

Practical applications of genomics in livestock

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The challenge for Livestock Production

**2050: Feeding 9 billion people
*within the carrying capacity
of planet earth***



*2 times more
with 2 times less*



Challenges for Livestock (Production)

Measuring and predicting (new) phenotypes for:

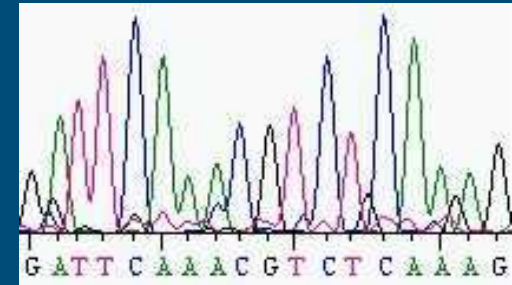
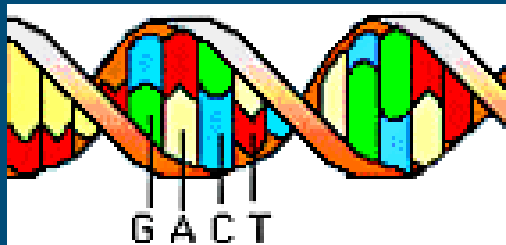
- On-farm management
 - Fine-tune nutrition, etc.
 - Predict status: disease, pregnancy
- Breeding purposes
 - Measuring (new) traits
 - Predict breeding value (for genomic selection)

=> Genomics: measure and predict an animals' phenotype

Genomics applications for breeding purposes

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Marker assisted selection & Genomic selection

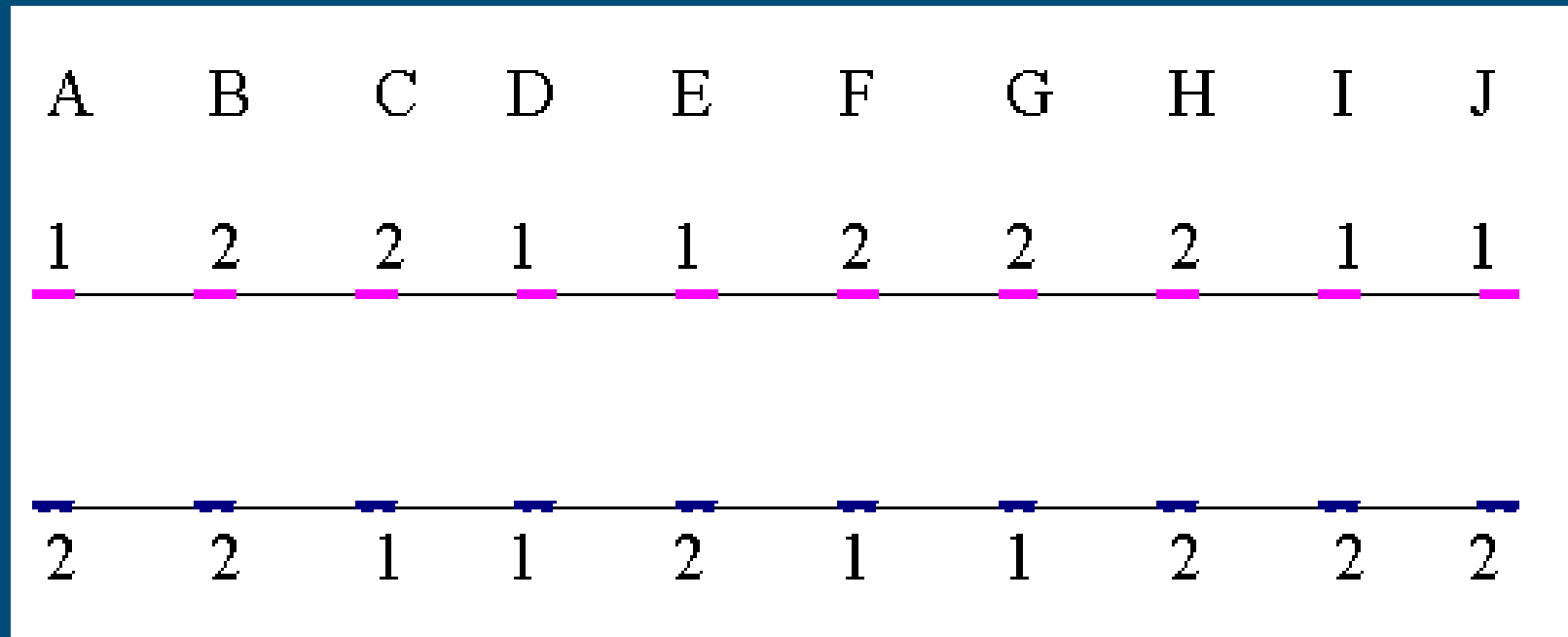


Marker-assisted selection

- Selection (partly) based on few genetic DNA-markers linked with QTL
- Limited uptake:
 - A small part of genetic variance captured
 - QTL discovery costs are high
- Availability of genome-wide dense markers enabled 'Genomic Selection'

Genomic Selection

Genome of animal X (SNPs A, B, ..., J):



Breeding value animal X = A1 + A2 + B2 + B2 + ... + J1 + J2

200_alleles_per_line.dat - WordPad

File Edit View Insert Format Help

100699-0001 AAGGATTACTTTATCGGGATATTGTACTACCAAGATTATTATTGTATAACACCGTTTTTCATTATTTCAAACGTTTTAAATTATATCTCATTGGATGAGTTGATCCAGGTGGGAAATTTAAATTCGGCTACACGGCTTAAT1

100699-0001 AAGGCCCGCCCCCGGGGGATCGGGCCCCGGGGCTACTGCCGGTAAACACCGCTGCCATTGTCCCGAACGTCGGGTCGTATCTCCCGGACGGCCGGTCCGGGGGGGAATTCACCTTCGGGTGCACCGCGGACC

100699-0002 AAGGATCACACTGTCCGGGTGTTAGGTTACCAAAATATTGCTATGTAAACATATTTTCAAACTCAGATGTTTGGGTTATATCTCATTGAGCGAGCTGATCTAGATGGAAAATTTAAATTTAGG-ACACACGCAATC

100699-0002 AAGGCCCGCCCCCGGGGGTTCGGGGCCACAGGGCGGTTGCCGCGACGGCCGTTGCCGCAACCCCGGGCGTTCCGGGGTGTGTGCCACCGGGCGGGCGGTCGGGTGGGGGATCCAGTTTCGGC-GCACCGCAATC

100699-0003 AAAGACTGTCCTGT

100699-0003 GAGGACCGTCCCGT

100699-0004 GAGGACCGTACTGT

100699-0004 GGGGCCCCGTCGGT

100699-0005 AAGGACTATCCTGC

100699-0005 AGGGCCCCCGCCCCG

100699-0006 AAGGATTATCCCGT

100699-0006 AAGGCCTGCCCGCG

100699-0007 AAGGCTTATATTGT

100699-0007 GGGGCCCCGCTCGC

100699-0008 AAGGATCACCTAC

100699-0008 AGGGCCCCCGCCCCG

100699-0009 AAGGACTGCCTTGT

100699-0009 GGGGACTGCCCGCG

100699-0010 GAGGATTGCCCTAT

100699-0010 GGGGCTGCCCGCG

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100699-0011 GAGGCCTGCCCTGC

100699-0012 AGGGCCTGTCTCGC

100699-0012 GGGGCCCCCGCCCCG

100699-0013 AAGGATTGCATCGT

100699-0013 GGGGACCGCACCGC

100699-0014 AAGGACCGTATCGT

100699-0014 GGGGCCCCGACCGC

100699-0015 AAGGATCGCATCGT

100699-0015 GAGGCCCGCACCGT

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100699-0016 GAGGCTCGCCCCCGGGAGGTCAGACCACCGAGGCTGCTACCACATAACGCGTCCCGGTTGTCCCGAACCGCCTAGTCCGTTGCCCGCCCGGGCGGTTCCGAGTGGGGACGCCACTTACGCTGCACCGCGGCGCC

100699-0017 AAGGCCACATTATCGGTGTGTTGGATTACCAGGGCTATTGCCGTGTAATACCATTTTAATAGTCTCAAAACGTTTTAGTCTATGTATCATCGGGTAAAGCCGGTCCGGATAGAGGATCCAAATTTAAGT-ACACCGGCAATC

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100699-0018 AAGGCTT

100699-0018 GGGGCC

100699-0019 AAGGACT

100699-0019 GGGGCC

100699-0020 AAGGACT

100699-0020 GGGGCC

100699-0021 AAGGACT

100699-0021 GGGGACT

100699-0022 AAGGACT

100699-0022 GGGGCC

100699-0023 GAGGATT

100699-0023 GAGGCC

100699-0024 GAAGATT

100699-0024 GAGGCT

100699-0025 AAGGACT

100699-0025 GGGGACT

100699-0026 AAGGACT

100699-0026 AGGGCC

100699-0027 -GGG-C-

100699-0027 -GGG-C-G-ACTGCCGGGGGCTGGACCCCGAGGGCG-CTACCGTGCACGCGG-CGTCACAGCCC-GAACGCGTGAAGGCTGTGTCCCC-CGGGGGGG-C-G-CGGGTGGGGGAGCCAACTTCGGTTGCACCGCGGGT

NUM

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SNP chips:

Pigs: 64k

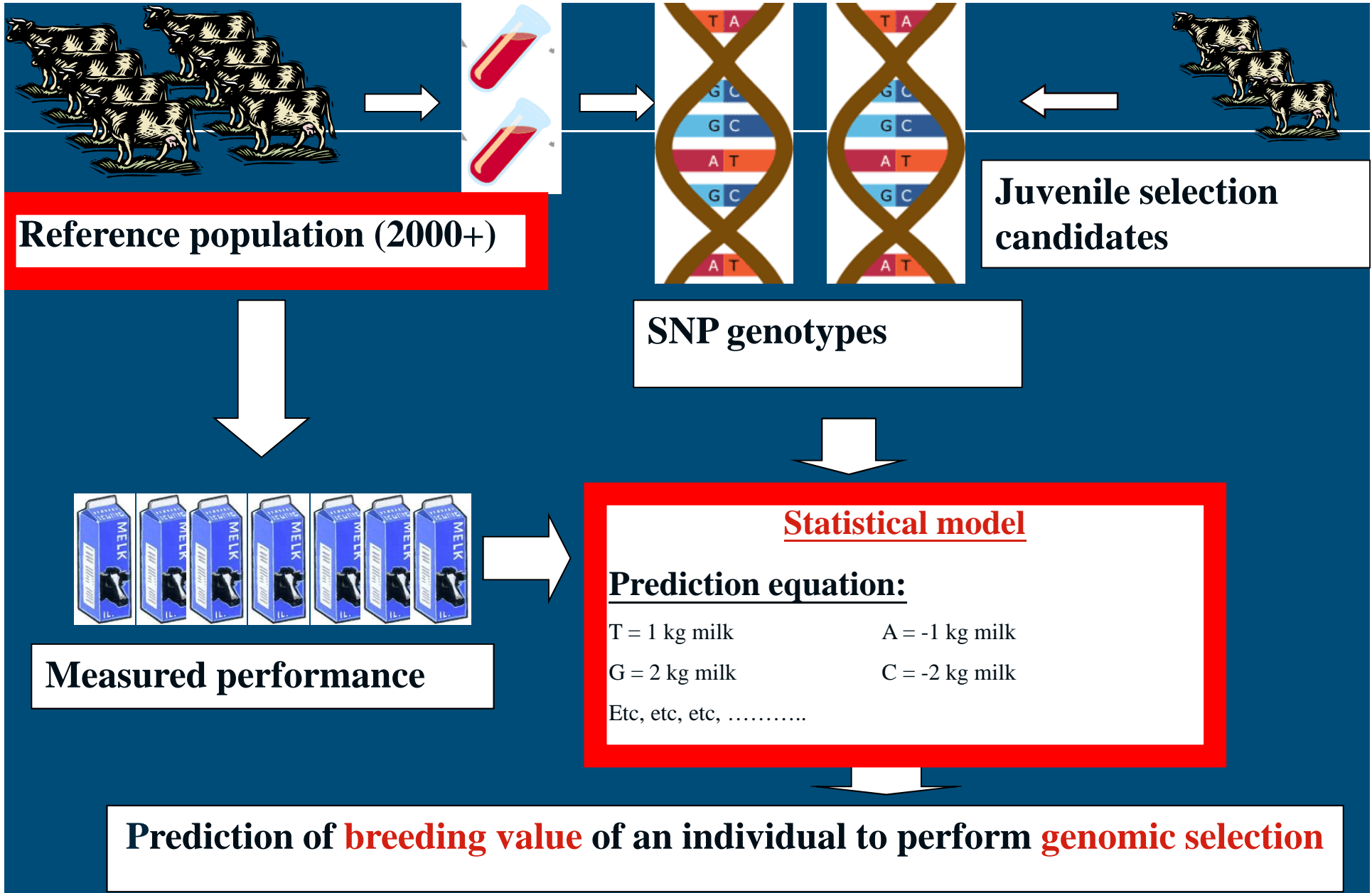
Poultry: 57k

Cattle: 6k, 54k, 640k & 777k SNP

Whole genome sequence:

Cattle: 3,500,000,000 base pairs

>10,000,000 SNP ???



Reference data

- Key for accurate prediction
- Size reference data
 - Up to 16,000 animals

=> Increasing reference data improves accuracy GS
for all traits

Genomic selection



Persbericht

Arnhem, 16 oktober 2006

EURIBRID FIRST TO USE GENOMIC SELECTION



FIRST COMMERCIAL USE OF GENOMIC SELECTION
20,000 GENETIC MARKERS USED

Genomic selection in Irish dairy cattle breeding scheme.



Genomic selection in Irish dairy cattle breeding scheme

PRESS RELEASE



VikingGenetics ready to use Genomic Selection

Genomic Selection will be possible in VikingGenetics in August. The breeding plan will be far more effective and we will be able to improve the breeding progress by 50% or more. At the moment we work closely together with researchers from Aarhus University in introducing Genomic Selection.

In January 2008 a new set of markers became available. This set has 60,000 markers.

Genomic Selection
traits of an animal
markers to test for

Ministry of Agriculture & Forestry

Print Email RSS

LIC salutes breeding revolution

4:00AM Thursday Oct 09, 2008
By Owen Hembray

New DNA breeding technology is being launched c
Kiwi farmers outstrips expectation, says listed ani
co-operative LIC.

Speaking at the annual meeting yesterday, chairma
company had achieved the greatest revolution sinc
introduced in the 1950s.

"The cumulative effect to the dairy industry will be
dollars in years to come."

LIC's (Livestock Improvement) genomic selection p
their DNA, compared with a conventional method
several cows and then production-testing the daughters when they come into
milk.

Current selection systems could return an increase of 1.3 per cent in milk
production from a cow in a year but LIC expected the new DNA process to
improve that result by at least half.

Chief executive Mark Dewdney said the initial estimate for DNA-proven
genetic sales in the first year was about 300,000 inseminations but LIC was
holding orders for about 700,000 straws.



Genomic Selection-A Practical Explanation

Dr. Kent Weigel
August 21, 2008

Since December, 2007 roughly 15,000 North American dairy bulls have been genotyped using a technology called the Illumina BovineSNP50 BeadChip. This technology was developed in a partnership between Illumina Inc., the USDA Agricultural Research Service, the National Association of Animal Breeders, Merial, and researchers at several other universities and institutes. The major breakthrough delivered by this technology is the ability to carry out 54,000 DNA marker tests simultaneously, for a modest cost of less than \$250 per animal. These single nucleotide polymorphism (SNP) markers, which



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Technology » Genomics

The Genomics Revolution Is Upon Us

Genetic progress just got faster with the release of Genomic Evaluations during the recent Dairy Sire Summary. A quick bit of history - prior to 1935 there was no national program for evaluating dairy cattle breeding and no real genetic progress was made. Over the past 74 years various programs and/or traits have been introduced, each increasing the rate of genetic progress in differing amounts and improving the dairy cow. The recent employment of genomic evaluations is projected to have one of the

Accelerated Genetics

GENETICVISIONS



WORLD WIDE SIRES, Ltd.

SEARCH

Genomic selection for new traits

- For traits that are hard or expensive to measure

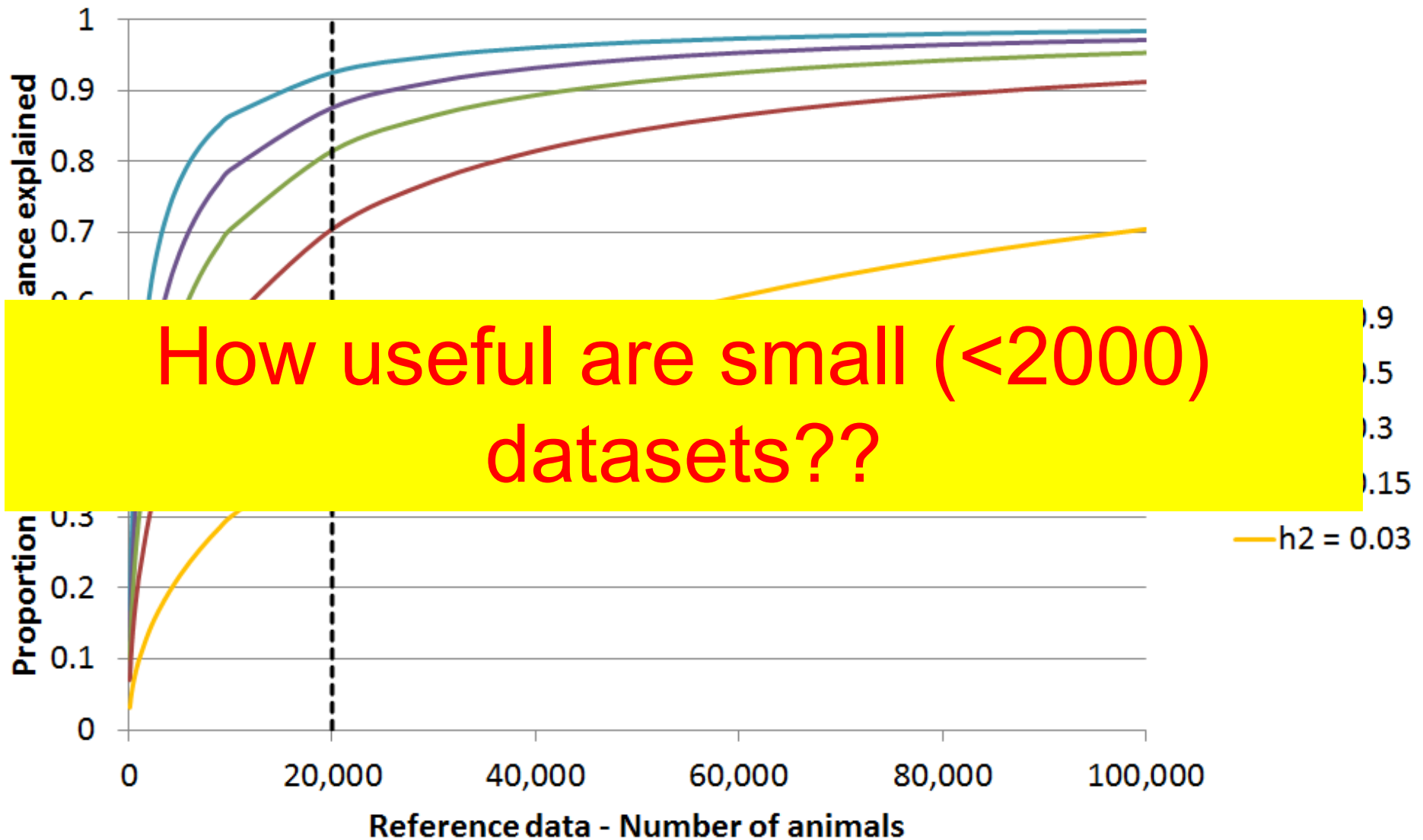
Allows for:

⇒ 'deep-phenotyping' difficult to measure traits
(e.g. progesterone, methane emission, etc.)

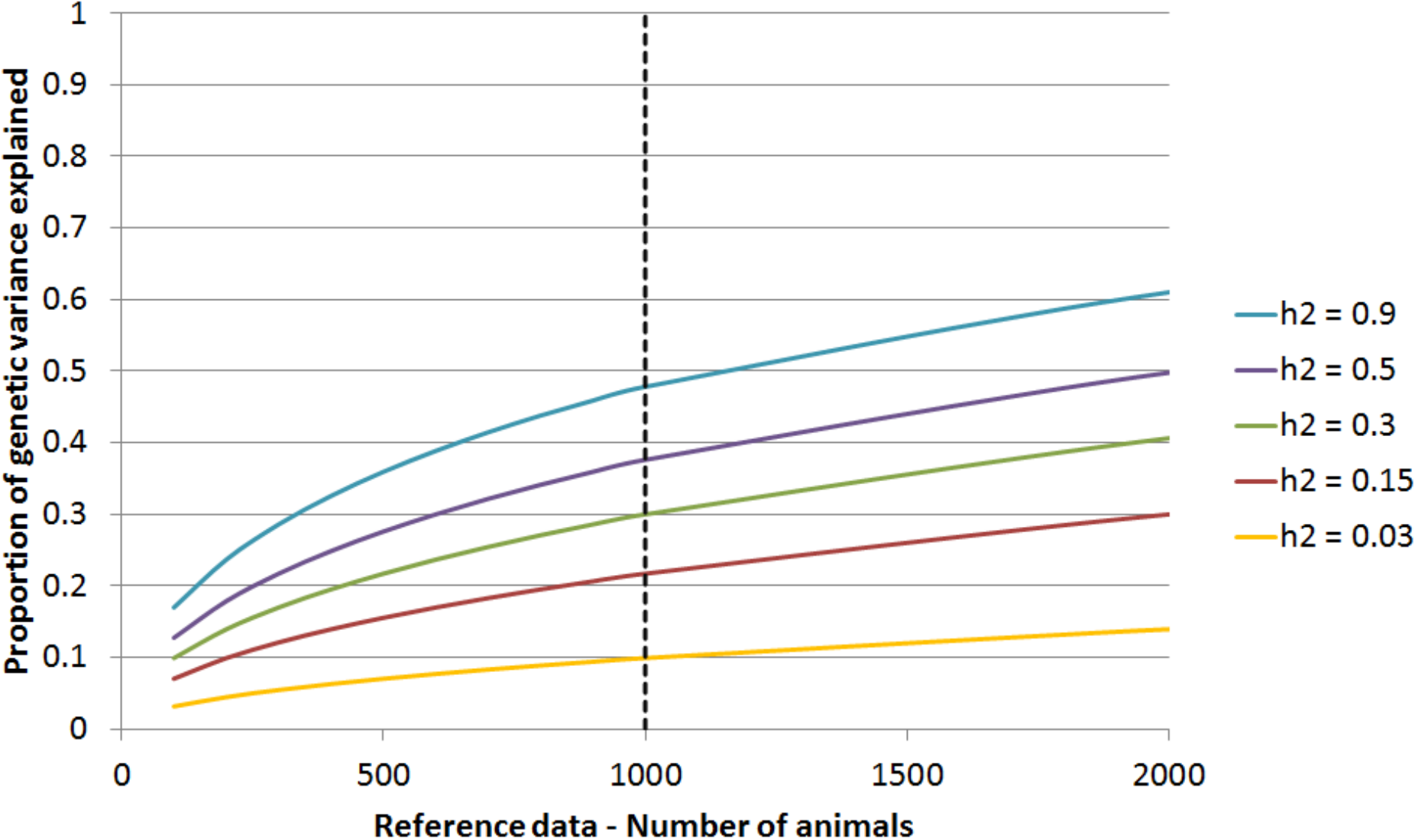
⇒ Re-focussing breeding goal

Reference data is required!

Genomic selection



Genomic selection



Building unique reference data

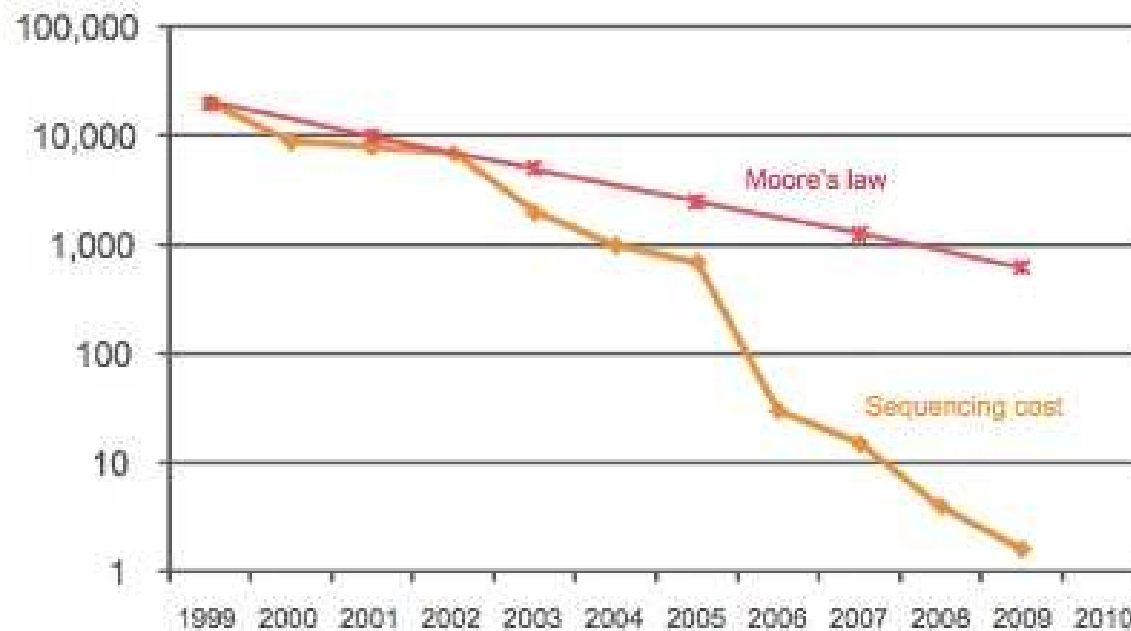
- Unique data available from experiments & research herds
- RobustMilk (EU-project) combines cow data 4 countries:
 - Feed intake
 - Progesterone measurements
 - Database of 1,000 - 2,000 animals
- Interest to increase this database
 - Contact roel.veerkamp@wur.nl

GS - Future perspectives

- Selection for “new” traits
 - More balanced selection
- Complete populations are genotyped
 - Better identification best breeding animals
- Extensions towards whole genome sequence selection
 - Closer to causal loci

Whole genome sequence data

Meanwhile the Price of Large-Scale Genetic Analysis to Discover and Utilize SNPs Dropped Precipitously...



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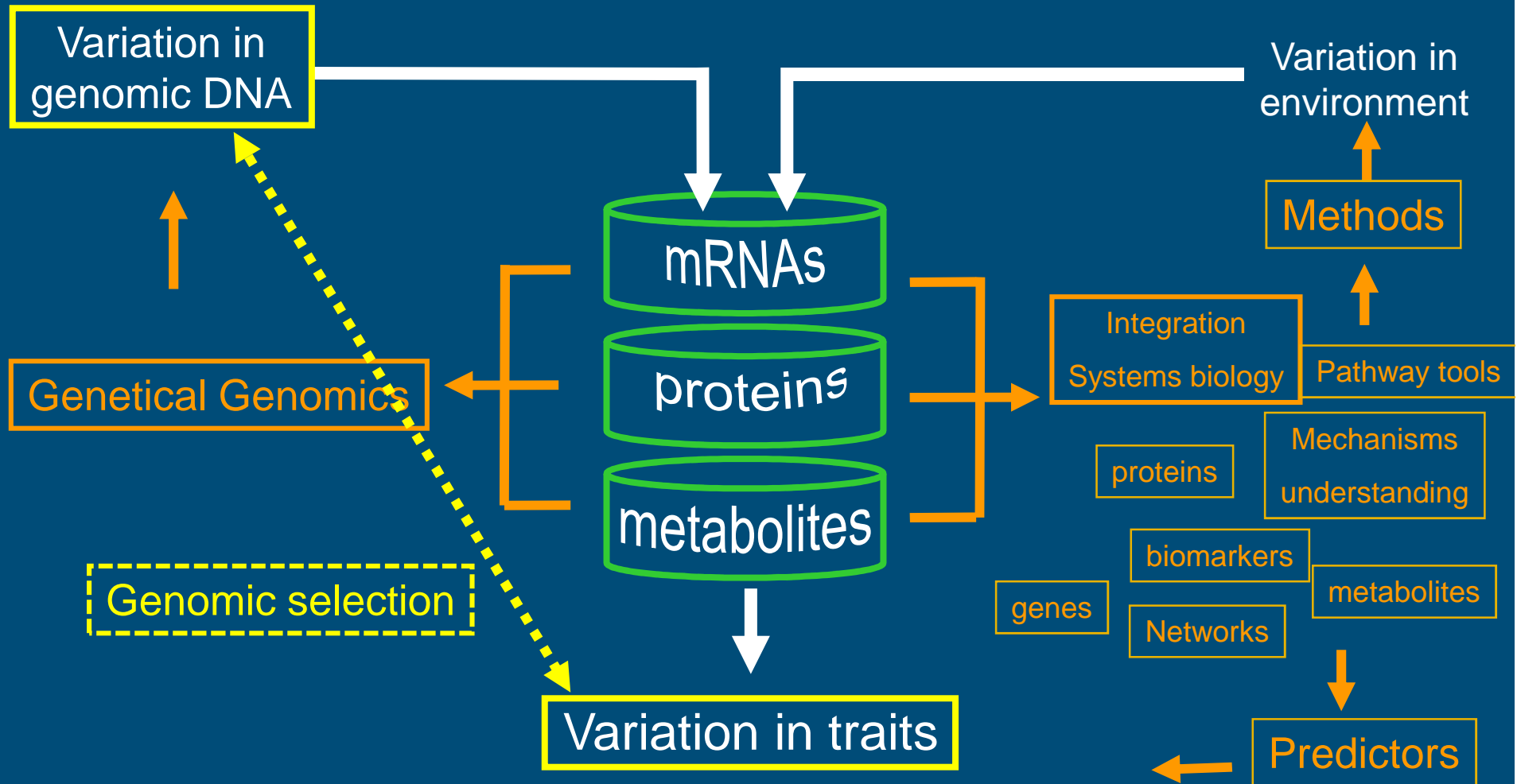
illumina

Genomic Selection - summarized

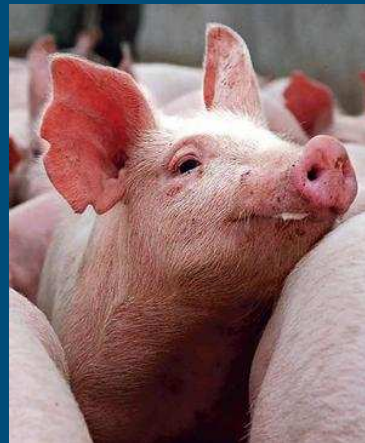
- Great uptake in practice
- Large datasets are created for practical applications
 - Generated data opens up opportunities for research
- Still a black box approach
 - Underlying causality maybe similarity in genome, proteome, metabolome, epigenome, etc.



Genomics: more than DNA



Genomics applications for on-farm management



Requirements for on-farm management

- Measuring for monitoring:

- Cheap
- Accurate
- Fast



- Different levels

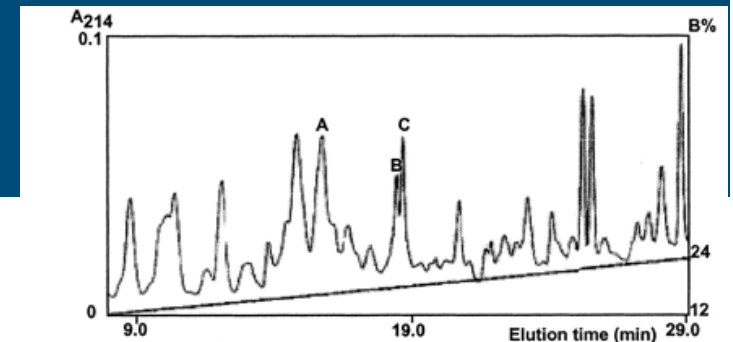
- Individual
- Herd



- Depending on purpose, find a balance between accuracy and costs

Pilot predicting pregnancy in dairy cows

- Protein profiles on day 21 after insemination
 - Using 18 pregnant & 14 non-pregnant cows & 1 protein
 - 93% pregnant animals correct classified (sensitivity)
 - 67% of non-pregnant animals (specificity)
- Pregnancy status can be predicted using milk samples
- Results are not reliable enough yet to develop practical test



Serum protein profiles to predict infectious disease status in pigs

- Pilot infection experiment
 - Control + 2 experimental groups



Classification

- Use protein profiles for classification of animals (PLS regression)
- Leave-one-out cross-validation
 - Predict every record using the rest of the data

True and predicted disease status

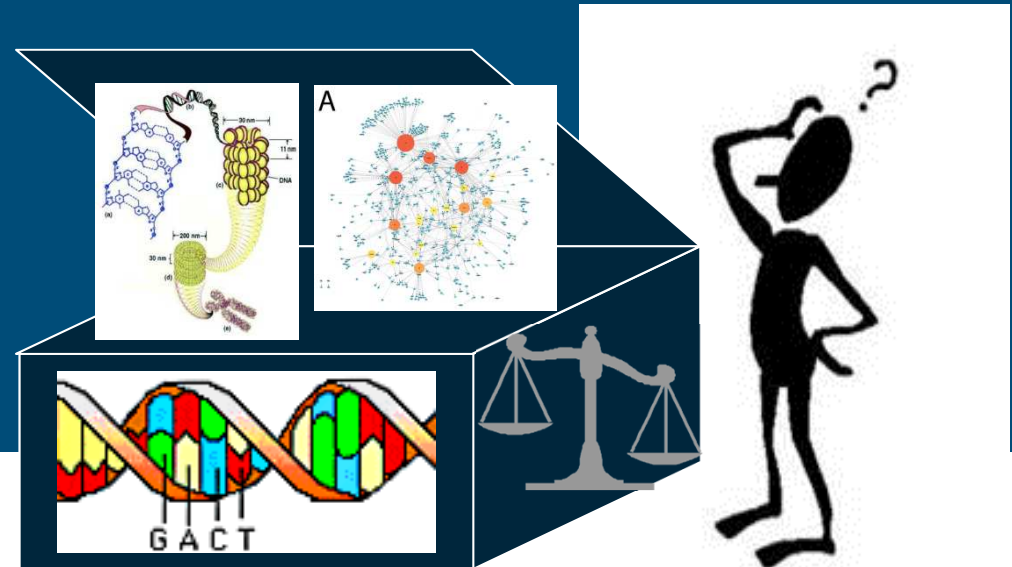
		Day 5			Day 19		
		True status			True status		
		PPV	Control	PRRSV	PPV	Control	PRRSV
predicted status	PPV	2	2	1	5	3	4
	Control	4	7	0	1	4	0
	PRRSV	1	0	8	2	0	3

Using 50 preselected proteins on combined data of day 5 and 19

- Serum protein profiles have potential for detection of (viral) infection in pigs in early phase of the disease
- Classification accuracy was moderate - good

Perspectives on-farm genomics applications

- Potential is huge
 - Bridging gap between DNA and phenotype
- Few practical applications so far
 - Large data sets needed to allow accurate prediction



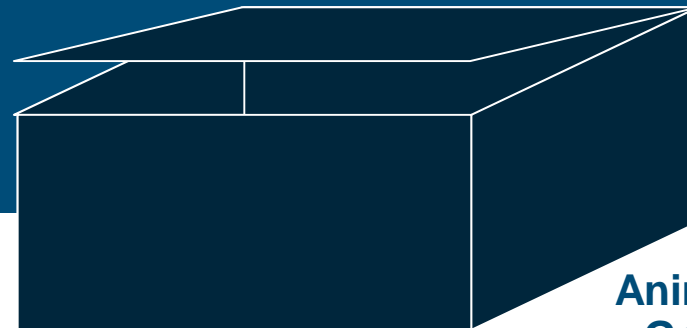
Unravelling black box (approaches)

- Presented approaches driven by statistical associations, not causality
- ‘Opening black box’ may improve performance
 - Improved understanding underlying mechanisms
- Practical applications generate large data
 - This helps to increase understanding

Conclusions

Predicting & measuring phenotypes using genomics:

- Requires sufficiently large data for deriving prediction equations
- Requires appropriate statistical methodology:
 - $y = b_1X_1 + b_2X_2 + \dots + b_nX_n$
- Has huge potential!



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- Norbert Stockhofe-Zurwieden

