Mammalian reproduction 2: short-term (hormonal) cycles and general patterns

1. Estrus cycles
2. Flexible kangaroos
3. Semelparity and iteroparity
4. Examples of iteroparity
5. Income and capital breeders
Eutherian estrous cycle

**Proestrus**: beginning stage, transition from anestrus to estrus

**Estrus**: peak estrogen production and ovulation

**Metestrus**: estrogen declines, progesterone increases, implantation occurs. If successful, gestation follows.

**Diestrus**: if no implantation, progesterone declines, corpus luteum regresses (still metestrus), then short period (diestrus) occurs before start of next cycle

*FSH = follicle stimulating hormone, LH = luteinizing hormone*
Pituitary secretes FSH, ovarian follicle in turn produces estrogen. Peak estrogen = ovulation ("heat").

Ovulation can be induced (rabbits, many carnivores, some rodents) or spontaneous (most mammals).

Ruptured follicle forms corpus luteum, glandular structure that contributes progesterone, which sensitizes uterus for implantation. Placenta later takes over as major producer of progesterone.

Abrupt drop in progesterone and switch to production of prolactin (stimulates mammary development), plus spike in oxytocin leads to parturition.

Stuff you don’t need to memorize, but I’ll review quickly… see Ch 20!
Differences:

Implantation occurs later, near peak progesterone (remember, first 2/3 w/shell membrane).

Lactation stops cycle (parturition occurs before next cycle would start in most species).

If gestation > estrous cycle (some kangaroos), new ovulation can occur, followed by mating. Fertilized egg goes dormant = diapause.
Record for longest gestation: 22 months
(shortest is a bandicoot, 12 days)
Assembly line production in kangaroos!
Milk composition also varies over time. Different mammary glands can be producing different kinds of milk for different young! 

Figure 10.18 Embryonic diapause. Illustration showing embryonic diapause in the red kangaroo. The complex reproductive pattern of many kangaroos may result in having three young in different stages of development dependent on the mother at one time.
Even in placentals (e.g., lab rat)

Lengths of various events can vary with energy demands

+ = fertile mating
- = sterile mating
○ = no mating

Possible events following estrous in the polyestrous laboratory rat - *Rattus norvegicus*
Menstrual cycle

Final variation: old world monkeys, apes, humans, similar pattern in tree shrews and elephant shrews. Estrogen maintained at higher levels than typical, P and E crash abruptly if no pregnancy, endometrial lining of uterus sloughs off along with some bleeding during first part of next proestrus.
Male cycles

Mostly controlled by testosterone. Production can respond to photoperiod, temperature, nutrition (more later).

In rodents and some others (e.g., bats) testes and associated glands grow and regress seasonally, may change location from abdominal to scrotal.

Behavior, characteristics like antler growth, affected.
Semelparity vs iteroparity

**Semelparous**: only 1 reproductive period per lifetime

**Iteroparous**: multiple reproductive events per lifetime

Semelparity is very unusual for mammals, but....
The Amazing Antechinus!

• Small marsupial

• All females give birth within a few days each year (synchrony; Oct = Australian spring)

• In late Sept, shortly after females mate, all males die!

• Males go into hormonal overdrive, turn all energy into breeding activities, form aggregations that are visited by females. After 3 weeks of this, males stressed out, gastrointestinal ulcers, hair loss, stress-induced diseases... Die!

• Females only receptive during mating period, can store sperm and only ovulate at end of mating period; get pregnant and give birth after all males in population are dead. (males live 1 yr, females mostly 1, 2, very rarely 3)
Most mammals are iteroparous, but iteroparity can vary:

• **Monestrous**: 1 reproductive event per year.
  Examples: large mammal with long gestation period, such as white-tailed deer, but also hibernators, such as ground squirrels. Iteroparous, but over multiple years.

• **Polyestrous**: many estrus cycles (ovulations) per year. Many rodents and shrews can be continuously active throughout their life. Some are opportunistic and can breed almost any month of the year if weather and resources permit.

• **Seasonally polyestrous**: multiple estrus cycles, but within limited times of year. Examples are many small mammals that are iteroparous within a breeding season but not reproductive all year.
An example: red foxes

• Monestrous

• Females come into estrous during late Jan to early Feb, for a short period of 3-4 days. Females within a population are relatively synchronous. (probably to keep those mates honest!)

• Males are reproductively capable (= active spermatogenesis) for a longer time, around Dec through March or so, that encompasses the time of female receptivity (probably to be available for any opportunities!)

• Gest = about 51 d. Mating in winter assures young will be born in late March or April, right at start of “good” season.
Illustration of text on previous page...

Lines just show “reproductive activity,” no particular levels of anything
Other species, such as **ground squirrels**, have short enough gestation periods that they can wait until the start of spring to initiate reproduction.

- Hibernators (7-8.5 months per year)
- Males emerge 1\textsuperscript{st}, mid-April, about 2 weeks before females in early May
- Breeding occurs after females emerge, gest = 26-28 d, young born by late May to early June
- Only time for 1 litter per year, so still monestrous

(why can’t hibernating ground squirrels go for a second litter like tree squirrels?)
Reproduction can be limited to part of the year, but gestation and lactation may be short enough to allow more than one litter.

Not always just due to cold. Tropics can have wet and dry seasons that affect resource availability.

Most small mammals show some form of seasonal polyestry (example: gray and fox squirrels in IL)
Reproductive patterns of gray and fox squirrels in Illinois

If 2 litters per year, 1 in spring and 1 in late summer. Litter size usually 2-3. Lifespan: gray up to 6 yrs, fox around 7 years.
Capital vs Income Breeders

Capital breeder: accumulate energy reserves for breeding

Income breeder: relies on high metabolic rate, ability to obtain and process energy currently available in environment for reproduction

Harbor seal: accumulates fat to help support annual, intense lactation period; predictable

White-footed mouse: litter size and reproduction adjusted to environmental conditions; opportunistic
Degree of newborn development

Altricial young: rodents, rabbits, insectivores, carnivores like canids and bears

Precocial young: ungulates, whales, most primates

What are pros and cons of these two approaches?
Precocial young typically require longer gestation periods.

Precocial young also typically come in smaller litters, often singles, since each offspring must come to a relatively advanced stage (and sometimes large size) by birth.

Smaller investment in individual offspring by birth in altricial young.

Not strictly conservative phylogenetically (e.g., rabbits vs hares; guinea pigs fairly precocial; humans vs other apes; bears vs other carnivorans).
Polyembryony in 9-banded armadillo

4 genetically identical siblings from same placenta
Study questions:

1. Why might the marsupial mode of reproduction be advantageous under some conditions?

2. Be able to define and give a mammalian example of:
   - Monestrous, polyestrous, seasonally polyestrous reproduction
   - Semelparous, iteroparous reproduction
   - Capital breeder, income breeder

3. How does a successful pregnancy and lactation affect the next sequential pregnancy in a kangaroo? Lab rat?