## Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI</td>
<td>Artificial insemination</td>
</tr>
<tr>
<td>CIDR</td>
<td>Controlled internal drug release</td>
</tr>
<tr>
<td>CL</td>
<td>Corpus luteum</td>
</tr>
<tr>
<td>ET</td>
<td>Embryo transfer</td>
</tr>
<tr>
<td>FSH</td>
<td>Follicle stimulating hormone</td>
</tr>
<tr>
<td>GnRH</td>
<td>Gonadotropin releasing hormone</td>
</tr>
<tr>
<td>LH</td>
<td>Luteinizing hormone</td>
</tr>
<tr>
<td>MOET</td>
<td>Multiple ovulations, embryo transfer</td>
</tr>
<tr>
<td>PGF&lt;sub&gt;2α&lt;/sub&gt;</td>
<td>Prostaglandin F&lt;sub&gt;2α&lt;/sub&gt;</td>
</tr>
<tr>
<td>SCR</td>
<td>Sire conception rate</td>
</tr>
</tbody>
</table>

## Cow’s Reproductive Tract

The **parts of the cow’s reproductive tract** are:

- Vulva
- Cervix
- Oviduct
- Vagina
- Uterus
- Ovary

The **broad ligament** is the structure that holds the uterus and ovaries in their proper position.

The **site of semen deposition** in natural service (bull) is in the vagina next to the cervix; in artificial insemination it is normally in the body of the uterus.

## Ovaries

The main **functions of the ovary** are:

- Production of ova
- Secretion of hormones essential for reproduction

One hundred percent (100%) of the **ova** in a mature cow’s ovaries were present at birth.

**Ovulation** is the process of releasing an ovum from the follicle on the ovary.

The **fertile life of an ovum** after its release from the follicle is 6 to 12 hours.

The **corpus luteum** is a temporary gland that forms on the ovary after the ovum is released. It is also called **yellow body**.

## Female Reproductive Hormones

**Gonadotropin Releasing Hormone (GnRH)** is secreted by the hypothalamus. It controls the secretion of pituitary hormones (FSH and LH).

**Follicle stimulating hormone (FSH)** is secreted by the anterior pituitary gland. It stimulates growth of follicles.

**Luteinizing hormone (LH)** is secreted by the anterior pituitary gland. It causes the follicle to rupture and then causes the corpus luteum to replace the follicle. It increases dramatically in concentration 24 hours prior to ovulation soon after the onset of estrus.

**Estrogen (E2)** is produced by the follicle. It is necessary for behavioral estrus and peaks at the onset of standing estrus.

**Progesterone (P4)** is produced by the corpus luteum. It is necessary for the maintenance of pregnancy. It inhibits the release of GnRH from the hypothalamus.

**Prostaglandin (PGF)** is produced by the uterus (endometrium). It causes destruction or regression of the corpus luteum.
Reproduction

**Estrous Cycle**

The normal range in length of the estrous cycle is 18 to 24 days. On average, there are 21 days between heat periods in dairy cows.

The phases of the estrous cycle are:
- Follicular (active follicles are present)
- Luteal (corpus luteum is the dominant ovarian structure)

The stages of the estrous cycle are:
1. Estrus – heat period
2. Metestrus – transition
3. Diestrus – corpus luteum present
4. Proestrus – prior to estrus

Follicles develop in a wave-like pattern known as the **follicular wave**. There are five phases of a follicular wave:
1. Recruitment
2. Selection
3. Growth
4. Dominance
5. Regression

There are normally 2 or 3 follicular waves during an estrous cycle in cattle.

**Estrus**

Estrus is the period of heat in dairy cattle.

Duration of standing heat is usually 2 to 12 hours with an average of 7 hours.

Pregnancy is the most common cause of a cow not coming back into heat. It is estimated that 3 to 5% of pregnant cows exhibit estrus.

Milk progestosterone levels are low during estrus.

A silent heat is the condition where the physical signs of heat are difficult to detect.

Anestrus is the failure to have an estrous cycle. Poor nutrition and uterine infections are the leading causes.

Signs of estrus in dairy cattle include:
- Restlessness
- Bellowing
- Following and smelling another cow
- Mounting other cow
- Standing to be mounted
- Clear mucus discharge from vulva
- Vulva becomes red and swollen

Standing to be mounted is the most reliable sign of estrus.

Heat detection aids include:
- Heat expectancy charts
- Pressure sensors
- Tail chalk
- Electronic heat detection systems
- Pedometers
- Detector animals
- Accelerometers

Estrus synchronization programs include:
- CIDR
- Co-Synch
- Ovsynch
- Heat-synch
- Pre-Synch

**Fertilization**

Fertilization is the process of joining an ovum and a sperm. It takes place in the oviduct.

A zygote is a fertilized ovum.

The fetus develops in the **uterus** after the ovum is fertilized.
## Reproduction

### Artificial Insemination

**Artificial insemination (AI)** is the process of freezing semen from a bull and thawing it later to fertilize ova.

**Advantages of using artificial insemination** over natural service include:
- Safety
- Better record keeping
- Genetic improvement
- Easier to prove bulls
- Better disease control
- Less expensive than keeping a bull

A cow should be **artificially inseminated** 5 to 15 hours after the onset of standing heat.

A French straw is a thin cylinder in which frozen semen is preserved.

Liquid nitrogen is used to freeze and store semen. The **temperature of liquid nitrogen** is -320°F.

Frozen semen should be thawed in a warm water bath (90 to 95°F) for a minimum of 40 seconds to maximize the number of motile sperm.

### Embryo Transfer

**Embryo transfer** is the process of removing a fertilized ovum from a donor cow and transferring it to another cow or heifer.

Most **embryo transfers** are conducted on day 7 or 8 after breeding.

A recipient is an animal that received a fertilized ovum from a donor.

**Superovulation** is the process that involves treating a cow with a hormone (FSH) to increase the number of ova produced.

**Transvaginal aspiration** uses ultrasonography to view the ovary while removing oocytes through the vagina using a needle. Harvested oocytes are matured and fertilized in vitro.

### Conception Rate

**Conception rate** is the percent of services (breedings) that result in a pregnancy. Factors affecting a dairy herd’s conception rate include:
- Heat detection accuracy
- Herd (cow) fertility
- Semen (bull) fertility
- Technician competency

**Reasons cows don't become pregnant** when the herd is bred by artificial insemination include:
- Failure to ovulate
- Fertilization failure
- Hormone imbalance
- Poor quality semen
- Failure to inseminate
- Improper insemination technique
- Heat detection errors

### Pregnancy Rate

**Pregnancy rate** is the percent of cows that become pregnant out of those cows eligible to become pregnant in a given period of time, usually 21 days. It is the combined effect of heat detection rate and conception rate.

**Pregnancy rate** is usually calculated every 21 days because that is the average length of the dairy cow’s estrous cycle.

**Pregnancy rate** can be calculated for AI bred herds, bull bred herds, or a combination of both.

### Placenta

The **placenta** is the structure through which the fetus receives all of its nutrients.

The placenta is attached to the uterus in dairy cattle by maternal **caruncles** and fetal **cotyledons** (placentones).

A **retained placenta** is the condition when the fetal membranes remain attached to the maternal caruncles within the uterus for an extended period of time after calving (greater than 24 hours). Incidence is highest in summer.
## Reproduction

<table>
<thead>
<tr>
<th>Sire Conception Rate</th>
<th><strong>Sire Conception Rate (SCR)</strong> is an evaluation of artificial insemination (AI) service-sire fertility computed by USDA-AIPL; it is calculated for Ayrshire, Brown Swiss, Guernsey, Holstein, Jersey, and Milking Shorthorn bulls.</th>
</tr>
</thead>
</table>
| Ultrasound | **Ultrasound** can be used in a reproductive management program in several ways including:  
- Pregnancy determination  
- Determine embryonic losses  
- Determine if twins are being carried  
- Monitor cystic ovaries  
- Determine sex of embryo |
| Reproductive Problems | **Reproductive failure** is the number one reason for culling in U.S. dairy herds.  
**Metritis** is an infection of the uterus. **Endometritis** is an inflammation of the uterine lining. Incidence is highest in summer.  
**Sterility** describes the animal that cannot reproduce. **Infertility** describes the animal that is neither normally fertile nor totally sterile.  
**Abortion** is the premature expulsion of a fetus. **Diseases that cause abortions** in dairy cattle include:  
- Brucellosis  
- Campylobacteriosis (Vibriosis)  
- Chlamydia  
- IBR  
- Leptospirosis  
- Listeriosis  
- Neospora  
- Trichomoniasis  
**Cystic ovaries** are found in 12-14% of problem breeders. They develop in 10-40% of dairy cows during their lifetime.  
Types of **cystic ovaries** are:  
- **Follicular cysts** are thin-walled, anovulatory (not ovulating) cysts. They secrete variable amounts of estrogen.  
- **Luteal cysts** are thick-walled cysts. They secrete low levels of progesterone.  
- **Cystic corpus lutea** have characteristics similar to normal corpora lutea.  
**Twinning** in dairy cattle has several disadvantages including:  
- Reduced milk production during the lactation  
- Calving difficulties are more frequent  
- Abortion rates are higher  
- Twins are often weak at birth  
- Potential for a freemartin heifer  
**A freemartin** is a sterile heifer born twin to a bull. Ninety percent (90%) of heifers born twin to a bull are sterile. |
<table>
<thead>
<tr>
<th>Acronyms</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIPL</td>
<td>Animal Improvement Programs Laboratory</td>
</tr>
<tr>
<td>BAA</td>
<td>Breed Age Average</td>
</tr>
<tr>
<td>BLAD</td>
<td>Bovine Leukocyte Adhesion Deficiency</td>
</tr>
<tr>
<td>BLUP</td>
<td>Best Linear Unbiased Predictor</td>
</tr>
<tr>
<td>CE</td>
<td>Cheese Ease</td>
</tr>
<tr>
<td>CHM</td>
<td>Complex Vertebral Malformation</td>
</tr>
<tr>
<td>CVM</td>
<td>Difficult Birth in Heifers</td>
</tr>
<tr>
<td>DBH</td>
<td>Daughter Calving Ease</td>
</tr>
<tr>
<td>DCE</td>
<td>Deoxyribonucleic Acid</td>
</tr>
<tr>
<td>DNA</td>
<td>Daughter Pregnancy Rate</td>
</tr>
<tr>
<td>DPR</td>
<td>Deficiency of Monophosphate Synthase</td>
</tr>
<tr>
<td>DUMPS</td>
<td>Estimated Breeding Value</td>
</tr>
<tr>
<td>EBV</td>
<td>Estimated Transmitting Ability</td>
</tr>
<tr>
<td>ETA</td>
<td>Farm Animal Identification and Records</td>
</tr>
<tr>
<td>FAIR</td>
<td>Fluid Merit</td>
</tr>
<tr>
<td>FMS</td>
<td>Functional Trait Index (Jersey)</td>
</tr>
<tr>
<td>FTI</td>
<td>Functional Udder Index (Jersey)</td>
</tr>
<tr>
<td>FUI</td>
<td>Gold Medal Dam (Holstein)</td>
</tr>
<tr>
<td>GMD</td>
<td>Genomic Predicted Transmitting Ability</td>
</tr>
<tr>
<td>gPTA</td>
<td>Jersey Performance Index</td>
</tr>
<tr>
<td>JPI</td>
<td>Multiple-trait Across Country Evaluations</td>
</tr>
<tr>
<td>MACE</td>
<td>Messenger Ribonucleic Acid</td>
</tr>
<tr>
<td>mRNA</td>
<td>Lifetime Net Merit</td>
</tr>
<tr>
<td>NBS</td>
<td>Parent Average</td>
</tr>
<tr>
<td>PA</td>
<td>Polymerase Chain Reaction</td>
</tr>
<tr>
<td>PCR</td>
<td>Productive Life</td>
</tr>
<tr>
<td>PL</td>
<td>Progressive Performance Rating (Brown Swiss)</td>
</tr>
<tr>
<td>PPR</td>
<td>Predicted Transmitting Ability</td>
</tr>
<tr>
<td>PTA</td>
<td>Production-Type Index (Ayrshire, Guernsey)</td>
</tr>
<tr>
<td>PTI</td>
<td>Radio Frequency Identification</td>
</tr>
<tr>
<td>RFID</td>
<td>Ribonucleic Acid</td>
</tr>
<tr>
<td>RNA</td>
<td>Ribosomal Ribonucleic Acid</td>
</tr>
<tr>
<td>RT</td>
<td>Recessive Tested</td>
</tr>
<tr>
<td>RVC</td>
<td>Rectovaginal Constriction (Jersey)</td>
</tr>
<tr>
<td>SB</td>
<td>Stillbirth</td>
</tr>
<tr>
<td>SCE</td>
<td>Service Sire Calving Ease</td>
</tr>
<tr>
<td>SDM</td>
<td>Spinal Dysmyelination (Brown Swiss)</td>
</tr>
<tr>
<td>SMA</td>
<td>Spinal Muscular Atrophy (Brown Swiss)</td>
</tr>
<tr>
<td>SNP</td>
<td>Single Nucleotide Polymorphism</td>
</tr>
<tr>
<td>TPI</td>
<td>Total Performance Index (Holstein)</td>
</tr>
</tbody>
</table>
### Animal Identification

**Identification** is the first step in a herd improvement program.

**American ID numbers** for dairy cattle consist of a three letter country code followed by a twelve digit animal number and will be used by DHI organizations, breed associations, and state animal health departments. The **country code for the U.S.** is 840.

**Visibility** is the most important feature when selecting tags or brands for identification.

### NAAB Code

The **NAAB code for a sire** has three parts.

1. The number before the letter indicates the **stud** from which the bull’s semen can be purchased. It is referred to as the **stud code**.
   
<table>
<thead>
<tr>
<th>Stud Code</th>
<th>Stud Name</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Genex/CRI</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Select Sires</td>
<td>7</td>
</tr>
<tr>
<td>11</td>
<td>Alta Genetics</td>
<td>11</td>
</tr>
<tr>
<td>14</td>
<td>Accelerated Genetics</td>
<td></td>
</tr>
</tbody>
</table>

2. The letters indicate the **breed**.

<table>
<thead>
<tr>
<th>Breed Code</th>
<th>Breed Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AY</td>
<td>Ayrshire</td>
</tr>
<tr>
<td>BS</td>
<td>Brown Swiss</td>
</tr>
<tr>
<td>GU</td>
<td>Guernsey</td>
</tr>
<tr>
<td>HO</td>
<td>Holstein</td>
</tr>
<tr>
<td>JE</td>
<td>Jersey</td>
</tr>
<tr>
<td>MS</td>
<td>Milking Shorthorn</td>
</tr>
<tr>
<td>WW</td>
<td>Red and White</td>
</tr>
</tbody>
</table>

3. The number following the letters is an **individual bull identification number**.

Example: 7HO00543 is the NAAB Code for CARLIN-M IVANHOE BELL.

### Basic Genetics

A **gene** is the basic unit of inheritance.

A **chromosome** is a threadlike linear strand of DNA and associated proteins found in the nucleus of animal and plant cells that carries the genes and functions in the transmission of hereditary information. Dairy cattle have 30 pairs of chromosomes.

A **locus** is the position that a given gene occupies on a chromosome.

An **allele** is any of the alternative forms of a gene that may occur at a given locus.

**Genotype** is the genetic make-up of an individual.

**Phenotype** is the observed trait of an individual resulting from the effects of the genotype, the environment, and their interaction.

### Basic Genetics

**Heritability** ($h^2$) is the measure of the percent of phenotypic differences between animals for a single trait that can be transmitted to offspring.

**Predicted Transmitting Ability (PTA)** is a measurement of average superiority or inferiority that will be transmitted to an offspring.

The **genetic make up of a population** can be changed by:

- Migration
- Selection
- Mutation
- Chance

### Genomics

The total genetic content of an organism is known as its **genome**.

**Genomics** is the study of genes or gene products in an organism.

**Proteomics** is the study of all of the proteins that genes create.

**Gene mapping** is the process of determining where genes are located on individual chromosomes.
### Relationships

A **pedigree** is a record of ancestry. A **purebred** is a dairy animal whose sire and dam of the same breed are registered or who are eligible to be registered in a herdbook. A **registration paper or certificate** accompanies a purebred animal and certifies its parentage. The **sire** determines the sex of a calf. **Siblings** is the technical term used to describe brothers and sisters.

### Animal Model

The **Animal Model** is the genetic method for evaluating bulls and cows currently used. When making its evaluation, the Animal Model uses **information** from:

- Parents (pedigree)
- Individual performance
- Progeny (offspring)

### Genetic Evaluations

USDA-AIPL publishes genetic evaluations. **Official evaluations** in 2013 will be released in April, August and December. **Genomic evaluations** will be released monthly. A minimum of ten (10) daughters is required for a bull to have a **bull proof** published.

The **genetic base** for USDA-AIPL genetic evaluations is updated every five years. It was updated in January 2010 and is the average PTA of animals born in 2005. **INTERBULL** is the name of the International Bull Evaluation Service based in Uppsala, Sweden.

**Reliability** is an indicator of the accuracy of genetic evaluations.

### Genetic Indexes

**Lifetime Net Merit (NM$)** is a genetic index. It combines the following traits for **Holsteins** and **Brown Swiss**:

- Fat
- Protein
- Somatic cell score
- Productive life
- Feet and legs composite
- Udder composite
- Body size composite
- Daughter pregnancy rate
- Calving ability*

*NM$ for **other breeds** does not include calving ability.

**Total Performance Index (TPI)** is a genetic index used by the Holstein breed that is determined by placing emphasis on production and type. The traits included are:

- Protein
- Fat
- Type
- Dairy Form
- Udder Composite
- Feet and Leg Composite
- Productive Life
- Somatic Cell Score
- Daughter Pregnancy Rate
- Daughter Calving Ease
- Daughter Stillbirth
### Genetic Indexes

Traits used in the **Udder Composite Index** for Holsteins are:
- Fore udder attachment
- Rear udder width
- Udder cleft
- Rear udder height
- Udder depth
- Front teat placement

Traits used in the **Body Size Composite Index** for Holsteins are:
- Stature
- Strength
- Body depth
- Thurl width

Traits used in the **Feet and Legs Composite Index** for Holsteins are:
- Rear legs – side view
- Rear legs – rear view
- Feet and legs score
- Dairy form
- Strength

Traits used in the **Dairy Capacity Composite Index** for Holsteins are:
- Dairy form
- Strength

The **Jersey Performance Index (JPI)** is a genetic index used by the Jersey breed that is determined by placing emphasis on production and type. The traits included are:
- PTA Protein
- Productive Life
- PTA Fat
- PTA Somatic Cell Score
- Functional Trait Index* (There are 14 linear traits used for calculating the **Functional Trait Index** for Jerseys.)
- Daughter Pregnancy Rate

The **Functional Udder Index** serves an indicator of mastitis resistance in Jerseys. It weighs the following traits:
- Fore udder
- Udder cleft
- Front teat placement
- Rear udder height
- Udder depth
- Front teat length

### Final Classification Scores

<table>
<thead>
<tr>
<th>Brown Swiss</th>
<th>Holstein</th>
<th>Jersey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>90-94</td>
<td>90-97</td>
</tr>
<tr>
<td>Very Good</td>
<td>85-89</td>
<td>85-89</td>
</tr>
<tr>
<td>Good Plus</td>
<td>80-84</td>
<td>80-84</td>
</tr>
<tr>
<td>Good</td>
<td>75-79</td>
<td>75-79</td>
</tr>
<tr>
<td>Fair</td>
<td>65-74</td>
<td>65-74</td>
</tr>
<tr>
<td>Poor</td>
<td>60-64</td>
<td>60-64</td>
</tr>
</tbody>
</table>

### Calving Ease

FARM EMPLOYEES SHOULD ASSIGN CALVING EASE SCORES AT THE TIME OF CALVING TO DESCRIBE THE EVENT. THE SCORING SYSTEM IS:
1 = No problem or unobserved
2 = Slight problem
3 = Needed assistance
4 = Considerable force
5 = Extremely difficult

**Calving Ease Summaries** are calculated by USDA-AIPL for the National Association of Animal Breeders (NAAB). Two summaries are now calculated:
- **Service Sire Calving Ease** measures a bull’s tendency to sire calves that are born easily.
- **Daughter Calving Ease** measures the influence of the sire of the cow on calving ease.
### Stillbirth

It is recommended that farm employees record **stillbirth scores** to provide accurate calf mortality information. The scoring system is:

- **1** = the calf was born alive and was alive 48 hours postpartum
- **2** = the calf was born dead
- **3** = the calf was born alive but died within 48 hours postpartum

**Daughter Stillbirth** measures the ability of a particular cow (daughter) to produce live calves.

**Service Sire Stillbirth** measures the tendency of calves from a particular service sire to be stillborn more or less often.

**Stillbirth evaluations** are expressed as percent stillbirths in heifers (%SBH), where stillborn calves are those scored as dead at birth or born alive but died within 48 hours of birth.

### Inbreeding

**Inbreeding** can decrease mature equivalent (ME) milk production by 60 to 80 pounds per lactation for each percent increase in inbreeding.

USDA-AIPL calculates **inbreeding coefficients** for dairy animals. For animals born in 2012, Holsteins or Red & Whites had the lowest percent inbreeding while Guernseys had the highest.

**Consequences of inbreeding** include:

- Decreased general vigor
- Decreased production
- Decreased reproductive performance
- Increased calf mortality
- Increasing similarity between animals
- Smaller mature size
- More recessive genes exposed
- Slower growth rate

### Undesirable Recessive Traits

**Undesirable recessive traits in Brown Swiss** cattle are:

- Weaver
- Spiderleg
- Spinal Dysmyelination
- Spinal Muscular Atrophy

**Undesirable recessive traits in Holsteins** include:

- Bovine Leukocyte Adhesion Deficiency
- Brachyspina
- Bulldog
- Complex Vertebral Malformations
- DUMPS
- Dwarfism
- Hairless
- Imperfect Skin
- Mule-Foot (Syndactylism)
- Pink Tooth (Porphyria)
- Prolonged Gestation

**Undesirable recessive traits found in Jerseys** are:

- Limber Legs
- Rectovaginal Constriction

**Undesirable recessive traits have not been documented for the Ayrshire, Guernsey, or Milking Shorthorn** breeds.

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