Technology of Animal Products Production

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Lecture 1.

Introduction to Animal Husbandry

Lecture outline

- The role of animal husbandry

- World production and consumption of animal products

- Factors that limit production and consumption of animal products

- New trends in the world agriculture and livestock farming

What is Animal Science?

Breeding

Feeding

Care and management

Animal Science

Marketing and processing of animals and their products

Animal Science = Life Science

1. The role of animal husbandry

Functions of animals

1. Production of food (meat, eggs, milk, fish and honey)

- Animals convert chemical energy in plants into a form available to people

Only 1% of the total solar energy reaching the planet is captured as chemical energy during photosynthesis; and only 5% of this captured energy is fixed in a form suitable for ready consumption by people as a food

- Animal convert inedible feeds into valuable products

About two-thirds of the feed used by livestock is not suited for human consumption: hay, pasture, coarse forages, certain grains, by-products obtained from mills and food-processing plants

- Animals as a source of **valuable protein**

  Proteins from animal sources have a higher value then proteins from plant sources because they have every amino acid needed for growth, including lysine and methionine, which are deficient in vegetable sources

- Animals transform grains to higher protein-content products

  Example: on a dry matter basis, a corn contains 10,5% protein, whereas beef – 30,7%, milk 26,4%, eggs – 47,0%

- Animal products are an excellent source of zinc, iron and many other **trace minerals and vitamins**, playing important metabolic role

2. Clothing for people (wool, leather, hair and furs)

- The unique characteristics and virtues of wool are:

a) It is porous and will absorb water more readily than any other textile fibre. It can absorb as much as 18% of its own weight in moisture without even feeling damp

b) Superior insulator (keeping the heat of the body from escaping and the cold air from entering)

c) It is light

d) It is very elastic

e) It dyes well

f) It is durable

g) It is strong (diameter for diameter, a wool fibre is stronger than steel)

3. A source of power

Draft animals are a part of agriculture in most of the developing countries of the world

4. Provide medicinal and other products

More then 100 pharmaceuticals come from animal

Medicines from Livestock

- Insulin: from the pancreas of animals for diabetics.
- Cortisone: adrenal gland and used for arthritis.
- Thrombin: from blood of animals, used in surgery to help blood clot.
  - Also used in skin-graft operations and ulcers.

Medicines from Livestock (cont.)

- Heparin: from the lungs and prevents blood from clotting in operations.
- Epinephrine: adrenal gland and used to treat allergies and asthma.
- Corticotropin: pituitary gland and is used from some breathing problems, severe allergies, and Leukemia

5. Animals maintain soil fertility

Manure is a precious fertiliser

1 tone of manure contains on average 227 kg organic matter, 4,5 kg nitrogen, 2,3 kg phosphoric acid, 4,5 kg potassium

Due to the slower availability of its nitrogen and to its contribution to the soil humus, manure produces rather lasting benefits which may continue for many years

The famous China's saying: "The more pigs, the more manure; and the more manure, the more grain"

Manure can be also used as a source of energy in form of animal gas (methane, bio-gas)

In the future, as fertiliser and feed become increasingly scare and expensive, the economic value of animal manure will increase, and it will be looked upon as a resource and not as a waste that presents a disposal problem

2. World production and consumption of animal products

In general, meat production and consumption are highest in countries that have extensive grasslands, temperate climates, well-developed livestock industries, and spares population

On a total tonnage production basis, meats rank as follows in descending order *:

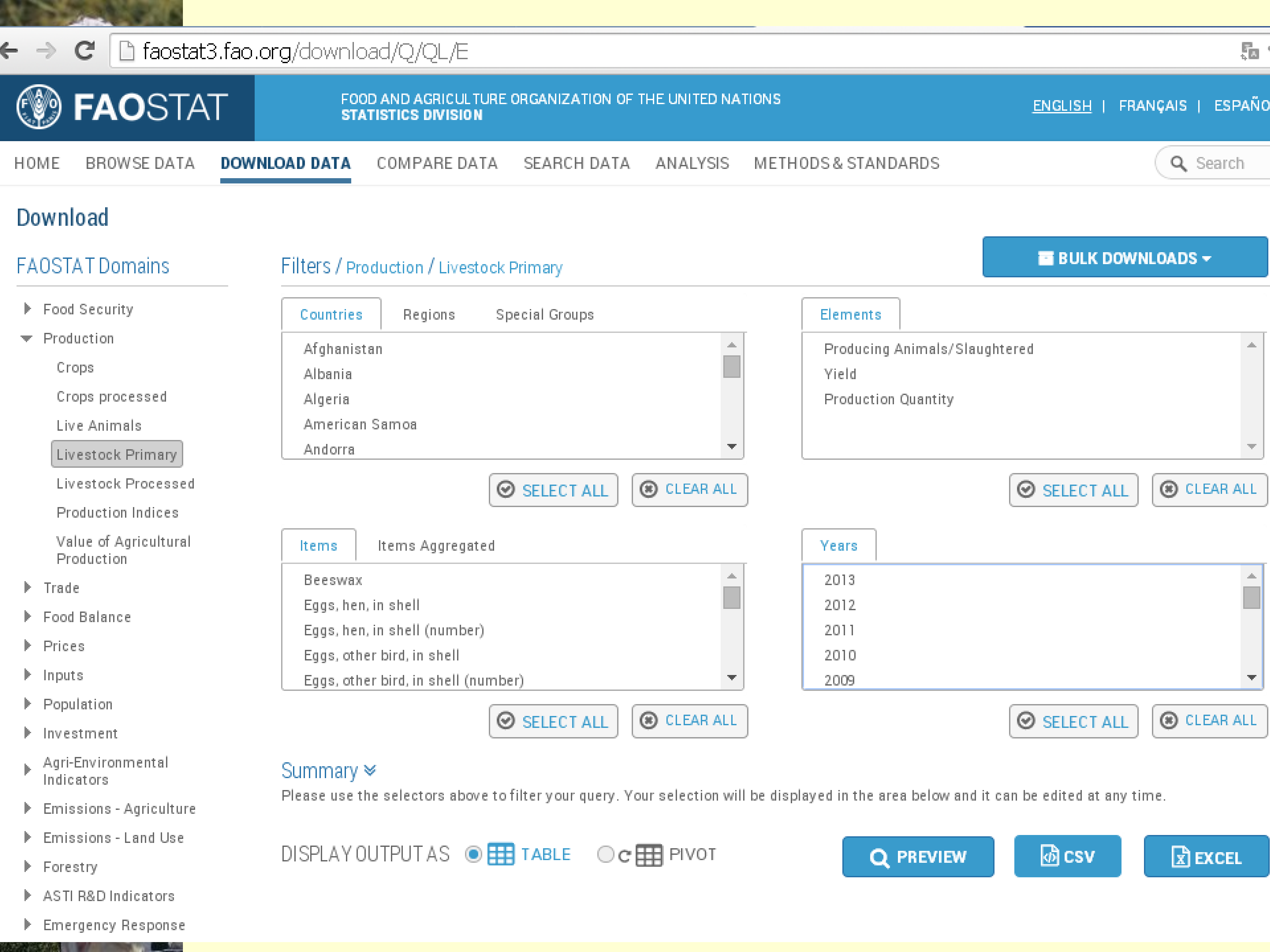
1. pork – over 109,0 million tones

2. poultry – about 98,0 million tones

3. beef – over 64 million tones

4. sheep and goat meat – about 14,0 million tones

* Note: here and then, official **FAO information** from *The FAOSTAT Database, http://faostat.fao.org*



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China is a world leader of pork production – about 51,7 million tones or 47% of the world pork production

<u>The United States</u> is a world leader of beef production – about 12,0 million tones or 20% of the world production of beef

<u>The United States</u> is a world leader in poultry meat production – about 19,6 million tones or 20% of the world poultry production

The annual world production of cow milk approaches 600 million tones

The world greatest milk producers are:

1. **The USA – 87,5 million tones**
2. **India – 50,3 million tones**
3. **China – 36,0 million tones**
4. **Russian Federation – 31,9 million tones**

… 14. Ukraine – 11,0 million tones

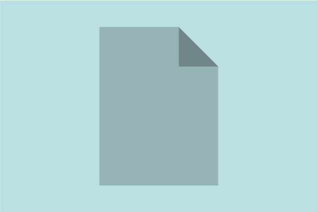
The annual egg production exceeds 1,25 trillion

The world greatest egg producers are:

1. **China – 476,5 billion eggs**
2. **The USA – 91,5 billion eggs**
3. **India – 61,4 billion eggs**
4. **Mexico – 47,6 billion eggs**

… 10. Ukraine – 16,9 billion eggs

Top countries in Honey production



Animal products consumption

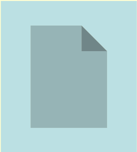
CONSUMPTION OF ANIMAL PRODUCTS

The leading countries in meat consumption are *:

1. The United States – 122,8 kg *(per year per capita consumption)*

2 Australia – 122,7 kg

3. New Zealand – 116,8 kg



*** From FAOSTAT database**

The world's greatest beef eaters are:

1. **Argentina – 54,9 kg** *(per capita per year consumption)*

2 **Australia – 44,1 kg**

3. **USA – 41,2 kg**

4. **Brazil – 37,2 kg**

The world's greatest poultry eaters by rank are:

1. Israel – 67,8 kg *(per capita consumption)*

2 Kuwait – 65 kg

3. United Arab Emirates – 60 kg

The world's leading whole milk consumers are:

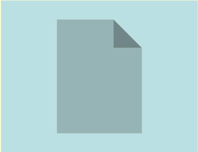
1. **Romania – 240 kg** *(per capita consumption)*
2. **Albania – 235 kg**
3. **Kazakhstan – 231 kg**
4. **Kyrgyzstan – 173 kg**

The world’s leading **cheese eaters** are:

1. **Greece– 30 kg** *(per capita consumption)*

2 Denmark, France – 24 kg

3. Island – 23 kg



The world's greatest **egg-eaters** **(in number of eggs per capita) are:**

1. **Denmark– 357 eggs** *(per capita consumption)*

2 Japan – 356 eggs

3. Paraguay – 341 eggs

The animal protein consumption is not evenly distributed throughout the world: for instance, the people of Europe have 4,7 times as much high quality animal protein per person as the people of Africa

3. Factors that limit production and consumption of animal products

1. Level of income: since animal products are more expensive than other foods, per capita animal product consumption is a good barometer of the GDP and standard of living in the country

2. Religious beliefs, social customs, and traditional eating habits: these forces dictate the kind of food eaten and many even prevent the consumption of meat and meat products

Examples:

1. India is the leading cattle country of the world in numbers (193 million heads), but to the Hindu the cow is regarded to a mother and an object to reverence – the eating of beef is taboo

2. African tribes, such as Massai, are much more concerned with numbers than with productivity. They evaluate cattle as a money, thinking in terms of the number of head required to purchase a bride

3. Swine is considered to be an unclean animal in Muslims and Judish people, thus resulting in taboo on pork eating

3. Lack of integration of animal and plant agriculture

In some areas of the earth, nomadism is still a way of life, resulting in a poor feed supply (northern Africa, Central Asia)

*A classical example of **desirable integration** in animal and plant production in the United States: the **Western range** (place of **feeder cattle production**) and **Corn Belt** (place of **finishing cattle**, reared on the west rangelands)*

4. Lack of facilities for marketing, processing, and distributing animals and their products

New trends in the world agriculture and livestock farming

Organic Farming

Organic farming is the form of agriculture that relies on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests, **excluding** or strictly limiting the use of **synthetic fertilizers** and **synthetic pesticides**, **plant growth regulators**, **livestock feed additives**, and **genetically modified organisms**.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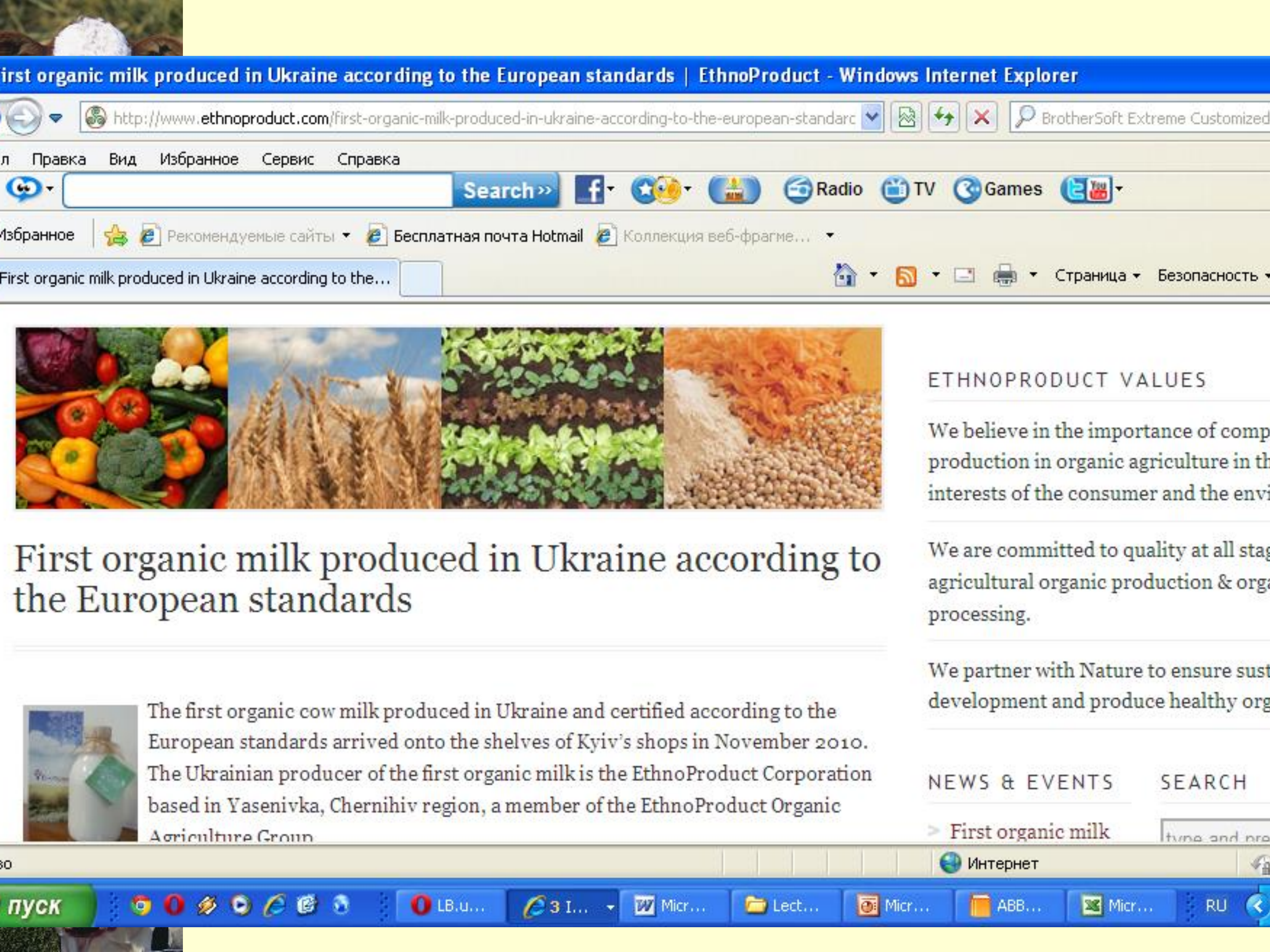
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First organic milk produced in Ukraine according to the European standards
The first organic cow milk produced in Ukraine and certified according to the
European standards arrived onto the shelves of Kyiv's shops in November 2010.
The Ukrainian producer of the first organic milk is the EthnoProduct Corporation
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Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the

International Federation of Organic Agriculture Movements **(IFOAM)**


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OLF requirements

Organic husbandry does not aim to maximise weight gain at the expense of animal health and happiness.

100% of food for organic livestock must be produced organically

Prohibited feed products include, but are not limited to:

- antibiotics, coccidiostats, medicinal substances, growth promoters or any other substance intended to stimulate growth or production;
- non-protein nitrogen compounds (e.g. urea);
- amino acid isolates;
- products and by-products (excluding milk and milk products fed to ruminants) fed to the same species;
- GMO products or their derivatives

While the aim of conventional livestock production is for **high, early productivity** (early maturity), the aim with organic livestock is to increase their **productive life** and this is often associated with **resistance to disease**

Embryo transplant is not permitted since this technique usually requires hormone injection to synchronise breeding cycles and tends to breed away from diversity within the herd.

Livestock produced using **genetic modification techniques** (genetic engineering) are not permitted under the organic standards

Animal welfare

- In recent years, the behaviour and environment of farm animals **in confinement** have come under increased scrutiny of animal welfare / animal right groups all over the world

Animal welfare

In 1987 Sweden passed legislation designed:

- to phase out layer cages as soon as a viable alternative can be found;

- to discontinue the use of sow stalls and farrowing crates;

- to provide more space and straw bedding for slaughter hogs;

- to forbid the use of genetic engineering, growth hormones and other drugs on farm animals except for veterinary therapy;

Animal welfare

Animal welfarists see many modern practices as unnatural, and not conductive to the welfare of animals

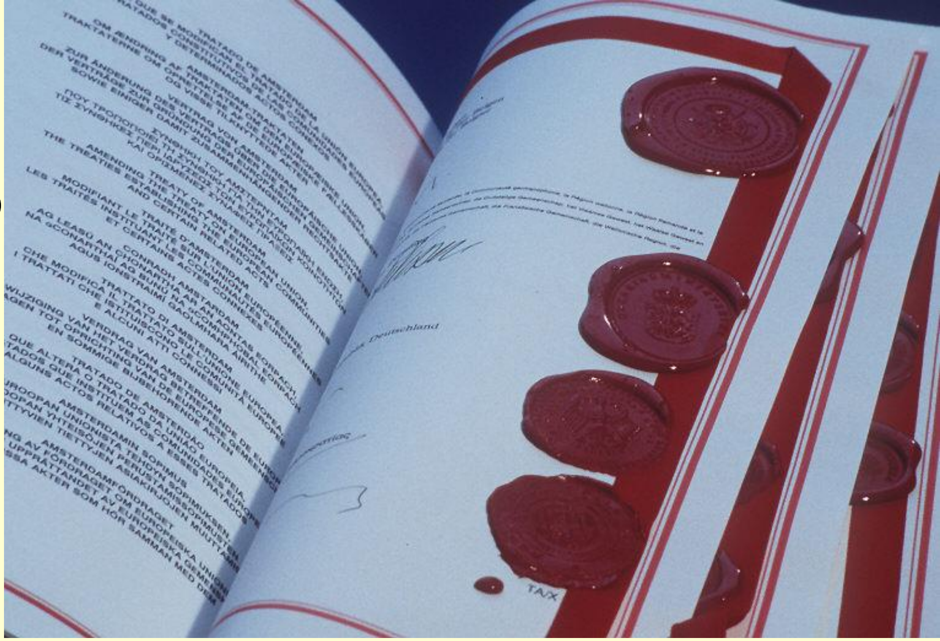
They construe animal welfare as the well-being, health, and happiness of animals, and they believe that certain intensive production systems are cruel and should be outlawed

Humans are animals, too, and that all animals should be accorded the same moral protection

Animal welfare

- 5 freedoms (Brambell 1965)
  - Freedom from hunger and thirst
  - Freedom from discomfort
  - Freedom from pain, injury, disease
  - Freedom to express normal behaviour
  - Freedom from fear and distress

EU regulations



Amsterdam Treaty (1997)

The High Contracting Parties, desiring to ensure improved **protection and respect for the welfare of animals** as **<u>sentient beings</u>**, have agreed upon the following provision: …..

… the Community and the Member States shall pay **full regard** to the **welfare requirements** of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to *religious rites*, *cultural traditions* and *regional heritage*".

European regulations

- Directive 98/58/EC concerning the protection of animals kept for farming purposes (after 1978 European Convention)
- Directive 97/2/EC laying down minimum standards for the protection of calves
- Directive 2001/88/EC laying down minimum standards for the protection of pigs
- Directive 1999/74/EC laying down minimum standards for the protection of laying hens
- Directive 93/119/EC on the protection of animals at the time of slaughter or killing (after 1988 European Convention)
- Directive 95/29/EC and Resolution of 19 June 2001 on the protection of animals during transport (2003 European Convention)

Welfare issues

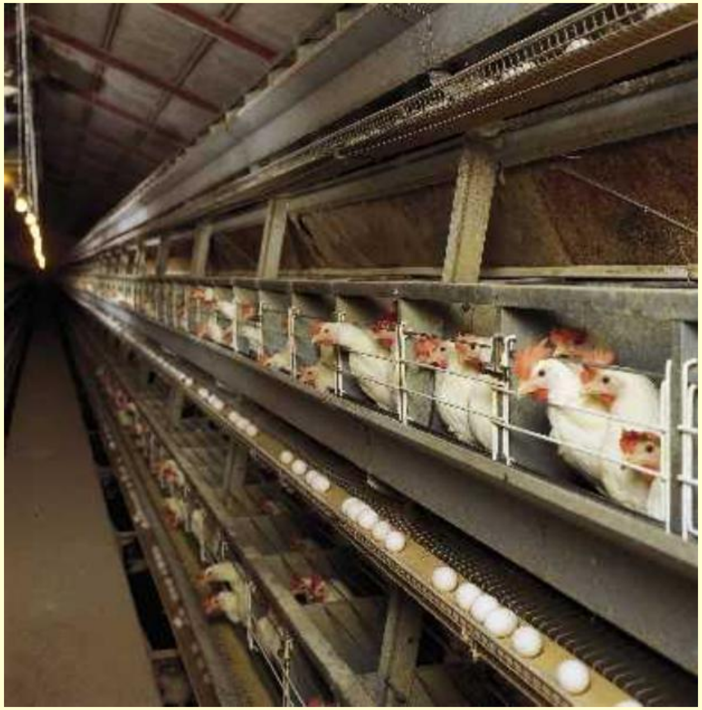
Directive 97/2/EC

- Calves
  - food
  - iron
  - movements
  - social contacts

Welfare issues

Directive 1999/74/EC

- Poultry
  - leg pathologies
  - cardio-vascular diseases



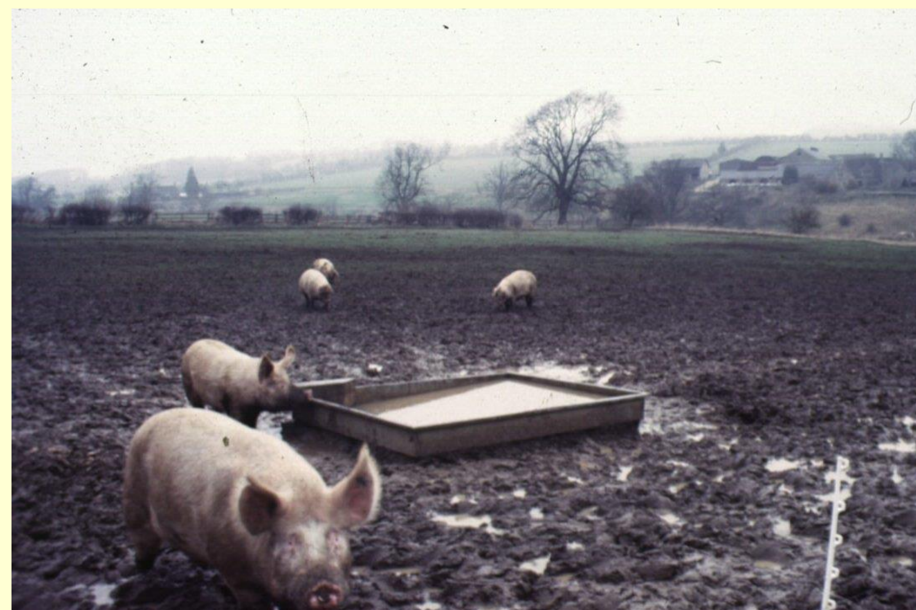
INRA Productions Animales, Février 2004

Welfare issues

- pigs
  - Directive 2001/88/EC
  - housing, stereotypies
  - reduced immunitary response
  - leg pathologies, agressivity

Welfare issues

- Outdoor breeding



BUT: wild animals are often more severely stressed than domesticated animals. They didn't have caretakers to store feed for winter or to irrigate during droughts; to provide protection against storms, extreme temperatures, and predators, and to control diseases and parasites

Breeding of farm animals

Lecture outline

- Origin and domestication of farm animals

- Systems of breeding

- Systems of selection

Origin and domestication of farm animals

The most important domestication areas are:

Southern part of Europe

South and Central Asia

North-East Africa

South America

Origin and domestication of farm animals

Domestication of cattle

Dated as early as 10000 years ago, during the New Stone Age

Modern domestic cattle evolved from tow ancient ancestors:

Bos taurus - derived from *Aurochs* ***(last killed by a poacher in 1627 near Warsaw)***

Bos indicus - derived from *Zebu*
(humped cattle, common to the tropical countries)

Origin and domestication of farm animals

Domestication of swine

Occurred about 9000 years ago

The majority of the breeds we now know are descended from the *Eurasian Wild Boar* and the *East Indian Pig*

While most livestock where utilized initially by nomadic people, swine are more indicative of a settled farming community

Origin and domestication of farm animals

Domestication of sheep

Sheep were among the first animals domesticated

There are a number of different theories regarding the origins of domestic sheep

The majority of the theories agree that they originated from ***Mouflon:***

Origin and domestication of farm animals

Domestication of goat

Dated between 6000 and 7000 B.C.

The major ancestor of modern goats is the

Bezoar goat:

Unlike sheep, goats easily revert to feral or wild condition given a chance. In fact, the only domestic species which will return to a wild state as rapidly as a goat is the domestic cat.

Origin and domestication of farm animals

Domestication of horses

Dated between 4000 and 3000 B.C.

From cave paintings it is believed that the equid from which modern horses are derived resemble the modern *Przewalski Horse*

The last remaining wild species of horses

Poultry

- First domesticated: 3,000 years ago
- Main bird in Poultry: Chicken
- Second poultry bird: Turkey
- Other types of poultry: pheasant, quail, guinea fowl

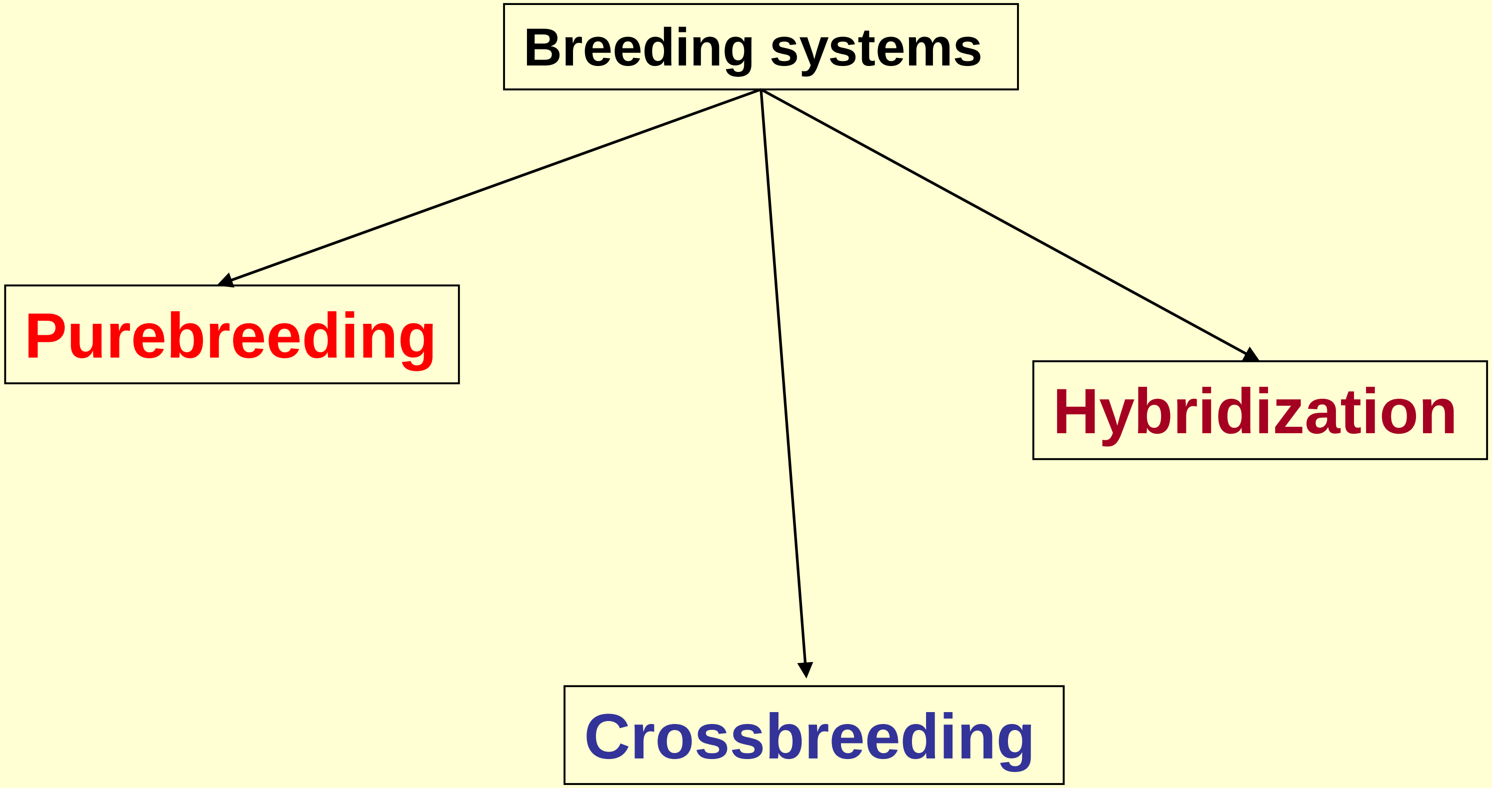
Systems of breeding

What is breed?

Breed is a group of animals that have a common ancestry and common distinctive characteristics

Breed has been developed for a special purpose

Systems of breeding



Systems of breeding

Purebreeding – mating of animals belonging to the same breed

Systems of breeding

Purebreeding systems

- **Inbreeding**
- **Linebreeding**
- **Outcrossing**

Systems of breeding

Inbreeding – mating of animals more closely related than the average of the population from which they came

Systems of breeding

Closebreeding – mating of closely related animals: sire to daughter, son to dam, and brother to sister

Closebreeding is the extreme form of inbreeding

Systems of breeding

Reasons for practising closebreeding systems:

1. It increases the degree of homozygosity within animals, so the less desirable genes are brought to light so that they can be more readily culled

Systems of breeding

Fundamentals of heredity

All hereditary characteristics of animals are determined by genes, located in chromosoms

Cattle has 60 chromosomes (30 pairs), horses - 32 pairs, sheep - 27 pairs, swine - 20 pairs, people - 23 pairs

Systems of breeding

Fundamentals of heredity

Each parent transmits 50% of hereditary information

Some of genes - dominant genes - are able to prevent or mask the expression of others

The genes suppressed are called - recessive genes

Systems of breeding

Fundamentals of heredity

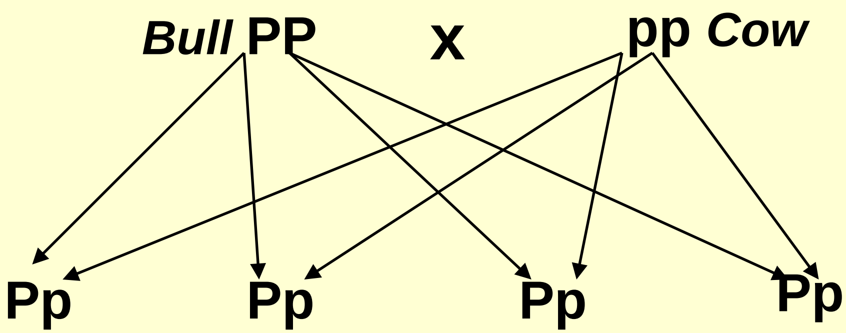
Animals that are pure of a certain character are called homozygous

Animals that have 1 dominant and 1 recessive factor are termed heterozygous

Systems of breeding

***Example:* in cattle, the polled character is dominant to the horned character**

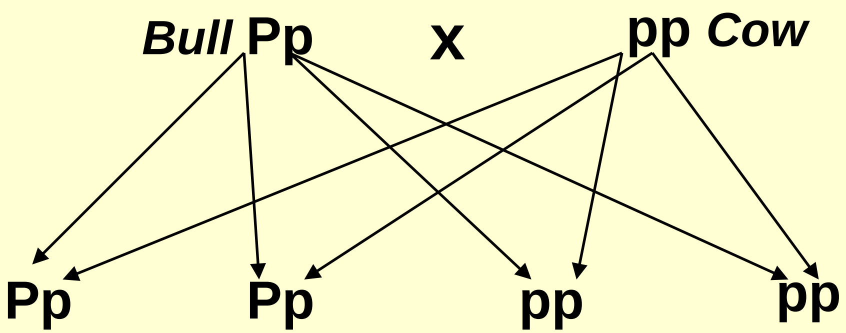
If a pure polled (PP) bull is used on pure horned (pp) cows, the resulting progeny are of polled character:



100% offspring is polled

Systems of breeding

If a ***heterozygous (Pp)*** *bull is mated with a number of* ***horned (pp)*** *cows, only half of the calves will be, on average, polled:*



50% offspring is polled and
50% is horned

Systems of breeding

Reasons for practising closebreeding systems:

Most recessives are undesirable, or even lethal genes

Relatives have more genes in common than the other average of the population, thus, matings among relatives tend to increase homozygosity, which often brings to light the harmful recessives

Systems of breeding

Reasons for practising closebreeding systems:

2. To create lines or strains of animals that are uniform in type and other characteristics

3. To keep the highest relationship to a desirable outstanding ancestor

4. To increase the homozgositzy of desirable genes and in this way to improve prepotency

Systems of breeding

5. To produce inbred lines for line crossing programs.

Prepotency – ability to pass desirable characteristics with great uniformity

Systems of breeding

Precautions of closebreeding:

1. It enhances the chances of appearance the undesirable degenerative characteristics

2. It requires skill in making planned matings and rigid selection

3. It is not adapted for use in average or below average stock

Systems of breeding

Linebreeding – mating of animals more distantly related than in closebreeding

Line – a group of males descending from one outstanding male ancestor and possessing common distinctive characteristics, steadily transmitted through generations

Matings are directed toward keeping the offspring closely related to some highly admired ancestor

Systems of breeding

Biologically, closebreeding and linebreeding are the same thing, differing merely in intensity

Linebreeding is usually practised in order to conserve the good traits of a certain outstanding sire or dam

Systems of breeding

Outcrossing – mating of animals that are members of the same breed but which show no relationship close up in the pedigree (for at least the first four or six generations)

It is relatively safe method of purebreeding
(it is unlikely that two unrelated animals will carry the same undesirable genes and pass them on to their offspring)

Systems of breeding

Crossbreeding – mating of animals of different breeds

Purposes of crossbreeding:

1. To increase productivity over straightbreds because of the resulting hybrid vigour or heterosis

Systems of breeding

Heterosis, **or hybrid vigour, is a name given to the biological phenomenon which causes crossbreds to outproduce the average of their parents.**

Systems of breeding

Purposes of crossbreeding:

2. To produce commercial animals with a desired combination of traits not available in any one breed

Systems of breeding

Purposes of crossbreeding:

3. To produce foundation stock for developing new breeds

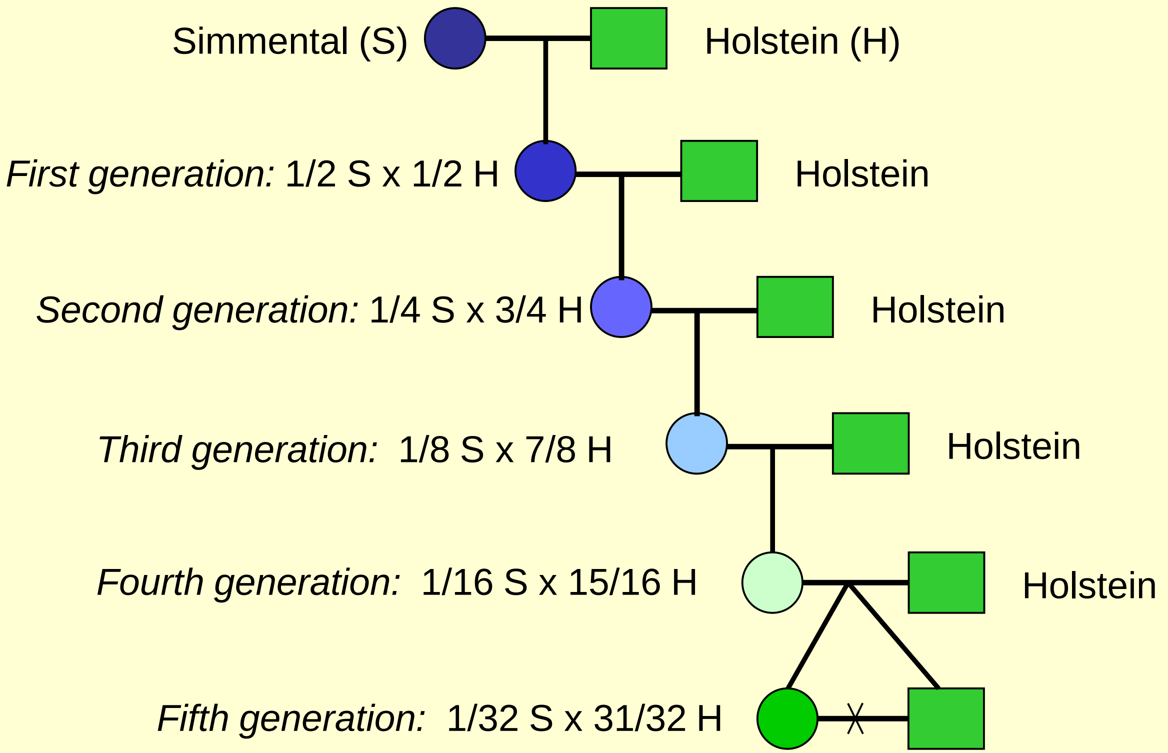
Systems of breeding

Grading up – is that system of breeding in which purebred sires of a given pure breed are mated to native females.

The purpose: to develop uniformity and quality and to increase performance in the offspring

Systems of breeding

The principle scheme of grading up program:



Systems of breeding

The grading up program:

The first generation carries 50% (or ½) of the heredity material of the purebred parent (or 50% of the blood of the purebred parent)

The second generation carries 75% (or ¾) of the blood of the purebred parent

In all subsequent generations the proportion of the inheritance remaining from the original females is halved with each cross

The fifth generation carries only 3% (or 1/32)of the blood of the original females and is considered to be purebred

Systems of breeding

Hybridization – mating of animals of different species

The same purposes as for the crossbreeding

The highest rate of hybrid vigour

Systems of breeding

Successful examples of hybridization:

The Mule is a cross between a donkey stallion (called a jack) and a horse mare. Hinnies are just the opposite - a stallion horse crossed to a donkey jennet.

Systems of breeding

Some mule characteristics:

- sterile and cannot reproduce

- they have more stamina and can carry more weight than a horse of equal size

Systems of breeding

Successful examples of hybridization:

Santa-Herdtruda – hybrid of a Shorthorn cattle with Brahman Zebu

Systems of breeding

Virtues of Santa-Herdtruda:

- relatively high degree of both heat and tick resistance

- ease of calving, good mothering ability and abundant milk supply

Systems of breeding

Successful examples of hybridization:

Brangus – hybrid of an Angus cattle with Brahman Zeby

Systems of breeding

Virtues of Brangus:

- more adapted to coastal climates

- resistant to heat and high humidity

- has an advantage in conception rate and calve earlier

- good mothering ability

Selection in livestock breeding

Selection – attempt to secure or retain the best of those animals in the current generation as parents for the next generation

Selection in livestock breeding

Bases of selection

- Type and individuality
- Production testing
- Pedigree

Selection in livestock breeding

Selection, based on type and individuality

- selecting those animals that most closely approach an ideal or standard of perfection

- culling out those that fall short of these standards

Selection in livestock breeding

Selection, based on pedigree

- the individuality and performance of the ancestors are relied upon for an estimate of the breeding value

- of special importance when production data is not available, or with young animals

Selection in livestock breeding

Selection, based on production testing

1. ***Performance testing***
2. ***Progeny testing***

Selection in livestock breeding

1. Performance testing

evaluating and selecting animals on the basis of their individual merit or performance

2. Progeny testing

selecting animals on the basis of merit of their progeny

more reliable and infallible than performance testing

Selection in livestock breeding

Individuality tells us what an animal ***seems to be**,*

His pedigree tells us what an animal ***ought to be**,*

But the performance of his progeny tells us

what he really is

Selection in livestock breeding

Methods of Progeny Testing *(as used in dairy farming)***:**

1. Daughter average – **the average production of a bull's daughter is indicative of its transmitting ability**

2. Daughter – dam comparison: **comparing the production of a bulls daughters with that of their dams**

3. Herdmate comparison: **comparing the production of a bulls daughters with that of their herdmates (other cows in the heard calved in the same year and season)**

4. Contemporary comparison: **based on the same principles as the herdmate comparison except that only first records are used**

Systems of selection

Three main systems of selection:

1. Tandem selection

Selection for one trait at a time until the desired improvement in that particular trait is reached

Then selection is made for another trait etc.

Selection methods

	Bull				
Trait	**A**	**B**	**C**	**D**	**E**
Birth wt, (lb)	**105**	**82**	**85**	**93**	**76**
Yearling wt, (lb)	**1,242**	**980**	**1,001**	**1,098**	**1,160**
Scrotal circ. (cm)	**34**	**37**	**31**	**29**	**35**

Selection methods

Tandem Selection

	Bull				
Trait	**A**	**B**	**C**	**D**	**E**
Birth wt, (lb)	105	82	85	93	76
Yearling wt, (lb)	1,242	980	1,001	1,098	1,160
Scrotal circ. (cm)	34	37	31	29	35

Systems of selection

2. Selection by independent culling level

Establishing minimum standards for each character, and selecting simultaneously but independently for each character

It is the most common system of selection

Selection methods

Independent culling

		Bull				
Trait		**A**	**B**	**C**	**D**	**E**
Birth wt, (lb)	**<85**	**105**	**82**	**85**	**93**	**76**
Yearling wt, (lb)	**>1000**	**1,242**	**980**	**1,001**	**1,098**	**1,160**
Scrotal circ. (cm)	**>30**	**34**	**37**	**31**	**29**	**35**

Selection methods

Independent culling

		Bull				
Trait		**A**	**B**	**C**	**D**	**E**
Birth wt, (lb)	**<85**	~~**105**~~	**82**	**85**	~~**93**~~	**76**
Yearling wt, (lb)	**>1000**	**1,242**	~~**980**~~	**1,001**	**1,098**	**1,160**
Scrotal circ. (cm)	**>30**	**34**	**37**	**31**	~~**29**~~	**35**

Systems of selection

3. Selection by selection index

Selection index combine all important traits into one overall value or index:

$$SI = b_1 x\ P_1 + b_2 x\ P_2 + b_3 x\ P_3 + \ldots .. + b_n x\ P_n$$

More desirable way than mentioned above methods, but more complicated

Selection methods

Selection Index (I = YW – 5.8*BW)

		Bull				
Trait		**A**	**B**	**C**	**D**	**E**
Birth wt, (lb)	<85	105	82	85	93	76
Yearling wt, (lb)	>1000	1,242	980	1,001	1,098	1,160
Scrotal circ. (cm)	>30	34	37	31	29	35
Index value		633	504	508	559	719

	Production					Maternal						Ultrasound				$ Values			
	CED	BW	WW	YW	SCR	CEM	MILK	MkH	MW	MH	$EN	%IMF	RE	FAT	H/P	$W	$F	$G	$B
EPDS	1	3.4	59	107	0.92	11	26	64	40	0.4	-4.09	-0.09	0.40	.012	643	30.06	44.83	5.64	36.50
ACC	.80	.97	.97	.94	.88	.58	.80	160	.39	.36		.94	.94	.94	1974				
RANK			3%	2%	15%	4%	15%						20%			10%	2%		

Calving Ease Rating ✔✔

Reg. No: 13512009 Mature: 2570 lbs.
Born: 1/1/00 Yrlg. Frame: 6.5
Birth Weight: 78 lbs. Mature Frame: 6.0
205 Days: 836 lbs. Scrotal: 43.0 cm.
365 Days: N/A Tattoo: 004
Owned By: Schaff Angus Valley, ND; Trowbridge Angus, NY; Shady Brook Farm, TN; KMK Ranch, TN; Genex, WI

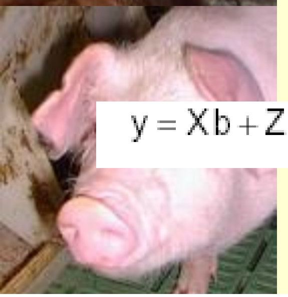
GeneSTAR			
QG1	0	QG2	0
T1	★★	T2	0
T3	★★		

Masterpiece Sire

QG

Champion Hill Blackcap 3804
Daughter of Traveler 004

EPD – expected progeny difference



$$y = Xb + Z_d u_d + Z_m u_m + Z_{pe} u_{pe} + e$$

$$V\begin{bmatrix} u_d \\ u_m \\ u_{pe} \\ e \end{bmatrix} = \begin{bmatrix} A\sigma_a^2 & A\sigma_{am} & 0 & 0 \\ A\sigma_{am} & A\sigma_m^2 & 0 & 0 \\ 0 & 0 & I\sigma_{pe}^2 & 0 \\ 0 & 0 & 0 & I\sigma_e^2 \end{bmatrix}$$

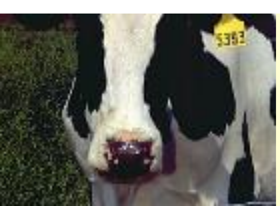
$$V\begin{bmatrix} u_w \\ u_m \\ u_g \\ u_{pe} \\ e_w \\ e_g \end{bmatrix} = \begin{bmatrix} g_{11}A & g_{12}A & g_{13}A & 0 & 0 & 0 \\ g_{12}A & g_{22}A & g_{23}A & 0 & 0 & 0 \\ g_{13}A & g_{23}A & g_{33}A & 0 & 0 & 0 \\ 0 & 0 & 0 & g_{44}I & 0 & 0 \\ 0 & 0 & 0 & 0 & \sigma_{ew}^2 I & \sigma_{ew,eg} I \\ 0 & 0 & 0 & 0 & \sigma_{ew,eg} I & \sigma_{eg}^2 I \end{bmatrix}$$

$$\begin{bmatrix} y_w \\ y_g \end{bmatrix} = \begin{bmatrix} X_w & O \\ O & X_g \end{bmatrix}\begin{bmatrix} b_w \\ b_g \end{bmatrix} + \begin{bmatrix} Z_w & O & Z_m & Z_{pe} \\ O & Z_g & O & O \end{bmatrix}\begin{bmatrix} u_w \\ u_m \\ u_g \\ u_{pe} \end{bmatrix} + \begin{bmatrix} e_w \\ e_g \end{bmatrix}$$

$$\begin{bmatrix} X'_w R^{11} X_w & X'_w R^{12} X_g & X'_w R^{11} Z_w & X'_w R^{11} Z_m & X'_w R^{12} Z_g & X'_w R^{11} Z_{pe} \\ X'_g R^{12} X_w & X'_g R^{22} X_g & X'_g R^{21} Z_w & X'_g R^{21} Z_m & X'_g R^{22} Z_g & X'_g R^{21} Z_{pe} \\ Z'_w R^{11} X_w & Z'_w R^{21} X_g & Z'_w R^{11} Z_w + A^{-1} g^{11} & Z'_w R^{11} Z_m + A^{-1} g^{12} & Z'_w R^{12} Z_g + A^{-1} g^{13} & Z'_w R^{11} Z_{pe} \\ Z'_m R^{11} X_w & Z'_m R^{21} X_g & Z'_m R^{11} Z_w + A^{-1} g^{12} & Z'_m R^{11} Z_m + A^{-1} g^{22} & Z'_m R^{12} Z_g + A^{-1} g^{23} & Z'_m R^{11} Z_{pe} \\ Z'_g R^{12} X_w & Z'_g R^{22} X_g & Z'_g R^{12} Z_w + A^{-1} g^{13} & Z'_g R^{12} Z_m + A^{-1} g^{23} & Z'_g R^{22} Z_g + A^{-1} g^{33} & Z'_g R^{21} Z_{pe} \\ Z'_{pe} R^{11} X_w & Z'_{pe} R^{21} X_g & Z'_{pe} R^{11} Z_w & Z'_{pe} R^{11} Z_m & Z'_{pe} R^{21} Z_g & Z'_{pe} R^{11} Z_{pe} + I g_{44}^{-1} \end{bmatrix}$$

$$\begin{bmatrix} X'X & X'Z_d & X'Z_m & X'Z_{pe} \\ Z'_d X & Z'_d Z_d + A^{-1}\alpha_1 & Z'_d Z_m + A^{-1}\alpha_2 & Z'_d Z_{pe} \\ Z'_m X & Z'_m Z_d + A^{-1}\alpha_2 & Z'_m Z_m + A^{-1}\alpha_3 & Z'_m Z_{pe} \\ Z'_{pe} X & Z'_{pe} Z_d & Z'_{pe} Z_m & Z'_{pe} Z_{pe} + I\alpha_4 \end{bmatrix}\begin{bmatrix} \hat{b} \\ \hat{u}_d \\ \hat{u}_m \\ \hat{u}_{pe} \end{bmatrix} = \begin{bmatrix} X'y \\ Z'_d y \\ Z'_m y \\ Z'_{pe} y \end{bmatrix}.$$

$$X\begin{bmatrix} \hat{b}_w \\ \hat{b}_g \\ \hat{u}_w \\ \hat{u}_m \\ \hat{u}_g \\ \hat{u}_{pe} \end{bmatrix} = \begin{bmatrix} X'_w R^{11} y_w + X'_w R^{12} y_g \\ X'_g R^{22} y_g + X'_g R^{21} y_w \\ Z'_w R^{11} y_w + Z'_w R^{12} y_g \\ Z'_m R^{11} y_w + Z'_m R^{12} y_g \\ Z'_g R^{22} y_g + Z'_g R^{21} y_w \\ Z'_{pe} R^{11} y_w + Z'_{pe} R^{12} y_g \end{bmatrix}$$



Animal reproduction

Lecture outline

- Reproductive organs

- Heat detection and timing of service or insemination

- Some terms of understanding

- Artificial insemination

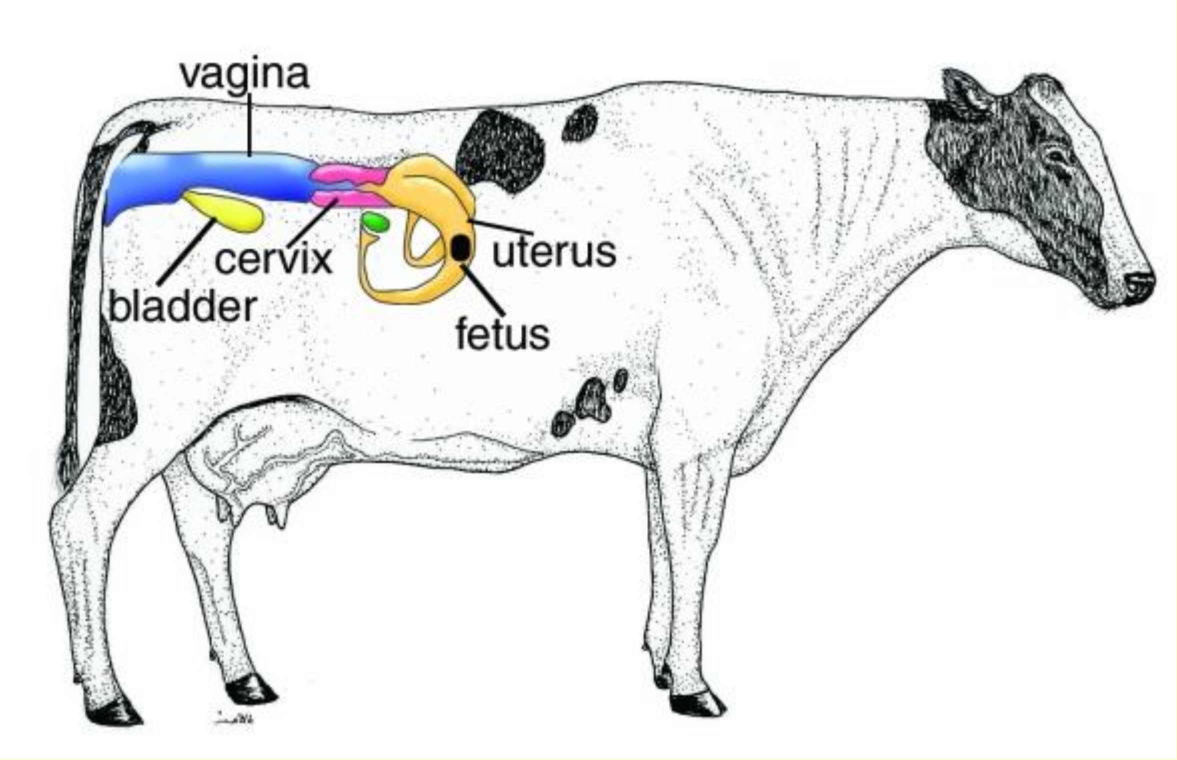
- Heat synchronization

- Embryo transfer

- Blood typing

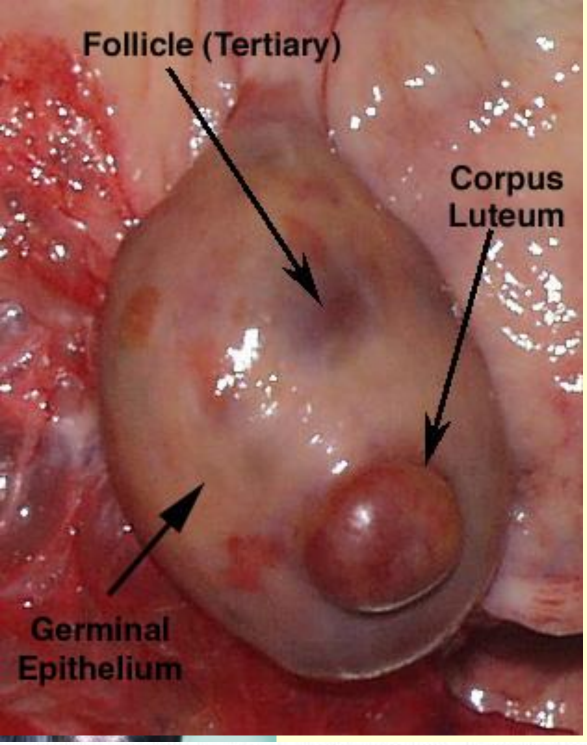
What is the function of the female?

- contribute 1/2 chromosomes
- care for young in uterus and after birth until weaning



Uterus - part of the reproductive tract where the developing calf is carried. In a non-pregnant cow, the body of the uterus is less than 5 cm long, and has left and right horns. It is capable of enormous expansion to accommodate a growing calf.

Oviducts - two convoluted tubes that join each of the uterine horns to one of the cow's two ovaries; they are more than 20 cm in length and only 0,6 cm in diameter. Fertilization, or the union of the egg and a spermatozoon, occurs in the oviduct. Ova remains in oviduct for 3-6 days



Reproductive organs

Ovaries. In a non-pregnant cow, the ovaries are oval (shaped like an egg), about 4 to 6 cm in length and 2 to 4 cm in diameter.

The major functions of the ovaries are to:

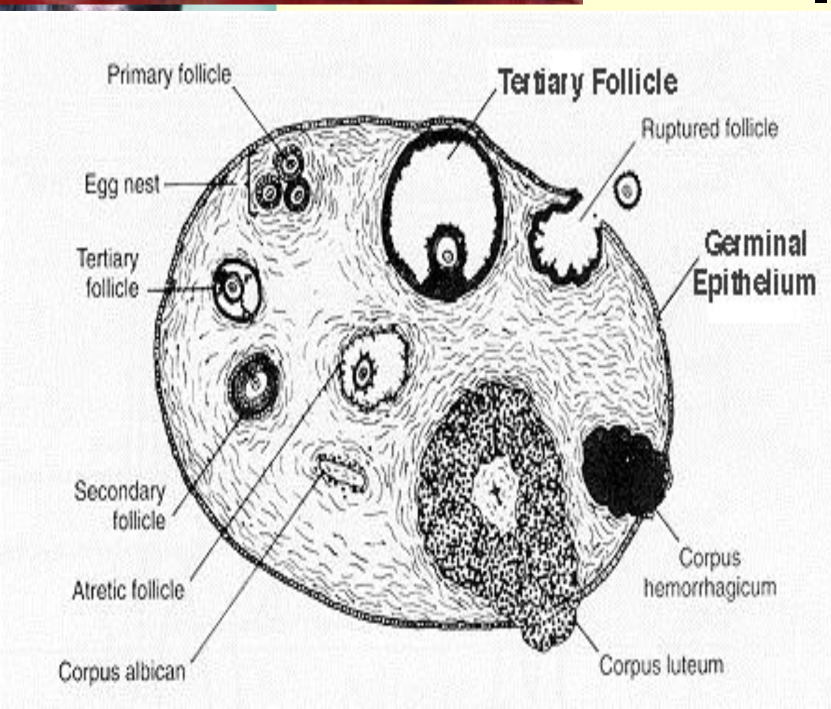
Produce a mature egg or ovum every 21 days when the cow has a normal estrus cycle (50,000 - 150,000 potential eggs present at birth)

Secrete hormones that:

Control the growth of an egg within the ovary;

Change the cow's behavior during estrus;

Prepare the reproductive tract for possible pregnancy.



What is the function of the male?

- produce large numbers of live sex cells (spermatozoa)
- contribute 1/2 chromosomes

Reproductive organs

Scrotum - the sack located outside the abdominal cavity that contains the testes.

By adjusting the distance between the testes and the body, the scrotum regulates the temperature of the testes.
Functions as a heat regulator.

The formation of spermatozoa functions better at a temperature 2 to 4°C lower than normal body temperature

Monorchid - one fertile testicle

Cryptorchid - both testes remain in body cavity (sterile)

Testicles – the masculine sex glands.

Produce viable, fertile spermatozoa

Produce male hormones (testosterone)

Castration - removal of testicles
- gain weight quicker

Reproductive organs

Semen consists of two parts:

The sperm (genetic portion), produced by the testes

The liquid (energy portion), secreted by the secondary sex organs (prostate, seminal vesicles and Cowper's glands)

At the time of mating the spermatozoa are mixed with secretions rich in nutritive substances

On the average, a bull ejaculates 4 to 7 cubic centimetres of semen, containing about 6 to 10 billion sperm or 1 ½ billion per cm^3

A normal mature boar ejaculates from 200 to 500 cubic centimetres of semen, containing from 10 to 100 billion sperm or on average 150-200 million per cm^3

Reproduction in Males

- After reaching maturity, semen production is continuous
- **Testosterone** is responsible for:
  - growth, development & activity of sex glands
  - survival of spermatozoa
  - secondary sex characteristics:male voice, sex drive (libido)

Reproduction in Females

- Farm animals reach maturity at 4 months (sow) to 24 months (mare), then
  - ☆Female comes in heat (estrus)
  - Egg released by ovary
  - Egg travels down tube until fertilized by sperm
- Estrogen - female hormone which regulates estrus
- Progesterone- hormone that keeps female out of heat

Heat detection

A cow must be bred within 80 to 90 days after calving

This will enable her to produce a new calf every 12,5 to 12,8 months

Heat detection is a critical component of good reproductive management on the farm

Recording of cows in heat and dates of services is necessary to predict future heat or calving dates and to manage the cows accordingly

Heat detection

What is heat?

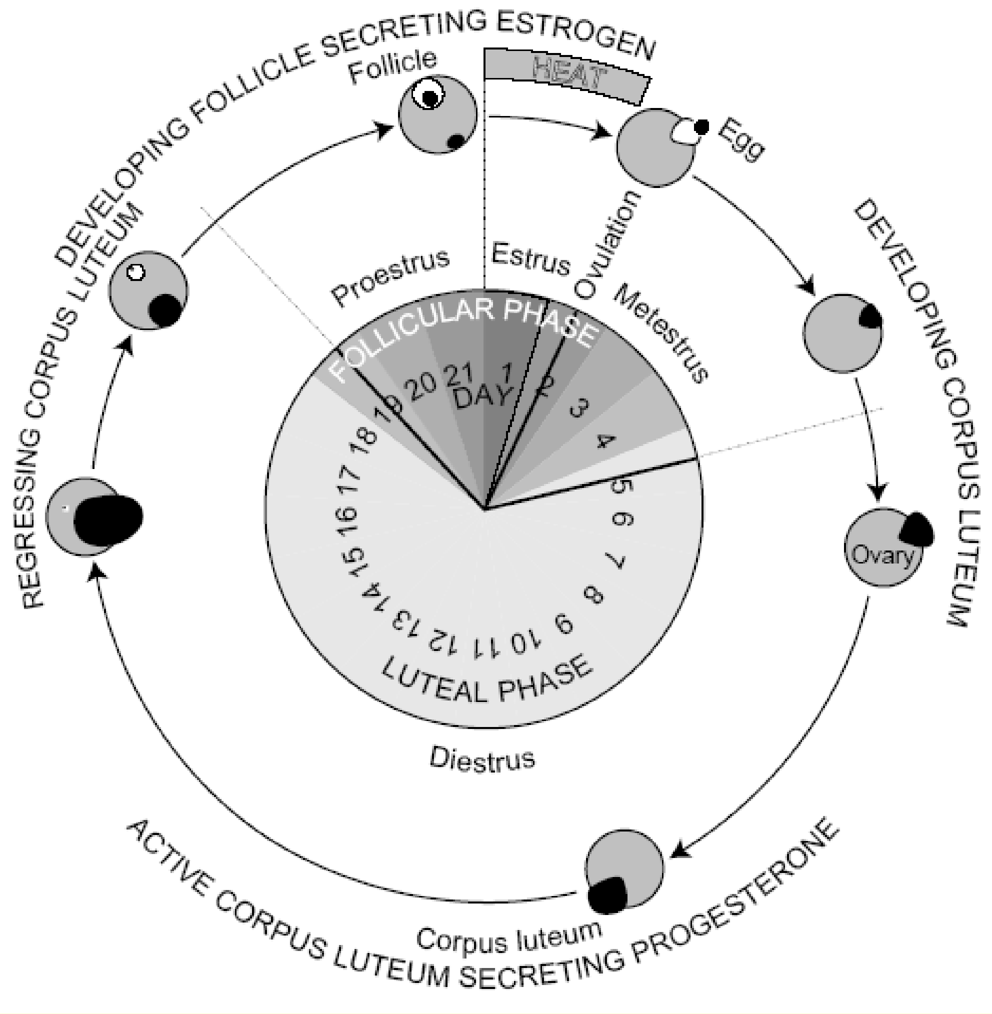
Heat (or estrus) is a period of acceptance for mating (sexual receptivity) that normally occurs in non-pregnant, pubescent heifers and non-pregnant cows

May last from 6 to 30 hours and occurs every 21 days on the average with variation from 18 to 24 days

Heat is actually divided into 4 phases of the cycle.

- **Proestrus**: ovary is about to release an egg
- **Estrus**: female receptivity
- **Metestrus**: uterus prepares for pregnancy
  - fertilized egg attaches to uterus
- **Diestrus**: longest period of cycle
  - inactive
- Estrous Cycles stop after conception, and begin soon after Parturition (birth)

THE HEAT CYCLE



The heat cycle is the interval (21 days average length) between two heats. A heat, or estrus, lasts six to 30 hours and is the period of sexual receptivity (Day 1 of a cycle).

THE ESTRUS CYCLE

1. Follicle develops - blister on ovary

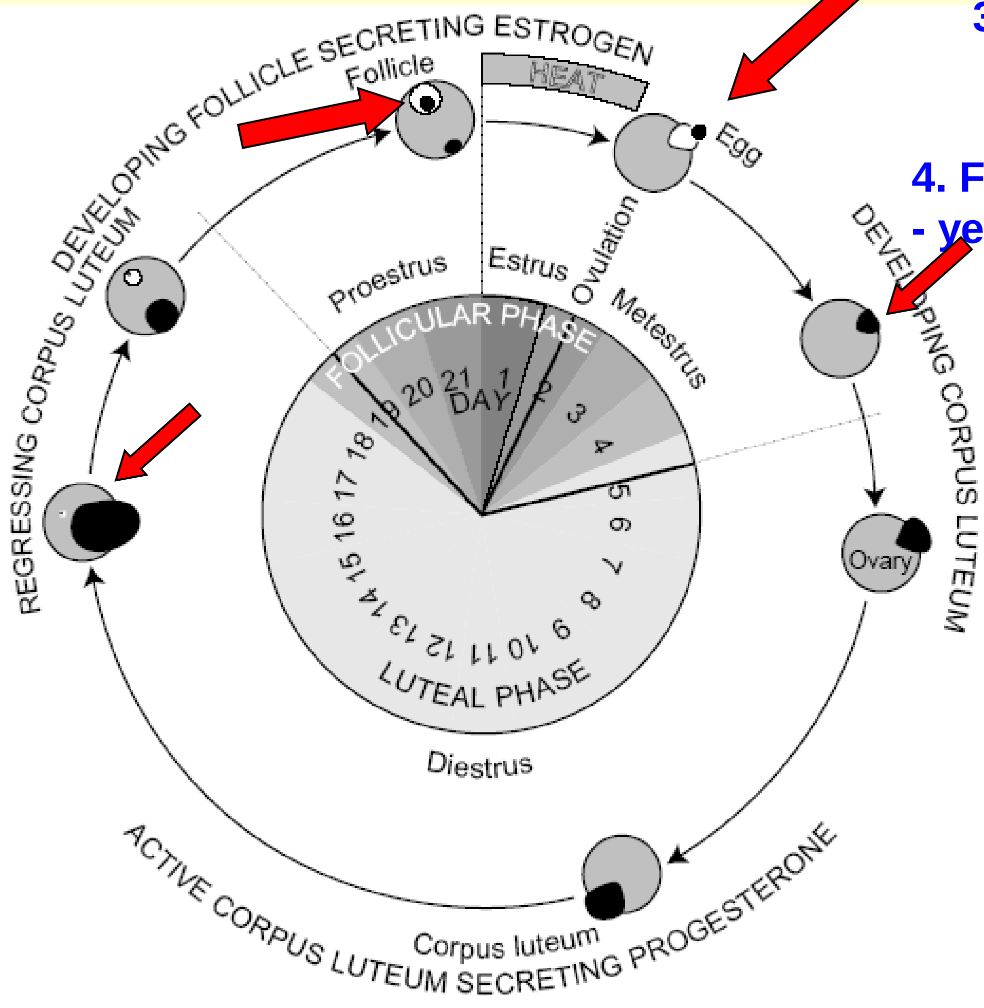
2. Follicle bursts - egg is released

3. Hole is left where the ova was

4. Forming a C.L. (Corpus Luteum) - yellow body:

- produces progesterone

- if female becomes pregnant a new follicle does not burst and estrogen production is reduced



Heat detection

Signs of heat

Detection of heat calls for acute observation

Most cows have a pattern of behavior that changes gradually from the beginning to the end of a heat

The best indicator that a cow is in heat is when she stands and allows herself to be mounted by herdmates or a bull:

Heat detection

Some other signs, typical to early and late heat

- ***Bellows like a bull***
- ***Displays general signs of nervousness***
- ***Pushes against the sides of other cows***
- ***Depressed appetite and milk yield***

Timing of service or insemination

Artificial insemination or natural service lead to a pregnancy only if the spermatozoa are "at the right place at the right time"

A common recommendation for the best timing of artificial insemination is the "morning-evening" rule

Cows observed in heat in the morning are inseminated the same evening, and cows observed in heat in the afternoon are inseminated the next morning

Timing of service or insemination

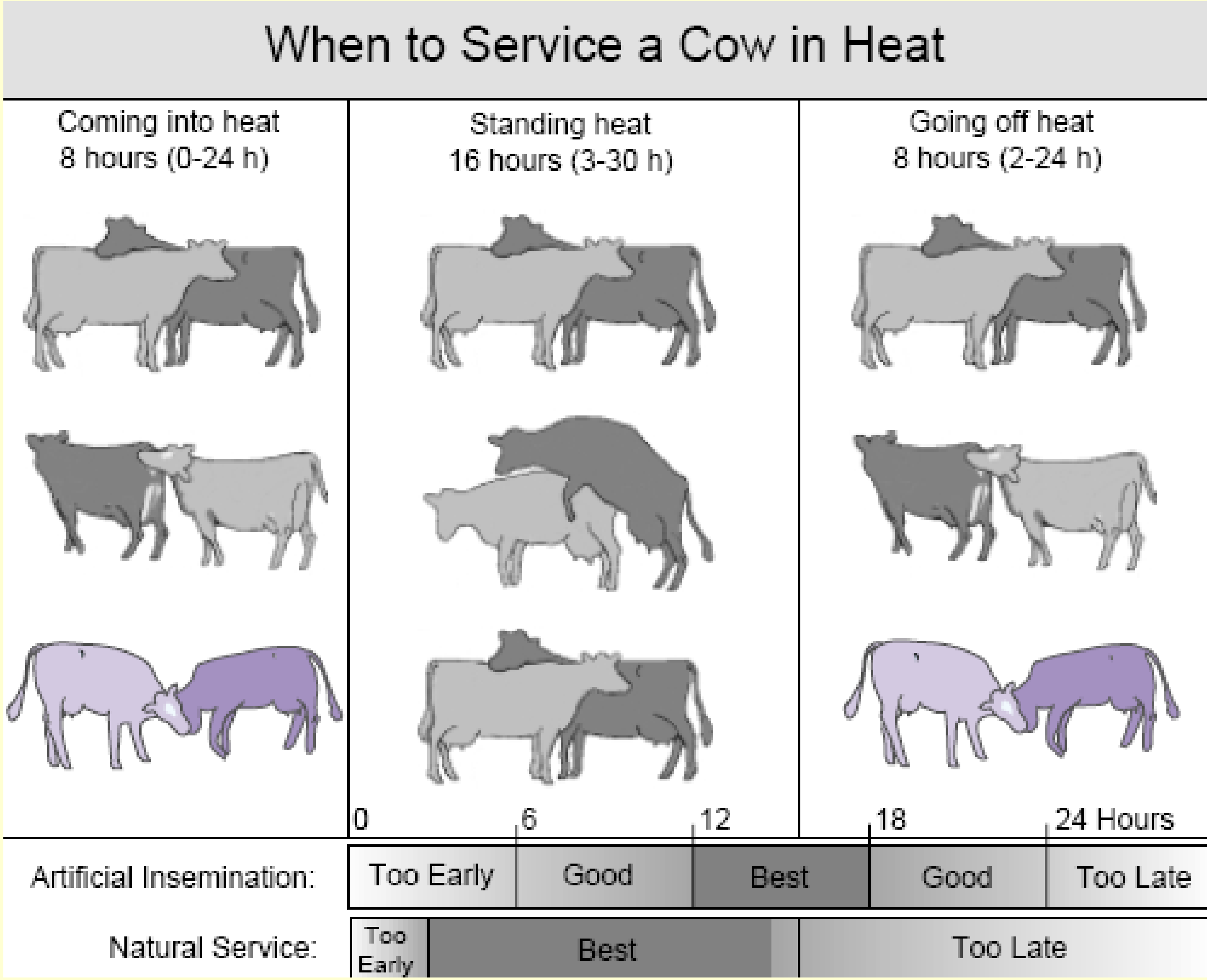


Table 27–1. Female Reproduction[1]

Animal	Onset of Puberty	Av. Age First Service	Length Estrous Cycle	Length Estrus	Gestation Period
Mare	18 mo (10 to 24 mo)	2 to 3 yrs	21 days (19 to 21 days)	5 days (4½ to 7½ days)	336 days (323 to 341 days)
Cow	4 to 24 mo	14 to 22 mo	21 days (18 to 24 days)	18 hrs (12 to 28 hrs)	282 days (274 to 291 days)
Ewe	4 to 12 mo (1st fall)	12 to 18 mo	16½ days (14 to 20 days)	24 to 48 hrs	150 days (140 to 160 days)
Sow	3 to 7 mo	8 to 10 mo	21 days (18 to 24 days)	2 days (1 to 5 days)	114 days (110 to 116 days)
Bitch	6 to 24 mo	12 to 18 mo	6 to 12 mo	9 days (5 to 19 days)	63 days (60 to 65 days)

Animal	Time of Ovulation	Optimum Time for Service	Advisable Time to Breed after Parturition
Mare	1 to 2 days before end of estrus	3 to 4 days before end of estrus or the second or third day of estrus	About 25 to 35 days or second estrus. About 9 days or first estrus only if normal in every way
Cow	10 to 15 hours after the end of estrus	Just before the middle of estrus to the end of estrus	60 to 90 days
Ewe	12 to 24 hours before the end of estrus	18 to 24 hours after the onset of estrus	Usually the following fall
Sow	30 to 36 hours after the onset of estrus	12 to 30 hours after the onset of estrus	First estrus 3 to 9 days after weaning pigs
Bitch	1 to 2 days after the onset of true estrus	2 to 3 days after onset of true estrus; or 10 to 14 days after onset of proestrous bleeding	Usually the first estrus or 2 to 3 months after weaning pups

[1] Data compiled from standard references, including Dukes, Payne, Roberts, and Spector.

Estrus heat is not always accompanied by ovulation, nor ovulation by estrus. Heat without ovulation will not result in pregnancy even though the female is bred.

Visual Heat Detection Aids

Mount Detection Aids

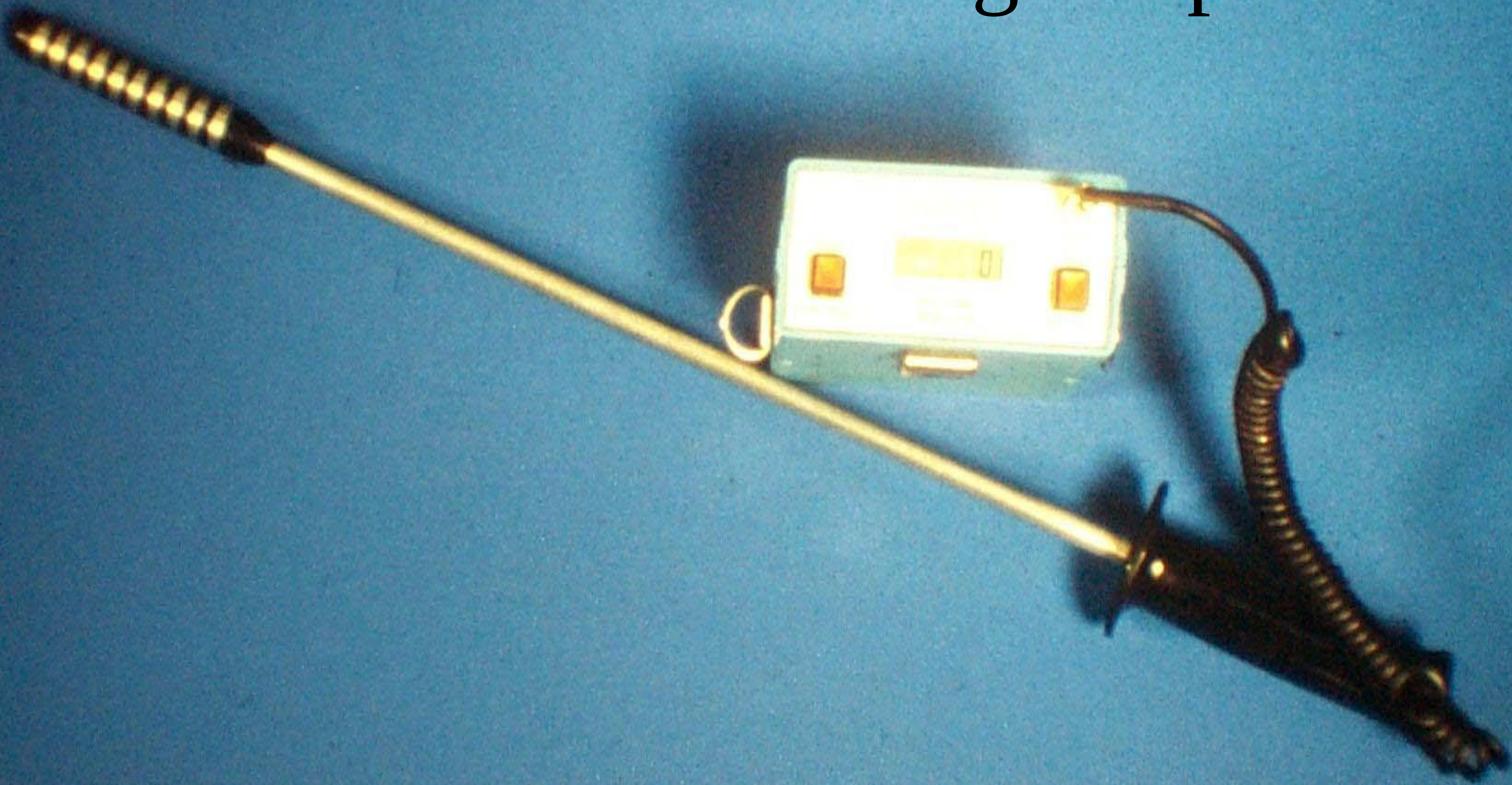

Applied to cow

Tail Paint

Tail Paint

Canine heat detectors

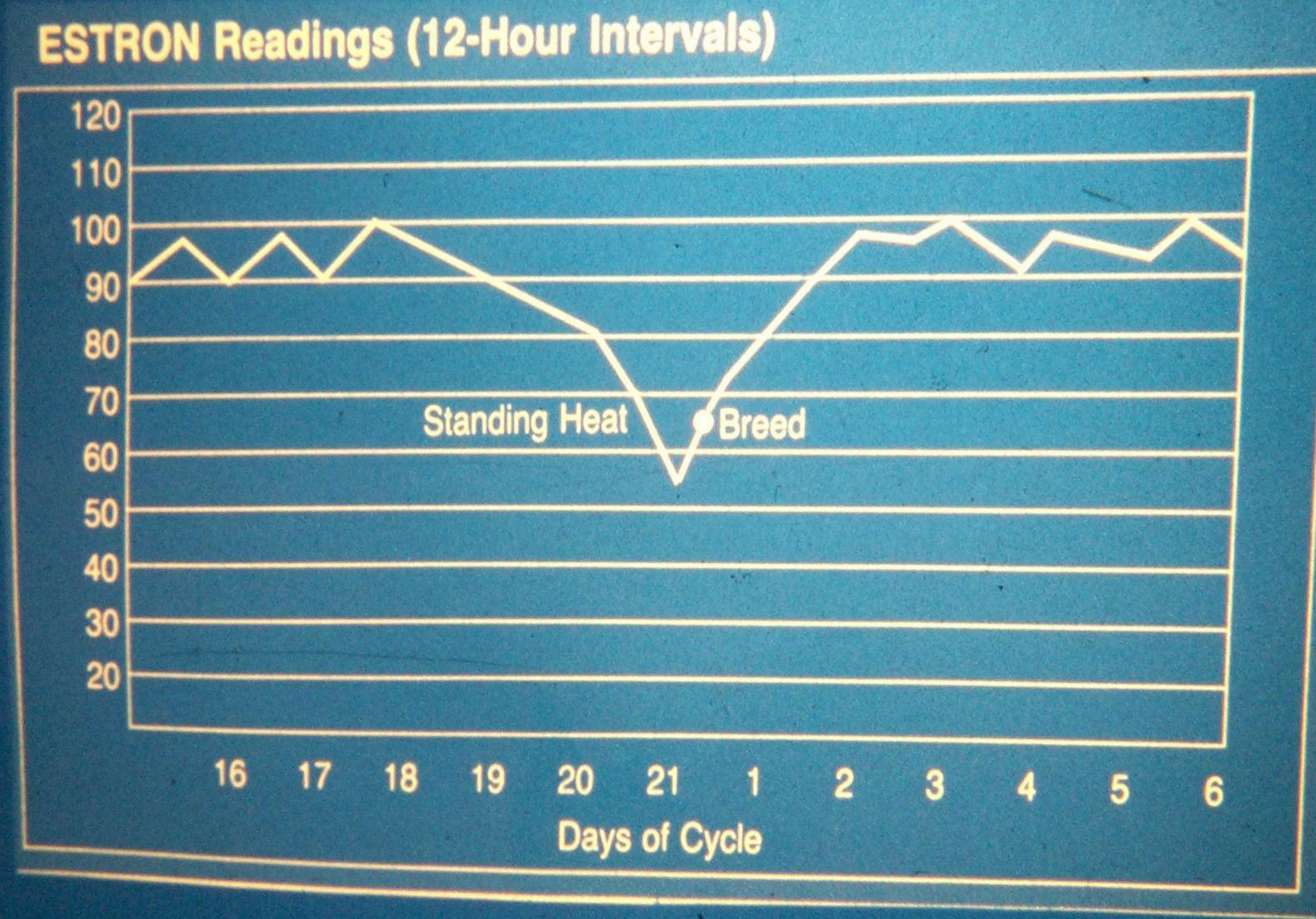
Vaginal probe



Vaginal Probe

- Measeures electrical resistance
- Labor intensive
- Cow to cow variation
- Costly equipment
- Potential to spread disease

Labor intensive



ESTRON Readings (12-Hour Intervals)
120
110
100
90
80
70
60
50
40
30
20
Standing Heat
Breed
16
17
18
19
20
21
1
2
3
4
5
6
Days of Cycle

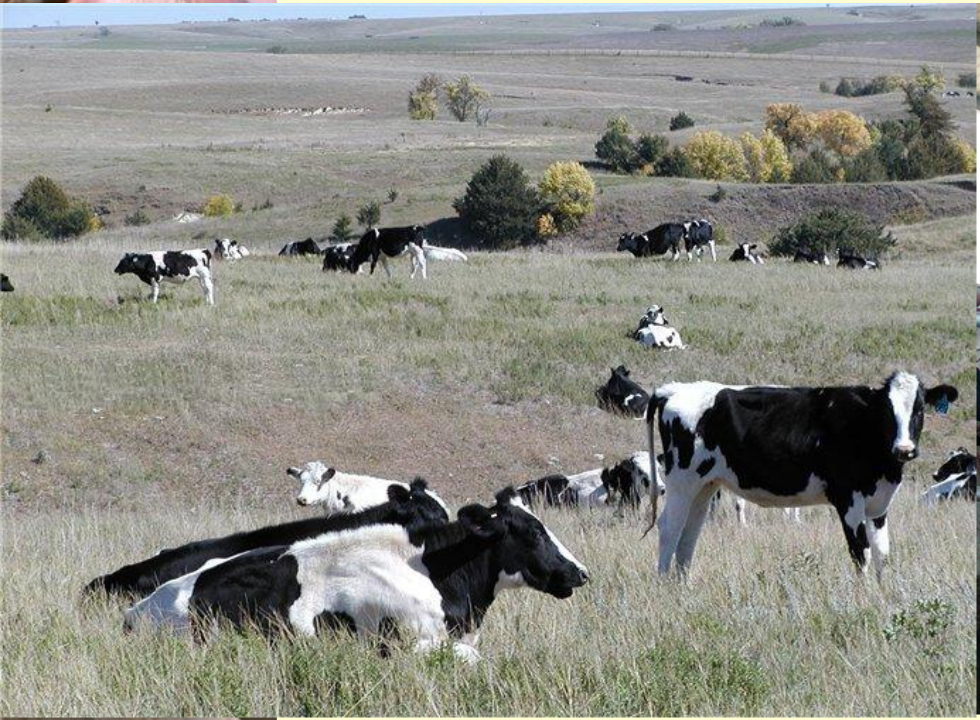
RFID technologies in heat detection

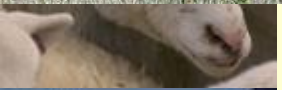
Lactivator (2- hours measuring)

Problems Heat detection

- less than 50% of all insemination will result in a pregnancy
- Milk production increases
- More animals per labor
- Work load increases

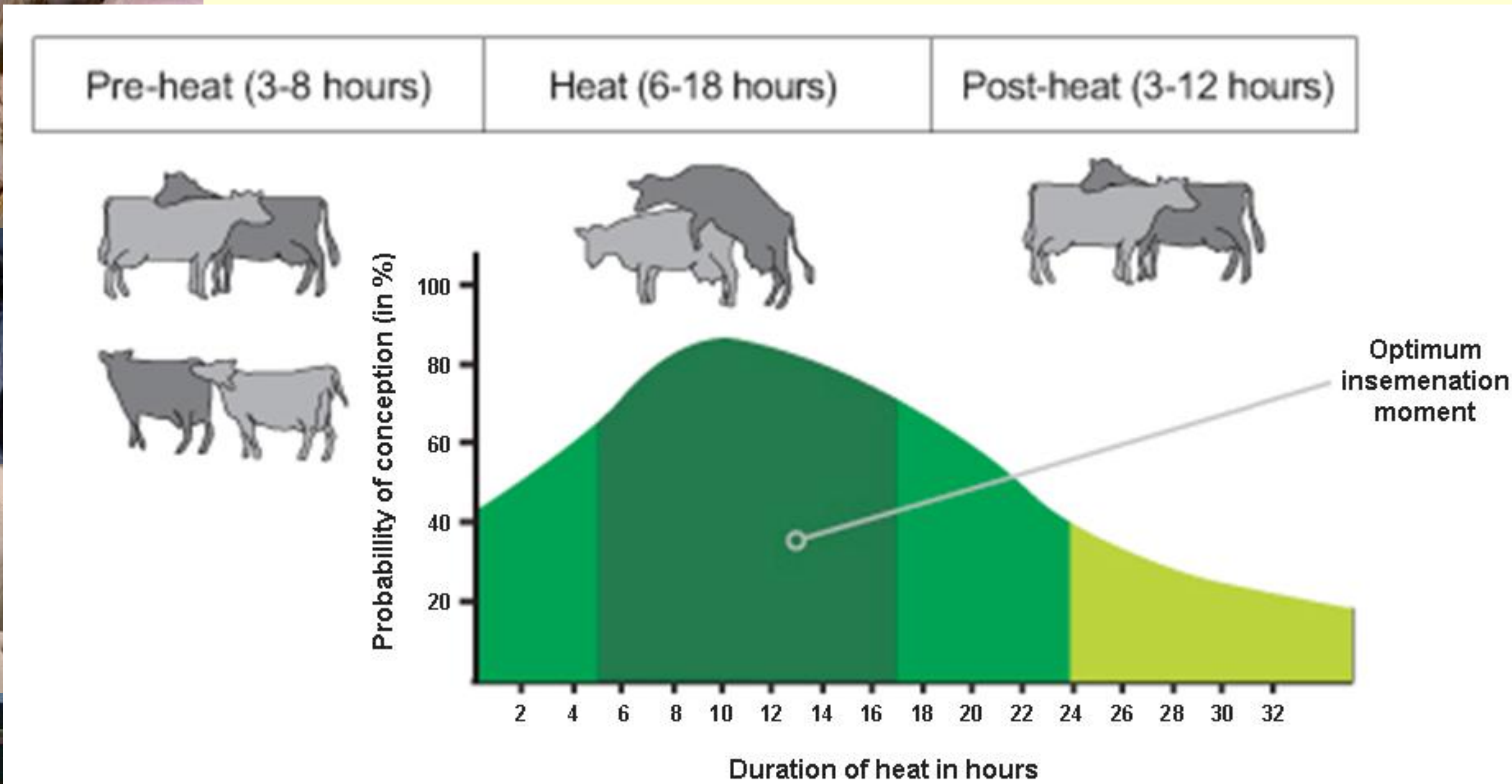
Industry Changes





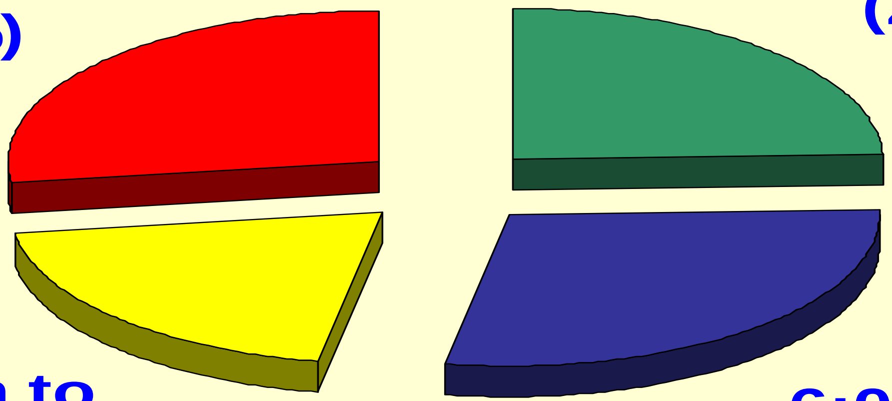
Past **2006**

Heat cycle



Pre-heat (3-8 hours)
Heat (6-18 hours)
Post-heat (3-12 hours)
Probability of conception (in %)
100
80
60
40
20
Optimum insemenation moment
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Duration of heat in hours

When are cows most likely to begin estrus?



(Dransfield et al., 1998; 2,055 cows)

Heat observation

	All heats			Heat with a minimum of **2** cows in heat		
	Observation frequenty			Observation frequenty		
	8 times observation 1 hour	3times observation1 hour	2times observation1 hour	8times observation1 hour	3times observation1 hour	2times observation1 hour
All heat signs(observation 24 hours per day)	100	90	77	100	90	83
Jump behaviour	89	61	48	95	71	65
Standing Heat	57	**30**	**19**	71	41	35

*** Source: WUR, Wageningen**

How can we improve heat detection?

- Longer observation
- More often observation
- Cow house optimalisation (slippery floor, etc.)
- Optimal feeding
- Use of auxiliary's
  - Temperature measurement
  - Ovatrec (conductvivity)
  - Progesteron (in the milk)
  - Activity measurement

Lactivator

Period activity measurement

- Activity and RFID combined in one
- 2 hours period measurement (14 periods)
- 24 hours monitoring behaviour of the cow
- 87% Heat detection
- Prediction of the best insemination time
- Lactivator very simple to mount on the leg

Two types

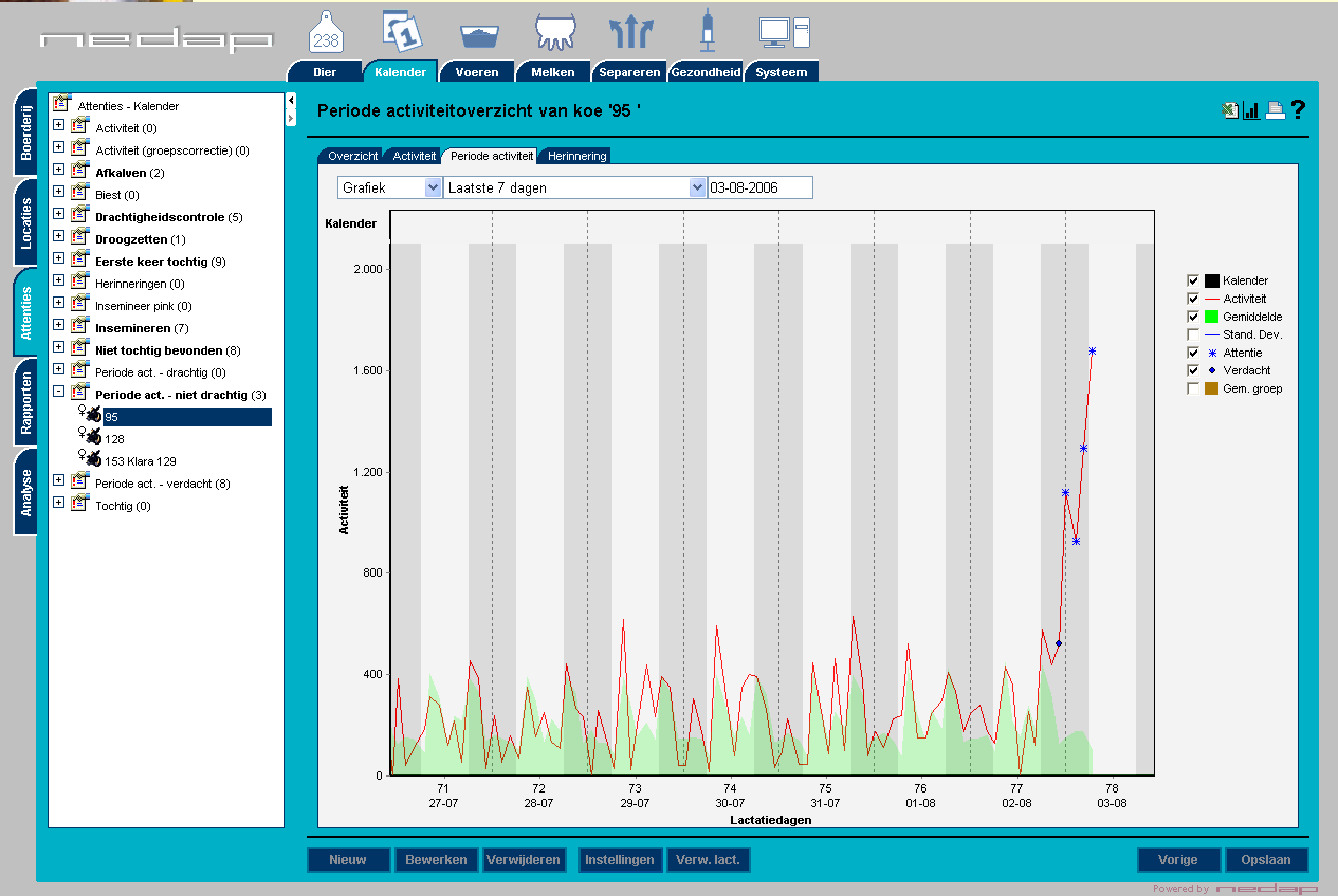
Neck

Leg

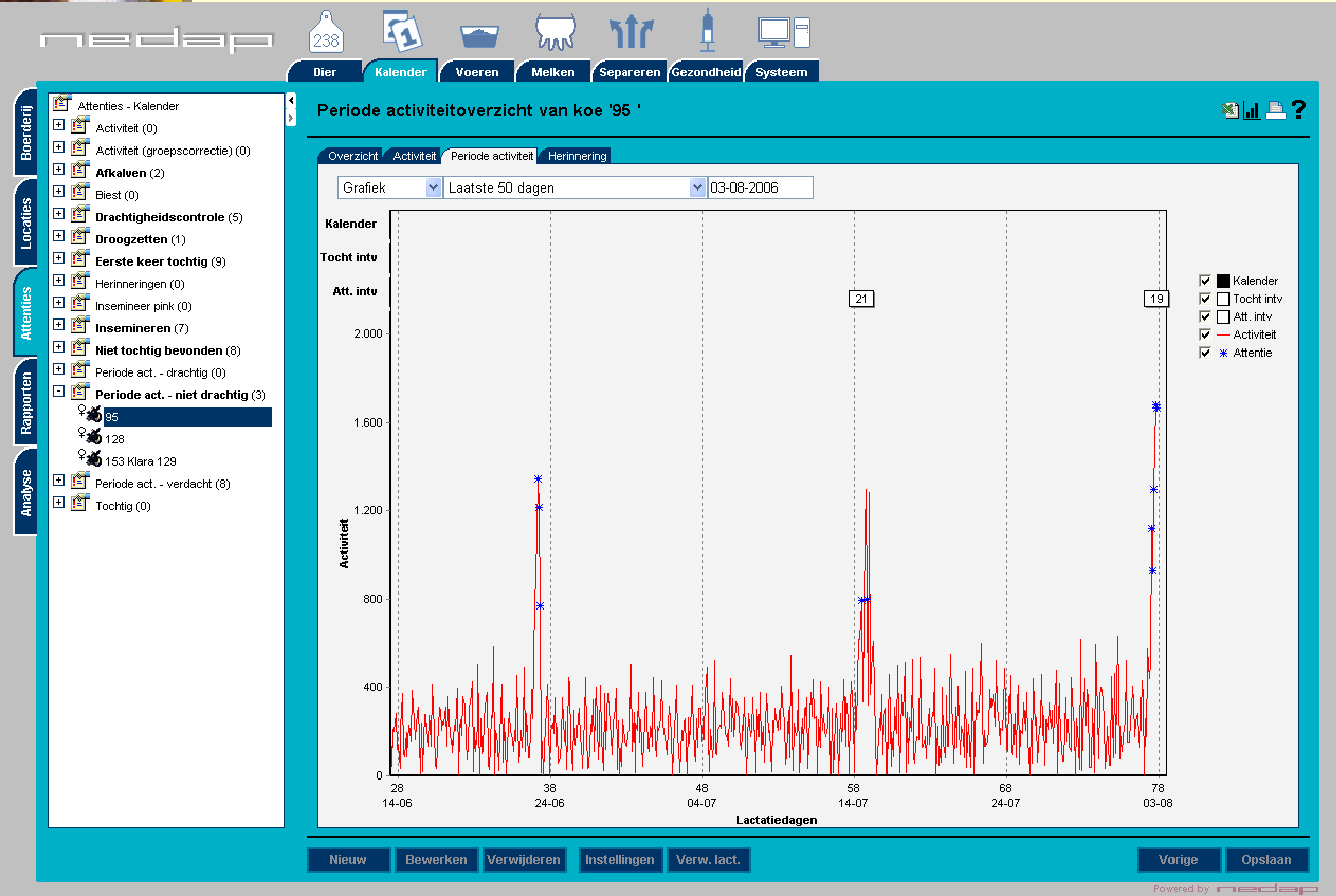
Heat Attentions

- The Lactivator stores the activity data of a cow in periods of **2 hours**
- The activity of a period will be compared with the activity of the same period in the days before
- If the activity in 3 periods after each other increases and has reach the settings she will get an attention.
- If there is an increase of activity for 2 periods she will get an suspicious mention

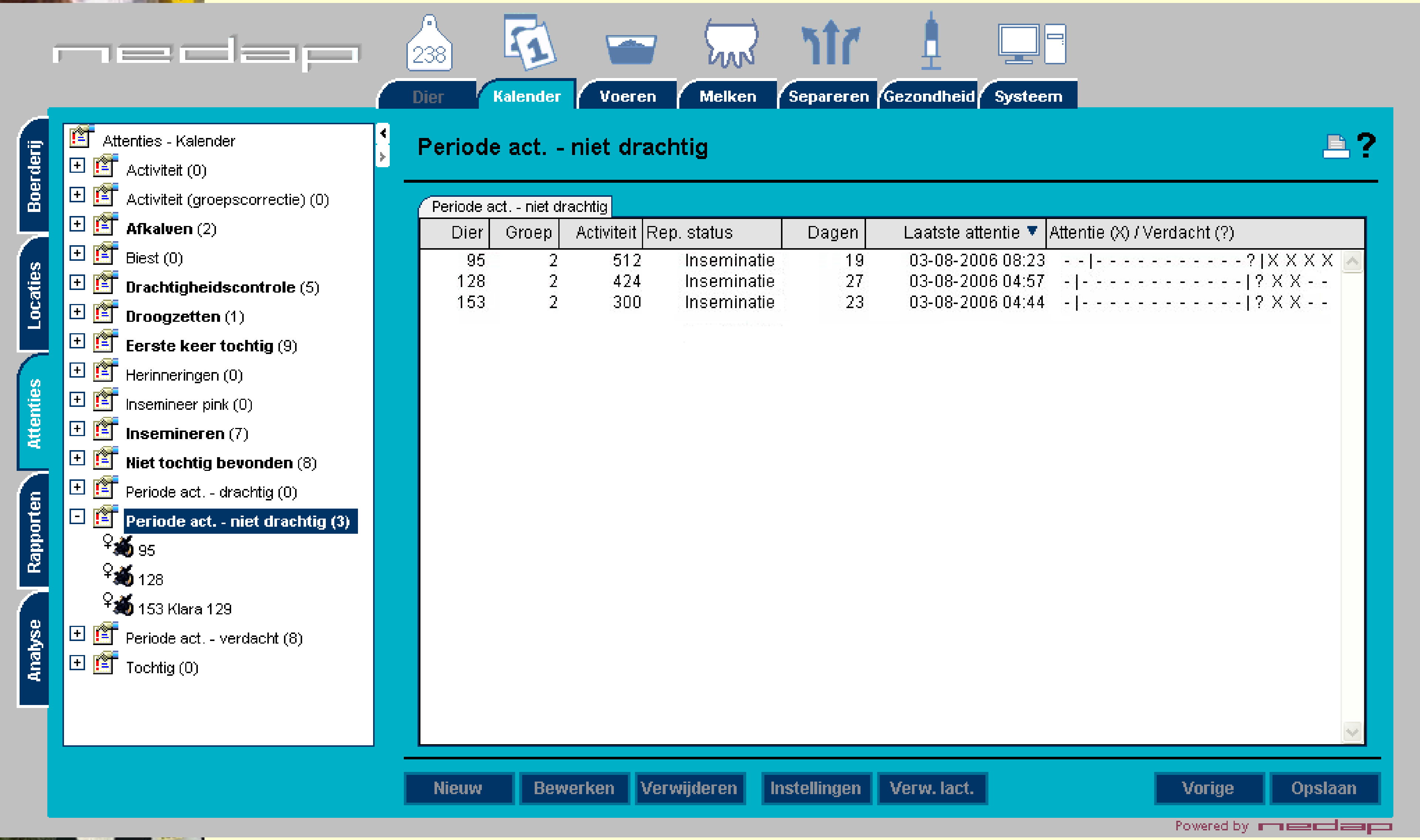
Overview activity (7 days)



Overview activity (50 days)

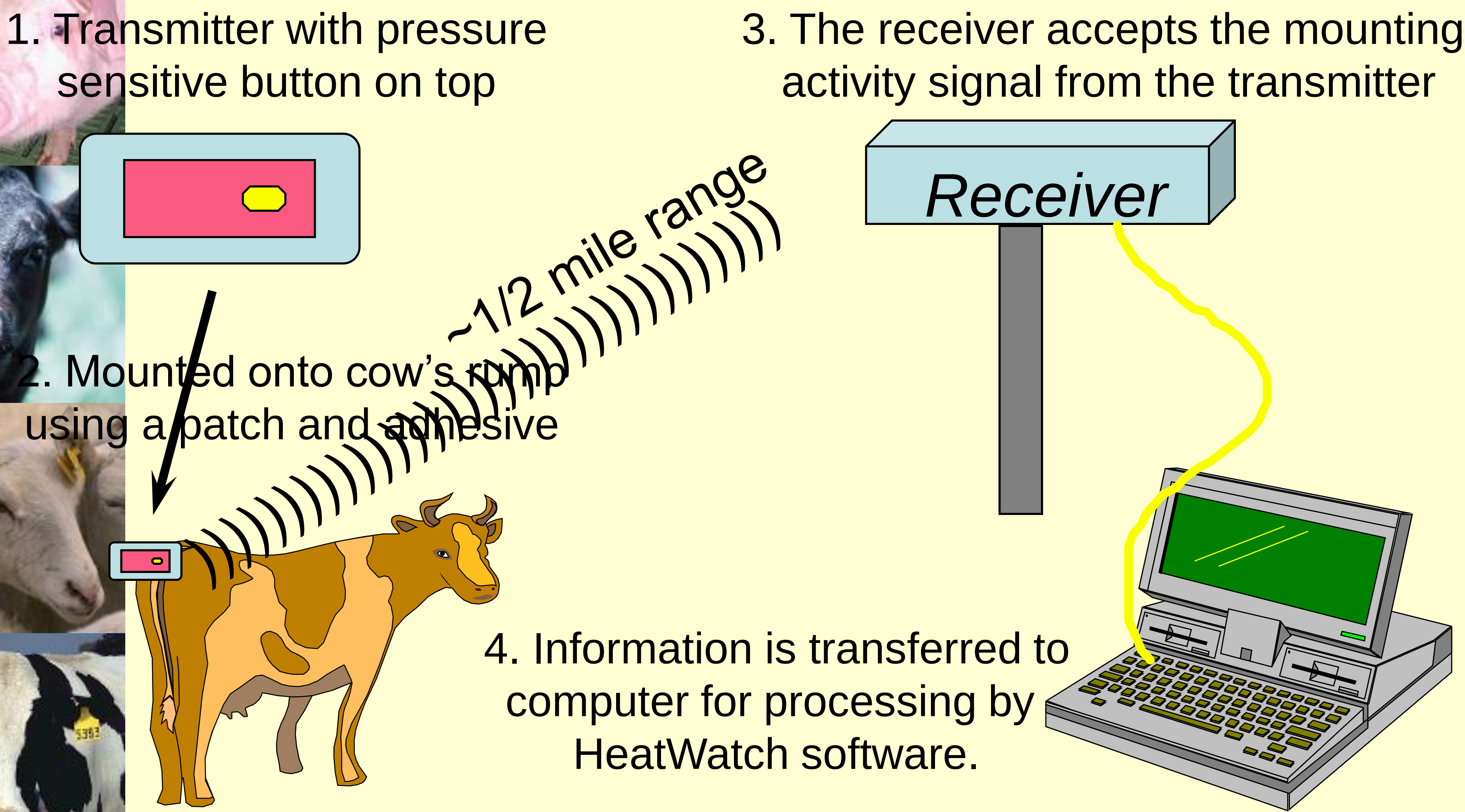


Attentions



238
Dier
Kalender
Voeren
Melken
Separeren
Gezondheid
Systeem
Boerderij
Locaties
Attenties
Rapporten
Analyse
Attenties - Kalender
Activiteit (0)
Activiteit (groepscorrectie) (0)
Afkalven (2)
Biest (0)
Drachtigheidscontrole (5)
Droogzetten (1)
Eerste keer tochtig (9)
Herinneringen (0)
Insemineer pink (0)
Insemineren (7)
Niet tochtig bevonden (8)
Periode act. - drachtig (0)
Periode act. - niet drachtig (3)
95
128
153 Klara 129
Periode act. - verdacht (8)
Tochtig (0)
Periode act. - niet drachtig
Periode act. - niet drachtig
Dier | Groep | Activiteit | Rep. status | Dagen | Laatste attentie | Attentie (X) / Verdacht (?)
95 | 2 | 512 | Inseminatie | 19 | 03-08-2006 08:23 | - - |- - - - - - - - - - - ? | X X X X
128 | 2 | 424 | Inseminatie | 27 | 03-08-2006 04:57 | - |- - - - - - - - - - - - | ? X X - -
153 | 2 | 300 | Inseminatie | 23 | 03-08-2006 04:44 | - |- - - - - - - - - - - - | ? X X - -
Nieuw
Bewerken
Verwijderen
Instellingen
Verw. lact.
Vorige
Opslaan
Powered by

Heat Watch Transmitters



Some terms of understanding - Cattle

- **A mature male is called a:**
  Bull
- **A mature female is called a:**
  Cow
- **The act of giving birth (parturition) is called:**
  Calving
- **Gestation (length of time from conception till birth) =**
  285 days
- **A castrated male is called a:**
  Steer
- **An immature female is called a:**
  Heifer
- **An immature male is called a:**
  Bullock
- **A young cattle either male or female is called a:**
  Calf

Some terms of understanding – Swine (Hogs or Pigs)

- **A mature uncastrated male hog is called a:**

  Boar
- **A mature female hog is called a:**

  Sow
- **The act of giving birth (parturition) is called:**

  Farrowing
- **Gestation =**

  114 days or 3 months, 3 weeks, & 3 days
- **A castrated male swine is called a:**

  Barrow
- **An immature female that has not had a litter is called a:**

  Gilt
- **An immature male hog is called a:**

  Shoat
- **A newborn or very young pig is called a:**

  Piglet

Some terms of understanding – Sheep

- **A mature uncastrated male sheep is called a:**

  Ram
- **A mature female sheep is called a:**

  Ewe
- **The act of giving birth (parturition) is called:**

  Lambing
- **Gestation =**

  148 days
- **A castrated male sheep is called a:**

  Wether
- **An immature female that has not had a litter is called a:**

  Ewe Lamb
- **An immature male sheep is called a:**

  Ram Lamb
- **A newborn or very young sheep is called a:**

  Lamb

Some terms of understanding – Goat

- **A mature uncastrated male goat is called a:**
  Billy
- **A mature female goat is called a:**
  Nanny or Doe
- **The act of giving birth (parturition) is called:**
  Kidding
- **Gestation =**
  151 days
- **A castrated male goat is called a:**
  Wether
- **An immature female goat is called a:**
  Doe Kid
- **An immature male goat is called a:**
  Buck Kid
- **A newborn or very young goat is called a:**
  Kid

Some terms of understanding – Horse

- **A mature uncastrated male horse is called a:**
  Stallion
- **A mature female horse is called a:**
  Mare
- **The act of giving birth (parturition) is called:**
  Foaling
- **Gestation =**
  330 days
- **A castrated male horse is called a:**
  Gelding
- **An immature female horse is called a:**
  Filly
- **A newborn or very young horse is called a:**
  Foal or Colt

Some terms of understanding – Poultry

- **A mature uncastrated male is called a:**

  Rooster or Cock
- **A mature female is called a:**

  Hen
- **A hen used for laying eggs is called a:**

  Layer
- **The act of giving birth (parturition) is called:**

  Chickens Hatch
- **Incubation period =**

  21 days
- **A castrated male is called a:**

  Capon
- **An immature female is called a:**

  Pullet
- **A newborn or very young chicken is called a:**

  Chick

Artificial insemination

Mating – natural process during which the mail and female join together and the male passes the sperm cells into the female

Artificial insemination is a technique by which semen is introduced artificially into the body of the uterus at the time of heat in an attempt to cause pregnancy

The injection of semen from a male into the female by a chosen tool

History Of Artificial Insemination

- Documents from around 1322 A.D. state that an Arab chief wanted to mate his mare to a stallion owned by his rival. So he preformed an amateur version of the artificial insemination we know today.
- Then in 1780, Spallanzani successfully bred two dogs with the use of A.I.
- In 1947 the Ukrainian scientist I.I. Smirnov made a revolutionized discovery: That semen could be frozen and stored for indefinite periods. He discovered that addition of glycerin to the semen extender improved resistance of sperm to freezing. Glycerin removes water from the sperm before freezing. It also prevents the ice crystals from damaging the sperm.

Advantages of Artificial Insemination

- It increases the use of outstanding sires
- It makes it possible to use a sire that is not alive at the time
- It lessens sire costs, eliminating the cost and danger of maintaining a bull on the farm
- It helps to control diseases and genetic defects
- It allows easier access for consumers to obtaining high quality sperm
- It increases accuracy and selection intensity

Disadvantages Of Artificial Insemination

- Should be timed properly (In order with the "heat" cycle)

- The semen should be handled properly

<u>{There are about 22 steps that must be done right to have an accurate fertilization}</u>

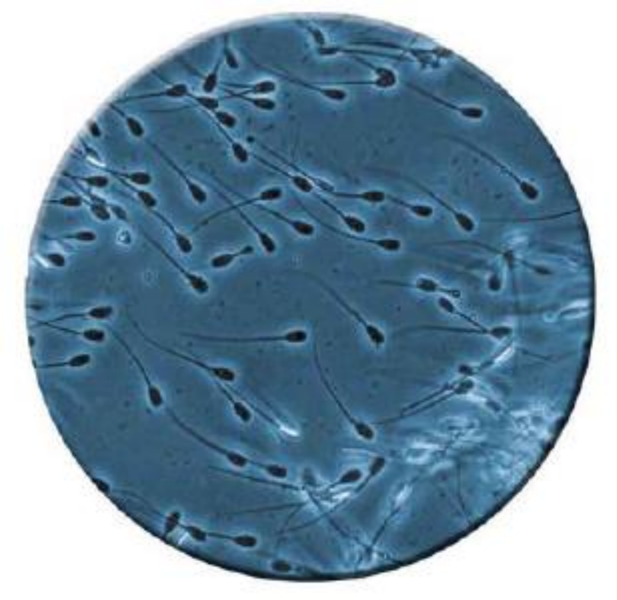
Artificial insemination

2. Evaluation

- Volume

- Motility

- Concentration



Artificial insemination

***Sperm Vision^{TM}* - Digital image technology for automatic, objective, immediate and accurate sperm analysis**

Artificial insemination

3. Dilution with semen extenders, processing, and freezing

Freezing is performed by means of liquid nitrogen at the temperature of -196°C

The frozen semen can be preserved for decades

It can be easily shipped to all parts of the world

Frozen bull's semen, preserved in straws

Diluted boar's semen, preserved in tubes

Semen Extension

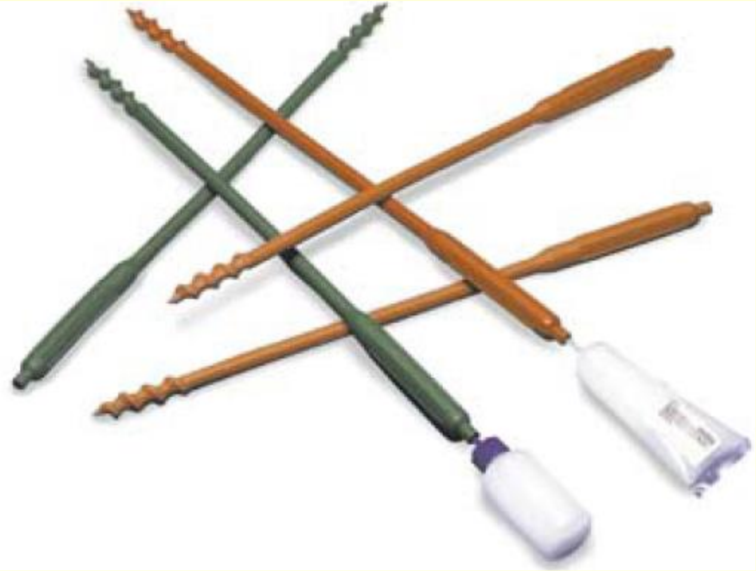
The main reason for extending (or diluting) the semen is to increase the number of females that can be inseminated from one ejaculation. A normal ejaculated from a dairy bull will contain 5 to 10 billion sperm, which can be used to inseminate 300 to 1000 cows if fully extended.

Artificial insemination

4. Thawing and insemination

Thawing unit with thermostatic control (38℃)

Catheters for cow insemination



Catheters for swine insemination

A.I. Possibilities:

Class	ml/ejaculate	Sperm concentration (million/ml)	No. of Females
Bull	4 – 7	800 - 1500	300 – 1000
Ram	1	800 – 4000	40 - 100
Boar	200 – 500	150-200	15 – 25
Stallion	50 – 150	30 – 800	8 - 12

Heat Synchronization

Estrous Synchronization

- Benefits of controlled breeding programs

✓ Improve efficiency of heat detection

✓ Control timing of first service postpartum

✓ Reduce variation of calving intervals

✓ Reduce reproductive culling

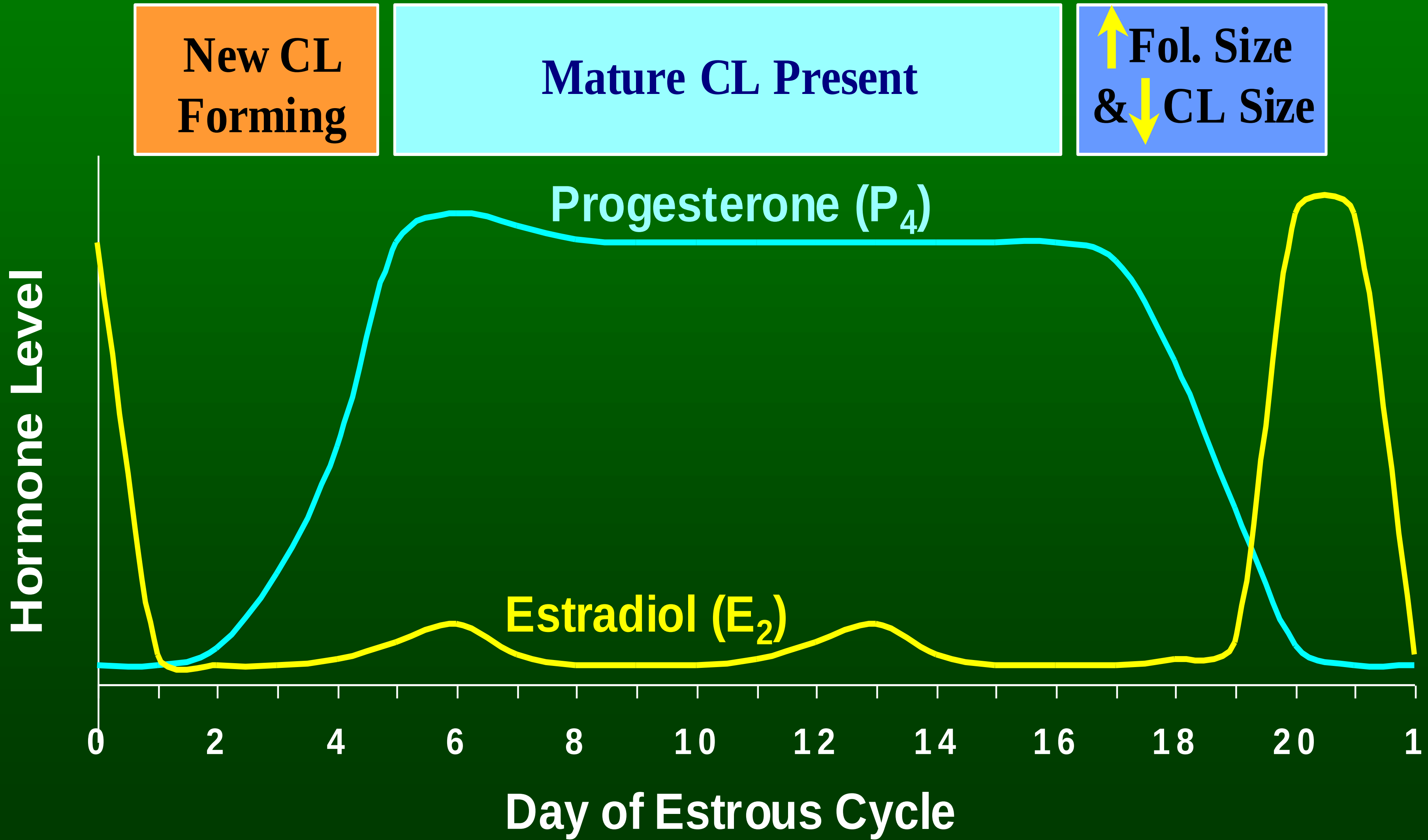
✓ Concentrate calving labor needs to certain times

✓ Improve reproductive performance

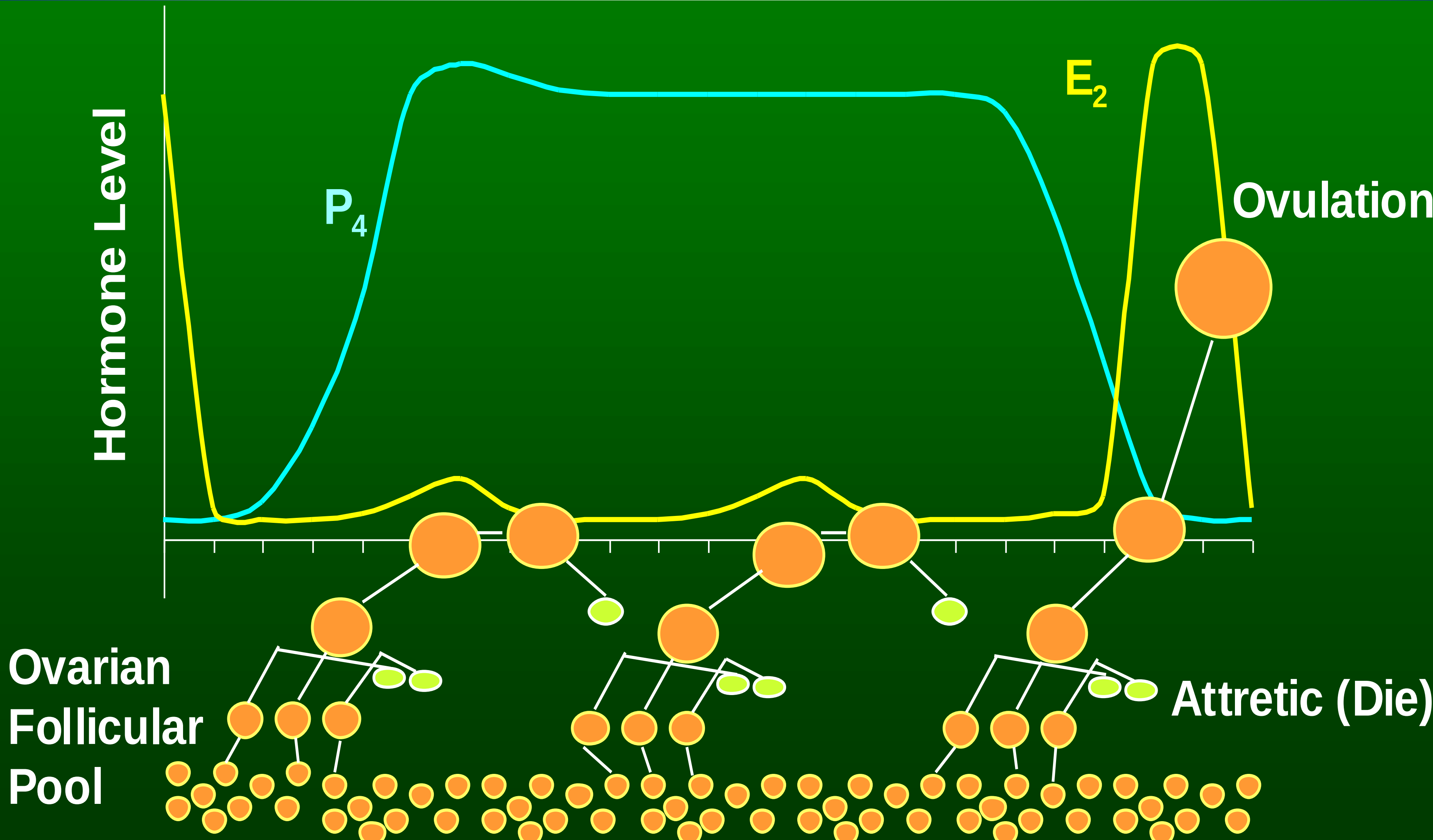
Potential Benefits of Controlled Breeding Programs

- Improve efficiency of heat detection
- Control timing of first service postpartum
- Reduce variation of calving intervals
- Reduce reproductive culling
- Concentrate labor need to certain times
- Improve reproductive performance

Estrous Cycle



Follicular Waves



Single Injection w/ Post-Breeding

Inject $PGF_{2\alpha}$

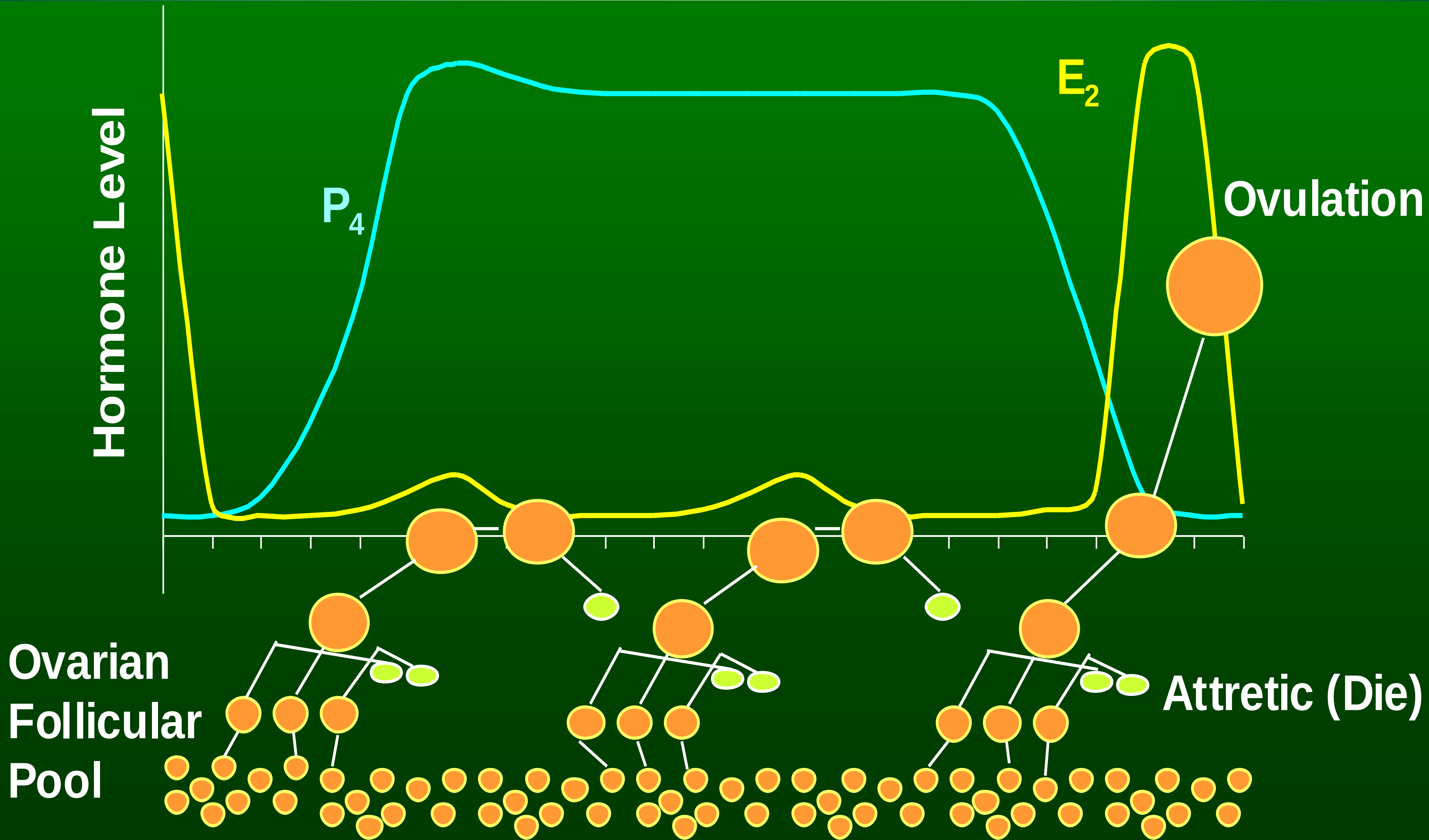
Turn in Bulls

Day 0

Day 5

Check for estrus and inseminate

Follicular Waves



Select Synch

GnRH injection

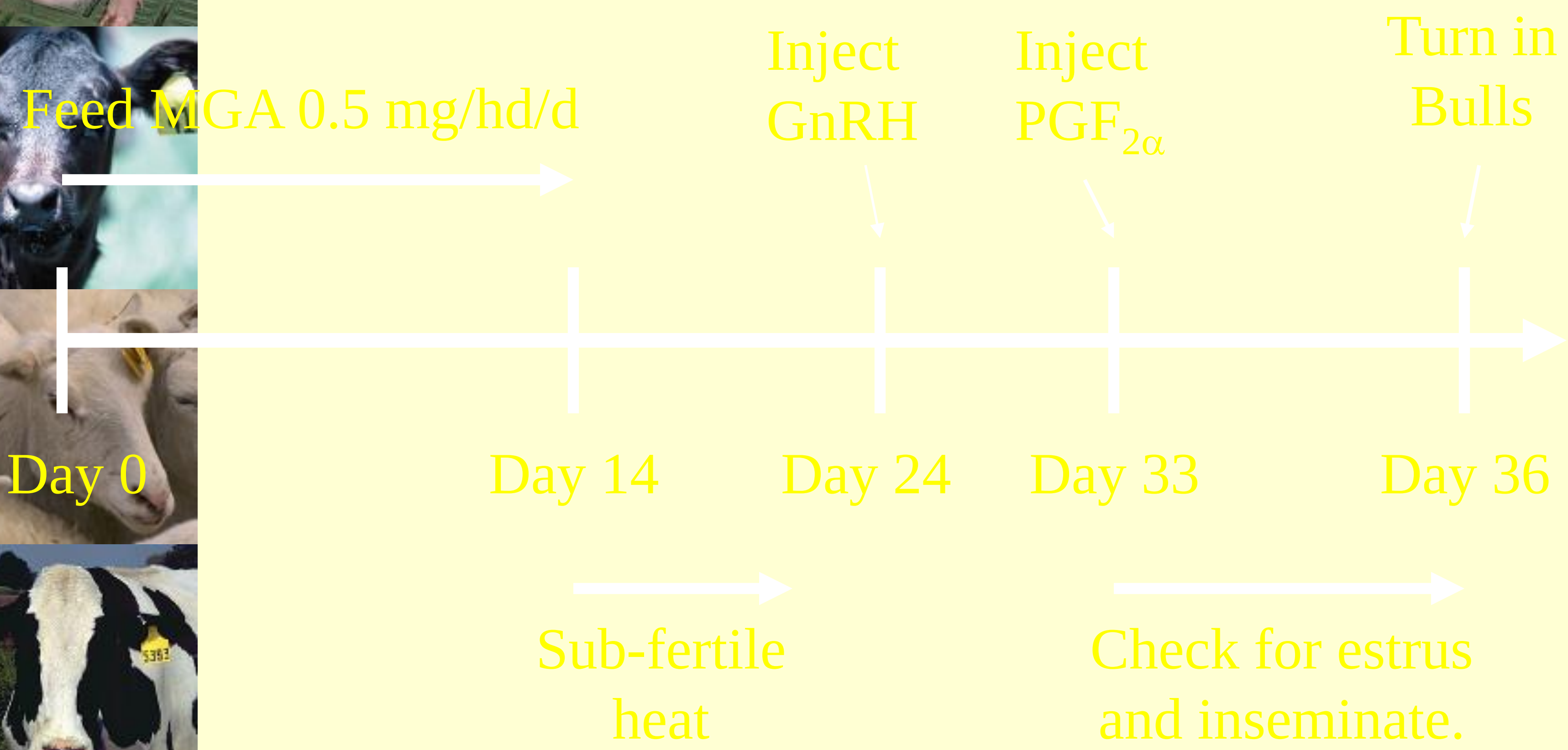
Day 0

$PGF_{2\alpha}$ injection

Day 7

Check for heat and breed
Day 6 to12

MGA-GnRH-PG (MGA® Select)



Comparing the Options

Treatment	Estrus Response	Pregnancy Rate
2 Shot PG	57%	35%
MGA-PG 14-19	83%	63%
Select Synch	67%	45%
Ov-Synch	NA	52%
CO-Synch	NA	55%
MGA Select	85%	66%
7-11 Synch	91%	68%

Embryo transfer

Embryo transfer – placing of an embryo of donor into the uterus of recipient

The main advantages of embryo transfer:

More intensive utilization of genetic potential of outstanding cows

Accelerate creation of highly productive lines and families

Obtaining twins through transfer of 2 embryos to 1 recipient

Preservation of rare and extinctive breeds

Embryo transfer

Embryo transfer – a 7 step process:

1. Synchronizing heat cycles of donor and recipient cows

2. Obtaining the large number of ova from the donor cow – super-ovulation

3. Breeding donor cow

4. Collecting ova from donor cow, 5 days after breeding

5. Examining and evaluation eggs

6. Preparation of foster mother

7. Transfer eggs to recipient

Blood typing

Blood typing – a study of the components of the blood (genetic markers), which are inherited according to strict genetic rules

It allows:

to verify parentage

to identify freemartins (sterile heifers born co-twins with bulls)

to use certain blood types in the marker-assisted selection

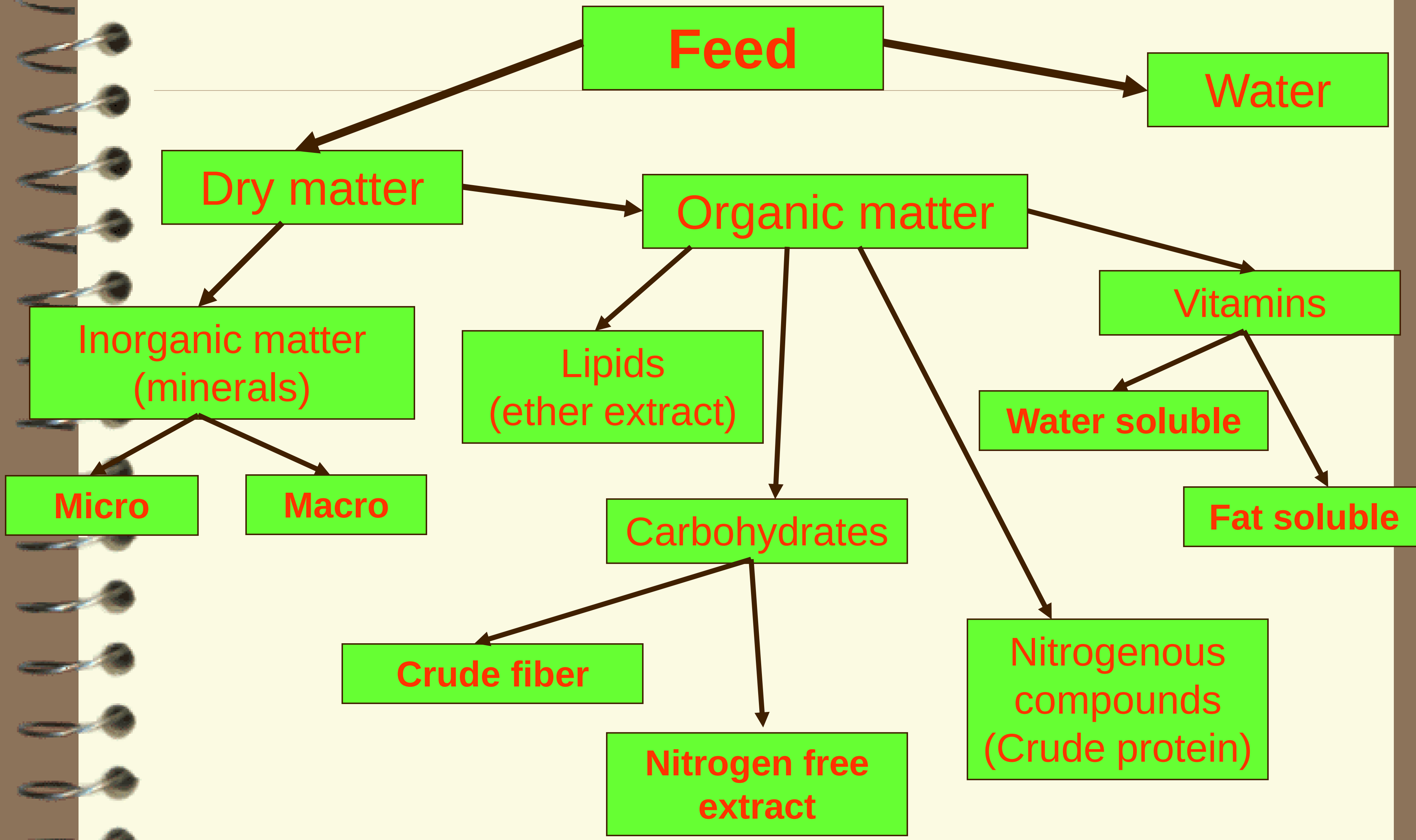
General Livestock Feeding. Classes of Feeds

Chemical composition of feedstuffs

Energy value of feeds

Feeds classification. Classes of feeds, their nutritive characteristics and scope of application

I. Chemical composition of feedstuffs



Water

- Most vital nutrient ingested
  - May lose 100% of body fat, 50% of body protein and live
  - Lose 10% of body water, dehydration occurs and may result in death
  - Water requirements are often not listed, but it is assumed that animals have free access to good quality water for optimum performance

Water

- Dietary needs
  - ➔ Cattle 40-80 liters/day
  - ➔ Horses 40-80 liters/day
  - ➔ Sheep 4-12 liters/day
  - ➔ Swine 4-8 liters/day
  - ➔ Poultry 2:1 water: dry feed ratio

Carbohydrates

- Carbohydrates are divided into two groups, CRUDE FIBER & NITROGEN-FREE EXTRACT.
- Fiber because of the lignin, cellulose and hemicellulose it is less efficient feed than NFE.
- The NFE group includes sugar, starch and some hemicelluloses.

Carbohydrates

- Starch
  - Non-structural or non-fibrous polysaccharide
  - Starch is made up of many molecules of glucose.
  - Grains have a high feeding value because the starch is easily digested.

Carbohydrates

- Cellulose
  - Structural or Fibrous polysaccharide
    - Less digestible
    - Requires microbial digestion

Carbohydrates

- Functions
  - Source of energy for bodily functions
  - Carbon skeletons for building other nutrients
  - Milk synthesis

Lipids

- Functions
  - Dietary energy source
  - Source of essential fatty acids
  - Insulation
  - Carrier of fat soluble vitamins
  - Major factor in quality grading of beef and pork

Lipids

- Essential fatty acid = Those fatty acids that an animal requires, but which it cannot synthesize in adequate amounts to meet the animal's need
  - Linoleic
  - Linolenic
  - Arachidonic
- Monogastric animals require a minimum of 1% of dietary essential fatty acids in the diet
- Necessary for production of some hormones and hormone like substances

Proteins

- Functions
  - Structure of organs and soft tissues
  - Enzymes
  - Hormones
  - Antibodies
  - Skin, Hair
  - Milk synthesis

Protein

- some animals need more protein than others:
  - young animals
  - lactating (milk producing) animals
- no other nutrient can replace protein in the diet
- depending upon the species, the minimum level of protein needed in the ration ranges from 8 to 21 percent

Protein

- Crude protein content

  - all of the nitrogenous compounds found in a feed.

  - calculated by multiplying nitrogen content percentage times 6,25 (the nitrogen content of protein averages 16%)

Protein

- Digestible protein

  - the protein in a feed that can be digested and used by the animal

  - usually about 50-80% of crude protein

Amino Acids

- Organic acids containing one or more alpha-amino groups that form the building blocks of proteins.
- The average protein contains 100 or more amino acids.
- There are 23 types of amino acids commonly found in proteins: 10 of them are essential

Dietary Essential Amino Acids

- Those acids which must be provided in the ration of non-ruminant animals because the animals cannot synthesize them fast enough to meet their needs.
- Ruminant animals can generally synthesize the essential amino acids by rumen microbial action.
- Non-essential amino acids are synthesized in the body from other amino acids and therefore, do not have to be provided in the ration.
- There are 10 essential and 13 nonessential for swine and 14 for poultry.

Dietary Essential Amino Acids

- Phenylalanine
- Valine
- Threonine
- Tryptophan
- Isoleucine
- Methionine
- Histidine
- Arginine
- Leucine
- Lysine

Amino Acids

- The quality of a protein is related to its amino acid content.
- High quality protein have a good balance of the essential amino acids.
- Poor quality proteins are deficient in amount or balance of the essential amino acids.
- When feeding non-ruminant animals, the amino acid content of the protein is of greater importance than the percent of protein present in the feed.

Dietary limiting amino acid

- The term for the essential amino acid that is present in the lowest amount in the feed
- Essential amino acids are required in the ration in definite proportions
- Lysine, Methionine and Tryptophan – are limiting amino acids in the ration, their content and proper relations are critical control points in feeding management

Basic Minerals for Proper Animal Nutrition

- Minerals are a group of inorganic elements needed by livestock for production and maintenance.
  - Because they are inorganic, minerals cannot be synthesized by animals or microorganisms
  - If a particular mineral is needed, it must be provided in the diet in a form that can be digested, absorbed, and used in metabolism
  - Rations must be formulated so that a mineral imbalance does not occur.

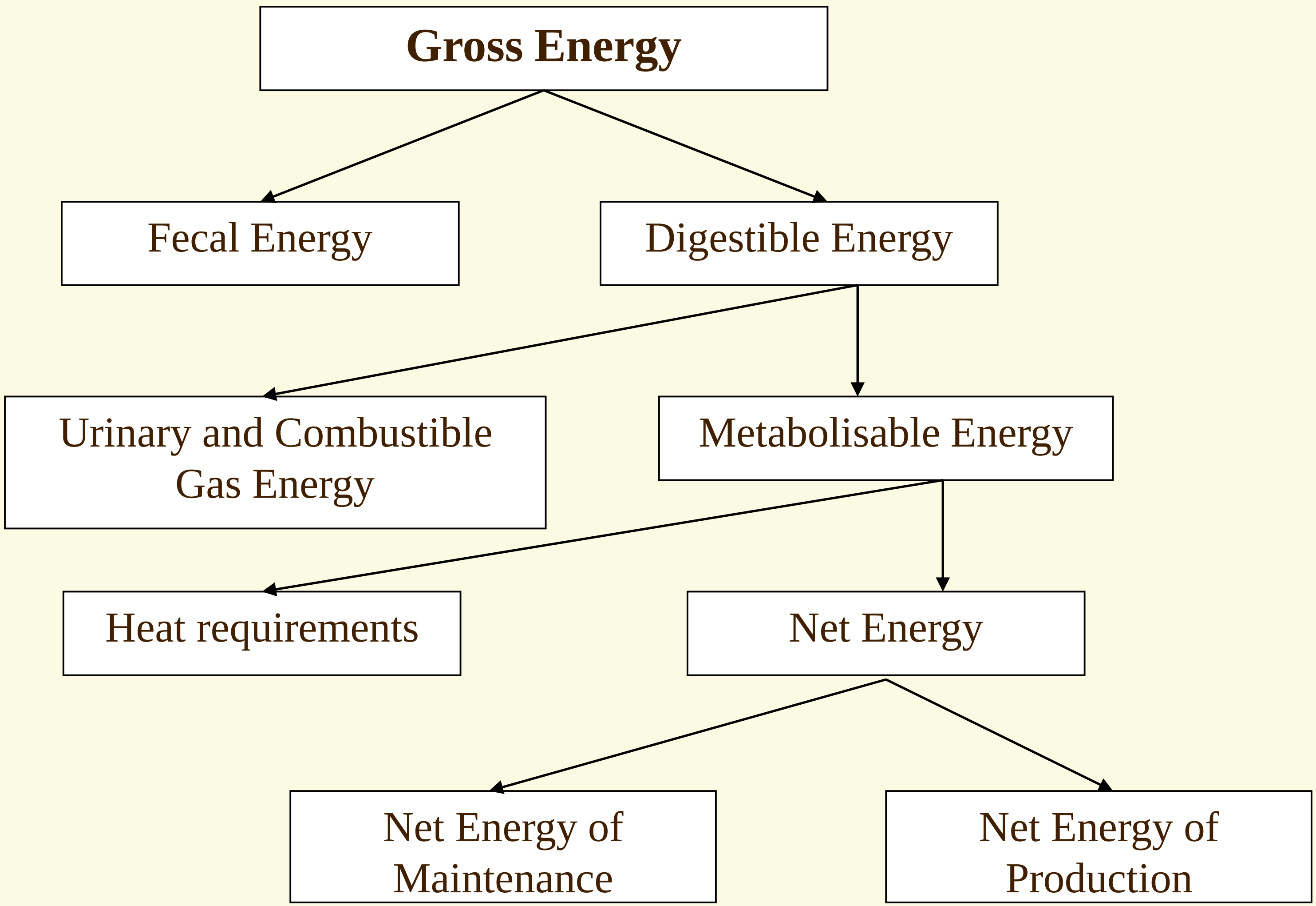
Minerals are classified according to the dietary concentration needed to fulfill the animal’s requirements

- Major (Macro) – needed in large amounts
  - Calcium
  - Phosphorus
  - Potassium
  - Salt – sodium chloride (NaCl)
  - Sulfur
  - Magnesium

- Minor or Trace – needed in small amounts
  - Iron
  - Copper
  - Cobalt
  - Iodine
  - Manganese
  - Selenium
  - Zinc

- General Functions of Minerals
  - Growth and development of bones, teeth and soft tissues
  - Regulation of cell acid:base balance
  - Part of organic compounds such as protein, amino acids, carbohydrates, and fats
  - Component of enzymes
  - Necessary components of hormones
  - Essential part of blood, body fluids, and some secretions in the body
  - Egg production

II. Energy value of feeds



Gross energy (GE)

- represents the total energy in a feedstuff.

Digestible energy (DE)

- is that portion of the GE in a feed that is not excreted in the feces.

Metabolizable energy (ME)

- represents that portion of the GE that is not lost in the feces, urine and gas. It more accurately describes the useful energy in the feed, but not take into account the energy lost as heat.

Net Energy (NE)

- represents the energy fraction in a feed that is left after the fecal, urinary, gas and heat losses.
- NE is a most precise measure of the real value of the feed than other energy values. But it is much more difficult to determine.

Oat Feed Unit (OFU) system

- feeding value of 1 kg average quality oat, which, fed to a mature steer over a maintenance ration, results in deposit of 150 g fat
- All feeds are compared by oat equivalent basis (oat feed units, OFU)
- 1 kg of oats=1 OFU, 1 kg barley = 1,15 kg OFU, 1 kg yellow corn = 1,33 kg OFU, 1 kg corn silage = 0,20 OFU etc.

OFU Advantages

- it has been used for a very long time and many people are acquainted with it

OFU disadvantages

- it is an empirical method based upon chemical determinations that are not related to actual metabolism of the animal
- it is expressed in weight (kg), whereas energy is expressed in calories or joules
- it takes into consideration only digestible losses; it does not take into account other important losses, such as losses in the urine, gases, and increased heat production

III. International Feed Classes

- Five main classes of feeds, based on composition and use.

Feed Classifications

- Forages
- Concentrates
  - Energy Concentrates
  - Protein Concentrates
- Minerals
- Vitamins
- Feed Additives

1. Forages

- Bulky feeds low in weight per unit
- Contain more than 19% crude fiber in DM
- Low in Energy
- Natural feeds of ruminants
- Generally low in digestibility
- High in Ca, K, and trace minerals
- Higher in fat-soluble vitamins
- Protein varies (from 3% to 22-23% CP)

Forages

- Pastures
- Hay
  - varies more than any other feed
  - harvest at optimum time
  - if cured properly, contain 20% moisture or less
- Crop Residues
  - left in field after harvest
  - straw, corn stalks, chaff etc

Forages

- Silage = fermented forage plants
  - mostly corn or sorghum
  - 2 1/2 to 3 kg silage replaces 1 kg hay due to lower dry matter content of silage
- Haylage = low moisture silage
  - grass or legume wilted to 40-60% moisture before ensiling
  - more dry matter & feed value

Forages

- Green Chop (soilage)
  - fresh plants cut and chopped in the field, transported and fed to animals in confinement
  - 50% more feed value
  - extra equipment required
  - harvest every day

Forages

- Other Roughages
  - beet tops
  - root crops
  - oat hulls

Forages as Energy Sources

- Forages (roughages) can supply some of the energy needs in the livestock ration, although they are not as concentrated source of energy as the grains.
- Value of forages for livestock feed is highly dependent on time of harvesting.
- As forage plants mature, the crude fiber content (cellulose and lignin) increases, which lowers the digestibility of the feed.
- When forages are harvested as silage, more of the nutritional value of the plant is preserved.

Corn Silage

- Corn silage, which contains almost 50% grain on a dry matter basis, is an excellent energy source for certain classes of livestock.
- Sorghum and small grain silages are lower in energy content than corn silage.

Straws

- Oat, barley and wheat straws are low in energy value and are not used as a major source of energy.
- It may be used if additional fiber is needed in the ration.

Pastures

- Properly managed pastures can be a good source of nutrients.
- Rotating and fertilizing pastures to get the best yield and nutritional value.
- Quality of pasture must be closely watched and supplemented with good quality stored forages when necessary.

2. Concentrates

- Feeds high in energy an low in fiber (under 19%)
- Highly palatable and eaten rapidly
- Low volume per unit of weight (high specific gravity)

Energy Concentrates

- A major source of energy nutrients is the cereal grains and grain byproduct.
- These feeds are called energy concentrates or basal feeds when their crude protein is less than 18% in DM.

Corn (Maize)

- One of the highest energy feeds available.
- The most widely grown and used feed grain crop.
- It is an economical and superior source of energy.
- Consideration must be given to amount to feed, frequency and combinations with other feeds, in order to get the most efficient use of this high energy feed source without causing digestive problems.

Oats

- About 85% of the energy of corn.
- Higher in crude protein than corn and add fiber and bulk to the ration.
- Help the rumen maintain bacterial and protozoa function.
- Not a good fattening feed but are used extensively in rations for horses, young growing stock, breeding animals.
- Usually fed rolled or ground.

Barley

- Almost equal to corn in energy value, but lies between corn and oats in fiber content.
- Used in a ration in a manner similar to oats.
- Barley may replace up to 50 % of the corn in rations for fattening animals.
- To improve palatability it is often steam rolled

Wheat

- High in both energy and protein.
- Wheat is similar to corn in composition and feeding value.
- If and when it is used in a ration it is included at low levels in a mix with other grains because it is rapidly digested and may cause digestive disturbances.

Grain Sorghum

- There are many varieties and various hybrids.
- Smaller than corn and may replace up to 100% of the corn in a feedlot ration.
- Generally rolled or ground when included in a ration.

Rye

- Rye is usually used for bread for human consumption and has limited use as a livestock feed.
- It is not as valuable as corn, whet or grain sorghum.
- Ergot contaminated rye can be toxic to livestock.
- The use of rye in livestock rations should be limited to no more than one-third of the ration.
- It should be coarsely ground or rolled to increase palatability.

Peas

- By 10% less energy value then that of corn.
- Significantly higher in crude protein than corn (up to 20% CP per 1 kg).
- A good source of protein and lysine .
- But includes some undesirable factors, which may cause digestive disturbances .
- Better to use after heat treatment (extrusion)

Sources of Energy---Fats & Oils

- A byproduct of oil and packing plants, poultry processing plants.
- Fats and oils in the feed reduces the dustiness of the feed.
- A highly concentrated source of energy (at least 300% of corn energy value)
- Increases calorie density of a ration (2,25 times energy of carbohydrates)
- Often treated with antioxidants to prevent the feed from becoming rancid in storage.
- Beef and dairy rations can contain up to 5% while swine rations may have up to 20%.

Sources of Energy---Molasses

- By-product of sugar manufacture
- Common types of molasses are cane, beet, citrus and wood.
- ¾ energy value of corn
- Molasses is used in rations for cattle, sheep and horses but is seldom used in swine rations, because it causes scouring.
- Appetizer, improves palatability, aids rumen microbial activity, reduces dust and serves as a binder when feeds are pelleted.
- Molasses is usually limited to not more than 10-15% of the ration.

Protein Concentrates

- Protein Supplements
  - Plant Origin (Oil By-Products: Meals and Cakes)
    - Expeller or Hydraulic Process - Crushed, Heated, Pressed, Ground = Cakes
      - 5% residual oil remains in cake
    - Solvent - Cracked, Heated, Rolled, Extracted with Hexane and Flakes Toasted and Ground = Meals
      - 1% residual oil remains in meal

Protein Concentrates

- Soybean Meal
  - Most Widely Used
  - Standard for Comparison of Other Protein Sources
  - Very palatable and digestible

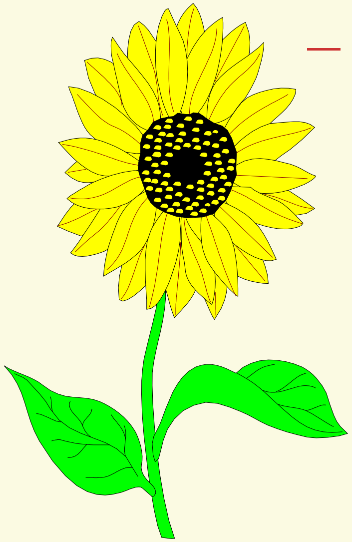
Protein Concentrates

Soybean Meal

- 44% CP = standard meal
  - soybean meal plus 5% soy hulls
  - used for ruminants, horses, older swine
- 48% CP= high protein meal
  - soybean meal
  - no soy hulls, very refined
  - higher protein, lysine
  - lower fiber
  - used for baby pigs and poultry

Protein Concentrates

- Sunflower Meals and Cakes
  - Protein varies with Process Used
    - 28, 32, 38 or 40%
  - Can Replace 30-50% of SBM in Swine Diets
  - Ruminants Can Use as a Sole Protein Supplement



Protein Concentrates

- Linseed meal
  - Mechanically extracted
  - Contains residual oil
  - Popular among horse owners and show animal feeders because of hair coat
- Peanut meal
  - 50% CP

Protein Concentrates

- Rapeseed Meal
  - Feeding Problems
    - Erucic Acid
  - Fed to Swine at 5% of Diet, Not Fed to Ruminants

Distiller's Byproduct Feeds

- Feeds Produced by the Fermentation of Grains (normally corn) for Alcohol Production
- Generally fed wet
- Concentrates Produced
  - Distiller's Dried Grains - Dried Grain Fraction.
  - Distiller's Dried Solubles - Condensing the Thin Stillage Fraction and Drying it.

Brewery By-Products

- By-Products as a Result of the Brewing Industry
  - Feed Products
    - Brewer’s Dried Grains - Dried Residue from Malting Process.

Protein Concentrates

- Protein Supplements
  - Animal and Marine Origin
    - Derived from Meat or Poultry Packing Plants, Rendering Plants, Surplus Milk or Milk By-Products, Marine Sources
    - Added to Improve Mixture
      - Rich in CP, lysine and other AA
      - Low in Sulfur and Tryptophan

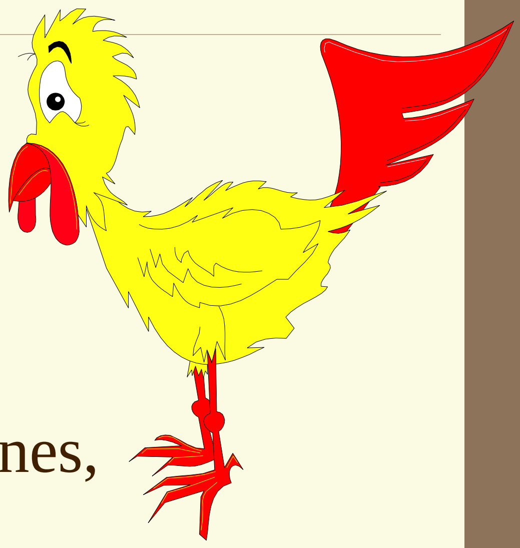
Protein Concentrates

- Protein Supplements
  - Tankage
    - By-Product from Meat Packing or Rendering
    - Unusable Animal Tissue (Bones, Gut, Tendons, Connective Tissue, Blood Meal)
    - If it Contains a Minimum 4,4% P it's called Meat and Bone Tankage
    - No Hair, Horns, Manure, Gut Contents or Hide

Protein Concentrates

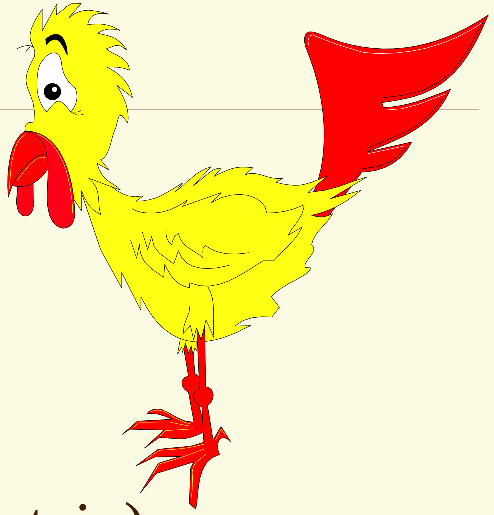
- Protein Supplements
  - Blood Meal (90% CP): excellent amino acid balance
  - Meat Meal (50 - 60% CP)
    - Contains Less Gut, Tendons and Connective Tissue than Tankage
    - Normally no Blood Meal
    - If 4,4% P it's called Meat and Bone Meal

Protein Concentrates



- Protein Supplements
  - Poultry By-Products
    - Poultry By-Product Meal
      - Contains Heads, Feet, Intestines, Undeveloped Eggs
      - No Feathers

Protein Concentrates



- Protein Supplements
  - Poultry By-Products
    - Feather Meal
      - 85% CP (75% digestible protein)
      - No more than 3% of swine diets

Protein Concentrates

- Protein Supplements
  - Fish Meal
    - Whole fish, fish cuttings; with or without oil
    - 66% CP, 6% Ca and 3,5% P
    - exceptional source of essential amino acids
    - contains “amines” which cause fishy smell in poultry or swine fed fish meal immediately prior to harvest as well as laying hens

Protein Concentrates

- Protein Supplements
  - Shrimp meal, crab meal, etc.
    - Exoskeleton contains “chitin” a cellulose-like polysaccharide that is very poorly digested
    - Protein content derived from meat residue

Protein Concentrates

- Protein Supplements
  - Animal Waste
    - Used Primarily in Ruminant Diets
    - Normally Broiler Litter (31% CP, 17% CF, 15% Ash)
    - 10-60% of the Protein Exists as NPN

Protein Concentrates

- Protein Supplements
  - Non-protein Nitrogen products
    - Urea
      - Requires readily available carbohydrate source to provide carbon chains for microbial protein synthesis
      - Rapidly degraded in rumen
      - May require adaptation period
      - Maximum levels established due to toxicity problems

Protein Concentrates

- Protein Supplements
  - Milk By-Products
    - Whey
      - Wet
        - By-Product of Cheese Manufacturing
      - Dried
        - 11% CP, 61% Lactose

Protein Concentrates

- Protein Supplements
  - Milk By-Products
    - Dried Whole Milk
    - Dried Skim Milk
    - Dried Buttermilk

Special Feeds of Animal Origin

- Colostrum: first milk given by mammals after parturition
  - contains antibodies
  - within 15 min to 4 hours
  - surplus colostrum can be frozen for up to a year or more
  - can feed cow colostrum to lambs etc., but some diseases are species specific

Special Feeds of Animal Origin

- Milk Replacers
  - can't replace colostrum
  - a good replacer should contain up to 20% dried milk
  - fortified with vitamins, minerals & antibiotics
  - can be used as whole milk diet alternative in rearing programs

Feed Additives

- 80% of farm animals get some drug during lifetime
- chemicals that regulate growth, modify rumen activity, improve feed efficiency
- lower production costs
- unsafe if used improperly

Feed Additives

- Abortifacients = induces abortion
  - feedlot heifers
- Antibiotics = produced by living organisms, bacteriostatic properties
  - growth stimulators
  - better feed efficiency

Antibiotics

- Low levels in feeds
- High (therapeutic) levels in feeds

Antioxidants

- Prevent oxidative rancidity of fats
- Other methods:
  - refrigeration
  - lack of light
  - lack of oxygen

Chemotherapeutics

- Similar to antibiotics
- produced chemically instead of biologically

Electrolytes

- Substance when disolved in water enables solution to conduct electric current
- Salts (saline)
- Replenish fluids lost from:
  – dehydration (heat stress, birth)
  – diarrhea
  – hemorrhage
  – vomiting

Flavouring Agents

- Increase palatability & feed intake
- Many additives taste or smell bad

Hormones

- Chemicals released by a specific area of the body, transported to another, to bring about a physiological response
- Increase growth, milk production, meat production

Implants

- Small pellets deposited under skin behind the ear
- Promote growth
- “Compudose”: steers any age or weight
- “Finaplex”:feedlot steers
- “Ralgro”:improves rate of gain
  - not a hormone (anabolic agent)

Ionophores

- Feed additives that change the metabolism within the rumen by altering the rumen microorganisms
- “Bovatec” & “Rumensin”
- Lower feed intake, gain same

Other Additives

- Mold inhibitors
- Probiotics - microbial cultures
- Steriods - increase muscle mass & eliminate pain
- Tranquilizers - quieting & curbing activity

General Livestock Feeding

Making a High Quality Forage

- Forage quality
- Factors, affecting forage quality
- Forage types
- Hay production
- Ensiling process
- Silage Production

What is forage quality?

- **Forage quality is a measure of the forage's capacity to provide the nutrients required to meet an expected animal performance**
- **Forage quality influences the amount of dry matter an animal will consume voluntarily and the energy derived from that feed**

Assessing Forage Quality

Chemical assessment

- Forage quality can be determined by a feed analysis which measures protein, energy, fiber, and mineral
- It may also be measured in terms of the rate of digestibility of forage material

Visual Assessment

- **Visually Assess for:**
  - **Color** - Green with no evidence of mold
  - ↑ **Leaf:stem** (80% of nutrients in leaf)
  - **Maturity** - seed heads, stems, moisture %
  - **Weeds** and trash

- **Moisture content**

Factors Affecting Forage Quality

- **Differences among forage species (e.g. legumes & grasses)**
- **Stage of plant growth-maturity**
- **Plant structure (leaf-stem ratio)**
- **Soil fertility**
- **Plant Density**
- **Harvest and Storage losses**

The importance of Forage Quality

- **The poorer the forage quality, the longer it remains in the ruminant digestive tract, which in turn, decreases animal productivity**
- **As forage quality declines, DM intake decreases**
- **Some of these negative effects can be overcome by processing the forages**

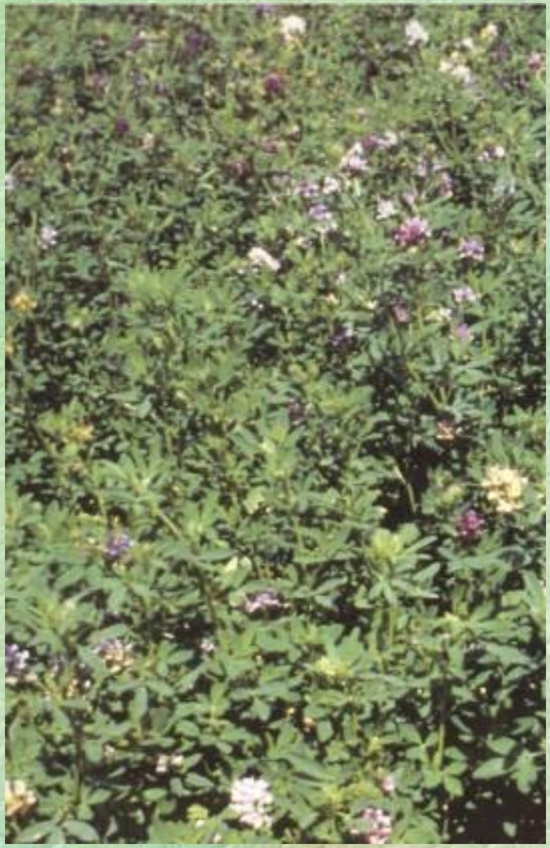
Forage Intake

- In ruminants - controlled by **physical fill**
  - Rate of **digestion**
  - Rate of **passage**

Forage Quality	Expected DMI (% of BW)
Low	1.50
Medium	2.00
High	2.50

Forage Types

- **Legumes**
  - Nitrogen fixers
    - Bacterial system associated w/roots
    - Assimilate N from the atmosphere
  - ↑ yields (3-4 cuttings)
  - ↑ protein (8-20% CP)
  - ↑ Ca and Mg
  - ↑ Vitamin A
  - ↑ Leaf:stem
  - Palatable



Alfalfa

Sweet clover

Alsike clover

Red clover

Sainfoin

Bird’s foot Trefoil

Forage Types

- **Grasses**
  - Long, blade-like leaf
  - > cell wall content (vs legumes)
  - Low to Moderate CP, dependent upon maturity
    - Young, growing plants: 8 - 14% CP
    - Mature, dormant plants: 2 - 6% CP
  - Moderate in Ca, but low in P
    - Can require year round Phos supplementation for many species


Crested Wheatgrass


Meadow Bromegrass


Timothy


Kentucky Bluegrass


English Ryegrass


Orchardgrass

Hay Production

- **Hay is a forage preserved by drying**
- **Dehydrated green forage: < 18% moisture**
- **Mechanical harvest**

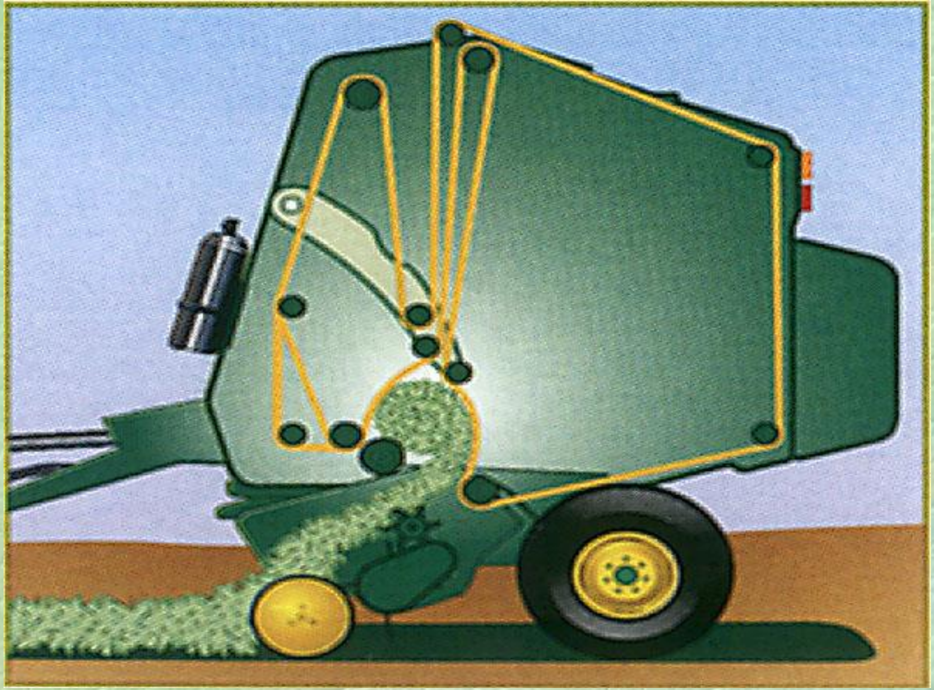
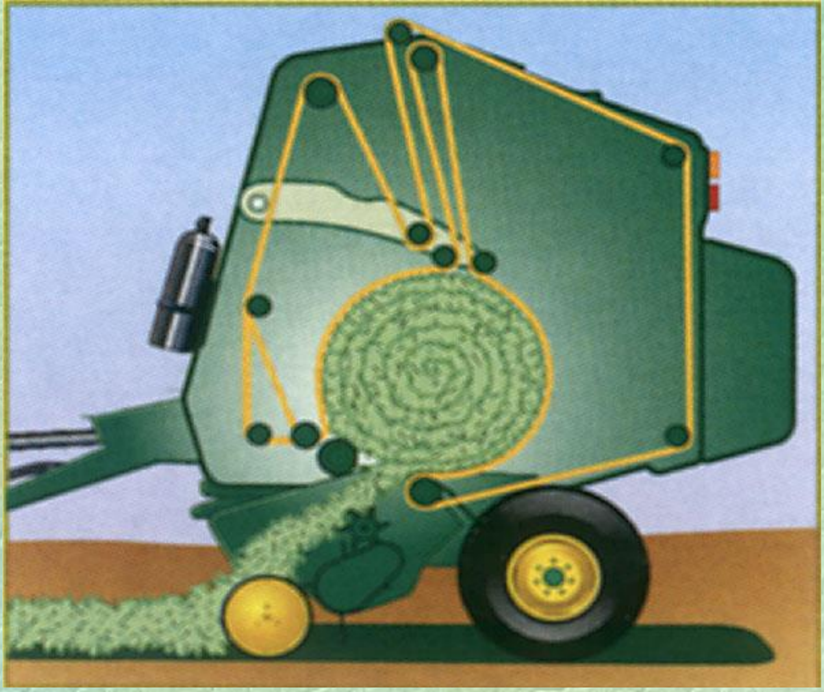
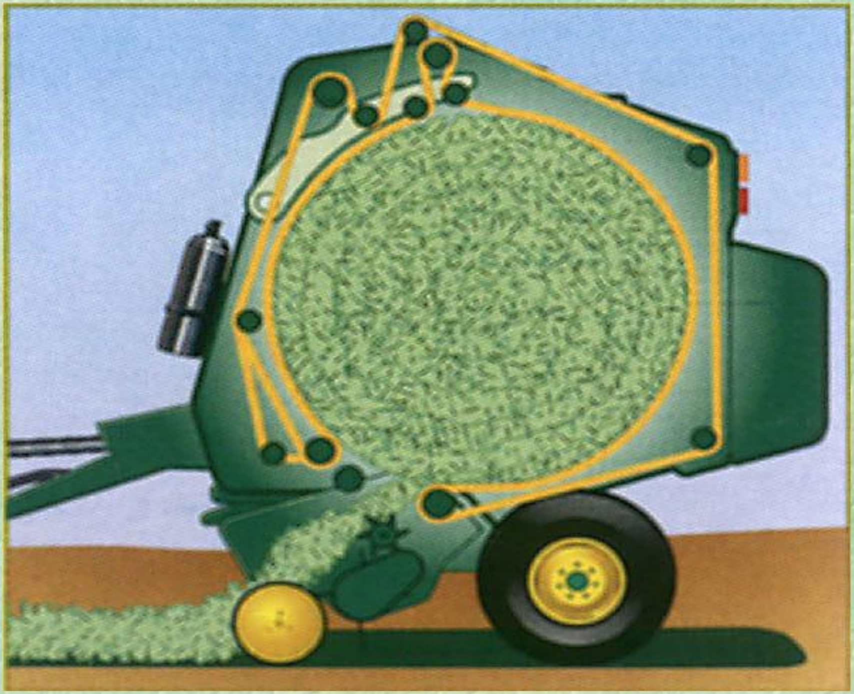
Forms of hay:

- Loose hay
- More progressive form: <u>Bales</u>

BALES

Rectangular:

Round bales

Hay Losses

- All methods of harvesting and storage involve loss of quality and yield
- Total crop losses from harvest and storage can range up to 30%
- Drying reduces the moisture content to a point where chemical and microbial action cease

Common Losses in Haymaking

- **Shattering** leaves
  - up to 8% loss for grass hays (5% normal)
  - up to 40% loss for legume hays (20% normal)
- **Heat damage**
  - 25-30% moisture promotes mold growth in hay
  - high moisture produces heat

Common Losses in Haymaking

- **Bleaching**
  - color loss due caused by the sunlight
  - reduces carotene or Vitamin A activity
- **Leaching** due to rainfall

- **Preventive Actions:**
  - Avoid over-maturing of stands
  - Cut, dry, bale and remove as soon as possible
  - Avoid excessive drying
  - Store on well drained site
  - Cover stacks

Stage of Maturity

- **Stage of maturity at cutting - the # 1 factor that determines the quality of the harvested forages .**
  - **If first cut delayed then RFV drops 3-4 points per day**
- **Cut early to minimize quality losses!**

Stage of Maturity

Cut at the right stage of maturity

- **Alfalfa at 10% bloom**
- **Grasses mostly at headed stage**
- **Earlier cutting gives high quality but sacrifices yield**
- **Later cutting (like full bloom) gives highest yield but sacrifices quality.**
- **Try to reach a satisfactory compromise**

Ensiling Process

Basic concept

- While haying conserves the forage by drying
- Ensiling (silage making) conserves high moisture forages by <u>acidification</u> (lowering the pH)
- Acidification is induced <u>biologically</u> by certain kind(s) of bacteria
- The bacteria causes the <u>fermentation</u>
- The key is to understand & properly <u>control</u> fermentation

Main phases of ensiling

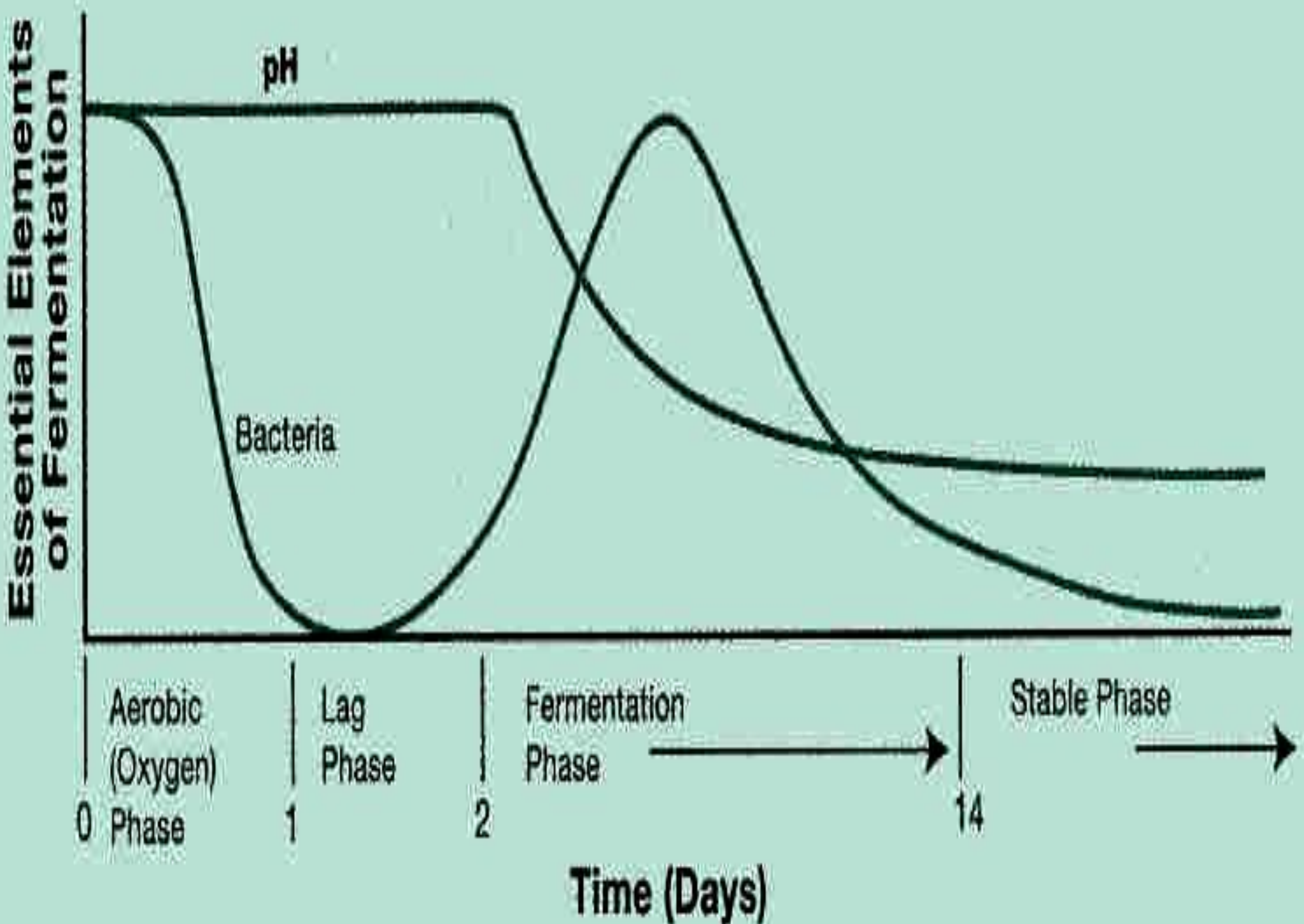
Phase 1: Aerobic

- Occurs in the presence of oxygen
- Plant enzymes and **aerobic** micro-organizms use the oxygen in respiration and consume the water-soluble carbohydrates.
- Lasts for few hours to several days
- As oxygen disappears the aerobic bacteria die and **anaerobic bacteria** begin to grow

Main phases of ensiling (concl.)

<u>Phase 2: Anaerobic</u>

- Occurs in the absence of oxygen
- The anaerobic bacteria multiply rapidly and the fermentation process begins
- Ideally: Lacto bacili species of bacteria which produce **<u>lactic acid</u>**
- Eventually, the **<u>pH</u>** is lowered inhibiting all microbial growth
- Takes 3-4 weeks


Essential Elements of Fermentation
pH
Bacteria
Aerobic (Oxygen) Phase
Lag Phase
Fermentation Phase
Stable Phase
0
1
2
14
Time (Days)

Factors affecting Fermentation

- Water-soluble carbohydrate content
- Buffering capacity
- Moisture content of the forage
- Type of bacteria that predominate
- Speed of fermentation

Water-Soluble Carbohydrates

- Fermentation may be limited by the amount of sugars in the forages (**<u>need 6-12% minimum</u>**)
- If the pH is not lowered it can not remain stable
- **Legumes** tend to have lower water soluble carbohydrates and that is why they are difficult to ensile
- **Grasses** will tend to have higher amounts when mature
- **Drought** will reduce the sugar content
- **High nitrogen** fertilizer tends to decrease the sugar content as well

Buffering Capacity

- Degree to which forage material resists changes in pH
- Forages with a high buffering capacity are highly resistant to lowering pH
- **Legumes** are usually well buffered and therefore require more acids to reduce pH
- **First cut** legumes are usually higher than second cut or third cut

Moisture Content

- The lower the moisture content, the higher the pH at which anaerobic stability is reached.
- Field wilting is beneficial
- Very wet forage is undesirable (greater than 70%)

Type of Bacteria

- Want lactic acid bacteria, but not always predominant

-Additives are formulated for this bacteria

Speed of Fermentation

-Try to put up silage as quickly and efficiently as possible

Requirements for Good Fermentation

- Exclusion of air
- Low Temperatures
- Rapid Acidification

Exclusion of Air

- Plant respiration results in the loss of nutrients which could be utilized by the animals
- Temperature will increase when oxygen is present (heat damage @ temperatures >30° C)
- Air encourages growth of harmful yeasts and molds

Low Temperature

- Temperatures of 15-25º C: growth of desirable bacteria
- Higher temperatures: formation of butyric acid and ammonia, lowering quality
- Should not exceed 30º C
- High temperatures (>40º C) cause heat damage (brown products - tobacco or caramelized smell) - the protein is then bound and unavailable to the animal

Rapid Acidification

- It is ultimately the drop in pH that makes silage stable
- high moisture situations require rapid ensiling

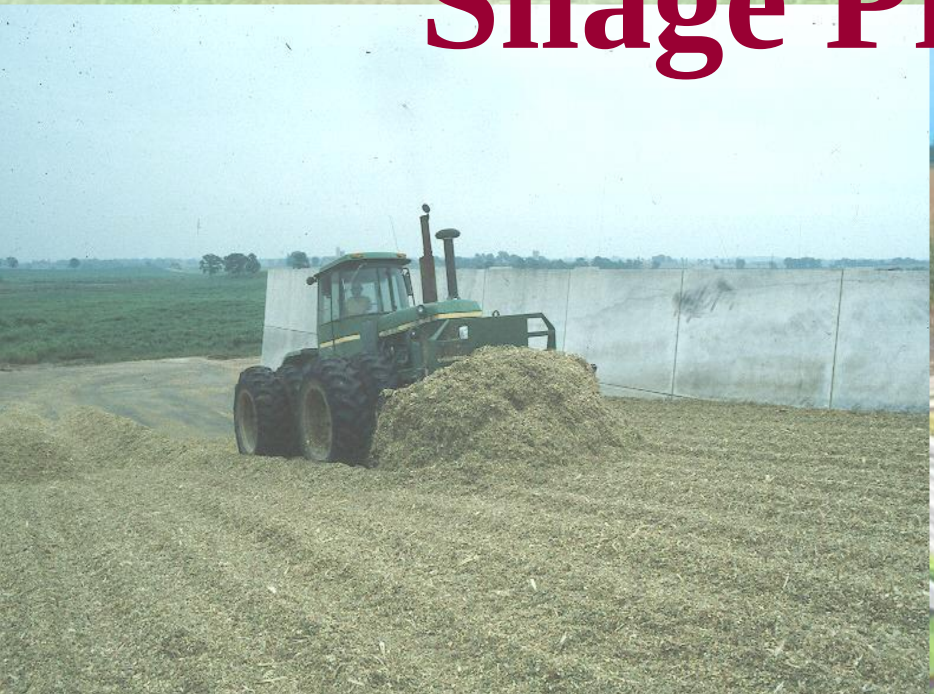
Controlling the Ensiling Process

- Moisture Content (65%, common silo types)
- Mechanical Pre-treatment (chopping and cutting)
- Rapid filling, packing and sealing
- Use of additives
- Opening the silo (exposure to oxygen)

To Realize Good Fermentation

- Harvest a forage that is young and rich in **soluble sugars**
- Reach and maintain **anaerobic** conditions quickly
- Reach and maintain a **low pH** that will remain stable

Silage Production



Silage

- Product of acid fermentation of green forage crops that have been compressed and stored under anaerobic conditions.

Advantages of Silage

- Silage can be harvested in almost any **weather** conditions
- **Lower dry matter losses** during harvesting (higher nutrients per hectare)
- Permits a wider **range of crops** than other forage systems
- Can **salvage crops** damaged by hail
- Large quantities of **uniform quality** feed can be stored
- **Palatability** in some cases improved

Disadvantages of Silage

- Requires **more labor** and time than hay
- Capital **investment** is required for extra machinery and storage facilities
- Has limited **market** potential
- Has an **odor** that may be offensive if stored

near populated areas

Losses during Silage Production

- Field losses
- Respiration losses
- Fermentation losses

Quality Silage Starts with Good Management!

- Moisture
- Maturity
- Weather
- Chop Length

Moisture

Crop	Upright	Bunker/Trench	Silo Bag
Alfalfa	50-65	60-70	50-70
Alfalfa/Grass	55-65	60-70	55-65
Corn Silage	60-70	65-72	60-70
Grasses	55-65	60-70	55-65
Small Grains	65-70	70-75	65-70

Maturity

Crop	Maturity
Alfalfa	Mid-bud to early bloom
Alfalfa/Grass	Mid-bud to early bloom for alfalfa boot for grasses
Corn Silage	Dough stage
Grasses	Boot stage
Small Grains	Soft dough stage

Weather

- The longer the wilting process the larger the dry matter losses
- Alfalfa that is too dry in the silo heats and has lower digestibility
- Warm and windy conditions tend to dry the crop in 3-4 hours
- Wilting of small grain is faster than for alfalfa

Chop Length

Crop/Moisture	Chop Length
Alfalfa, Legumes and Grasses	
65-75% moisture	0.95 cm
below 65% moisture	0.64 cm
Corn	
65-70% moisture	0.95 cm
60-65% moisture	1.3 cm
55-60% moisture	0.95 cm
Small Grains	0.64 cm

Legume vs. Cereal Silages

Legume

- Harder to make
- May not ferment properly
- May need silage additive
- High CP and Ca (buffers)
- Low soluble CHOs

Cereal

- High soluble CHOs
- Low buffers (CP and minerals)
- Ferments easily

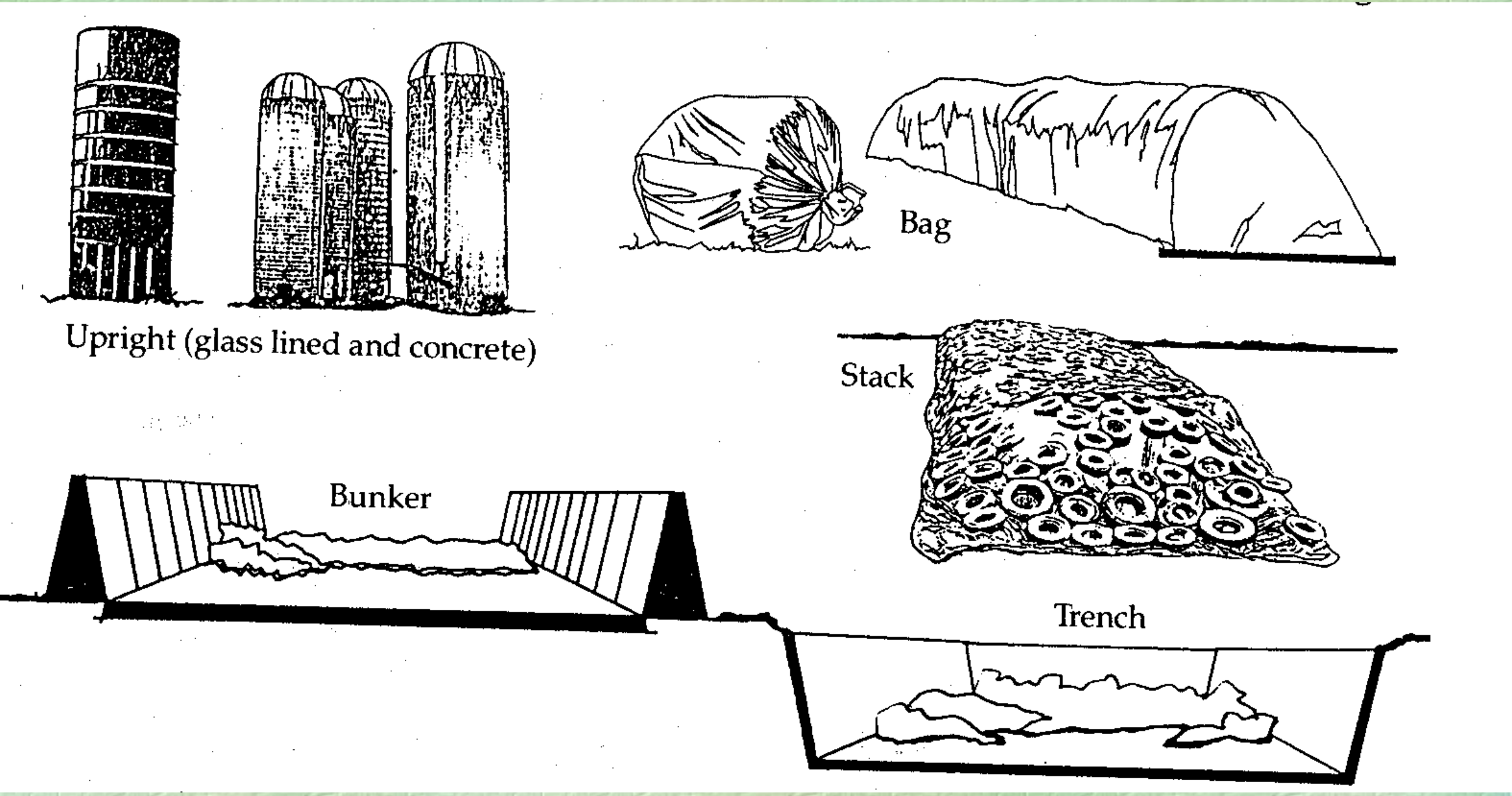
Filling, Packing and Sealing

- **Fill, pack and seal as <u>quickly</u> as possible to reduce nutrient loss**
- **Always distribute silage evenly and drive a heavy wheeled tractor over the silage to <u>pack</u> it down**

Sealing:

- Cover with airtight plastic that does not have any holes to speed up fermentation

Types of storage structures (silos)



Types of storage structures (silos)

Horizontal:
Simplest, least cost, large volumes
Below-ground: trench or pits
Above-ground: bunkers (walls needed)
piles (stacks)

Horizontal Silo Advantages

- Holds large capacity
- Can be filled with conventional farm equipment
- Offers faster unloading rates

Horizontal Silo Disadvantages

- **Higher initial cost**
- **Requires greater care in filling and packing**
- **Will not work for smaller herds**

Horizontal Silo Recommendations

- **Packing is essential for good silage preservation**
- **Must be covered to avoid large storage losses**
- **Face removal of more than 6 in/day is recommended to avoid spoilage**

Tower Silo Advantages

- **Smaller exposed surface area of silage**
- **Requires less area for construction**
- **Allows greater mechanization during filling and feedout**
- **Convenient to unload in wi**

Tower Silo Disadvantages

- **Higher initial cost**
- **Unloads more slowly**
- **Silage moisture cannot be as high as compared to other silo types**

Silo Bag Advantages

- **Lower capital investment**
- **Flexible storage system**
- **Feed is easily inventoried**
- **Can be used for small and large herds**
- **Fewer safety and health hazards**

Silo Bag Disadvantages

- **Bags must be protected to prevent rips and tears**
- **Specialized equipment may be needed**

Silage Pile Advantages

- **Inexpensive**
- **Good for short term storage needs**

Silage Pile Disadvantages

- **Large amount of exposed surface area**
- **Greatest loss of dry matter during storage**
- **More difficult to pack**

Silage Pile Recommendations

- **Packing is essential for good silage preservation**
- **Must be covered to avoid large storage losses**
- **Side walls should be 3 horizontal units for each vertical unit**


Silage Additives

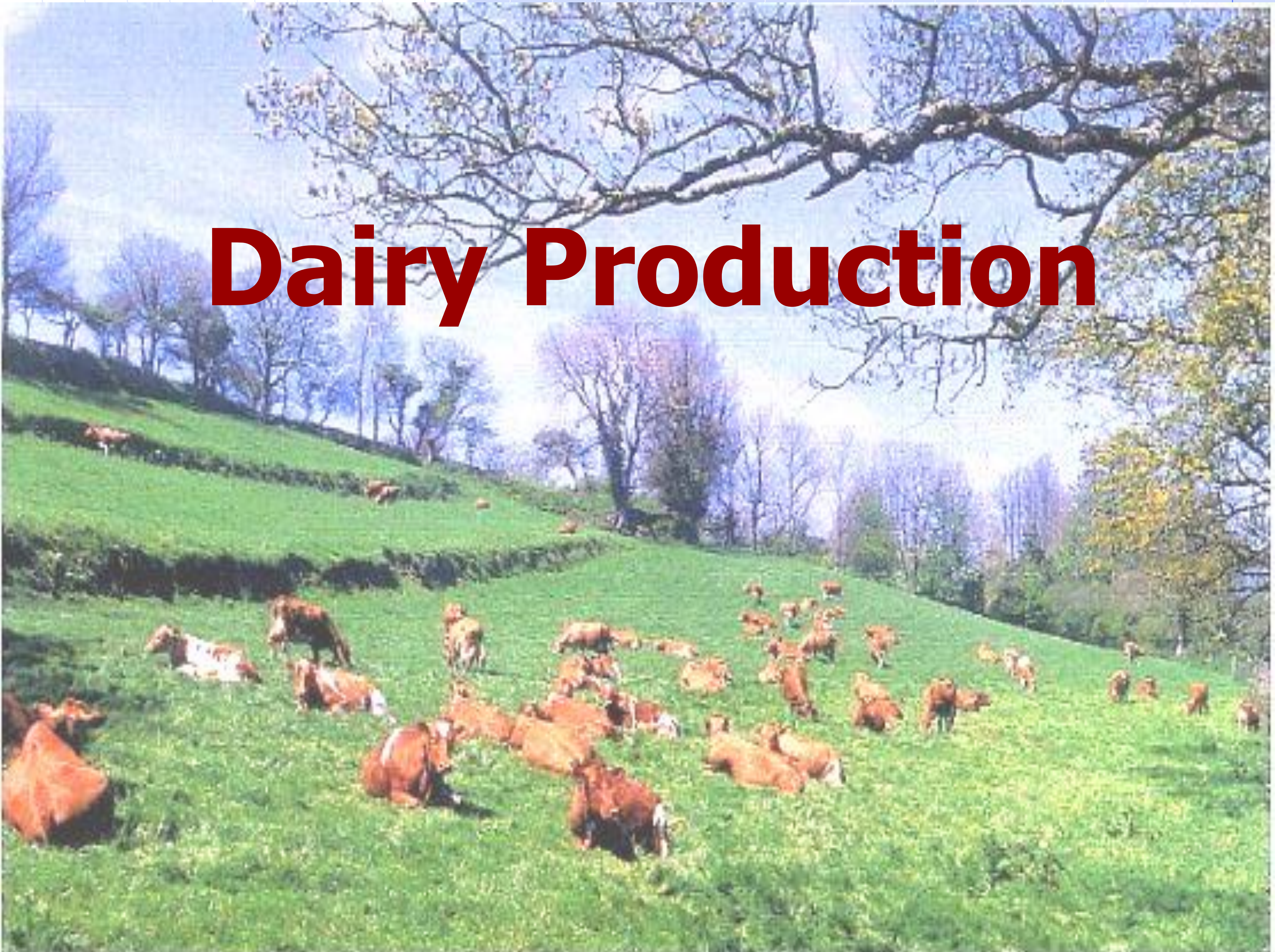
- Stimulate fermentation - ensure a well-fermented, low pH silage is achieved rapidly
  - CHO sources (corn, molasses)
    - Soluble CHOs for bacteria
  - Innoculants (bacterial cultures)
    - Ensure that proper species are present in silage

Remember

- Select the crop that works best for you
- Cut at right stage and chop to the right length

- Minimize losses by ensiling the forage as quickly as possible
- Level and PACK silage well
- Cover and seal the silage structure
- During feeding, remove the recommended amount of silage from the unloading face

Dairy Production



1. Milk composition and nutritional value
2. Dairy breeds overview
3. Dairy production in numbers
4. Factors, that influence milk performance of a dairy cow

What is Milk?

Definition of Milk

Definition - Normal secretion of the mammary gland of mammals

More precisely it is a very complex product that contains more than 100,000 chemicals that are either in solution, suspension or emulsion with water.

Milk

- Nature's most perfect food
- Nutritional value is greater than the sum of it's parts
- One of only two foods we eat whose sole purpose in nature is food (Honey is the other)
- High quality ingredients
  - Protein
  - Fat
  - Sugars
- Complete nutrition for the young animal

Variation in milk composition between species

Species	Water %	Fat %	Casein %	Whey protein %	Lactose %	Ash %	Energy (kcal/100 g)
Human	87.1	4.5	0.4	0.5	7.1	0.2	72
Rat	79.0	10.3	6.4	2.0	2.6	1.3	137
Dolphin	58.3	33.0	3.9	2.9	1.1	0.7	329
Dog	76.4	10.7	5.1	2.3	3.3	1.2	139
Horse	88.8	1.9	1.3	1.2	6.2	0.5	52
Cow	**87.3**	**3.7**	**2.6**	**0.6**	**4.9**	**0.7**	**66**
Reindeer	66.7	18.0	8.6	1.5	2.8	1.5	214

Factors That Effect Milk Composition in Dairy Cattle

- Breed
- Stage of Lactation
- Season
- Genetics
- Nutrition
- Disease – Mastitis

Milk components variations in dairy cows

Fat: normally from 3,2 to 6,0%, varying between breeds and with feeding practises

Proteins: The concentration of protein in milk varies from 3.0 to 4.0% (30-40 grams per liter)

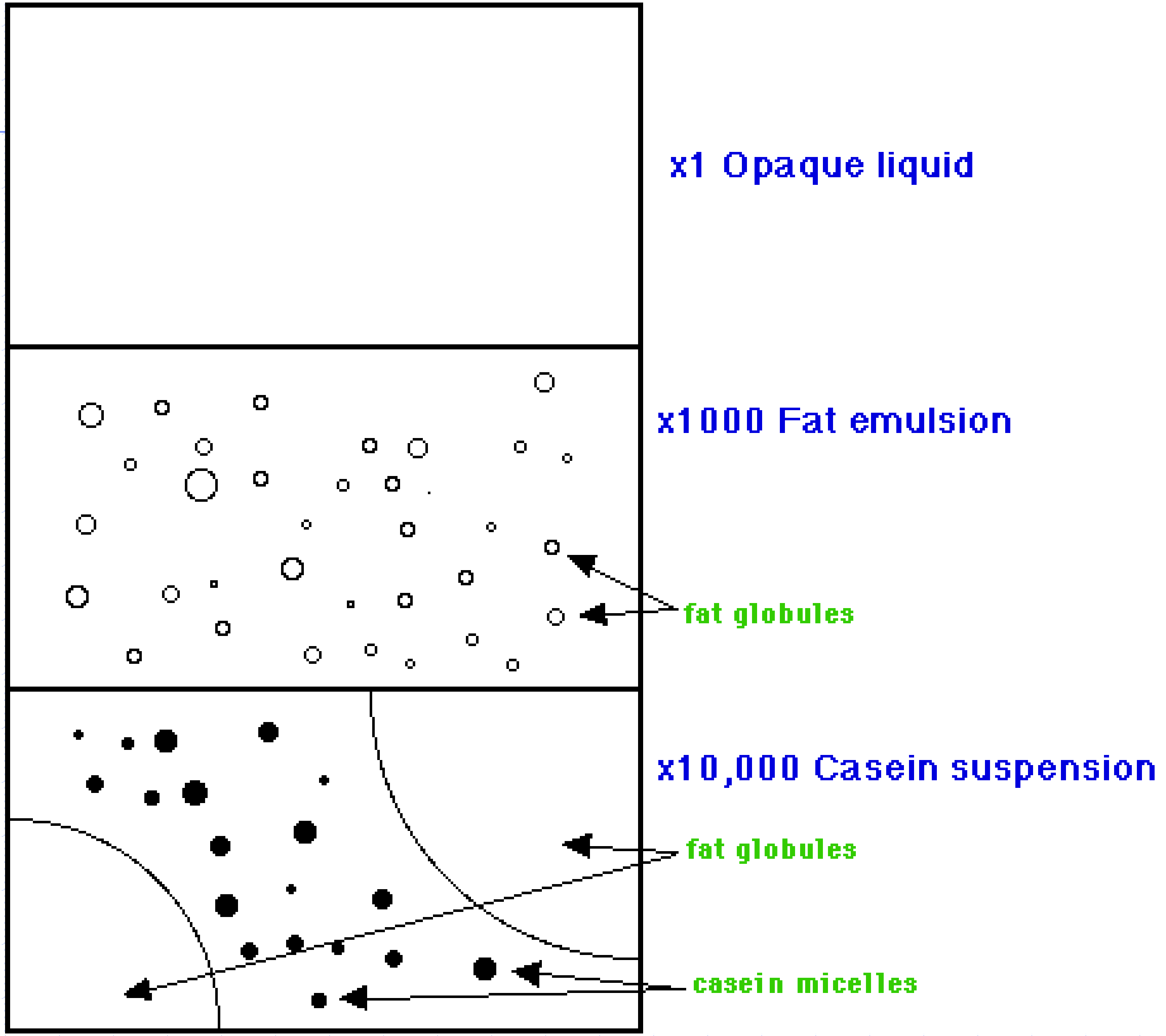
The protein falls into two major groups: caseins (80%) and whey proteins (20%).

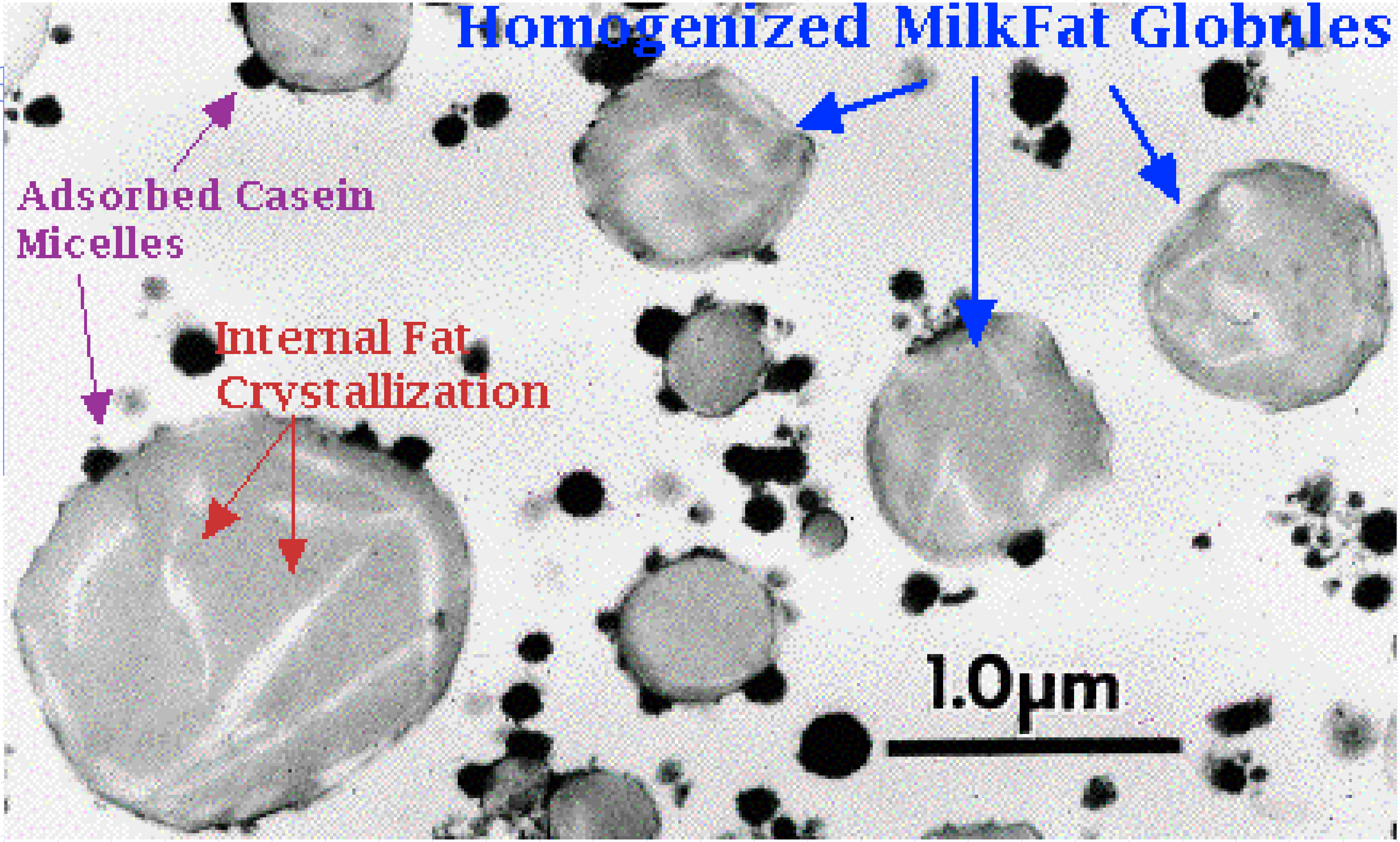
Lactose: concentration is relatively constant and averages about 5% (4.8-5.2%) in all breeds

Other Compounds Normally Found in Milk

- Acids
  - Citrate, Formate, Acetate, Lactate, Oxalate
- Enzymes
  - Peroxidase, Catalase, Lipase, Phosphatase
- Gases
  - Oxygen, Nitrogen, Carbon dioxide
- Vitamins
  - A, C, D, B Complex

Milk Structure




Homogenized MilkFat Globules
Adsorbed Casein Micelles
Internal Fat Crystallization
1.0µm

MILK AS FOOD FOR THE CALF

Milk contains proteins called immunoglobulins that are one of the calf's principal defenses against infectious organisms (viruses, bacteria, etc.)

Concentrations of immunoglobulins are especially high in the colostrum, the milk produced immediately at the onset of lactation.

Milk is an excellent source of most minerals (esp. Ca for sceletal growth) required for the growth of the young

Undesirable components in Milk

- Bacteria
- Sediment
- Detergents and disinfectants
- Antibiotics
- Pesticides or insecticides
- Additional water

Kgs of raw milk required to make 1 kg of product

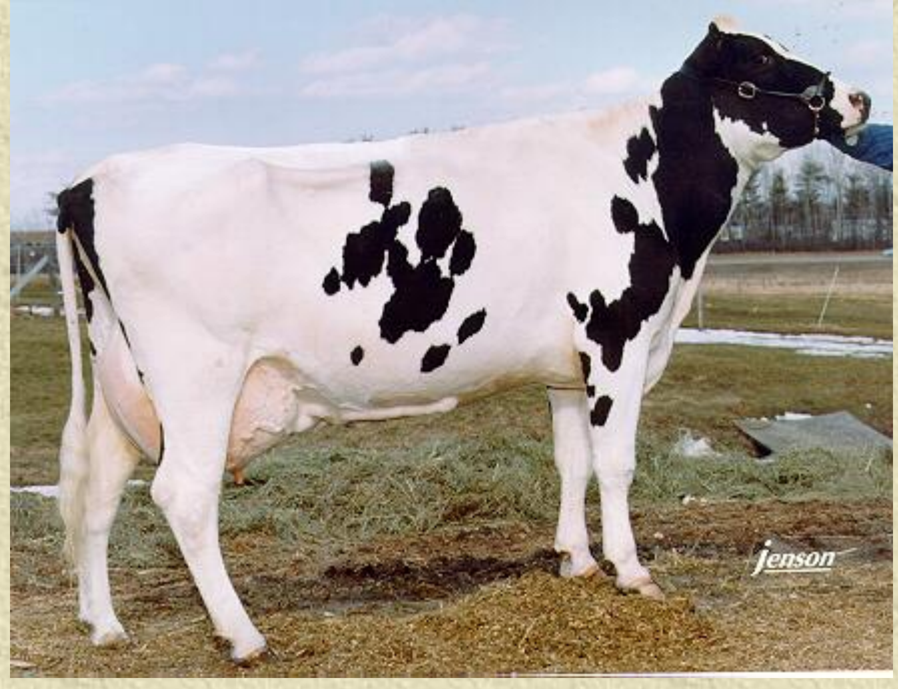
Product	Milk Equivalence
Butter	22
Nonfat Dry milk	12
Cheese	10 -15,00
Evaporated Milk	2.2

Dairy Breeds Overview.

Holstein breed

Holstein history

- **The Holstein cow originated in Europe**
- **The major historical development of this breed occurred in what is now the Netherlands**



Holstein Characteristics

- **Black and White or Red and White color pattern**
- **Large sized:** A mature Holstein cow weighs about 680 kg and stand 145 cm tall at the shoulder
- **Excellent milk producers:** Average milk production of Holsteins in developed countries reaches 8500-9000 kg milk, 3,2-3,4% fat, 3,1-3,3% protein

World's Records

Beecher Arlinda Ellen
(25398 kg/yr)

- Highest voluntary feed intake
  - About 7.5% of body weight per day
- On conventional ration (50:50 alfalfa hay: grain)

World's Records

30989 kg in 365 days - 3,6% fat - 3,1% protein
November, 1997 (USA)

New WORLD RECORD!!

Hartje-Meyer 9792
(March, 2005,
Wisconsin, USA)

Hartje-Meyer 9792

Daily Ration:

41 kg corn silage

18 kg CCM

9 kg alfalfa hay

6 kg protein supplement

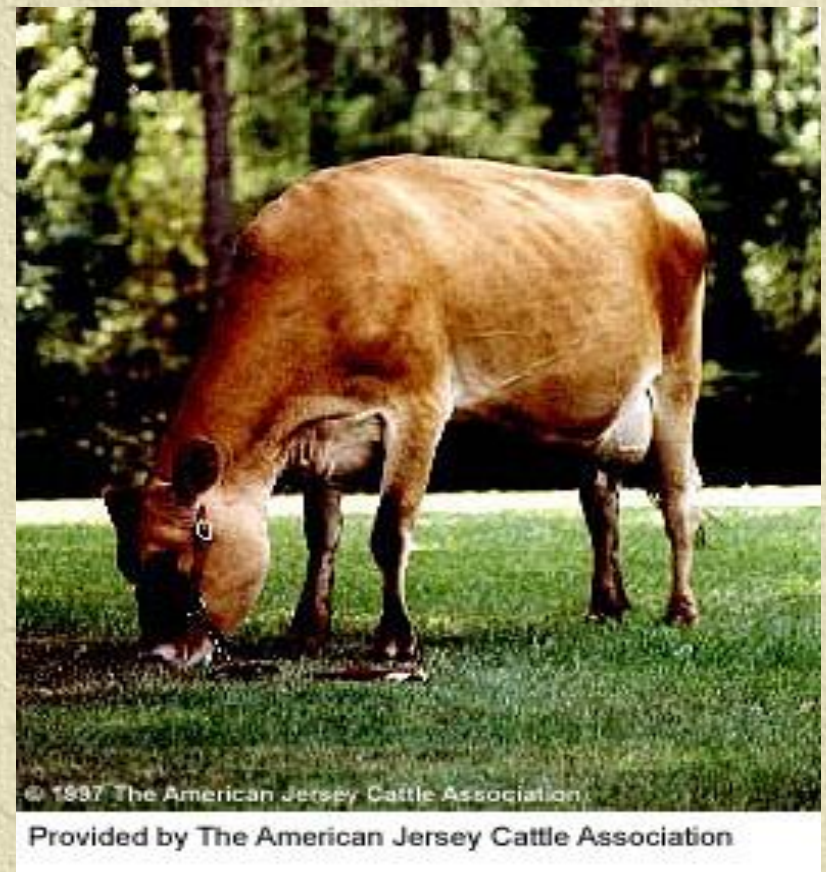
0,7 kg mineral mix

34533 kg in 365 days 3.2% fat, 2.9% protein
peak at 125,9 kg/day averaged 94,9 kg/day

Jersey Breed

Jersey History

- **The Jersey breed originated on the Island of Jersey, a small British island in the English Channel**
- **The island of Jersey was very protective of this breed. Because of this the breed stayed distinctive for many years**



Jersey Characteristics

- color varies (light gray to a dark fawn being darker around the head and hips)
- adapted to a wide range of climatic and geographical conditions
- smallest of the dairy breeds
- high longevity
- milk nutritive content is 28,46% greater than ordinary milk
- milk yield in developed countries averages 5000kg per cow per year, with the best individual animals yielding around 9000kg or higher
- produces more pounds of milk per body weight than any other dairy breed

Jersey Champions

Duncan Belle

No. lact	Days	Milk yield, kg	Fat, %	Protein, %
4	305	9310	5.2	4.0
6	305	9590	5.5	4.2

Jersey Champions

Greenridge FW Chief

No. lact	Days	Milk yield kg	Fat, %	Protein, %
4	305	9375	4.7	3.9
6	305	9290	4.5	3.8

Guernsey Breed

provided by Hoard's Dairyman

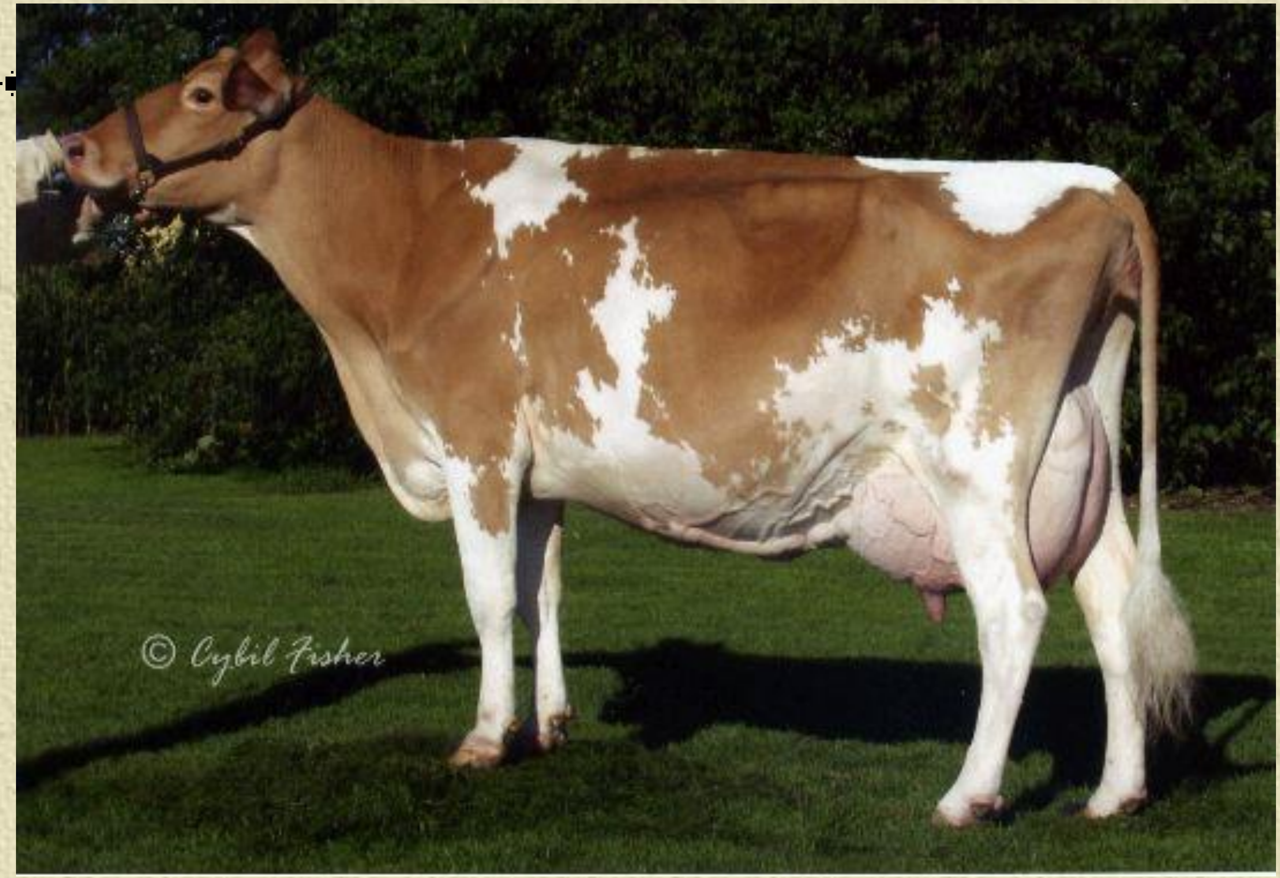
Guernsey History

- **The Isle of Guernsey, a tiny island in the English Channel off the coast of France, is the birthplace of the Guernsey cow**

Guernsey Characteristics

- **fawn and white in colour**
- **the Guernsey cow is known for producing high-butterfat, high-protein milk with a high concentration of betacarotene (“the Golden Milk of Guernsey”)**
- **medium sized, produce their high quality milk while consuming 20 to 30 percent less feed per pound of milk produced than larger dairy breeds**
- **lack of any known undesirable genetic recessives and their adaptability to warmer climates**
- **milk yield in developed countries averages 4500-5000kg per cow per year**

Guernsey Champion



FLAMBEAU MANOR G LAUREN EX 91 (USA)

10024 kg milk - 5.1% fat - 3.2% protein

Guernsey Show

Word Dairy Expo, Wisconsin, USA, October 2013

Brown Swiss Breed

Brown Swiss History

- Brown Swiss breed originated in the mountain pastures of the Swiss Alps

Brown Swiss Characteristics

- **light silver to dark brown with dark points**
- **6500 - 7000 kg of milk per lactation; 3.97% fat**
- **large sized, a mature female weighs 630 kg**
- **particularly strong feet and legs because of the mountains**
- **light coloured band around the muzzle**
- **docile, people-friendly demeanor**

Brown Swiss Champion

Cruella Rose

365days – 15894 kg milk - 4.4% fat - 3.8% protein

Ayrshire Breed

Ayrshire History

- **The Ayrshire breed originated in the County of Ayr in Scotland, prior to 1800**

provided by Hoard's Dairyman

Ayrshire Characteristics

- **red and white color**
- **medium-sized cattle (weighing about 550 kg at maturity)**
- **strong cattle that adapt to all management systems**
- **moderate milk and fat production: 5500 kg of milk with a 3.9% butterfat**
- **especially noted for the superior shape and quality of the udder**
- **calves are strong and easy to raise**

Ayrshire Champion

Ida (USA)

305 days -16949 kg of milk - 4,28% fat

Simmental Breed

provided by Beate Milerski

Simmental History

The Simmental is among the oldest and most widely distributed of all breeds of cattle in the world

The Simmental name is derived from their original location, the Simme Valley of Switzerland
(Tal=Valley, Simmental = Simme Valley)

Since its origin in Switzerland, the breed has spread to all six continents. Total numbers are estimated between 40 and 60 million Simmental cattle world-wide. More than half of these are in Europe

The breed is known by a variety of names: "Fleckvieh" in Germany, Austria. "Pie Rouge", "Montbeliard", and "Abondance" in France; and "Pezzata Rossa" in Italy

Simmental Characteristics

- red and white or light yellow and white in colour
- recognized for their ruggedness and heavy skeletal structure, strong feet and legs
- a mature cow weighs 600 – 650 kg
- moderate milk and fat production: 5000 - 6000 kg of milk with a 3.7 - 3.9% butterfat
- excellent maternal traits
- gentle temperament, stress resistant

Simmental Champion

Sisi AT 304.029.715 **(Austria, 2005)**

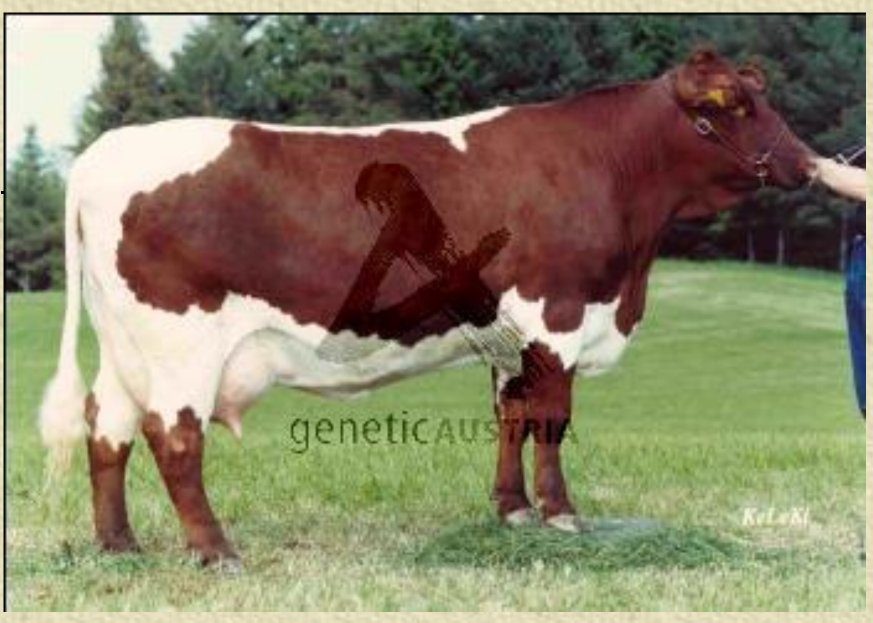
305 days -14954 kg of milk - 5,57% fat - 4,23 protein

Pinzgauer Breed

Pinzgauer History

- the native breed of Austria
- the designation "Pinzgauer" drives from the "Pinzgau" district in the province of Salzburg, Austria, and appears for the first time in documents of the 1600's
- derived from the red Bavarian cattle

Pinzgauer Characteristics



- **chestnut red colour with white markings on the back, tail and barrel**
- **adapt readily and easily to a variety of climates**
- **good temperament, maternal instinct and fertility**
- **mature cow weigh 450 – 500 kg**
- **moderate milk production: 4000 – 5000 kg milk**