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Phenotyping for optimized decision making on cow and herd level

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Phenotyping

A **phenotype** is the composite of e.g. an animals observable characteristics or traits. Examples:

› Birth weight, growth rate, BW, body composition, ultrasound measurements, anatomical characteristics, body images ….

› Activity (resting, eating, chewing, ruminating, walking, walking gait, ...), abnormal behavior, social behavior, abnormal behavior …

› Appetite, meal frequency, meal size, dry matter intake, nutrient intake, residual feed intake, water intake, …….

Phenotyping - continued

- Digestive tract parameters (rumen ph, rumen motility, saliva production, …), rate of fermentation/passage, digestibility, ….
- Emission of greenhouse gasses, N and P losses…..
- Voluntary milking frequency, milk flow, milk yield, milk composition (nutrients, metabolites, hormones, enzymes, cytokines, acute phase proteins, …), conductivity in quarter milk, SCC, cell types…
- Product quality, processing ability (%cheese from milk)
- Physiological / Immunological parameters
  - Status
  - response

Phenotyping - continued

› Disease (subclinical/clinical), disease severenes/duration, ….

› Reproductive parameters (days open, oestrus, strength of oestrus, ins/pregnancy, cysts, ….

› MIR spectra of milk/body fluids,

› Metabolome / proteome of body fluids/tissue, …………

› ……

› Etc., etc., etc.

New parameters for phenotyping?

Yes! But what to chose?

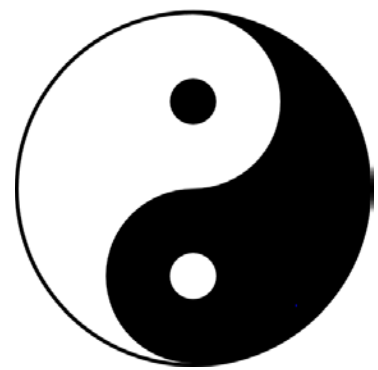
Two slides from my talk on 27. Aug. on my subject:

- Physiological biomarkers for prevention of production diseases in dairy cows.

Need for automated precision management systems

There is a need for **cost effective** automated precision management systems where equipment combines advanced technologies and biological knowledge to obtain:

› low disease incidence and severity
› animal welfare
› low impact on the environment,
› requested product quality,
› optimal production and reproduction
› profitability for the producer.



Individual cow monitoring
cow as its own control ➔ **optimization**

Conclusion and future challenges

- To better understand the physiology and immunology of the dairy cow, particularly in the periparturient period, including basic needs, requirements (not only for production)
- Make better use of existing data (from data to information)
- To better understand the biological basis of individual differences, physiological imbalance and risk:
  - quantitative understanding
  - importance for e.g. immune function, risk of disease, reproduction etc.
  - proactive management - efficient surveillance and overcome the physiological imbalance by being able to predict individual animal responses to changes in e.g. nutrient supply or management
- We lack more biomarkers and sensors to take on the challenge of further develop future automatic and proactive management strategies

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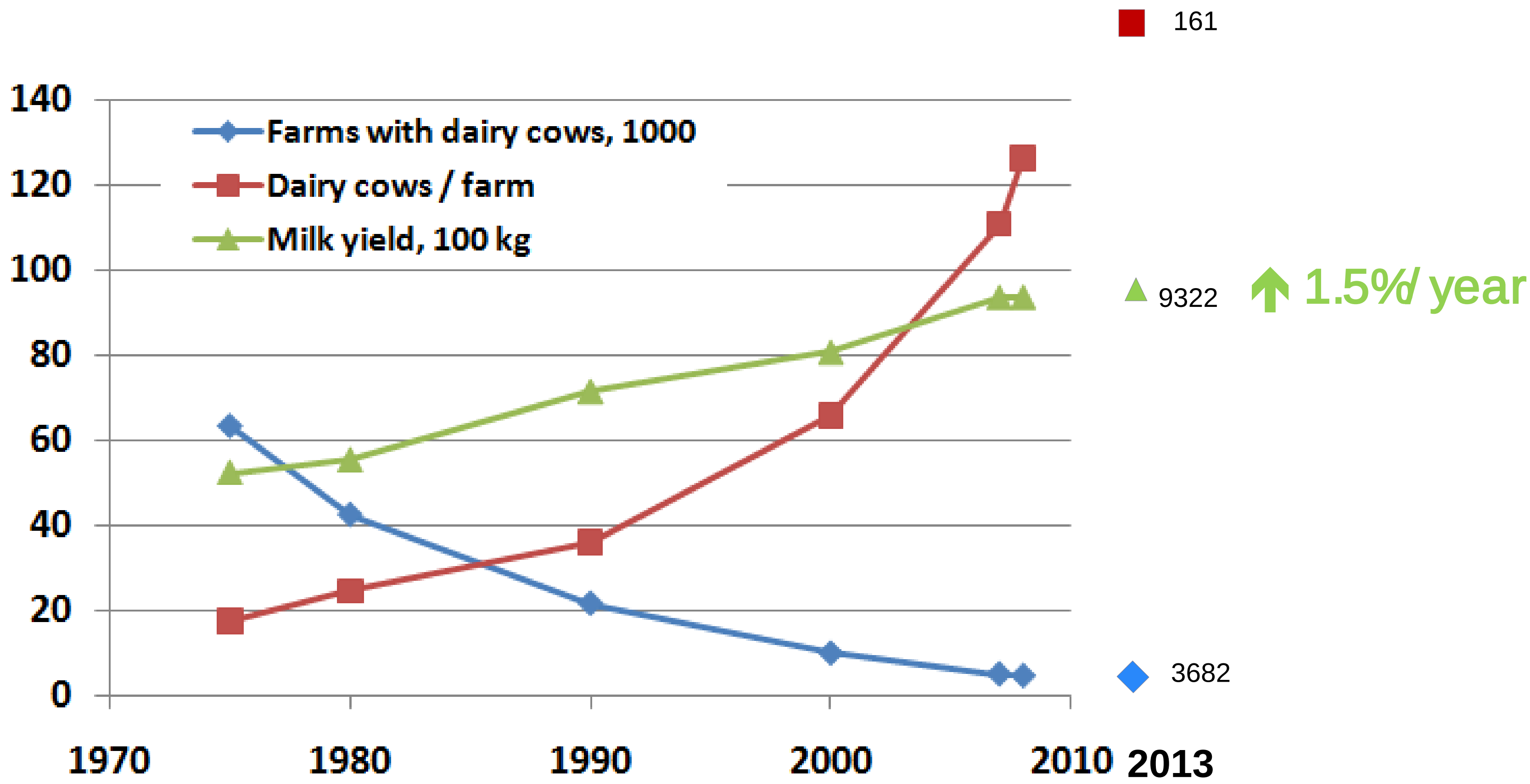
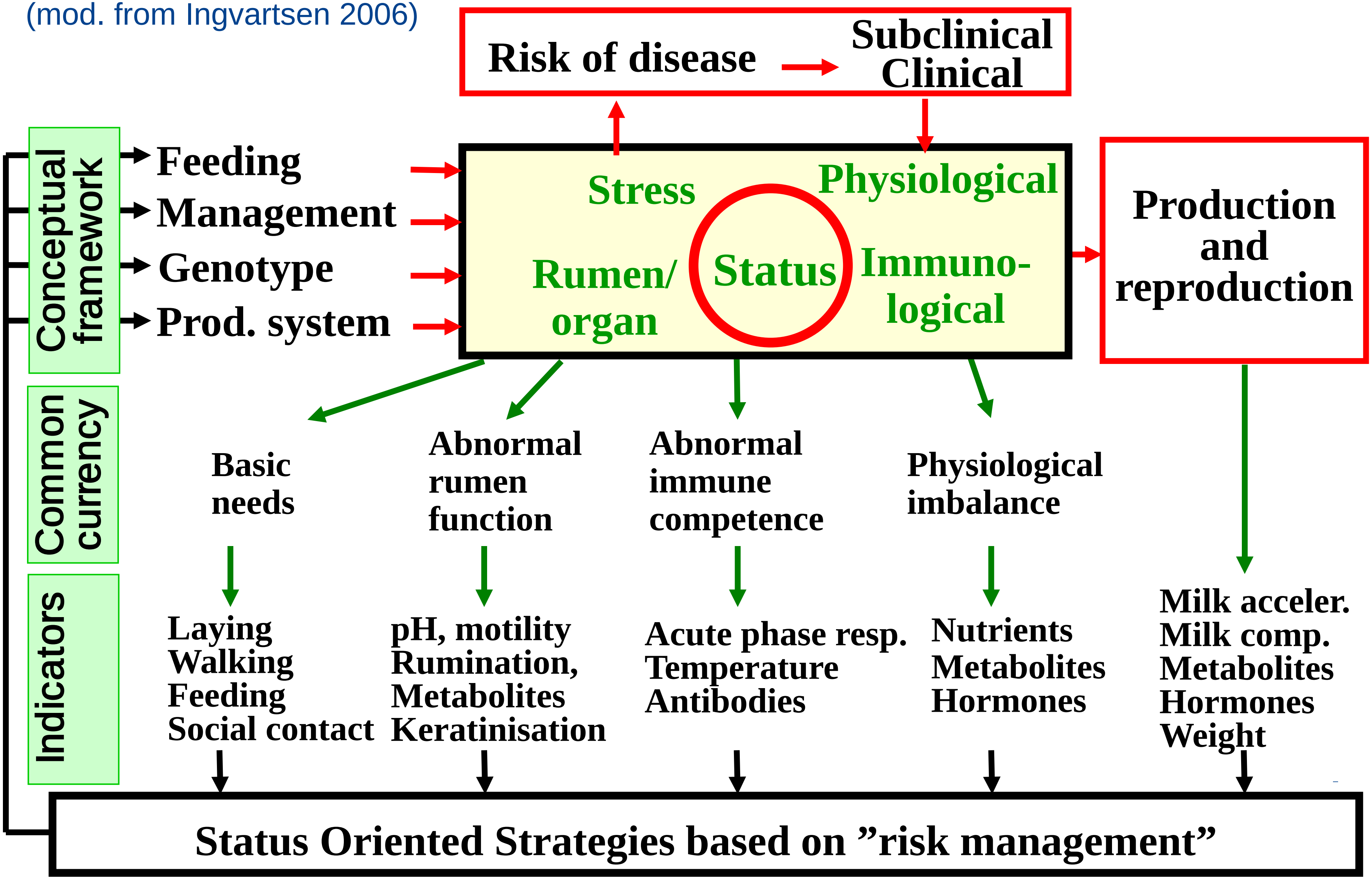
Changes in the primary structure in Denmark



From 1984 and onwards these are farms with milk quota

Risk management & optimization of individuals

(mod. from Ingvartsen 2006)



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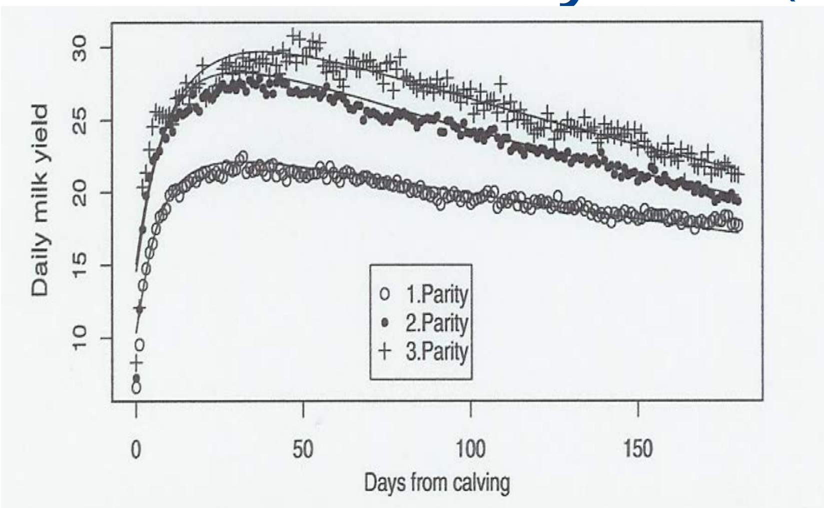
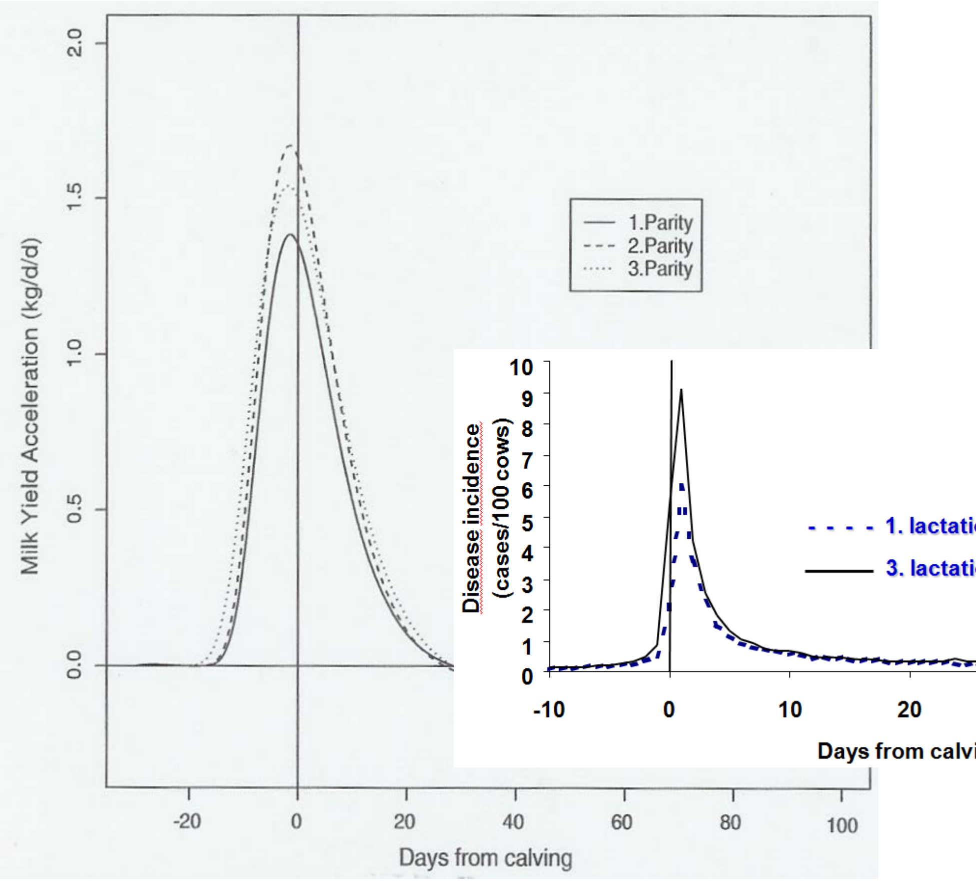
Improved phenotyping based on existing data. Acceleration vs yield. (Ingvartsen et al., 2003, Hansen et al. 2006





- Cause of increased disease risk:
  - Probably not yield pre se
  - Rate of increase in daily milk yield (acceleration) ' Adaptational problems. Physiological imbalance?

EB - what do we e.g. know?

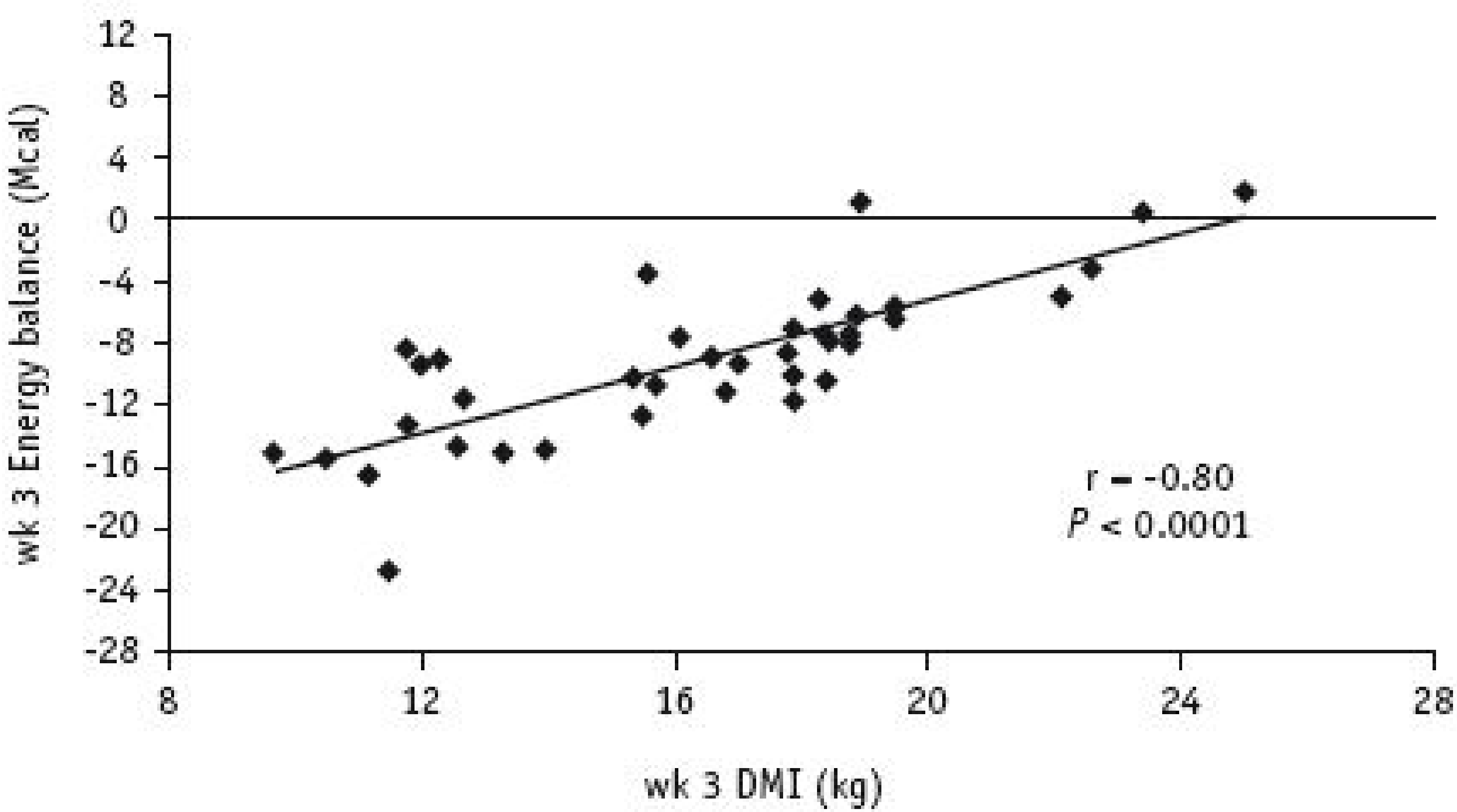
- EB is documented / argued to be a risk factor for:
  - Reduced reproduction
  - Metabolic diseases
  - Immune suppression / infectious diseases

- EB is documented / argued to be:
  - Highly negatively correlated to BCS in early lacttation
  - Highly positively correlated to DMI in early lactation

- Traditional estimation of EB (input-output method):
  - EB = Energy intake – energy output (milk, maint., activity, growth, pregnancy)

- Alternative estimation of EB (the body reserve changes method)
  - $EB_{body} = z$

High correlation between DMI and EB in early lactation (Drackley, 2006)



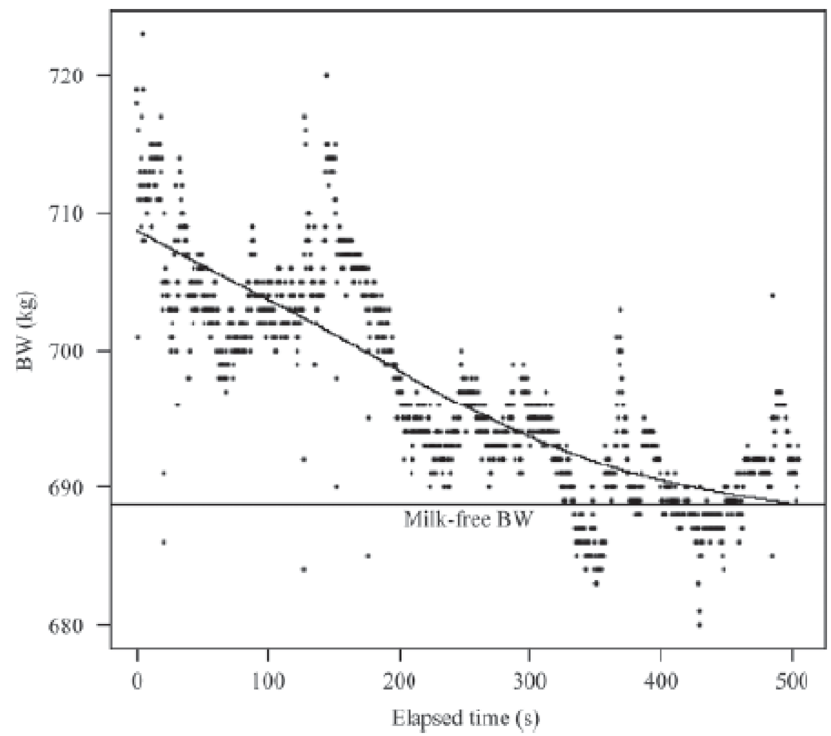
EB estimated in real-time on-farm from BW and BCS

- On-farm estimation of energy balance in dairy cows using only frequent body weight measurements and body condition score (Thorup et al. 2012, JDS Vol 95, 1784-1793).
  - EB estimated from body reserve changes (EB_{body}) using BW and BCS.
  - $EB_{body} = z$

Automated BW measurement and milk free BW

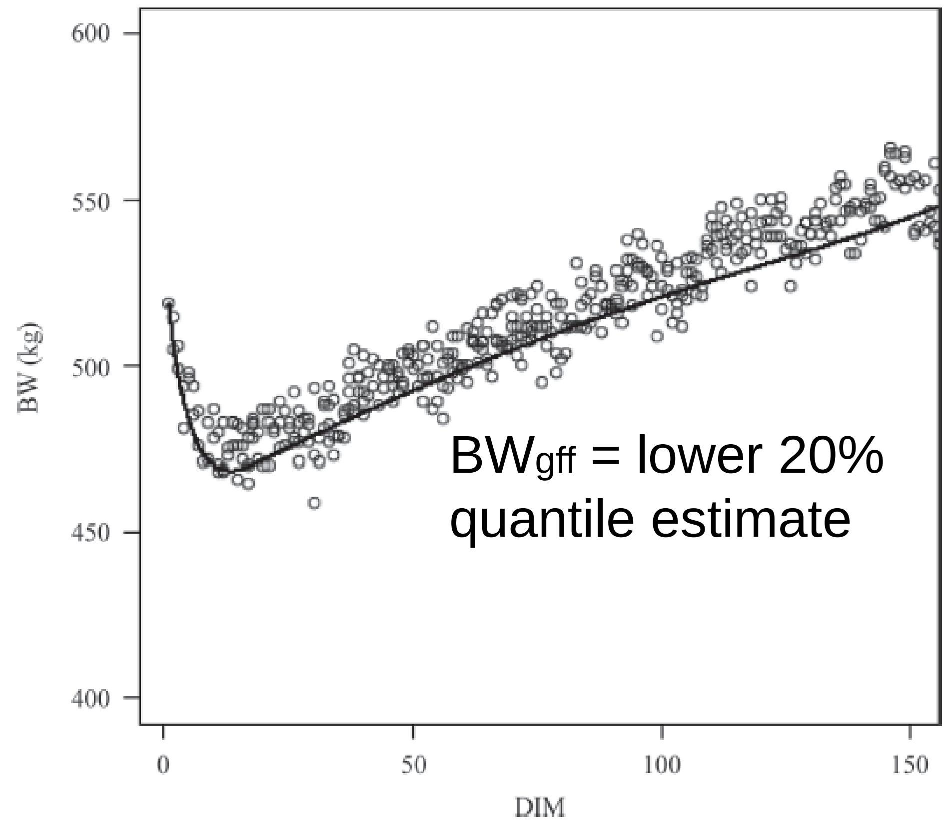
› BW measured during milking in VMS

› Milk free BW is estimated end of milking (BW_{mf})



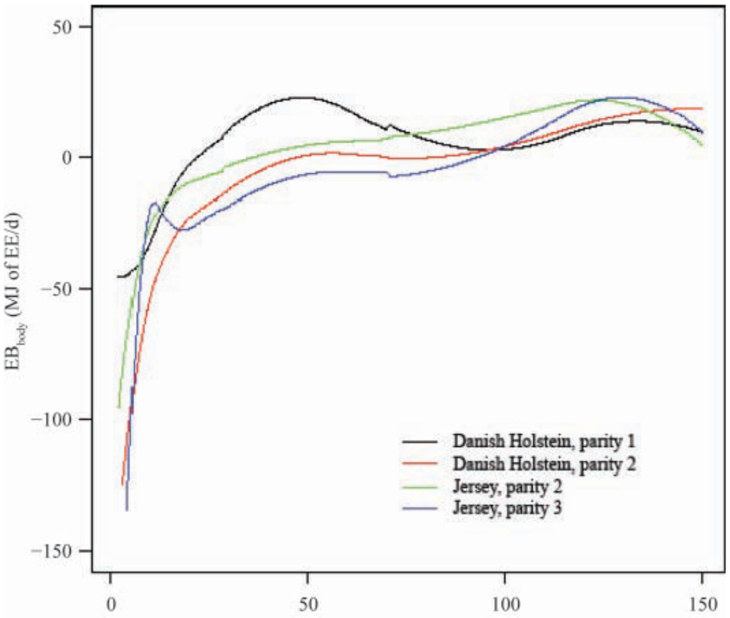
Correcting for gut fill and pregnancy

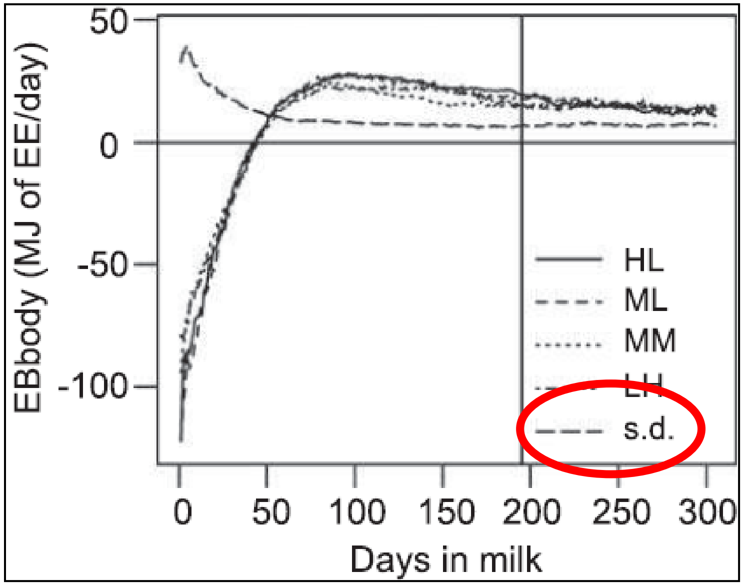
- The noise in this time-series is mainly due to variation in gutfill due to meals ingested. A meal-related gutfill-free BW (BW_{gff}) was estimated (fig.)
- Gut fill = meal related + residual gutfill
- Residual gutfill estimated (Martin & Survant 2010a)
- W_{foetus}º(Martin & Survant 2010b)



EB estimated in real-time on-farm from only BW

› Energy balance of individual cows can be estimated in real-time on farm using frequent liveweight measures even in the absence of body condition score (Thorup et al. 2013, Animal, In press)





What is needed for efficient management

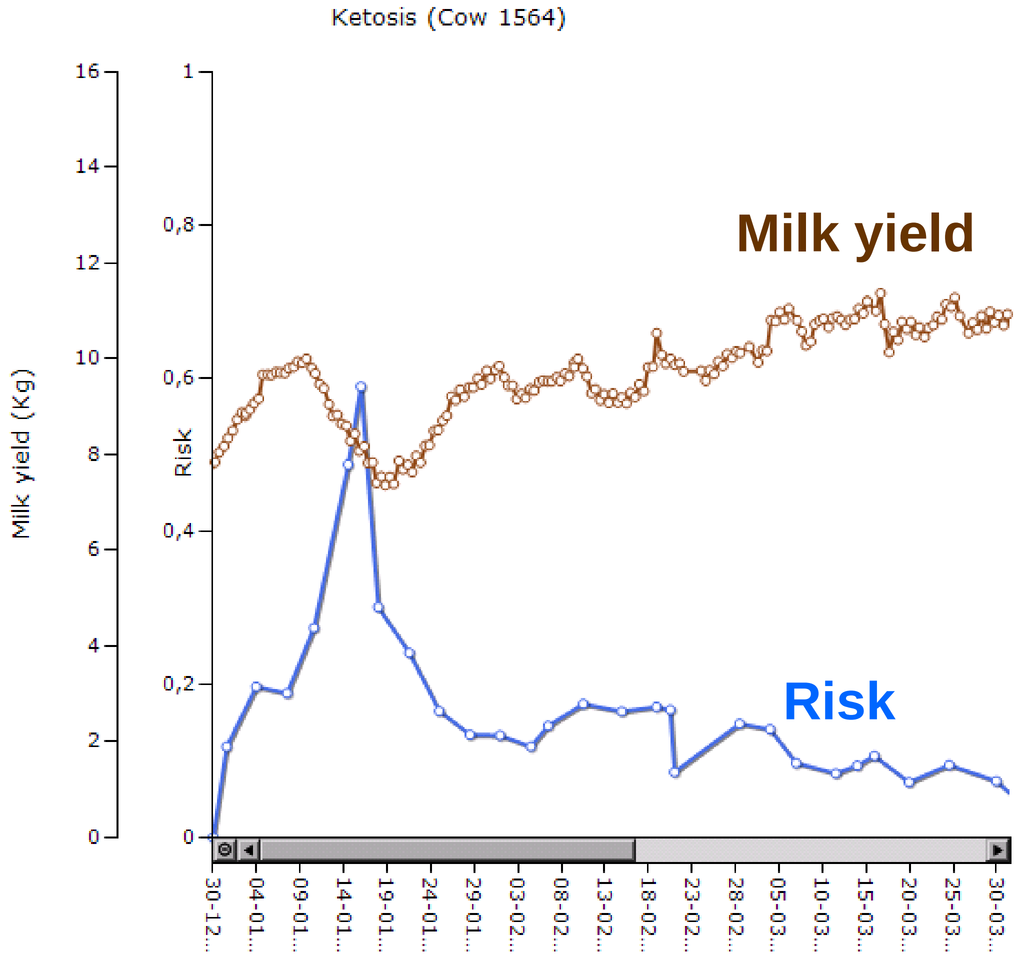
- › Early identification of "risk cows"
- › Manage animal status & risk by
- › changing "input" to "risk cows"

Calls for **real-time on-farm solutions** based on:

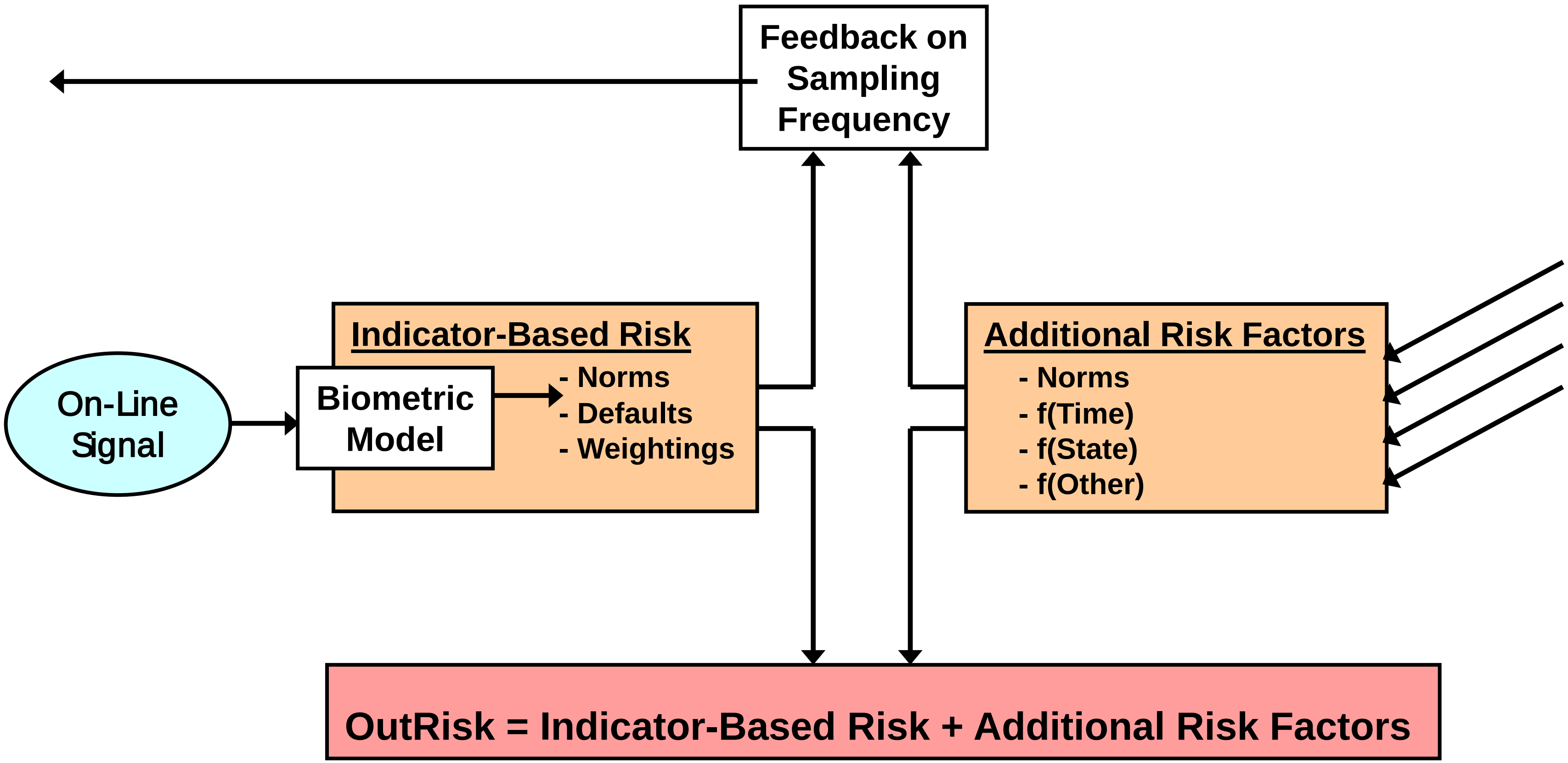
Efficient biomarkers
Automated sampling / analysis (sensors)
Biological and biometric models
Ability to describe animal status
Methods to describe risk (e.g. for a disease)
(autom.) change of "input" for prevention
Optimization at cow and herd level

Real time on-farm systems exist – e.g. Herd Navigator

BOHB – raw, smoothed, risk

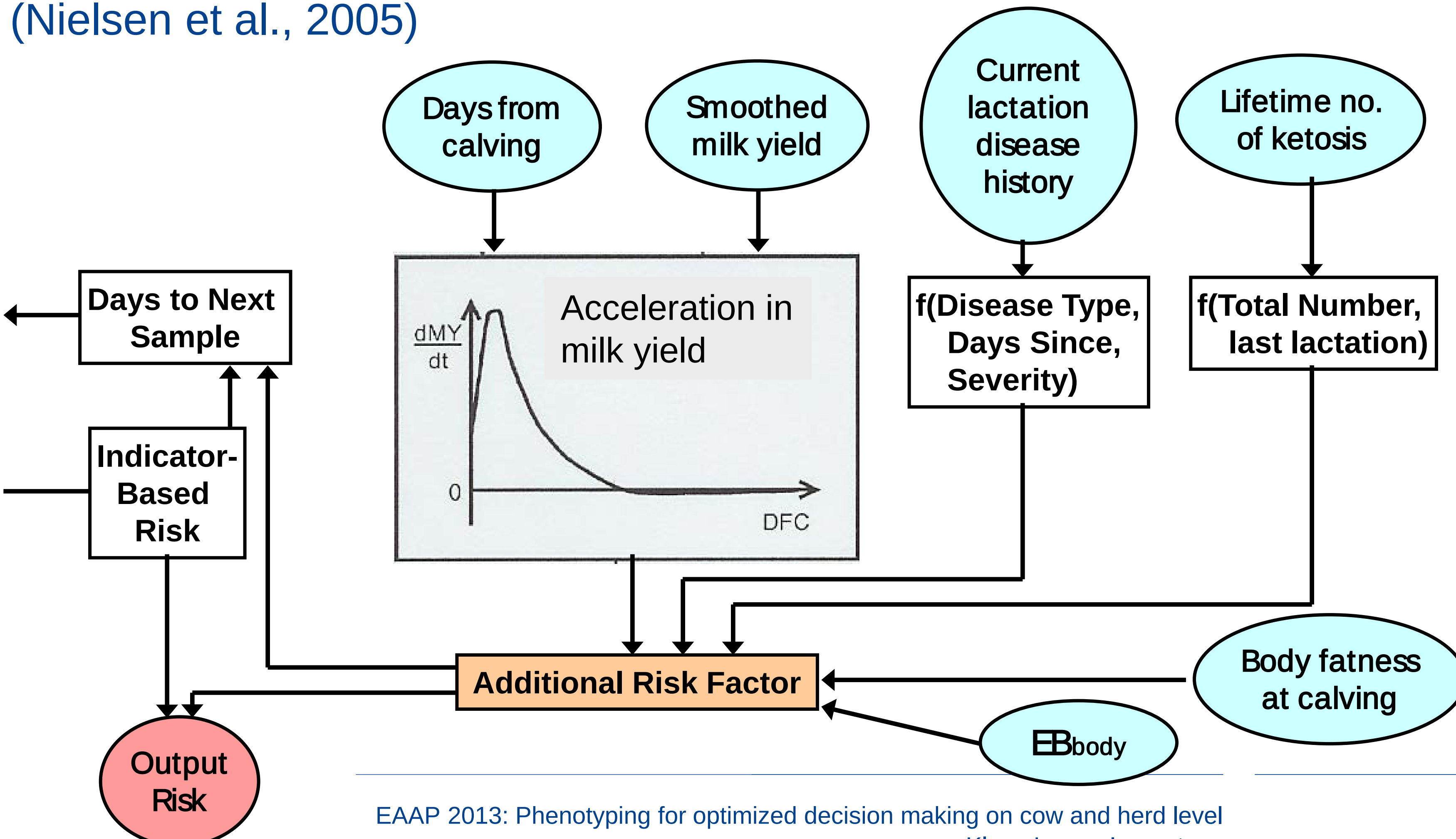


The ketosis model – overall structure
(Nielsen et al., 2005)

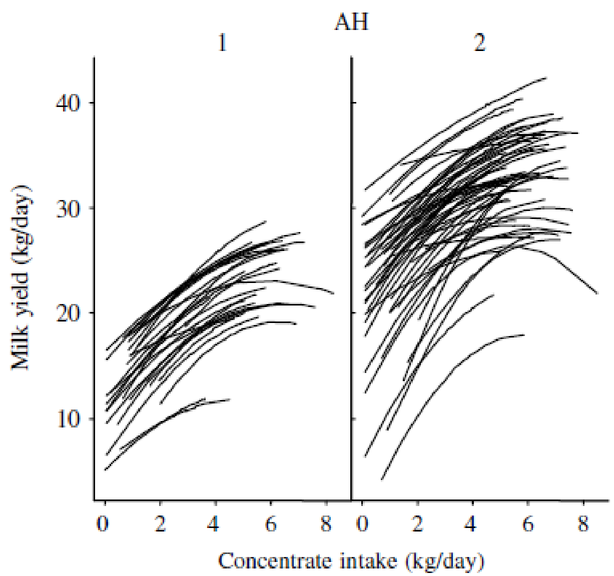


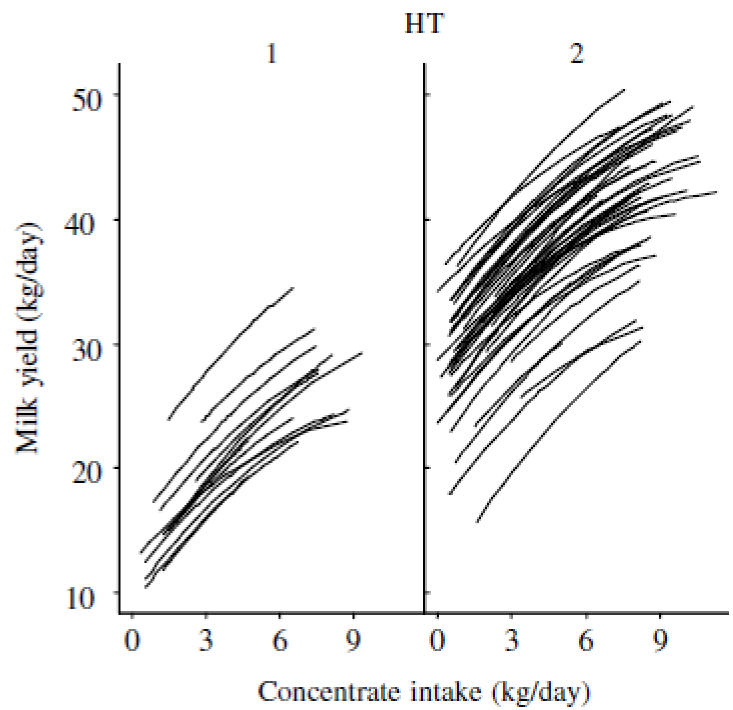
The ketosis model – Additional Risk Factors

(Nielsen et al., 2005)



Individual cow response curves in different herds and parity





› **Find "the local truth"**

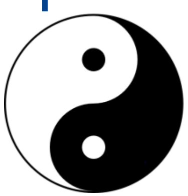
Optimization of cow and herd

- Both individuals and herd needs to be optimized
  - At herd level – e.g. culling

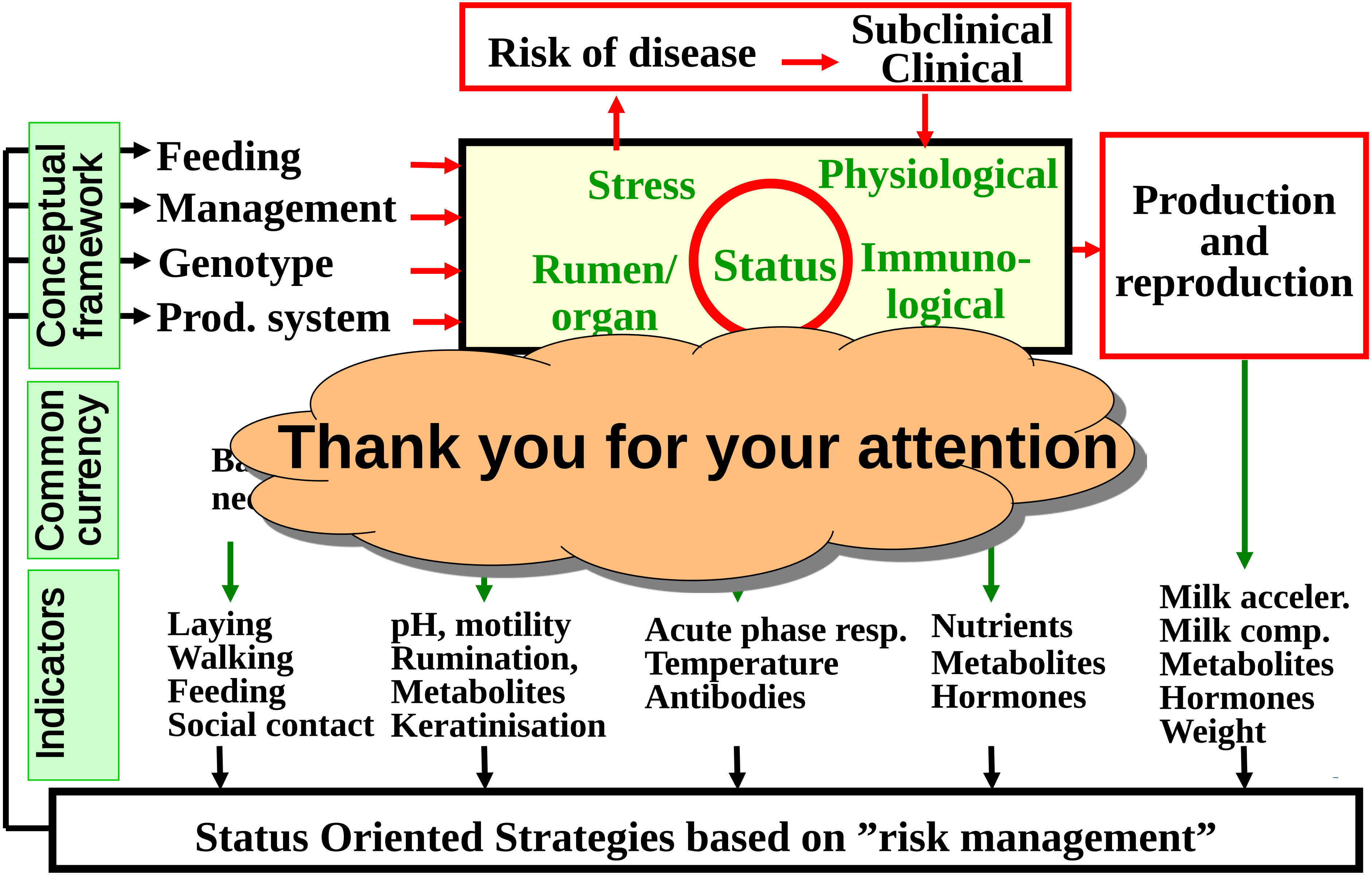
- Real time phenotyping allows real time optimization of indiv.
  - Solid biomodels is a prerequsite
  - Numerous uncontrolled factors may influence the “truth” for the individual cow
  - Biologically (e.g. production, risks, emissions) and economically

- The EVOP answer (Søren Østergaard, pers. comm.)
  - The concepts of EVolutionary OPerations (EVOP) is known from the manufacturing industry
  - EVOP implies to make systematic (randomized) small changes in production factors and procedures and thereby find ways to a more efficient production
  - **We get causal effects within the current local environment**

In conclusion - future challenges

- To better understand the physiology and immunology of the dairy cow, particularly in the periparturient period
- To understand the biological basis of individual differences
- To improve phenotyping by:
  - Making better use of existing data
  - Develop new biomarkers for common use in management and genomic selection (e.g. physiological imbalance)
- Further develop sensors and technology for future automatic proactive management strategies (incl. optimization)
- Find “the local truth”
- Optimization at both individual cow and herd level
-  production, reproduction, risk of disease,
- environmental impact, animal welfare, ……

Precision management (risk assesment & optimization) of individuals (mod. from Ingvartsen 2006)



The ketosis model – Indicator based risk (Nielsen et al., 2005)