Basic Concepts of Applied Genetics

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Concepts

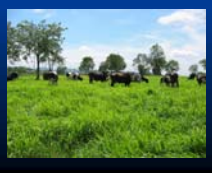
- Population
- Traits
- Environmental Effects
- Genetic Effects
- Genetic Evaluation Models
- Computational Procedures
- Selection
- Mating Strategies
- Genetic Trends
- Future Developments

Population

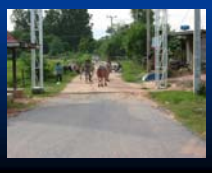
Group of purebred and (or) crossbred animals that interbreed

Unibreed

Multibreed



More Examples of Populations



Traits

- Dairy Cattle
  - Calving Ability ($)
  - Daughter Pregnancy Rate (% pregnant)
  - Milk Yield (lb)
  - Fat Yield (lb)
  - Protein Yield (lb)
  - Somatic Cell Score (0 to 9)
  - Productive Life (mo)
  - Net Merit ($), Cheese Merit ($), Fluid Merit ($)
- Beef Cattle
  - Calving Ease (% unassisted births on heifers)
  - Maternal Calving Ease (% unass births 1st calf daugh)
  - Birth Weight (lb)
  - Weaning Weight (lb)
  - Maternal Wean Weight (lb)
  - Maternal Milk (lb)
  - Yearling Weight (lb)
  - Carcass Traits: Marbling, REA, Shear Force, YG)
  - Stayability (% daugh in herd at 6 yr age)
  - All Purpose Index ($), Terminal Index ($)

Environmental Effects

- Herd
- Year
- Season
- Sex of Calf
- Management Group
- Age of Dam
- Age of Calf
- Days Open
- Contemporary Groups

Unibreed Contemporary Groups

Herd-Year-Season

Herd-Year-Season
x
Sex Calf
x
Age Calf [± 90 d]
x
Breed Group

Multibreed Contemporary Groups

Herd-Year-Season
x
Sex Calf
x
Age Calf [± 90 d]

Connectedness

Herd-Yr-Season		
1	X	
2	X	X
3	X	X
4		X
5	X	X
6	X	X
7	X	

Genetic Effects

Breed of Sire

Breed of Dam

Heterosis

Recombination Loss

Additive

Nonadditive

Direct

Maternal

Intrabreed

Interbreed

Breed

Breed of Sire

Breed of Dam

Purebred Populations

Model
Fractions of component breeds
¾ Jersey ¼ Holstein

Heterosis

Advantage of crossbreds over purebreds
Interaction among alleles at one or more loci

Model
Prob (allele breed 1/allele breed 2)
in one locus

Recombination Loss

Loss of productivity in crossbreds due to recombination in gametes

Model
Prob (recombinant gametes) considering two loci

Additive Genetic Effects

Transmissible across generations
Cumulative effect of all genes involved

Model
Breed of Sire and Dam (0 <= p <= 1)
Animal, Sire, and Dam effects (1,0)

Nonadditive Genetic Effects

Non-transmissible across generations
Recreated during meiosis

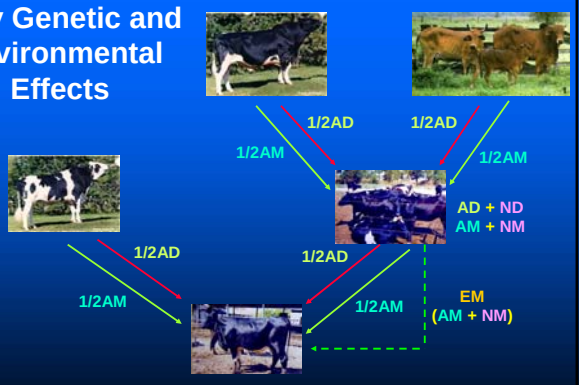
Model
Heterosis (0 <= p <= 1)
Recombination Loss (0 <= p <= 1)
Sire x BGDam Heterosis(0 <= p <= 1)
Sire x BGDam Recomb Loss (0 <= p <= 1)

Direct and Maternal Genetic Effects

Direct Genetic Effects
Own ability to perform

Maternal Genetic Effects
Influence of dams on progeny
Genetic to the dam
Environmental to the progeny

Dairy Genetic and Environmental Effects



(AD + ND) + (AM +NM) + ED (AD + ND) + EM (AM + NM)

Chart of Genetic Effects

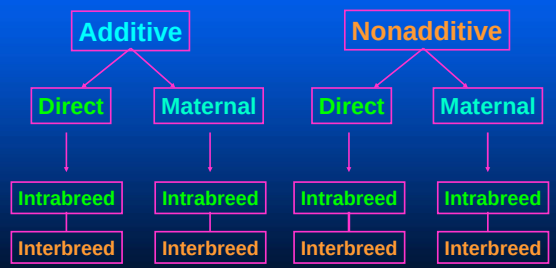
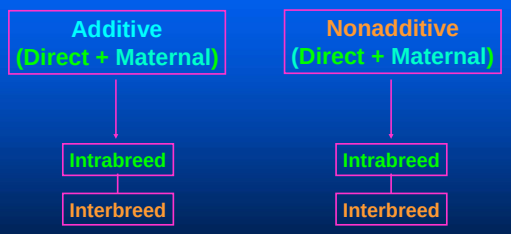


Chart of Residual Effects



Genetic Evaluation Models

Type of Population

Unibreed
Multibreed

Type of Trait

Categorical
Continuous

Dairy Unibreed Model

Pre-Corrected Milk Yield

Herd-Year-Season
Parity x Dam Calving Age
Registry Status

Genetic Group (Unknown parents by year)

Animal Additive Genetic Effect
Herd x Sire
Permanent Environment

Residual

Pre-Corrections

Milk Yield

Age at Calving
Month
Times Milked per Day (2x)
Previous Days Open
Lactation Length (305 d)
Heterogeneous Variance

http://aipl.arsusda.gov/reference/yield.htm

Dairy Multibreed Model

Milk Yield

Herd-Year-Season
Dam Calving Age (Regression on H)

Holstein Fraction (Regression)

Animal Additive Genetic Effect

Residual

Beef Multibreed Model

{Birth Wt, Weaning Wt, Yearling Wt}

Contemporary Group
Age of Dam x Sex of Calf [Regr on breed fract]

Breed Group [Regr on breed fract]
Heterosis [Regr on $p(b_1/b_2)$]

Animal Additive Genetic Effect
Sire x BGDam [Regr on $p(b_1/b_2)$]

Residual

Computational Procedures

Type of Population
Unibreed
Multibreed

Type of Trait
Categorical
Continuous

Population Size

Number of Traits

Small Number of Equations -> Direct Procedures

Large Number of Equations -> Iterative Procedures

Genetic Predictions

Dairy Cattle

Predicted Transmitting Abilities (PTA)

PTA = ½ EBV

Beef Cattle

Expected Progeny Differences (EPD)

EPD = ½ EBV

Genetic Evaluations

Unibreed
Multibreed

Multitrait
Quantitative Trait Loci (QTL)
(BLUP, Bayesian Methods)

Additive and Nonadditive Genetic Effects
(Interbreed)

Genetic Bases

Dairy Cattle

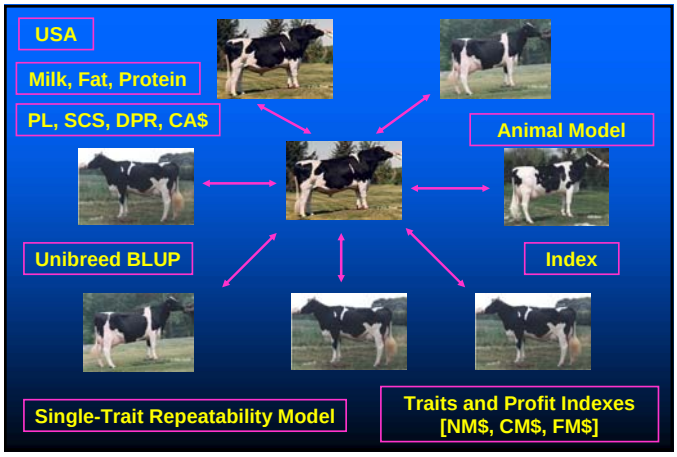
Mean Additive Genetic Value of Cows Born in 2000

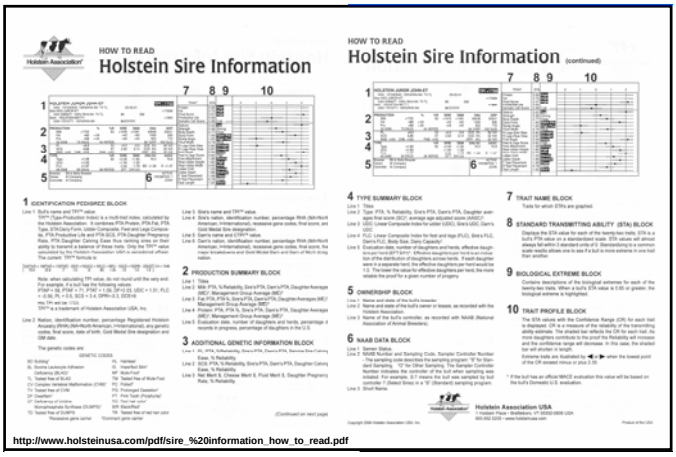
http://aipl.arsusda.gov/reference/yield.htm

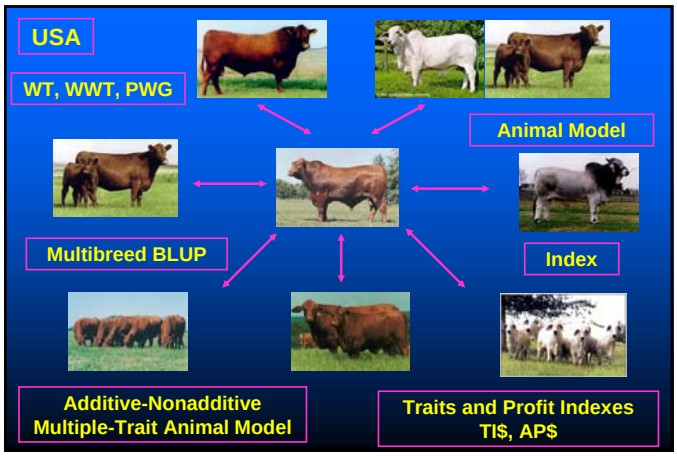
Beef Cattle

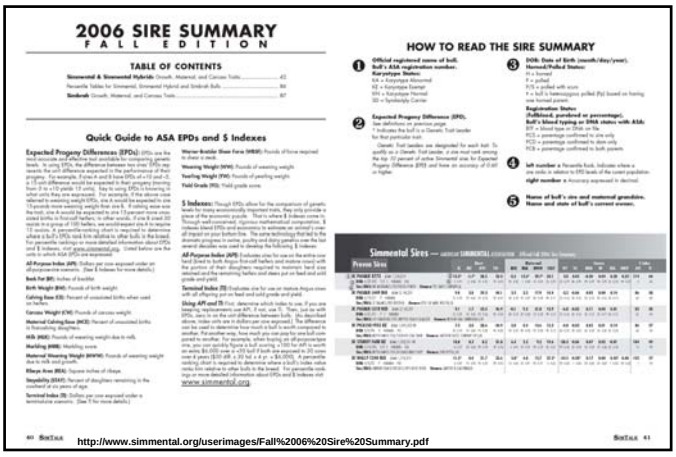
Mean Value of Simmental, Angus, Hereford, and Brahman genes in 1991

http://www.simmental.org/index.php?pageid=91









Selection and Mating Strategies

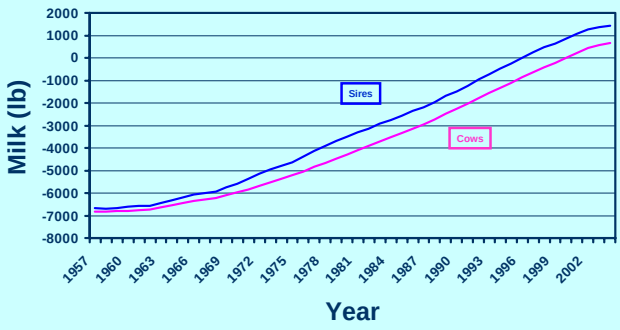
Selection Unitrait Multitrait - Indexes	Mating Strategies Unibreed Multibreed
Dairy Milk Profit Indexes	Dairy Pure breeding (US) Crossbreeding (OC)
Beef Weight Traits (D, M) Profit Indexes	Beef Pure Breeding (US, OC) Crossbreeding (US, OC)

Dairy Genetic Trends

Milk Yield
Fat Yield
Protein Yield
Somatic Cell Score (SCS)
Daughter Pregnancy Rate (DPR)

http://www.aipl.arsusda.gov/eval/summary/trend.cfm

Genetic Trend - USA



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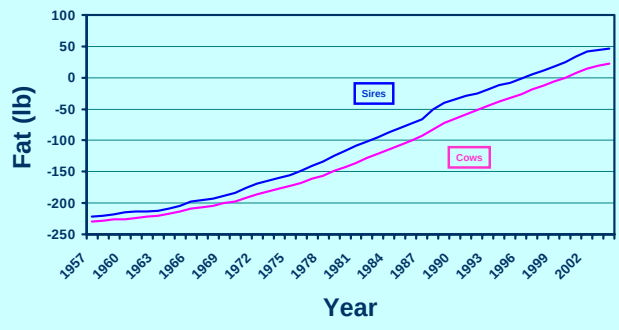

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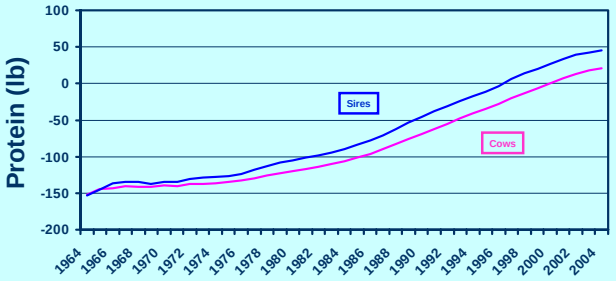
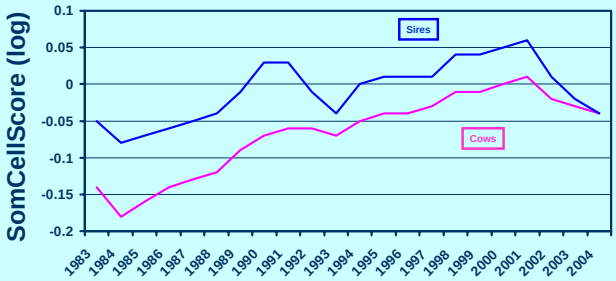
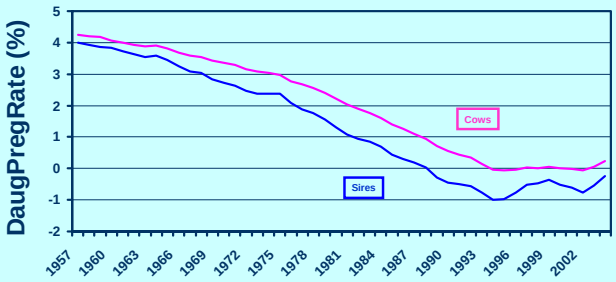


Genetic Trend - USA



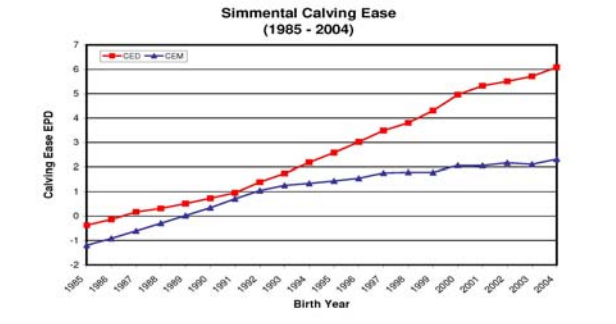
Genetic Trend - USA

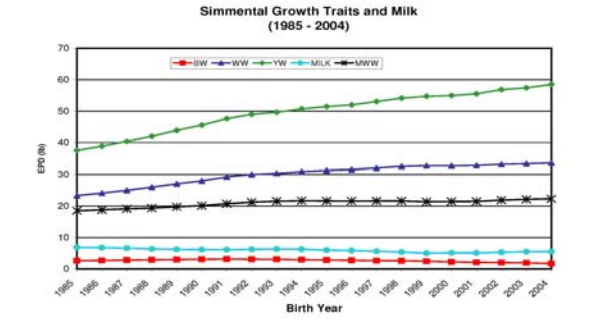


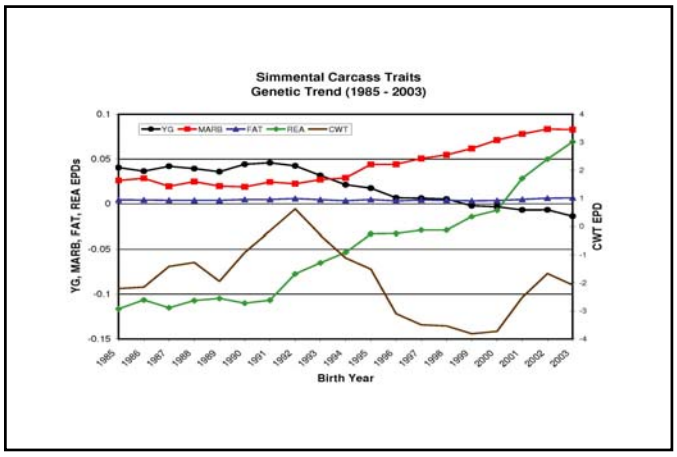
Beef Genetic Trends

Calving Ease Traits (CED, CEM)
Direct Growth Traits (BW, WW, YW)
Maternal Growth Traits (MILK, MWW)
Carcass Traits (YG, MARB, FAT, REA, CWT)

http://www.simmental.org/index.php?pageid=233



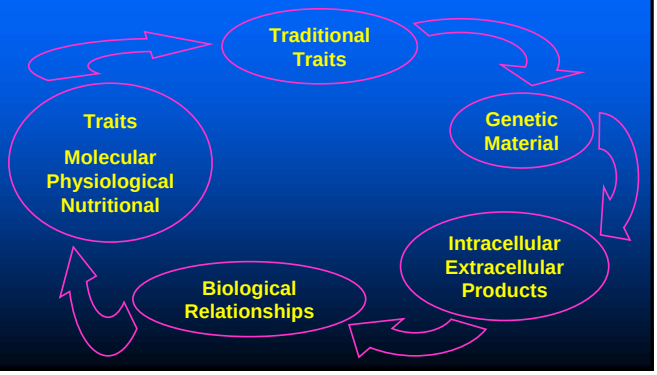




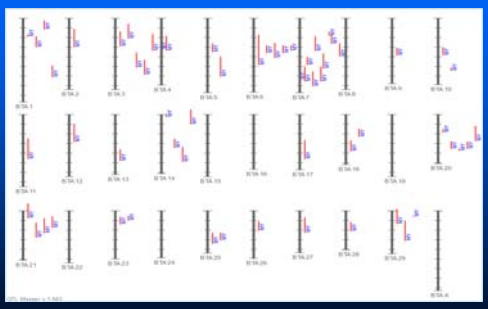
Future Genetic Evaluations

- New Traits
- New Procedures
- Composite Traits
- Integraton of QTL and Phenotypic Data
- New Flow of Information
- New Research Development Structure

New Traits

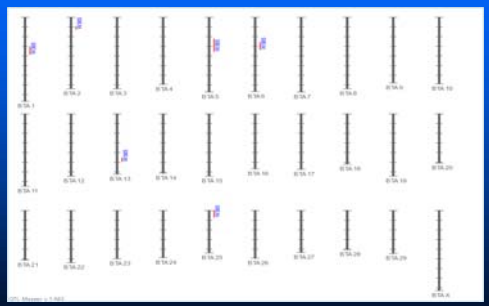


Cattle Genome - Milk Yield QTL



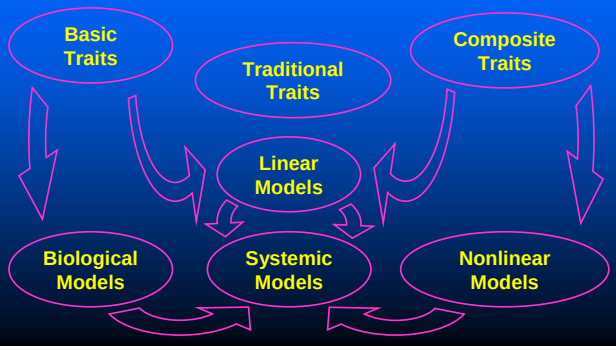
http://www.animalgenome.org/cgi-bin/QTLdb/BT/qtraitology?class_ID=1003

Cattle Genome – Yearling WT QTL



http://www.animalgenome.org/cgi-bin/QTLdb/BT/qtraitology?class_ID=1004

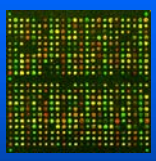
New Models



Microarray Technology

Milk

Fat



Ninth Month

Seventh Month

Level of Activity

Fifth Month

Active Genes

Third Month

First Month

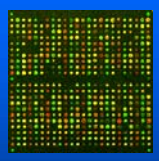
Groups of Genes

Relationships Among Genes

Microarray Technology

Milk

Fat



Ninth Month

Heat Resistance

Seventh Month

Immunologic Resistance

Fifth Month

Digestive Efficiency

Third Month

First Month

Oxytocin GH

Parasite Resistance

New Research Structure

Expensive Research Projects (Equipment, Personnel)

Large Number of Simultaneous Measurements (Biochips)

Private Companies Will Collect Most of the Genetic Information ?

Role of Universities ?

Role of National Organizations ?

Role of Breed Associations ?

Dairy Improvement Structure

Breed Associations
Phenotypes and DNA

Universities
Basic and Applied Research

Animal Improvement Program Laboratory (AIPL ARS-USDA)

Genetic Evaluation Center

Private Companies
Sire Sampling
DNA Analysis

Dairy Herd Improvement Association (DHIA)
Milk Sampling

Beef Improvement Structure

Breed Associations
Phenotypes and DNA

Universities
Basic and Applied Research

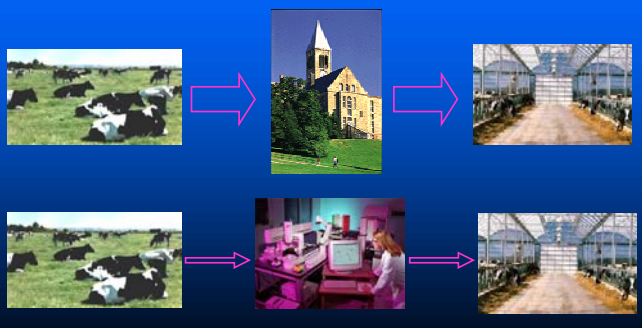
National Beef Cattle Evaluation Consortium (NBCEC)

Genetic Evaluation Center

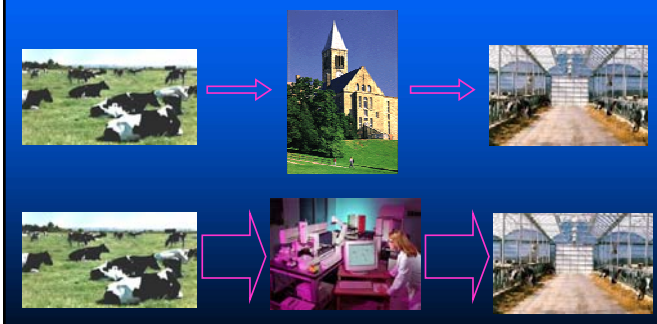
Private Companies
DNA Analysis

Research Centers
MARC

Current Flow of Information



Future Flow of Information



Universities

- Larger Integration with Private Sector
- Joint Basic and Applied Research with Private Sector
- Research Parks
- National Research Committees
- Participation in Product Development and Commercialization with the Private Sector

Globalization

- International Companies
- International Projects for Research and Development
- International Databases
- Regional Agreements
- Larger Genetic Changes
- Larger Economic Benefits