

ENDOCRINOLOGY OF PUBERTY AND ESTROUS CYCLE

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- Puberty encompasses the transition from the anovular state to one of regular ovulations.
- Various physiological factors like Nutrition, environment, photoperiod and endocrine factors like GH, IGF-1, leptin, Neuropeptide-Y (NPY) are important in the induction of puberty. Studies on puberty have mostly focused on sheep and cattle.
- The **gonadostat** hypothesis, states that a decrease in response to the inhibitory feedback action of gonadal steroids occurs during puberty.



- The low levels of estrogens before puberty inhibits the surge center of hypothalamus and the tonic release of LH is not sufficient for maturation of follicles.
- The positive feedback effect of increasing levels of estrogens produced by the growing follicles on the hypothalamus occurs at the pubertal onset which stimulates the LH surge centers triggering follicular maturation



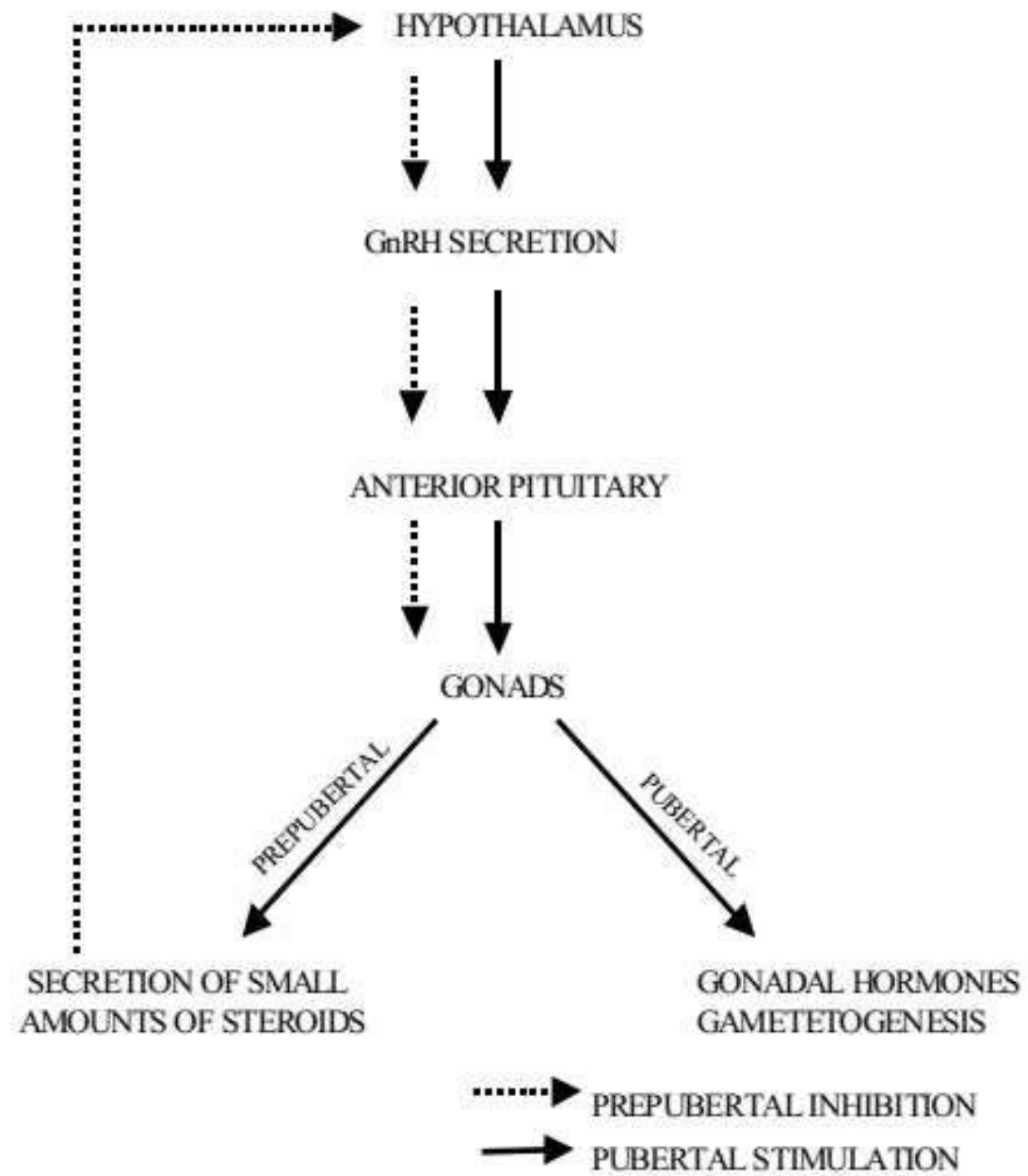


Fig 1: Neuroendocrine events in the initiation of Puberty

FACTORS THAT INFLUENCE HYPOTHALAMIC SENSITIVITY TO ESTRADIOL FEEDBACK

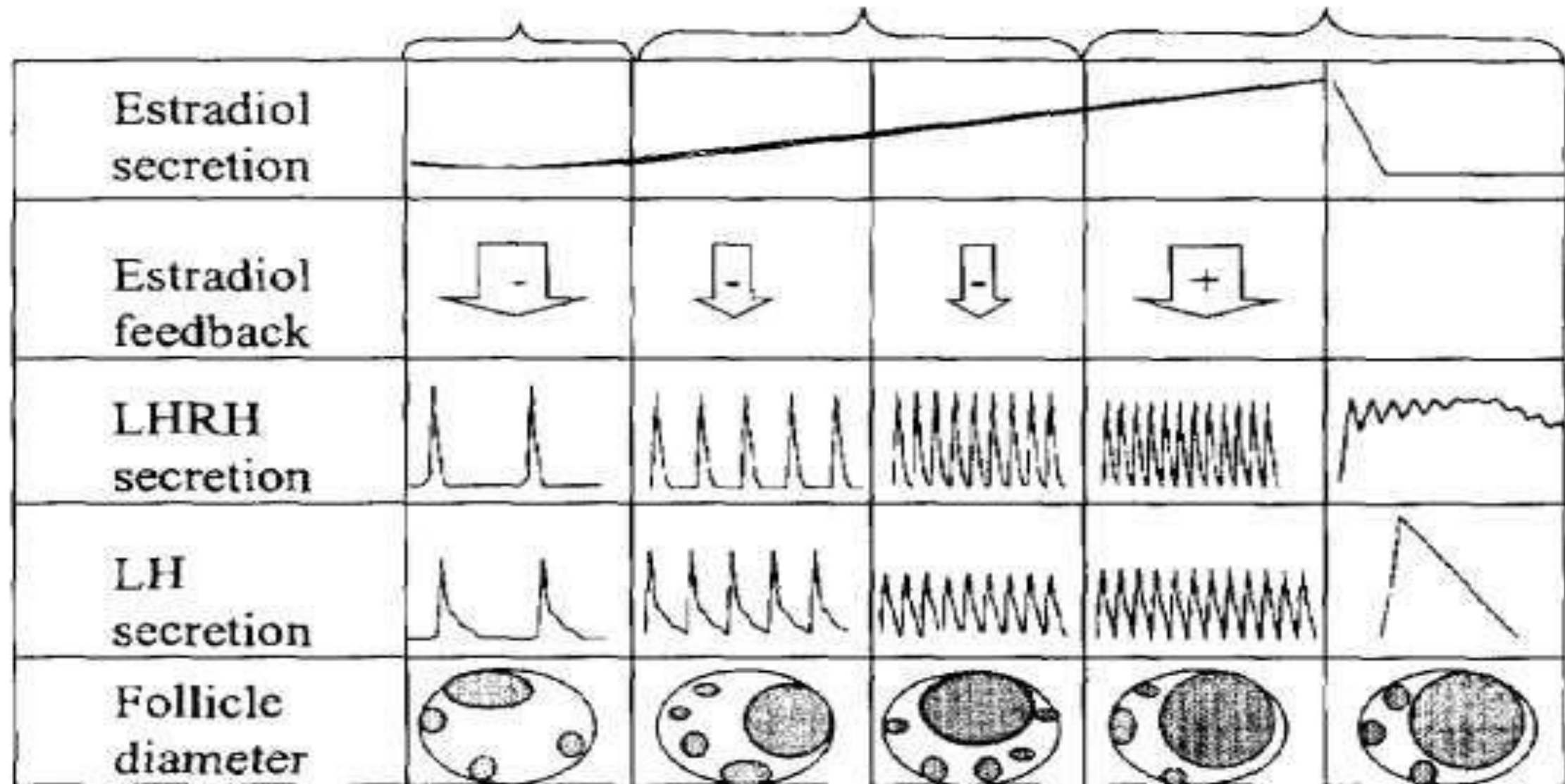
- Alterations in hypothalamic function probably result from changes in either the LHRH neurons themselves, in the systems that control LHRH neuronal function, or perhaps both.
- Several lines of evidence suggest that modifications in the morphology of the LHRH-containing neurons occur during the prepubertal period.

Model for Endocrine Control of Puberty

Prepubertal

Peripubertal

Pubertal



- **Leptins**

Leptins are produced primarily by the adipose tissue with other sites being stomach, skeletal muscle, fetal cartilage, pituitary, mammary tissue and placenta.

They are molecules that signal the nutritional status of the animal to the central reproductive axis.

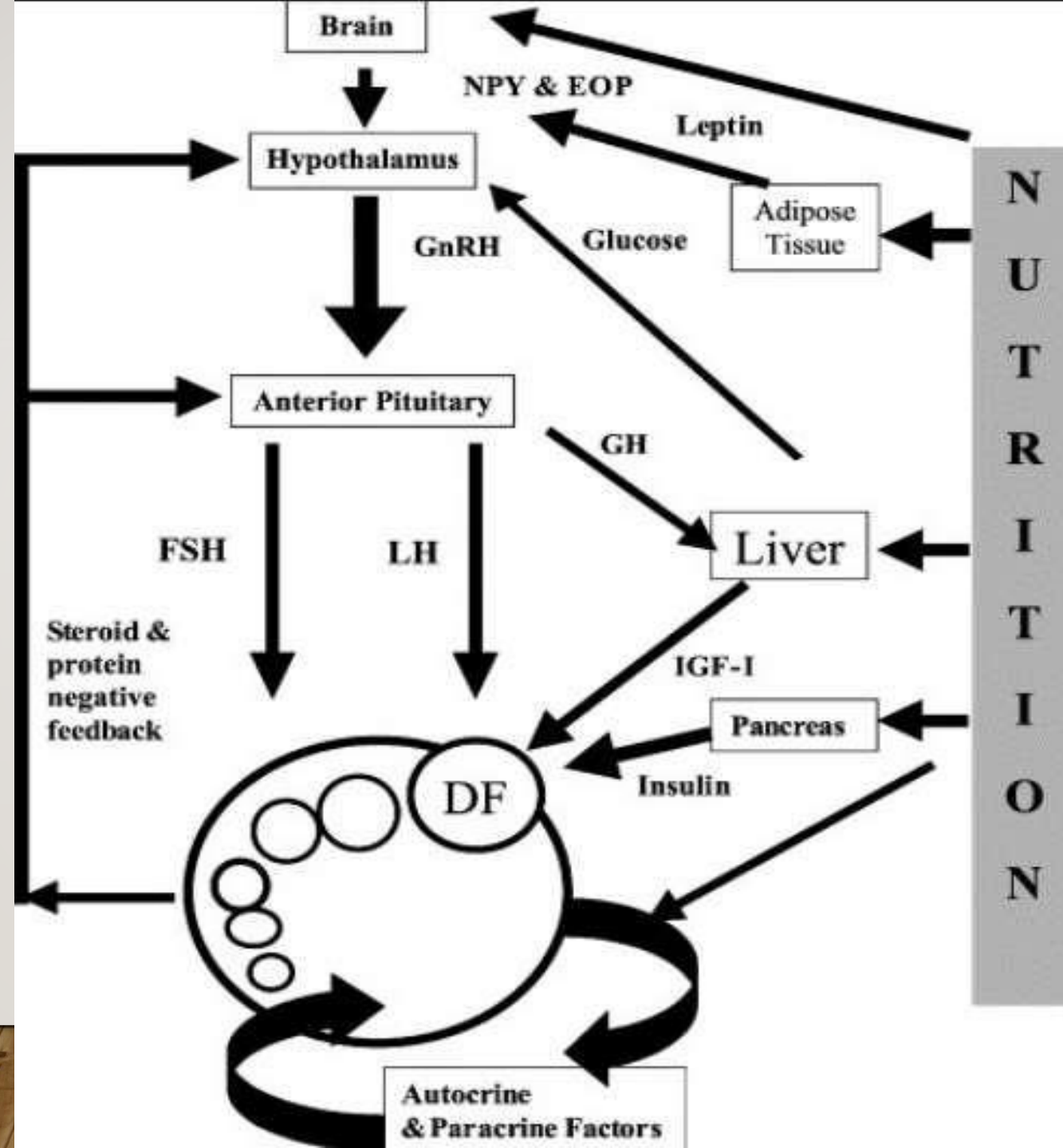
Studies have shown that prepubertal heifers with higher plasma leptins attain puberty earlier.



GROWTH HORMONE AND INSULIN

- GH pulses are known to increase just before puberty
- The role of Insulin in setting pace for the pubertal onset has been addressed in many studies and so also the role of Insulin-like growth factor-1 on nutritional mediators of puberty have been found in many studies on cattle and other species.
- Pubertal onset is known to be positively associated with circulatory IGF-I independent of growth rate, leptin concentrations, and body fat.

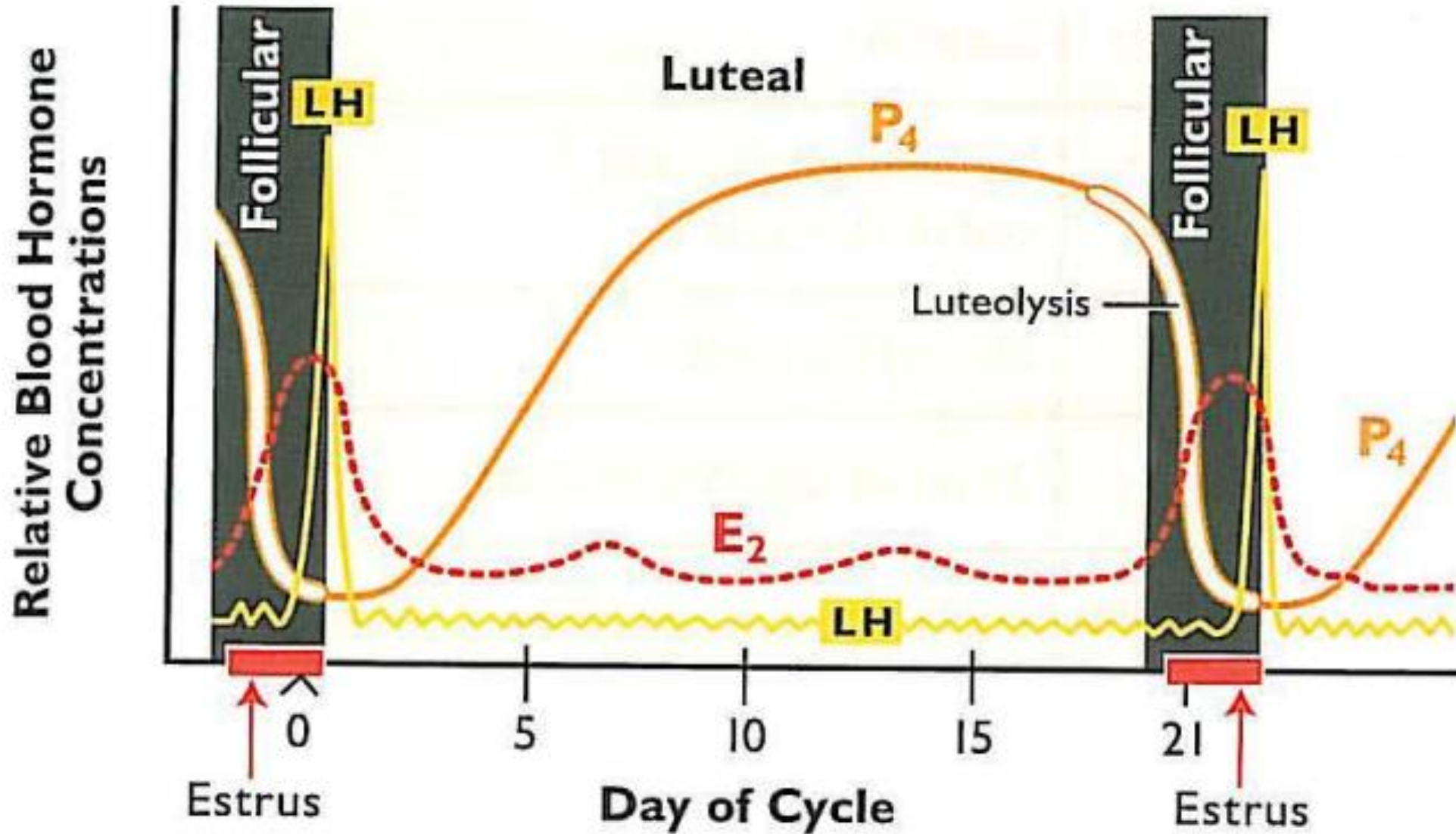
THE EFFECTS OF NUTRITION ON THE ONSET OF PUBERTY

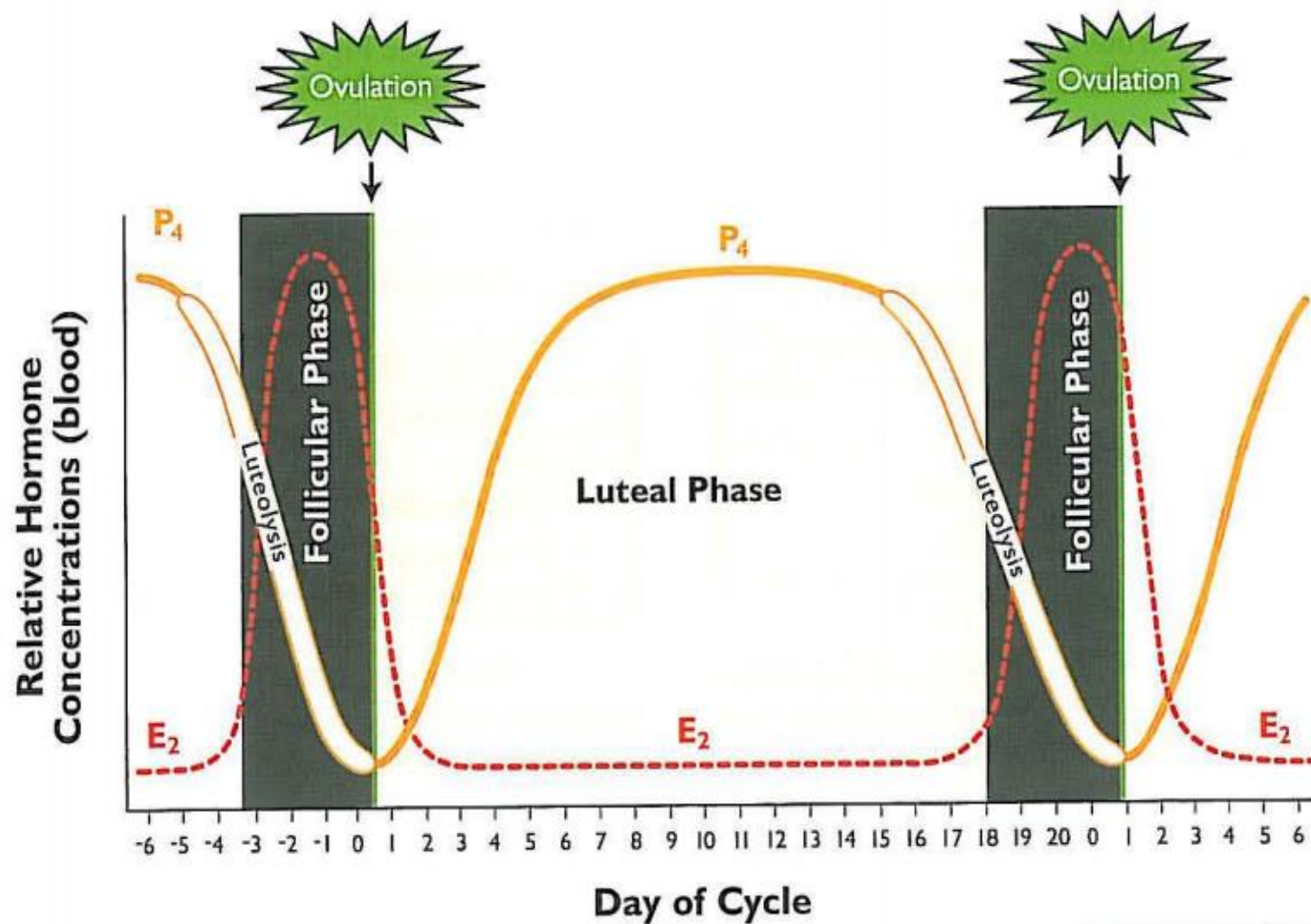


ENDOCRINOLOGY OF ESTROUS CYCLE



The Estrous Cycle

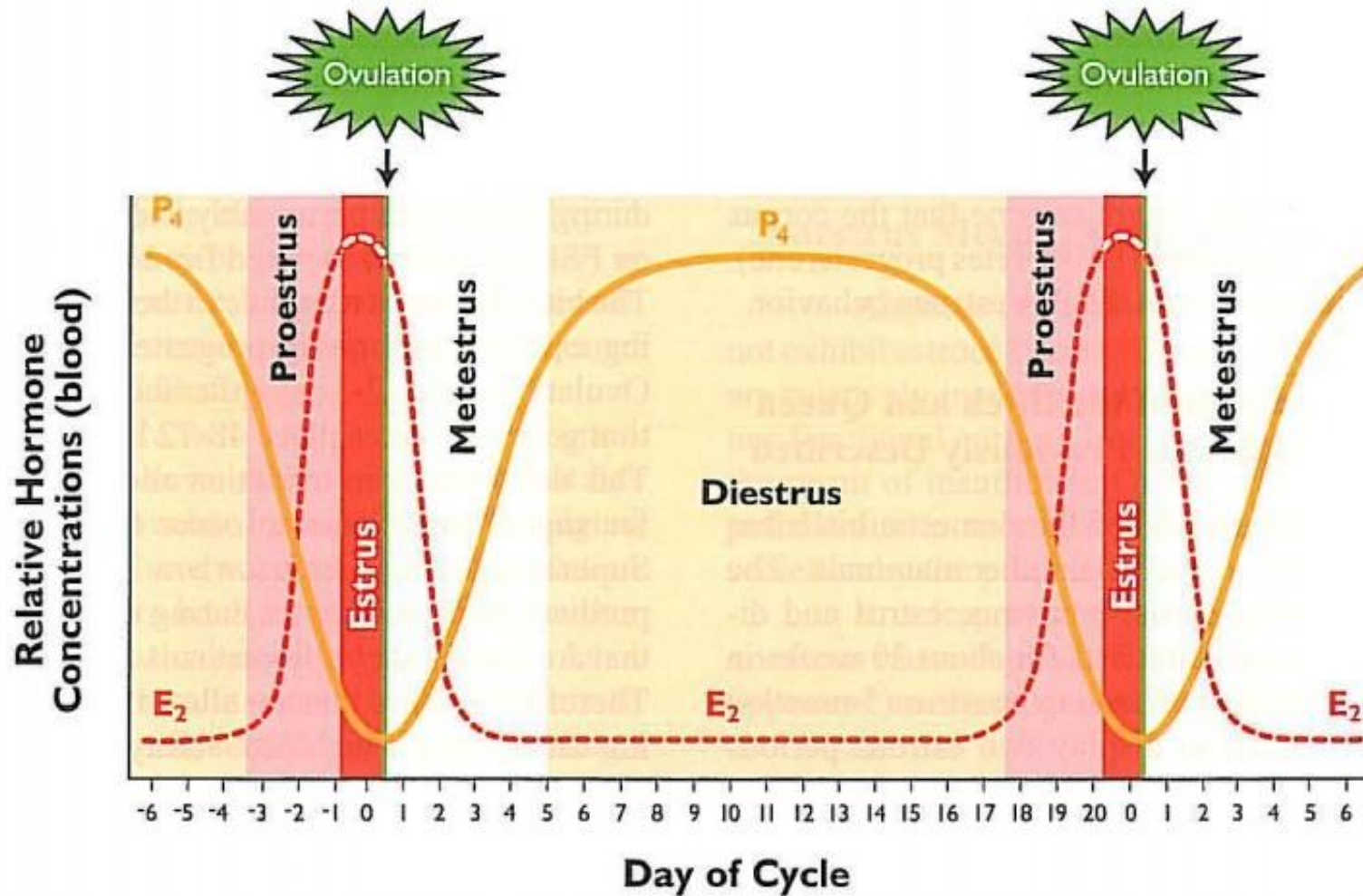




The follicular phase begins after luteolysis that causes the decline in progesterone. Gonadotropins (FSH and LH) are therefore secreted that cause follicles to secrete estradiol (E_2). The follicular phase is dominated by estradiol secreted by ovarian follicles. The follicular phase ends at ovulation. Estrus is designated as day 0.

The luteal phase begins after ovulation and includes the development of corpora lutea that secrete progesterone (P_4). The luteal phase also includes luteolysis that is accompanied by a rapid drop in progesterone. Luteolysis is brought about by prostaglandin $F_{2\alpha}$.

Stages of the Estrous Cycle



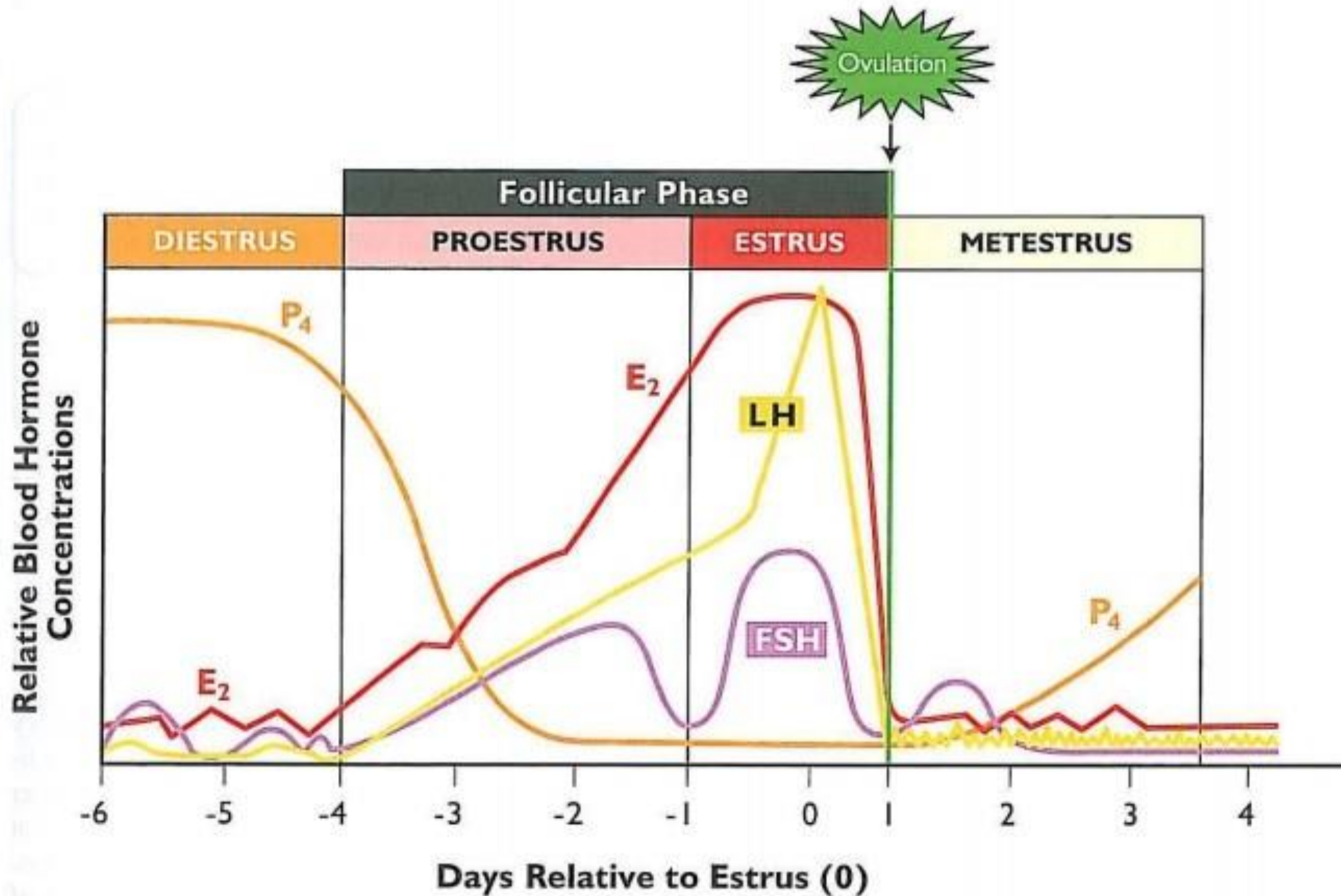
Proestrus is characterized by a significant rise in estradiol (E₂) secreted by maturing follicles.

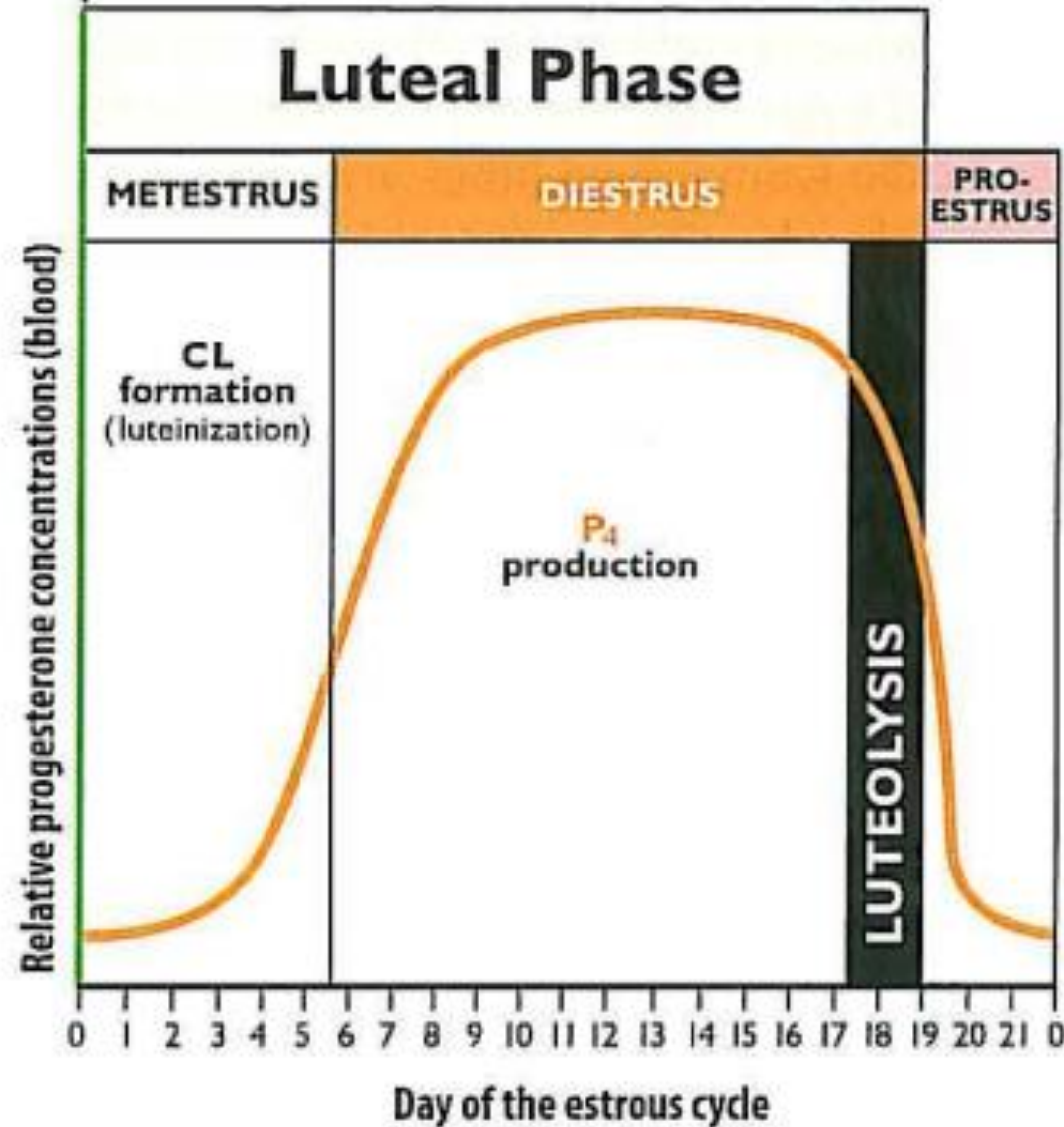
When estradiol reaches a certain level, the female shows behavioral estrus and then ovulates.

Following ovulation, cells of the follicle are transformed into luteal cells that form the corpus luteum (CL) during metestrus.

Diestrus is characterized by a fully functional CL and high progesterone (P₄).

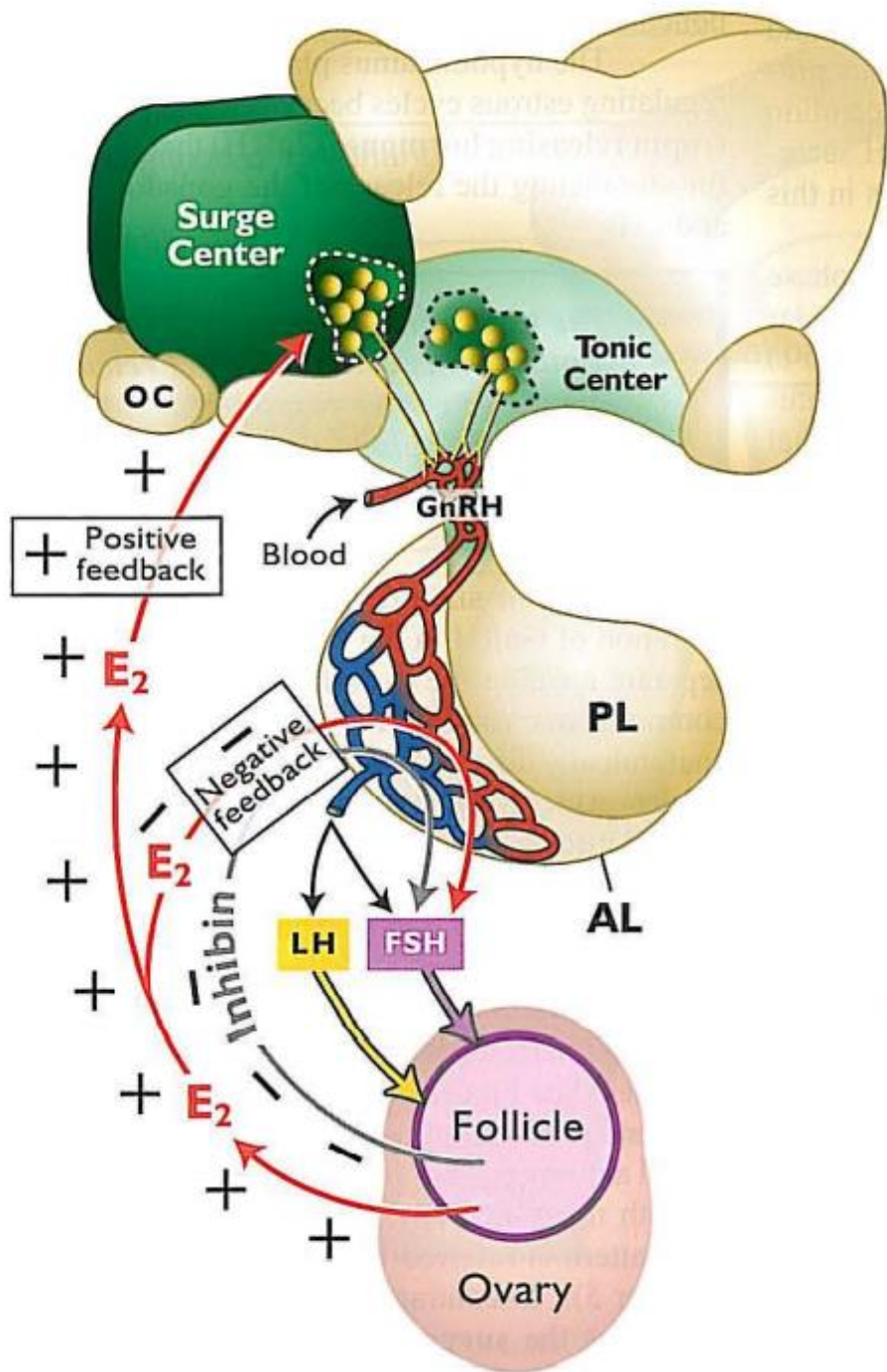
Hormonal Changes During the Follicular Phase





The luteal phase begins immediately after ovulation. During the early luteal phase, the corpus luteum (CL) develops (luteinization) and progesterone increases. During the mid-luteal phase (diestrus) the corpus luteum is fully functional and progesterone (P₄) plateaus. During the last 2-3 days of the luteal phase, destruction of the corpus luteum occurs (luteolysis) and the luteal phase terminates. Following luteolysis, proestrus is initiated.

Relationship between Hypothalamus Pituitary and Ovary during follicular phase



Early follicular phase

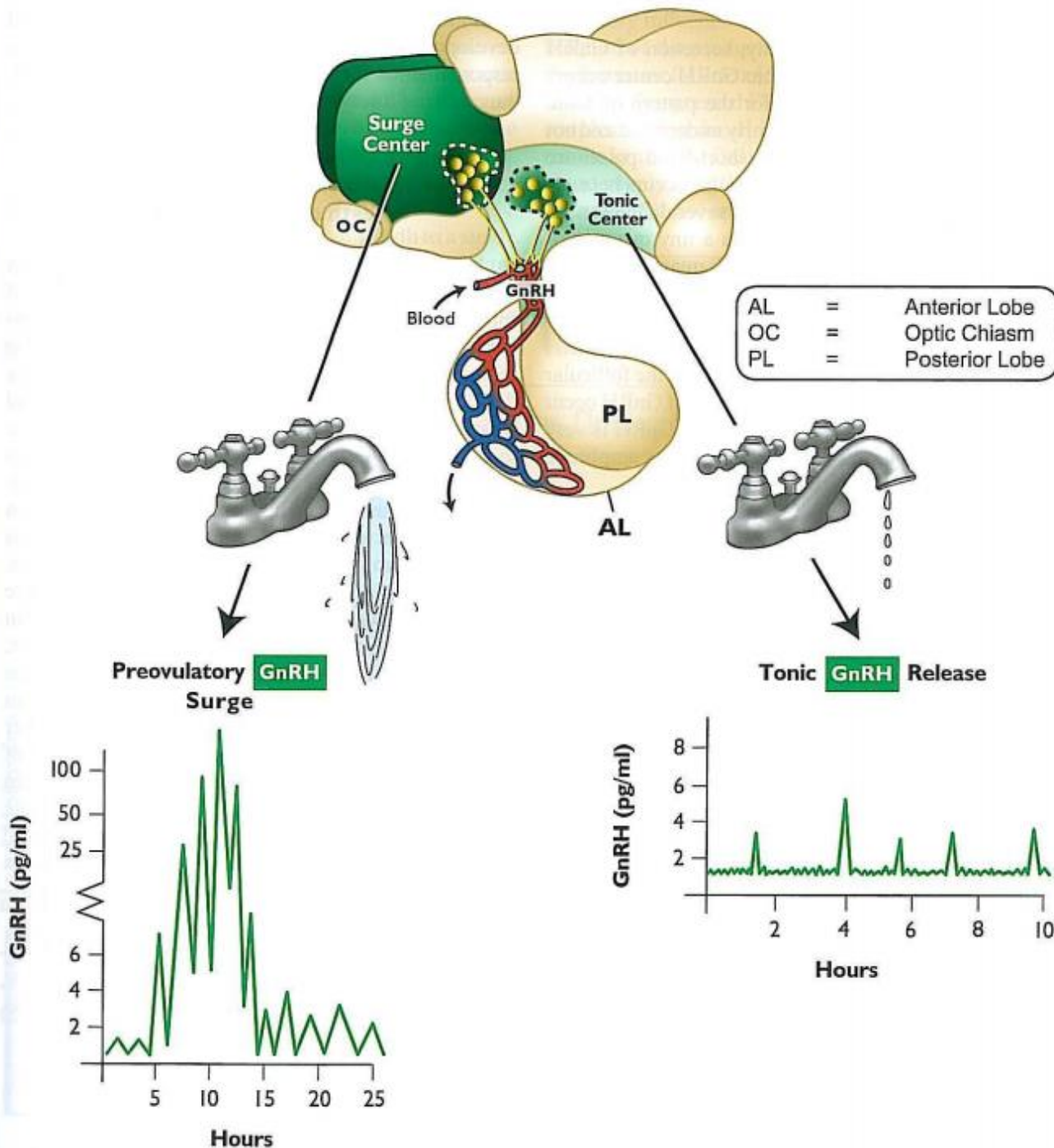
- GnRH pulse frequency begins to increase, causing FSH and LH to be secreted from AP.
- Ovaries get stimulated to secrete estradiol, +ve feedback to hypothalamic surge centre occurs, GnRH neurons secrete a burst of GnRH.

Late follicular phase

- Follicles secrete inhibin that causes a -ve feedback on FSH secretion.

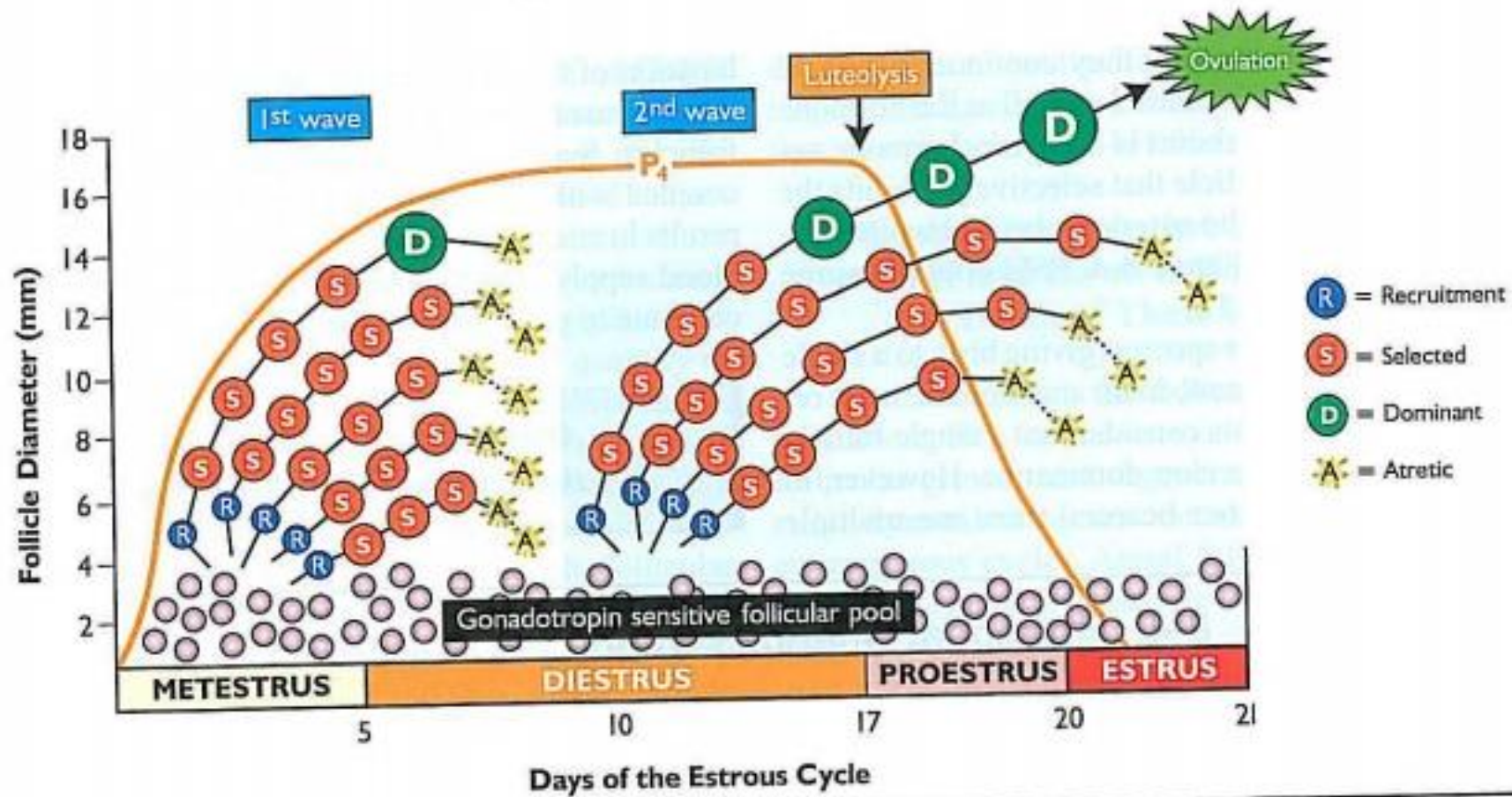
GnRH secretion from hypothalamic tonic and surgic centres

- The surgic centre is sensitive to positive feedback and secretes high amplitude frequency pulses of GnRH in a relatively short period after estradiol reaches a threshold concentration.
- The tonic centre secretes small episodes of GnRH in a pulsatile fashion.
- The episodic secretion is continuous throughout reproductive life.



Several Follicular Waves May Occur During One Cycle in the Cow

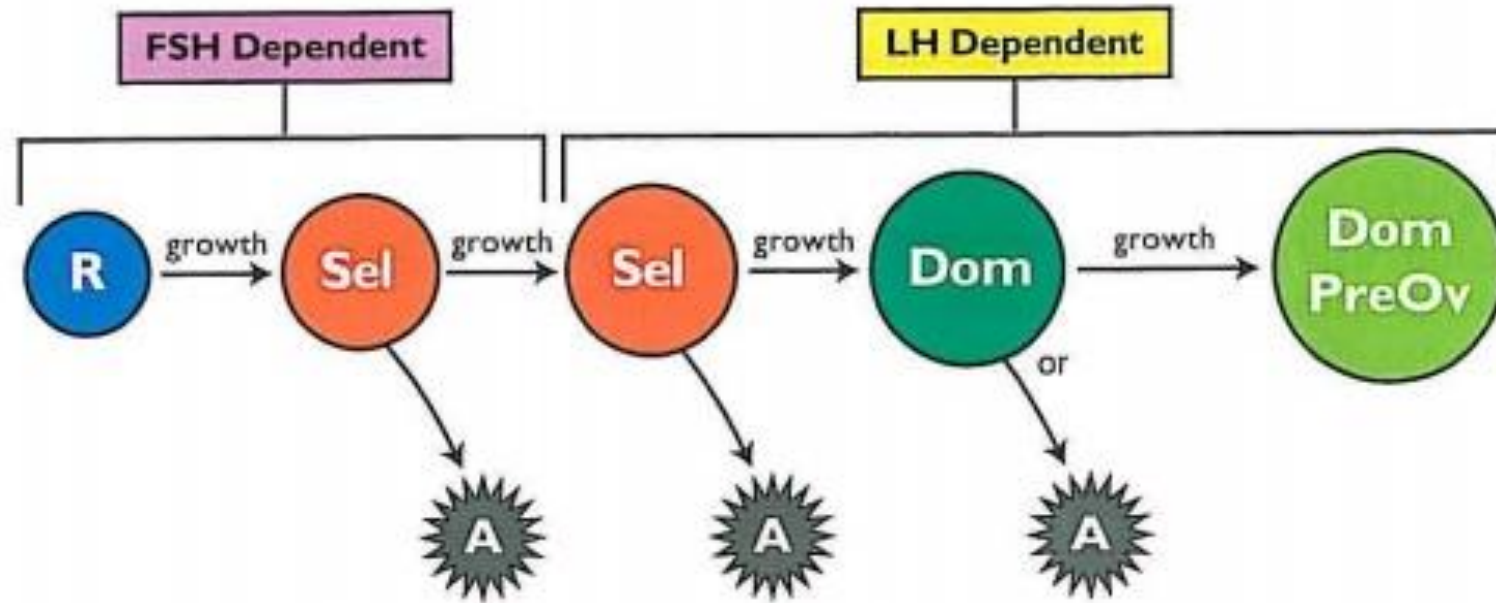
(Modified from Lucy *et al.* 1992)



The first follicular wave occurs either as progesterone is rising or during peak progesterone secretion. Follicles recruited and selected during the first wave will become atretic. *Note: about 80% of estrous cycles in the cow have two waves, but some have three waves. This model illustrates a two-wave cycle.*

The second follicular wave is initiated before luteolysis and results in a dominant follicle that will ovulate. Only those follicles in a growing phase when luteolysis occurs will become eligible for ovulation.

Relative Roles of FSH and LH in Follicular Dynamics



Emerging or recruited follicles and early selected follicles are predominantly FSH dependent. Larger selected follicles and dominant follicles are predominantly LH dependent. Follicles with high numbers of LH receptors become preovulatory follicles.

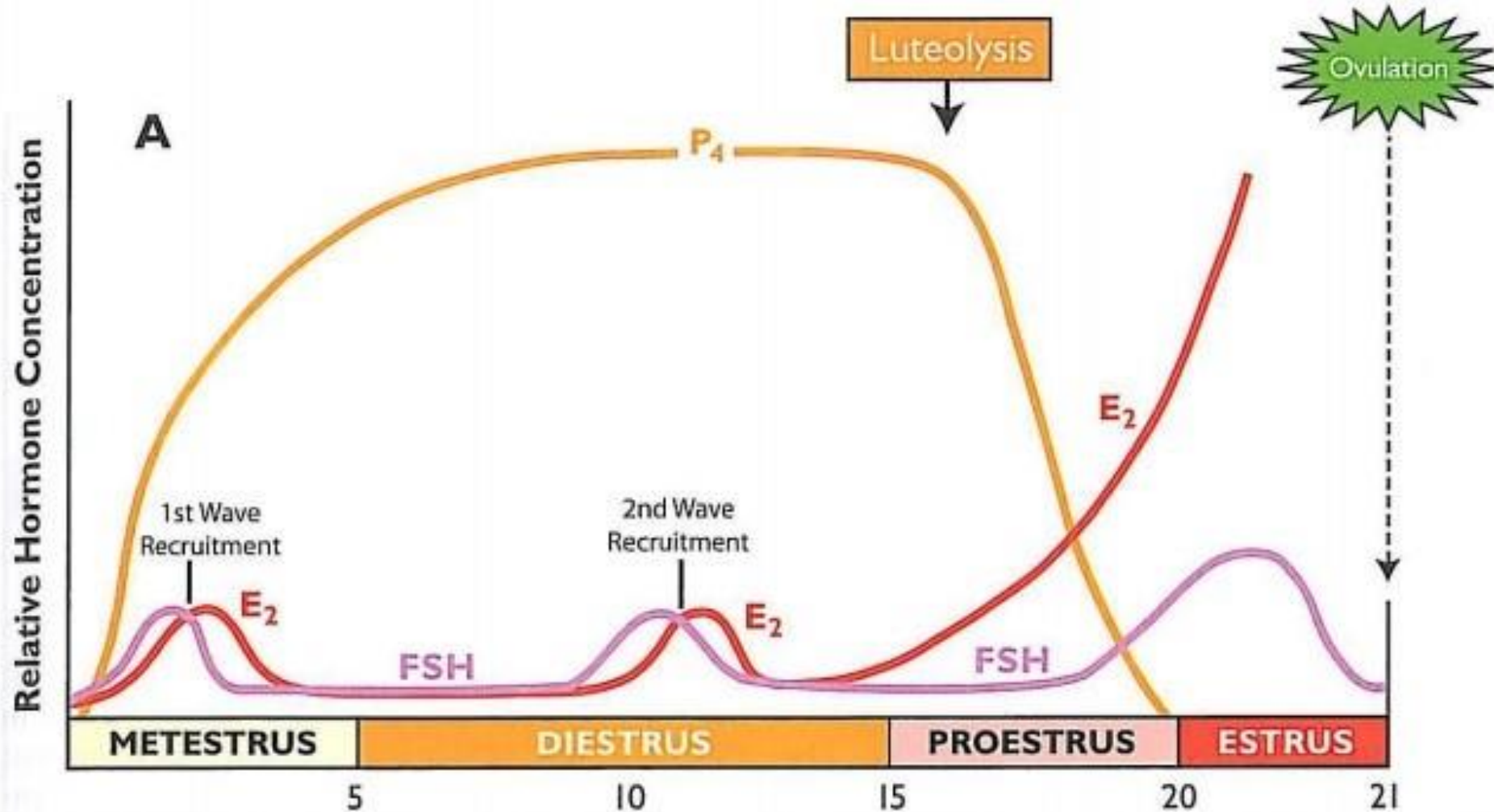
Recruitment = high FSH + low LH pulse frequency + low inhibin + low estradiol

Selection = low FSH + moderate LH + low inhibin

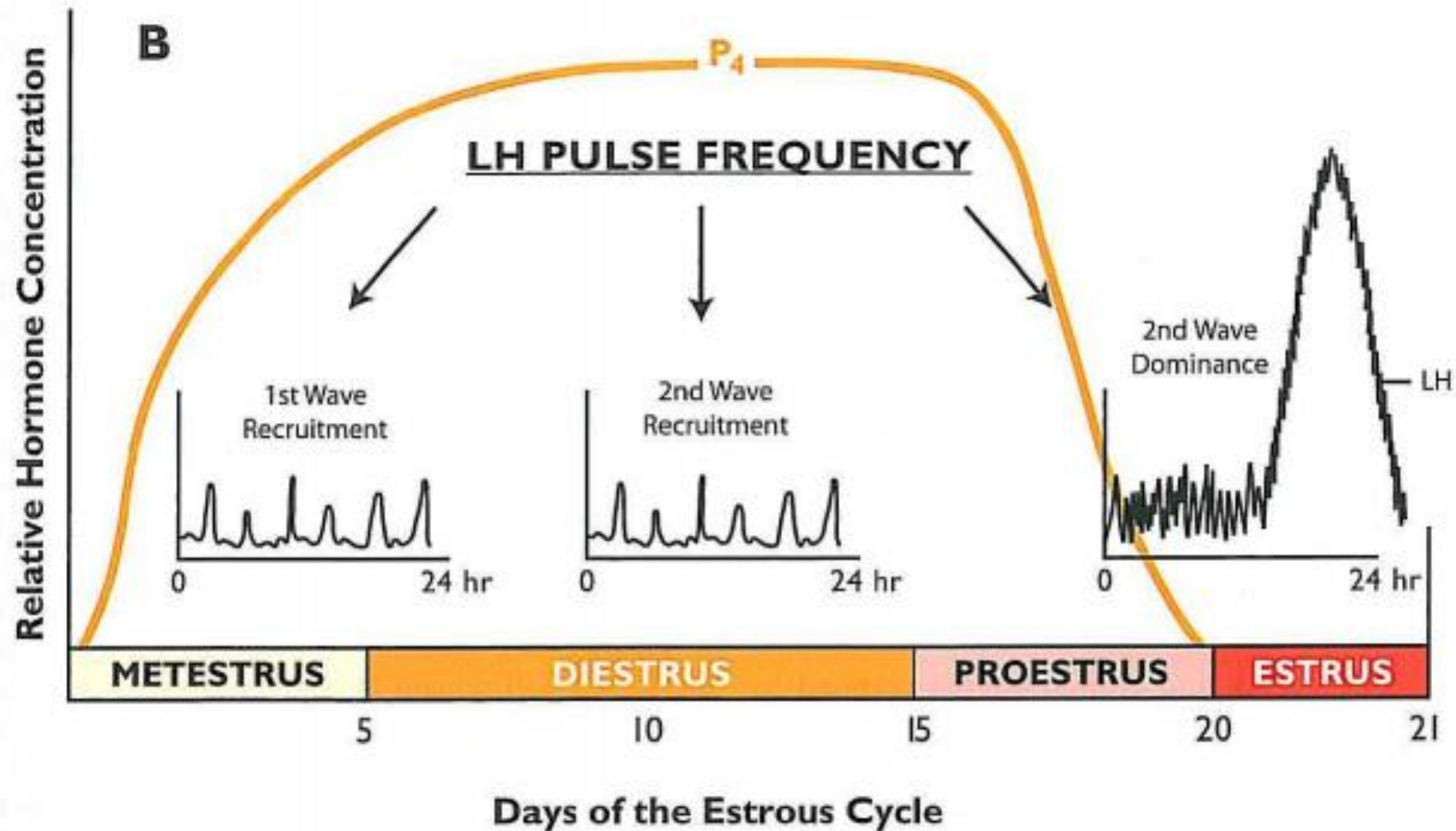
Dominance = low FSH + high LH pulse frequency + high inhibin

Atresia = degeneration of follicles

Relative Progesterone, Estradiol, FSH (A) and LH (B) Secretion During the Estrous Cycle in the Cow



FSH secretion followed by estradiol secretion occurs during metestrus even though progesterone is high. Antral follicles secrete estradiol in response to FSH. They also secrete inhibin and this causes FSH secretion to drop. After luteolysis, progesterone decreases. As a consequence, FSH and estradiol increase dramatically. FSH secretion is controlled by inhibin and estradiol.



LH pulse frequency is low during metestrus (6 pulses per day) and diestrus (3 pulses per day). After luteolysis, progesterone secretion decreases and the negative feedback on GnRH is lifted and the pulse frequency for LH increases dramatically to about one pulse every hour. This frequent pulses of LH drives final follicular development and ovulation.

Endocrine regulation of the bovine estrous cycle

