Lactation

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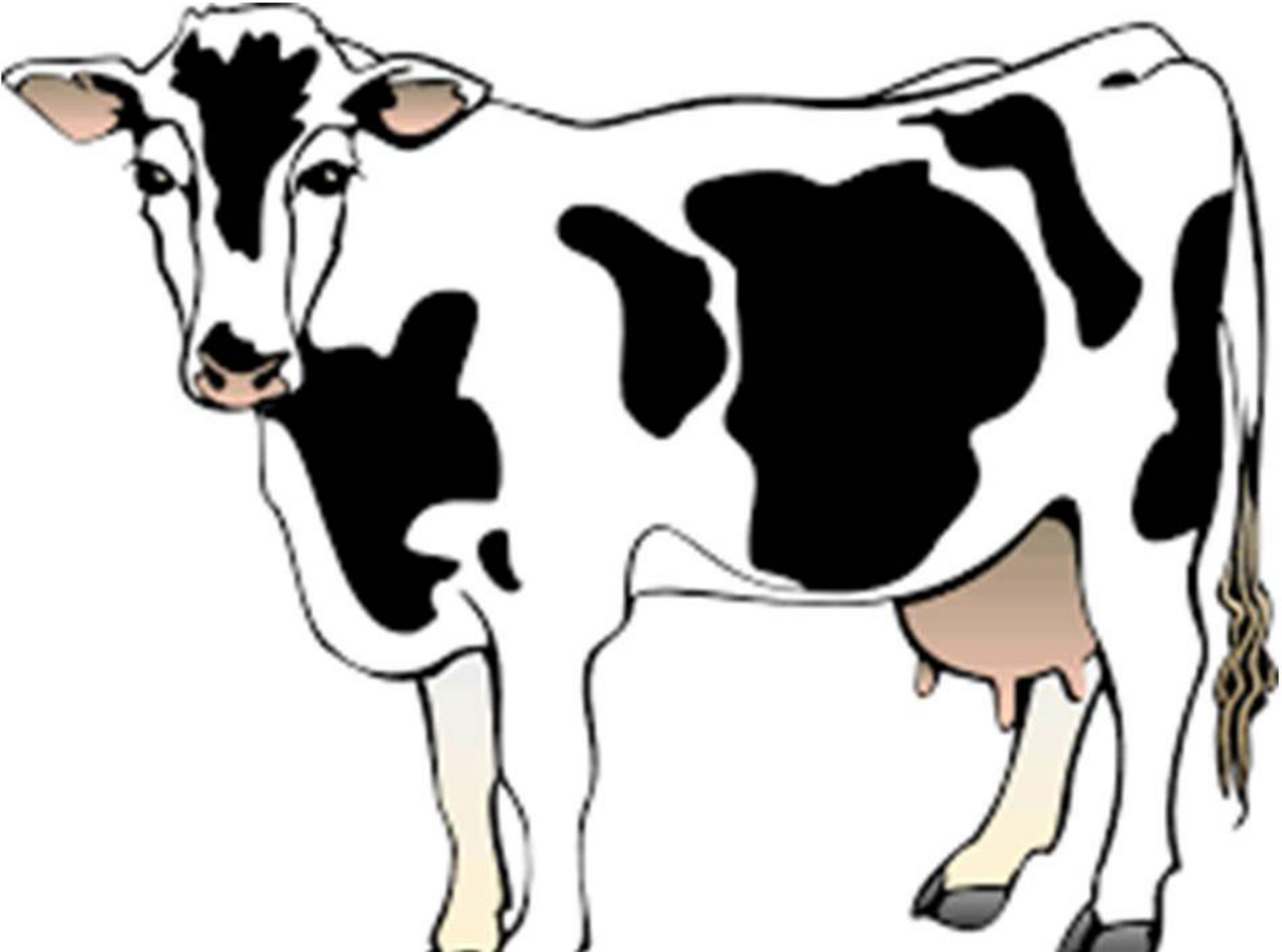
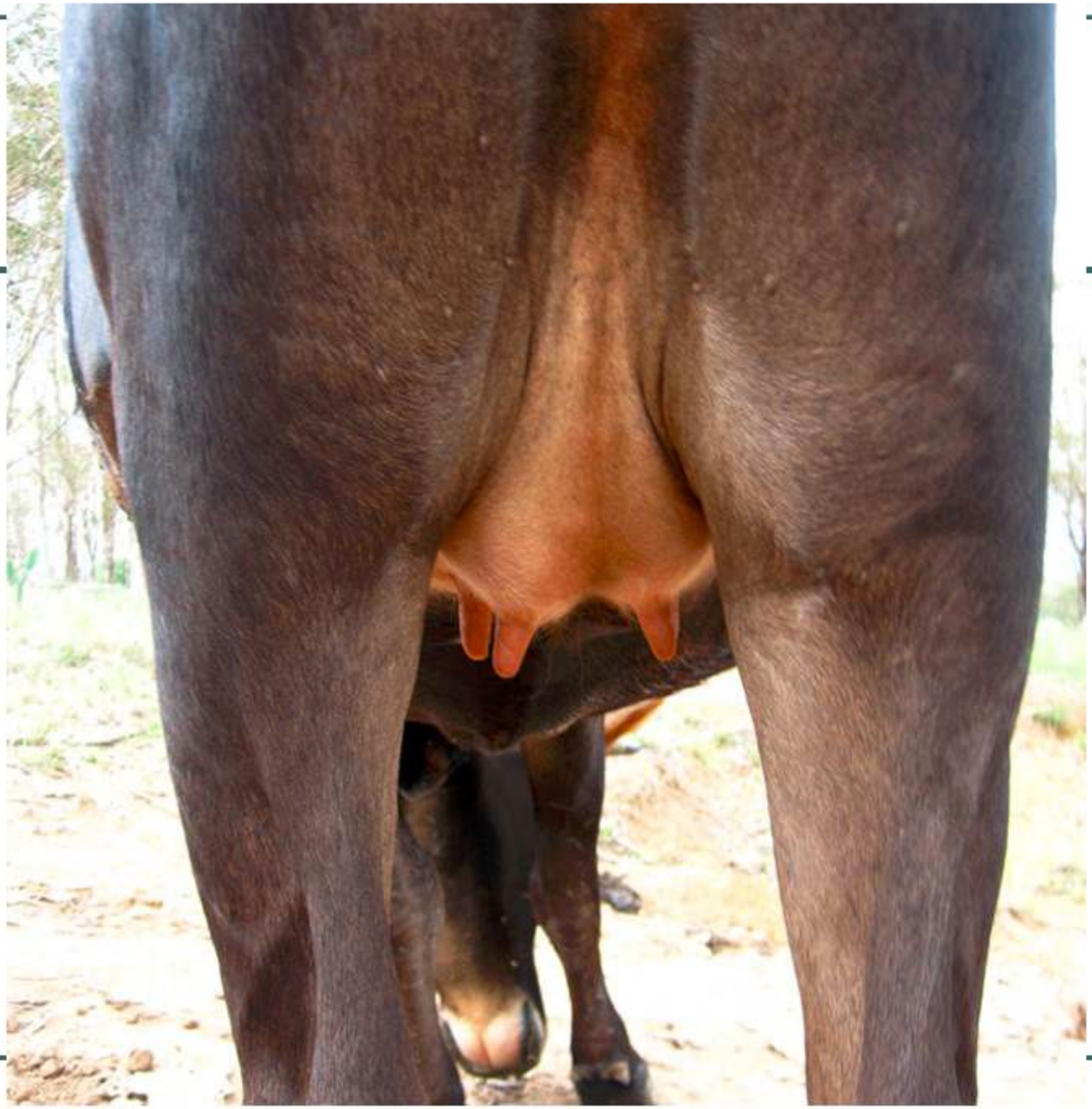


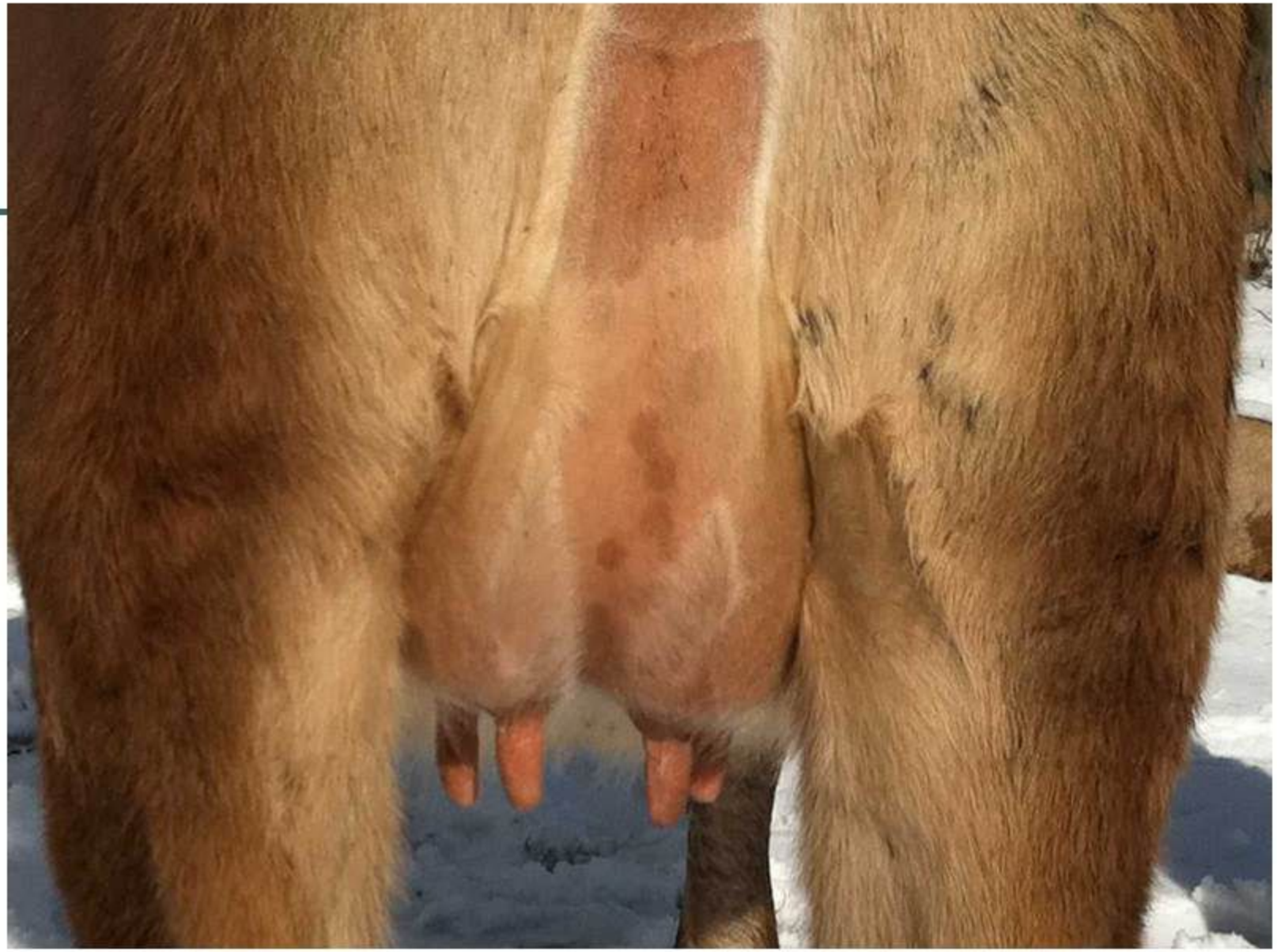
Mammary growth, differentiation, and lactation

- Milk secretion involves both intracellular synthesis of milk and subsequent passage of milk from the cytoplasm of the epithelial cells into the alveolar lumen. Milk removal includes passive withdrawal from the cisterns and active ejection from the alveolar lumina. The term lactation refers to the combined processes of milk secretion and removal. Mammogenesis describes the development of the mammary gland. Lactogenesis refers to the initiation of milk secretion, and the term galactopoiesis is used in a general sense to refer to the maintenance of milk secretion and/or the enhancement of established lactation.



Mammogenesis

- Growth of the mammary gland (mammogenesis) takes place during various reproductive epochs beginning in the prenatal period to early lactation. Mammary development during fetal and pre-pubertal stages is not necessarily under hormonal control. During puberty, pregnancy, and lactation, however, growth and development are largely under the influence of hormonal changes. Most structural development of the mammary gland takes place during pregnancy.



Lactogenesis

- Lactogenesis (induction of milk synthesis) is a process of differentiation whereby the mammary gland alveolar cells acquire the ability to secrete milk; it is conveniently defined as a two-stage mechanism.

Lactogenesis

- The first stage of lactogenesis consists of partial enzymatic and cytological differentiation of the alveolar cells and coincides with limited milk secretion before parturition.

Lactogenesis

- The second stage begins with the copious secretion of all milk components shortly before parturition and extends throughout several days postpartum in most species. The onset of copious milk secretion at parturition to meet the nutritional needs of youngs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Galactopoiesis

- Galactopoiesis (maintenance of lactation) requires of alveolar cell number, synthetic activity per cell, and efficacy of the milk-ejection reflex. After parturition, there is a marked increase in milk yield in cows, which reaches a maximum in 6 to 8 weeks and then gradually declines (lactation curve). During this decline, the rate of mammary cell loss presumably exceeds the rate of cell division. This loss of secretory cells lowers milk yield as lactation advances.

Mammary involution

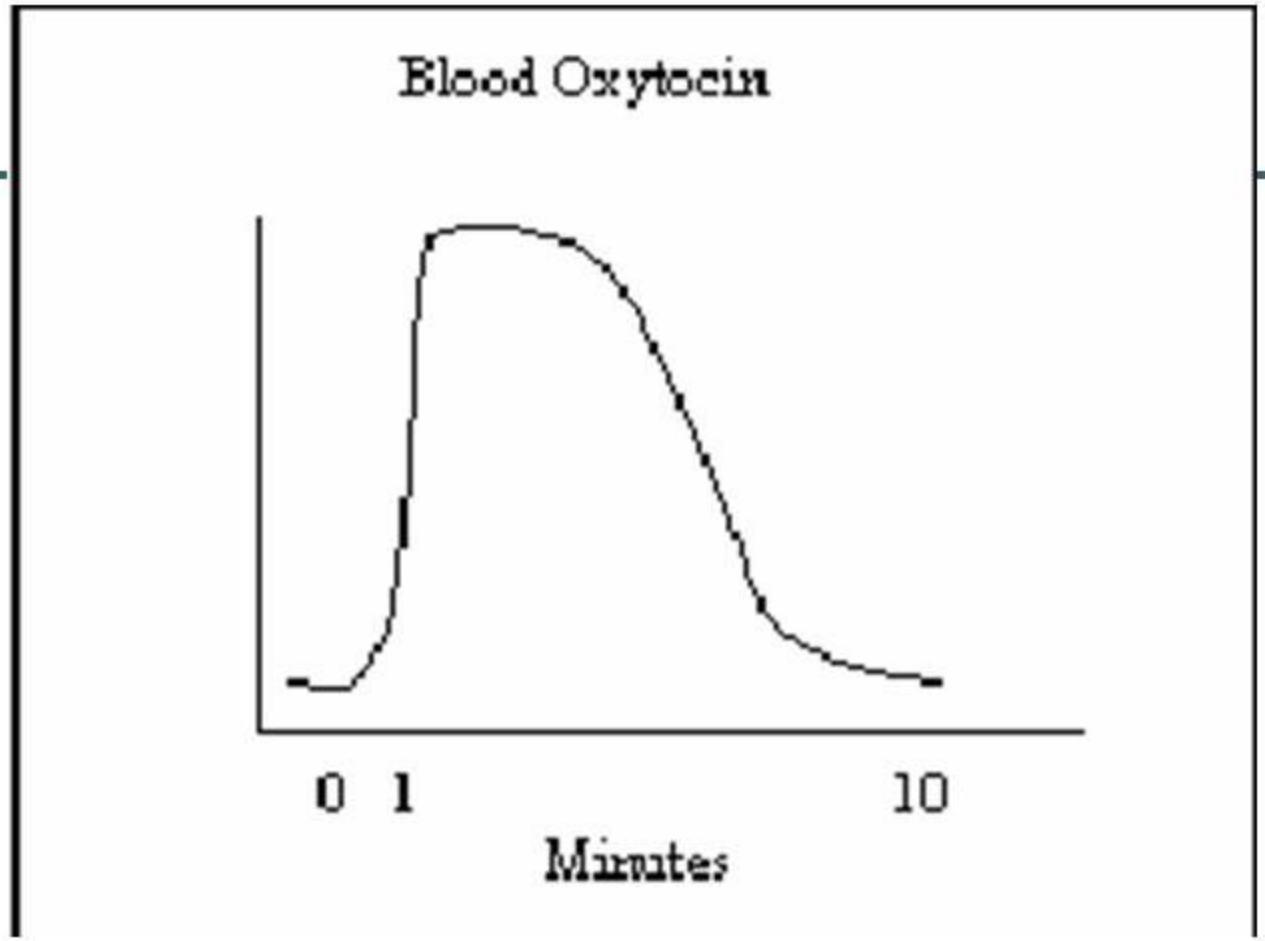
- In most species, the cessation of suckling or milking rapidly brings about mammary involution, which is characterized by a decrease in the number of mammary epithelial cells and also in the amount of secretory activity per cell. Lysosomal enzymes are released, and many epithelial cells are lysed. During this period, epithelial cells may undergo apoptosis, a mode of physiological cell death (i.e., programmed cell death). Myoepithelial cells remain in the gland during involution and maintain the structure of the remaining epithelial cells. The space previously occupied by the degenerating alveoli is replaced with adipose cells.

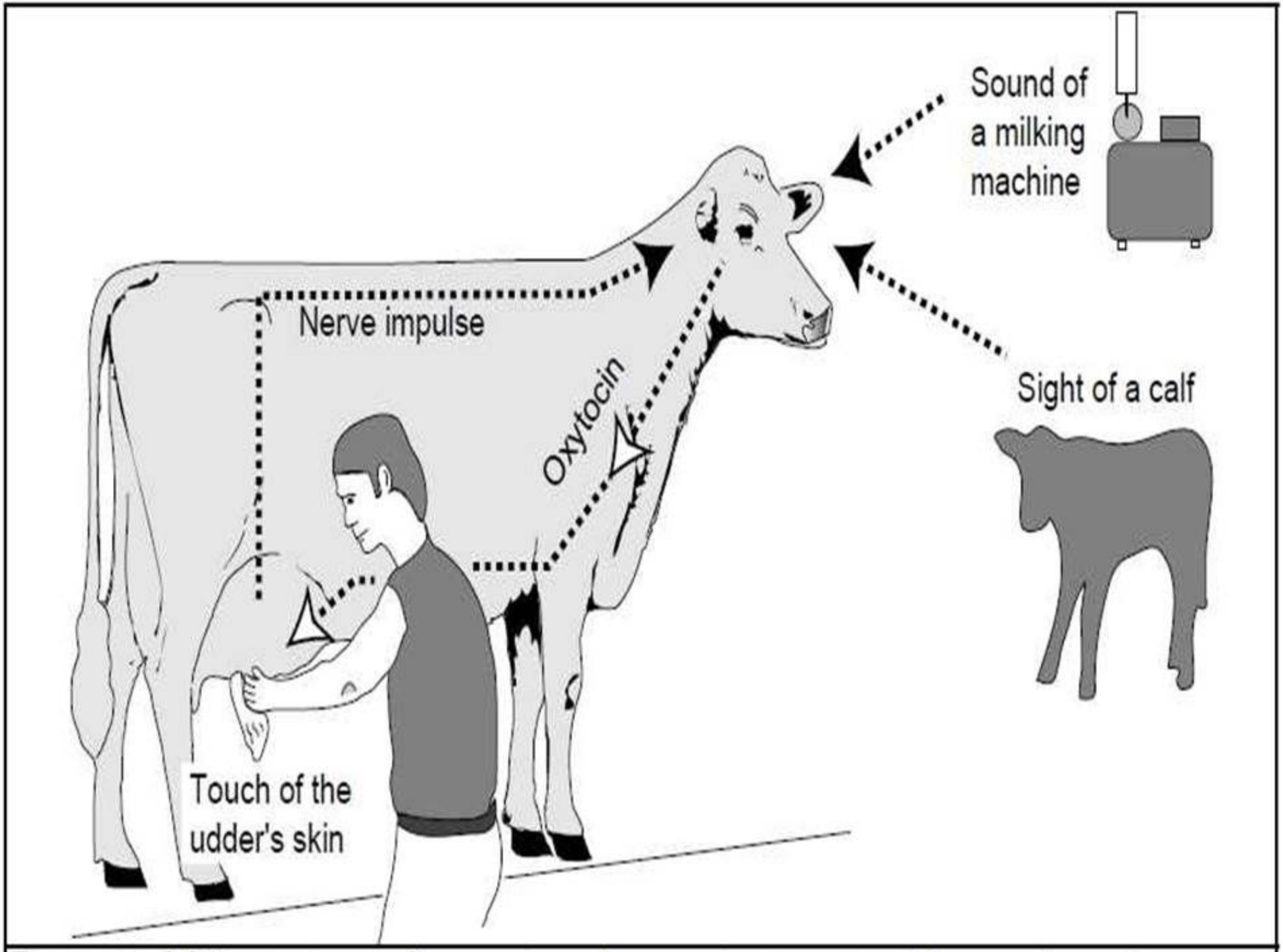
Composition of milk

- Milk contains all of the nutrients necessary for survival and initial growth of mammalian neonates. The nutrients in milk include sources of energy (lipids and carbohydrates), proteins to provide amino acids, vitamins minerals for electrolytes, and water. The relative amounts of these nutrients in milk vary among species

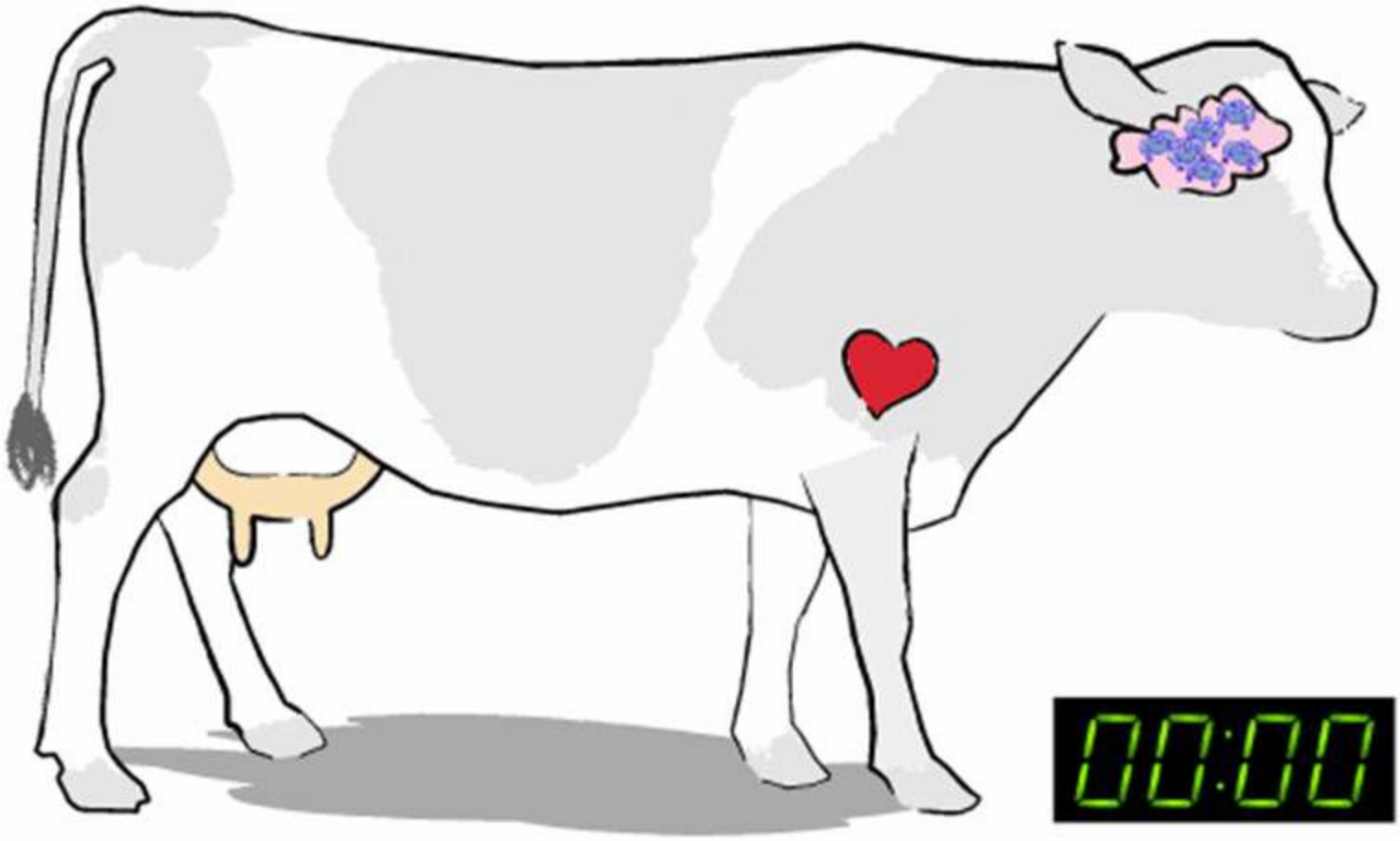
Milk Let-Down

- Neuro-hormonal reflex
- The suckling stimulus or massaging of the udder stimulates somatic nerves in the teat, which send a signal to the **posterior pituitary** gland and causes the release of the hormone **oxytocin**.
- Oxytocin causes the myoepithelial (muscle) cells around the alveoli to contract.
- For efficient milking, there are several important factors to remember.
  - Stimulate 1 min before milk let-down
  - The maximal effect of oxytocin occurs during the first 2 to 3 minutes of milk let-down.
  - Stress during cow preparation or during milking will inhibit oxytocin release.
  - Inhibition of oxytocin release


Blood Oxytocin
0
1
10
Minutes


Sound of
a milking
machine
Nerve impulse
Oxytocin
Sight of a calf
Touch of the
udder's skin

Oxytocin Flow & Milk Let-Down

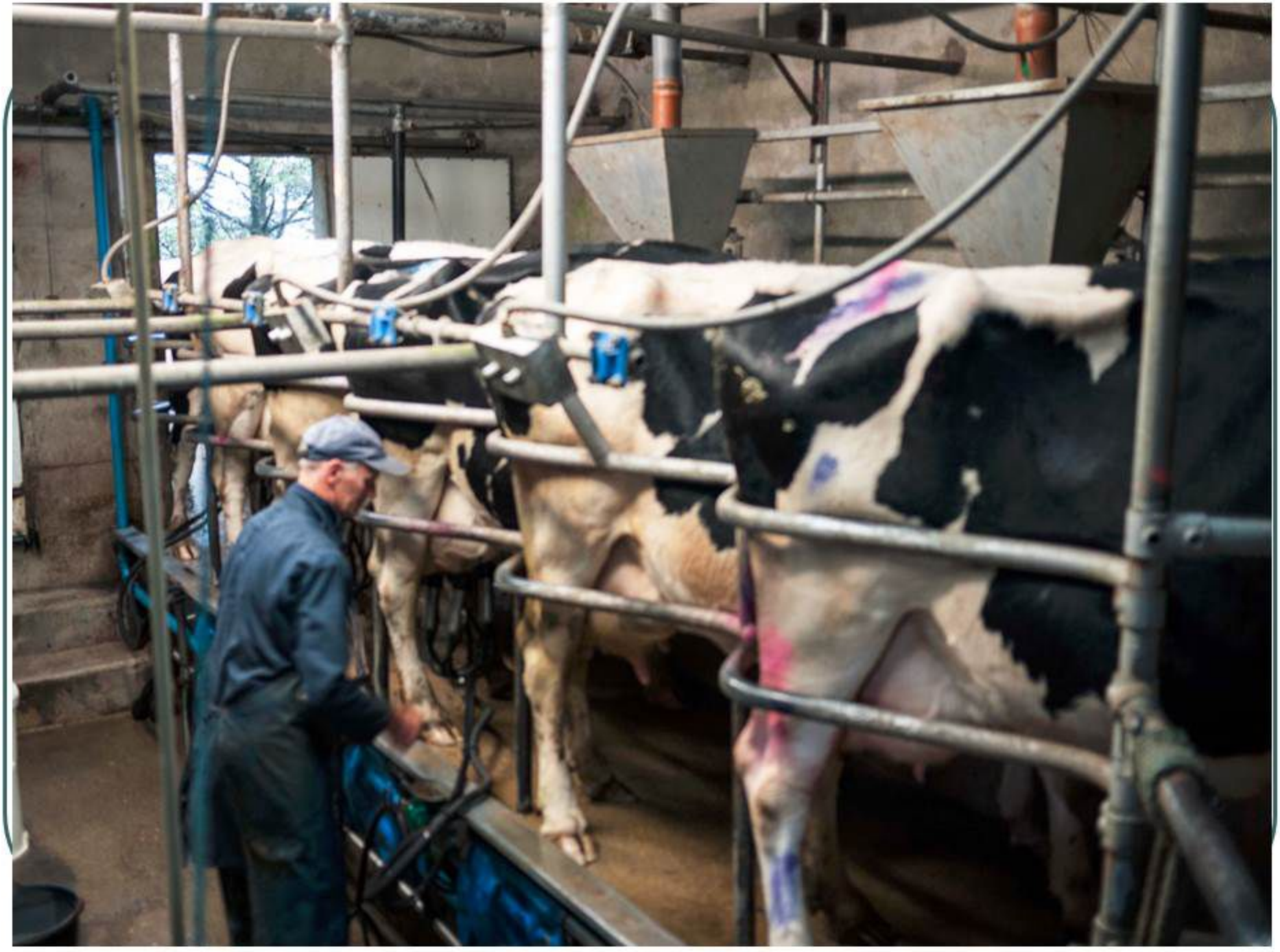


Other Mechanisms of Milk Ejection

- Myoepithelial cells will also contract in response to vasopressin (ADH or antidiuretic hormone). Vasopressin has about 20% the oxytocic activity of oxytocin.
- Visual or auditory stimuli can cause milk ejection. Milk ejection is a condition response.
- Stimulation of the genital tract such as vaginal distention causes release of large amounts of oxytocin.
- The mechanical tap stimulus does not involve oxytocin. It will occur under anesthesia or denervation of the udder. It is not inhibited by epinephrine. Kneading or butting of the udder by the young may elicit this response. This may involve distortion of the alveolar structure or the myoepithelial cell structure, resulting in milk ejection.

Timing is very important

- Oxytocin has a short half-life in the blood = 0.55 to 3.6 min.
- Milking must be done after initiation of milk let down by 2 minutes
- The sensitivity of the neuroendocrine reflex seems to decline as lactation progresses. Peak oxytocin occurs 1 minute at 1-2 weeks of lactation, 2 min at 5-6 weeks.



Inhibition of Milk Ejection

- Various stressful stimuli that inhibit milk ejection are associated with increased activity of the sympathetic nervous system.
- Oxytocin action can be blocked be catecholamines (epinephrine and norepinephrine).
- Epinepherin directly blocks oxytocin from binding to myoepithelial cells. This is termed ***peripheral inhibition of milk ejection***.

Cow hold up her milk

- Without the milk ejection reflex the milking process takes about 40% of the total cow milk.
- This amount of the milk which represents in teat and gland cisterns as well as major lactiferous ducts.
- Any stressors or fear during the milking process leak to stopping of the milk ejection reflex and the cow up hold her milk

Control of Lactation

- Endocrine control
  - Studied in physiology course
- Autocrine control
  - Intra-mammary pressure
  - FIL

Milk removal and maintenance of lactation

- Frequent removal of milk is essential for maintaining of lactation
- The milk stopes when the intramammary pressure increased than 70 mm Hg
- FIL is removed via frequent lactation

Immediate effects of milk removal

- Immediate effects of milk removal occur within seconds to minutes of stimulation of the gland and removal of milk.
- Removal of feedback inhibitor of lactation (FIL) is secreted from the alveolar epithelial cells and accumulates in the alveolar lumen.
- Milk accumulation in the gland also causes an increase in intramammary pressure, which reduces blood flow to the tissue.

Short term effects of milk removal

- occur through the enhancement of epithelial cell differentiation. This work has been done primarily in ruminants and is based on increasing frequency of milk removal. Higher frequency of milking in ruminants results in greater activities of milk synthesizing enzymes per cell in lactating tissue.

Long term effects of more frequent milking

- Long term effects of more frequent milking in ruminants are thought to occur over a period of weeks or longer and occur in response to increased cell proliferation.

Dairy Cow

- Expected to calve one time each year
- Give milk for 305 days
- Dry for 2 months
  - Rest and prepare for next lactation

Stages of Lactation

- Fresh Cows
  - 1- 14 days
  - Cows produced non sealable milk
  - Colostrum secretion in the first 5-6 days
  - Hazards from mastitis and metritis is high

Stages of Lactation

- Early Lactation
  - 14 – 100 days
  - Achieve peak (60 days for Holstein)
  - Milk yield increases more rapidly than dry matter intake

Stages of Lactation

- Mid- Lactation
  - 100 – 200 days
  - Goal is to maintain peak milk productions as long as possible.

Stages of Lactation

- Late Lactation
  - 200 days after calving and end when the cow dries off (day 305)
  - Cow gains weight to replenish body condition

Complementary milk (Residual milk)

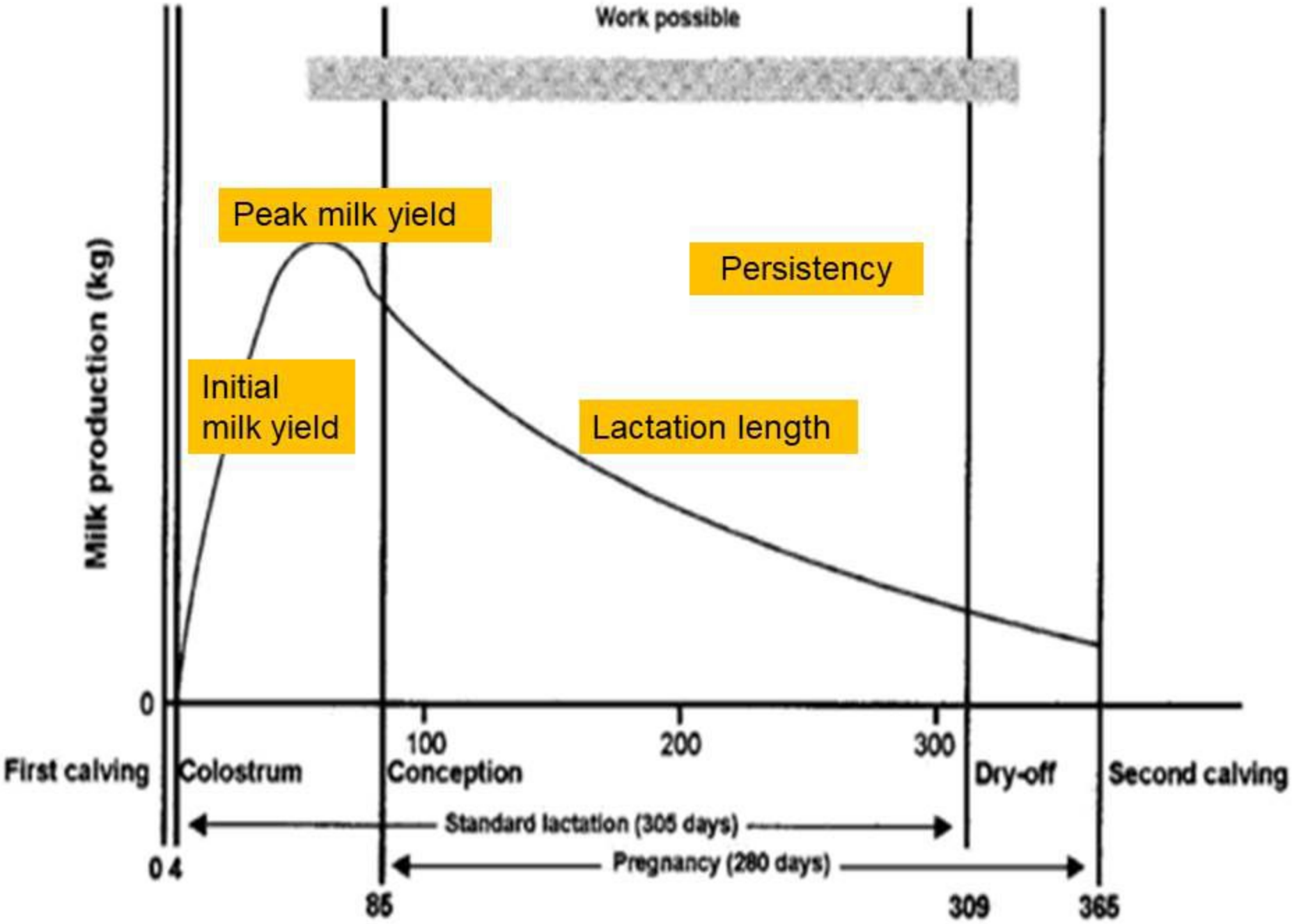
- It is the milk represent within the udder after complete milking
- It represents about 15-25% of the milk in the upper
- It have the function of prevention of the milk alveoli from collapsing
- It could be obtained via injection of oxytocin hormone after complete milking and re-milking the cow

Complementary milk

- Lactating heifers have less residual milk than older cows.
- The percentage of residual milk is greater for lower producing cows than for higher producing cows.
- Cows with a higher percentage of residual milk usually have a lower persistency of lactation
- Residual milk decreases in proportion to milk yield as lactation progresses

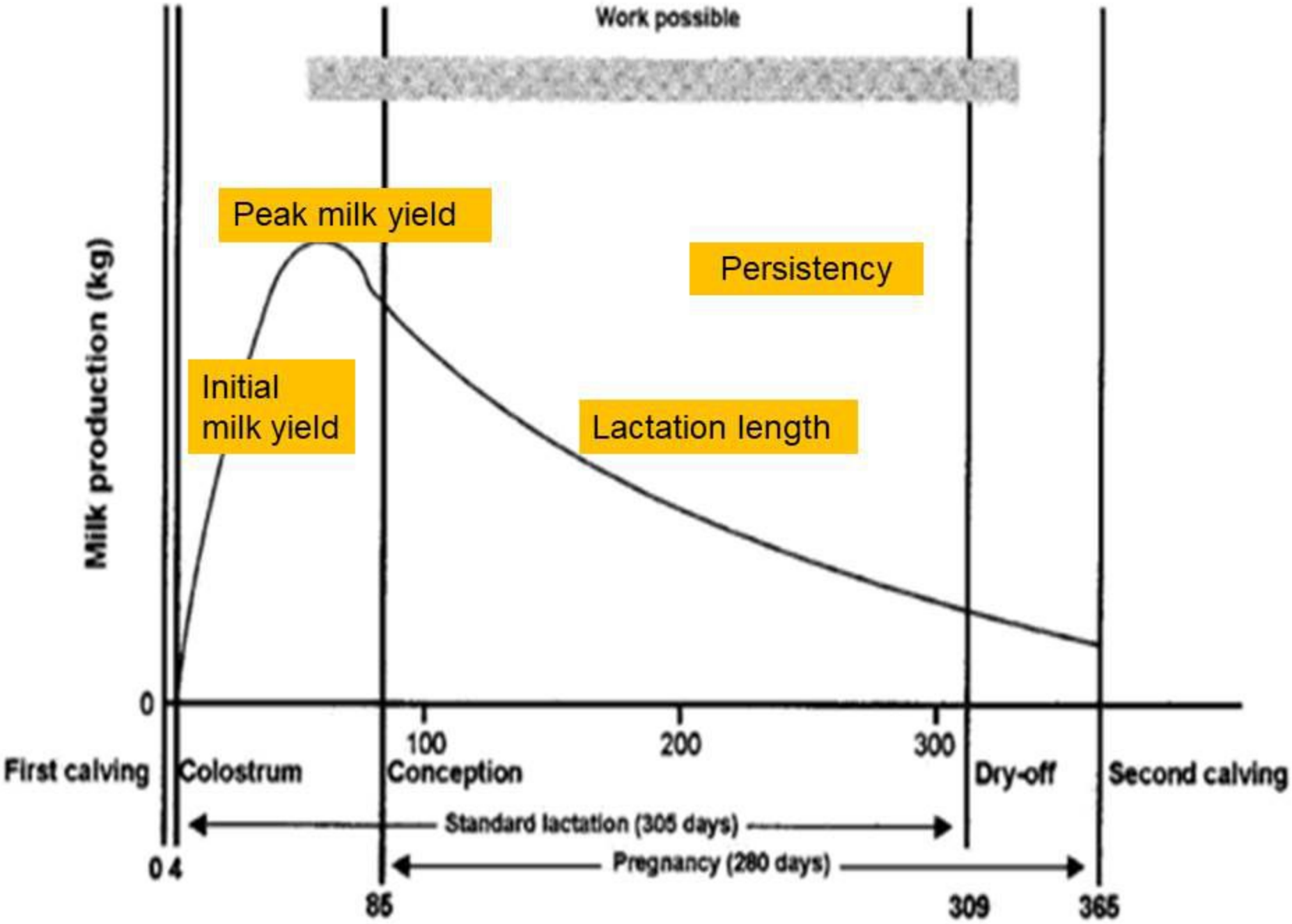
Normal pattern of milk production

- The milk production have special characters in the dairy animals
- The milk production beginning low then it spontaneously increase towards its peak. Then the milk yield is gradually decrease.
- This phenomena draw a curve termed milk curve


Work possible
Peak milk yield
Persistency
Initial milk yield
Lactation length
Milk production (kg)
0
First calving
Colostrum
100
Conception
200
300
Dry-off
Second calving
Standard lactation (305 days)
Pregnancy (280 days)
0 4
85
309
365

Initial milk yield

- It is the average daily milk yield given by the cow in the first 3-4 weeks of lactation
- It is good indicator that the cow will succeed in her rest of lactation phase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Second calving
Standard lactation (305 days)
Pregnancy (280 days)
0 4
85
309
365

Peak milk yield

- It is the maximum milk production which can produced by the cow
- The dairy cow reached to their peak milk yield 6-8 week from the beginning of lactation phase
- The peak milk yield in Holstein Friesian cows ranged from 45-55 L/ milk
- The genetic factor for each cow determine the level peak milk yield

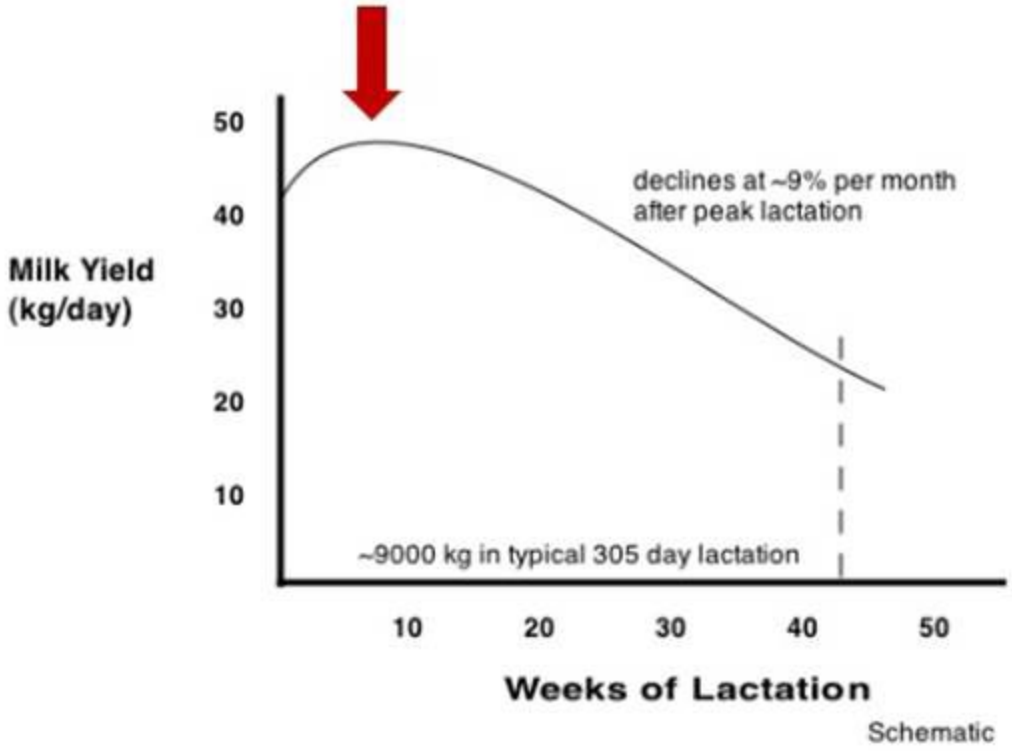
Peak milk yield

- Peak milk yield could be determined the total milk yield obtained by the cow according to the following formula:

- Total milk yield= 200 x Peak milk yield

This is a lactation curve

Milk yield declines during lactation



Schematic

Lactation length

- The milk production after the peak of lactation tended to decline.
- The rate of decline in the dairy cows known as persistency
- The rate of decline increased in the pregnant cows (20%) than non pregnant cows (10%)
- Sharp decrease of the milk production occurs at the 7^{th}– 8^{th} month of pregnancy

Lactation length

- 40% of the milk yield produced at first 90 days of lactation
- 75% of the milk yield produced at the first 180 days of lactation

Lactation persistency

- It is the ability of the dairy cows to withstand with high milk yield as much as it can. In other words, it is the rate of decline in milk production after peak milk production
- It measured via the following equations

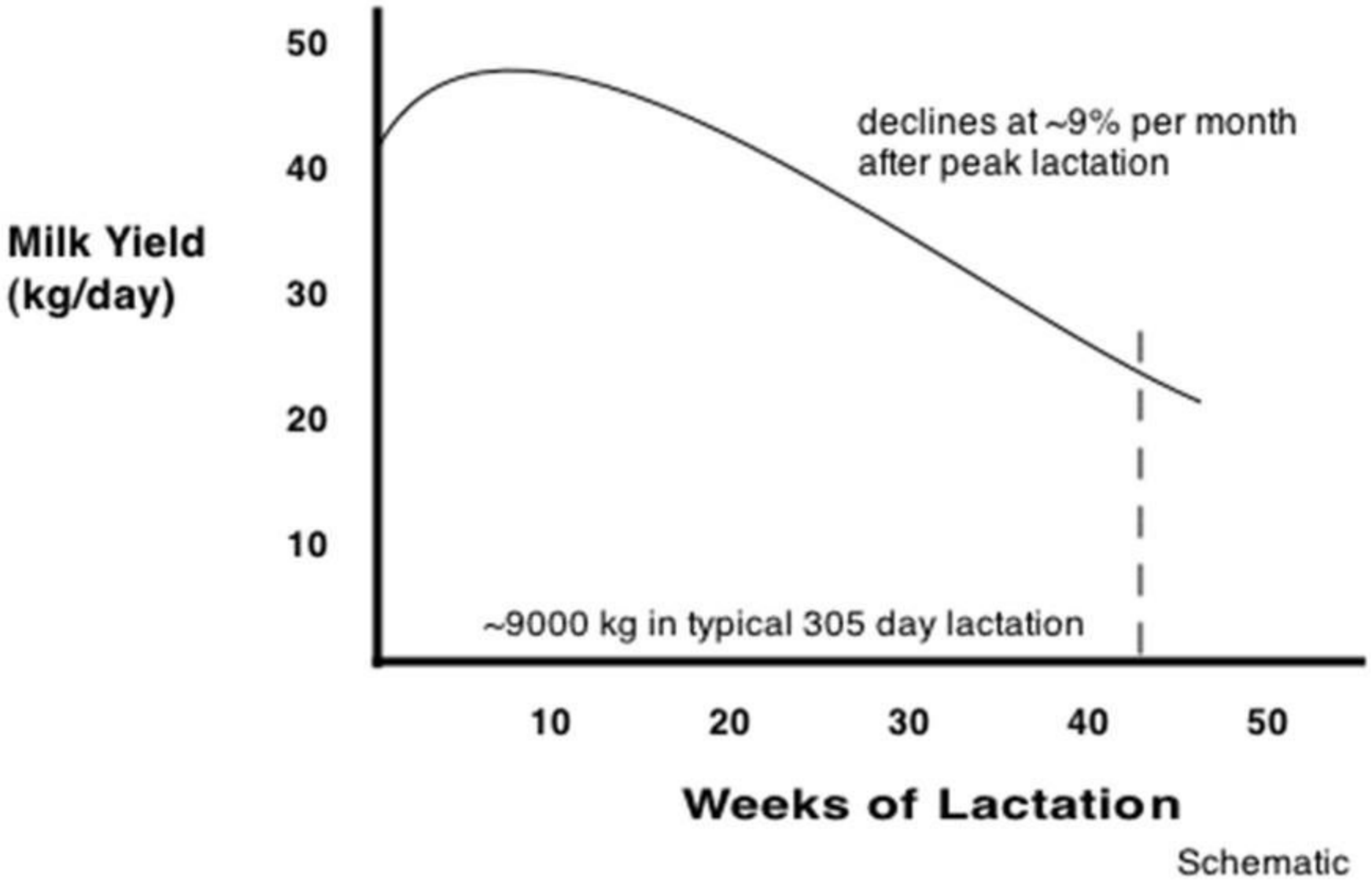
$$LP = \frac{\text{milk production at second 100 days}}{\text{Milk production at first 100 days}} \times 100$$

Lactation persistency

- Also the persistency could be estimated via

$$LP = \frac{\text{Milk production at first 70 days}}{\text{Milk production the next 110 days}} \times 100$$

$$LP = \frac{\text{Current month milk yield}}{\text{Last month yield}} \times 100$$


50
40
30
20
10
Milk Yield
(kg/day)
declines at ~9% per month
after peak lactation
~9000 kg in typical 305 day lactation
10
20
30
40
50
Weeks of Lactation

Schematic

Stages of lactation and milk composition

- Milk protein, fat are high in the beginning of lactation then they are declined towards the mid-lactation then increase towards the late lactation

Dry period

- The ideal dry length cannot be determined for all cows as it depends on days in milk (DIM), gestation stage, health status are the main factors determining the length of the dry period.
- the period from 45- 60 days is efficient for dairy cows also the period of 35-45 days is good for young dairy cows (cows which have 2-3 parity).

Impacts of short lactation length

- Short lactation length usually occurs if poor BCS management or inefficient feeding strategies used in practice. Poor feeding management of potentially high yielding cows can create many problems such as.
- Lactation anoestrus
- low peak milk yields and shortened lactation lengths.
- Cows will dry off prematurely