

Bovine Reproductive Endocrinology

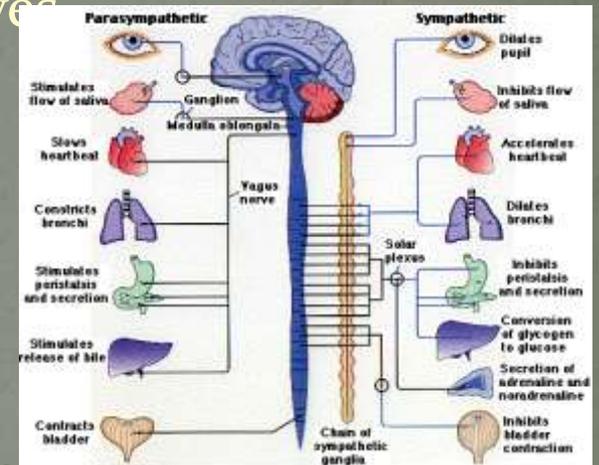
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Hormones 101

- An animal's body must have consistency – a body's physiological variables must be kept within a narrow range
 - For example, you must always keep blood sugar, dissolved oxygen, the pH, and the salinity of the body's tissues at a consistent level
 - When these variables cannot be controlled, a disease will occur
 - E.g. Diabetes is a disease in which the body cannot control the levels of sugar (glucose) in the blood

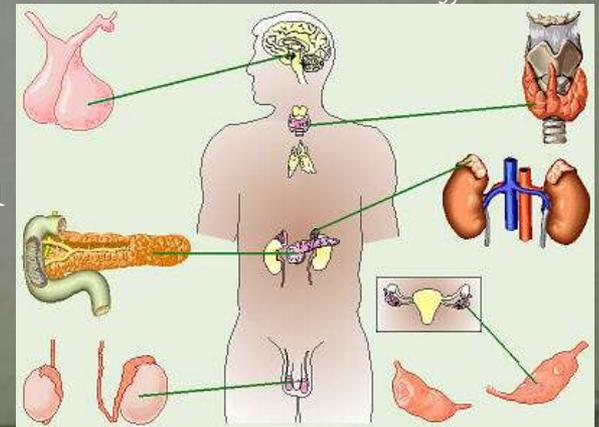
The Body's Regulators

- There are two systems responsible for maintaining homeostasis (*homeostasis is maintaining a constant internal environment*)
 - Nervous system – brain, spinal cord, nerves
 - Endocrine system – endocrine glands (pancreas, thyroid, adrenal glands, ovaries/testicles) and hormones
- The nervous system is responsible for quick, split second responses, such as reflexes and reactions.
- The endocrine system is responsible for very long-term responses; for example, puberty and sexual maturation occur over a period of years in humans and other animals.



Source: users.rcn.com

Source: biology.clc.uc.edu

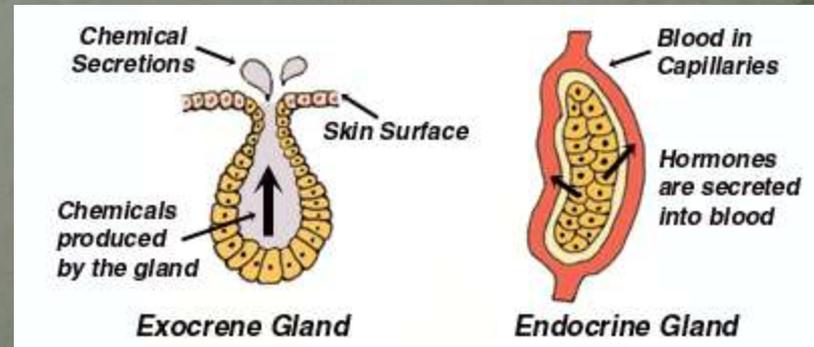


The Endocrine vs. Nervous System

- The endocrine system coordinates bodily responses with the nervous system, but each works in different ways
- The endocrine system functions by releasing chemicals into the blood to change, tweak, or reverse the metabolic activities of a specific group of cells
 - It works relatively slowly and usually the results are long lasting or even permanent
- The nervous system uses electrical signals that travel at lighting fast speeds to alter the activities of muscle, glands, and other structures.
 - The results are immediate but short-lived

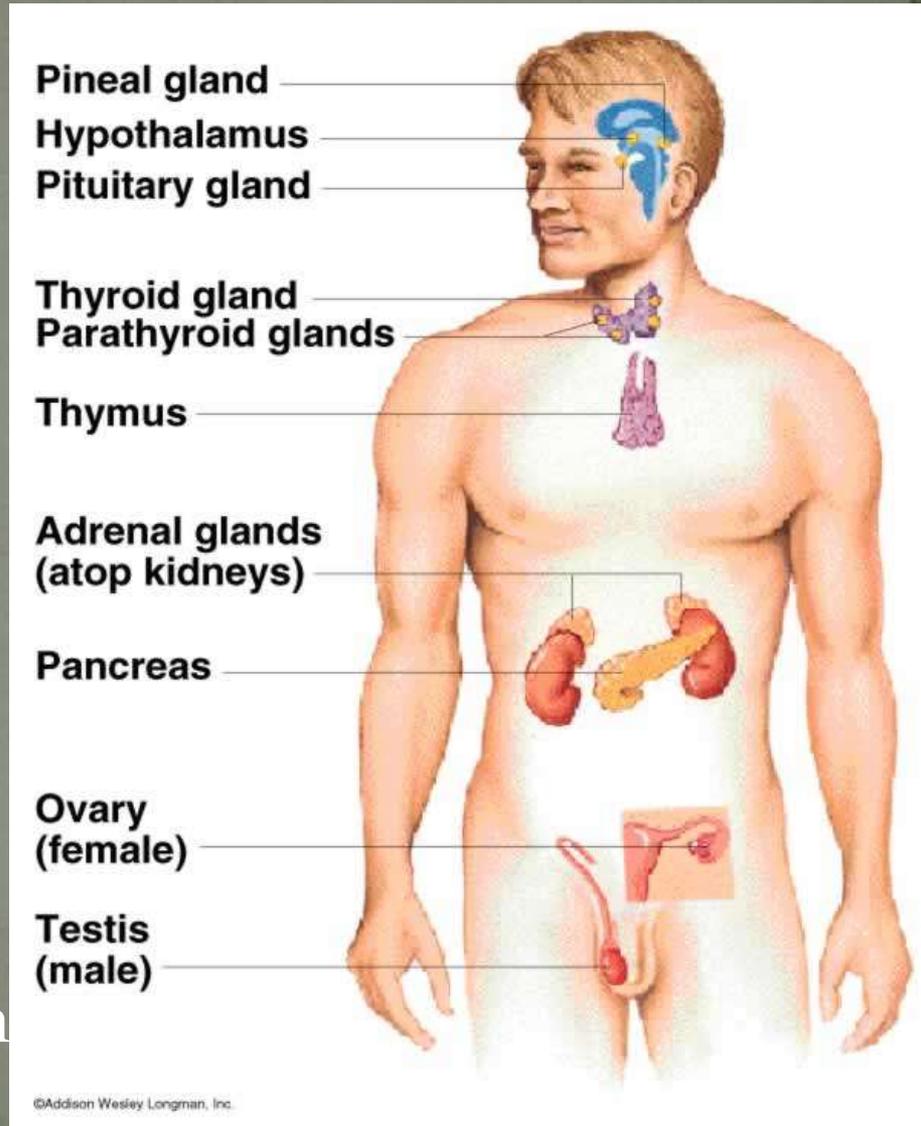
Endocrine Glands

- A gland is a type of organ that secretes a substance into another part of the body
 - E.g. your salivary glands secrete saliva into your mouth
- There are two types of glands
 - Exocrine – releases a substance into an empty space in the body (e.g. the salivary glands releasing saliva into the mouth, or sweat glands onto the surface of the skin)
 - Endocrine – releases substances called hormones directly into the bloodstream – e.g. your pancreas secretes insulin directly into your blood to control blood sugar levels



Endocrine Glands

- The endocrine glands include
 - Pineal
 - Hypothalamus
 - Pituitary
 - Thyroid
 - Parathyroid
 - Adrenal
 - Pancreas
 - Ovaries or Testes
- Note that some parts of the brain are considered part of the endocrine system and not the nervous system!



Classes of Hormones

- Hormones are created in one of three ways
 - **Amine-hormones are derived from the amino acid tyrosine**
 - For example, epinephrine (adrenalin) is created in this way
 - **Peptide or Protein-based Hormones – these are derived from proteins created by the body**
 - E.g. growth hormone is created from a protein
 - **Steroid hormones – these are created from cholesterol**
 - E.g. testosterone and progesterone are created in this way

Reproductive Hormone Cycles

Hormones in Estrus

- During the estrus cycle, hormones control signs of heat, the release of the egg from the ovary, maintain pregnancy, and regulate almost all aspects of reproduction.
 - *they are:* chemical messengers secreted by tissue (an endocrine gland) and carried by blood to different tissue (a target tissue) with a direct specific effect.
 - Endocrine gland – not a specific organ, just an organ that secretes the hormone in the specific case
 - (just like Air Force One is not a specific plane but the name given to any plane carrying the president)
 - Endocrine gland and target tissue can even be the same thing



Hormones

Chapter 1 Appendix: Hormones

Table 1.2: Hormones that regulate the 21-day estrous cycle

Hormone	Site of production	Target tissue	Action
GnRH*	Hypothalamus	Anterior Pituitary	Allows the release of FSH and LH.
FSH*	Pituitary	Ovary (Follicle)	Stimulates follicle development and estrogen production.
LH*	Pituitary	Ovary (Follicle)	Induces ovulation, corpus luteum development and progesterone production.
Estrogen	Ovary (Follicle)	Brain	Induces changes in behavior associated with heat.
		Anterior Pituitary	Enhances the release of FSH and particularly LH during estrus.
Progesterone	Ovary (Corpus luteum)	Oviduct, Uterus, Cervix, Vagina and Vulva	Increases muscular activity and production of a fluid of low viscosity to facilitate the migration of the sperm and the egg towards each other.
		Anterior Pituitary	Prevents complete maturation and ovulation of follicles.
Prostaglandins	Uterus	Uterus	Decreases muscular activity and prepares the uterus to be a suitable environment for the embryo.
		Ovary (Corpus luteum)	Induces the regression of the corpus luteum and a decrease in progesterone.

* GnRH = Gonadotropin Releasing Hormone; FSH = Follicle Stimulating Hormone; LH = Luteinizing Hormone

Hormones

- Tissue only responds to a hormone if it has a receptor for that particular hormone
 - works sort of like a lock and key
 - a hormone is the key, but a key can only work if it has a lock to work on
 - tissue can have (and usually does have) multiple receptors for multiple organs
- Summary: an endocrine gland releases a hormone into the blood, which travels throughout the body and affects tissue with a receptor for that particular hormone with a specific targeted effect.



Hormone Type and Function

- GnRH – gonadotropin releasing hormone
 - Regulates the secretion of FSH
 - Injections of GnRH cause developing eggs in follicles to be ovulated (released) and stimulates the growth of immature eggs in new follicles ~

Hormone Type and Function

- FSH – Follicle Stimulating Hormone
 - Stimulates growth of eggs in follicles on the ovary
- LH – leutenizing hormone
 - Promotes ovulation (release of eggs from the follicle) ~

Hormone Type and Function

- Estrogen – jack of all trades
 - Causes behavioral changes in the cow
 - Causes LH surge just prior to release of follicle
 - Coordinates acceptance of bull and release of follicle
 - Necessary to ensure that sperm and egg meet
 - Stimulates muscular contractions that move egg into oviduct and contractions in vagina, cervix, and uterus to move sperm towards oviduct ~

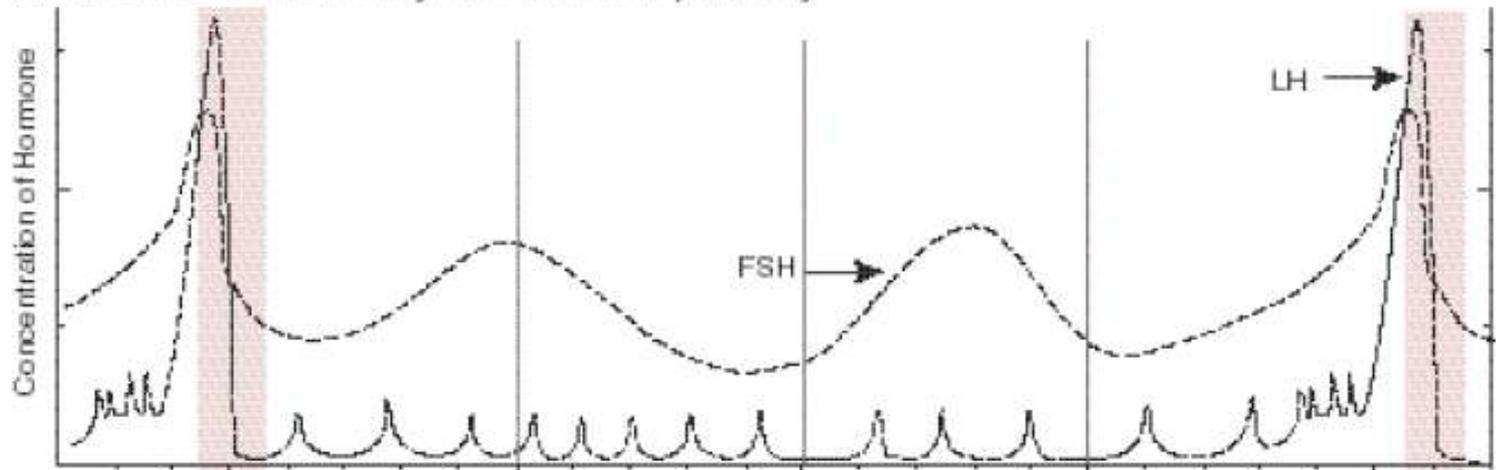
Hormone Type and Function

- Progesterone
 - Prepares uterus for pregnancy
 - Prevents development of new follicles
 - Prevents recurrence of estrous cycle during pregnancy ~

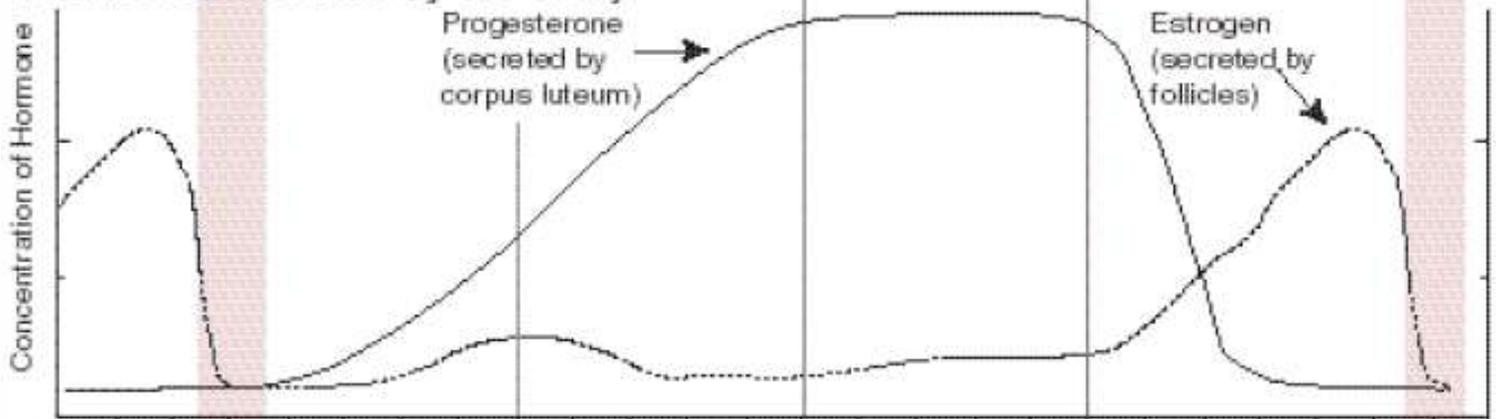
Hormone Type and Function

- Prostaglandins ($\text{PGF}_{2\alpha}$)
 - In non-pregnant cows, uterus secretes prostaglandins
 - Cause the corpus luteum to regress and stop producing progesterone
 - Follicles are no longer inhibited and can grow and develop
 - In animals with a mature corpus luteum, a heat typically occurs 2-7 days after an injection of prostaglandins ~

Hormones secreted by the anterior pituitary



Hormones secreted by the ovary



Hormone secreted by the uterus

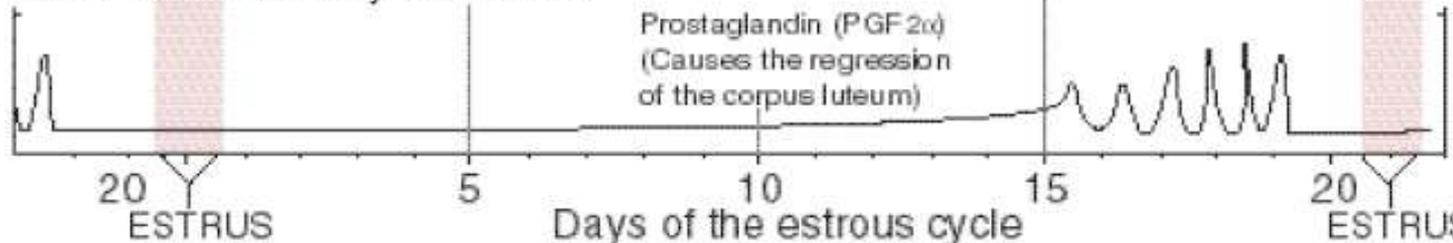


Figure 1.12: Major hormones and ovarian structures regulating the estrous cycle

Estrus Hormone Cycles

- Day 20 and 21 (of previous cycle) – Corpus luteum decays; final maturation of a follicle for the next cycle begins
- Day 1 and part of Day 2 (30 hours total): estrus (heat period), the point of sexual receptivity.
 - The only time that a cow will allow herself to be mounted.
 - Egg and follicle reach final maturation. ~

Estrus Hormone Cycles

- Day 2-5 [Starting 10-14 hours after last sign of estrus]: follicle is expelled from the ovary into the oviduct (a.k.a. ovulation).
 - Wall of ruptured follicle that remains on the surface of the ovary will become the corpus luteum.
- Days 6-16: corpus luteum is large and fully functional.
 - Some growth of follicles which will not fully mature until current corpus luteum regresses, at which time a dominant follicle will emerge and eventually ovulate in the next cycle. ~

Estrus Hormone Cycles

- Days 16-20: Corpus luteum will start to regress. The uterus will begin to try to detect the presence of an embryo.
 - if no embryo is detected, the uterus will send a signal to the corpus luteum telling it to regress so that a new cycle can begin.
 - If egg has been fertilized, the cow is pregnant and the corpus luteum will continue to produce hormones (progesterone) that inhibit follicular development.
- Day 20 – 21 – Corpus Luteum decays if there is no fertilized egg;
 - final maturation of a follicle for the next cycle begins. ~

Hormone Therapies

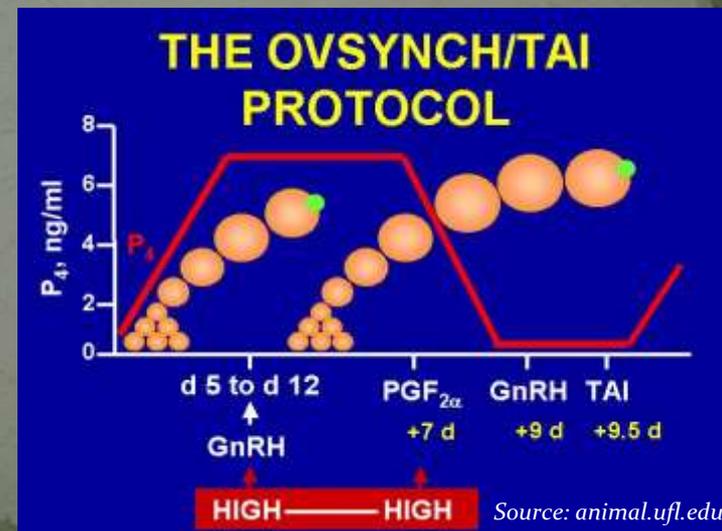
Artificial Hormone Therapies

- Knowledge of the physiology and endocrinology of the reproductive tract has resulted in the creation of numerous pharmaceuticals that aid in regulating, adjusting, or terminating the estrus cycle
 - This can be of great advantage to the producer.
- All treatments must be thoroughly researched and extensively tested to determine whether or not they are safe for administration to animals and must show that they cause no harmful effects in humans who consume products from those animals
 - All of these products available for sale must be FDA approved.



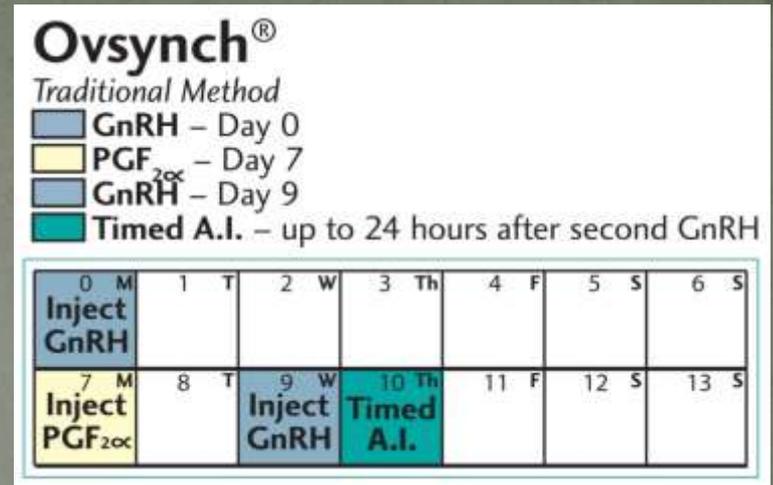
Artificial Regulation of Ovulation

- If a producer misses a cow in heat, or if the heats are not easily detectable, profits can quickly be lost if the cow is not bred in a timely fashion.
- Research at UW-Madison led to the creation of Ovsynch, a hormone therapy treatment to synchronize ovulation and allow for predictable, timed inseminations.
 - In short, we can use this treatment to make a cow go into heat at a specific time that is known in advance
 - This can greatly increase the chances of impregnating the cow

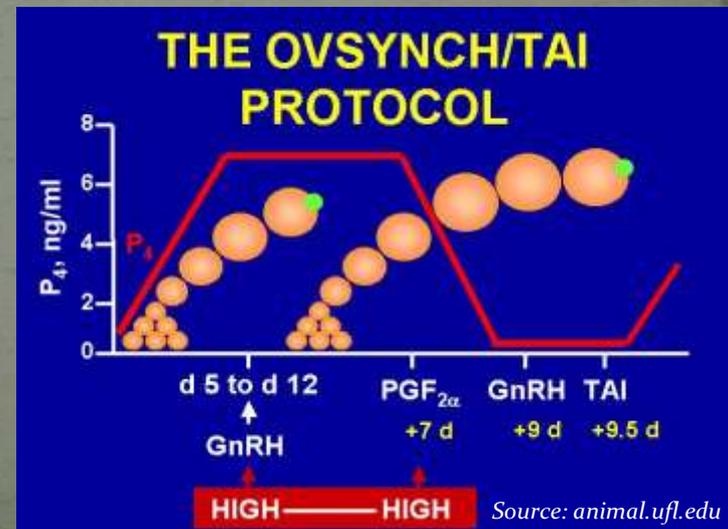


Ovsynch

- Ovsynch uses two hormones
 - $\text{PGF}_{2\alpha}$ and GnRH
- Ovsynch occurs in three stages
 - Day 0 - Stage 1: GnRH injection to create a new follicle
 - Day 7 - Stage 2: $\text{PGF}_{2\alpha}$ injection to end the current estrus cycle and regress the corpus luteum
 - Day 9 – Stage 3: Second GnRH injection to cause the new follicle to ovulate and release the egg
 - All cows will ovulate 24-32 hours after the second GnRH injection
 - Day 10 – Insemination



Source: genex.crinet.com



CIDR - *Source: ansci.wisc.edu*

- CIDRs (Controlled Internal Drug Release) are an intravaginal progesterone insert used in the beef cattle, dairy cattle, goat and sheep industries.
 - The progesterone is released at a controlled rate into the bloodstream after insertion.
- In all species, CIDRs are used for the synchronization of estrus.
 - This can be highly beneficial in large herds because with the synchronization of estrus, groups of cows and heifers can be bred at the same time in a narrow window.



Source: northsbreedingsolutions.com.au

How CIDR Works

- CIDRs are coated with progesterone.
 - In vivo, progesterone functions to 'progress' or sustain the pregnancy.
- Progesterone will prevent the animal from going into heat.
- When the CIDR is removed at the end of a treatment period, the progesterone production also immediately stops
 - This enables ovulation to occur



How CIDR Works

- All animals on the CIDR treatment will go into heat at the same time, reducing labor costs
- The animal will respond to the progesterone from the CIDR in the exact same way it will respond to progesterone from its own body
 - The two hormones are physiologically indistinguishable

Source: drugs.com



Figure 1



Figure 2



Figure 3

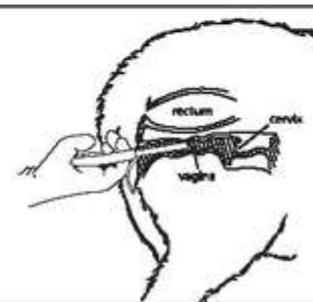


Figure 4

Lutalyse

- Lutalyse is a veterinary pharmaceutical brand name
 - Lutalyse is a $\text{PGF}_{2\alpha}$ therapy treatment
- If an animal is known to be open (i.e. her ovulated egg was not inseminated), a shot of Lutalyse will end the cycle and start a new one.
 - Lutalyse/ $\text{PGF}_{2\alpha}$ will cause the death of the corpus luteum, resulting in reduced progesterone production.
- Pregnant women **SHOULD NOT** administer shots of Lutalyse; it can cause their bodies to terminate the pregnancy!



Summary

- Ovsynch – ends current cycle, and re-starts a new follicular wave at a predictable time
- CIDR – a vaginal insert used to delay estrus to a certain time so that all animals in a herd will be able to be bred at the same time
- Lutalyse – a $\text{PGF}_{2\alpha}$ treatment used to end a cycle in an open, unbred cow