The US Dairy Feed Efficiency Database

Mike VandeHaar
Rob Tempelman
Kent Weigel

United States Department of Agriculture
National Institute of Food and Agriculture

Grant Number 2011-68004-30340: Genomic Selection and Herd Management to Improve Feed Efficiency of the Dairy Industry

Goal: to increase the efficiency and sustainability of producing milk.

Specific aims:

1) develop a database of 8000 genomically characterized Holstein cows.

2) determine the genetic architecture of feed efficiency.

3) facilitate implementation of genomic selection programs for efficiency.

4) develop decision support tools to improve efficiency of the whole herd.

5) educate students about key practices that promote efficiency.

Nutrition: M VandeHaar (MI), L Armentano (WI), M Hanigan (VA), C Staples (FL), D Beede (MI), R Shaver (WI), J Dijkstra (NL)

Genetics: R Tempelman (MI), K Weigel (WI), D Spurlock (IA), R Veerkamp (NL), M Coffey (SAC), Z Wang (Alb), E Connor, G Wiggans (USDA)

Management: V Cabrera (WI), M Worku (NC), M Nielsen (MI), M Wautiaux (WI), R Pursley (MI), B Simpson (GeneSeek)

Outline and goals

Outline

1. The basics of feed efficiency and why it matters.
2. Relationships to level of production and body size
3. A summary of our project findings.
4. Where we are headed.

Ever-Green-View, 2/15/2010
2790 #F, 2140 #P in 365 d

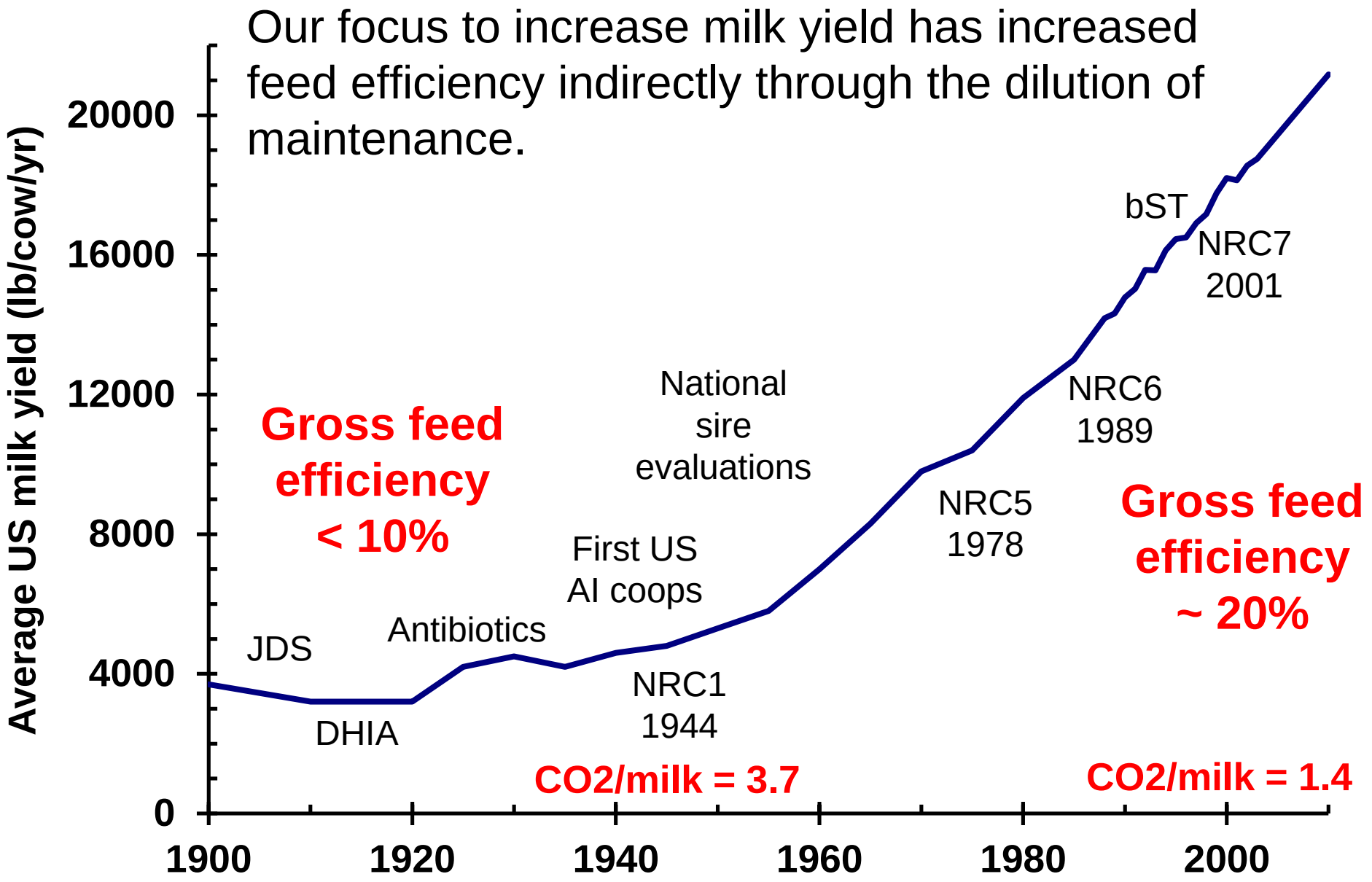
The modern dairy cow is a different beast!

Eurasian auroch

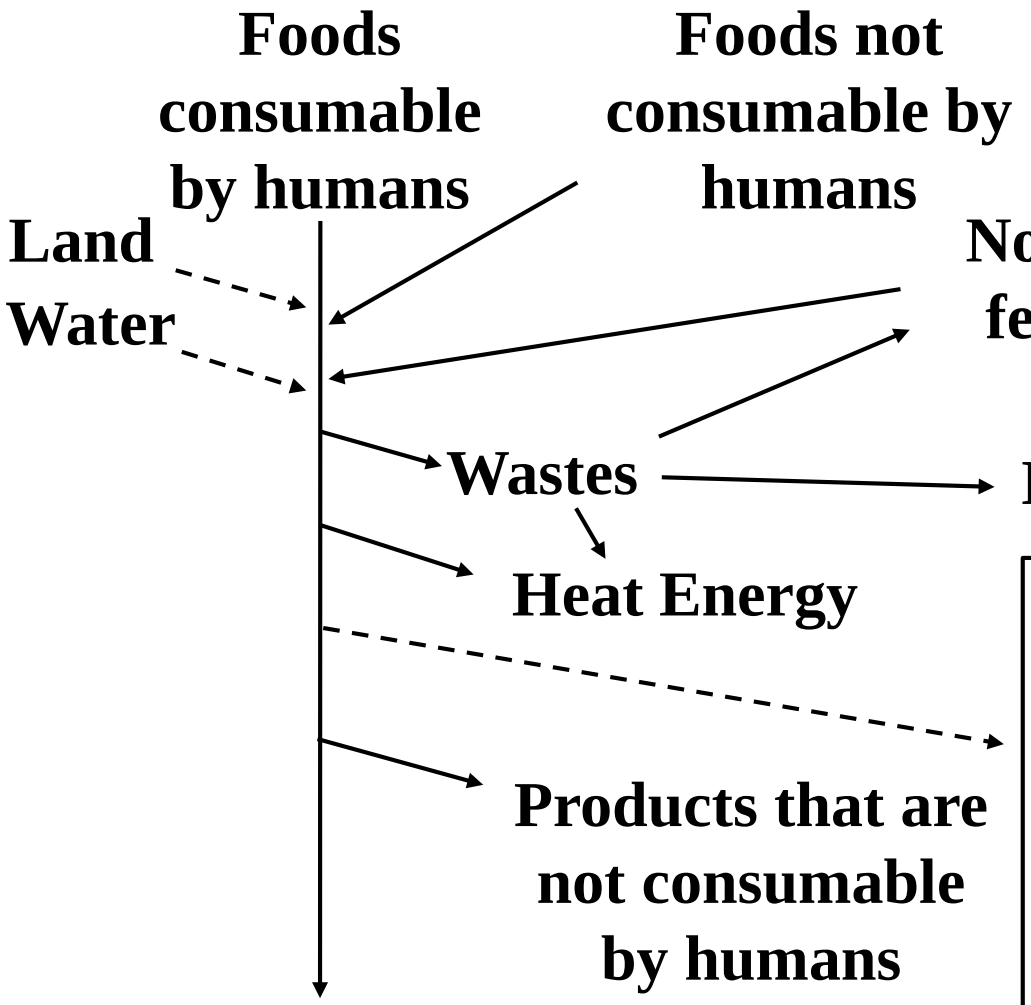
→

- We have been altering cattle genetics for 9000 years.
- Most selection was made based on animal's own phenotype.
- Population genetics (>1937) accelerated the progress.
- We made a lot of progress based on looks and a few numbers.
- Modern dairy cows are taller, thinner, and less muscular, and they have bigger udders.
- Today we have data. Lots of it.

Increased productivity in the past has resulted in increased efficiency



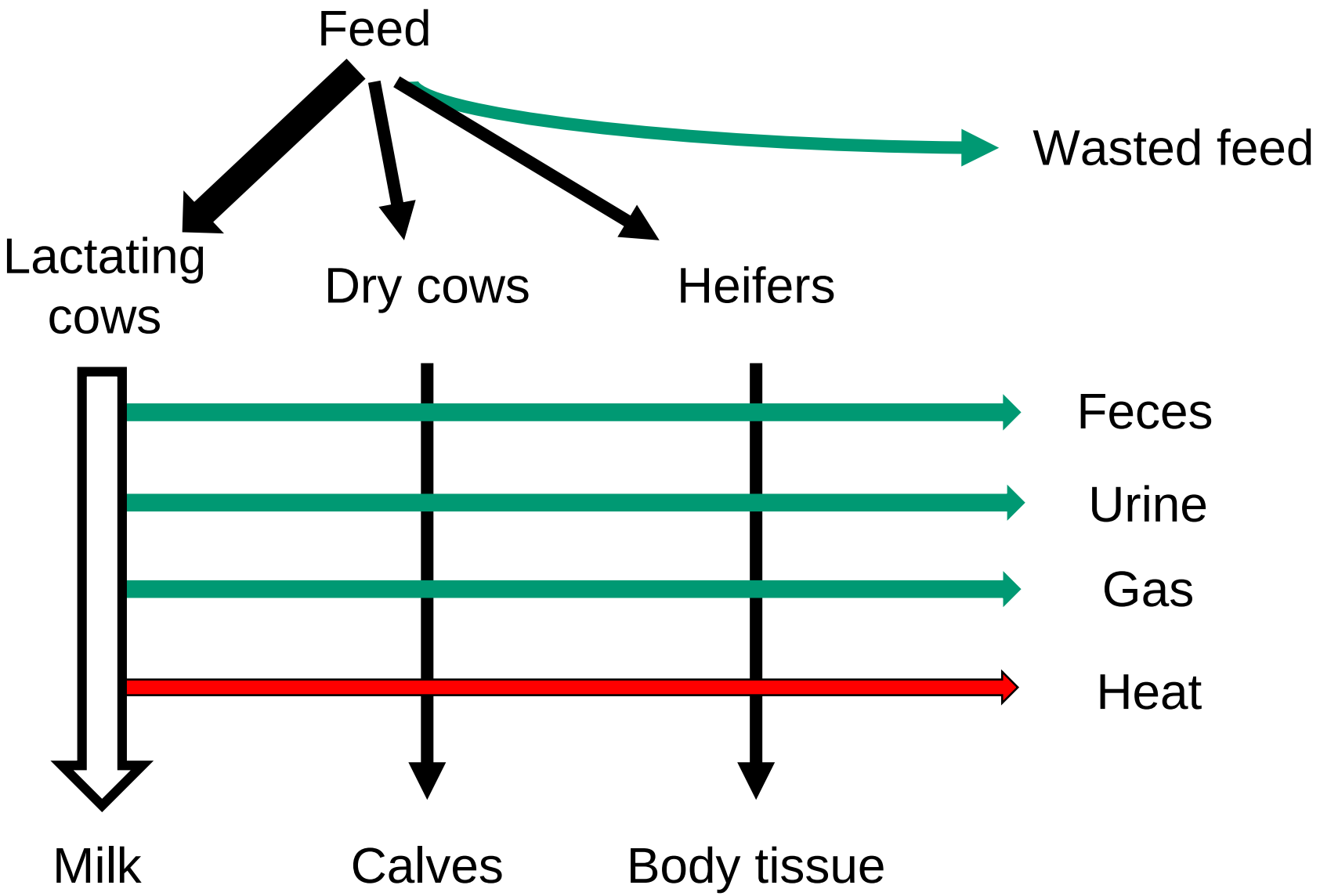
Feed efficiency is a complex trait.



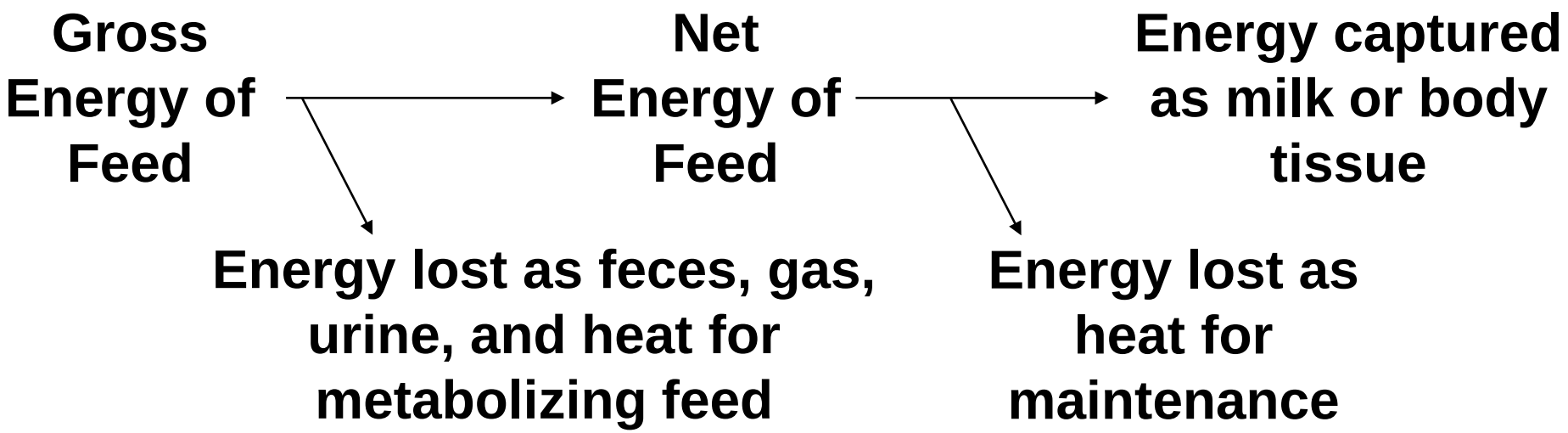
- *climate impacts*
- *farm profitability*
- *ecosystem services*
- *soil erosion and conservation*
- *imported oil*
- *rural aesthetics*
- *rural sociology*
- *food quality and healthfulness*
- *food security*
- *animal behavior and well-being*
- *efficiency of the beef industry*

This is too complicated to use!

Feed efficiency on the farm



The basics of feed efficiency



Gross feed efficiency is the percentage of feed energy captured in milk and body tissues.

To improve gross feed efficiency:

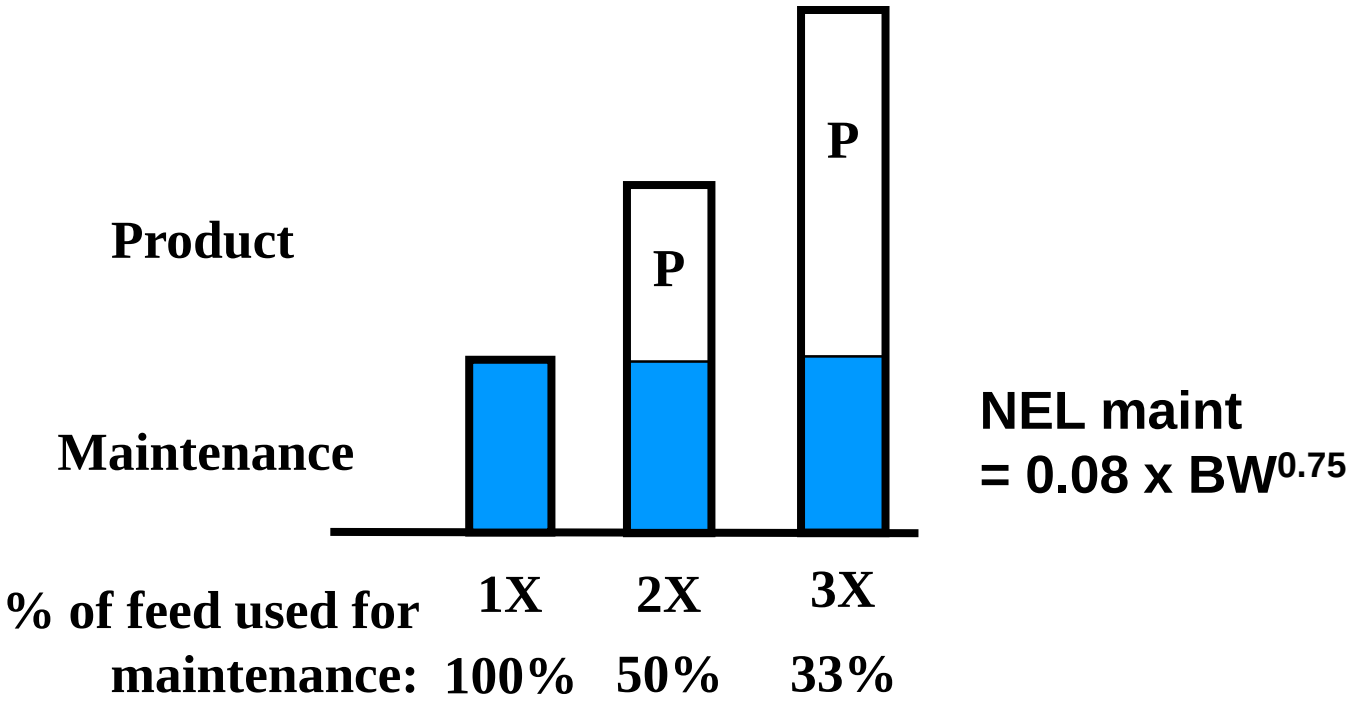
1. Increase the conversion of GE to NE
2. Increase milk production relative to maintenance.

Is there an optimal milk production and body size?

Feb 15, 2010: Wisconsin cow Ever-Green-View My 1326-ET became the national milk production record holder, at 4 yr 5 mo. of age. She produced a 365-day record of 72,200 lbs of milk, with 2,790 lbs of fat and 2,140 lbs of protein.

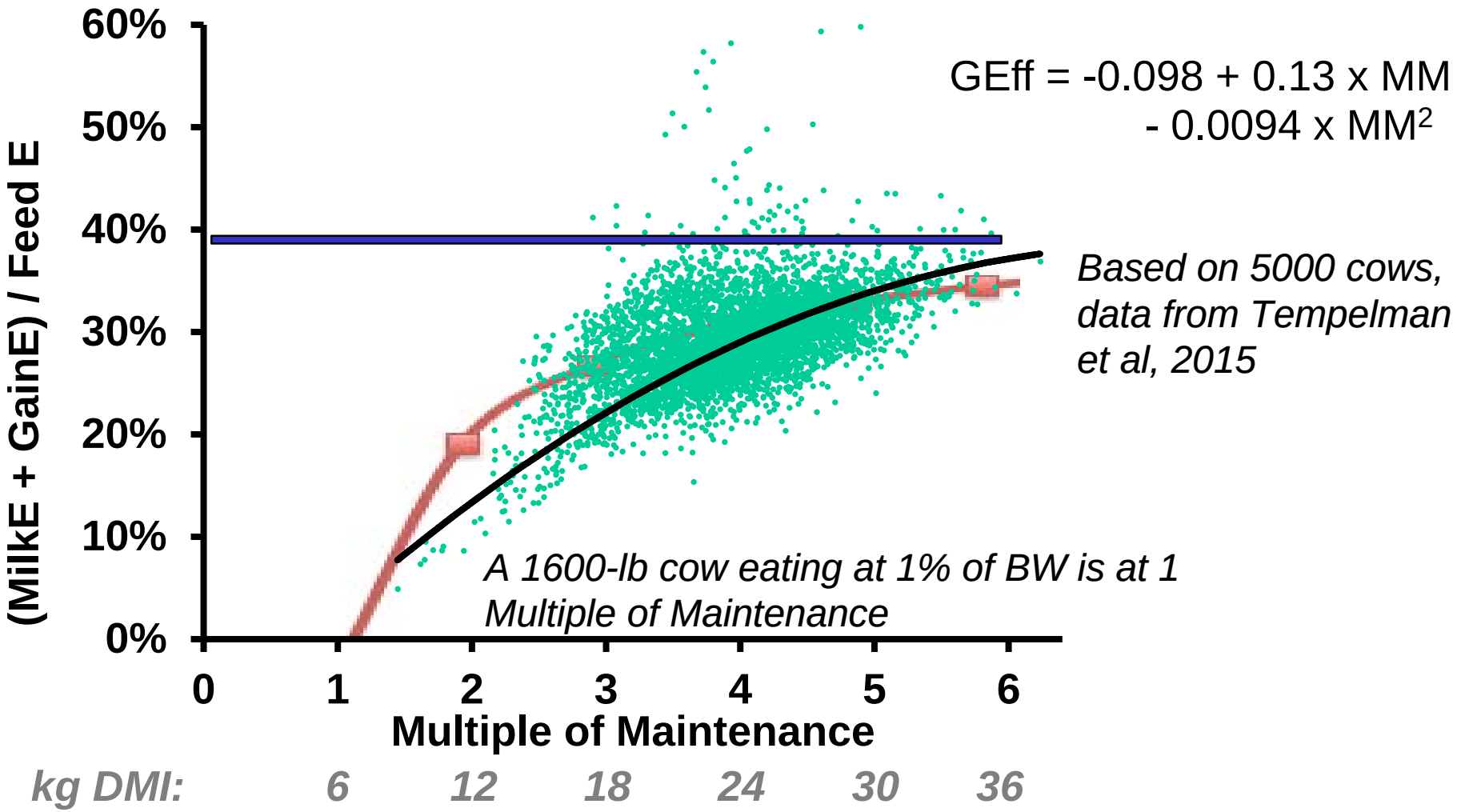
If a cow produces this much, I don't care if she weighs 2000 lb!

Efficiency increases from the "Dilution of Maintenance"



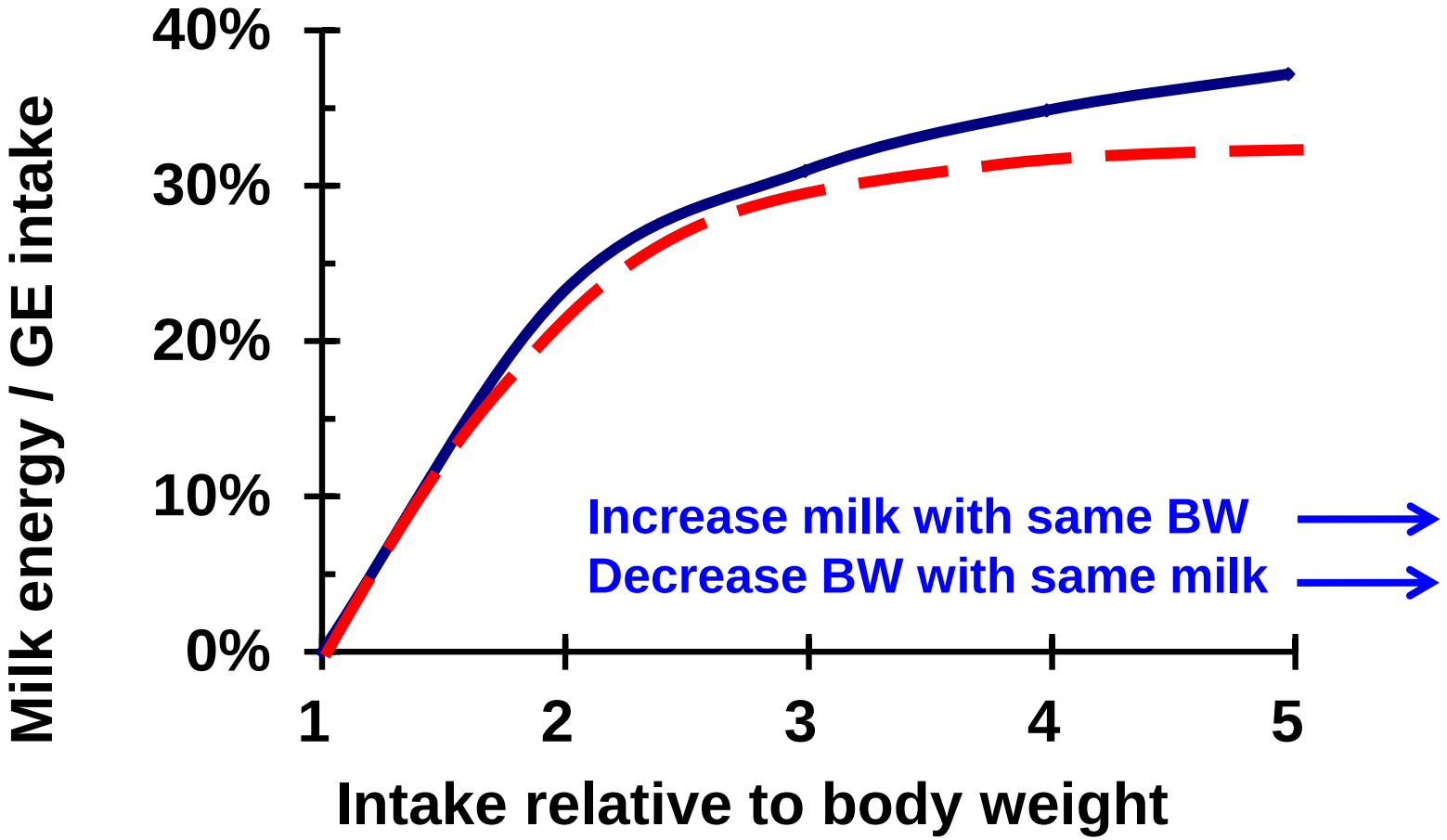
As cows eat more and produce more per day, a smaller percentage of the food they eat is used for maintenance and a greater percentage is converted to product.

Optimal production per unit BW based on current data



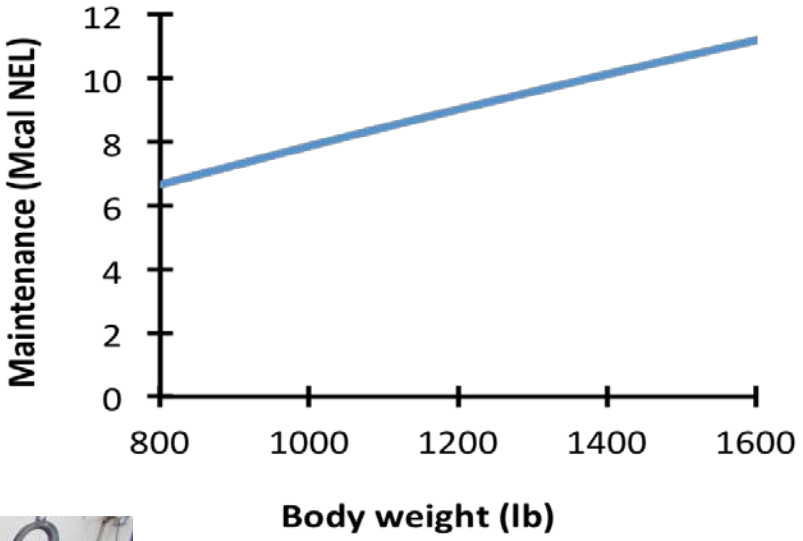
High production per unit BW means greater efficiency, but the returns in efficiency from more milk are diminishing.

The dilution of maintenance: milk vs cow size



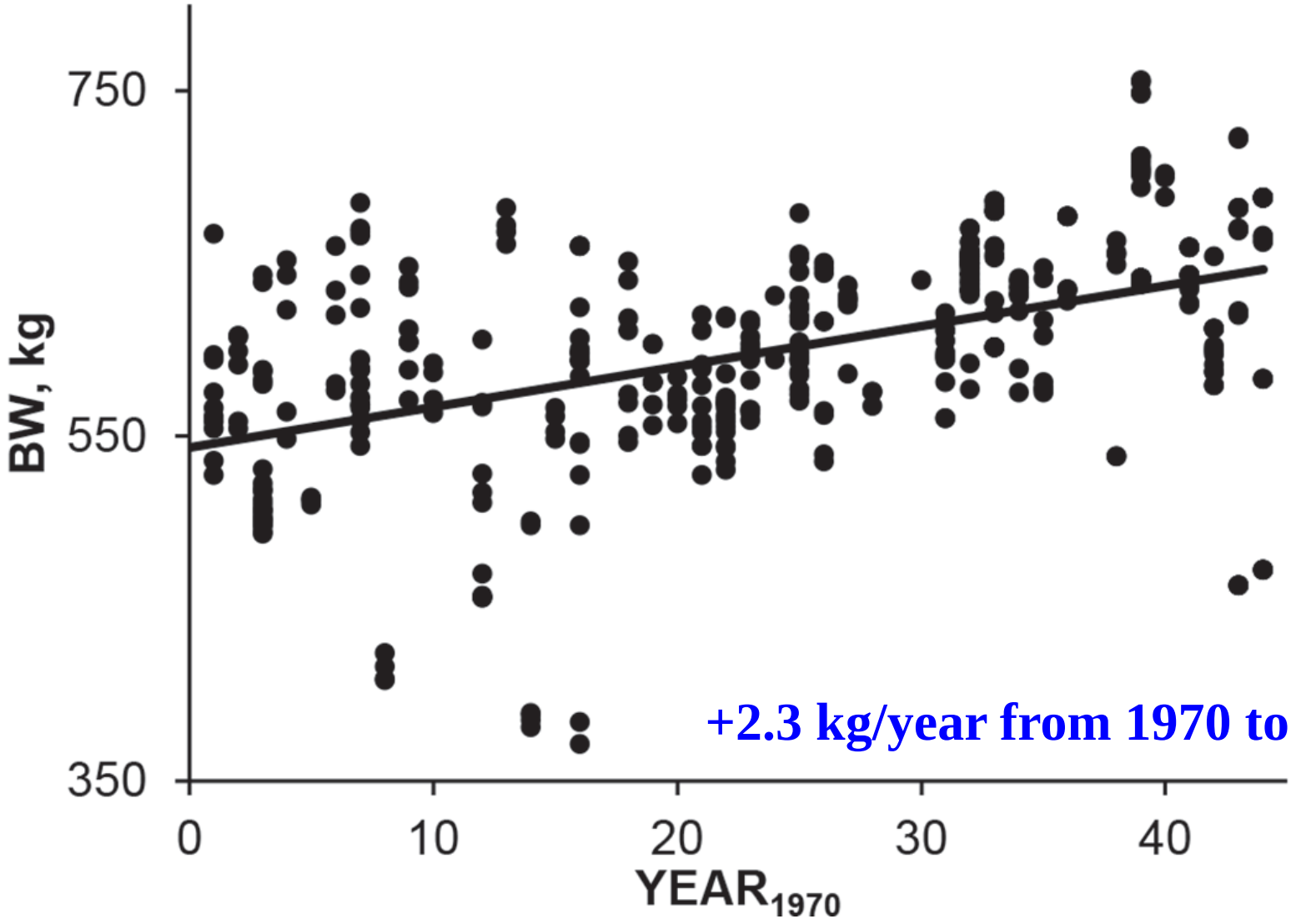
Whether we get more milk with the same BW or the same milk with a smaller BW, the cow is operating at a higher level and efficiency increases (but maybe not much).

Should we select for smaller cows?



Assumption for last 60 years was that
NEL requirement for maintenance = 0.08 x $BW^{0.75}$

Body Weight Trend in U.S. Holsteins



Potts et al., 2017

Maintenance requirement – what is it?

- NRC 2001: 0.08 x Metabolic BW
- Birnie et al., 2000: 0.084 to 0.113 x MBW
  depending on BCS
- Moraes et al, 2015: 0.086 to 0.115 x MBW
  depending on decade
- Tempelman et al., 2015: 0.11 to 0.17 x MBW
  depending on research farm

If the maintenance requirement increases, then the optimal level of milk production relative to body weight to achieve maximal feed efficiency will also increase.

Genetic (upper right)and non-genetic (lower left) correlations and heritabilities (diagonal) for efficiency traits on 5700 Holsteins. Lu et al., unpublished.

	MilkE	MBW	DMI	Gross Eff.		IOFC
MilkE	0.37 ±0.03	**0.06** ±0.06	0.66 ±0.04	**0.66** ± 0.08		**0.97** ±0.01
MBW	**0.22** ±0.04	0.51 ±0.03	**0.45** ±0.05	**-0.28** ±0.06		**0.02** ±0.07
DMI	0.56 ±0.02	0.37 ±0.03	0.38 ±0.03	-0.11 ±0.04		0.54 ±0.06
Gross Eff.	0.39 ±0.02	-0.03 ±0.01	-0.19 ±0.02	0.13 ±0.00		0.70 ±0.05
IOFC	0.85 ±0.01	0.17 ±0.04	0.34 ±0.03	0.77 ±0.01		

Selection against body size will enhance feed efficiency but not milk income per cow. Selection for milk increases both.

Summary for body size and efficiency

Liu et al., 2015. Body weight.

- For 5700 Holsteins, body weight was not genetically correlated with milk energy per day. The genetic correlation of body weight with gross feed efficiency was -0.3.

Manzanilla-Pech et al., 2015. Stature.

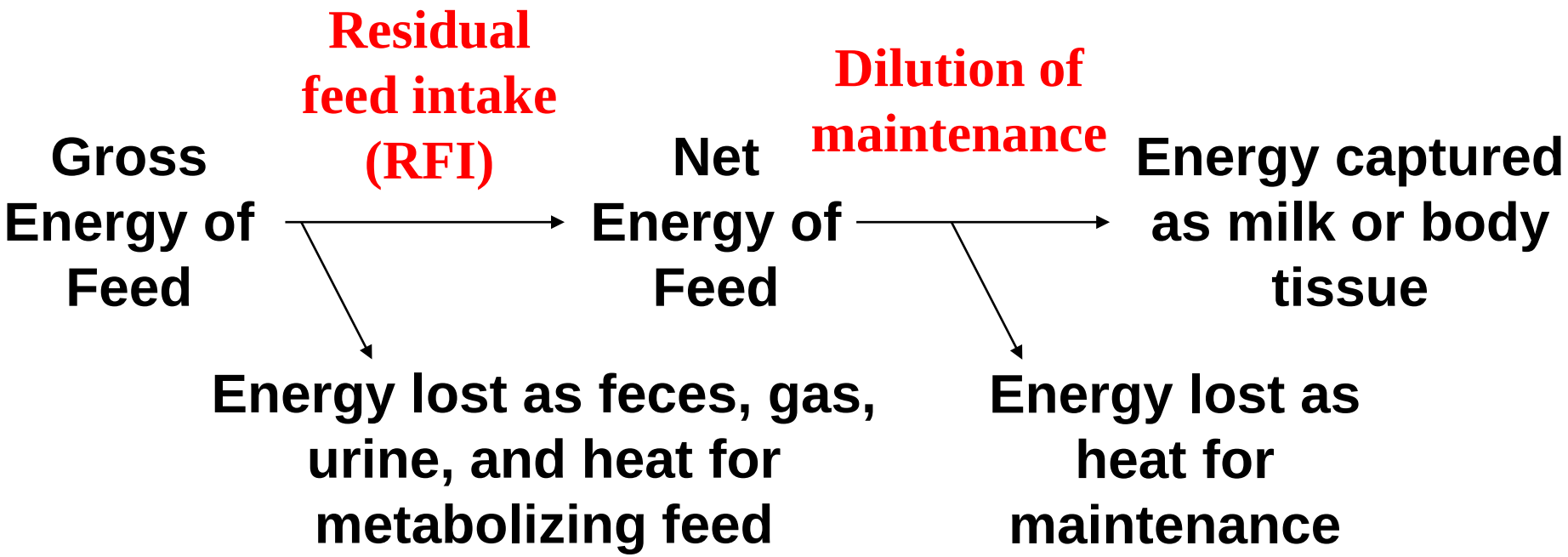
- For 1900 US Holsteins, stature was not genetically correlated with milk energy/day. The genetic correlation of stature with gross feed efficiency was -0.7 and with residual feed intake was +0.4.

- **Selecting for bigger, taller cows does not increase milk.**
- **Selecting for bigger, taller cows decreases feed efficiency.**

Other considerations in the size debate

- Milk yield is more important than body size.
- Feed efficiency must be considered on a whole-farm basis.
- Smaller cows need less space so get more cows per farm.
- Smaller cows take about as much time to manage per head.
- Smaller cows and their bull calves have less salvage value.
- Smaller cows might have fewer health problems.
- Smaller cows might handle heat stress better.
- Smaller cows might be better in a grazing system.
- Smaller cows might need more digestible diets.
- Height might be more important than weight.

Two main components of feed efficiency



1. Efficient cows produce a lot of milk for their size!

2. Efficient cows efficiently convert feed to net energy—they likely eat a lot but the feed is used for milk.

We want more than just efficiency

Our goal is a cow that efficiently converts feed to milk

- has high GE to NE (low RFI) because of greater digestibility, greater % of DE to NE, or lower maintenance
- efficiently captures (partitions) lifetime NE to product because she operates at a high multiple of maintenance
- is profitable (high production dilutes out farm fixed costs)
- has minimal negative environmental impacts

AND

- is healthy and thrives through the transition period
- yields products of high quality and salability
- is fertile and produces high-value offspring
- is adaptable to different climates and diets
- can use human-inedible foods, pasture, and cheap feeds
- can digest feeds better
- requires less protein and phosphorus per unit of milk
- has a good disposition and looks happy to the general public

Conclusions of USDA Study

- Stature and body weight are negatively correlated with Gross Feed Efficiency at r = -0.7 and -0.3.
- Residual feed intake (RFI) is moderately heritable at ~0.17.
- 61,000 SNP markers accounted for 14% of the variance in RFI. Top ten SNP accounted for 7% of the variance.
- The range in sire breeding values for RFI is ~900 lb of feed DM per lactation. The range in DMI due to BW variation and RFI in combination is ~1400 lb/lactation.
- Residual feed intake could get ~16% of relative emphasis in net merit, but low REL for young animals will limit progress.

US Feed efficiency database 9/30/2019

	# cows	# records	# genotypes
U Florida	687	858	551
Iowa State U	1014	1106	995
Michigan State U	461	712	439
U Wisconsin	1608	1977	1555
Dairy Forage Res Center	708	977	592
USDA-ARS Beltsville MD	592	949	560
Virginia Tech	209	215	133
Other	296	345	121
U Alberta	288	516	261
TOTAL	**5863**	**7655**	**5207**
European collaborators	*3600*		*1900*

Improving dairy feed efficiency, sustainability, and profitability by impacting breeding and culling decisions.

$2 million for 2019 - 2024

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Our Team

Michigan State	Rob Tempelman	Mike VandeHaar
U Wisconsin	Kent Weigel	Heather White
Iowa State	James Koltes	Hugo Ramirez-Ramirez
U Florida	Francisco Peñagaricano	Jose Santos
USDA AGIL	Paul Van Raden	Randy Baldwin
CDCB	Joao Durr Kristen Parker-Gaddis Javier Burchard	

Overview of Project Aims