

# Ovarian Follicular dynamics in domestic animals

- The Female gamete the oocyte originate and develop from the ovarian follicles. The ovarian follicles develop from the primordial germ cells during fetal period and are called primordial follicles.
- Follicle is the primary functional unit of ovary that releases the oocyte and produces the steroid hormones.



- Gestation

- Embryonic sac → endoderm → primordial germ cells

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germ cell cords

Epithelial cells

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- Condense around

- germ cells

migrate

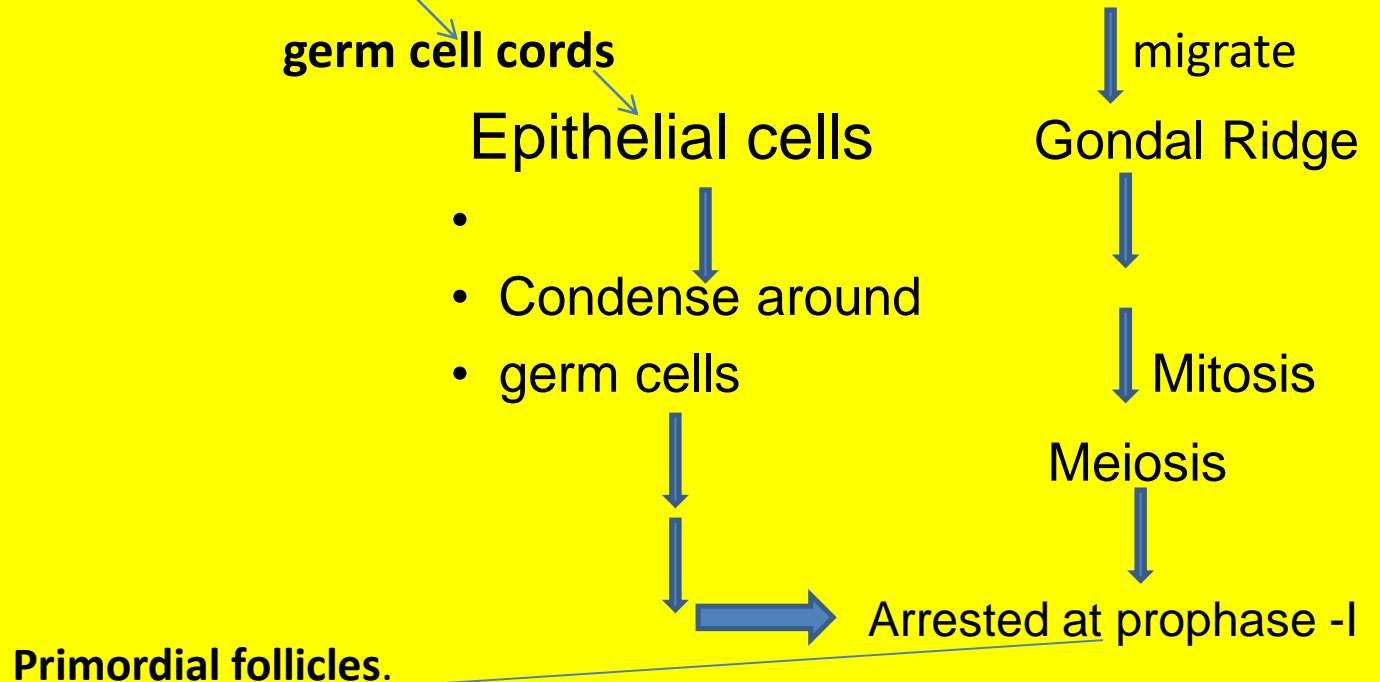
Gondal Ridge

Mitosis

Meiosis

Primordial follicles.

Arrested at prophase -I



# Fate of follicles and oocytes.

100 Days of Gestation  
2.9 million

Total number of follicles	
At birth	100,000
12 months	75,000
4-6 years	21,000
Aged cow	2,500



Follicles grow to tertiary characteristic and degenerate.

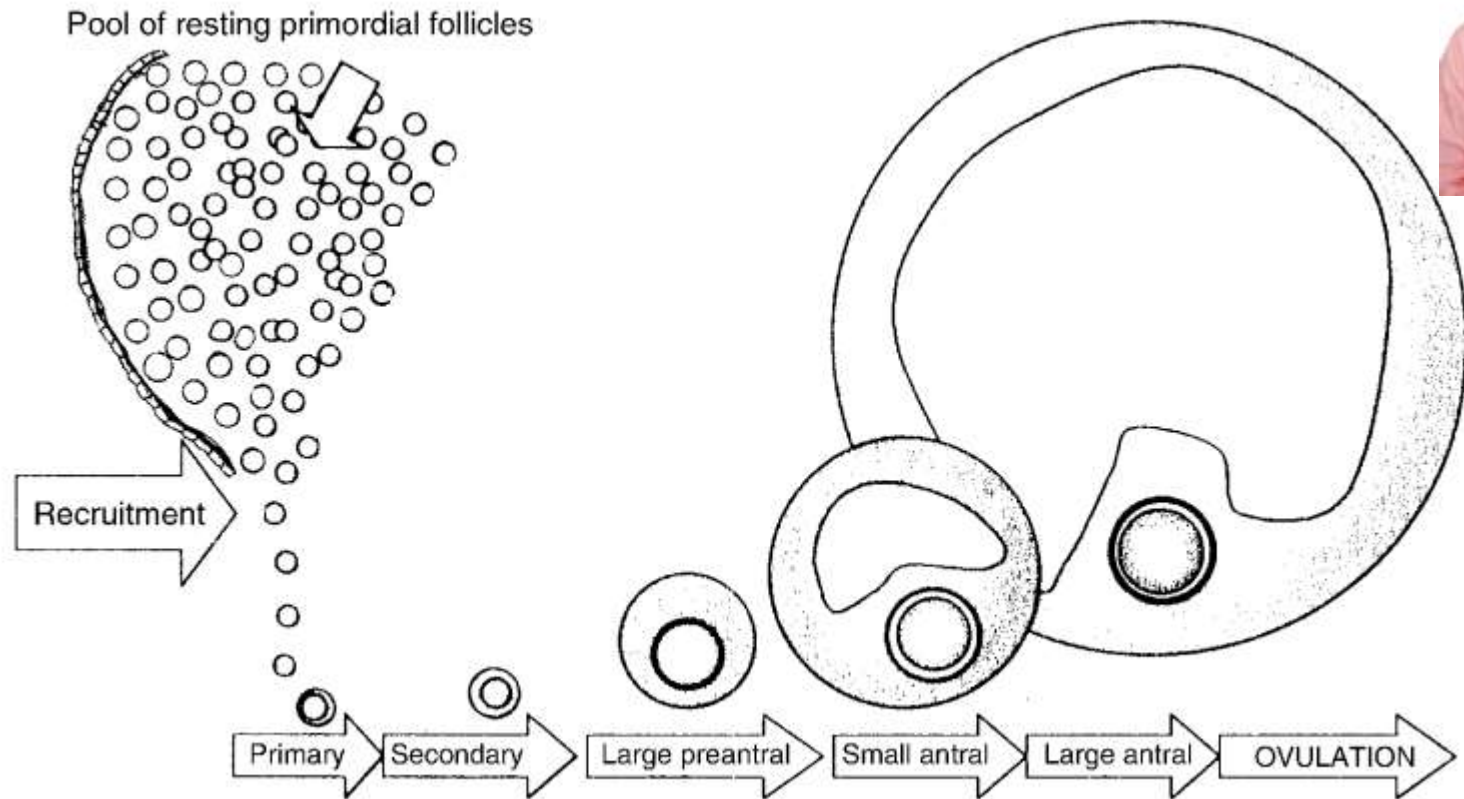
Maximum number of oocytes ovulated for a cow

$10 \text{ cycles/year} \times 12 \text{ year} = 120 \text{ oocytes ovulated/lifespan}$

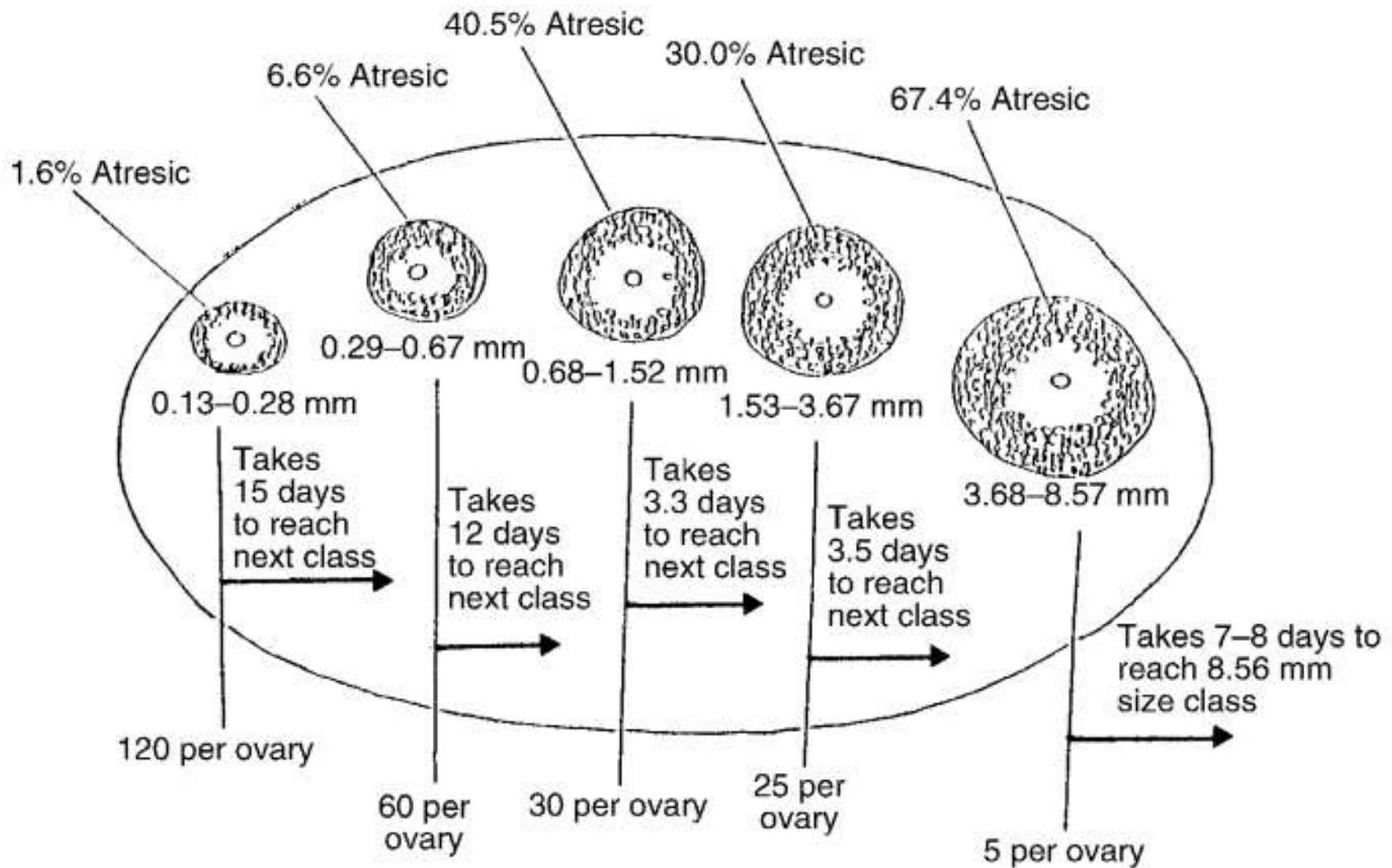
It has been estimated that no more than about 300 oocytes are ever likely to reach the ovulatory stage during the normal reproductive lifespan of the cow.

- Follicular growth can be classified into three phases according to their developmental stage and gonadotropin dependence : (1) follicular growth through primordial, primary, and secondary stages gonadotropin-independent phase), (2) transition from preantral to early antral stage (gonadotropin-responsive phase), and (3) continual growth beyond the early antral stage (gonadotropin-dependent phase), which includes follicle recruitment, selection, and ovulation.

- Ovaries of cattle contain two different pools of follicles, the non-growing pool and the growing pool. The non-growing pool contains the primordial follicles, whereas the growing pool contains the primary, secondary and tertiary follicles. Entry of primordial follicles into the growth phase occurs throughout the reproductive life. The primordial follicles continuously leave the arrested pool and undergo the primordial to primary follicle transition.



After the preovulatory LH surge in the early hours of estrus in the cow, the follicle is known as the **preovulatory follicle**.



**Fig. 2.13.** Follicle size categories in the bovine ovary (based on data from Lussier *et al.*, 1987).

- The growth of follicles from the primordial to ovulatory follicles is complex and requires a couple of days to months.
- The sequence of events involves the growth of primordial follicles into preantral and then antral follicles (follicles with a central fluid filled cavity-the antrum). This transformation involves the proliferation of granulosa cells and reorganization of cells forming the follicle.



- The growth of the primordial follicles is resumed at puberty subsequent to which the follicles grow in a cyclic fashion that is repeated at defined intervals regularly throughout the year in non seasonal breeding species.



- During this transition the oocytes increase in size and the surrounding squamous pre-granulosa cells become cuboidal and proliferate to form a layer of cuboidal cells around the growing oocyte. The follicle is now called the primary follicle. The mechanisms responsible for the initiation of follicular growth during this phase are poorly understood although some molecules such as growth factors and gonadotrophins have been discussed.

# Puberty

Gonadotropin-independent phase

Primordial follicle activated → Primary and Sec follicle

Gonadotropin-dependent phase

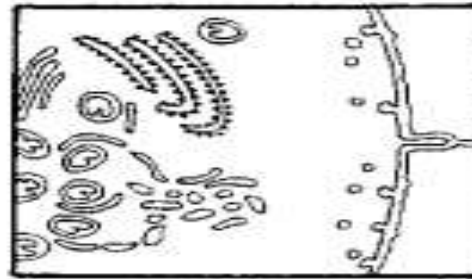
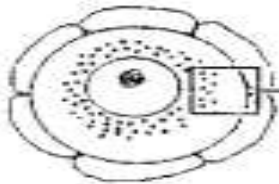
- Preamtral → Antral follicles

Gonadotropin-dependent phase

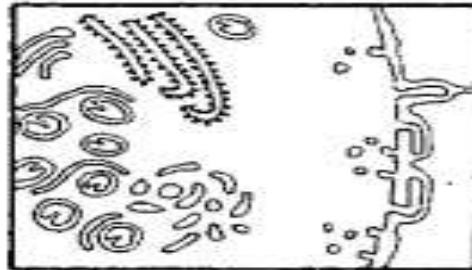
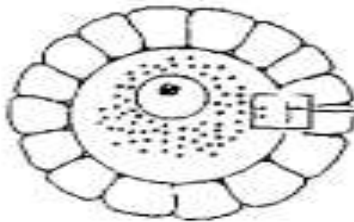
- Early antral → Follicle recruitment, selection,  
and ovulation-Follicular waves

## Follicular stage

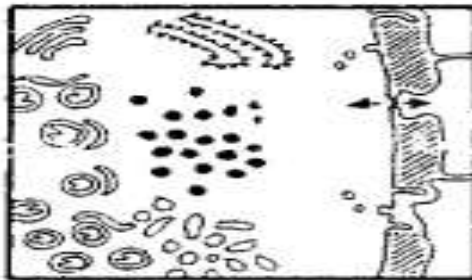
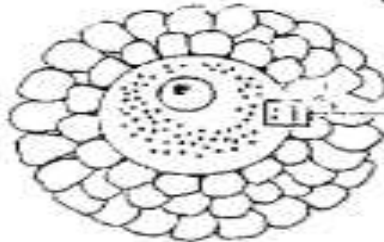
Primordial



Primary

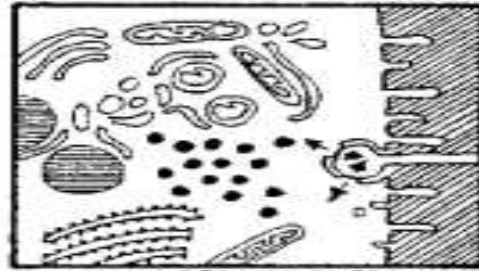
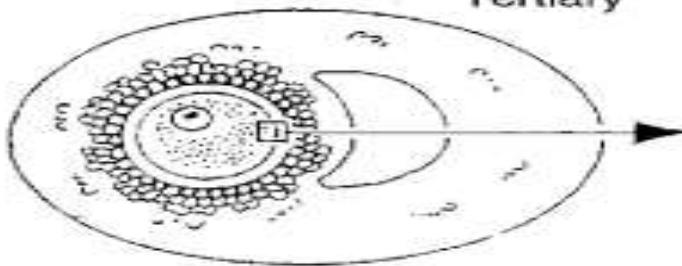


Secondary



Mucopolysaccharide  
layer Zona pellucida

Tertiary

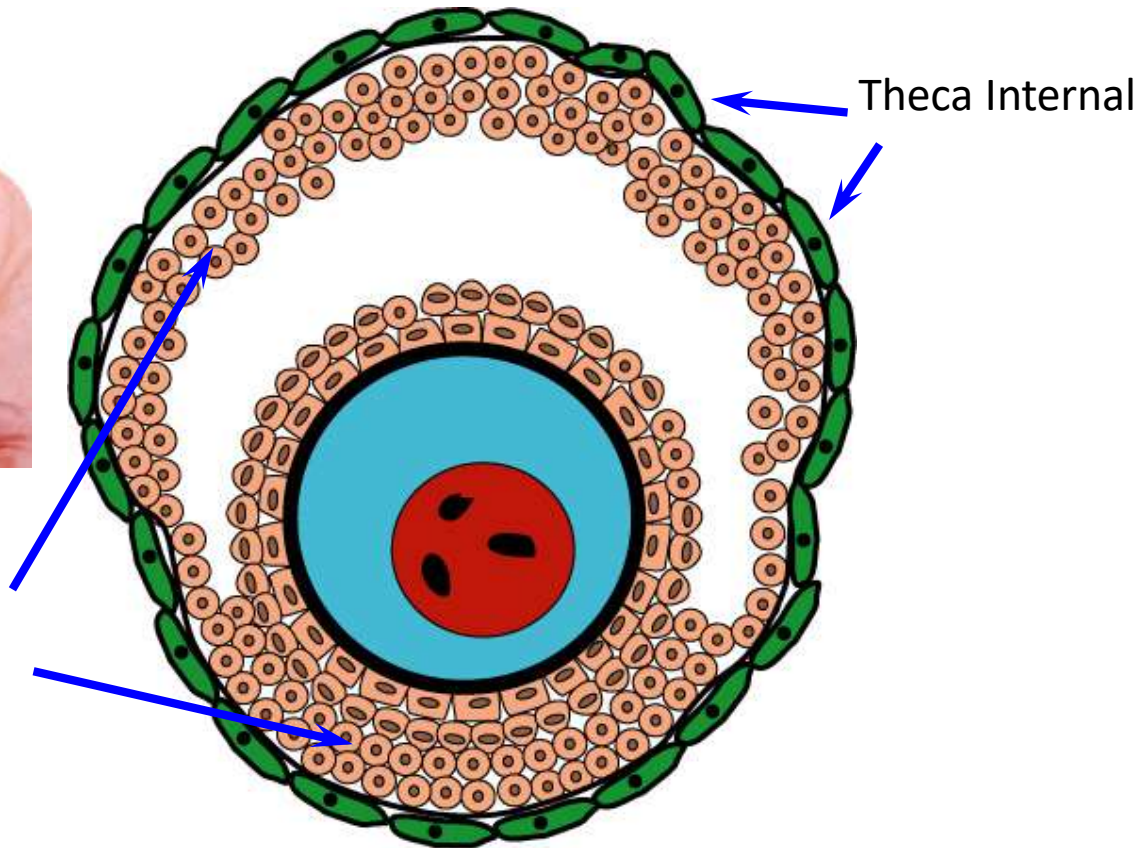


Tertiary follicles also  
called small antral  
follicles

# Antral Follicle



Granulosa



It is now known that the antral follicles are selected to grow and this growth occurs in a wave like fashion in most domestic mammalian species. The follicular growth waves lead to growth in the size and fluid secretions within the follicle, expression of estrus, and ovulation with release of mature oocyte.

- Normally three to six follicles with a diameter of 4 to 5 mm occur after recruitment of follicle into a follicular wave.
- From the cohort of the growing follicles one follicle is selected for continued growth and becomes **dominant**. If luteolysis occurs during the growth phase of the dominant follicles, final maturation and ovulation occurs. If luteolysis does not occur during the growing and maintenance phase of follicles, the fate is atresia

Follicular size (mm)

Ovulation

Large  
dominant  
follicle

SELECTION

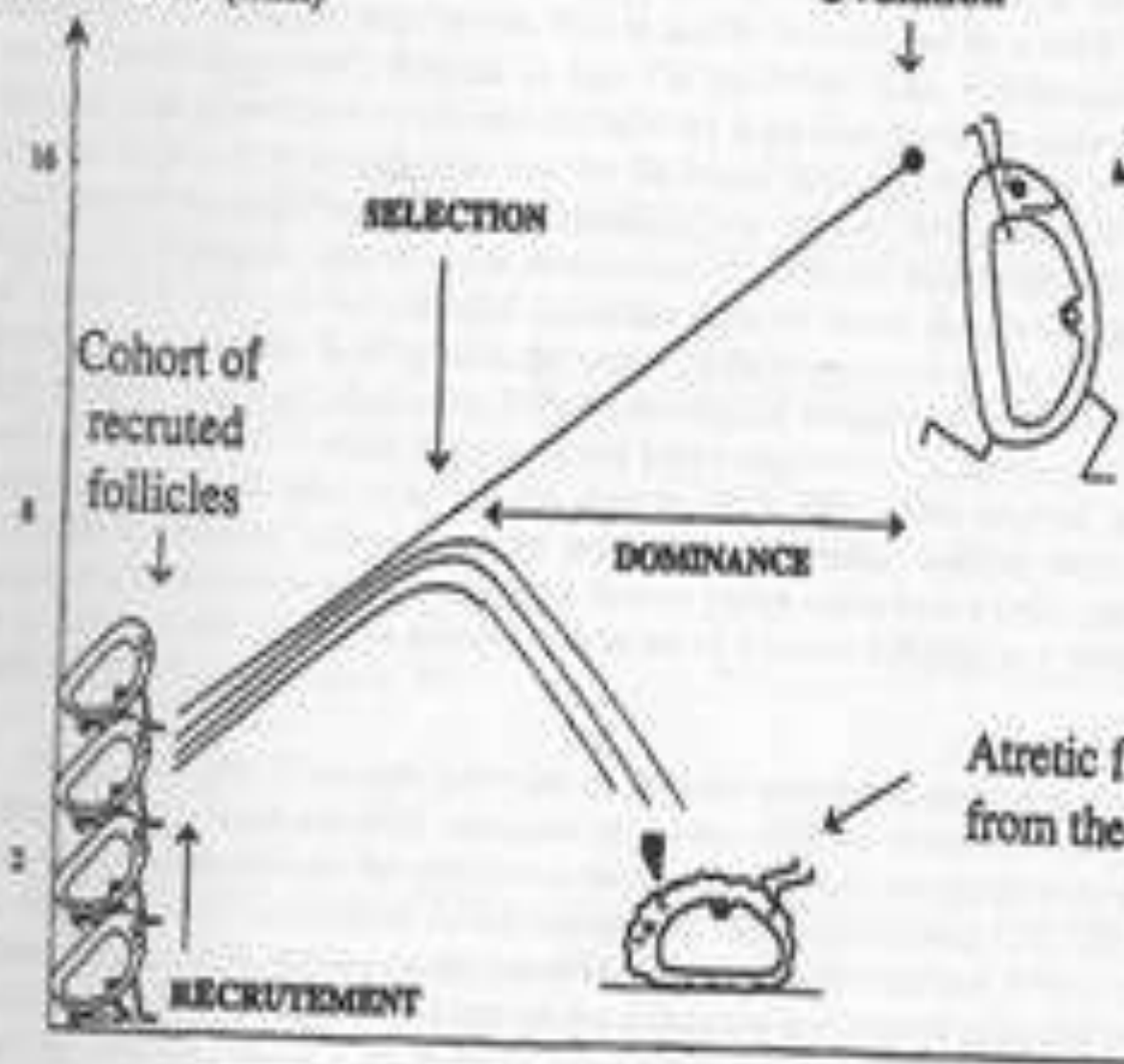
Cohort of  
recruited  
follicles

DOMINANCE

Atretic follicles  
from the cohort

RECRUTEMENT

Days of the cycle





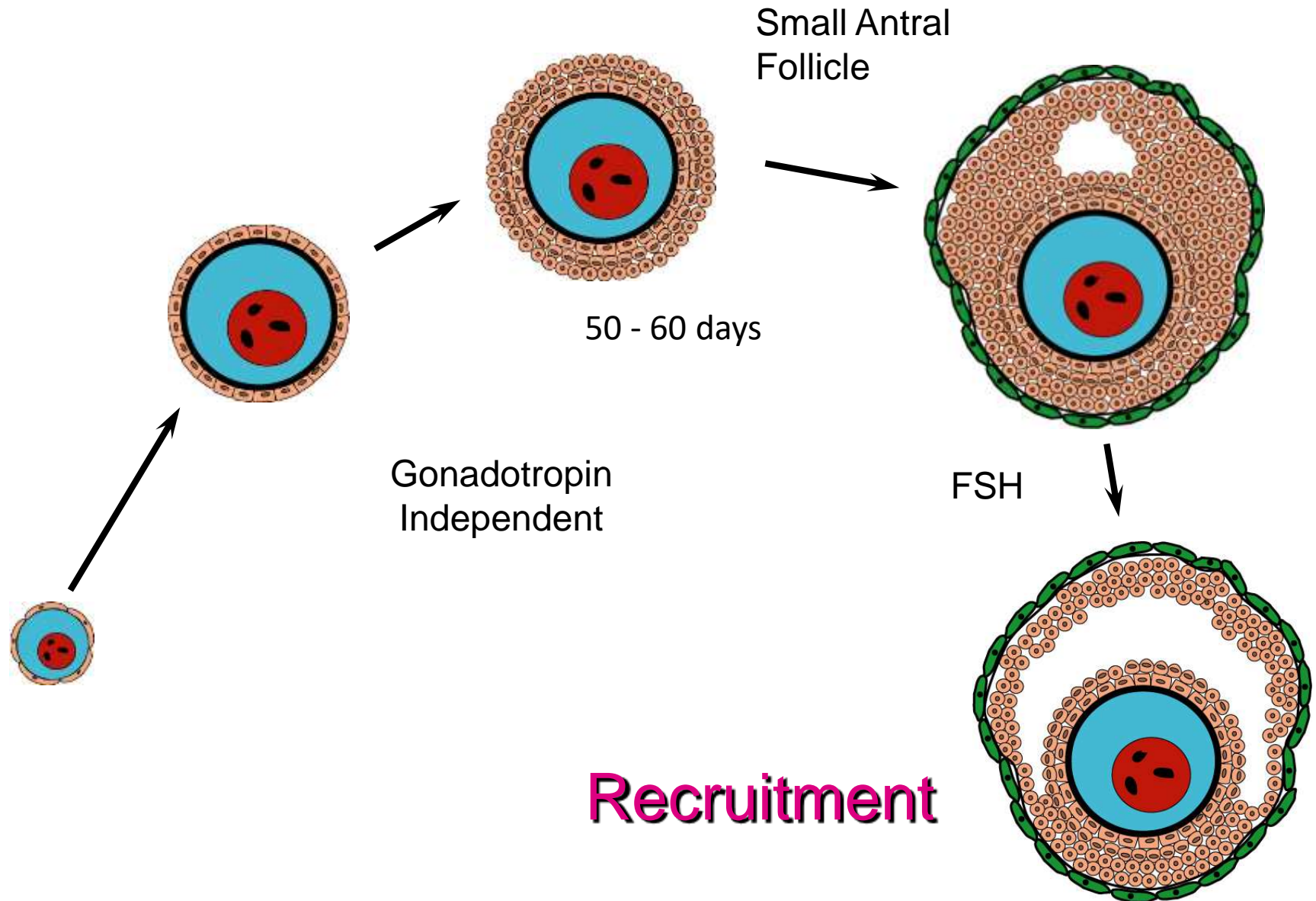
- **Follicle recruitment**
- The concept recruitment is used for the entrance of follicles in the growing pool, but also for the processes associated with the entrance of follicles in a wave like growth. **FSH** appears to be the key hormone for the initiation of the follicular wave. The surges in FSH precede the emergence of a wave. **The FSH surges begin 2-4 days before** the detectable (ultrasound) **emergence of a follicular wave** (follicles of 4 and 5 mm), peaked 1 or 2 days and started declining nearly when the follicles of a wave begin to diverge into a dominant follicle and subordinate follicles (follicles 6 to 8 mm).

- Recruitment of the cohort containing the future preovulatory follicle occurs during a recruitment window which lasts 1, 2 or 3 days in sheep, cattle or horses respectively. Only **gonadotrophin dependent healthy follicles** are **recruited**. The number of recruited follicles growing in the cohort appears to be highly variable between species. It ranges from over 50 in **pigs**, to 5 to 10 in **cattle** and 1 to 4 in **horses**. All follicles of the cohort are capable of ovulating, since selective ablation of all except one will not postpone ovulation in sheep and cattle.

- **Selection**
- Selection means that the number of growing follicles is brought into line with the species-specific ovulation number. After recruitment fewer and fewer recruited follicles continue in growth and **one follicle** is selected to become **dominant** while the **remaining members of the recruited follicles become static and eventually undergo atresia** via apoptosis.

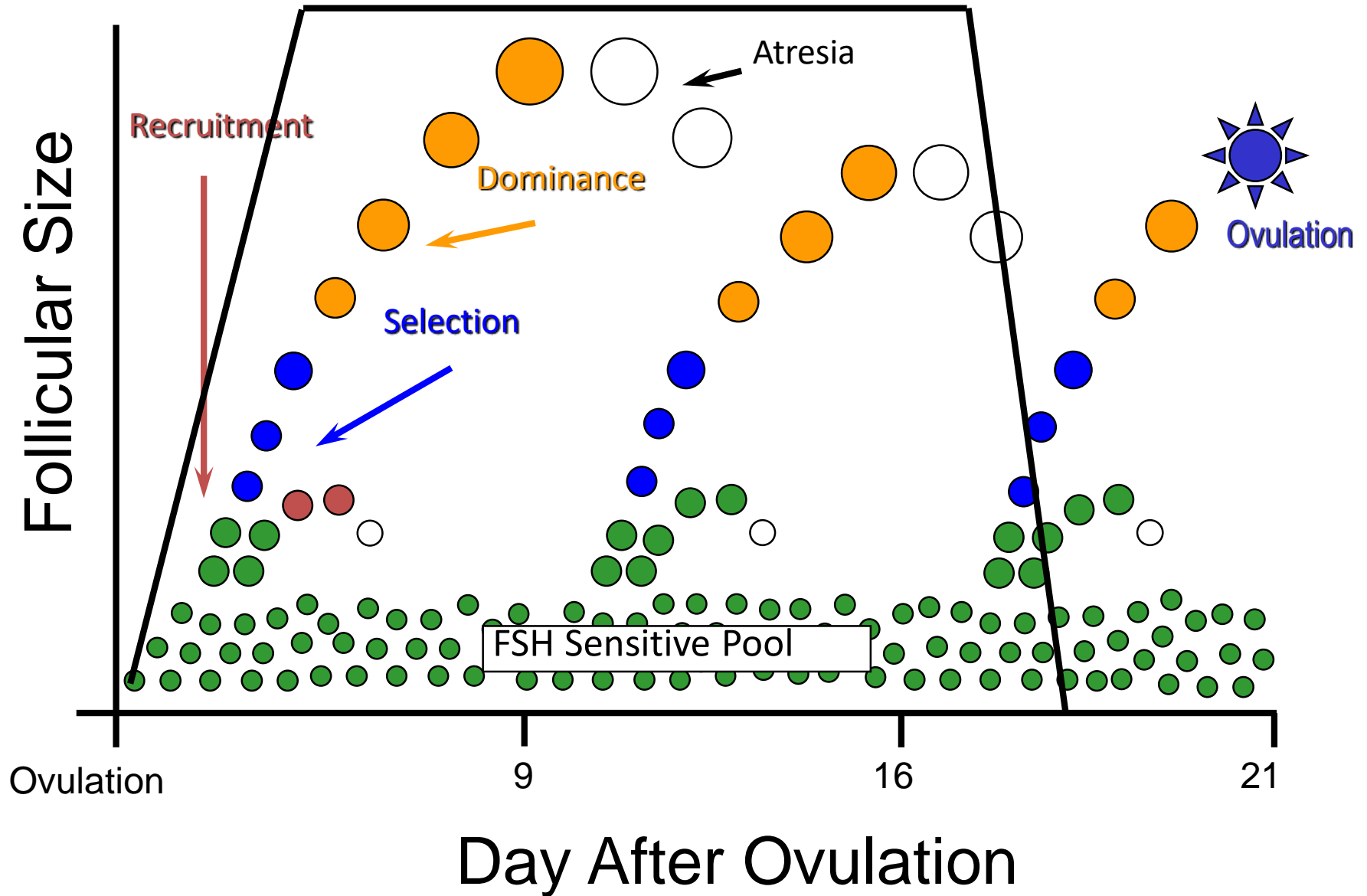
- **Dominance**
- Follicles are functionally dominant (capable of ovulating after luteal regression) while they are still growing. Follicles acquired ovulatory capacity at about 10 mm, corresponding to about 1 day after the start of follicular deviation.
- Dominance → negative feedback effects of products of the dominant follicle on circulating FSH.
- Dominance → progressive increases in the ability of theca cells to produce androgen and granulosa cells to aromatize androgen to estradiol.
- Dominant follicles grow to a much larger size (from 8.5 mm at the end of selection to 12-20 mm) in 3 to 4 days.
- Dominant follicle ↓ Progesterone ↑ LH → Ovulation
- Dominant follicle → No follicular wave

# Initial Follicular Growth

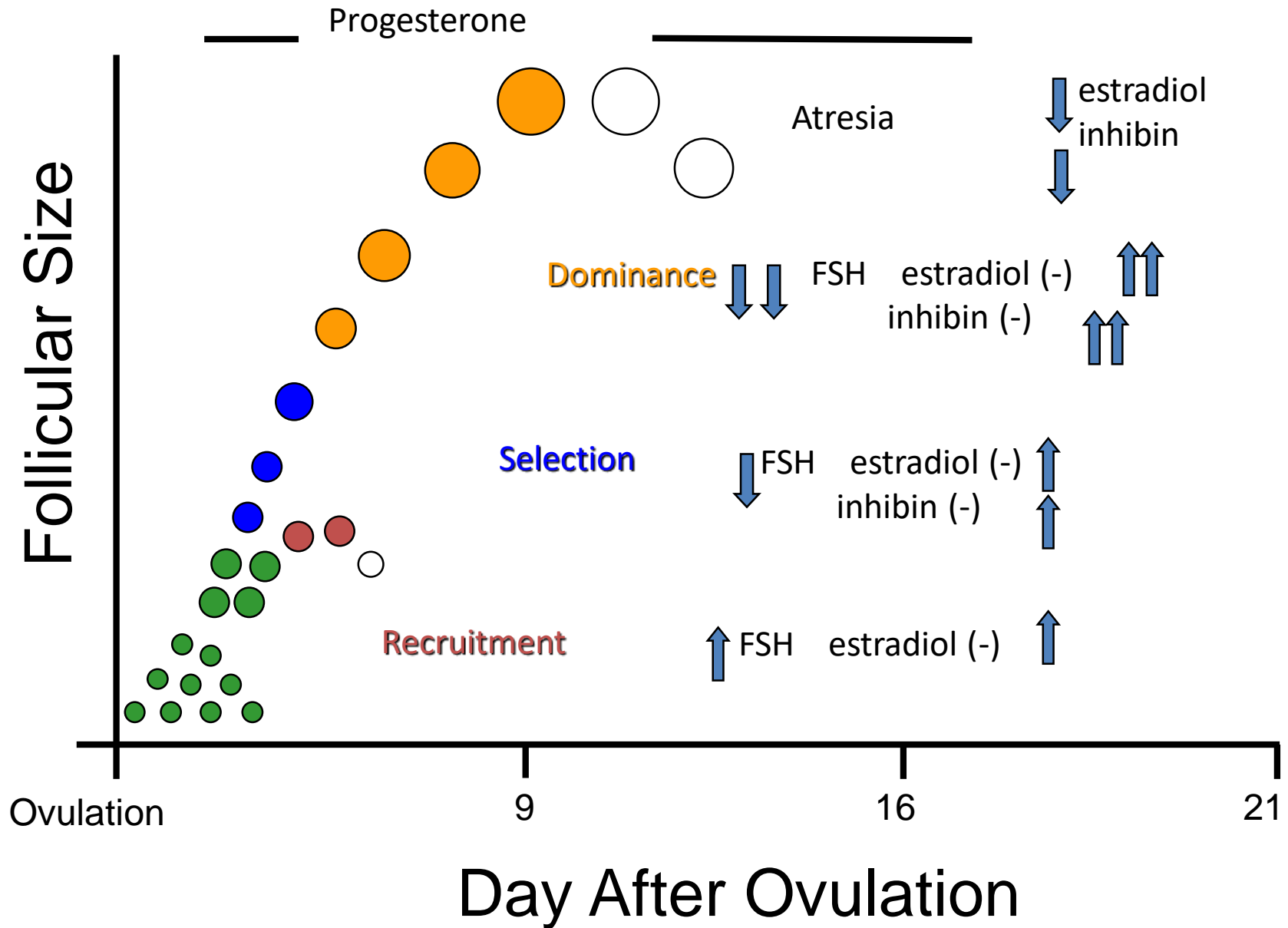


# Follicular Waves in Cattle

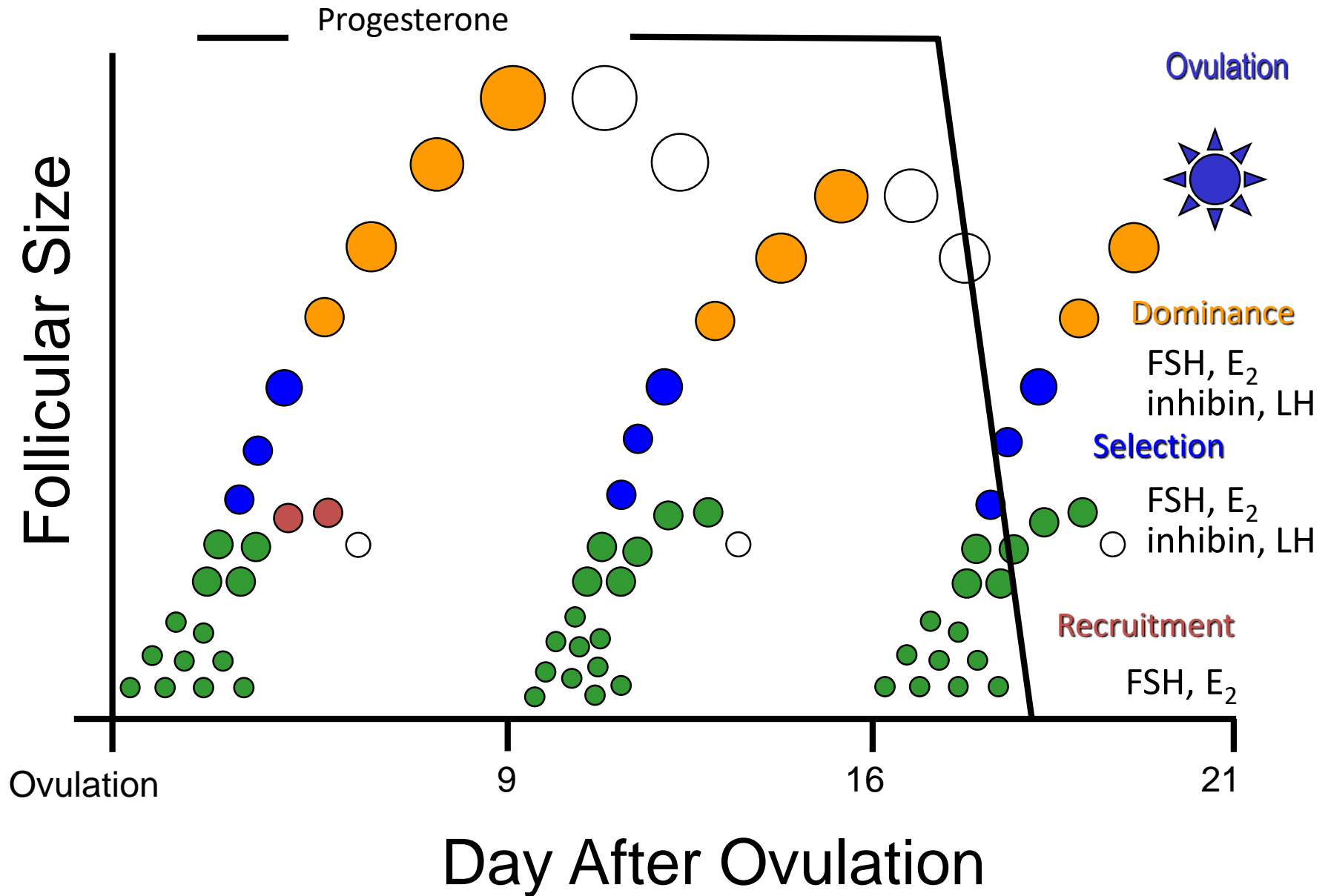
Progesterone



# Follicular Waves in Cattle

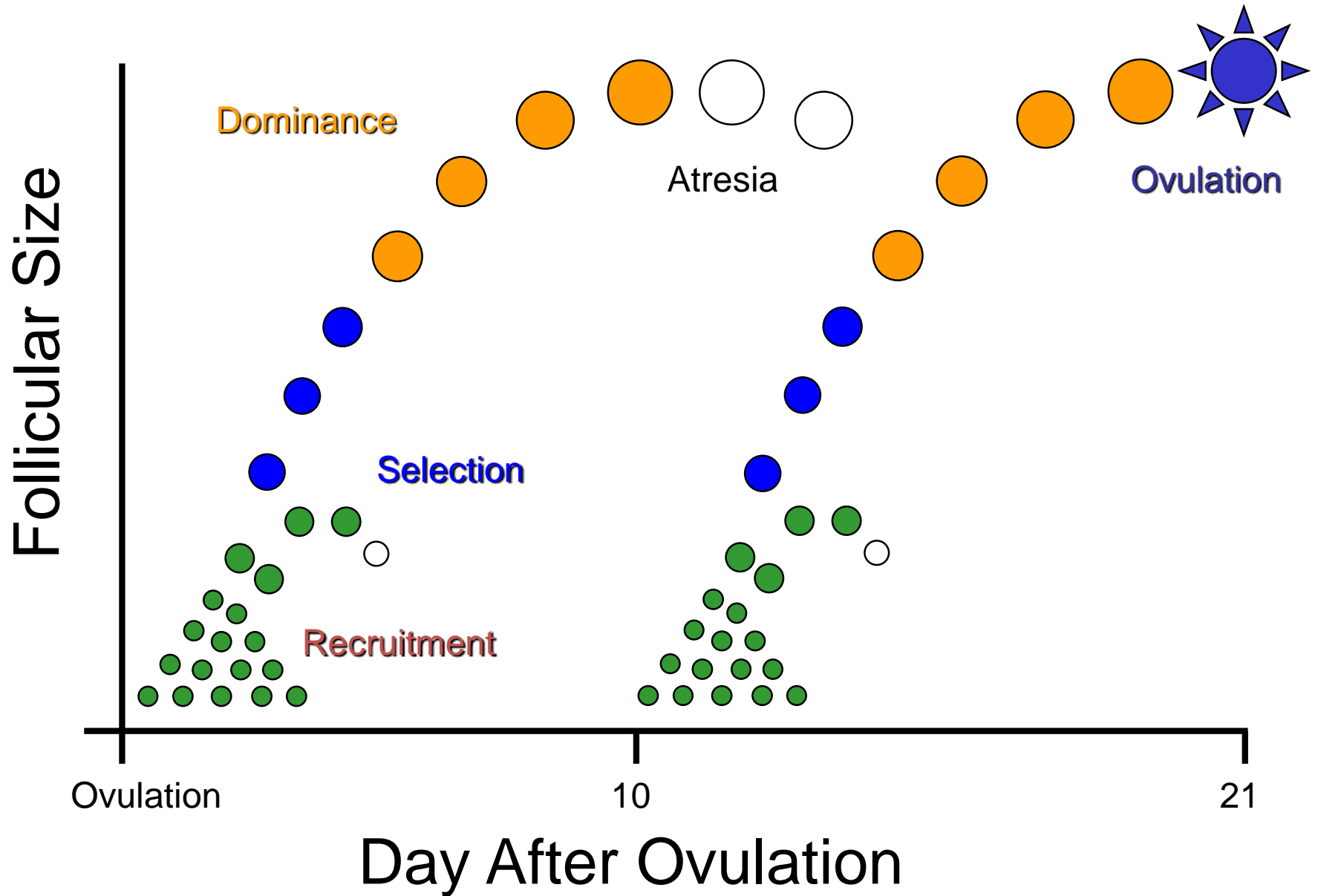


# Three Follicular Waves in Cattle





# Two Follicular Waves




# Species Variation in Follicular Waves

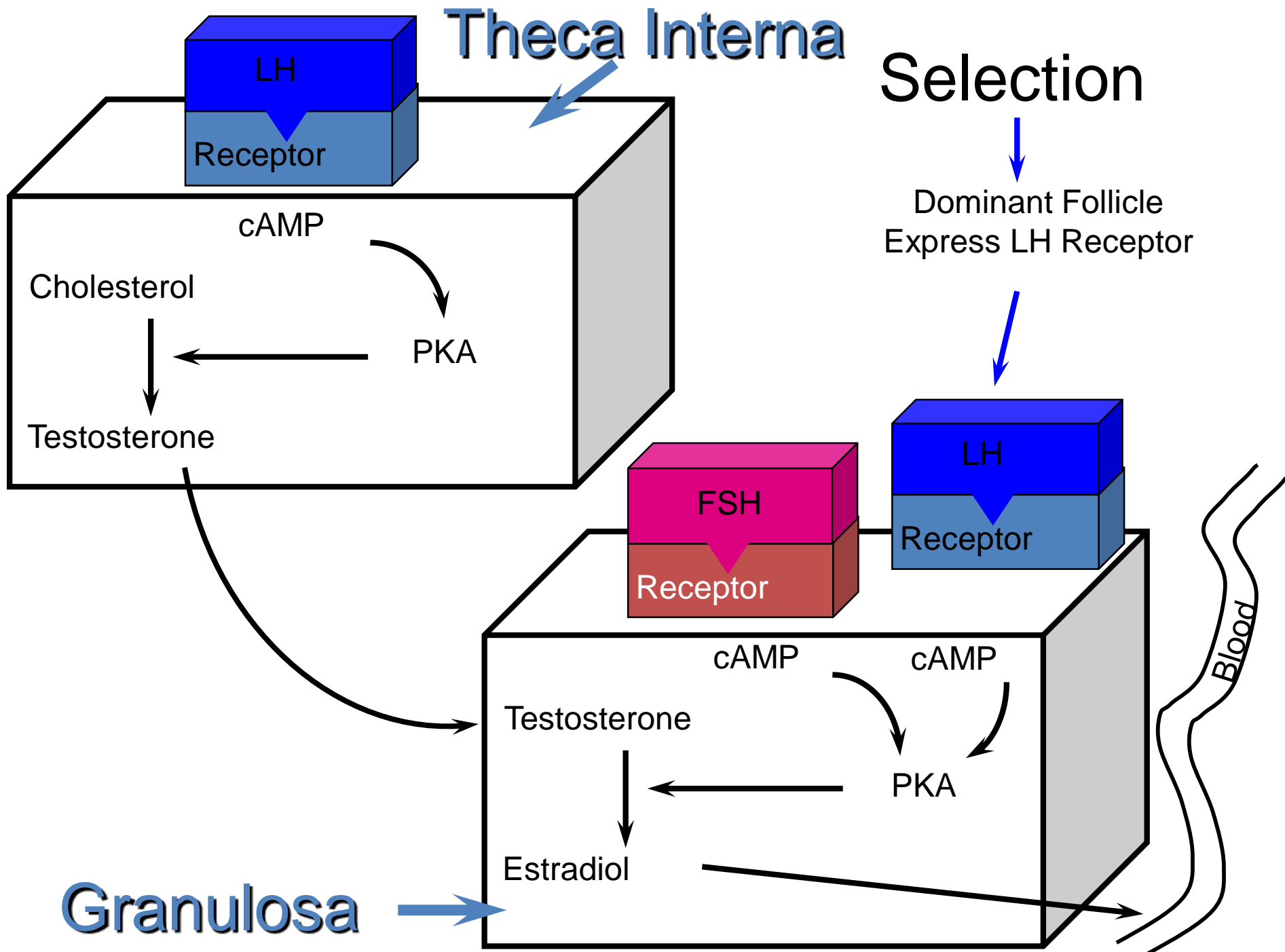
- Cattle - 2 or 3 / cycle
- Sheep - 4 or 5 / cycle
- Pigs - 1 / cycle
- Horses - 1 / cycle



Cl-progesterone



Cl-progesterone, inhibin



# Preovulatory LH Surge

Cumulus Expansion

Protein Synthesis  
in and around Follicle

Increased Blood  
Flow to Ovary and  
Follicle

Progesterone

Plasminogen  
Activator

Prostaglandin  
Synthesis  
PGE and PGF

Vascular  
Permeability

Collagenase (inactive)

Plasmin

Plasminogen

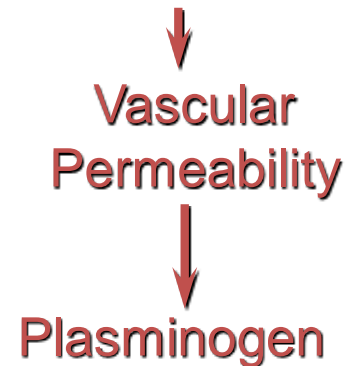
Oocyte  
Separates  
From  
Follicular  
Wall

Collagenase (active)

Follicular Wall  
Weakens

Contraction  
of Smooth  
Muscle

Ovulation



# Follicular dynamics in buffaloes

Buffaloes evidence 1-, 2- or 3- wave cycles with the 2-wave cycle being the most common pattern of follicular growth Size of ovulatory follicle above 8.5mm

In some breeds one wave cycle is common for example the Surti breed

During hot summer months there is variable degree of ovarian follicular turnover in one or both ovaries without expression of estrus signs and regression of dominant follicles instead of their ovulation.

# Follicular dynamics in mares



In the mare ovary there are approximately 40,000 primordial follicles and 100 growing follicles

Atresia (regression) of follicles is rare until they reach 1 mm

The types of follicular waves that develop in mares are major waves (characterized by dominant and subordinate follicles) and minor waves (largest follicle does not attain the diameter of a dominant follicle).

In some breeds (e.g. Quarter-Horses, Ponies), usually only one major wave develops in late diestrus and culminates in the estrous ovulation. In other breeds (e.g. Thoroughbreds), a secondary major wave frequently develops in early diestrus, and the dominant follicle may be anovulatory (more common), or occasionally ovulatory (diestrus ovulation).

Minor follicular waves have been demonstrated in mares in variable patterns. In all horse breeds, however, a major ovulatory wave begins at mid-cycle and one follicle (occasionally two, rarely three) becomes dominant and ovulates.

- The ovulatory waves, as well as major anovulatory waves and minor waves, originate from the stimulation of an FSH surge, which reaches a peak when the largest follicle is about 13 mm.
- The physiologically selected dominant follicle grows to a large diameter ( $\geq 28$  mm) and then either regresses (anovulatory major wave) or ovulates (ovulatory wave).



- Maximum diameter of the dominant follicle is smaller for major anovulatory waves than for ovulatory waves (e.g., means of 37 and 46 mm)
- A paradox in mares is the occurrence of ovulation from the dominant follicle of what was expected to be an anovulatory wave. These ovulations have been called secondary or diestrus ovulations and occur during high progesterone concentrations.

# Follicular dynamics in sheep

- In sheep follicles  $\geq 5\text{mm}$  in diameter would exhibit a wave-like pattern while follicles smaller than 4mm would grow randomly. Both patterns of growth are classified as primary and secondary follicular waves, respectively.
- Two to 3 follicular waves per cycle are common in sheep, and 3 or 4 follicular waves per cycle are most common in goats

- During estrous cycles, the dominant and largest subordinate follicles reach maximum diameters of 5 to 7 mm and 3 to 5 mm respectively in sheep. In most cases the ovulatory follicles develop from the cohort of follicles from the last follicular wave. However, the ovulatory follicles can also derive from the penultimate follicular wave with the result that follicles can ovulate both from the last and the second last follicular waves of the cycle.

# Follicular dynamics in goats

- In goats on any one day of the estrous cycle there are 5 to 10 follicles  $> 3$  mm in diameter in the ovaries and follicles ovulate at or between 6 and 9 mm in diameter. As in sheep double ovulations can derive from follicles of the last and the second last wave.

- The above lectures are also explained in video lectures at my YouTube Channel Govind Narayan Purohit
- Kindly share the videos and subscribe to my channel if you like them
- Thanks