Genetics matter

- Genetics provide the foundation for potential
  - Set the “genetic” ceiling of the herd
- Management and the environment allow animal to reach that potential
- Some animals will exceed estimated potential while others do not achieve expected potential
- Farms which don’t use genetic information will generally still improve due to overall industry improvement
  - Slower rate of improvement
Genetics versus Genomics
Genomic testing

- Companies who perform genomic testing
  - **Council on Dairy Cattle Breeding (CDCB)** - calculates the U.S. National Dairy Cattle Genetic Evaluations. Works closely with USDA researchers and academic institutions for supporting research and methodology. Advising board comprised of AI companies, breed associations, data recording companies, and academic members.
  - Breed Associations
  - Genotyping companies (Zoetis and Geneseek)
  - AI companies

- Sample submission
  - Biological samples for DNA: hair (follicle), blood, tissue, semen, nasal swabs
  - Animal ID, sex, date of birth, sire, dam, breed
1. Farm submits biological sample for genomic evaluation through a registered “requester”. $3/sample

2. “Requester” submits genotype data to CDCB for processing of genomic evaluations.

3. CDCB generates the national genomic prediction scores which are then returned to “requester” and in turn to farm.
Estimations of genetic merit

• **Genotypic value**: value of an individual’s genes on their **OWN** performance

• **Breeding value**: value of an individual’s genes on their **PROGENY’s** performance (EBV)

• **Progeny difference = Transmitting ability**: expectation of what the **PROGENY** inherits from the parent (PTA)

• **Producing ability**: (PA) performance potential of an individual for a repeated trait

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**Parent Average**: Genetic average of each parent’s genetic value

- Assumes that offspring inherit exactly ½ of each parents’ genetic merit for all traits
- Assumes that parents are identified as 100% accurate

---

**Cornell CALS**: College of Agriculture and Life Sciences

**PRODAIRY**: Education & Applied Research

**NY Farm Viability Institute**
Phenotype

Economically important traits

Genotype

Statistics

Predicted Genetic Merit

Pedigree
What’s included in genetic evaluations

- Parentage
- Estimations of genetic merit
  - Individual traits
  - Targeted indexes
  - Total performance indexes
- Inbreeding
- Genetic conditions
Individual traits

Production Traits

Conformation/Type Traits

Health Traits
### Individual traits

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<th>Production Traits</th>
<th>Conformation/Type Traits</th>
<th>Health Traits</th>
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<td>Strength (chest width)</td>
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<td>Protein</td>
<td>Body depth (rib cage)</td>
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<td>Protein %</td>
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<td>- Heifer conception rate</td>
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<td>Rump width</td>
<td>- Cow conception rate</td>
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<td>- Sire calving ease</td>
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<td>Rear leg rear view</td>
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“Total Performance” indexes

- Combines multiple traits into a single numerical selection index or breeding value
- Goal: To select for a high “performance” individual (performance includes production, conformation, and health traits)
  - Considers correlation of traits to one another
  - Economic value of the trait
- There are many different “total performance indexes” available for use
  - Net Merit (NM$) = National evaluation index generated by CDCB
  - Breed Associations
    - Total Performance Index (TPI) = Holstein breed index generated by Holstein Association USA
    - Jersey Performance Index (JPI) = Jersey breed index generated by US Jersey Association
  - Company Indexes – Zoetis, Geneseek, Genex, CRV.......

Net Merit

- Production: 44%
- Conformation: 16%
- Health: 40%

Total Performance
Comparison of Total Performance Indexes

**Net Merit**
- Production: 44%
- Health: 40%
- Conf.: 16%

**TPI**
- Production: 46%
- Health: 28%
- Conf.: 26%

**JPI**
- Production: 58%
- Health: 27%
- Conf.: 15%

Holstein, Jersey, Ayrshire, Brown Swiss, Guernsey, Milking Shorthorn
“Targeted” indexes

- Index using a subset of individual traits to improve achieve a more specific goal

CDCB/ USDA targeted indexes including economic values

- Cheese merit (CM$): combines the same traits as NM$ with greater emphasis on protein and fat %, making this information particularly useful for producers selling their milk in the cheese market.

- Fluid merit (FM$): combines the same traits as NM$ with more emphasis on milk yield, making this information particularly useful for producers selling their milk solely on volume.

Reproductive indexes

- Calving ability (CA$): Genetic index that measures the ability of a calf to be born easily and alive. Specific traits used in the CA$ index include sire calving ease, daughter calving ease, sire still birth and daughter still birth

- Fertility Index (FI): Holstein only; Genetic index incorporating the following fertility traits: heifer conception rate, cow conception rate, and daughter pregnancy rate.
Inbreeding

• Provides an estimation of an individual’s inbreeding level as well as the potential inbreeding level of any progeny if that progeny is mated at random (within the breed)
• Increased inbreeding decreases genetic merit scores

Inbreeding: Could we be Headed to a Genetic Dead End?
By Murray Hunt · Comments (0)
Tuesday, April 21st, 2015

Inbreeding and the lack of genetic diversity are on the radar screen of milk producers, breeding stock suppliers, A.I. companies and scientists. In some cases, they are barely there while for others it is a major concern. Every year there is new evidence that points to the fact that these factors should not be ignored when it comes to breeding decisions.
Information included in Genomic evaluations that are not given a numeric value

• **Parentage verification** - confirm whether or not the pedigree parentage matches the genomic data.
  • An individual’s genotype is compared to the reference population.
  • Genomic parentage is suggested based on genomic reference population available.

• **Genetic Conditions** - information is provided on whether an individual is a carrier for a genetic condition.
  • Diseases - fertility haplotypes, BLAD, CVM, Mulefoot, etc.
  • Production – specific proteins such as casein proteins (A1/A2)
  • Appearance/ Conformation – Coat color, polledness
Genomic data by bull
BULL PROOF

LNMS$ - CDCB Total Performance Index

ICC$ - Genex Total Performance Index
“Ideal Commercial Cow”

TPI - Breed specific (Holstein) Total Performance Index

Parentage & Genetic Conditions

Conformation Traits

WHISKER

Breed: 004M17
Reg. No: 3421600321
Classification Score: Rd
DMS: 846
BetaCasein: aAa
KappaCasein: aa
MGS: MELANRY SPRING 9000-BT
MCD: MELANRY SPRING 9000-BT
VOG: 9045
VOS: 9045
205-2: 3385.59, 1519.5, 1214.9, 3.5, 105.6
Recessives: M$ $ T$ $T$ $T$ $T$ $T$ $T$ $T$
Haplotypes:
Genomic data by farm

- Generally cow data
# Table of Contents

<table>
<thead>
<tr>
<th>Sheet Name</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Actions Needed</strong></td>
<td>Lists conflicts between customer-provided pedigree and genomically determined parentage; these conflicts must be resolved in order to receive CLARIFIDE results. Requirements do not apply to herds that have authorized auto-accept functionality for non-registered animals.</td>
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<tr>
<td><strong>Job Summary</strong></td>
<td>Summary statistics for animals in the job for the most commonly used traits</td>
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<td><strong>All Data - Sortable</strong></td>
<td>Genetic prediction results for all traits, indexes, and haplotypes in a format that can be sorted or filtered using Excel</td>
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<td><strong>Core Traits</strong></td>
<td>Prediction results for commonly used traits and indexes</td>
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<tr>
<td><strong>Net Merit</strong></td>
<td>Net Merit prediction results, including each animal's rank as compared with the USDA breed specific populations. Net Merit is one of the most comprehensive predictions available from the CLARIFIDE report</td>
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<tr>
<td><strong>Composite Indexes</strong></td>
<td>Prediction results for several composite indexes, where each combines several related trait predictions into one composite value</td>
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<tr>
<td><strong>Genetic Conditions</strong></td>
<td>Results for all complimentary genetic conditions and milk components as well as any additional conditions ordered. (Some conditions are only available with purchase of CLARIFIDE or CLARIFIDE Ultra)</td>
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<td><strong>Type Traits</strong></td>
<td>Prediction results for type traits</td>
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<td><strong>Trait Definitions</strong></td>
<td>Reference material which defines all traits, indexes, and haplotypes included in the CLARIFIDE report</td>
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<td><strong>Reliability</strong></td>
<td>Reliability values which describe the relationship between predicted and actual genetic merit - the higher the reliability, the less likely genetic values will change in future evaluations</td>
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<td><strong>Parentage Definitions</strong></td>
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F** = Free (doesn’t carry gene)  
C** = Carrier (carries at least 1 copy of gene)
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**Averages for 60 Cows:**

- Prot: 13
- Fat: 17
- Milk: 548
- SCS: 2.95
- PL: 0.32
- DPR: -0.2
- Type: -0.4
- UDC: -0.46
- FLC: -0.30
- TPI: 1690

**2013 Breed Averages for Cows:**

- Prot: 10
- Fat: 13
- Milk: 297
- SCS: 3.04
- PL: 1.00
- DPR: 0.2
- Type: 0.8
- UDC: 0.67
- FLC: 0.55
- TPI: 1814
GENESEEK IGENITY INDIVIDUAL REPORTS

Animals Tested: 601

Sire: HOUSA000060767057
Dam: HOUSA00007006644
F Ho DOB: 5/3/2014
Status: Active

Key Traits

Viewing: Key Traits Compared To All Hards

Health Yield Fertility

T= Tested free; C= Carrier; A= Homozygous affected
Management tool

Provides an *objective* value for an individual reflecting health, production, and conformation

- Bull selection
  - Individual matings
  - Bulls for groups of animals
  - Bulls for herd
- Reproductive strategies
  - Sexed semen
  - Embryo transfer (donors / recipients)
  - IVF
- Culling decisions
- Marketing of animals
  - General merit
  - Niche marketing
# Bull Selection

## Proven Bulls

- Increased reliability in estimation of genetic merit
  - Phenotypic and genomic data
  - 85-90% reliability (B. Cassell, 2010)
    - [https://pubs.ext.vt.edu/404/404-090/404-090.pdf](https://pubs.ext.vt.edu/404/404-090/404-090.pdf)
- Higher probability of progeny having expected genetic merit

## Young Bulls

- Reduces generation interval- increasing rate of genetic change
- Genomic estimation of merit slightly less than proven estimates – 70% reliability (B. Cassell, 2010)
  - [https://pubs.ext.vt.edu/404/404-090/404-090.pdf](https://pubs.ext.vt.edu/404/404-090/404-090.pdf)
  - (~30% reliability – phenotype only)

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*The use of a variety of bulls buffers the impact of any bull decreasing in genetic merit over time.*
Take home: Genomic & reproductive technologies

Reduce generation interval

Increase selection intensity

Increase rate of genetic change
Culling

• Cow longevity depends on intrinsic and extrinsic factors.
  • Intrinsic- cow’s health and performance
  • Extrinsic- factors external to the cow (availability of heifers, quota, and farmer attitude towards risk and uncertainty

• Survival analysis has shown that a large number of cows leave the herd early in lactation largely due to metabolic health reasons.

• Forced culling of cows early in lactation is expensive, in the order of $500 to $1000 per cow.

• Efforts to reduce death rates and improve early lactation health, and therefore intrinsic cow longevity, are to be profitable.

• The average cow longevity is determined by extrinsic economic factors unrelated to an individual cow’s health and performance. To extend the average cow longevity, dairy farmers would need to be motivated to bring fewer heifers into the herd and therefore cull fewer cows.
  • This could be accomplished by creating fewer dairy heifer calves, for example through delayed inseminations in heifers and/or cows, or not breeding non-pregnant cows that are late in lactation.
  • A portion of the heifers and cows could also be inseminated with beef semen and the crossbred calves could be sold.
Focused Use of Genomic information

**Specific**
- Improved reproductive efficiency within herd

**Meaningful**
- How will it improve your herd? Economics, health, welfare
  - Net merit
  - Fertility index = (18% Heifer Conception Rate) + (18% Cow conception rate) + (64% Daughter Pregnancy Rate)
  - Individual traits: DPR, HCR, CCR, CA, SCE, DCE, SSB, DSB
  - Genetic conditions: Recessive fertility haplotypes (HH1, HH2... JH1...)

**Actionable**
- What endpoint is achievable given resources?

**Realistic**
- Pregnancy rate, conception rate, calf survival

**Trackable**
- Improved reproductive efficiency within herd
- How will it improve your herd? Economics, health, welfare
- What endpoint is achievable given resources?
- Pregnancy rate, conception rate, calf survival
Reproductive management

“Total Performance Indexes”
- Net Merit
  - Conf. 16%
  - Production 44%
  - Health 40%

“Targeted Indexes”
- Calving ability (CA$)
- Fertility Index (FI)

Individual Reproductive Traits
- Daughter pregnancy rate
- Heifer conception rate
- Cow conception rate
- Sire calving ease
- Daughter calving ease
- Sire still birth
- Daughter still birth

Genetic Conditions
- Recessive Fertility Haplotypes

Big Picture

Details
Summary

• Genetics matter
• What’s included in genetic evaluations
• What genetic evaluations look like
• Using genetics as a management tool
Questions?

Elite cattle drive genetic change