afbi Agri-Food and Biosciences Institute

SHAPING LIVESTOCK FARMING FOR 2030

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Animal breeding in the era of big data – opportunities and challenges

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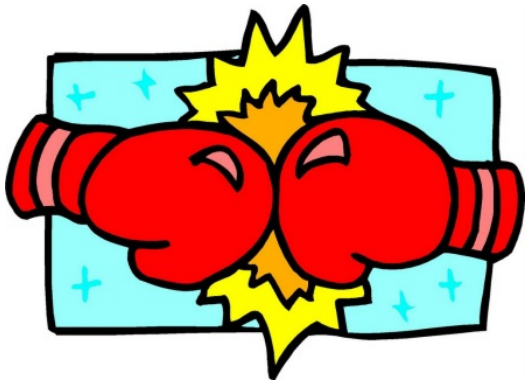
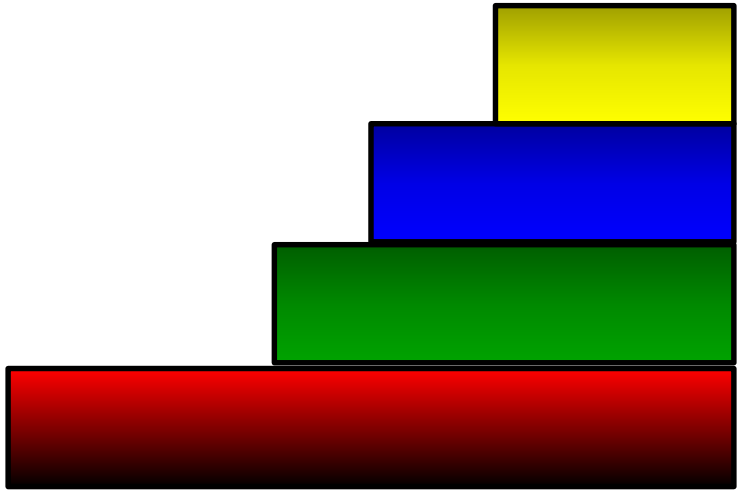
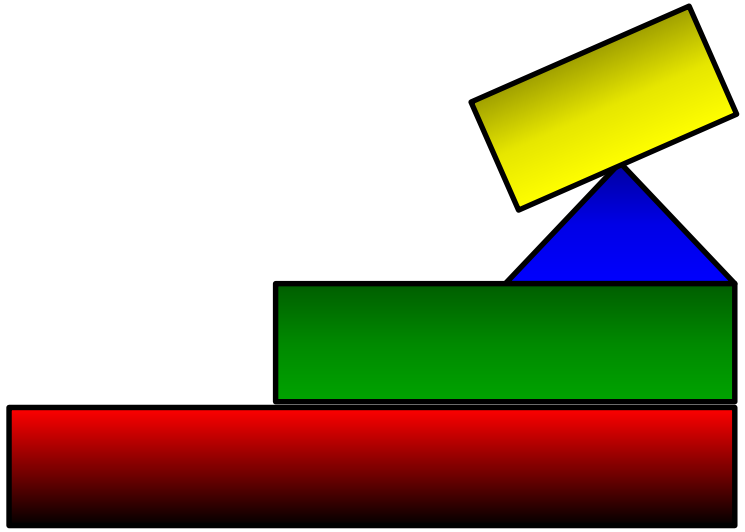
Genetics v management

"Free"
Cumulative and permanent

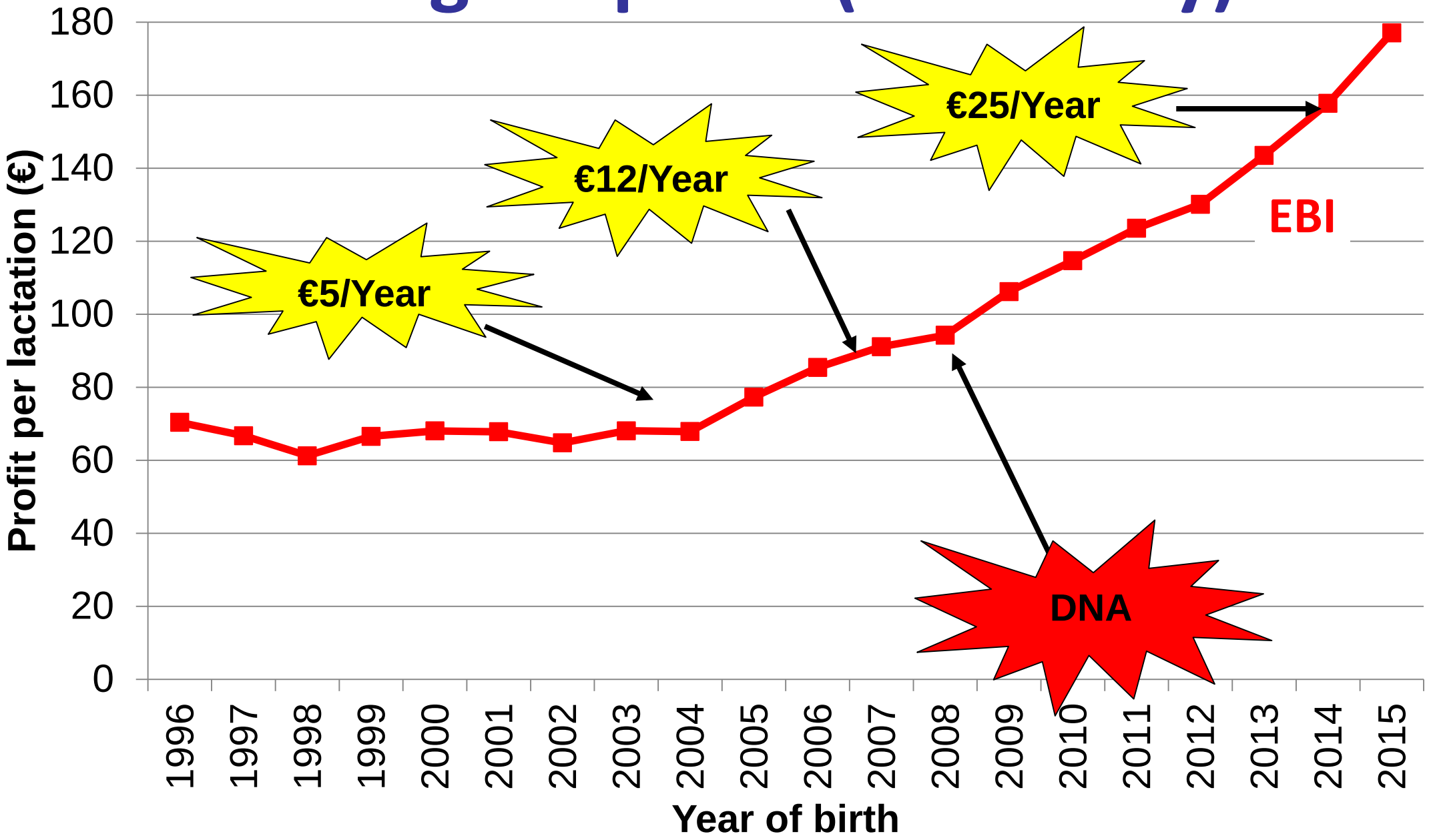


Costly
Quick "fix"
On-going requirement





Breeding for profit (Irish dairy)

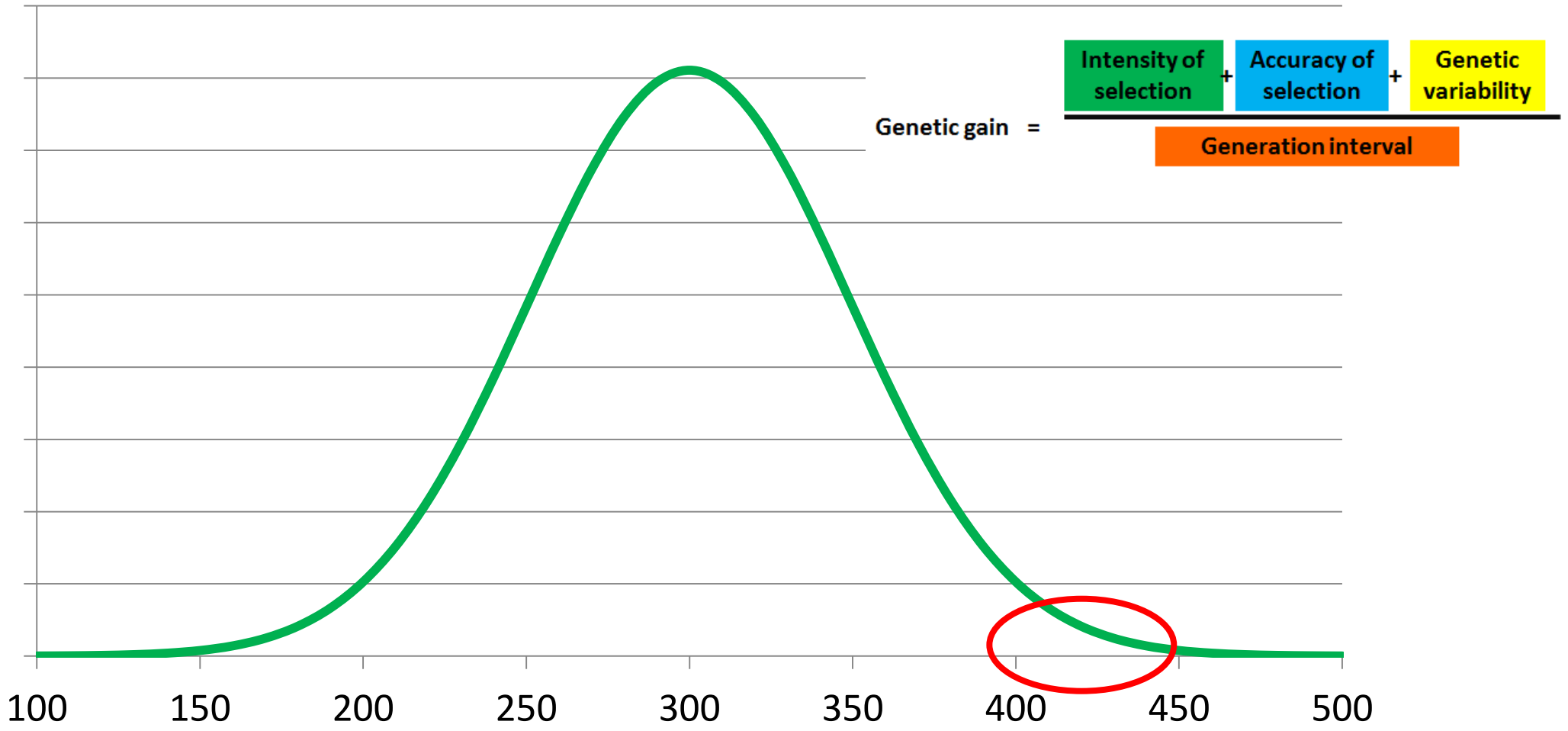


New technologies - Genetic gain

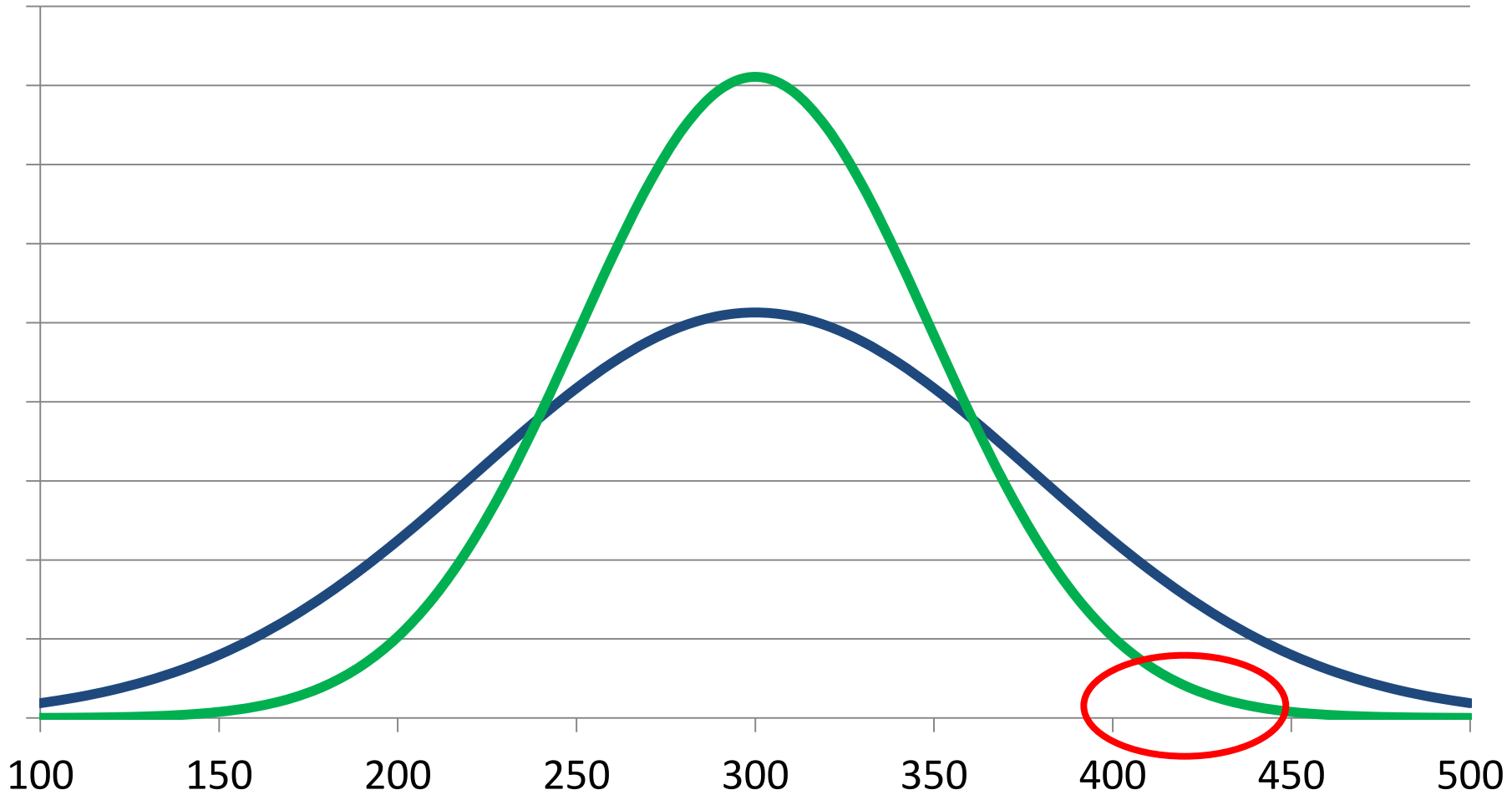
$$\text{Genetic gain} = \frac{\text{Intensity of selection} + \text{Accuracy of selection} + \text{Genetic variability}}{\text{Generation interval}}$$

Coevolution of breeding and management

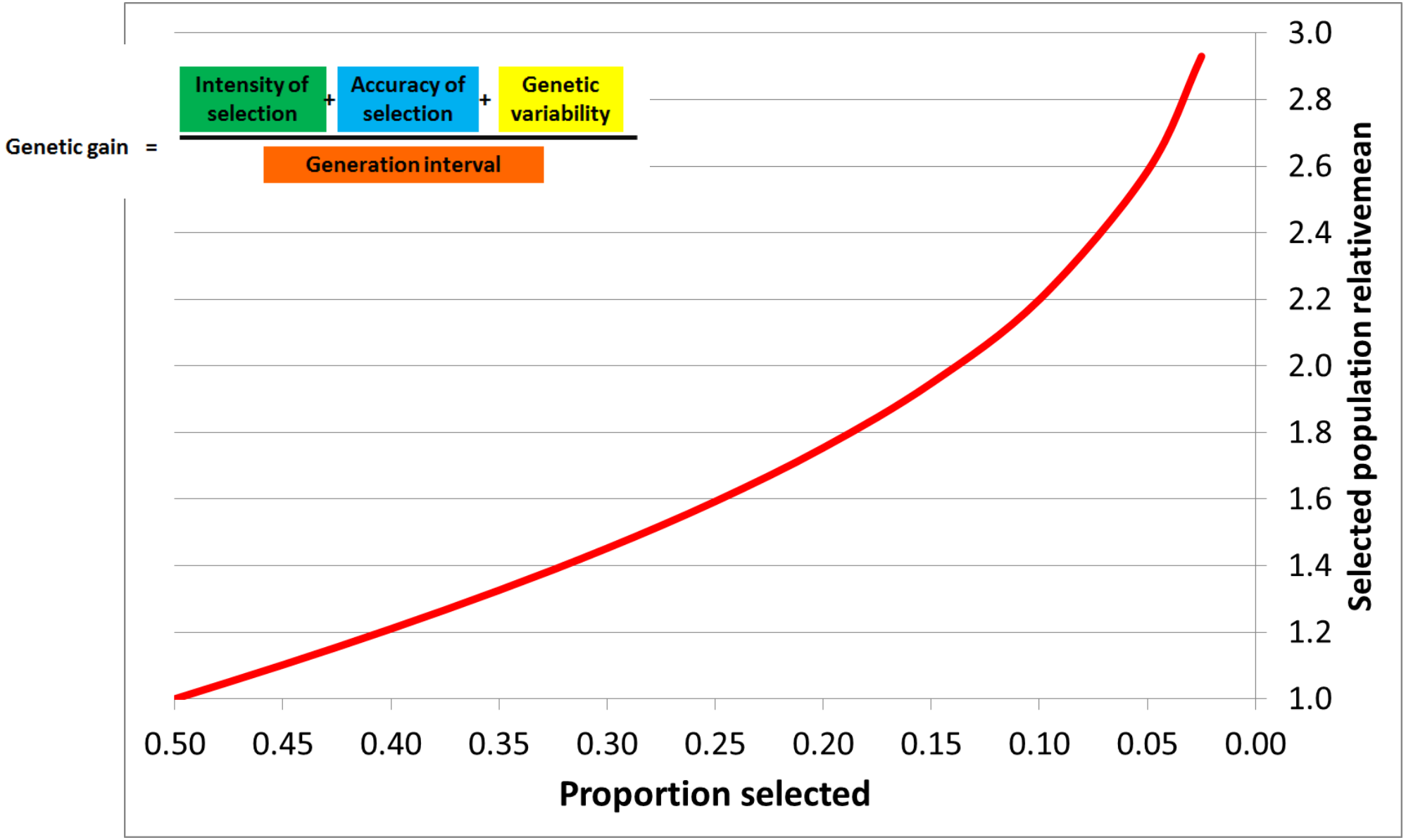
Intensity of selection



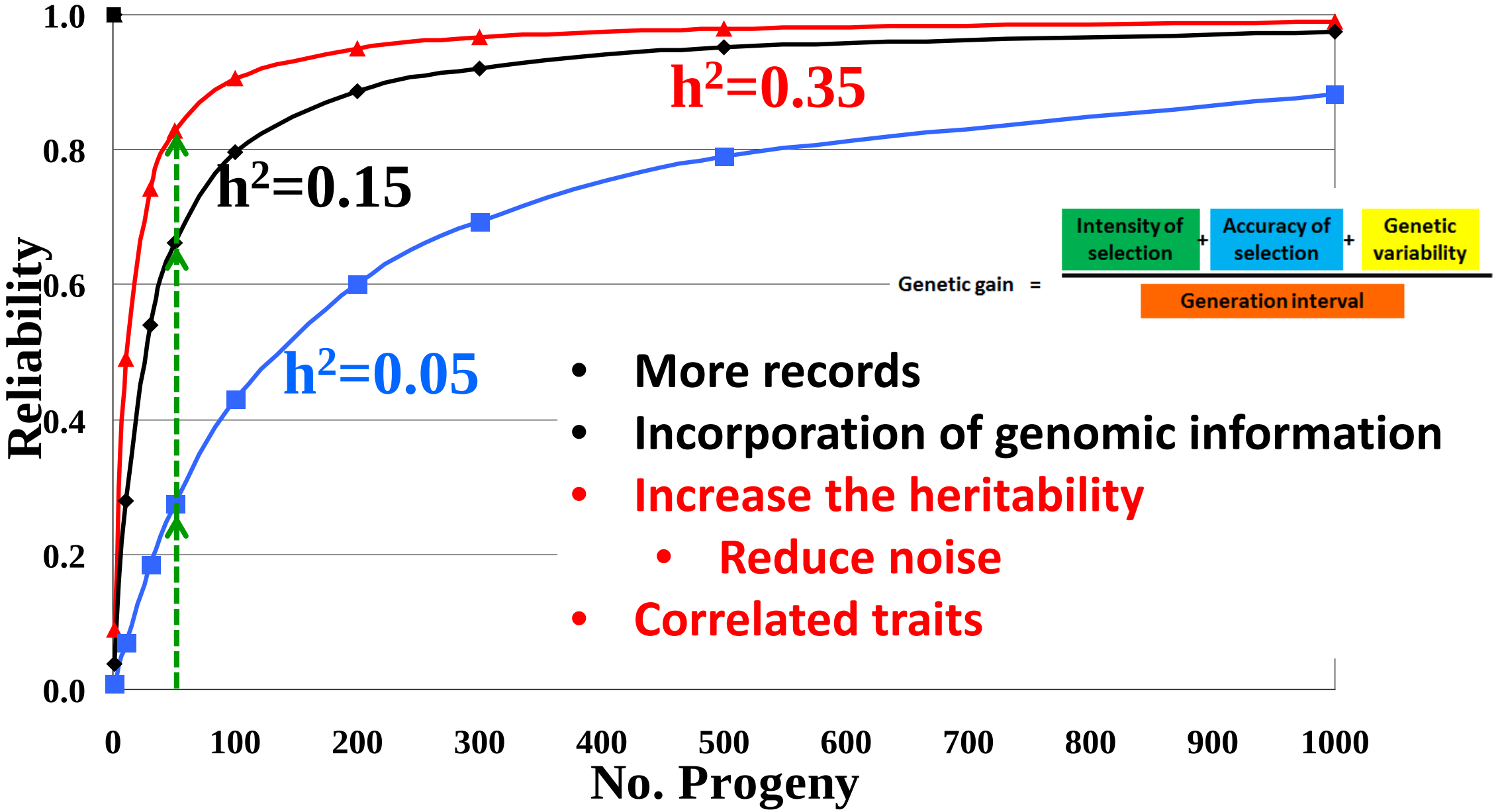
Intensity of selection



Smaller the proportion → greater the mean



Accuracy of selection



Genetic gain = (Intensity of selection + Accuracy of selection + Genetic variability) / Generation interval

- More records
- Incorporation of genomic information
- Increase the heritability
  - Reduce noise
- Correlated traits

Increase the heritability

$$\text{Heritability} = \frac{\text{Genetic variance}}{\text{Genetic variance} + \text{noise}}$$

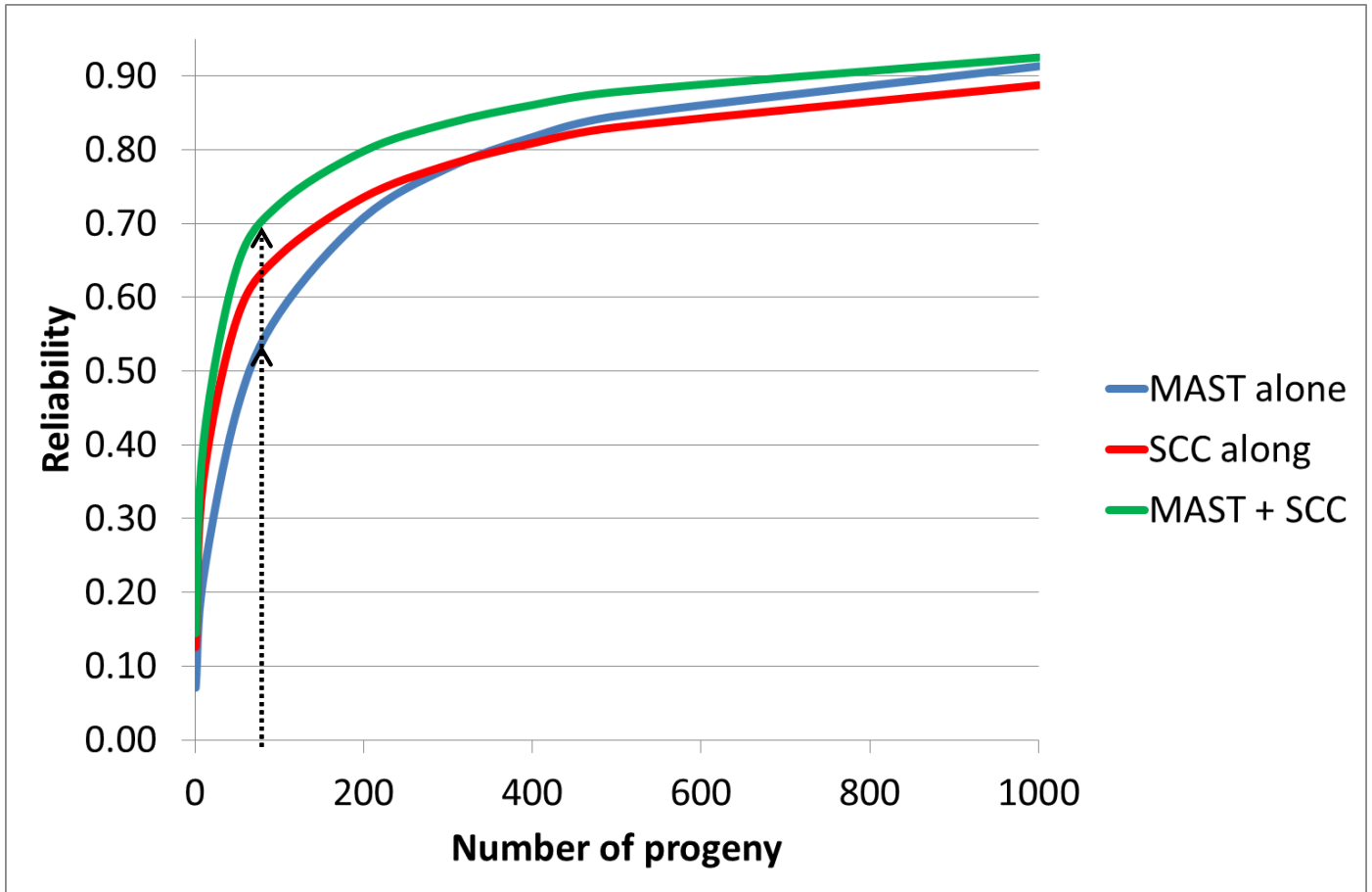
1. Fewer pedigree errors
   - Heritability biased downwards by incorrect pedigree
   - 10% errors → 25% increase
2. True fertility & health measures
   - 5% inseminations at incorrect time (Royal et al., 2002)
3. Average of repeated measures

- **Can still compensate low heritability with more records**

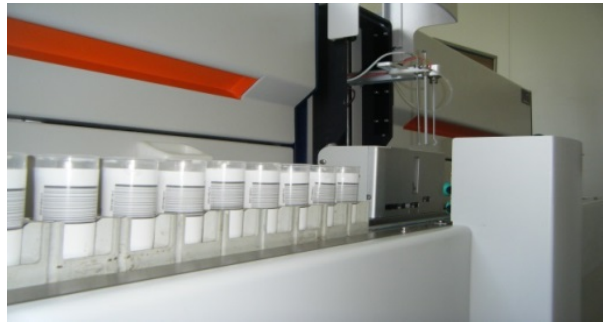
Correlated traits

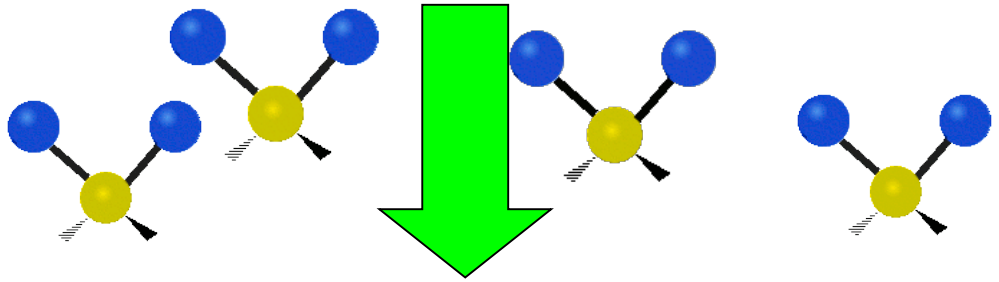
- Somatic cell count and mastitis
- Locomotion and lameness
- Body condition score with health and fertility
- Others….

$$\text{Genetic gain} = \frac{\text{Intensity of selection} + \text{Accuracy of selection} + \text{Genetic variability}}{\text{Generation interval}}$$

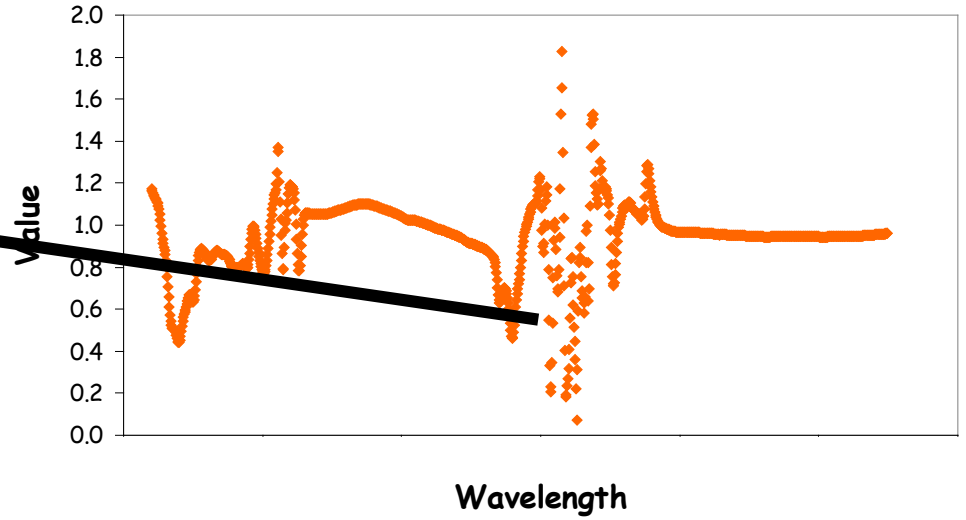


Case study - Correlated traits





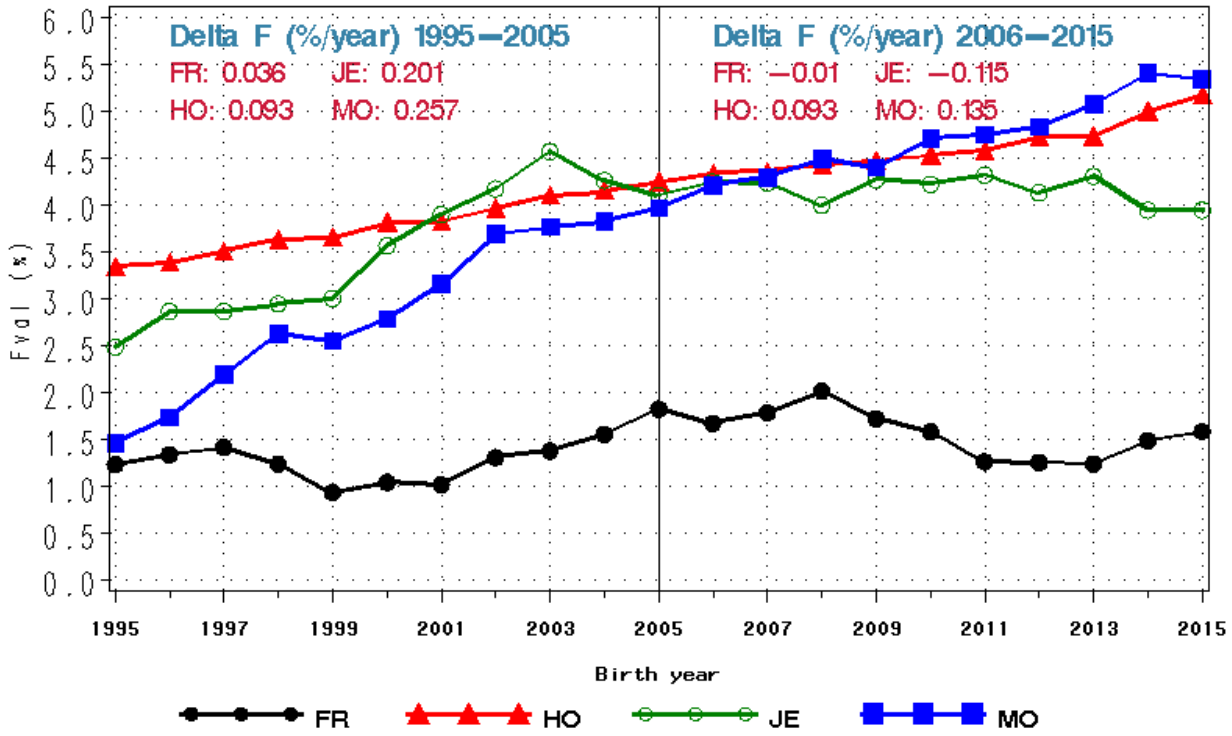
Trait	Acc
Fatty acids	98%
Protein fractions	74%
Tech. properties	84%
Energy intake	80%
Energy balance	69%
Feed efficiency	60%
Methane emissions	89%



Genetic variability

$$\text{Genetic gain} = \frac{\text{Intensity of selection} + \text{Accuracy of selection} + \text{Genetic variability}}{\text{Generation interval}}$$

Within-family genetic variance is a function of the inbreeding of sire & and dam

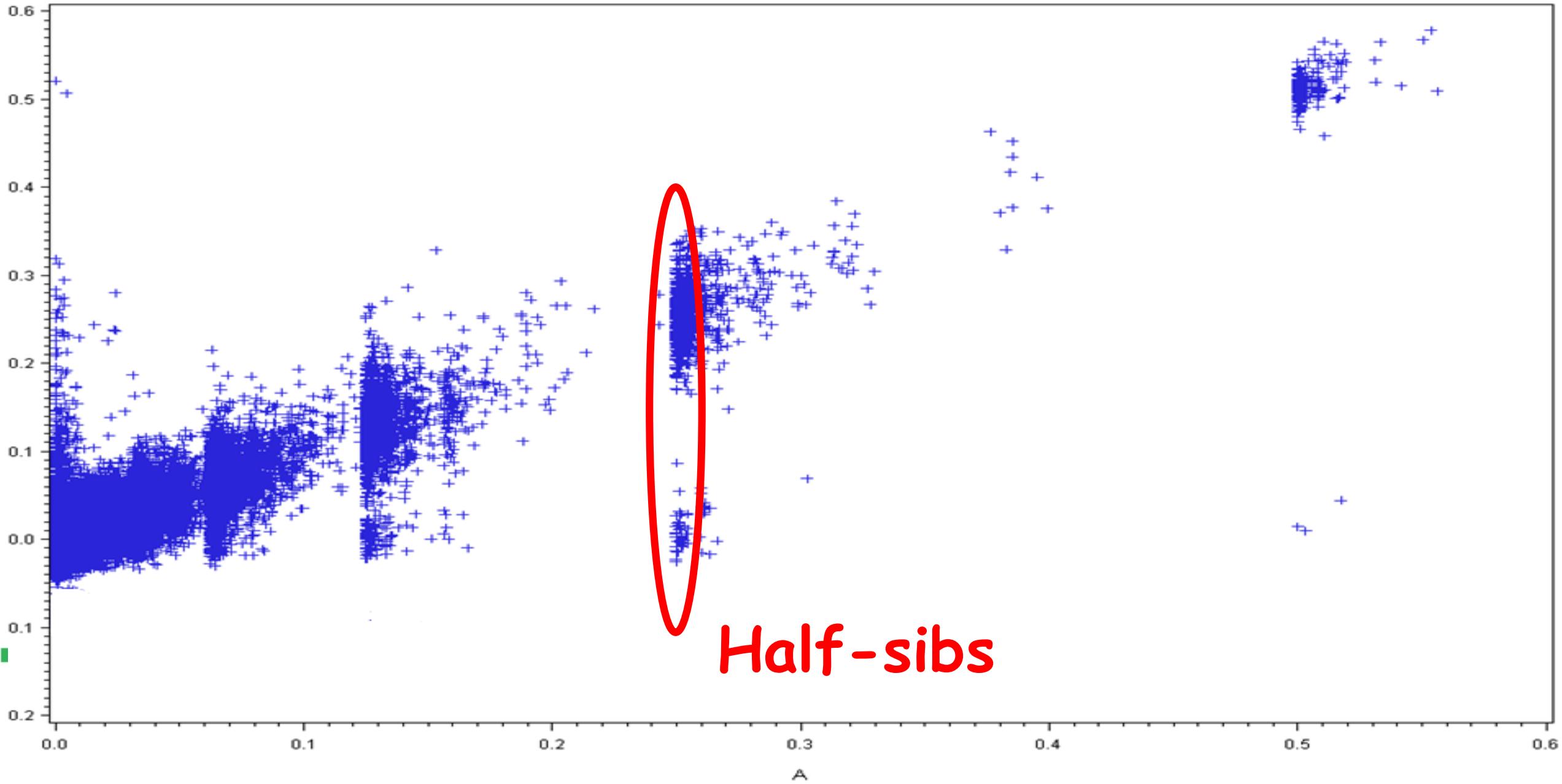


At a simple level

50% LM : 50% HF
(assuming parents are pure)

50% CH : 25% HF : 25% LM
50% CH : 50% HF : 0% LM
50% CH : 0% HF : 50% LM

Mating advice



Generation interval

$$\text{Genetic gain} = \frac{\text{Intensity of selection} + \text{Accuracy of selection} + \text{Genetic variability}}{\text{Generation interval}}$$

- Average age of parents when progeny are born
- Juvenile predictors → DNA

- Heritability v repeatability
  - Milk: 35% v 52%
  - **More to life than genetics!**

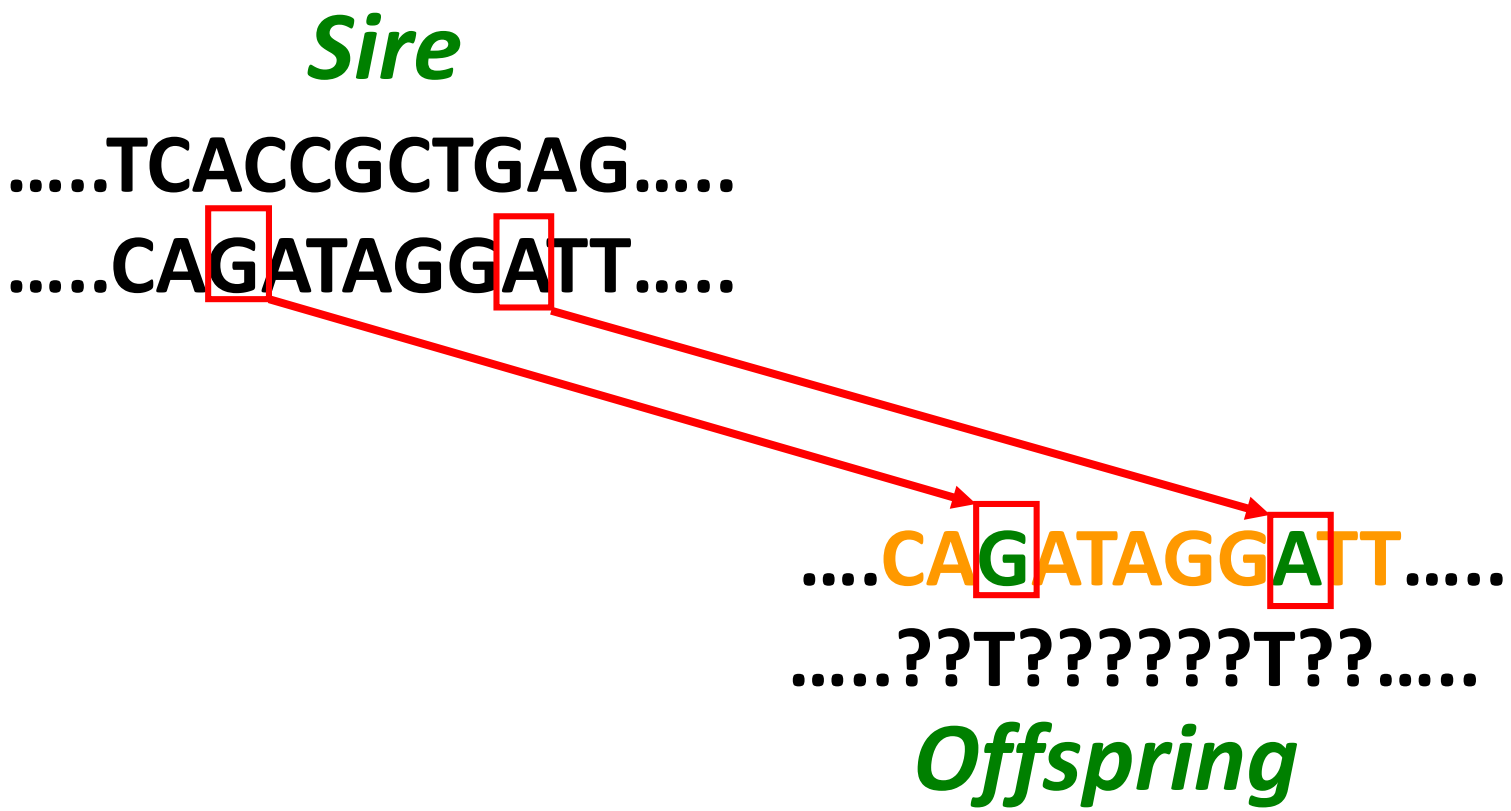
Opportunities and challenges

1. DNA information
   - Low cost screening tools
     - €282 in 2008 → <€20
   - Return on investment

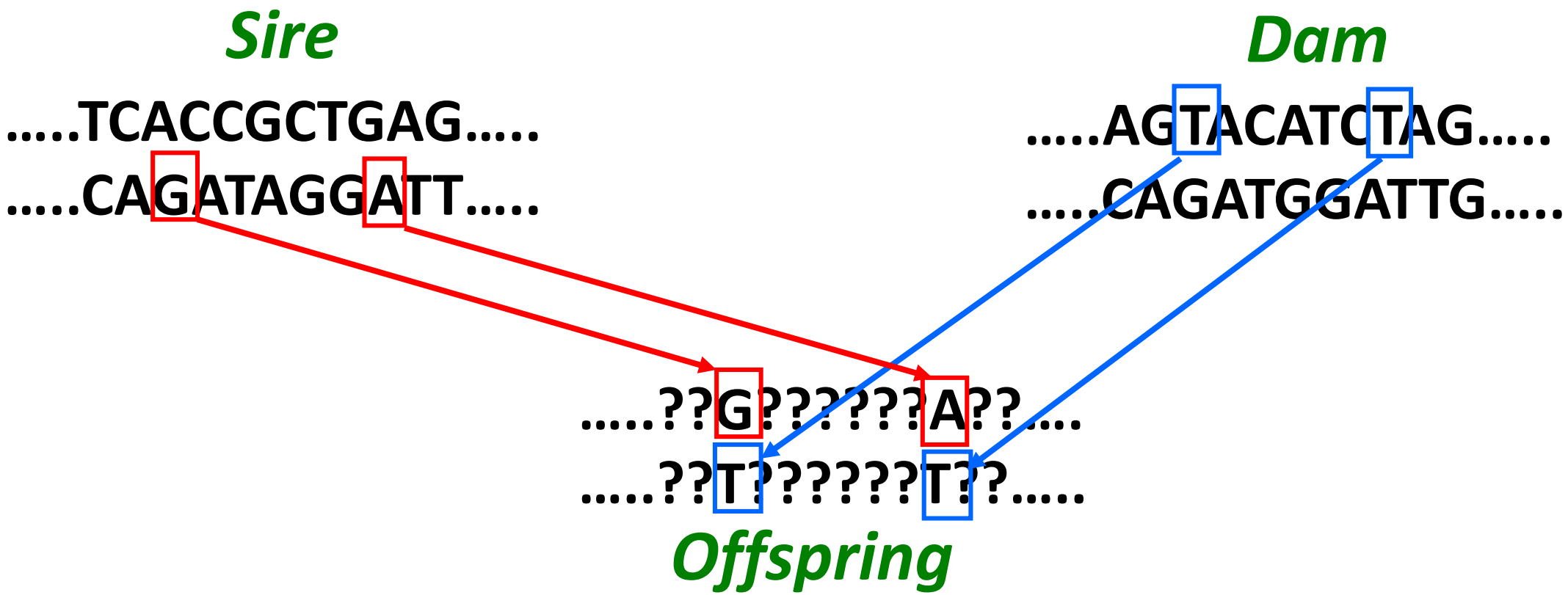
2. Precision technologies

Imputation

Imputation

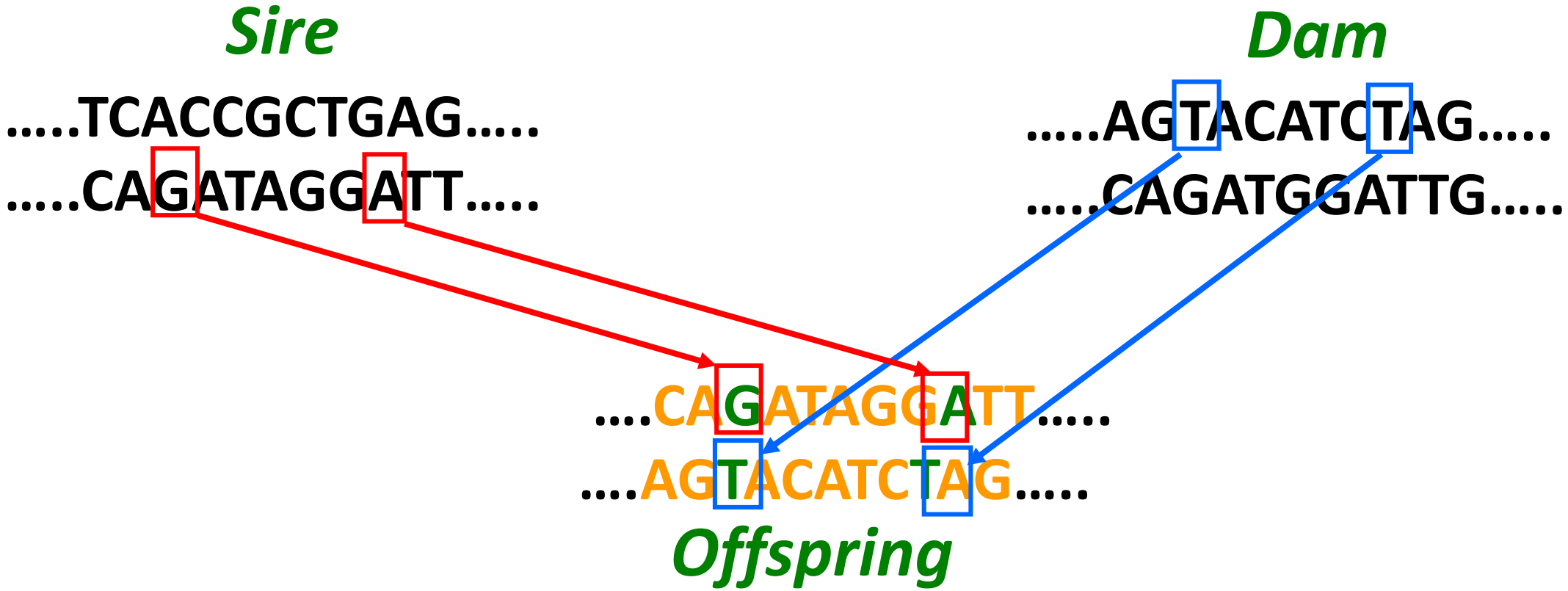


Imputation

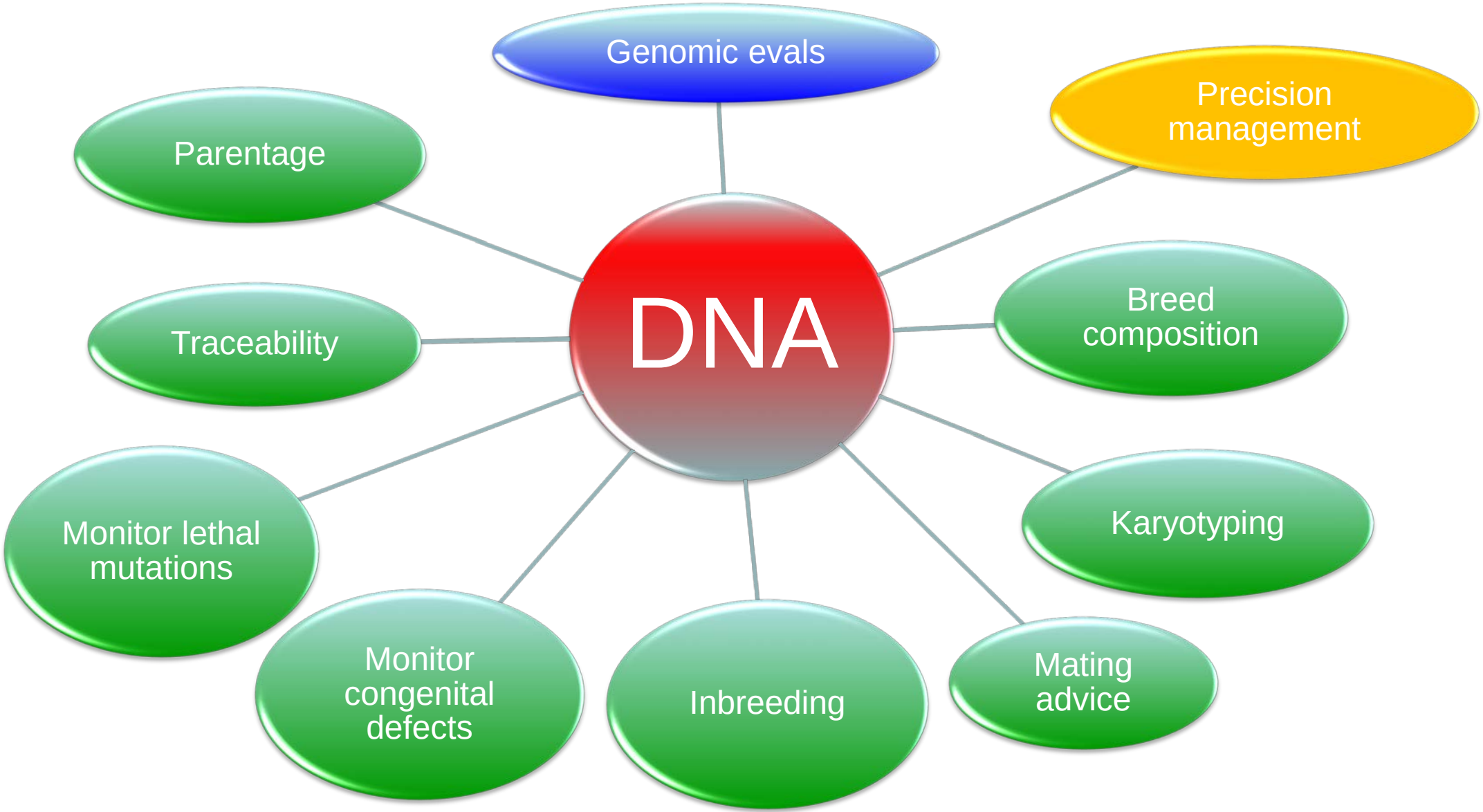

Sire
.....TCACCGCTGAG.....
.....CAGATAGGATT.....
Dam
.....AGTACATCTAG.....
.....CAGATGGATTG.....
.....??G??????A??....
.....??T??????T??.....
Offspring

Imputation

€850 v <€20



Return on investment



Diagnostics??

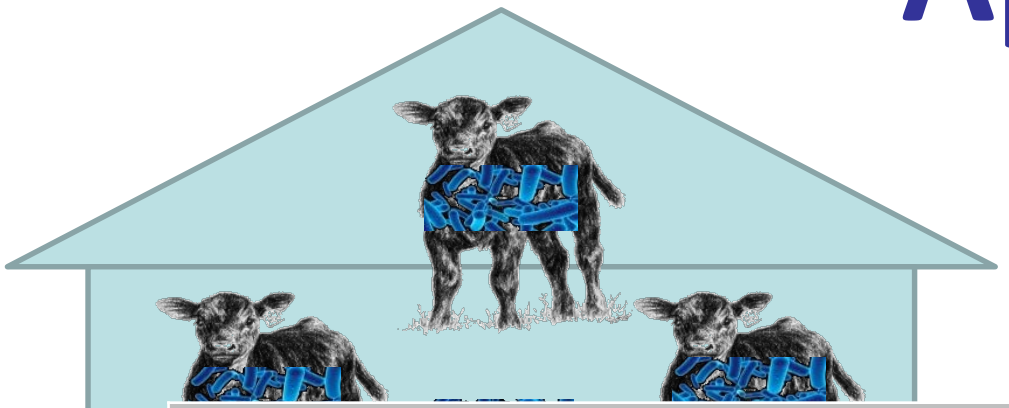
A beef cross calf showing BVD signs – dull coat, diarrhoea and runny nose.

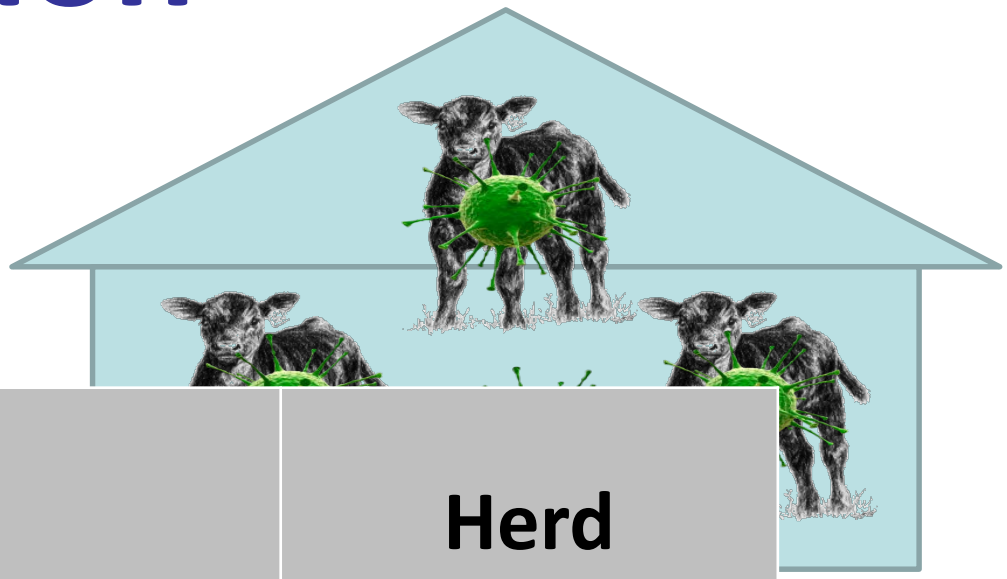
Doubters??

- BRAC1 & BRAC2
  - 5 times the risk of breast cancer
  - 10-30 times risk for ovarian cancer

- Enhanced screening
- Prophylactic treatment
- Management/chemoprevention

Application

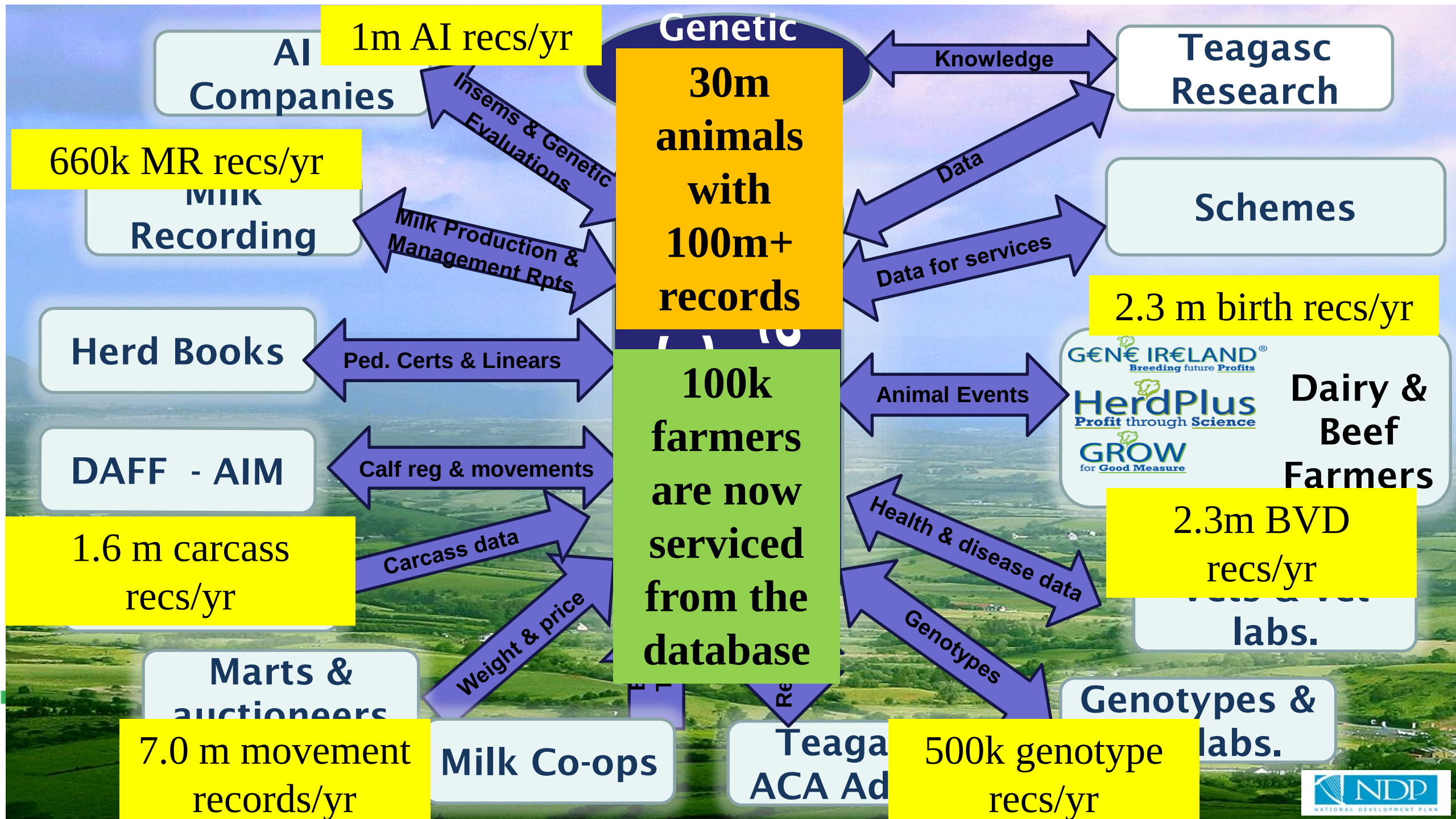




Predicted probability of TB	Cow Incidence	Herd incidence
Worse 10% EPD	31	13%
Best 10% EPD	5	8%

Opportunities

- New paradigms in data analytics
  - Machine learning/deep learning
- Precision technologies
- Vast quantities of **data**


1m AI recs/yr
AI Companies
Genetic
30m animals with 100m+ records
Knowledge
Teagasc Research
Insems & Genetic Evaluations
660k MR recs/yr
Milk Recording
Milk Production & Management Rpts
Data
Data for services
Schemes
2.3 m birth recs/yr
Herd Books
Ped. Certs & Linears
100k farmers are now serviced from the database
Animal Events
GENE IRELAND Breeding future Profits
HerdPlus Profit through Science
GROW for Good Measure
Dairy & Beef Farmers
DAFF - AIM
Calf reg & movements
2.3m BVD recs/yr
1.6 m carcass recs/yr
Carcass data
Health & disease data
Weight & price
Genotypes
labs.
Marts & auctioneers
Genotypes & labs.
7.0 m movement records/yr
Milk Co-ops
500k genotype recs/yr
NDP NATIONAL DEVELOPMENT PLAN

Challenges

- New paradigms in data analytics
  - Machine learning/deep learning
- Precision technologies
- Vast quantities of **data**

Expectations
Validation

- Data ownership, privacy and access
- Computing power and institutional “rules”

Case study – COW index

Cow's Own Worth

=

C.O.W

Current Lactation

- Production
- Management
- Health (SCC)
- Maintenance
- Fertility (calving date)

Net Replacement Cost

- Cull cow value
- Replacement cost

Future Lactations

- Production
- Management
- Health
- Maintenance
- Beef
- Fertility
- Calving
- Descendants

+ predictions on fertility, survival and SCC performance

Case study - KISS

$$\text{Efficiency} = \frac{O_{Mature} \cdot NMature + O_{Replace} \cdot NReplace + O_{Surplus} \cdot NSurplus}{I_{Mature} \cdot NMature + I_{Replace} \cdot NReplace + I_{Surplus} \cdot NSurplus}$$

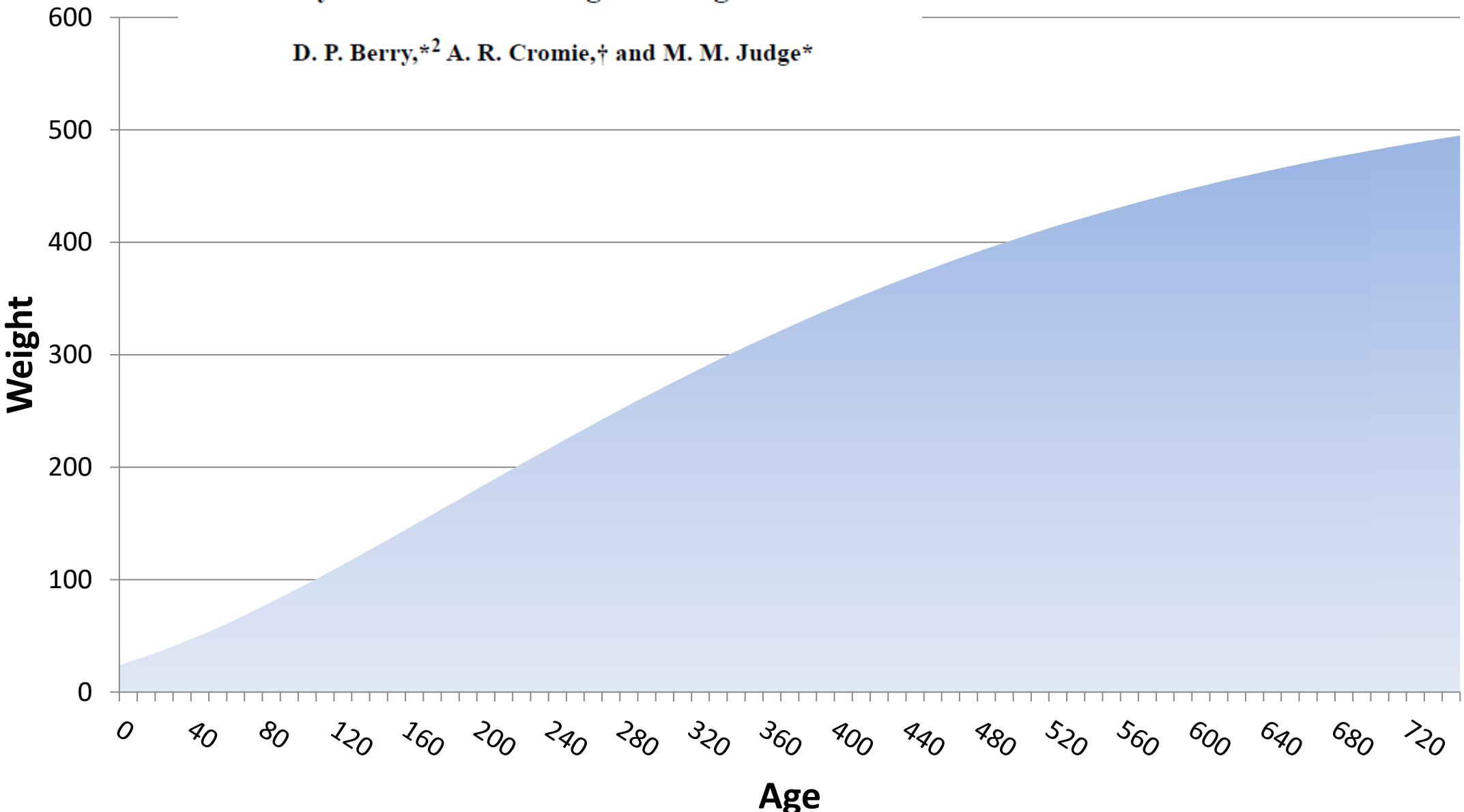
Feed intake per day

Number of days

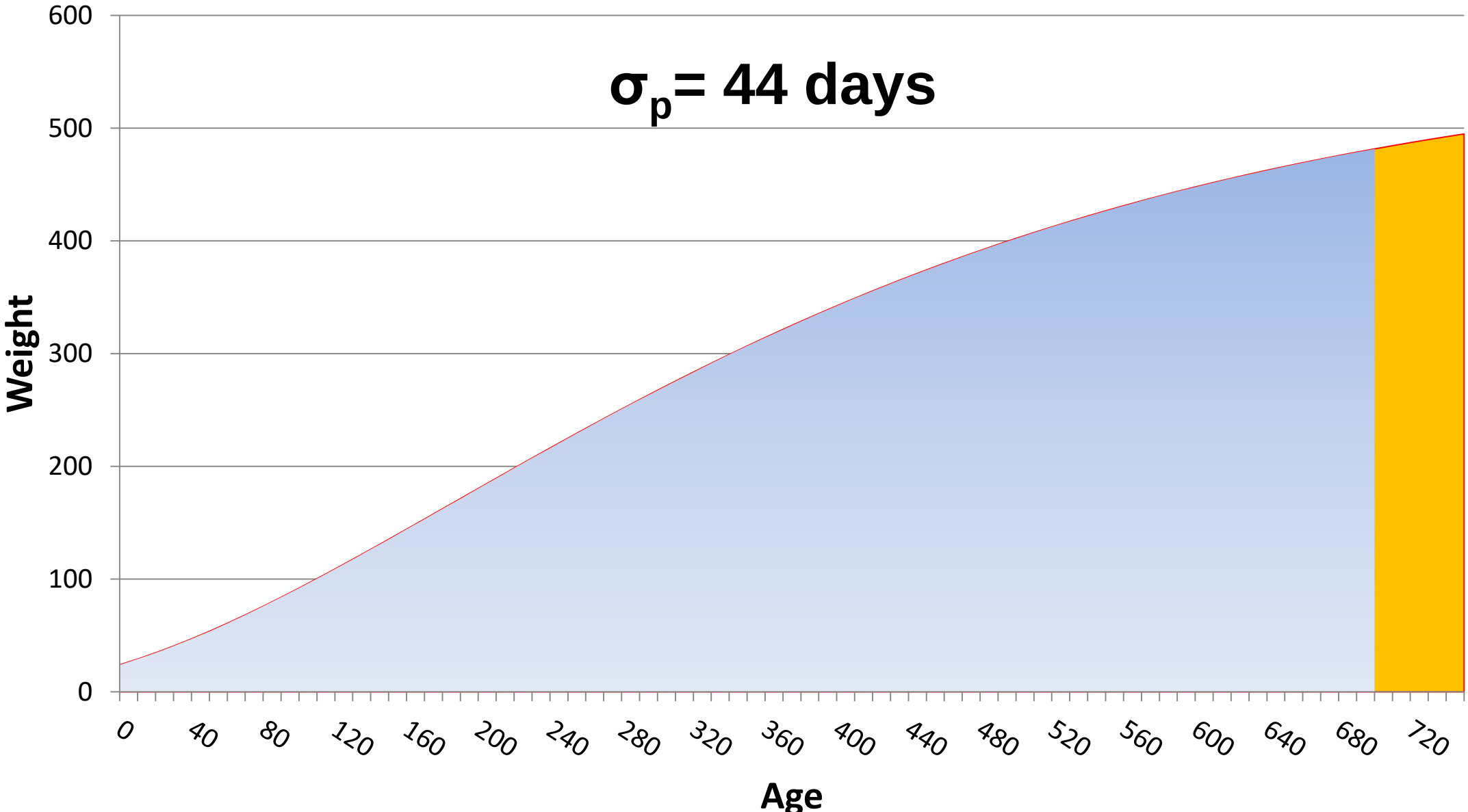
(Feed) efficiency – the easy way

Rapid Communication: Large exploitable genetic variability exists to shorten age at slaughter in cattle[1]

D. P. Berry,*[2] A. R. Cromie,† and M. M. Judge*



(Feed) efficiency – the easy way



Take home messages

- Big data and precision agriculture has the potential….
  - To be useful
  - Be disastrous – unwelcome distraction!
  - Has genomics delivered its potential?
- Fundamental principles do not change