North American perspective on developments in performance testing of dairy cattle and applications in breeding programs

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Outline

- Traditional milk recording
- Today's functional traits
- Herd management software
- Other novel traits
- Impact of genomic selection

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Traditional Milk Recording

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Milk Recording, by Plan

Type of Plan	1998	2008
Supervised, all milk weights, all components	20.7%	16.4%
Supervised, all milk weights, AM-PM components	8.7%	13.8%
Supervised AM-PM milk weights, AM-PM components	48.3%	58.6%
Supervised, milk weights only (no components)	3.3%	1.4%
Unsupervised (owner-sampler)	18.7%	9.7%
Total herds	38,920	23,005
Total cows	4,446,460	4,414,821

48% of the USA cow population

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Progeny Testing, by Stud

Breeding Company	No. Active Cooperator Herds	No. Bulls Sampled in USA per year	Ratio
ABS Global	1,989	240	8:1
Accelerated Genetics	2,321	161	14:1
Alta Genetics	170	185	<1:1
Genex-CRI	1,304	252	5:1
New Generation Genetics	95	12	8:1
Select Sires	2,819	351	8:1
Semex USA	1,645	64	26:1
Taurus Service	874	17	51:1
Total (unique)	11,218 (7,619)	1,282	(6:1)

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Progeny Testing, by Herd

Percentage of Cooperator Herds *	Percentage of Calves
Top 1% (76 herds)	20.3%
Top 2.5% (190 herds)	34.1%
Top 5% (381 herds)	47.7%
Top 10% (762 herds)	62.7%
Top 25% (1,905 herds)	80.8%
Top 50% (3,809 herds)	92.4%
Total (7,619 herds)	100.0%

* Note that the USA has 23,005 milk-recorded herds and approximately 48,000 total dairy herds

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Progeny Testing, by Year

(Holstein)

Birth Year of Bull	Bulls Sampled per Year	Median Number of Daughters	Median Number of Herds	Median Contemporary Group Size
1986 to 1988	1,273	63	46	20
1989 to 1991	1,424	66	48	23
1992 to 1994	1,526	67	49	28
1995 to 1997	1,322	83	59	37
1998 to 2000	1,245	86	60	43
2001 to 2003	1,194	89	58	55

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Today's Functional Traits

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- Linear type traits
  - 4 body traits
    - economic value -4%
  - 2 rump traits
    - economic value 0%
  - 4 mobility traits
    - economic value +3%
  - 8 udder traits
    - economic value +6%
  - "OK" as indirect predictors

since early 1980's

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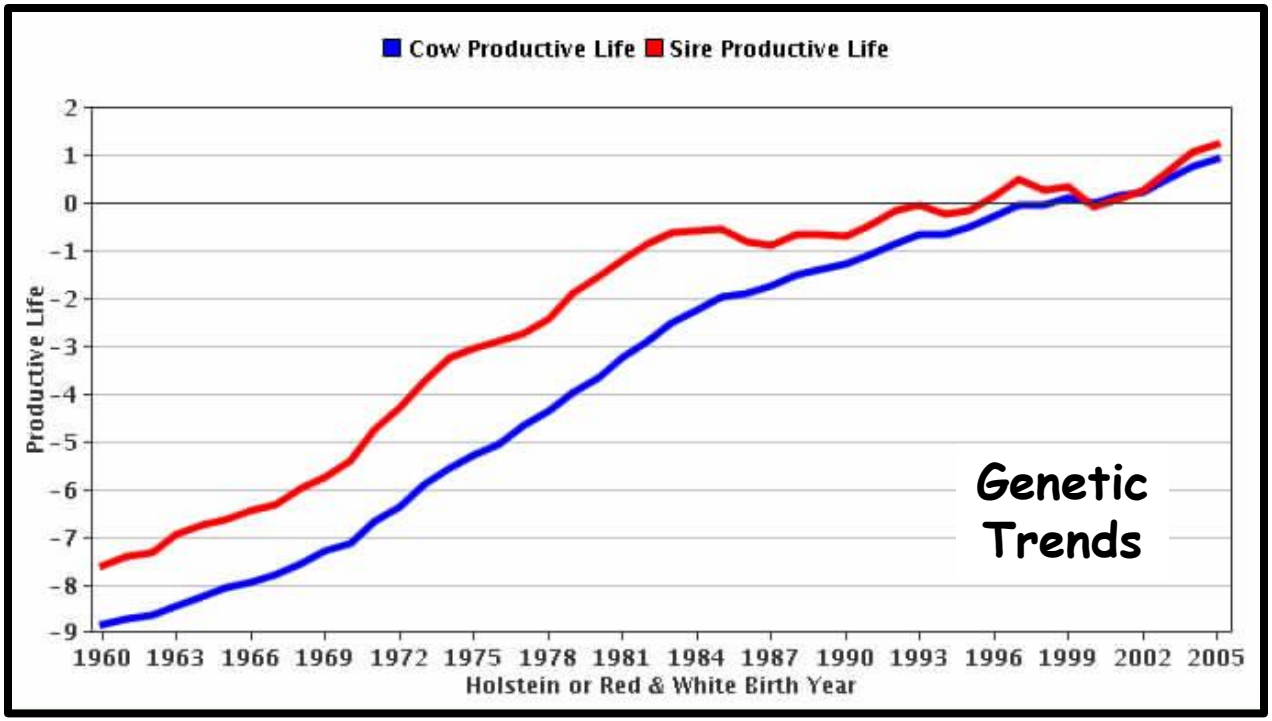
- Longevity
  - length of productive life
    - economic value +17%
    - available late in life

since 1994



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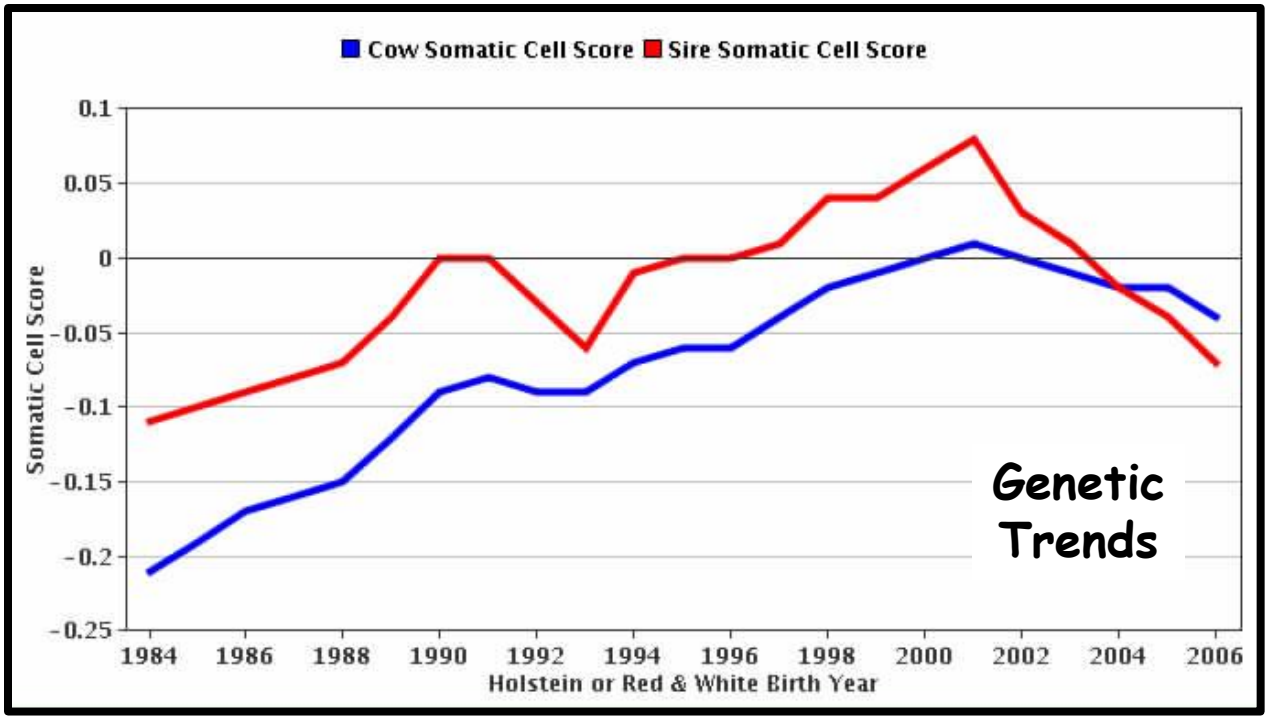
- Udder health
  - somatic cell score
    - economic value -9%
    - indirect predictor

since 1994



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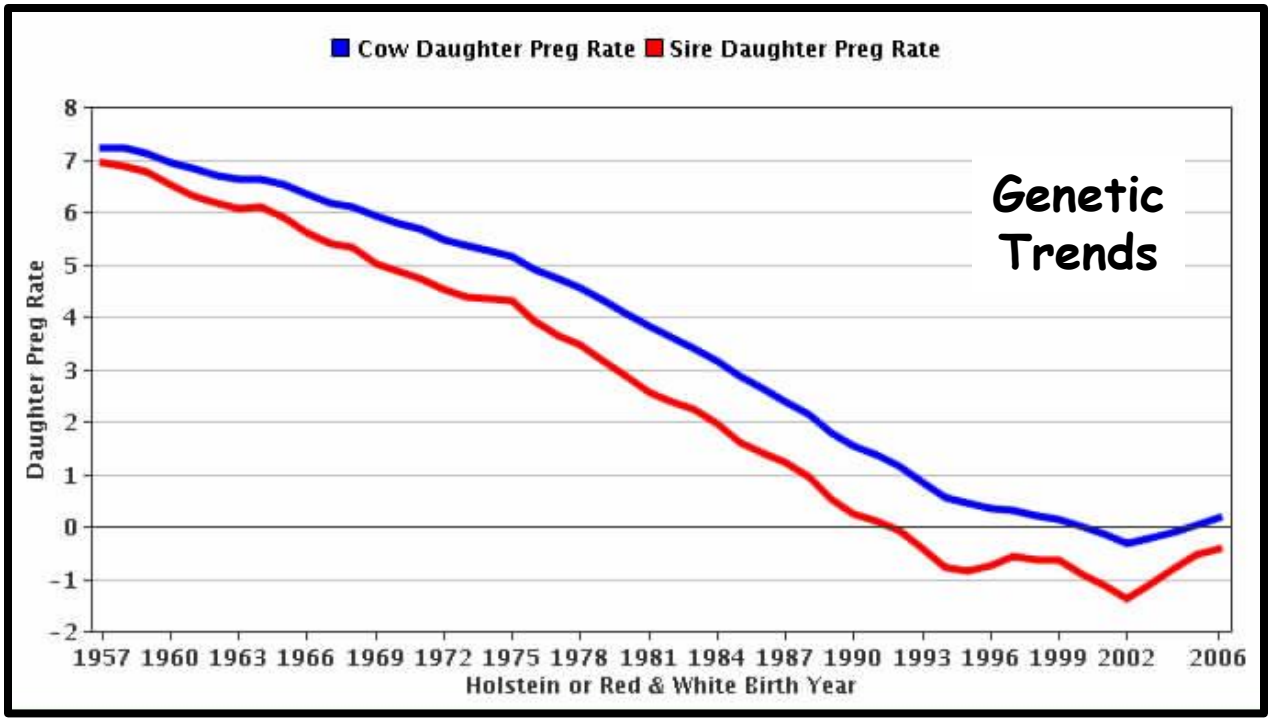
- Female fertility
  - daughter pregnancy rate
    - economic value +9%
    - data quality challenges

since 2003



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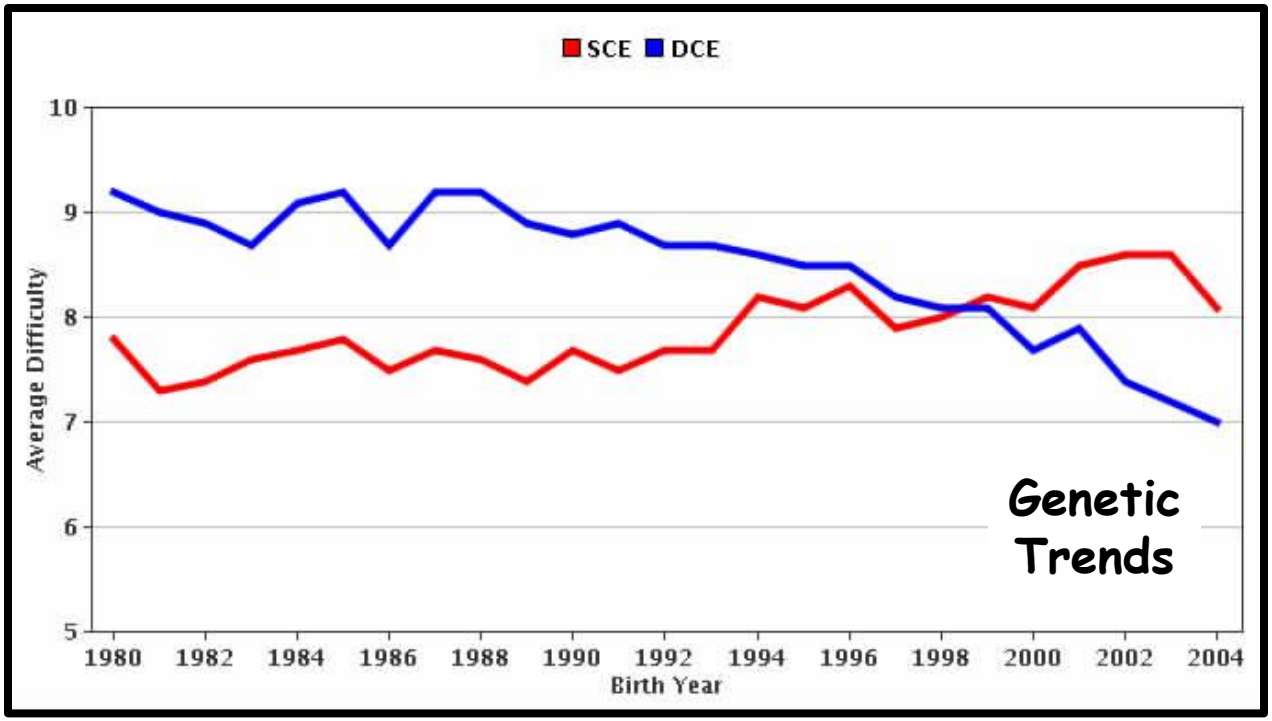
- Calving ease
  - direct and maternal
    - economic value +2.4%
    - mainly used for mating

since 2002



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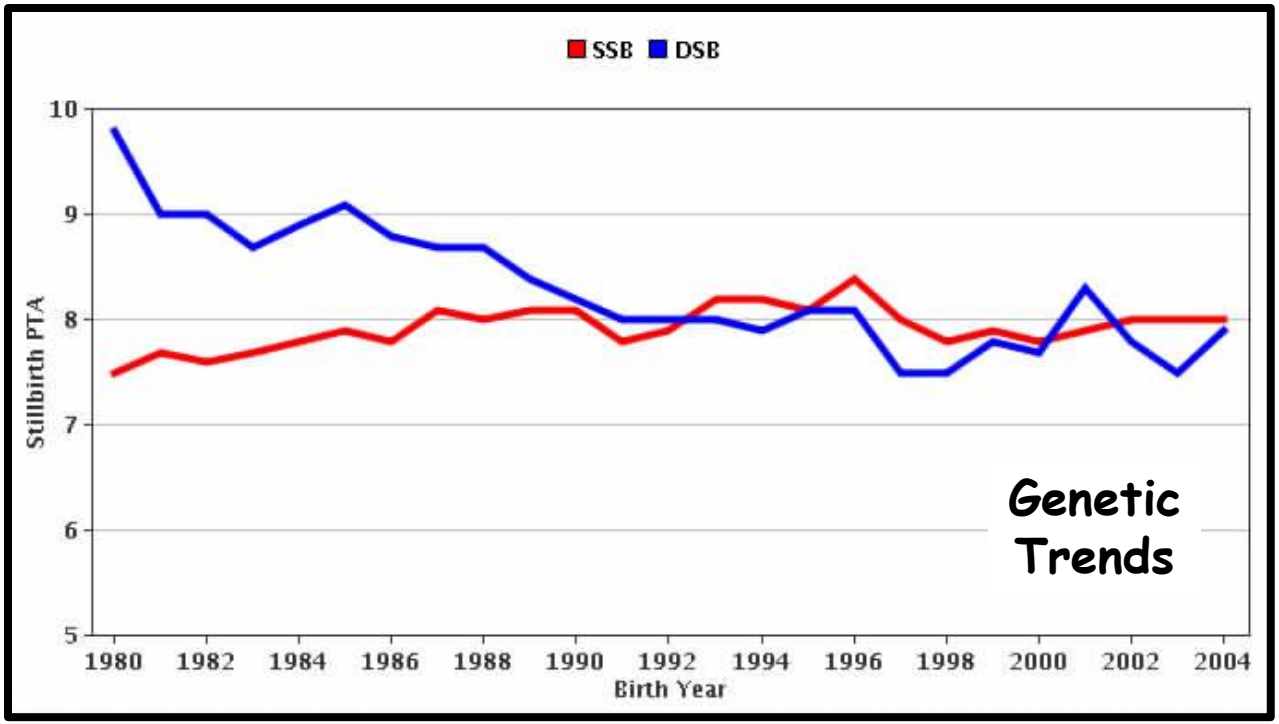
- Stillbirth rate
  - direct and maternal
    - economic value +3.6%
    - recorded in most herds

since 2006



Herd Management Software

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- Electronic capture of data
  - prevalent in large herds
  - primary source of data for genetic evaluations
  - continuous monitoring
  - manufacturer-specific
  - examples
    - flow rate of milk
    - physical activity

Health Disorders

Table 1. On-farm codes or acronyms used to record the 6 health disorders analyzed in the present study.

Displaced abomasum	Ketosis	Mastitis	Lameness	Cystic ovaries	Metritis
DA	KETOSIS	MAST	ABCS	CYST	MET/RP
D.A.	KETOTIC	RF	ABSS	CYSTG	MET
LDA	KET	LF	HROT	CYSTO	METR
RDA	KETO	RR	HFROT	CYSTIC	RP
L-DA	KETOS	LR	LAMINIT	RCYST	RETAINP
R-DA	KET1	MLFQ	LAME	LCYST	RETP
DAS	KET2	MLRQ	WRAP	CYSTRO	INFU
DALF	KET3	MRRQ	LAMI	CYSTLO	INF
DART	KETI	MRFQ	LIMP		MTRI
DAR	KETR	MLF	SOREFT		RETN
DAL	KETS	MLR	ABCSRR		RPL
	KETH	MRR	ABCSLR		RPIN
	KETD	MRF	FOOT		RPRE
	KETP	RFMT	FEET		UCND
	METB[1]	LFMT			RTPL
		LRMT			UINF
		RRMT			PYOM
		M2TIT			UTCN
		MASTALL			RE-PLA
		MAST2Q			
		MAST3Q			

[1]Used as an acronym for ketosis in herds with the PCDART software only.

(Zwald et al., 2004)

Heritability Estimates

Table 4. Heritability estimates (± SE) from the first lactation and all lactation analyses for each health trait and for pooled incidence of any disease (among these 6 diseases) between calving and 50 d postpartum.

Disorder	Analysis	Heritability
Displaced abomasum	1st lactation	0.18 ± 0.010
	All lactations	0.15 ± 0.006
Ketosis	1st lactation	0.11 ± 0.007
	All lactations	0.06 ± 0.005
Mastitis	1st lactation	0.10 ± 0.003
	All lactations	0.09 ± 0.003
Lameness	1st lactation	0.07 ± 0.003
	All lactations	0.06 ± 0.003
Cystic ovaries	1st lactation	0.08 ± 0.005
	All lactations	0.05 ± 0.005
Metritis	1st lactation	0.08 ± 0.004
	All lactations	0.07 ± 0.003
Any disease within 50 d postpartum	1st lactation	0.12 ± 0.005
	All lactations	0.10 ± 0.004

(Zwald et al., 2004)

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Sire PTAs

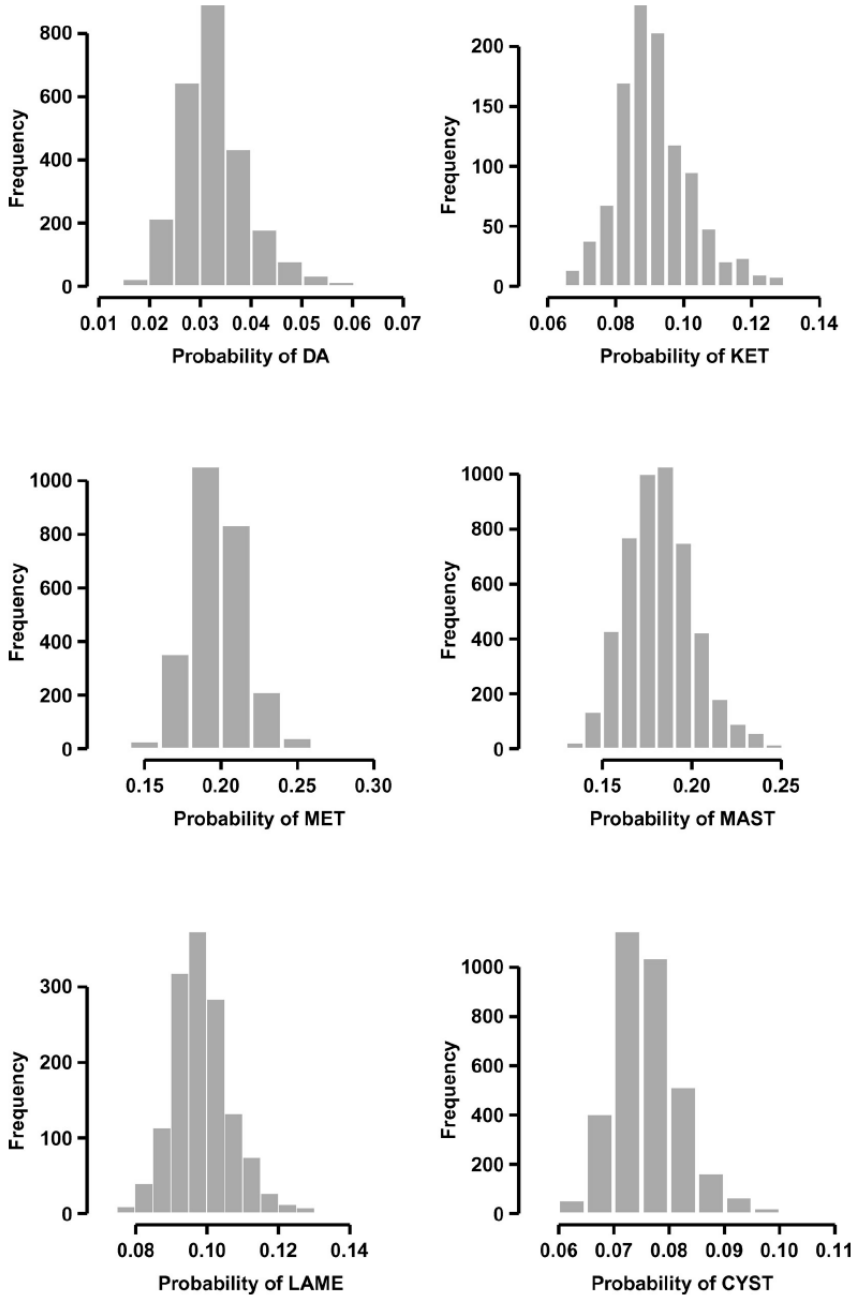

Figure 1. Distribution of sire PTA, expressed as probabilities of disease, for displaced abomasum (DA), ketosis (KET), metritis (MET), mastitis (MAST), lameness (LAME), and cystic ovaries (CYST).

(Zwald et al., 2004)

Health Database

Health Events (up to 20 segments)
Type of health event code
Date of health event (YYYYMMDD)

USDA Format 6

Health Traits	
Cystic Ovary	CYST
Diarrhea/Scours	DIAR
Digestive Problem/Off Feed	DIGE
Displaced Abomasum	DA--
Downer Cow	DOWN
Dystocia	DYST
Johne's Disease (clinical)	JOHN
Ketosis/Acetonemia	KETO
Lameness	LAME
Mastitis (clinical)	MAST
Metritis	METR
Milk Fever/Hypocalcemia	MILK
Nervous System Problem	NERV
Reproductive problem other than CYST, DYST, METR, RETP	REPR
Respiratory Problem	RESP
Retained Placenta	RETP
Stillbirth/Perinatal Survival	STIL
Teat Injury	TEAT
Udder Edema	EDEM

Management Traits	
Body Condition Score	BCS-
Milking Speed	SPEE
Temperament	TEMP

- Infectious diseases and metabolic disorders
  - differences in exposure
    - e.g., mastitis pathogens
  - inconclusive test results
    - e.g., Johne's disease
  - incomplete reporting
    - incorrect diagnosis
    - underestimated severity
    - selective treatment

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- Health disorders, continued
  - periodic recording
    - record during outbreak
    - cease once problem solved
    - may require meta-analysis
  - identification of "outliers"
    - identify cows to genotype
      - affected individuals
      - healthy contemporaries
      - case-control studies

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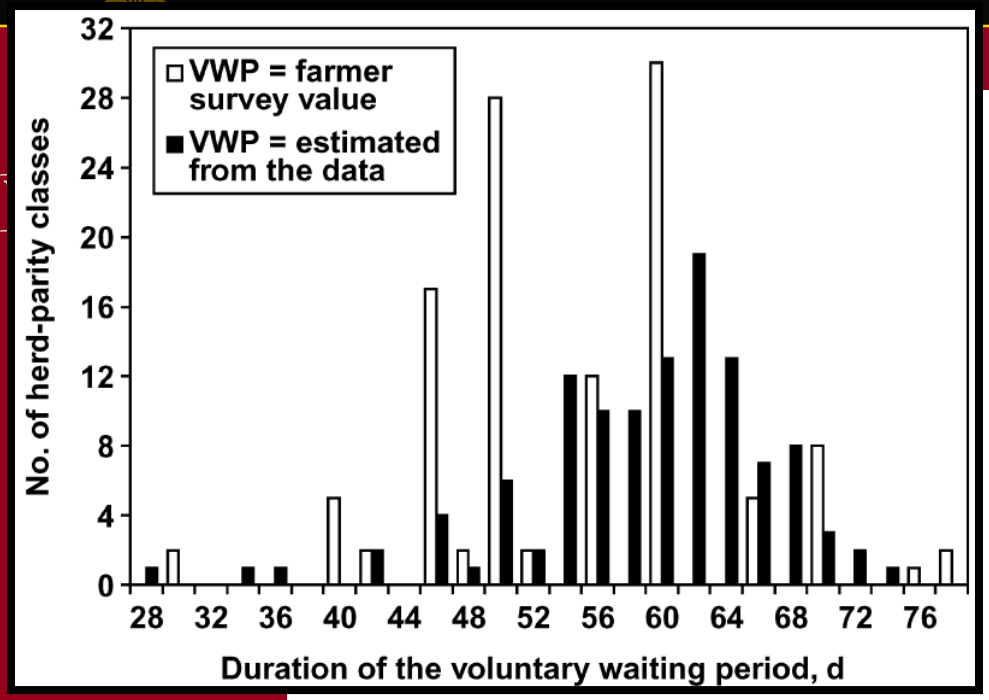
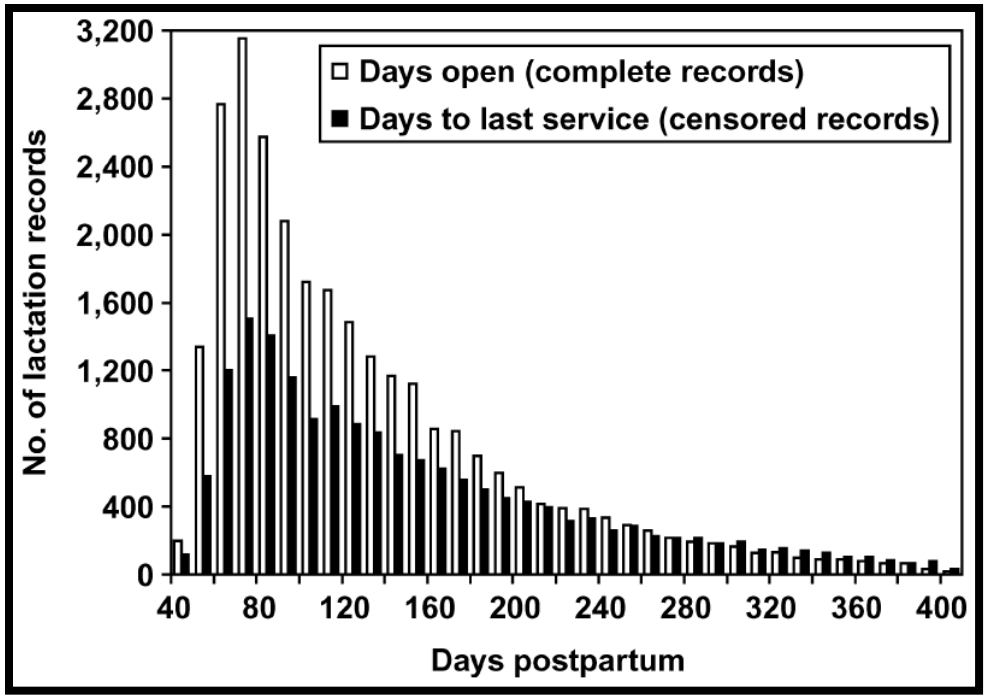
- Challenges with "outliers"
  - biological variation
    - genetic predisposition
    - illness, estrus, etc.
  - random variation
    - human influence or error
    - RFID reader error

Reproductive Events





(Chang et al., 2007)

Reproductive Database

Reproductive Events (up to 20 segments)
Type of reproductive event code
Date of reproductive event (YYYYMMDD)

USDA Format 5

H	Observed in estrus (heat) but not inseminated
S	Synchronized estrus event (injection or other methods)
A	Artificial insemination
N	Natural service breeding
E	Embryo donation
I	Embryo implantation (reporting sire of embryo)
J	Embryo implantation (reporting dam of embryo)
P	Confirmed pregnant
O	Confirmed not pregnant (open)
X	Cow given a "do not breed" designation
G	AI breeding with gender selected semen

Milking Duration

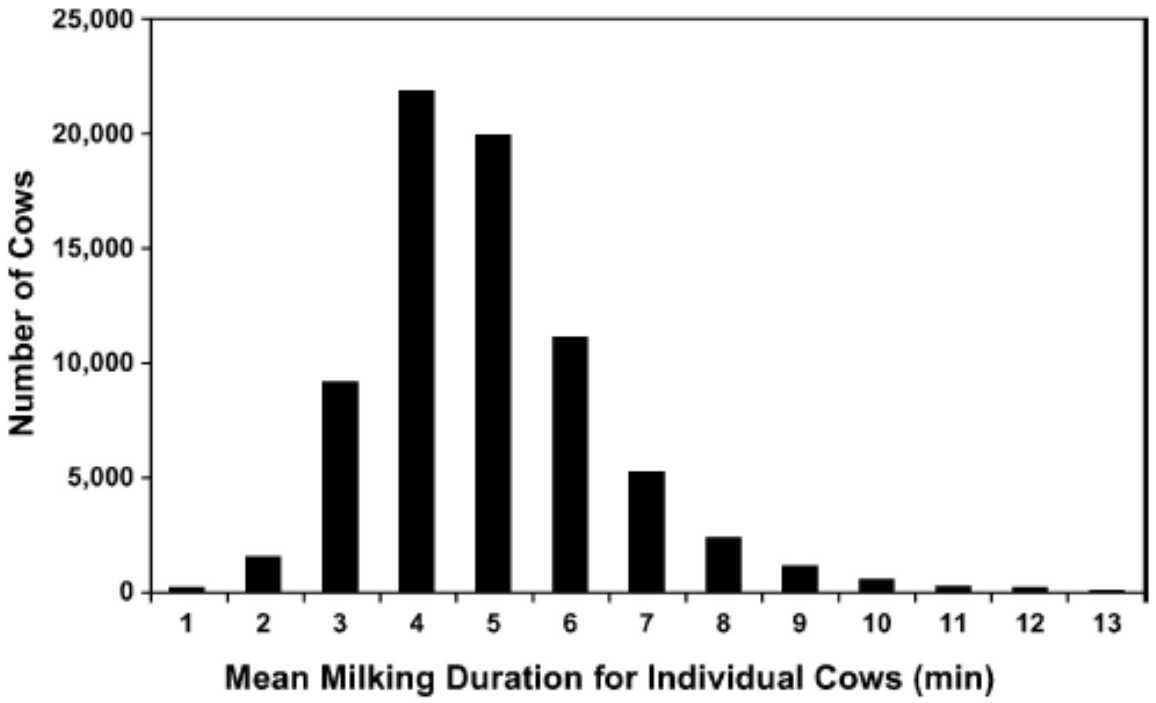


Figure 1. Distribution of the mean of single, weekly measurements of milking duration for individual cows in the present study.

Table 2. Estimated genetic parameters for milking duration, based on a single measurement per cow per week.

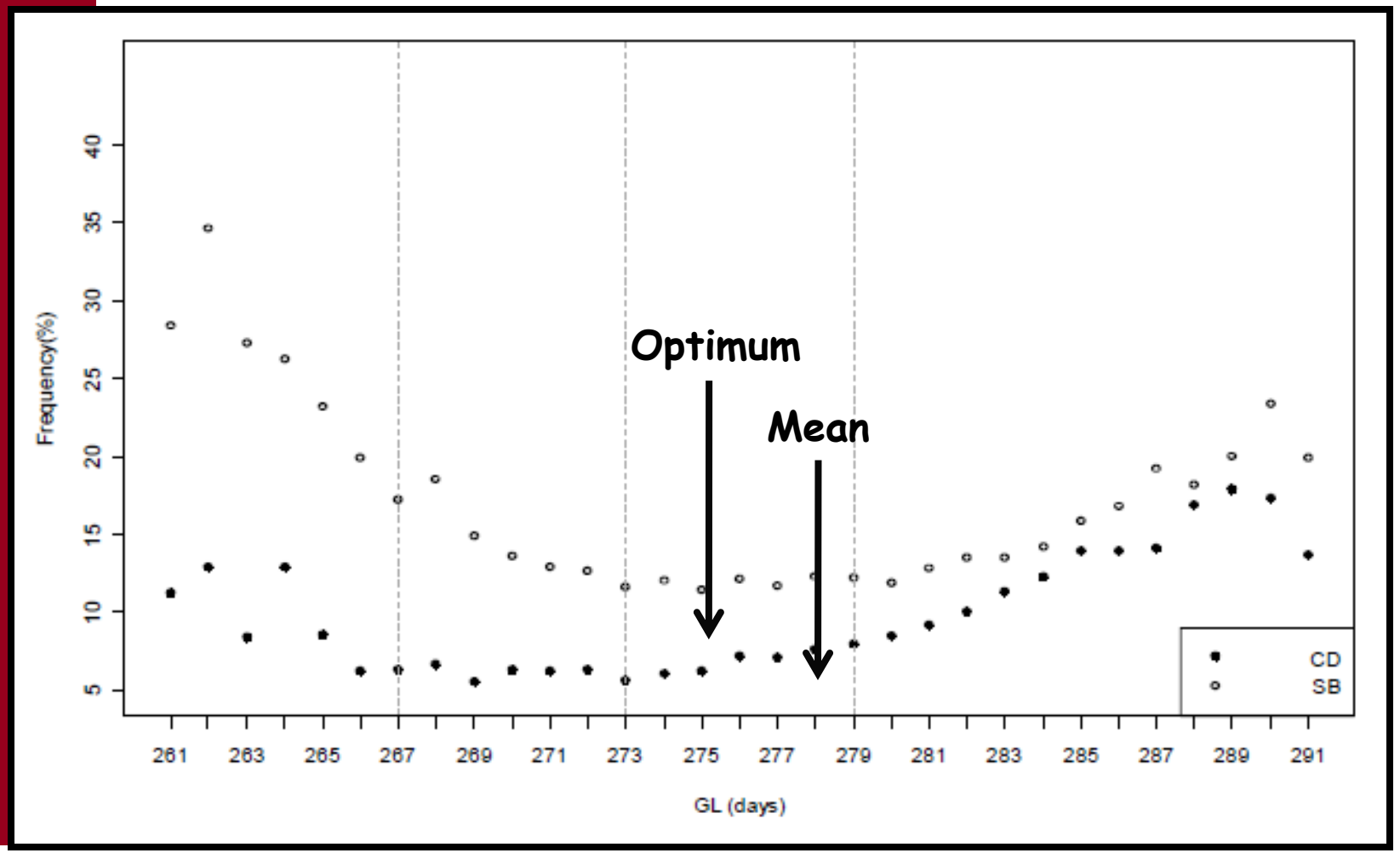
Parameter	Posterior mean	Posterior SD
Herd-test date variance (min^2)	1.13	0.18
Sire variance (min^2)	0.09	0.03
Cow variance (min^2)	1.01	0.02
Residual variance (min^2)	1.00	0.01
Heritability	0.17	0.03

(Zwald et al., 2005)

Other Novel Traits

Gestation Length

(1st parity Holsteins)



(López de Maturana et al., 2008)

Gestation Length

7HO6417 O Man
14,871 calves
1,387 herds

Direct Gestation Length PTA: -3.6 days

Body Temperature

	Internal Body Temperature							Ambient	
Date & Time	Cow 1	Cow 2	Cow 3	Cow 4	Cow 4	Cow 6	Cow 7	Temp.	Humid.
7/6/2005 8:00	101.71	101.56	102.11	101.01	101.26	101.81	100.91	83.40	30.30
7/6/2005 8:05	101.76	101.61	102.06	100.91	101.26	101.76	100.81	84.83	30.30
7/6/2005 8:10	101.81	101.61	101.91	100.81	101.26	101.81	100.76	86.32	29.40
7/6/2005 8:15	101.91	101.66	101.81	100.76	101.31	101.81	100.76	87.50	29.40
7/6/2005 8:20	101.96	101.66	101.76	100.76	101.41	101.86	100.76	88.78	28.90
7/6/2005 8:25	102.01	101.71	101.76	100.76	101.51	101.91	100.76	88.83	28.40
7/6/2005 8:30	102.01	101.76	101.76	100.81	101.56	101.86	100.81	88.46	28.40
7/6/2005 8:35	101.91	101.76	101.81	100.76	101.56	101.91	100.86	88.32	28.00
7/6/2005 8:40	101.81	101.76	101.86	100.81	101.56	101.91	100.86	88.65	28.00
7/6/2005 8:45	101.76	101.76	101.91	100.86	101.56	101.96	100.86	88.51	28.00
7/6/2005 8:50	101.71	101.66	101.91	100.91	101.56	101.96	100.81	88.10	28.00
7/6/2005 8:55	101.66	101.56	101.96	101.01	101.61	101.96	100.71	87.91	27.50
7/6/2005 9:00	101.66	101.51	101.91	101.11	101.61	101.96	100.71	87.96	27.00
7/6/2005 9:05	101.66	101.46	101.86	101.16	101.56	102.01	100.71	88.00	26.60
7/6/2005 9:10	101.71	101.46	101.86	101.16	101.51	102.11	100.76	88.42	26.10
7/6/2005 9:15	101.76	101.46	101.91	101.21	101.56	102.22	100.81	89.38	25.60
7/6/2005 9:20	101.81	101.51	101.81	101.31	101.61	102.27	100.96	90.96	24.30
7/6/2005 9:25	101.81	101.46	101.66	101.36	101.66	102.27	101.06	92.12	23.80
7/6/2005 9:30	101.71	101.46	101.56	101.36	101.66	102.11	101.16	93.07	22.90
7/6/2005 9:35	101.56	101.46	101.41	101.31	101.66	102.01	101.16	93.68	22.50
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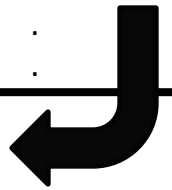

barn or weather station

(Schefers et al., 2008)

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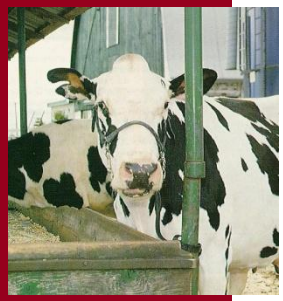

- Indicators of cow health
  - body condition score
    - opposite of dairy form?
  - locomotion score
    - same as feet & leg score?
  - behavior
    - walking, lying, eating
  - hormones and enzymes
    - BHBA, progesterone, etc.

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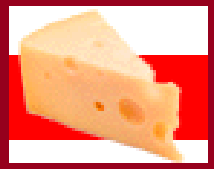

- Indicators of product value
  - Mid-IR spectrometry
    - caseins
    - fatty acids
    - minerals
- Indicators of efficiency
  - body weight
  - feeding behavior
    - number of meals
    - intake at each meal

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Impact of Genomic Selection

What will be the role of progeny testing in the future?

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- Progeny testing
  - fewer bulls, fewer herds
  - may not be necessary at all
  - impact on milk recording ???
- Sire acquisitions
  - multi-stage genomic screening
  - dedicated supplier herds
    - long-term contracts
    - routine genotyping
    - detailed phenotypes

Are traditional "all inclusive" data collection systems the best strategy in the future?

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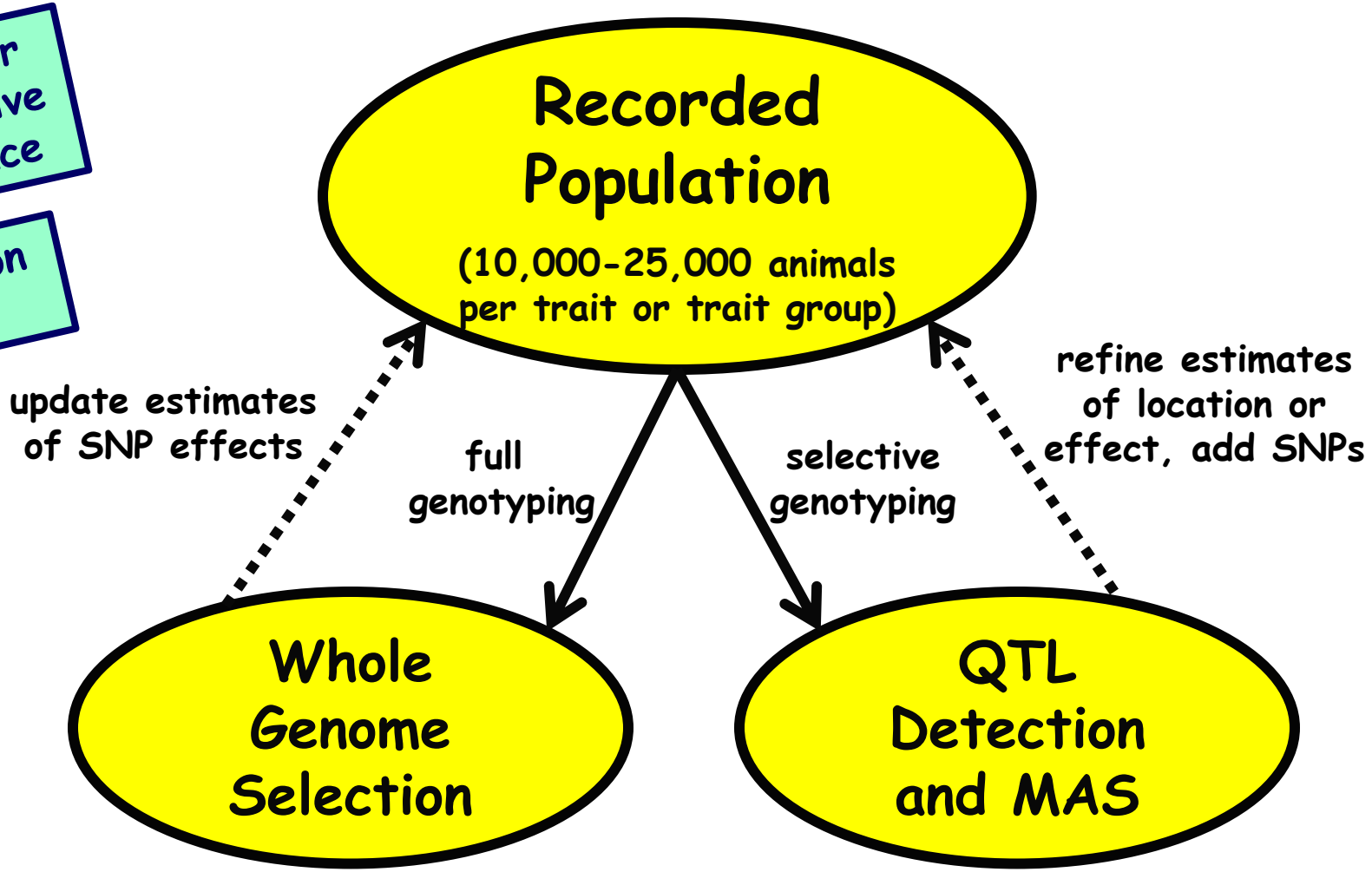
- Potential sources of data
  - experimental herds
  - selected cooperator herds
  - nucleus or supplier herds
  - custom heifer growers
  - calf ranches
  - veterinary databases
    - Johne's, mastitis, etc.
    - sire ID via DNA testing
    - case-control studies

Novel Traits and Genomics

additive or non-additive inheritance

no selection bias



$200/genotype
$100/trait
5 traits/group
select high/low 10%

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