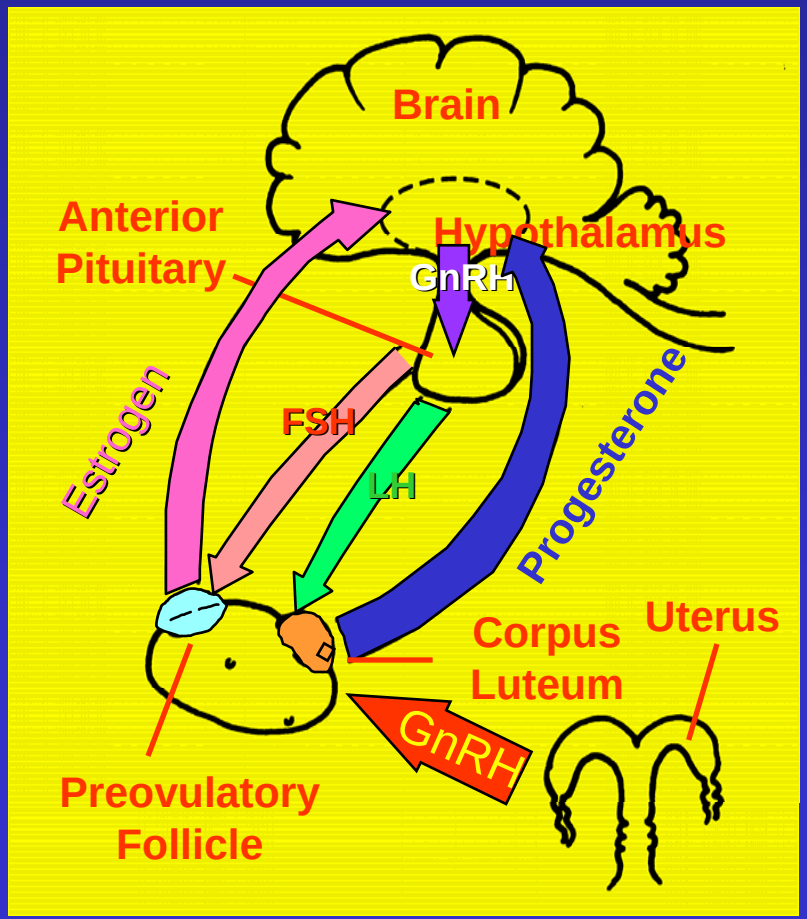
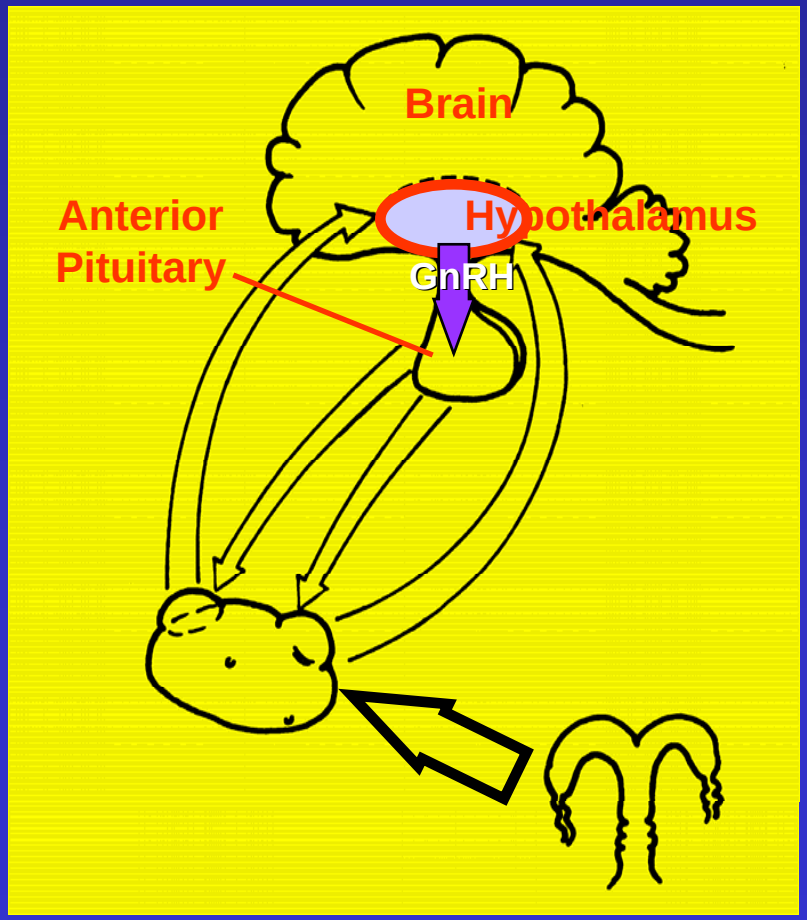
Reproductive Physiology of the Beef Heifer

Bob L. Larson, DVM, PhD, ACT

Hormones Controlling the Estrous Cycle



Hypothalamus - Releases small peptides of which GnRH is of direct importance



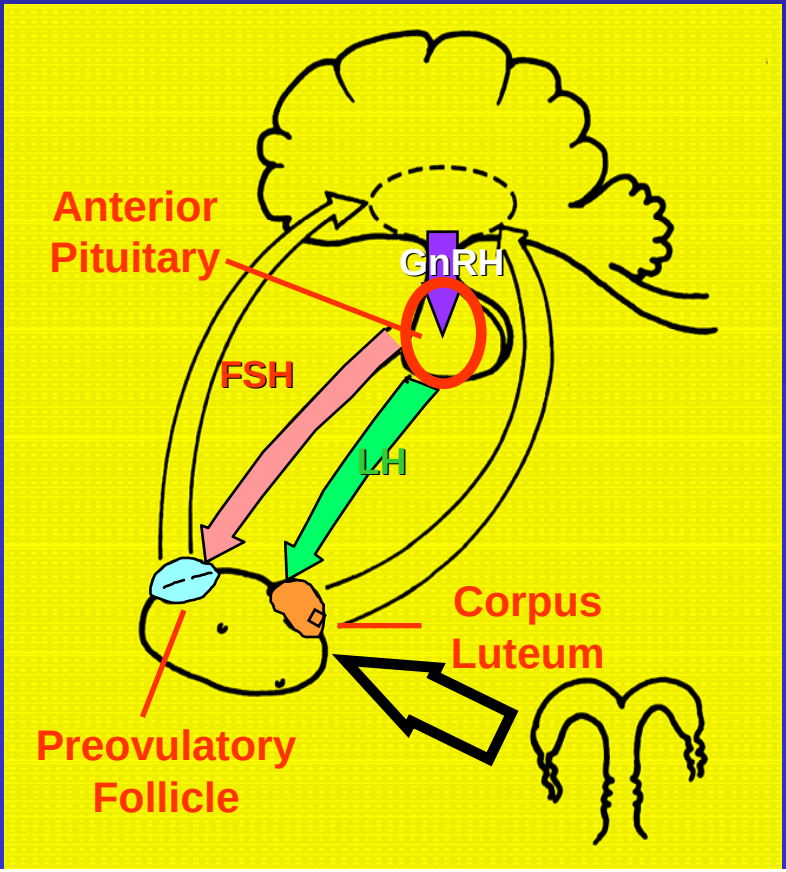
GnRH causes pituitary release of FSH and LH

Cystorelin®, Factrel®, and Fertagyl® are commercially available

Ant. Pituitary -

FSH stimulates the maturation of 2º follicles

LH stimulates maturation of 3º follicles and stimulates estrogen production



LH stimulates CL production of P_4

PMSG (eCG) gives primarily FSH activity

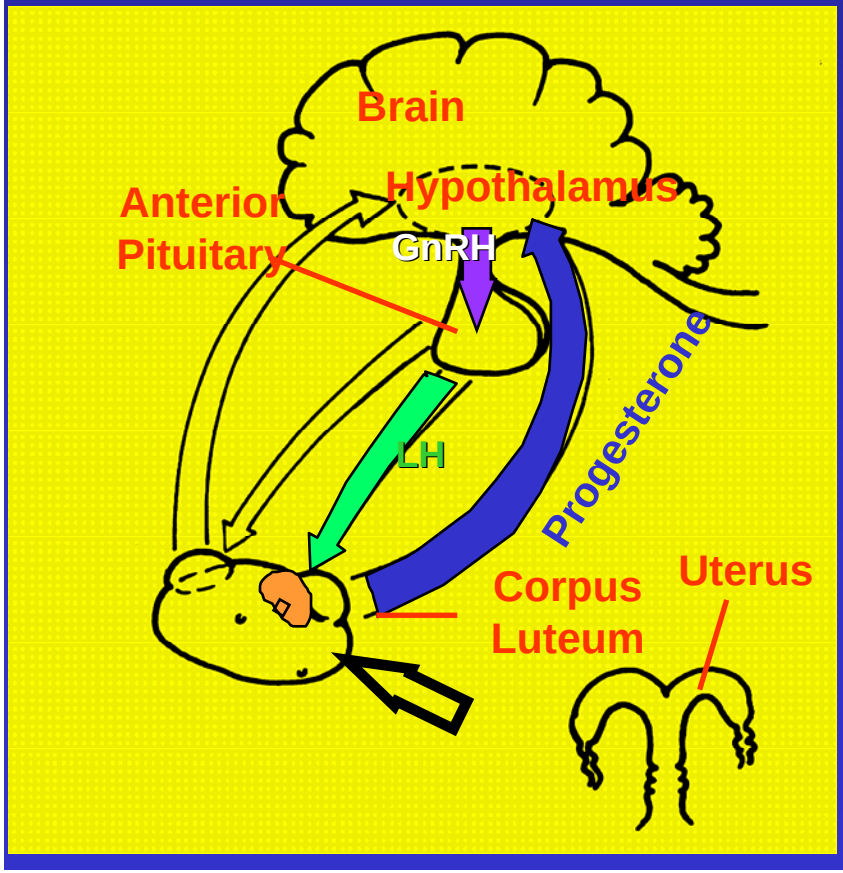
hCG gives primarily LH activity

Action of GnRH

- Causes release of Luteinizing Hormone (LH)
- Ovulation or luteinization
- Initiates new follicular wave
- CL formation

Corpus Luteum - Progesterone prepares the uterus for the egg (d5)

P4 acts on the brain to override estrogen to prevent estrus behavior



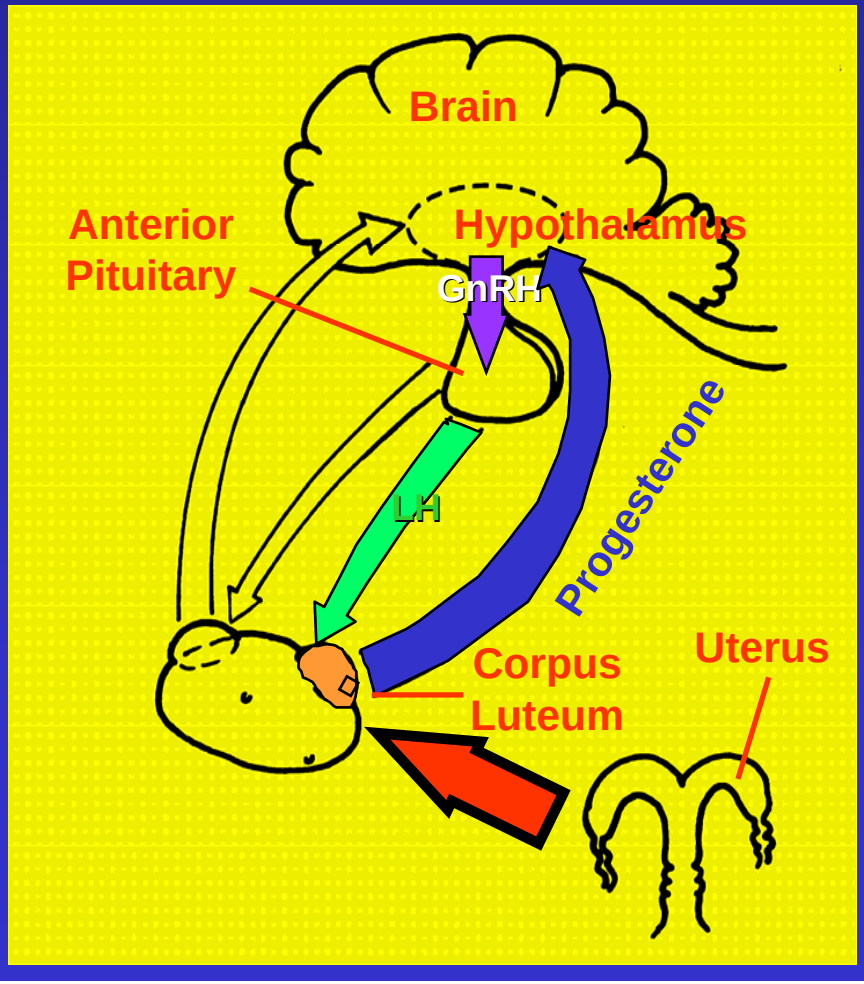
Melengestrol acetate (MGA) is synthetic progestogen and natural progesterone is found in CIDR® insert

Higher levels of P_4 are needed to prevent ovulation than estrus

Action of Progesterone

- Secreted by CL
- Suppress estrus and ovulation
- Pregnancy maintenance
- “Jump starts” anestrus cows

Corpus Luteum

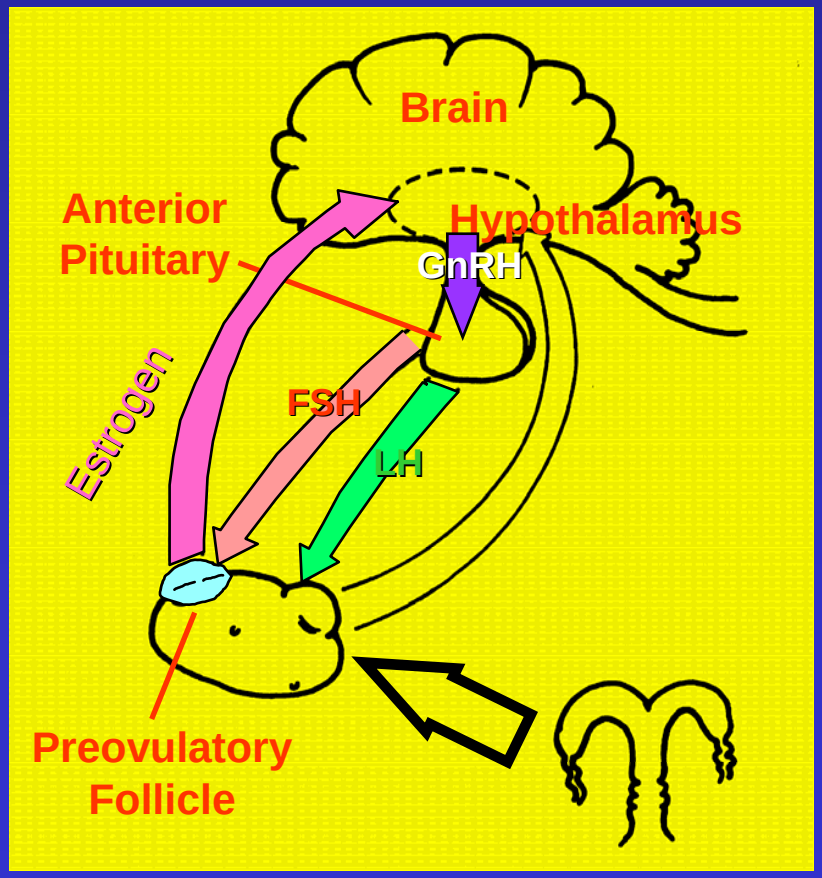


We control the estrous cycle by controlling the CL (or progesterone)

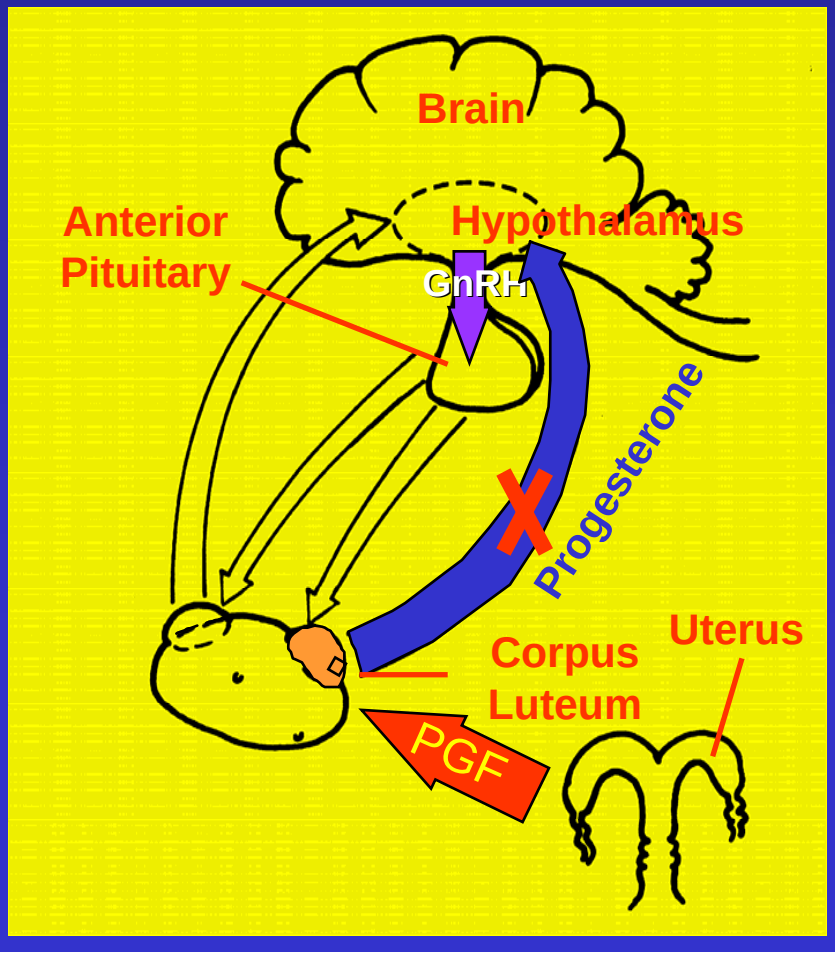
Ovarian Follicle -

Estrogen acts in a positive feed-back loop with LH

Estrogen acts on the brain to initiate estrus



Uterus - $PGF_{2\alpha}$ is produced by the non-pregnant endometrium to lyse the CL and initiate the process that leads to ovulation



Lutalyse®, Estrumate®, and other PGs will lyse a mature CL (diestrus) which causes a rapid decline in P_4 production by the CL

Onset of Puberty

- Onset of puberty is primarily influenced by age and weight within breed
- Other factors
  - Time of year
  - Exposure to progestogens

Onset of Puberty

- Management tool = Animal Breeding

Age at puberty can be decreased:

1) Selecting breeds with younger age at puberty

2) Selecting within breed for younger age at puberty

3) Crossbreeding with another breed that has similar or younger age at puberty

Onset of Puberty

- Management tool = Pharmacology

  Age at puberty can be decreased:

  1) Utilizing progestogens

  2) Utilizing ionophores

  3) Utilizing anthelmintics

Progestogen Effect on Onset of Puberty

- Estradiol negative feedback on the hypothalamus controls onset of puberty
- Progestogens reduce the negative feedback effect of estradiol

Results in increased LH secretion

Progestogen Effect on Onset of Puberty

- Estradiol negative feedback naturally decreases about 50 days prior to puberty
- If E_2 feedback is already declining, progestogens hasten the onset of puberty

Progestogen Effect

Angus × Simmental heifers (avg. 709 lbs) were treated with a 10-day 6 mg norgestomet implant starting at 320 days of age or left as untreated controls

Treatment	Age at Puberty
Control	383 ± 21.5 days[a]
Norgestomet Implant	342 ± 9.9 days[b]

[a,b] Ages differ ($P<0.05$)

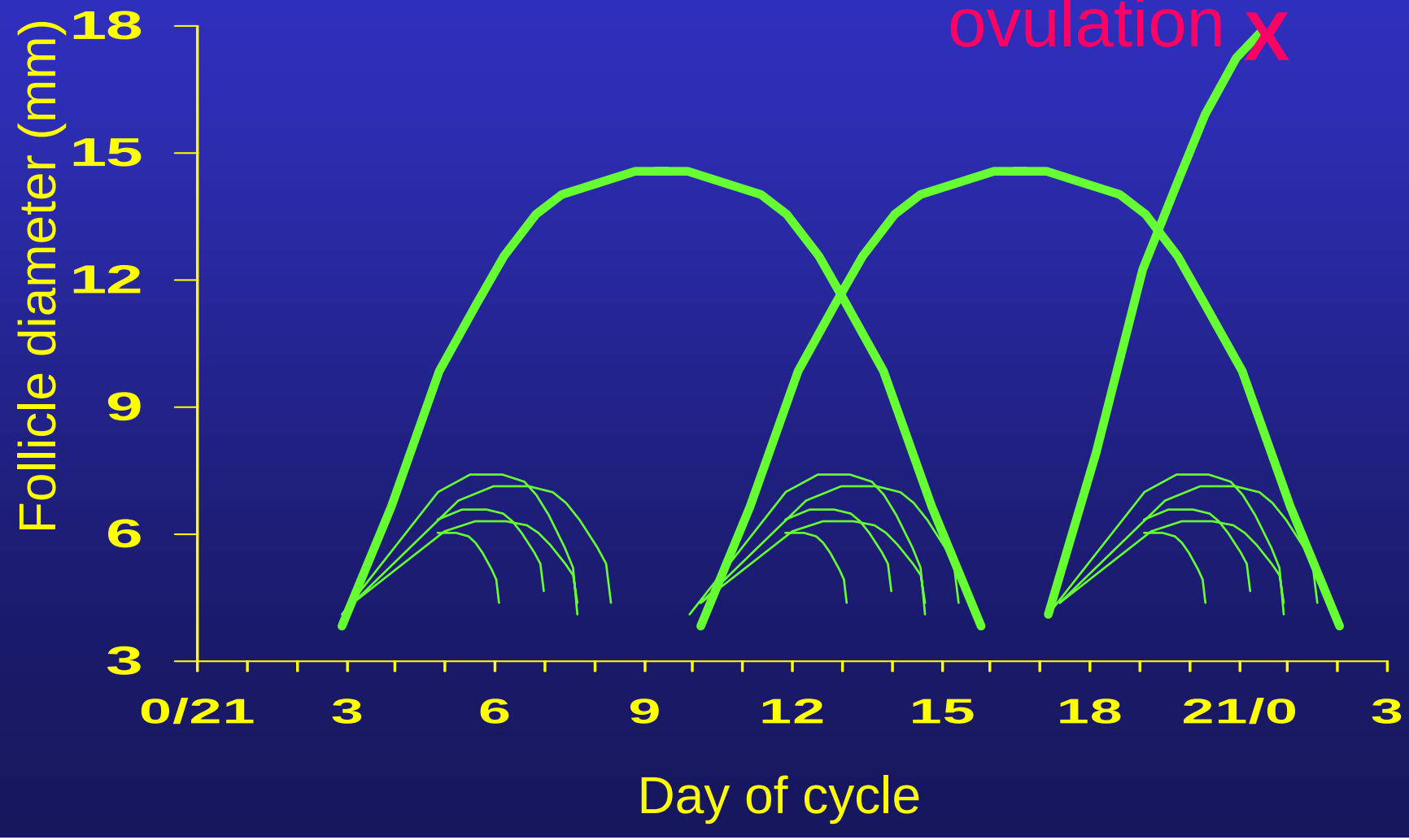
Anderson, McDowell, Day; 1996.

Bovine Estrous Cycle

19-23 days in mature cows

19-22 days in heifers

Follicular growth occurs in waves (2 to 4) in the bovine



Follicular Waves

- Follicular growth is not continuous
- A large follicle (>8 mm) is present every day of the estrous cycle

Follicular Waves

- Every 6 to 7 days (3 wave females) a new “crop” of growing follicles undergoes growth and maturation
- This “crop” begins to grow when the dominant follicle of the previous wave has reached maximal size

Follicular Waves

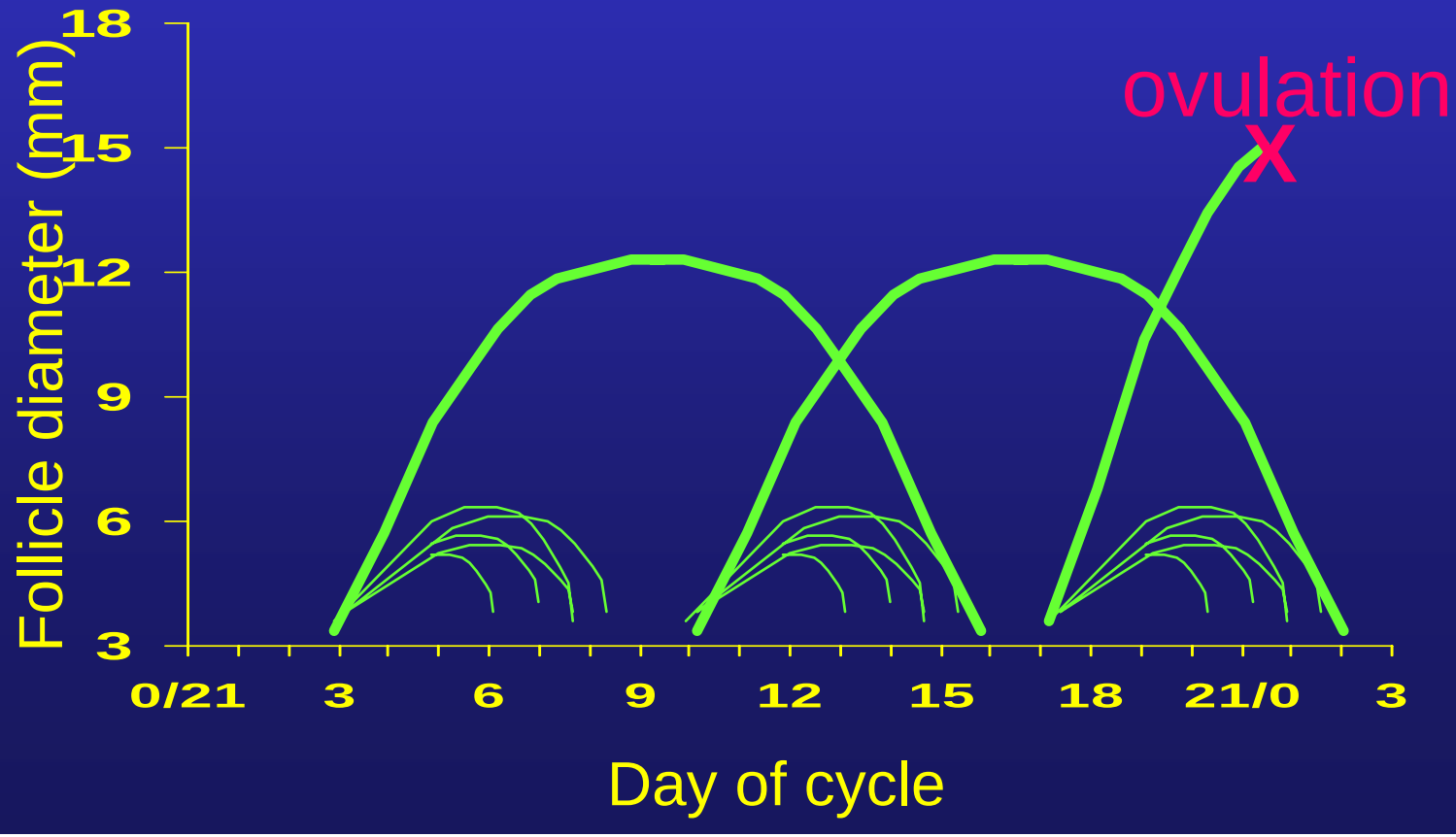
- One follicle from this “crop” is allowed to grow larger than the others (Dominant Follicle)
- The dominant follicle secretes substances that inhibit the rest of the smaller follicles from its “crop”

Follicular Waves

- A few days after reaching maximum size, the dominant follicle begins to degenerate
- As the dominant follicle degenerates, its ability to restrict other follicles decreases, and the next “crop” is recruited

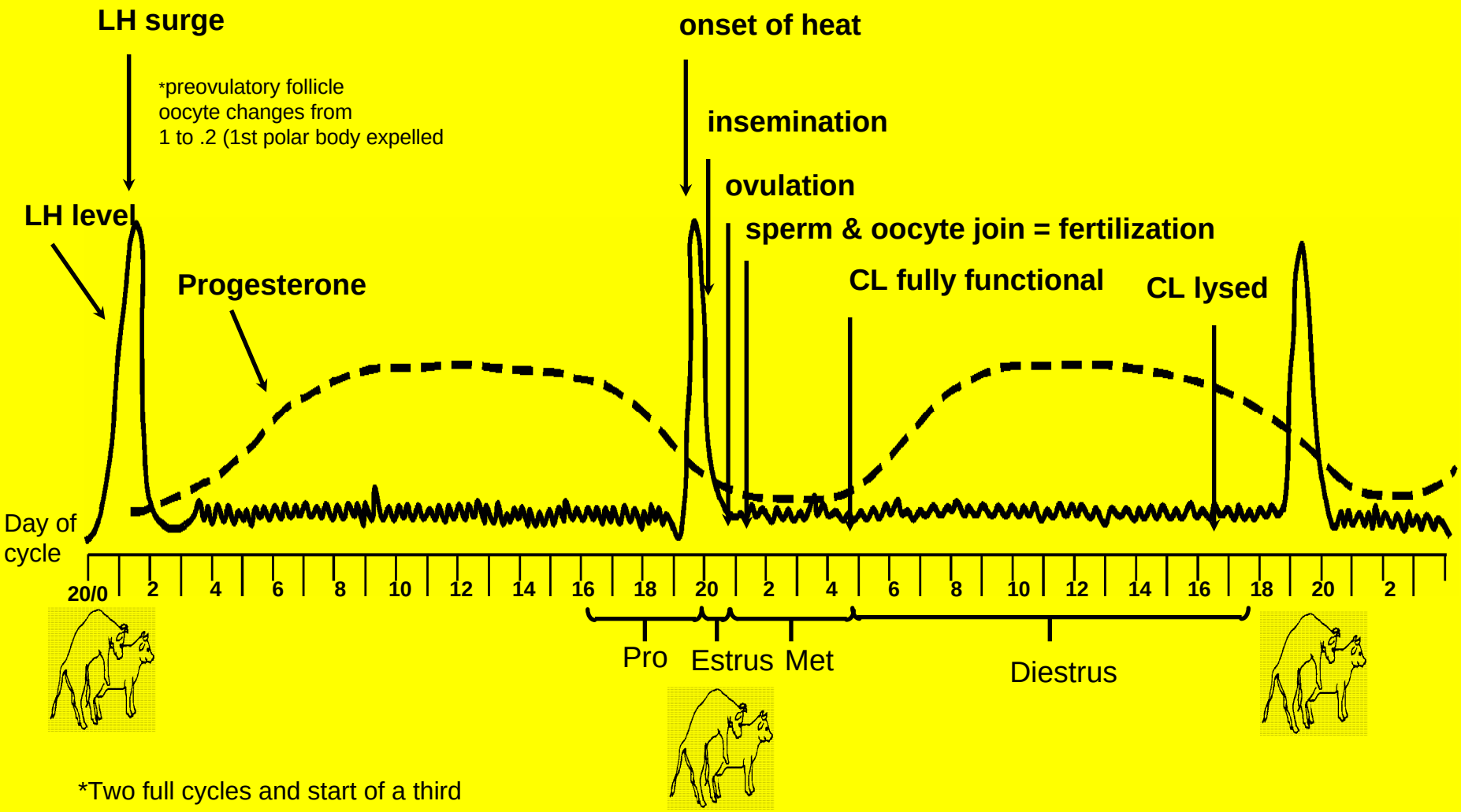
Characteristics of a 3-wave estrous cycle

Dominant follicle	wave 1	wave 2	wave 3
Day wave begins	2	9	16
Maximum size	12 mm	10 mm	13 mm
Persistence	16.9 d	13.1 d	5.9 d



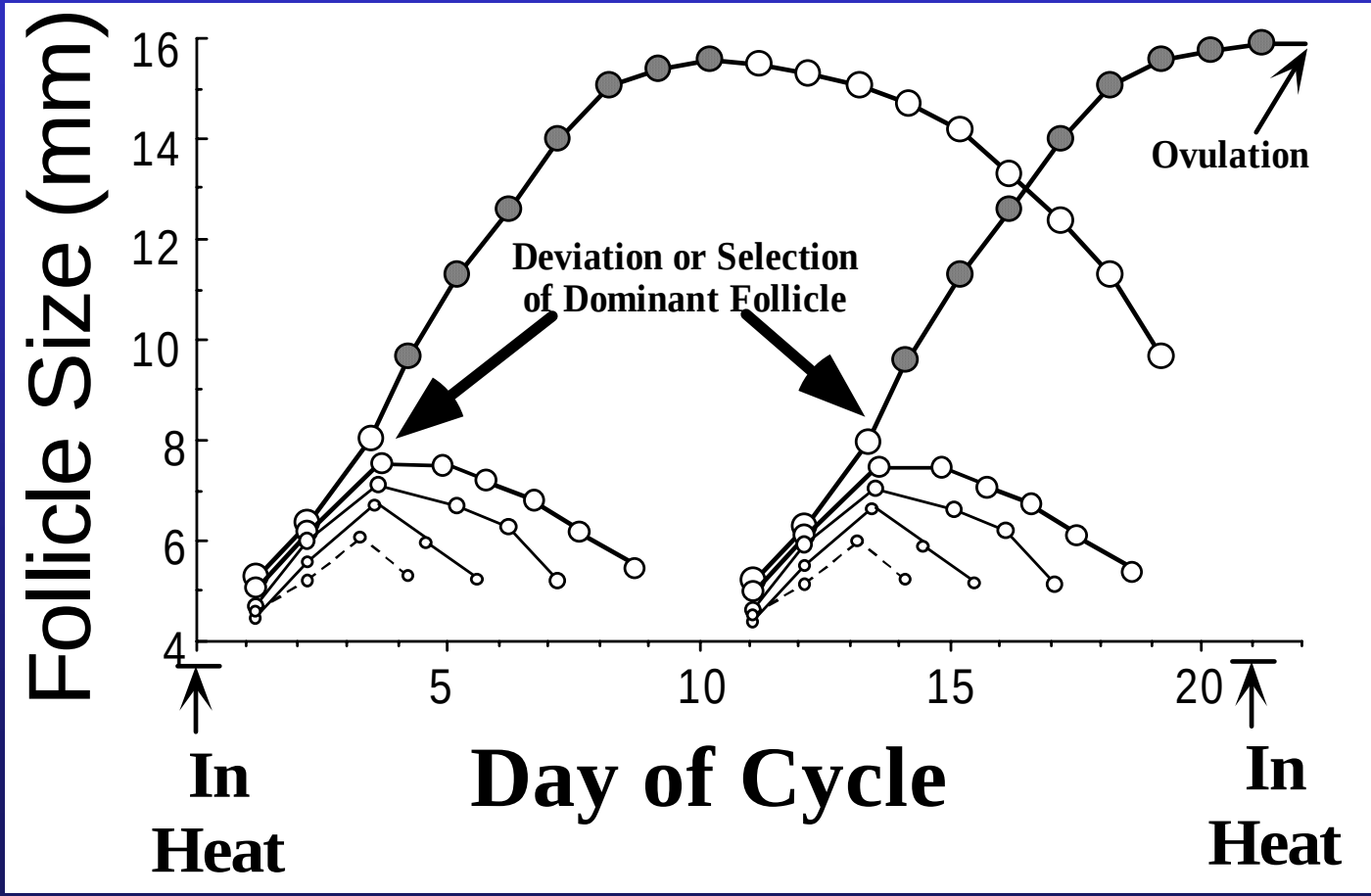
Cycle is divided into four periods:

Estrus
Metestrus
Diestrus
Proestrus



*Two full cycles and start of a third

Typical Pattern of Follicular Growth in Cows

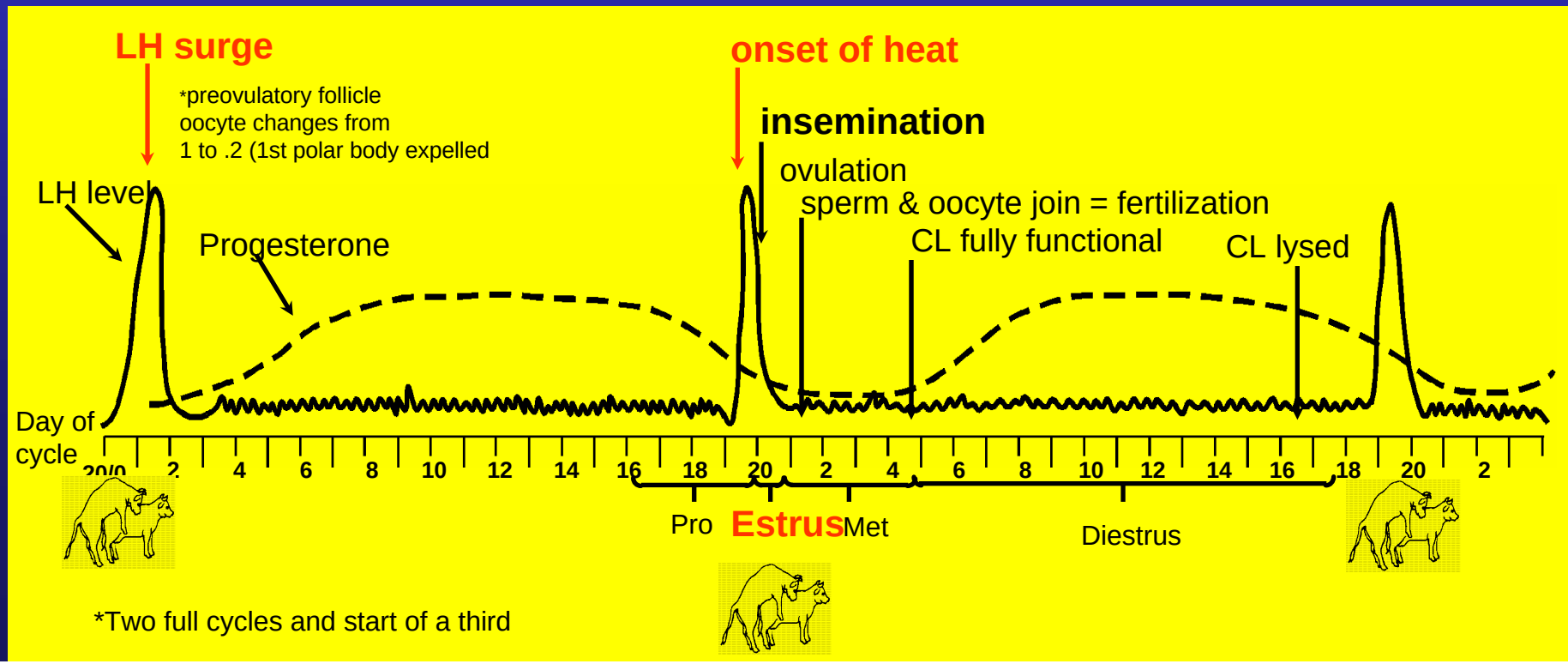


Estrus - Standing to be mounted

Lasts 20 hours (6 to 30)

Progesterone levels are low

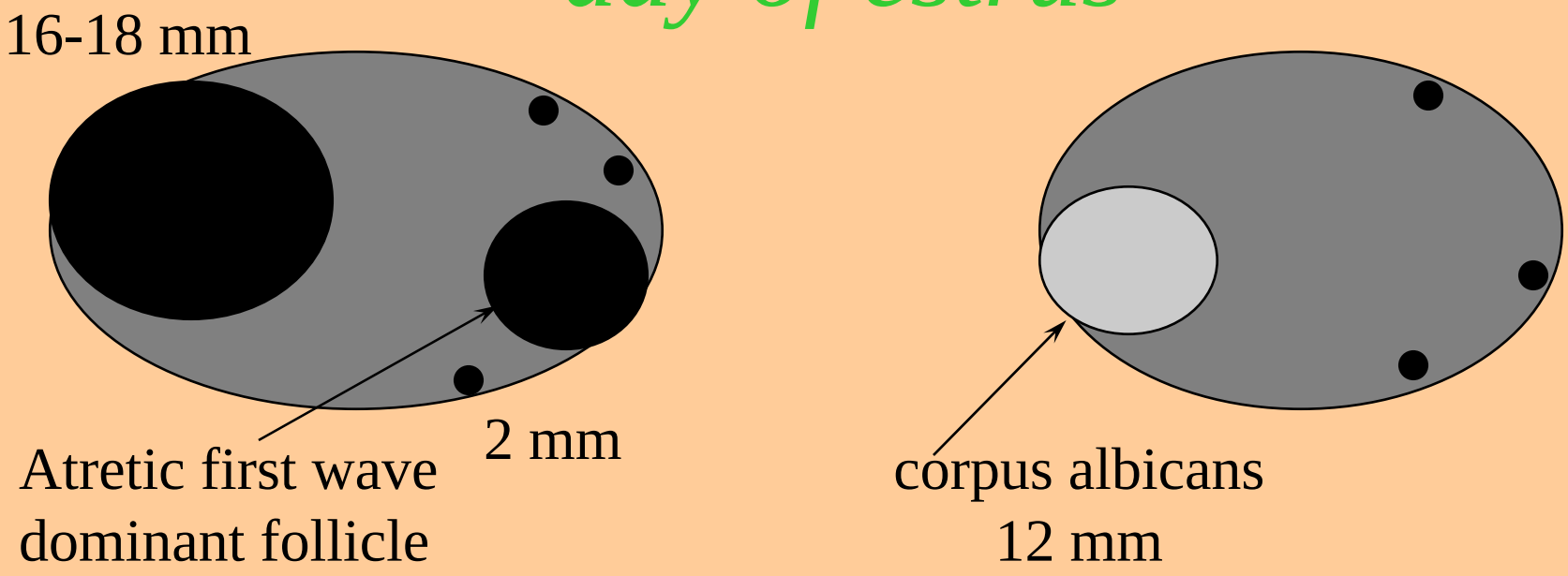
Estrogen levels are falling



*Two full cycles and start of a third

Follicle Growth in Cows

day of estrus



Estradiol positive feedback elicits a surge of LH and FSH.

LH ⟶ Ovulation

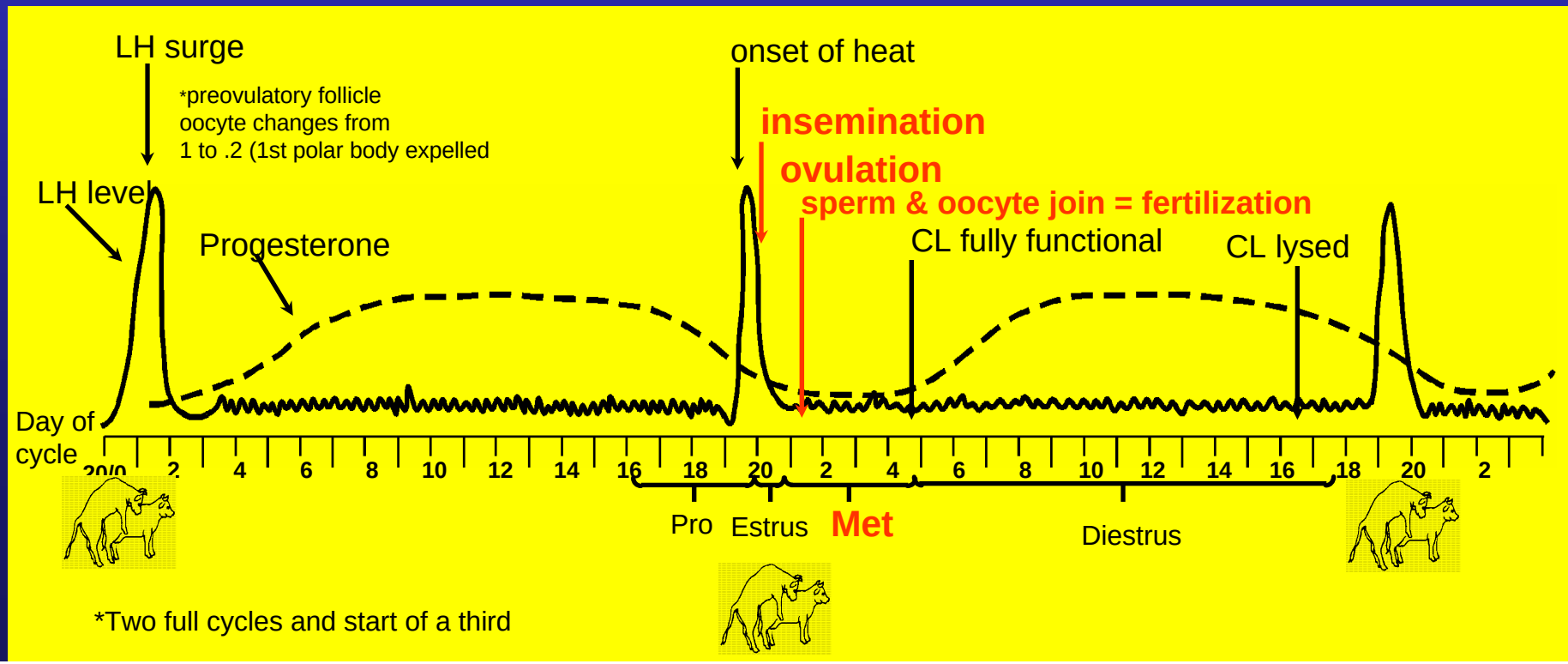
FSH ⟶ Starts new follicular wave

Metestrus - No longer standing

Ovulation 10-15 h after estrus ends

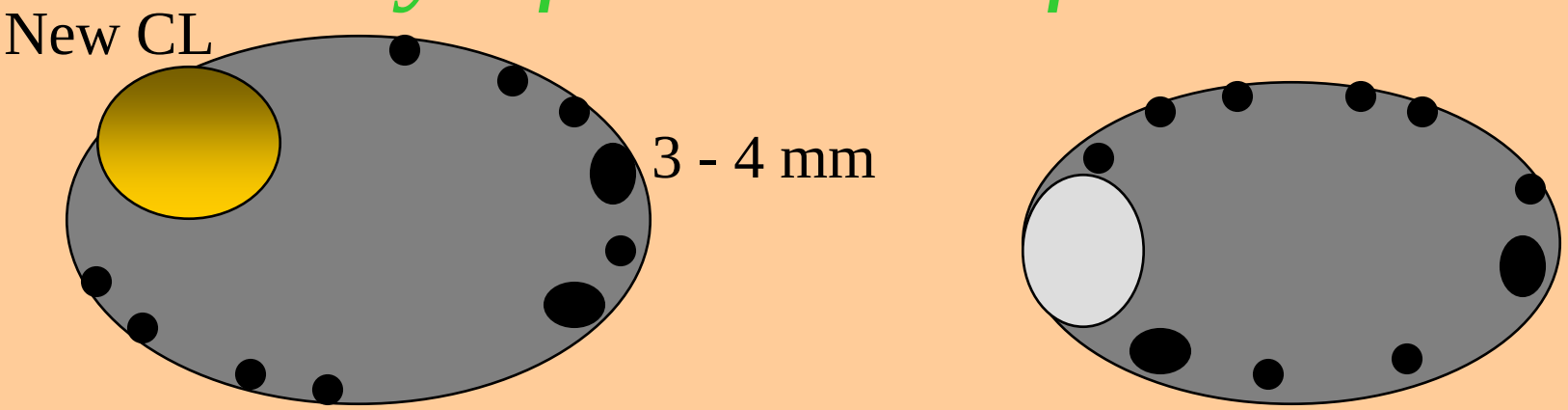
Lasts 3 to 5 days

CL is being developed



Follicle Growth

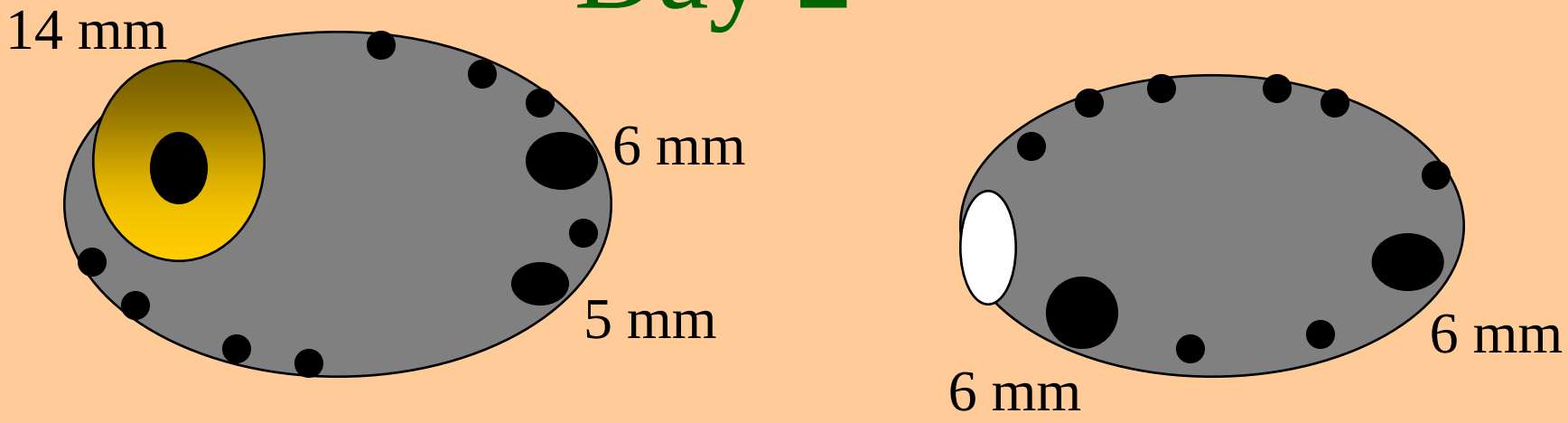
1 day after onset of estrus



Concentrations of FSH rebound after initial surge.

Growth of numerous follicles continue.

Day 2

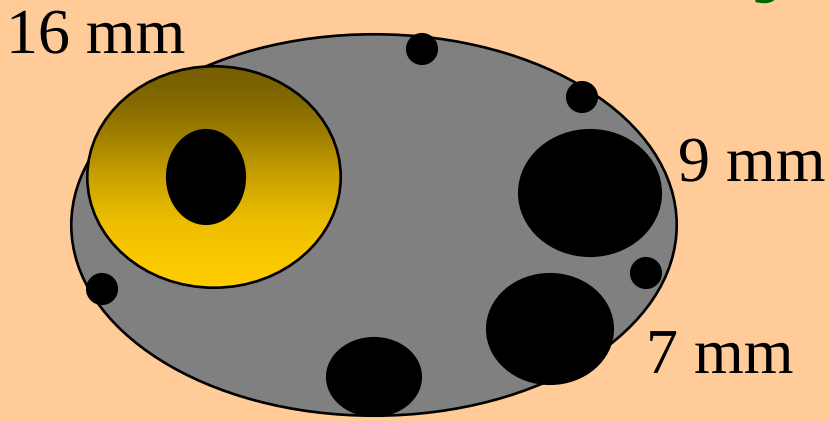


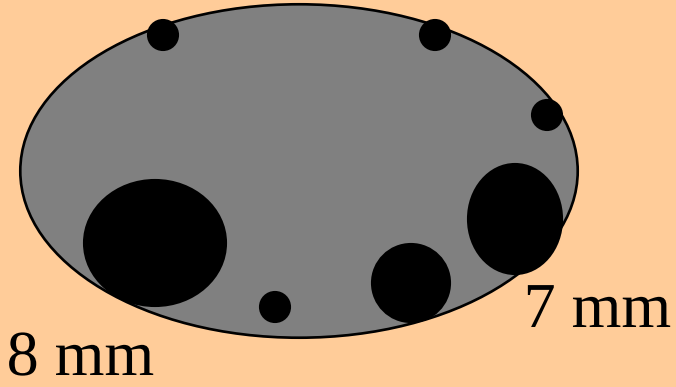
Progesterone concentrations begin to increase.

FSH concentrations remain above basal levels.

Dominance of growing follicles begin to affect smallest follicles.

Day 3





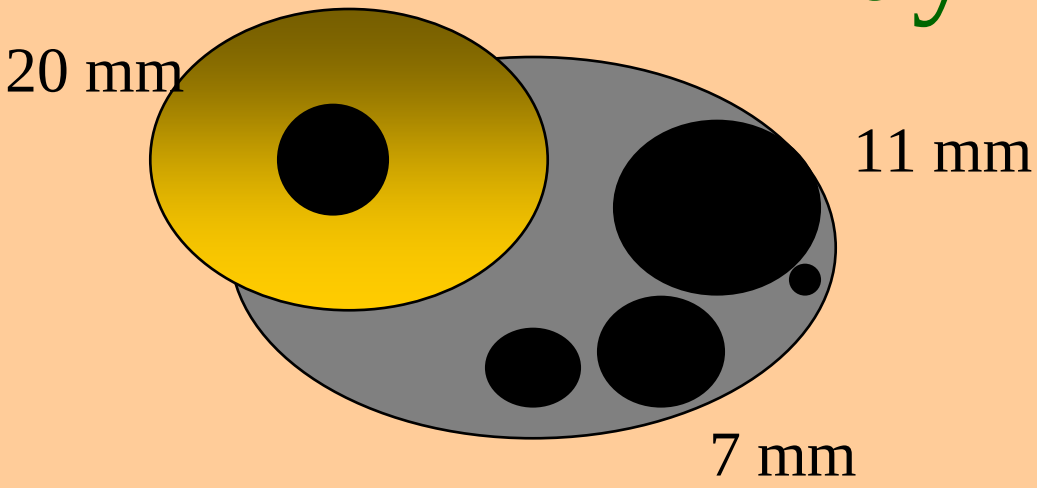
FSH decreasing but still above basal concentrations

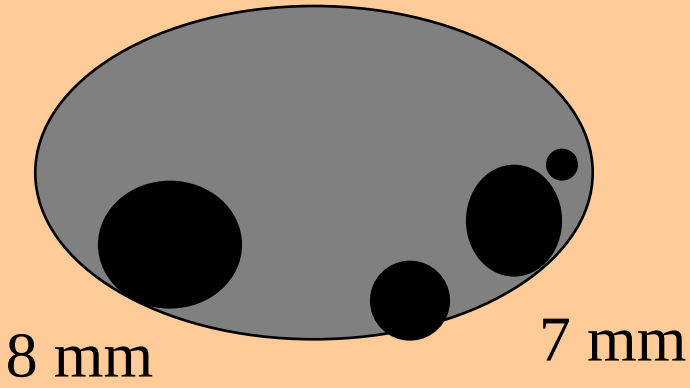
Dominant and subordinate follicles secreting estradiol and inhibin

These two compounds are suppressing the growth of other follicles

If the largest follicle was ablated or aspirated, the largest subordinate would continue to grow and become dominant

Day 4





CL size and progesterone concentrations increase substantially

Divergence of largest follicle from subordinates between day 3 and 4

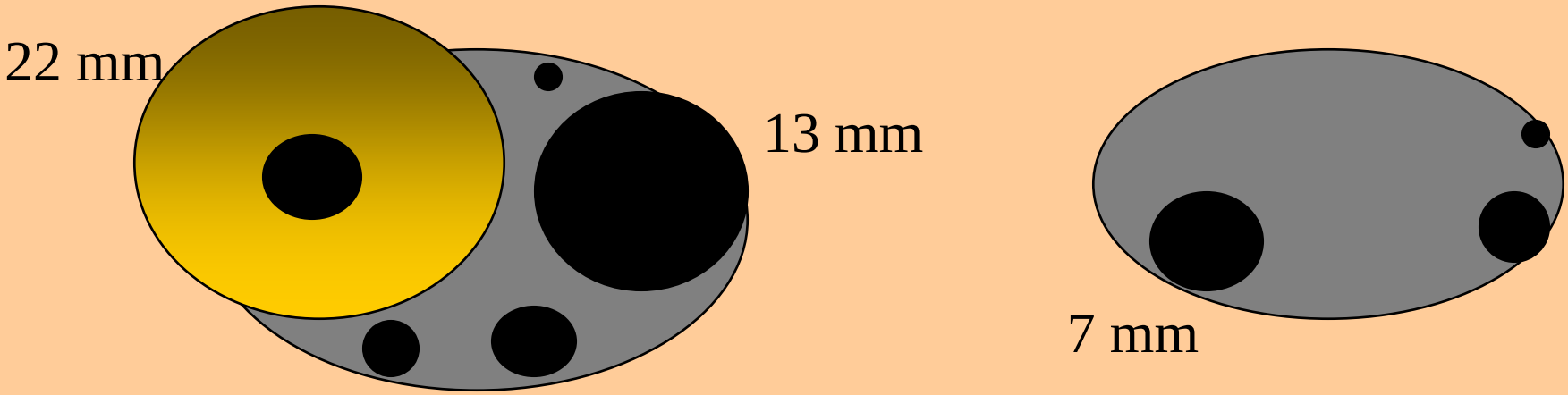
Subordinate follicles become atretic.

Dominant follicle acquires LH receptors

Dominant follicle needs LH support for continued growth

GnRH induced LH surge can ovulate the dominant follicle

Day 5



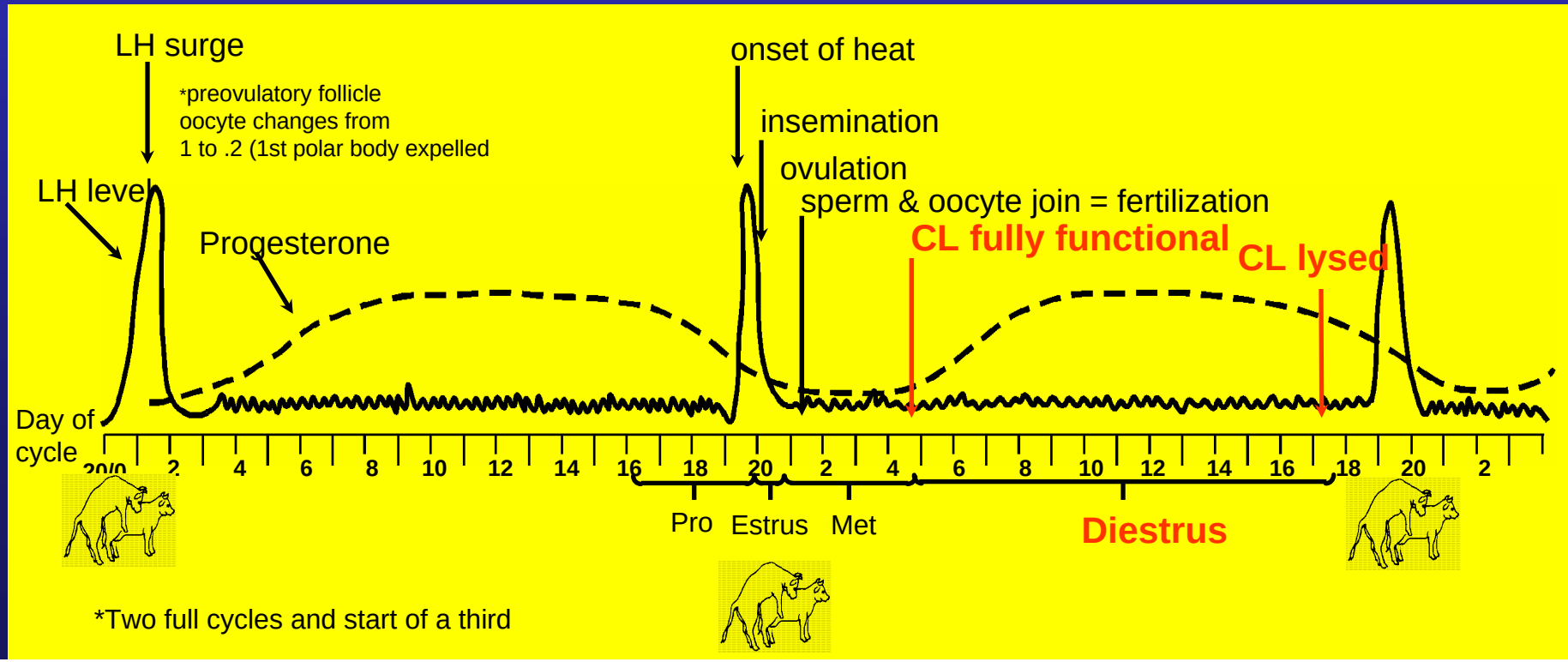
Few corpora lutea responsive to $PGF_{2\alpha}$

GnRH induced LH surge can ovulate the dominant follicle.

Diestrus - "Period of the CL"

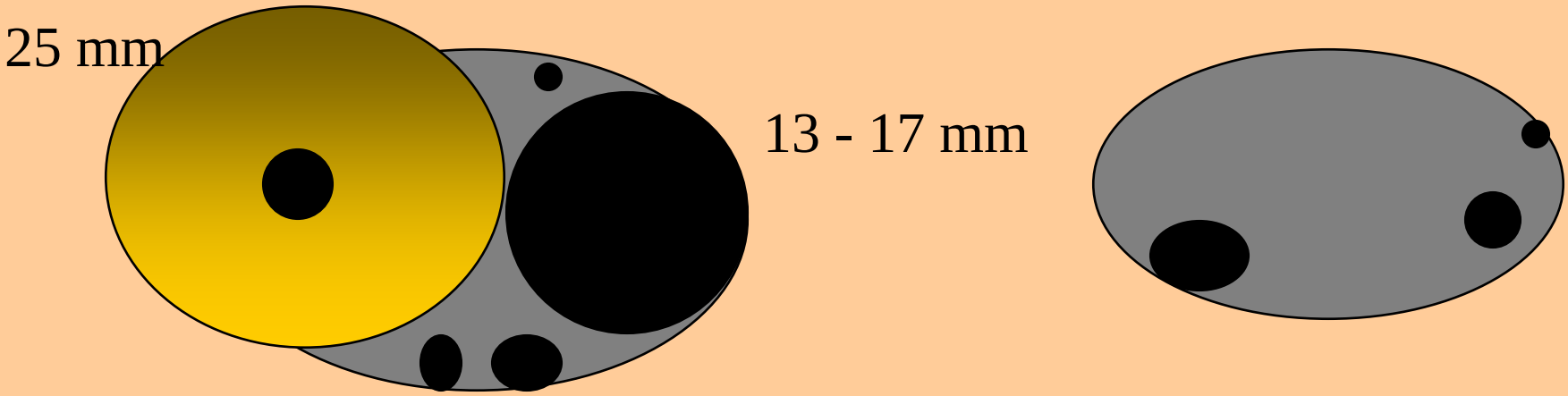
Lasts about 12 days

High levels of progesterone



*Two full cycles and start of a third

Days 6 - 11

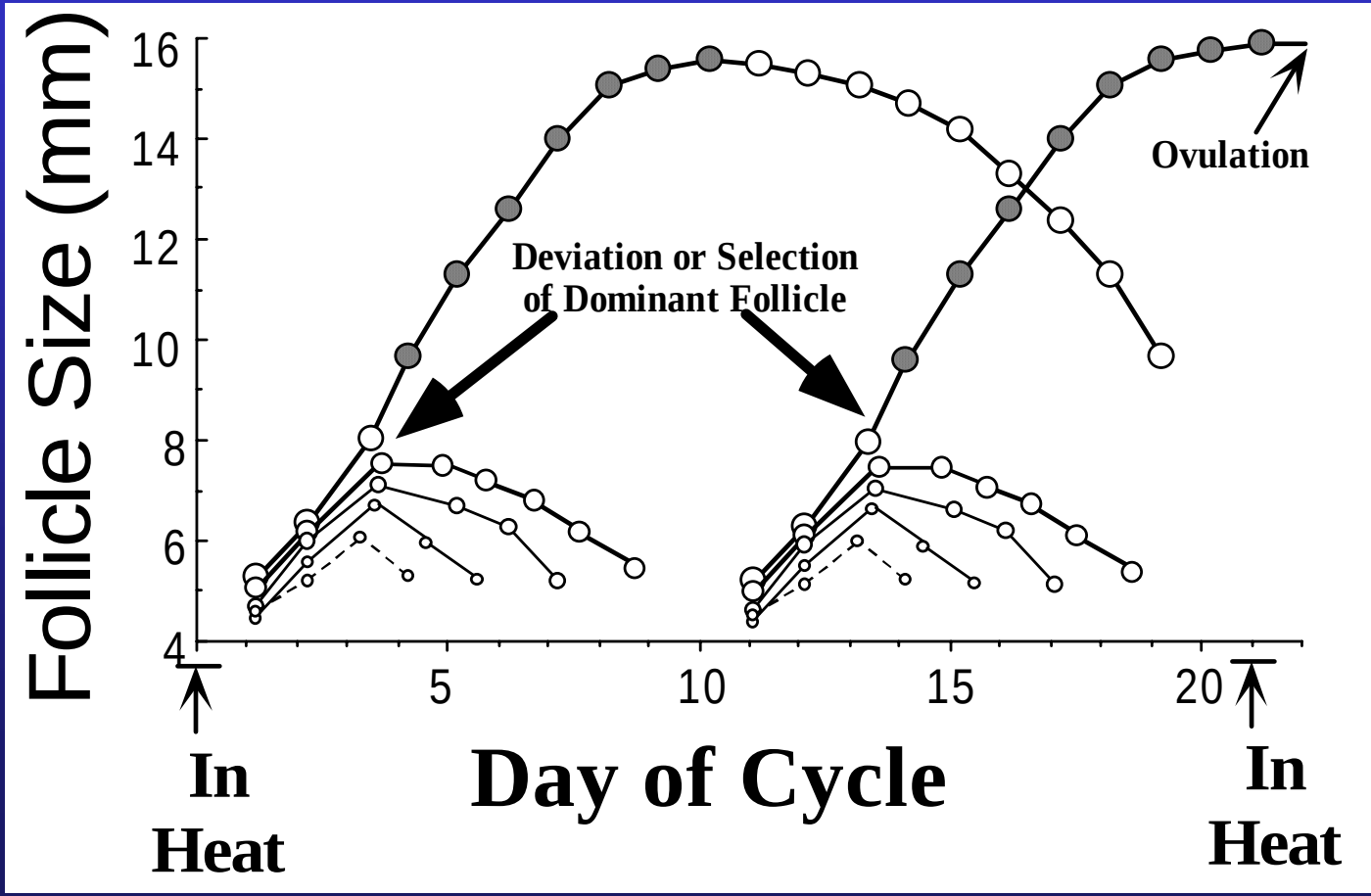


Nearly all corpora lutea are responsive to $PGF_{2\alpha}$

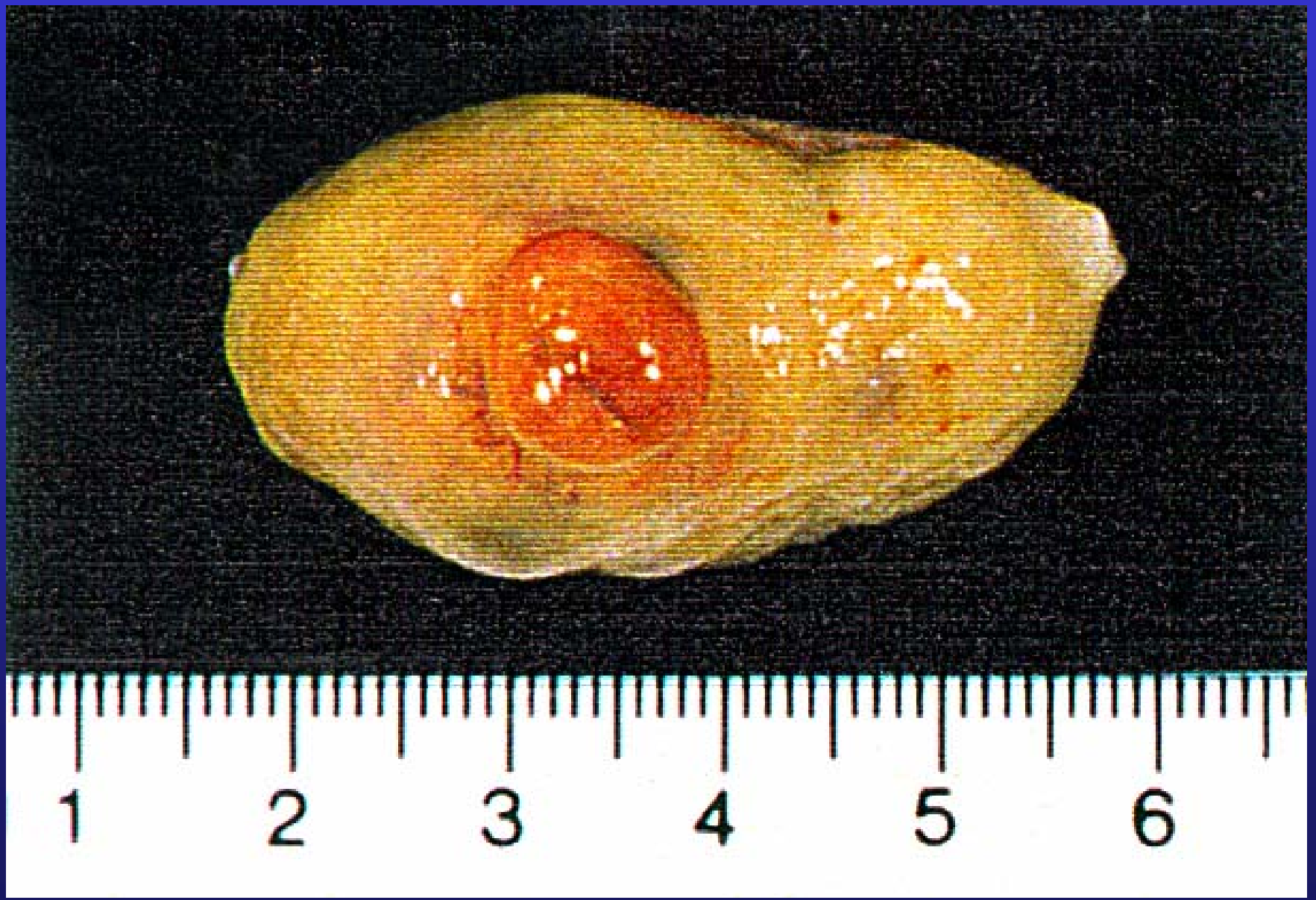
GnRH induced LH surge can ovulate the dominant follicle.

FSH suppressed.

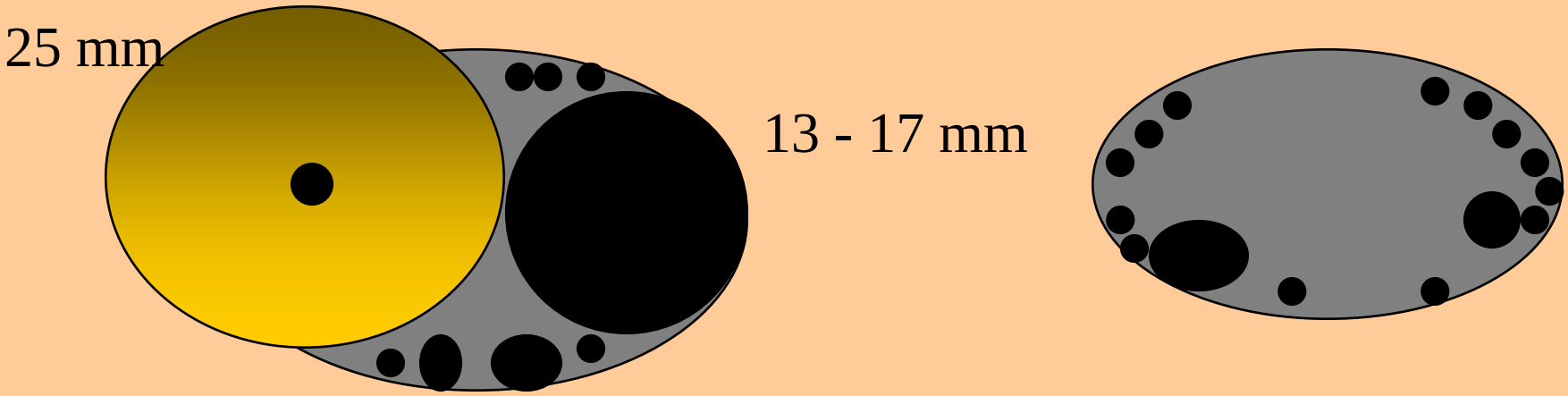
Typical Pattern of Follicular Growth in Cows



Day 7



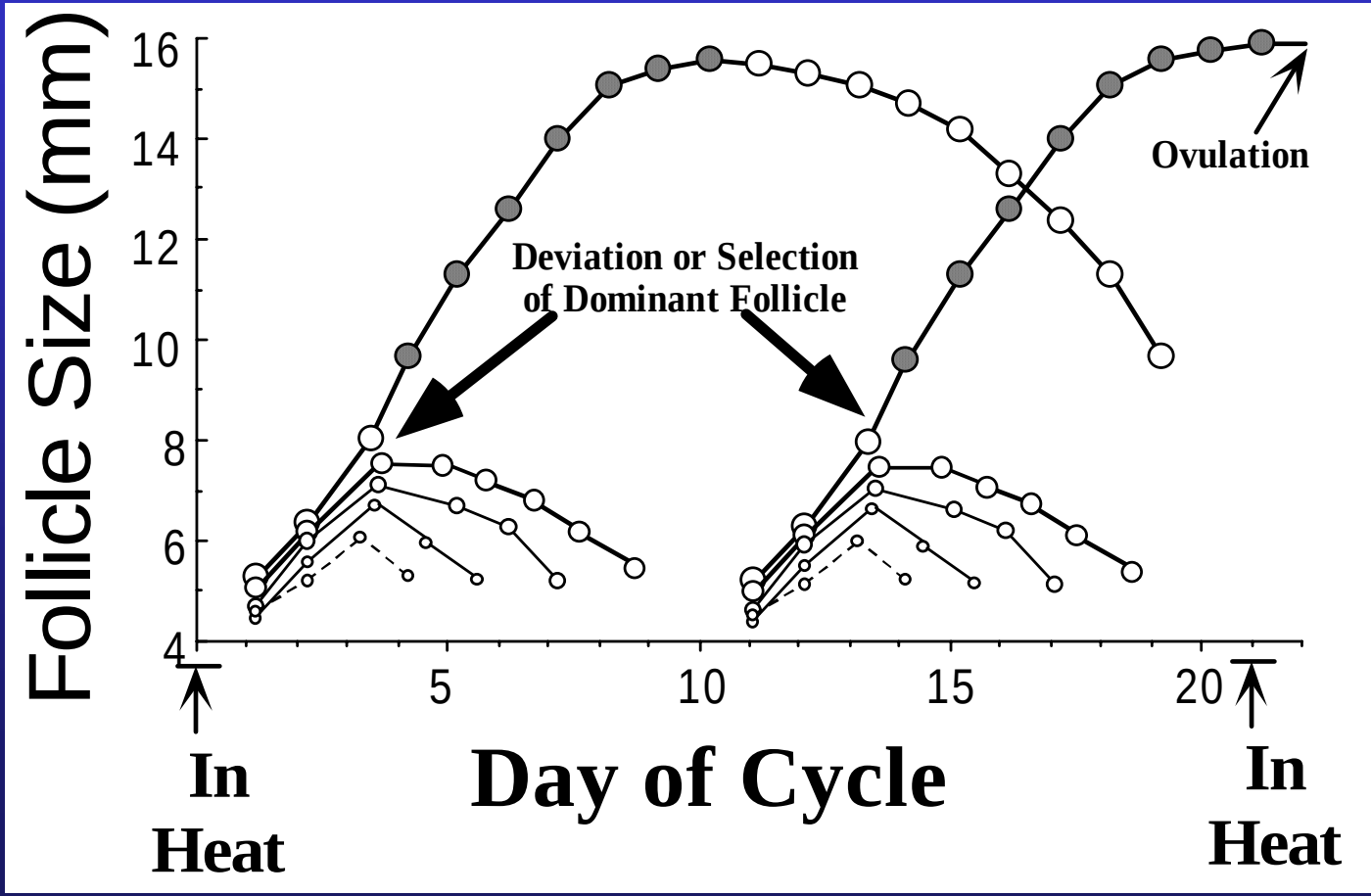
Days 10 - 14



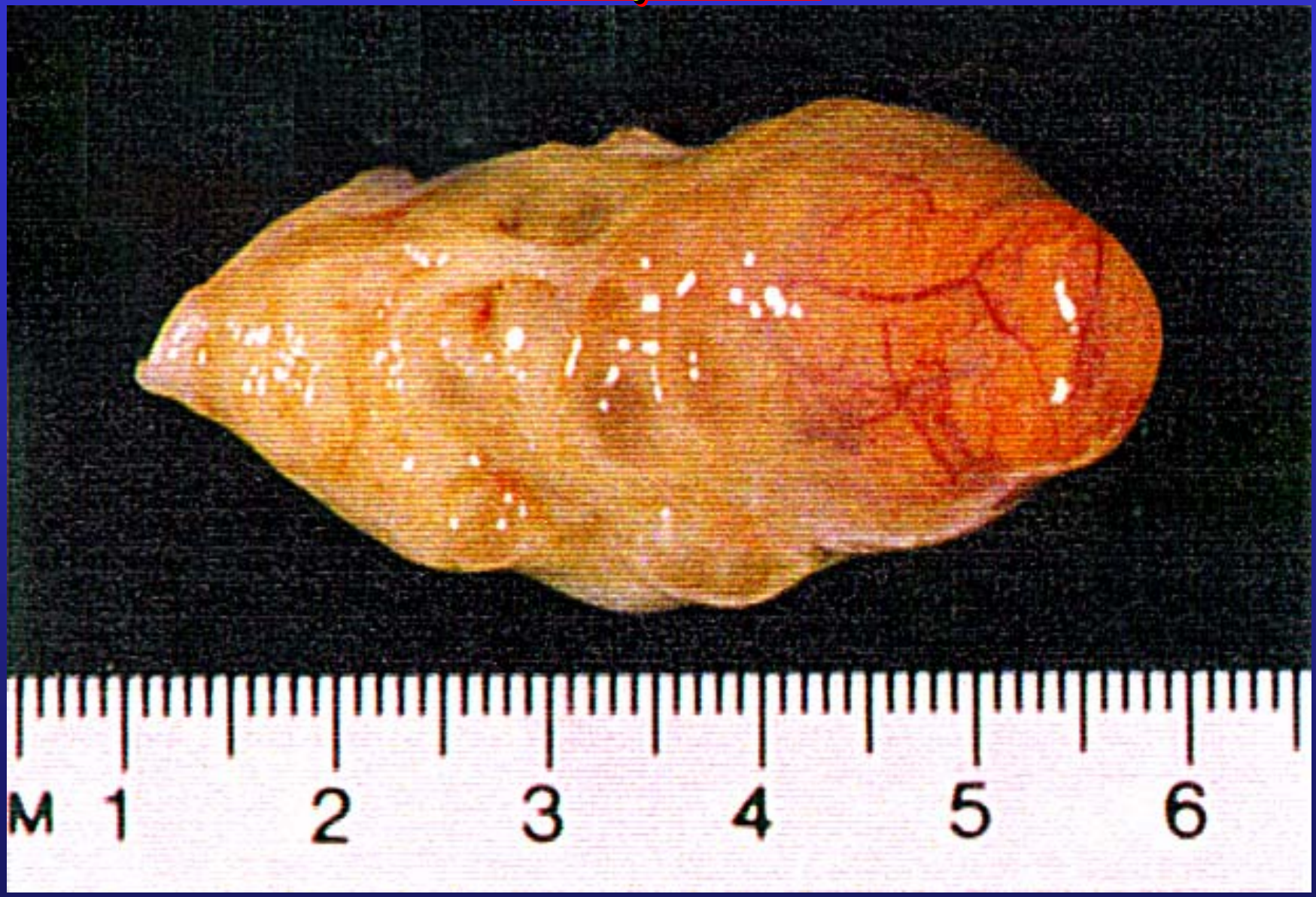
Nearly all corpora lutea are responsive to $PGF_{2\alpha}$

GnRH induced LH surge **will not** ovulate the largest follicle.

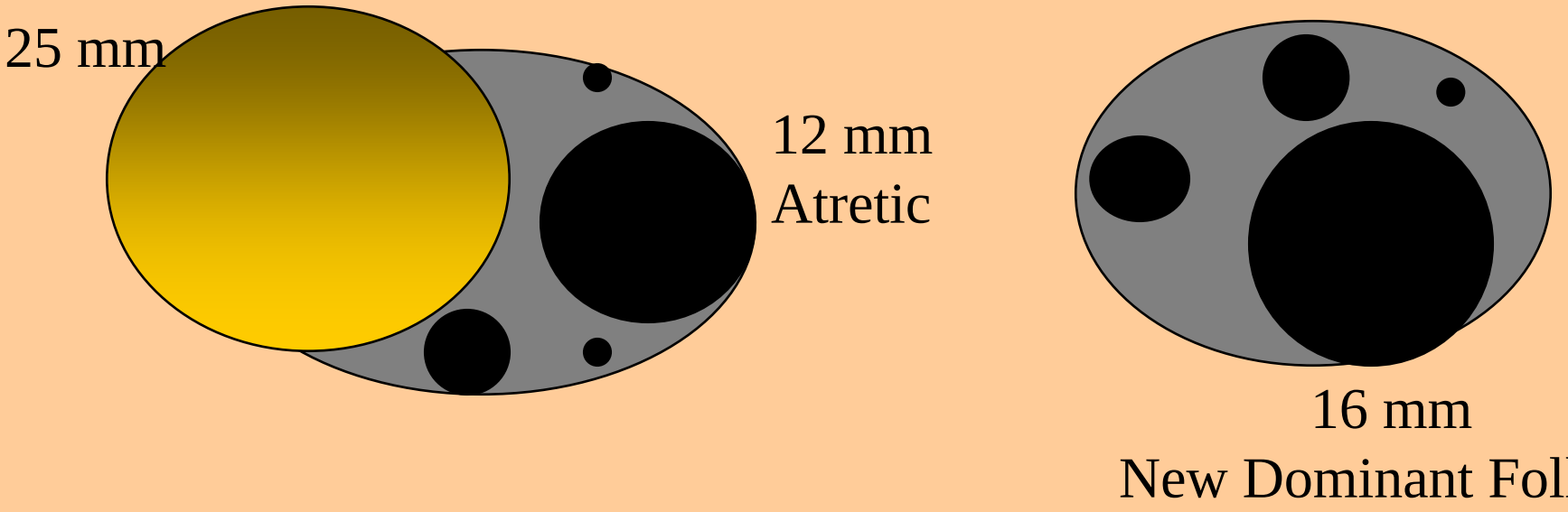
Typical Pattern of Follicular Growth in Cows



Day 11



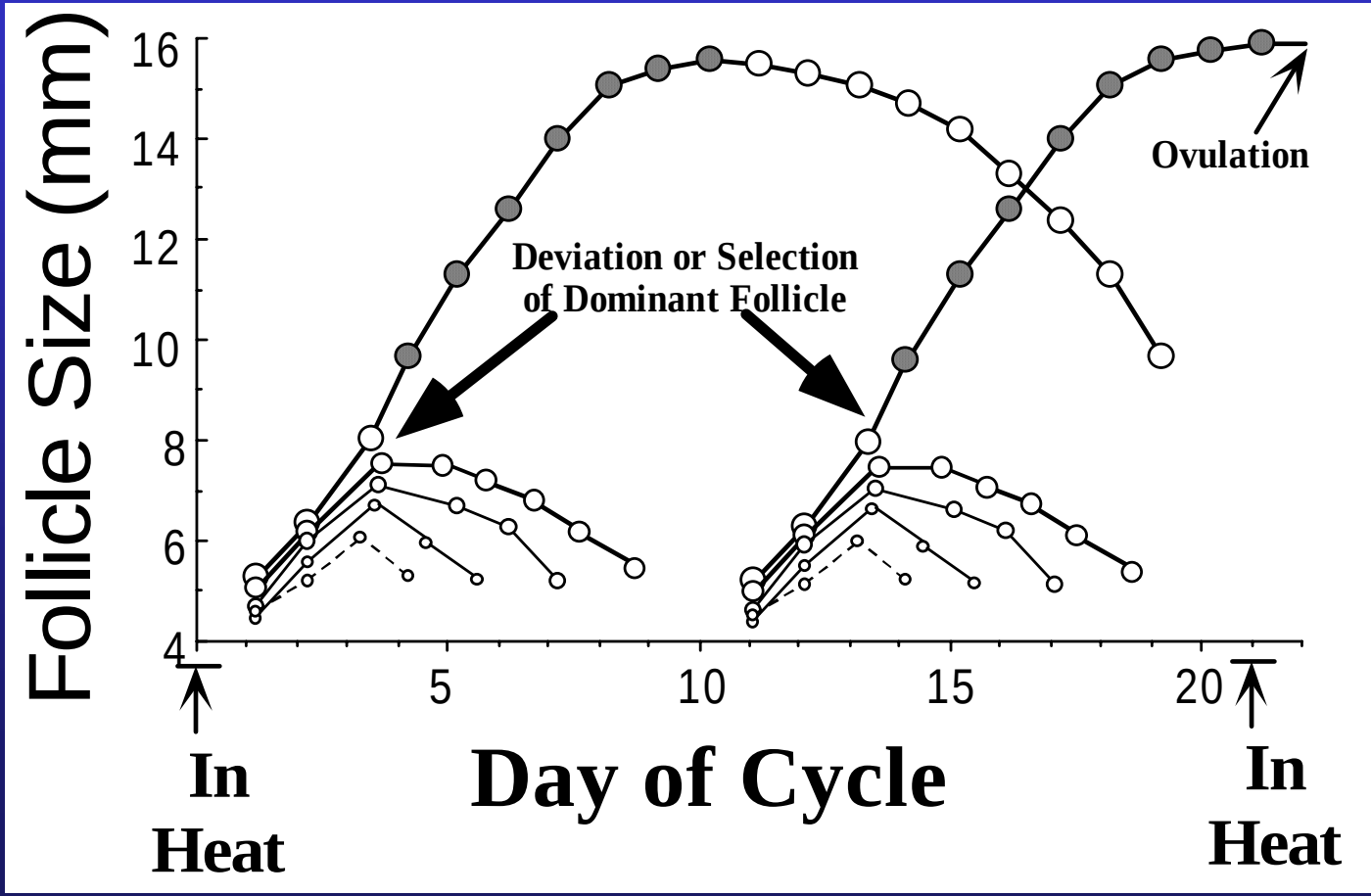
Days 15 - 17



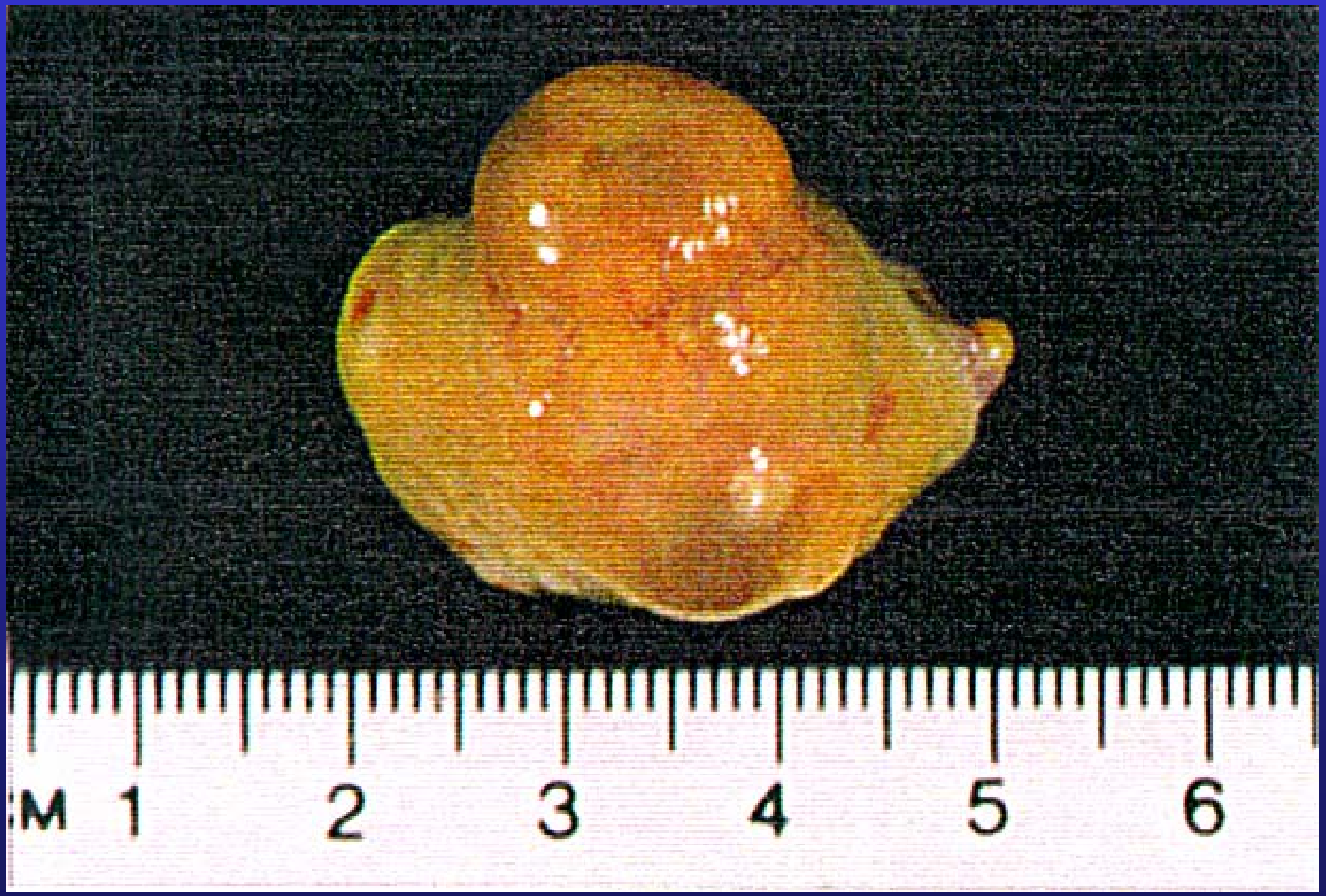
Nearly all corpora lutea are responsive to $PGF_{2\alpha}$

GnRH induced LH surge **will** ovulate the new dominant follicle

Typical Pattern of Follicular Growth in Cows



Day 17

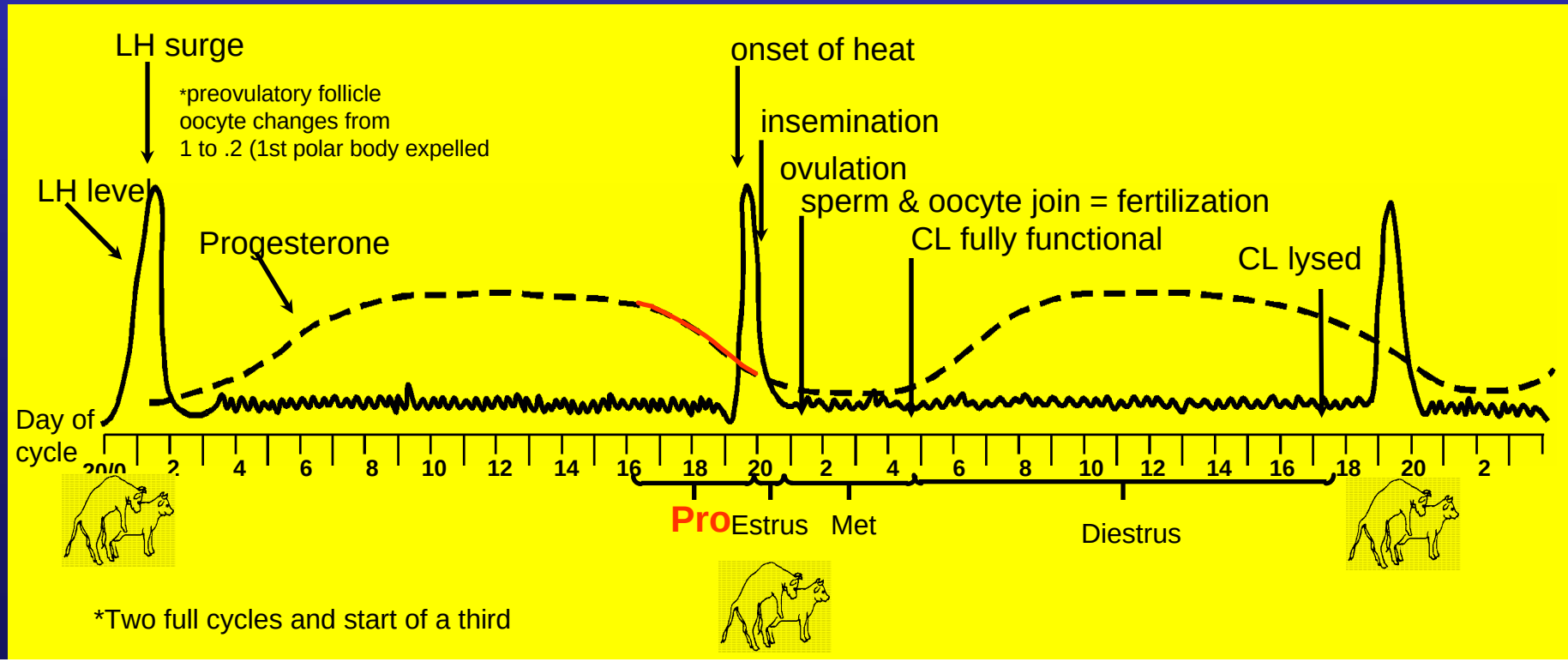


Proestrus - CL is regressing

Lasts 2 to 3 days

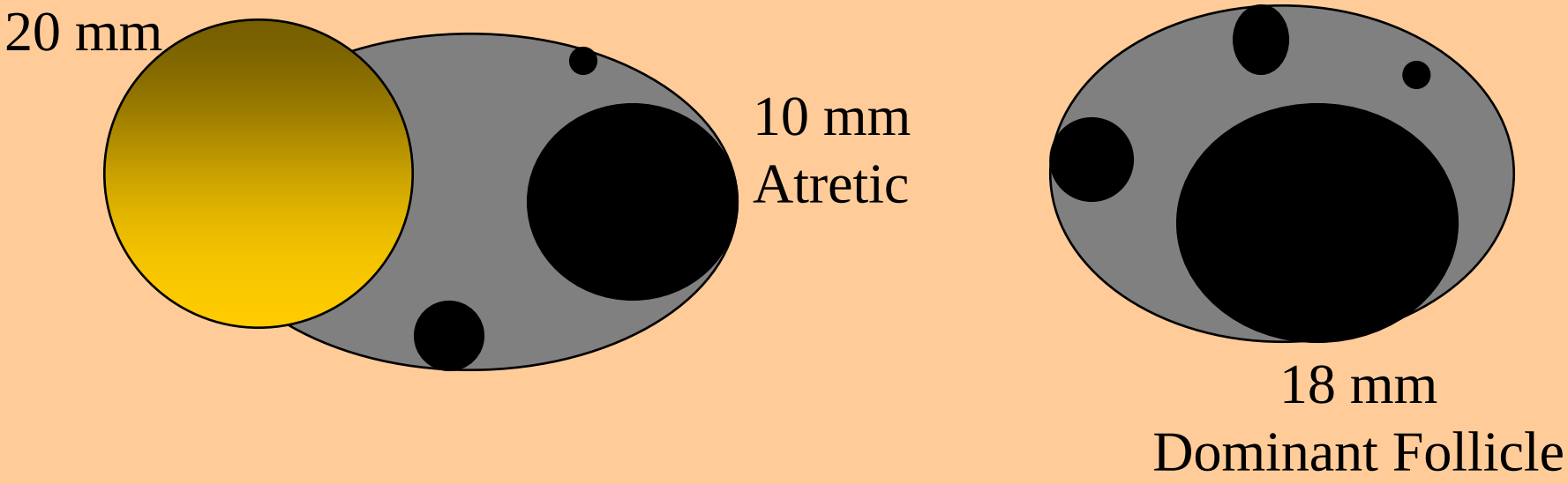
Progesterone levels decreasing

Estrogen levels increasing



*Two full cycles and start of a third

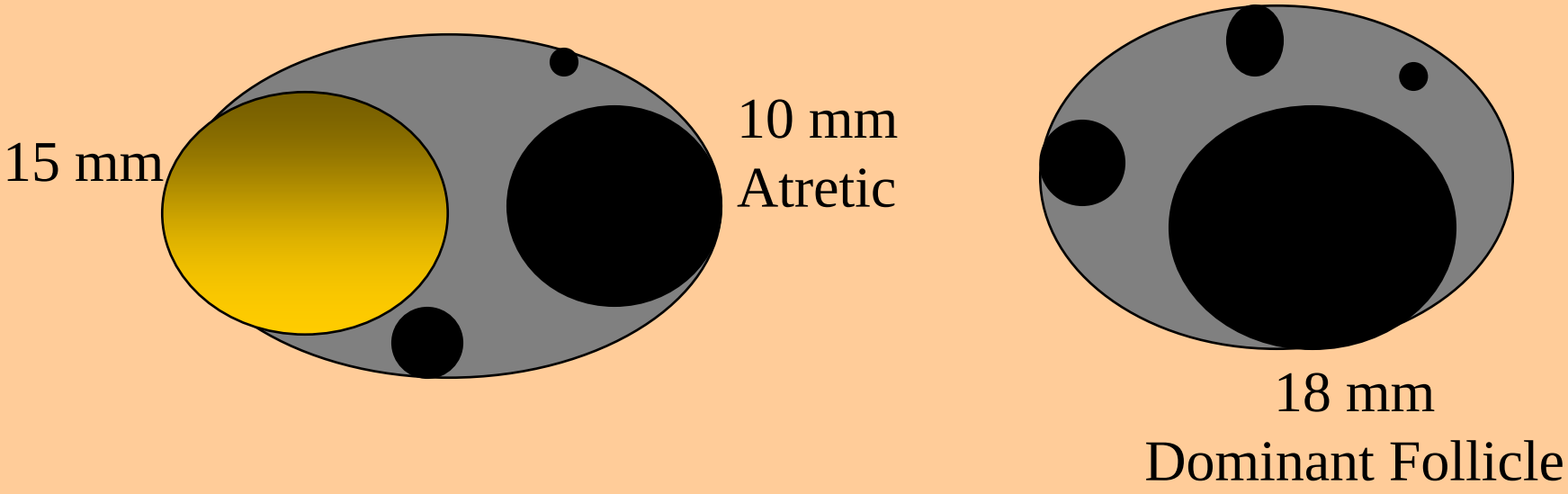
Day 18



CL regression induced endogenously.

GnRH induced LH surge **will** ovulate the dominant follicle.

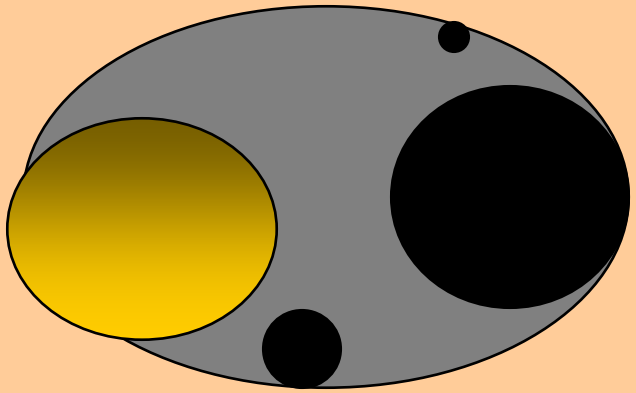
Day 19 and 20



CL regression induced endogenously.

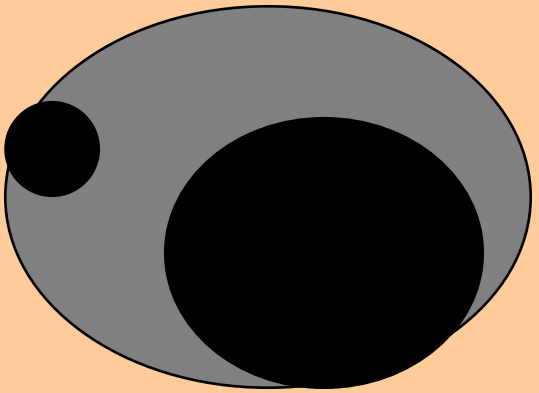
GnRH induced LH surge **will** ovulate the dominant follicle.

Day of Estrus



10 mm
Atretic

corpus albicans
12 mm



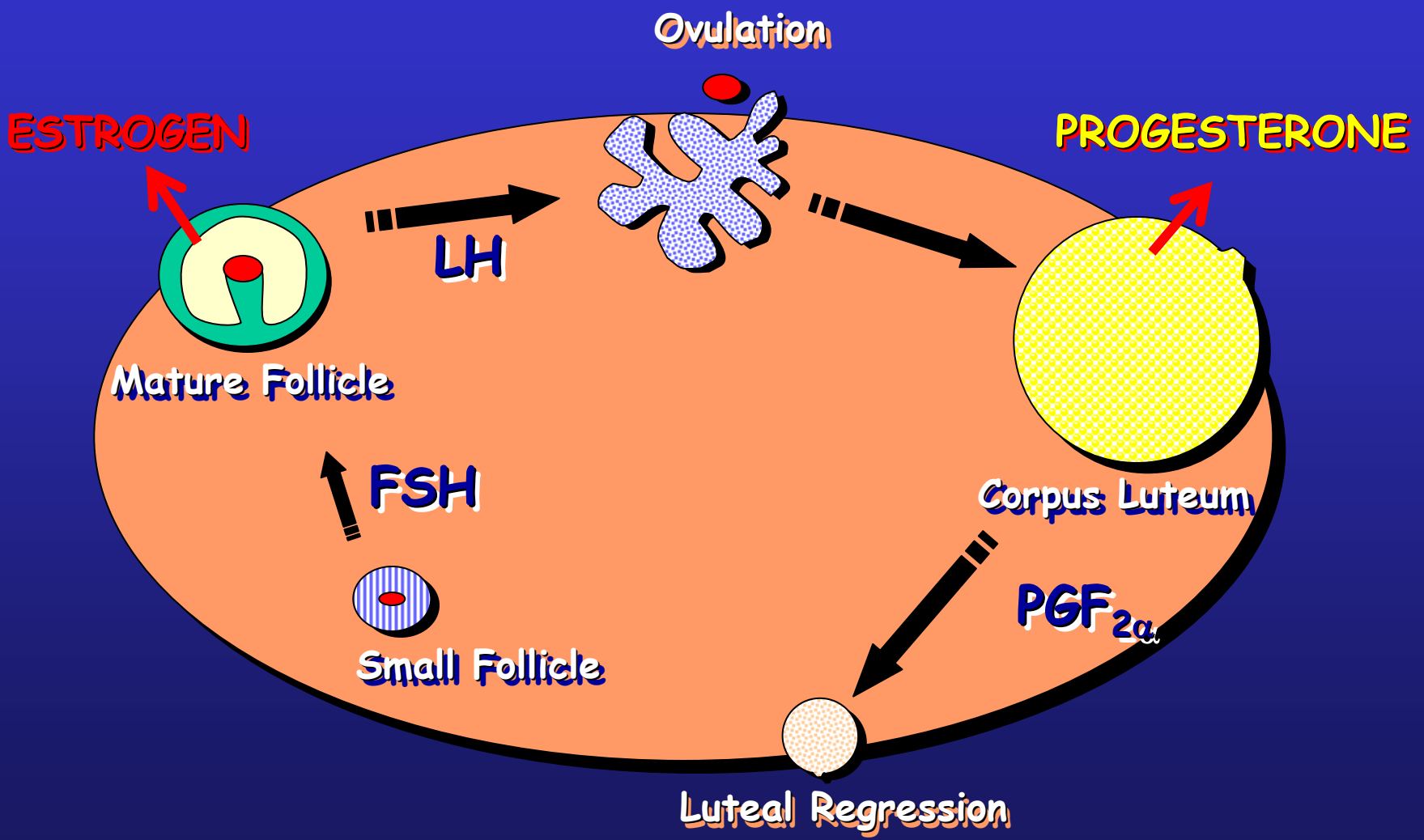
18 mm
Dominant Follicle

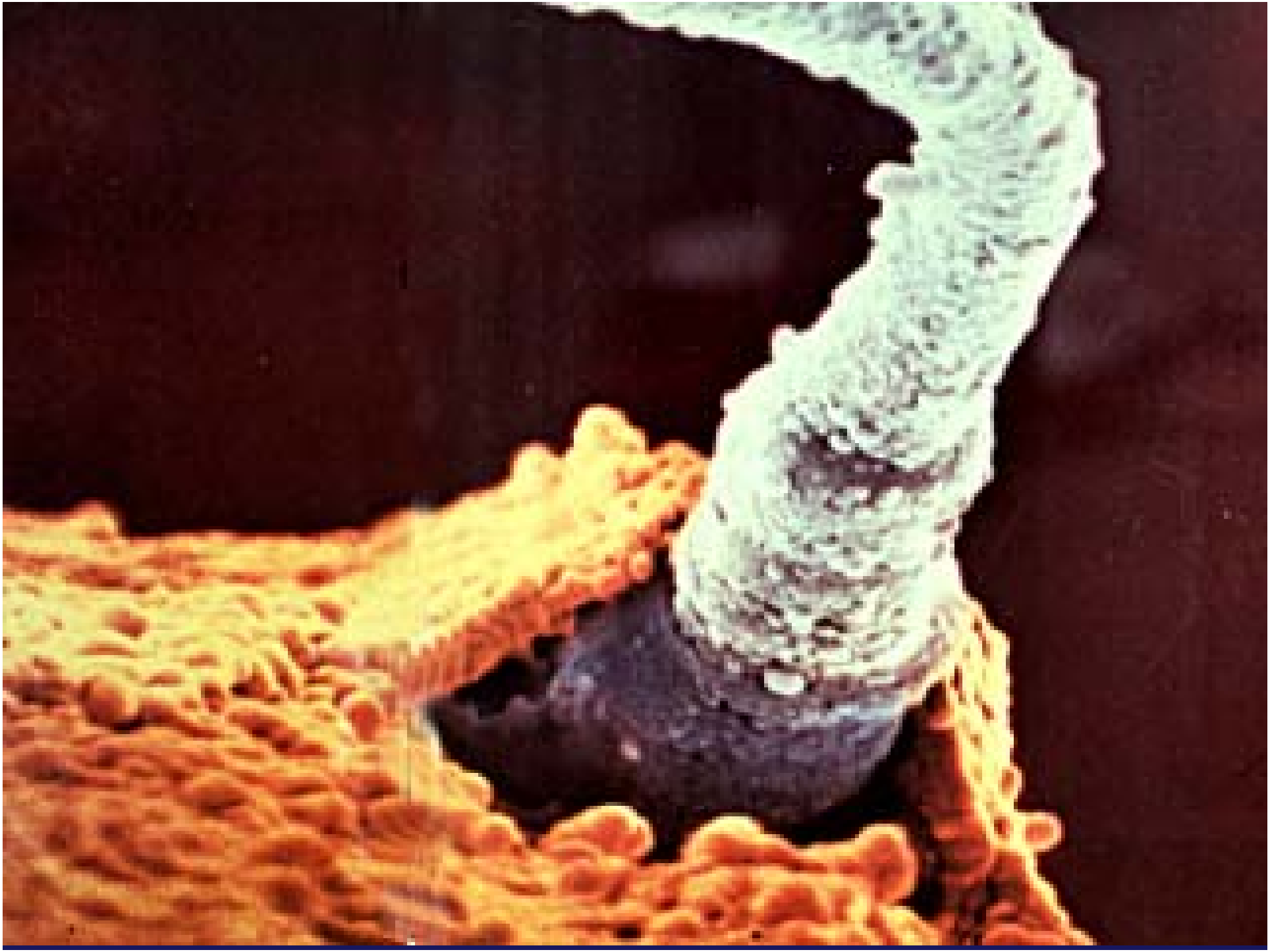
Estradiol positive feedback elicits a surge of LH and FSH.

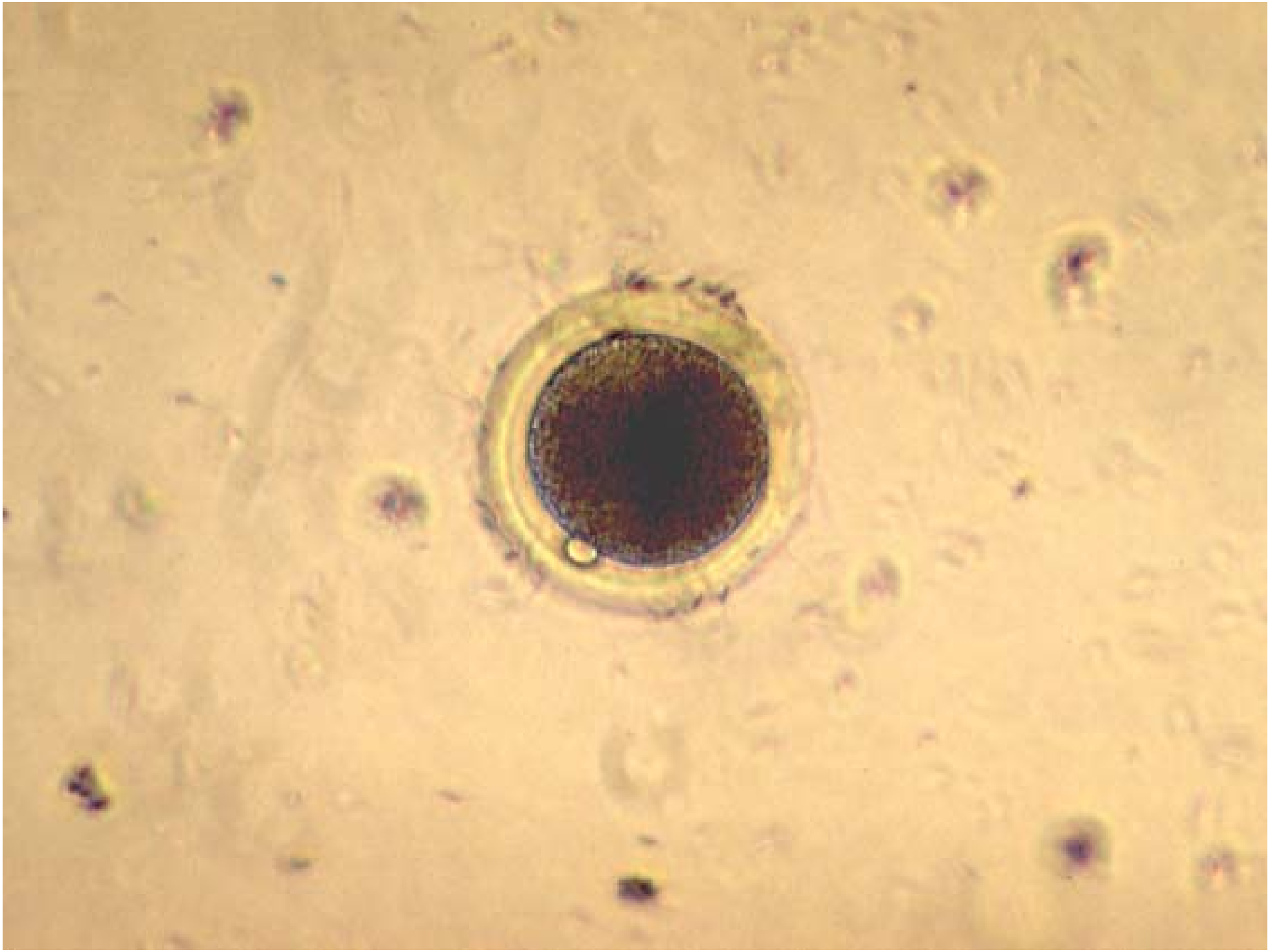
LH ⟶ Ovulation

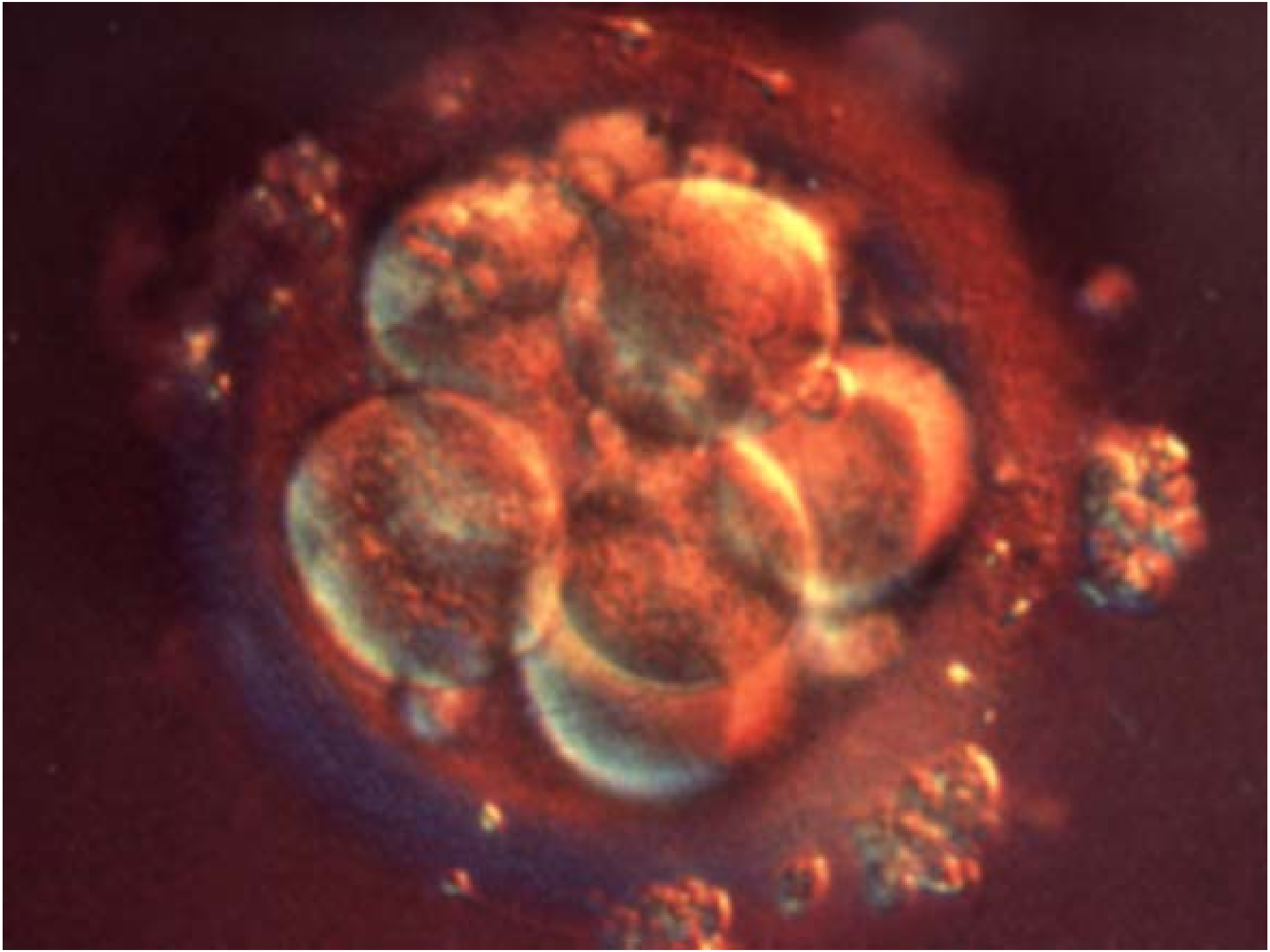
FSH ⟶ Starts new follicular wave

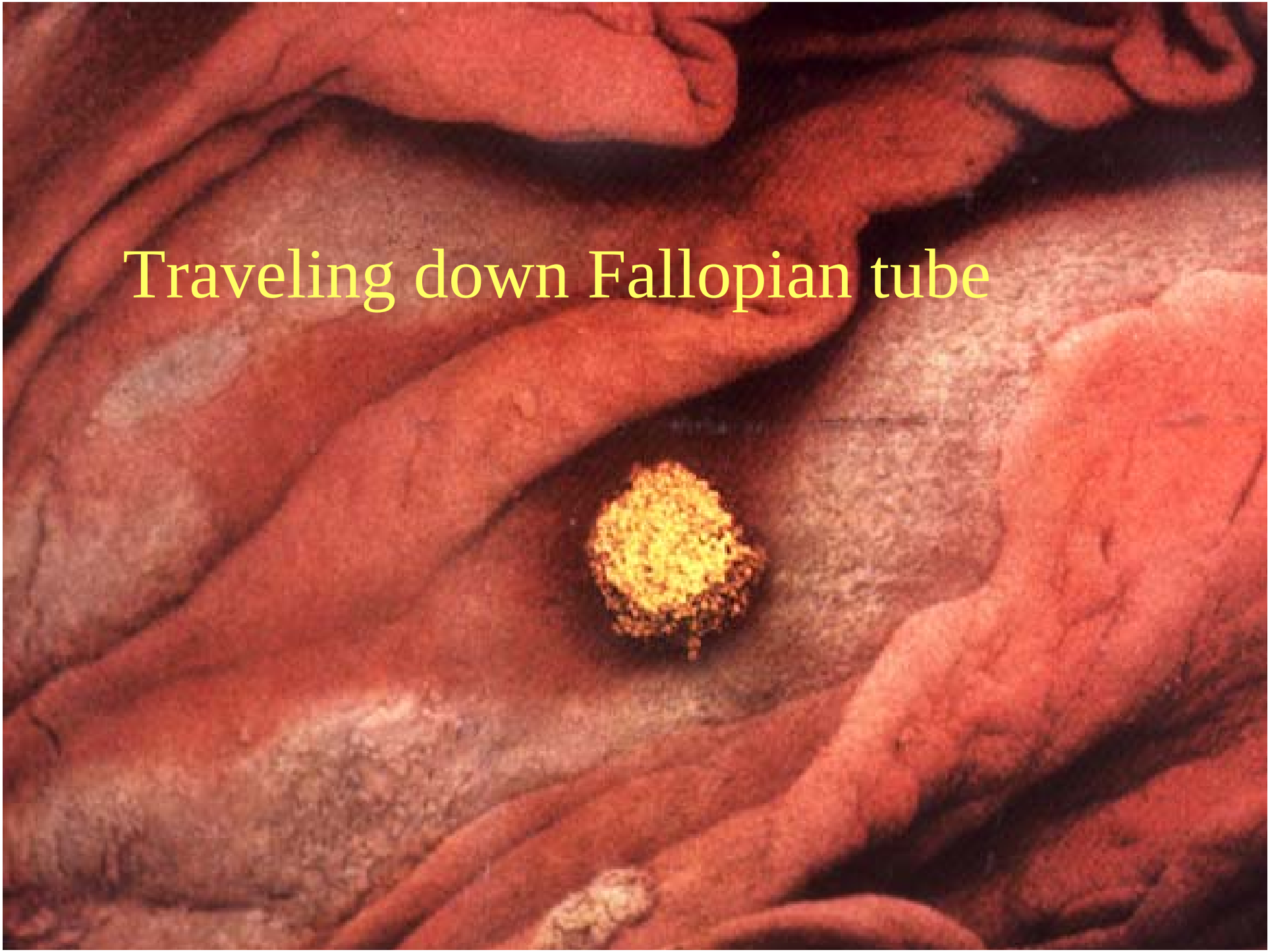
The Ovary


Ovulation
ESTROGEN
PROGESTERONE
LH
Mature Follicle
FSH
Corpus Luteum
PGF2α
Small Follicle
Luteal Regression








Traveling down Fallopian tube