Dramatic changes in structure/secretory capacity of endometrium of uterus occur during ovarian cycle in female-induced by both E and P

1) follicular phase: ↑E from growing follicle
2) ↑E stimulates proliferation of endometrium of uterus
3) ↑E increases P receptors in uterus
4) just before ovulation, follicle stops secreting E: ↓E titers in blood
5) luteal phase: E & P from corpus luteum stimulated continued growth/proliferation of coiled blood vessels of endometrium
6) tubular glands of endometrium fill with glycogen
7) enzymes accumulate in connective tissues of endometrium
8) endometrium swells/thickens 4-6 mm: growth glands, blood vessels & connective tissues
   a) endometrial cells: continual source of nutrients for fertilized ovum
   b) ovum not fertilized; corpus luteum degenerates on Day 8 post ovulation & stops secreting E & P
9) decrease in E & P
   a) causes hemorrhagic changes in endometrium onset of menstruation
   b) necrosis of endometrium
   c) arterioles of endometrium constrict à slowing of circulation
   d) blood enters vascular layer of endometrium à blood pooling
10) gradually outer layers of endometrium separate from uterus at site of hemorrhage
11) prostaglandins produced by uterus stimulates uterine smooth muscle
to contract rhythmically
   a) discharge of blood (20-200 ml)/endometrial cells = menstrual flow (5-7 days)
   b) ↑prostaglandin = uterine contractions = menstrual cramps (dysmenorrhea)
   c) prostaglandin act on smooth muscle in other areas of body ➔ nausea, vomiting & headache
Estrous Cycle

Periodic episodes of “heat” (estrus) marked by sexual receptivity in mature females of most mammalian species

Duration of follicular & luteal phases of reproductive cycle vary among different mammals

1) primates: equal duration follicular & luteal phases
2) nonprimate mammals: luteal phase much shorter

Humans: 28 d —> 13 x/yr
Nonprimates: spring —> 1/yr
Lab rat: 4 d —> polyestrous

Four major differences between cycles of menstrual & estrous mammals

Estrous mammals
1) luteal phase greatly reduced
   little/no proliferation & shedding of endometrium —> no menses*
   estrous vagina show pronounced changes in epithelial morphology to monitor cycle
2) estrous cycle sensitive to environmental (seasonal) factors
3) period in which follicle ready for ovulation, female becomes receptive to male
   a) exhibition of pronounced behavioral changes increasing probability of mating
      this period termed estrus (female is “in heat”)
4) some estrous spp. (cat, rabbit) ovulation normally triggered during estrus by coitus;
   coitus seldom occurs at times other than estrus
   ovulating response to coitus assures high % of fertilizations in response to mating

majority of estrous mammals ovulation occurs independent of coitus
(e.g. menstrual mammals)

*shedding uterine lining
HORMONAL CHANGES DURING PREGNANCY

PREGNANCY
begins when fertilized ovum implanted in uterine endometrium

1) $\uparrow$ E & P inhibit GnRH secretion by hypothalamus $\Rightarrow$ $\downarrow$ LH & FSH
   
   a) no follicular development
   b) no ovulation
   c) no menstruation

2) prolactin
   
   a) maternal pituitary
   b) titers increase progressively & reach maximum at birth
   c) essential for E & P stimulation $\Rightarrow$
      1. maternal breast development
      2. milk synthesis

---

**TABLE 18.2 The Estrous Cycle of Various Mammalian Species**

<table>
<thead>
<tr>
<th>Species</th>
<th>Length of cycle (days)</th>
<th>Duration of estrus</th>
<th>Ovulation Type</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cow (Bos taurus)</td>
<td>21</td>
<td>13-14 hours</td>
<td>Spontaneous</td>
<td>12-16 hours after end of estrus</td>
</tr>
<tr>
<td>Goat (Capra hircus)</td>
<td>20-21</td>
<td>1-2 days</td>
<td>Spontaneous</td>
<td>30-35 hours after onset of estrus</td>
</tr>
<tr>
<td>Sheep (Ovis Aries)</td>
<td>16</td>
<td>20-48 hours</td>
<td>Spontaneous</td>
<td>12-24 hours before end of estrus</td>
</tr>
<tr>
<td>Pig (Sus scrofa)</td>
<td>21</td>
<td>2-3 days</td>
<td>Spontaneous</td>
<td>35 hours after onset of estrus</td>
</tr>
<tr>
<td>Horse (Equus caballus)</td>
<td>19-23</td>
<td>4-7 days</td>
<td>Spontaneous</td>
<td>1-2 days after end of estrus</td>
</tr>
<tr>
<td>Dog (Canis familiaris)</td>
<td>60</td>
<td>7-9 days</td>
<td>Spontaneous</td>
<td>1-3 days after start of estrus</td>
</tr>
<tr>
<td>Cat (Felis catus)</td>
<td>-</td>
<td>4 days with male</td>
<td>Induced</td>
<td>20-30 hours after mating</td>
</tr>
<tr>
<td>Ferret (Mustela putorius)</td>
<td>-</td>
<td>9-10 days without male</td>
<td>Induced</td>
<td>30 hours after mating</td>
</tr>
<tr>
<td>Mink (Mustela vison)</td>
<td>8-9</td>
<td>Continuous</td>
<td>Induced</td>
<td>40-90 hours after mating</td>
</tr>
<tr>
<td>Fox (Vulpes vulpes)</td>
<td>59</td>
<td>1-5 days</td>
<td>Spontaneous</td>
<td>1-2 days after onset of estrus</td>
</tr>
<tr>
<td>Ground squirrel (Citellus tridecemlineatus)</td>
<td>16</td>
<td>6-11 hours</td>
<td>Induced</td>
<td>8-12 hours after mating</td>
</tr>
<tr>
<td>Guinea pig (Cavia porcellus)</td>
<td>19</td>
<td>20 hours</td>
<td>Spontaneous</td>
<td>10 hours after start of estrus</td>
</tr>
<tr>
<td>Golden hamster (Mesocricetus auratus)</td>
<td>4</td>
<td>10 hours</td>
<td>Spontaneous</td>
<td>8-12 hours after start of estrus</td>
</tr>
<tr>
<td>Mouse (Mus musculus)</td>
<td>6</td>
<td>10 hours</td>
<td>Spontaneous</td>
<td>2-3 hours after start of estrus</td>
</tr>
<tr>
<td>Rat (Rattus norvegicus)</td>
<td>4-5</td>
<td>13-15 hours</td>
<td>Spontaneous</td>
<td>8-10 hours after start of estrus</td>
</tr>
<tr>
<td>Rabbit (Oryctolagus cuniculus)</td>
<td>No cycle</td>
<td>Continuous</td>
<td>Induced</td>
<td>10 hours after mating</td>
</tr>
<tr>
<td>Rhesus monkey (Macaca mulatta)</td>
<td>20</td>
<td>None</td>
<td>Spontaneous</td>
<td>14 days prior to onset of menstrual bleeding</td>
</tr>
<tr>
<td>Human (Homo sapiens)</td>
<td>28$^b$</td>
<td>None</td>
<td>Spontaneous</td>
<td>14 days prior to onset of menstrual bleeding</td>
</tr>
</tbody>
</table>

*From van Tienhoven 1951, with permission.

$^a$ Maximal cycle.
3) relaxin
   a) hCG stimulates CL \(\rightarrow\) relaxin 0-8 weeks
   b) after this time endometrium secretes
   c) relaxes pelvic ligaments in preparation of parturition (birth)
   d) with P inhibits uterine contraction à premature expulsion of fetus

4) insulin
   a) 3rd month from maternal pancreas
   b) maternal response \(\rightarrow\) decreased sensitivity to insulin
   c) severe insensitivity \(\rightarrow\) gestational diabetes
   temporary condition returns normal after birth

5) aldosterone
   a) maternal adrenal cortex
   b) maintain adequate Na\(^+\) levels in maternal circulation
      1. Na\(^+\) uptake by fetus
      2. Na\(^+\)/water retention \(\rightarrow\) maternal/fetal plasma volumes

6) cortisol
   a) maternal adrenal glands
   b) ↑ free/protein bound cortisol during pregnancy
   c) E \(\rightarrow\) maternal liver \(\rightarrow\) cortisol binding globulin (CBG)
   d) ↑ maternal adipose tissue volume & development of mammary glands
      a) maternal adrenal glands
   b) free/protein bound cortisol during pregnancy
   c) E \(\rightarrow\) maternal liver \(\rightarrow\) cortisol binding globulin (CBG)
   d) maternal adipose tissue volume & development of mammary glands

7) thyroxine (T\(_4\)) and triiodothyronine (T\(_3\))
   a) maternal thyroid ↑ size
   b) ↑ T\(_4\)/T\(_3\) production
   c) ↑ basal metabolic rate
   d) ↑ resting pulse rate
   e) hormones ↑ maternal cardiopulmonary function
      ↑ rate of delivery of O\(_2\)/nutrients to developing fetus