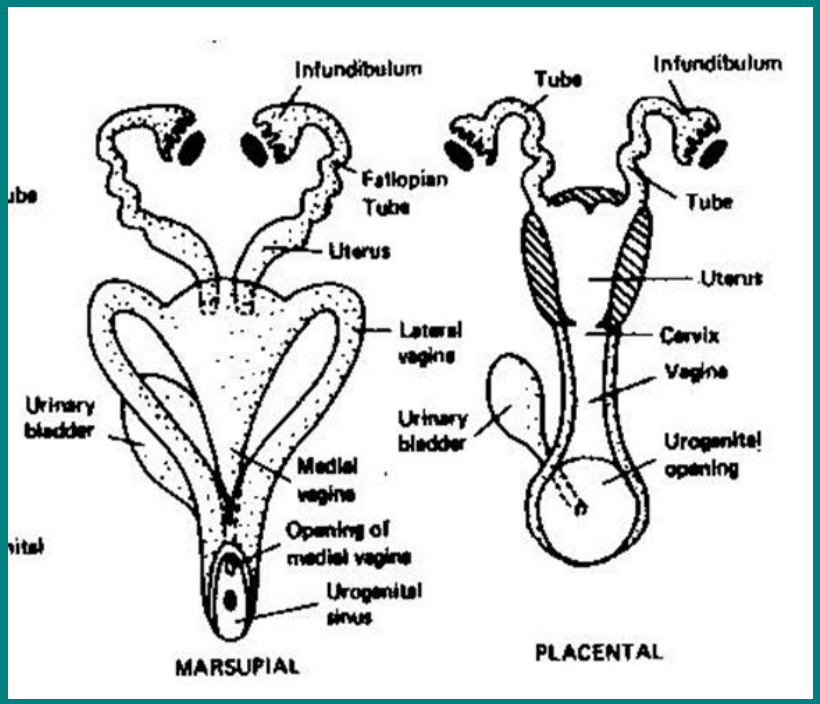
- Tb of monotremes (about 32^{o} C) lower than most other mammals (36-37^{o} C)

- As in other mammals with internal testes (e.g., whales, elephants, hyraxes, porcupines, shrews), sperm produced in internal testes but stored in caudal epididymys located near surface of body (skin); slightly cooler than core temp.

Marsupials also differ from placentals in important ways:

- Female reproductive tract has paired uteri but also paired, lateral vaginae (eutherians have single vagina)

- Birth occurs through midline passage = pseudovaginal canal. Reforms with each birth in small and primitive marsupials, may remain after first birth in larger marsupials like kangaroos.



Differences in reproductive tracts begin early in development

See handout for diagram of arrangement of ducts during development

Wolffian ducts: intially involved in excretion, become sperm ducts

Müllerian ducts: become fallopian tubes, uterus, vagina

In marsupials, ureters pass between Müllerian ducts and run to bladder.
In placentals, ureters pass lateral to (outside) Müllerian ducts.

Difference allows partial fusion of ducts in placentals.

- Males have pre-penal scrotum (penis is anterior to scrotum in eutherians but reversed in marsupials)

- Penis often bifid (forked) to ejaculate in both sides of paired vaginae

- Marsupial ova also larger than eutherian ova, but not as large as monotreme ova:

- Monotreme egg = 4 mm diameter
- Marsupial egg = 0.12 – 0.28 mm
- Placental egg = 0.07 – 0.15 mm

Typical marsupial reproductive process:

Marsupial egg ovulated, fertilized, then coated by shell membrane like monotremes.

Combination of yolk and uterine secretions provide nutrition for embryo in early development (first 2/3 of gestation).

Shell membrane shed, egg sinks into depression in uterine wall for last 1/3 of gestation. BUT doesn't really implant to extent that it does in placentals… some wrinkling of surface but placenta not as invasive. (see handout for placenta types)

In contrast, eutherian gets almost all nutrition through highly invasive placenta, directly from diffusion from mother's blood supply.

Review table in handout on sources of nutrients from ovary (egg), oviduct (uterine secretions), and placenta (diffusion from mother's blood supply) for monotreme, marsupial, and placental mammals.

Major other difference between marsupials and placentals:

Relative maternal investment by gestation versus lactation

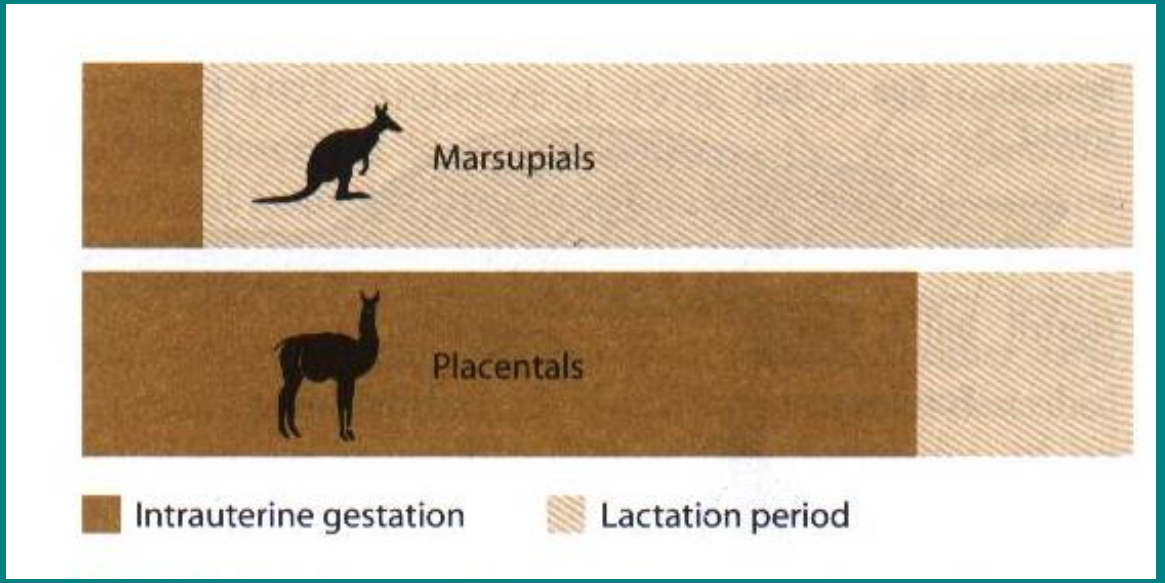
Marsupials: gestation shorter than or about equal to estrous cycle (can be short as about 13 days to 4-5 weeks). Birth occurs before next estrous period.

Placentals: pregnancy stops estrous cycle, gestation can be longer.

Gestation versus lactation

Because marsupials have such short gestation periods, no newborn marsupial weighs >1 g!

Marsupials require a longer period of extra-uterine development to compensate, usually in a protective pouch. Can be about 2 months to over a year.



For the same body size, marsupials invest shorter times in gestation, but longer times in lactation.

Does this difference matter?

Often said that eutherians outcompete marsupials, partly because reproductive mode is superior. Is it?

Energetic cost of reproduction for female:

Relative investment by mother (PI) =

(Mass of litter at weaning/ maternal body mass) x 100

At BIRTH, no marsupial litter exceeds 1% of maternal body mass (newborns <1 g). Mass of litters in eutherians variable, but can be as high as 50% for some rodents and shrews.

Investment by weaning more informative.

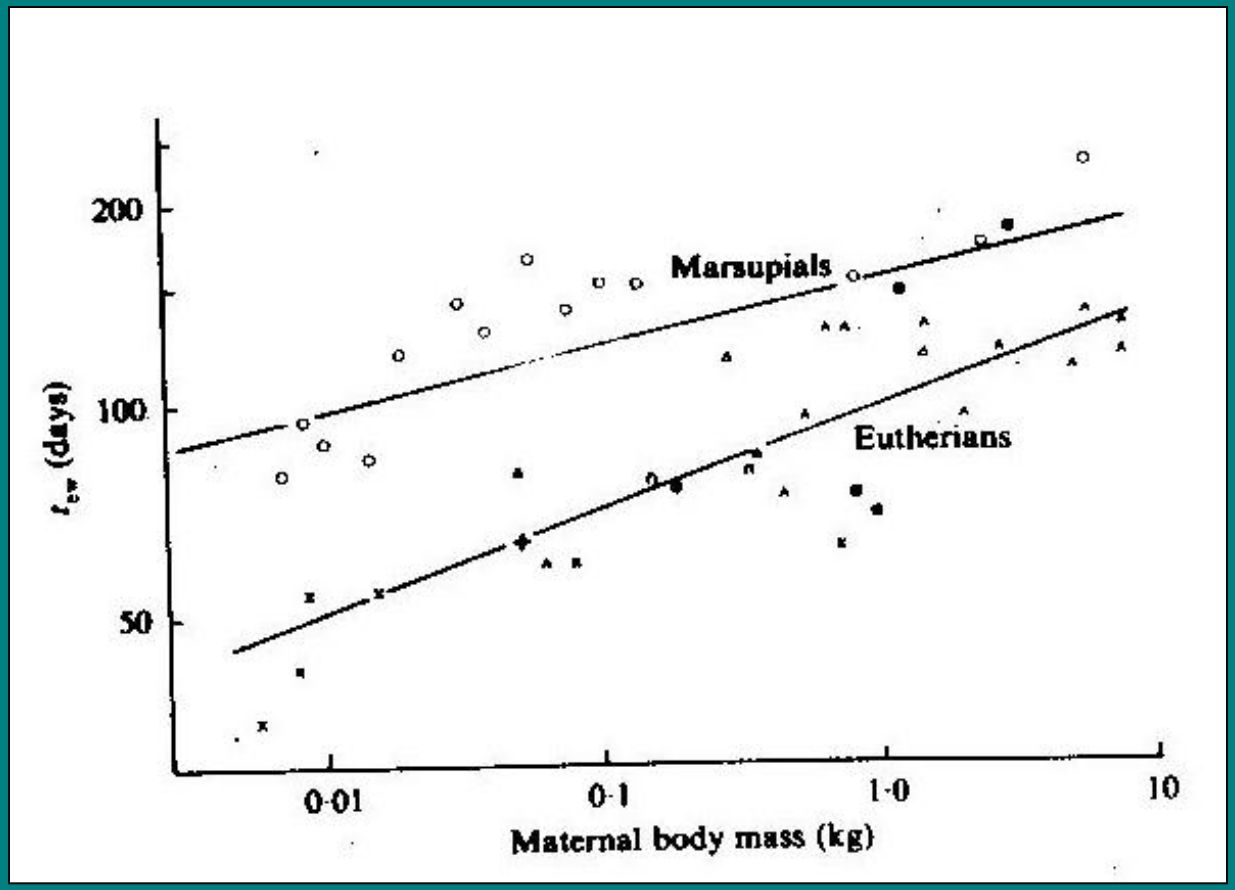
(Draw on board): Length of gestation increases with maternal body mass in placentals, but no relationship in marsupials (flat line, all gestation lengths short).

(Handout, “Fig. 3.8”): By end of weaning, young of marsupials and placentals are similar relative size (same size relative to maternal mass… most mammals wean offspring at about 40% of adult size).

So, total investment in amount of tissue of young at time of weaning is similar. BUT…

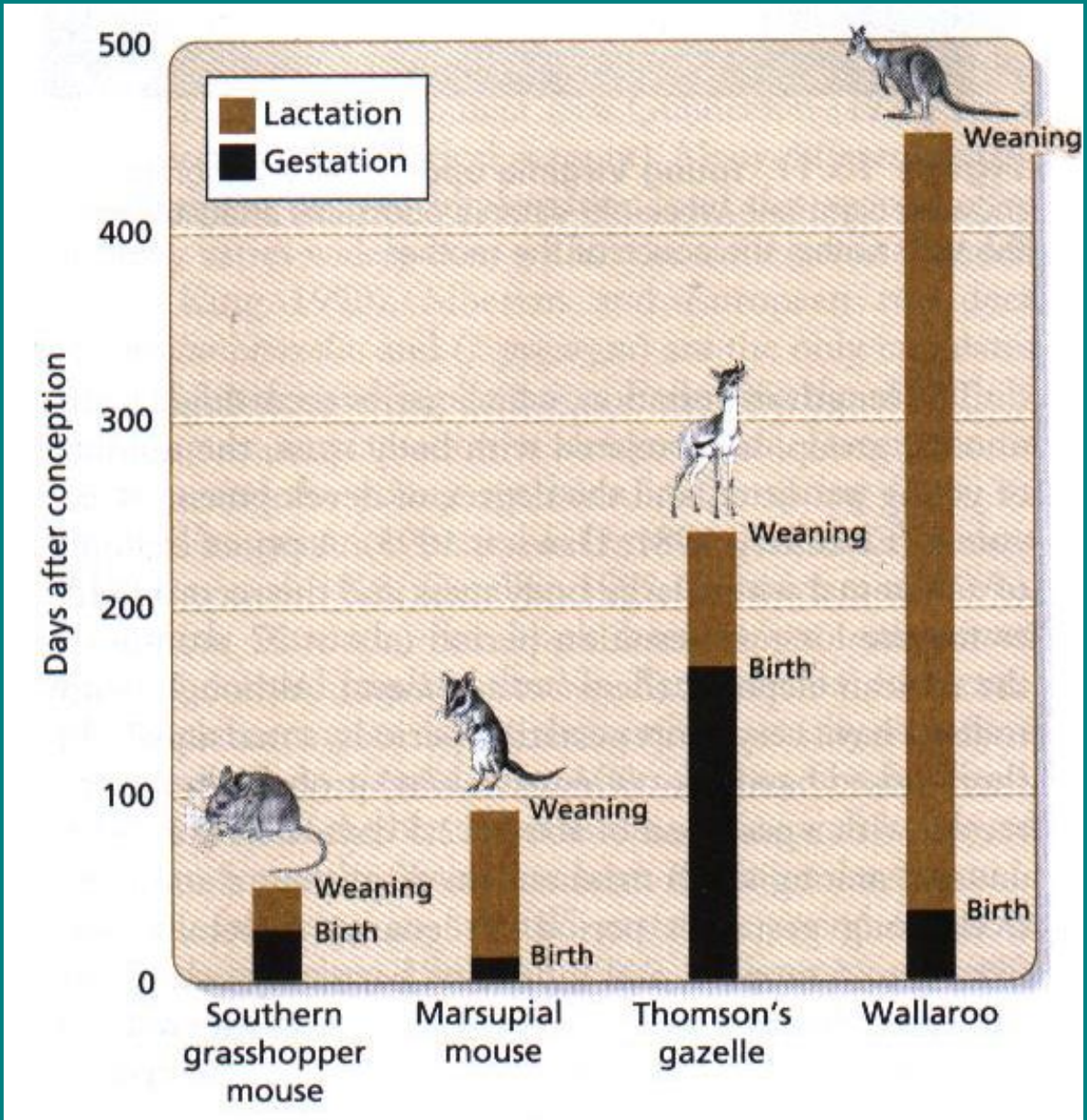
Lactation is less efficient way to transfer energy to young, so total mass of young at weaning doesn’t capture full cost of investment.

Time: conception to weaning



Takes marsupial longer than placental to raise young to same size (weaning age). Females probably “pay” more energetically for same mass of weaned offspring.

Gestation versus lactation



Evolutionary cost?

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Marsupials not totally altricial at birth.

Must be able to use front limbs to climb to pouch, attach to nipple. Then must breathe, suckle, digest milk, have more advanced stages for nervous system, kidneys, lungs, etc. So more advaned in some aspects than placental embryo at that stage.

Figure 10.17 Young Virginia opossums. Photograph showing eight one-week-old Virginia opossums attached to the teats within the pouch of the mother.

No marsupial bats (wings), marine marsupials (flippers, underwater birth), hoofed marsupials, few true fossorial forms.

More limited range of body sizes (not as huge?).

Perhaps developmental options more limited due to reproductive mode.

So, which is “better”?

Costs: Lactation is most energetically costly period of reproduction, and less efficient means of energy transfer to young. Marsupials eventually raise offspring of similar relative body sizes as placentals, but costs them more time and energy.

Constraints: Newborn marsupials need to be able to crawl to pouch or teat, suckle, breathe, digest... More advanced than placental embryo at same stage. But no wings, hooves, or flippers!

Flexibility: Very little investment by marsupials in individual offspring by time of birth, can adjust litter sizes according to environmental conditions, etc. Could be a positive in unpredictable environment.

Study questions:

1. How do monotremes, marsupials, and placental mammals differ in terms of the sources and relative contributions to embryonic development (e.g., from ovary, oviducts, placenta) in each reproductive mode?
2. How do marsupials and placental mammals differ in maternal investment via gestation versus lactation?
3. Is the eutherian mode of reproduction “better” than the metatherian mode? Discuss some plusses and minuses of each to defend your answer.
4. Describe some ways that monotremes differ from other extant mammals in their reproductive mode and related morphology.

How opossums do it

- Mating season, January – July,
- 1-2 litters depending on latitude (2 is typical for Illinois)
- Gestation totals ~12-13 days.
- Avg. 13 nipples (some variation), ~7-9 young make it to suckling stage.
- Fixed to nipples about 50-65 days, about 12% mortality.
- Lactation continues to a total of about 95-105 days.

No continued association after weaning.

- Rarely live longer than 18 months. In wild, maximum lifespan of 3 years.
- Females often get just 1 breeding season, some early-born females may get 2.