SUPPORT - SOLUTIONS - RESULTS

MarSyt

An Agricultural Company
Since 1995

Unparalleled **SUPPORT**

Effective **SOLUTIONS**

Meaningful **RESULTS**

Visit Our Website!

Stacked stressors and their impact on physiology and health of dairy cows

Matt Lucy

Division of Animal Sciences

University of Missouri, Columbia, USA

Division of Animal Sciences
University of Missouri

Stress versus strain

Current Holstein Record for Milk Production

Selz-Pralle Aftershock 3918

Selz-Pralle Dairy, Humbird, WI

78,170 lbs of milk*

3,094 lbs fat (4.0%)

2,393 lbs protein (3.1%)

365 d lactation

*3-times average US cow

"3918 is a solid, hardworking, 'blue collar' Holstein cow who lives in a free stall barn and likes to be left alone. She is the perfect cow since she causes no problems, you don't even know she's there."
- Scott Pralle

Stress versus strain

New Record!

Selz-Pralle Aftershock 3918

Selz-Pralle Dairy, Humbird, WI

How many gallons of milk per day (peak lactation)?

The question

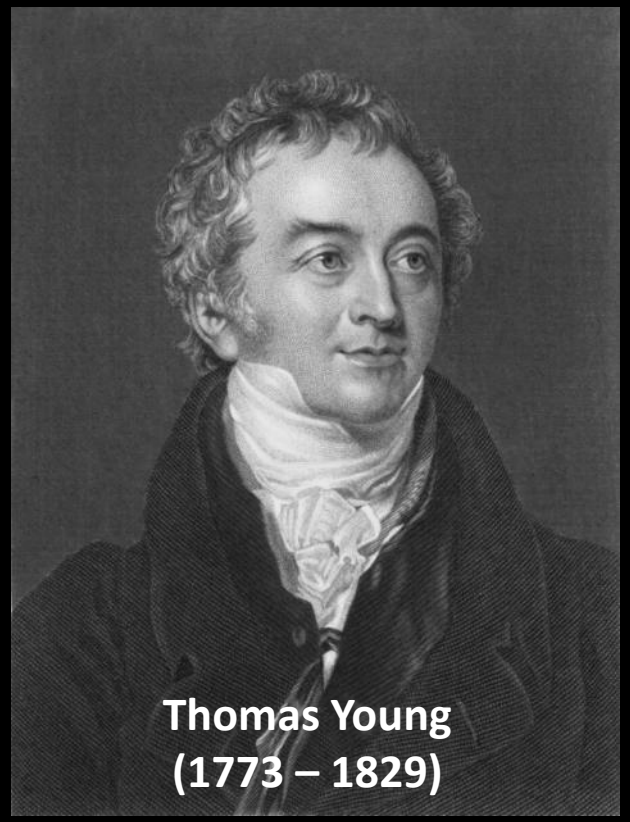
Are high-producing dairy cows “stressed” ?

YES!

But the “stress” is not the problem

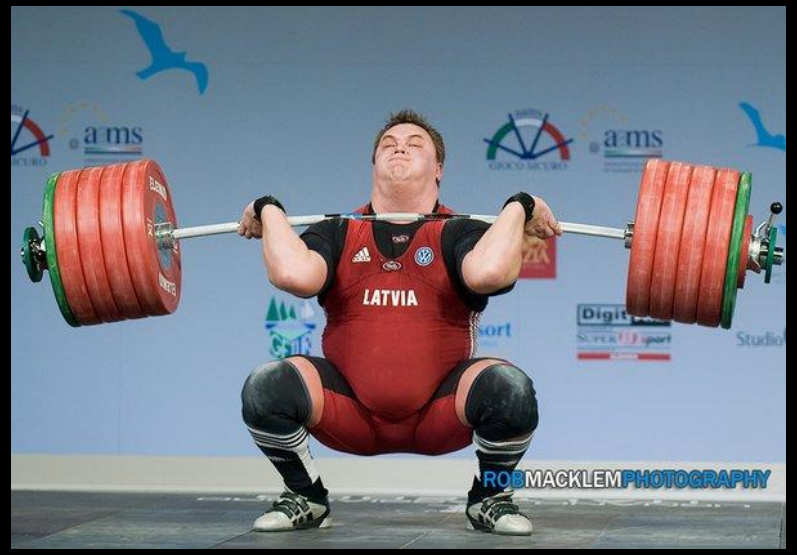
Stress versus strain

Stress, Strain, and Young's Modulus of Elasticity



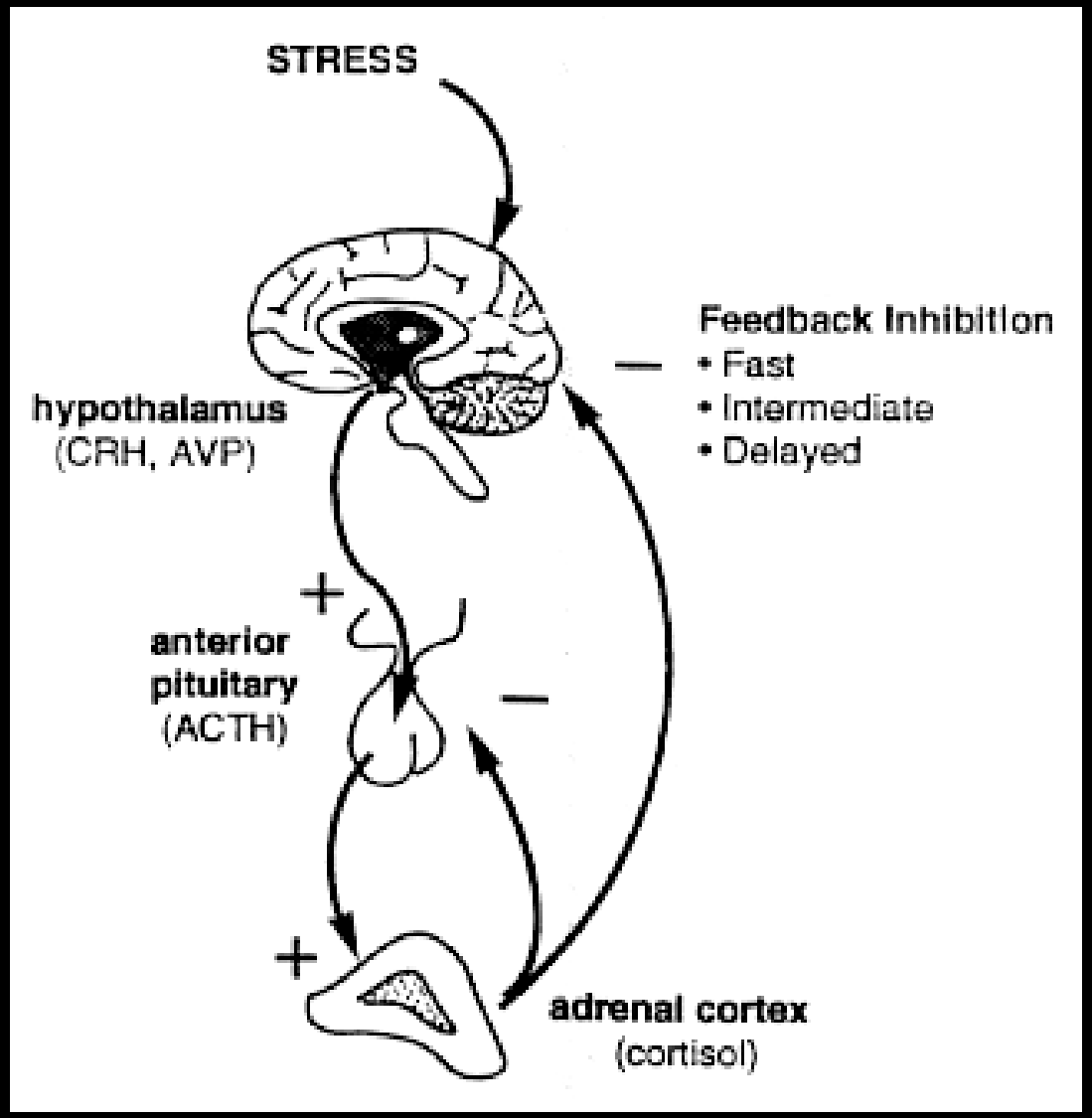
Thomas Young
(1773 – 1829)

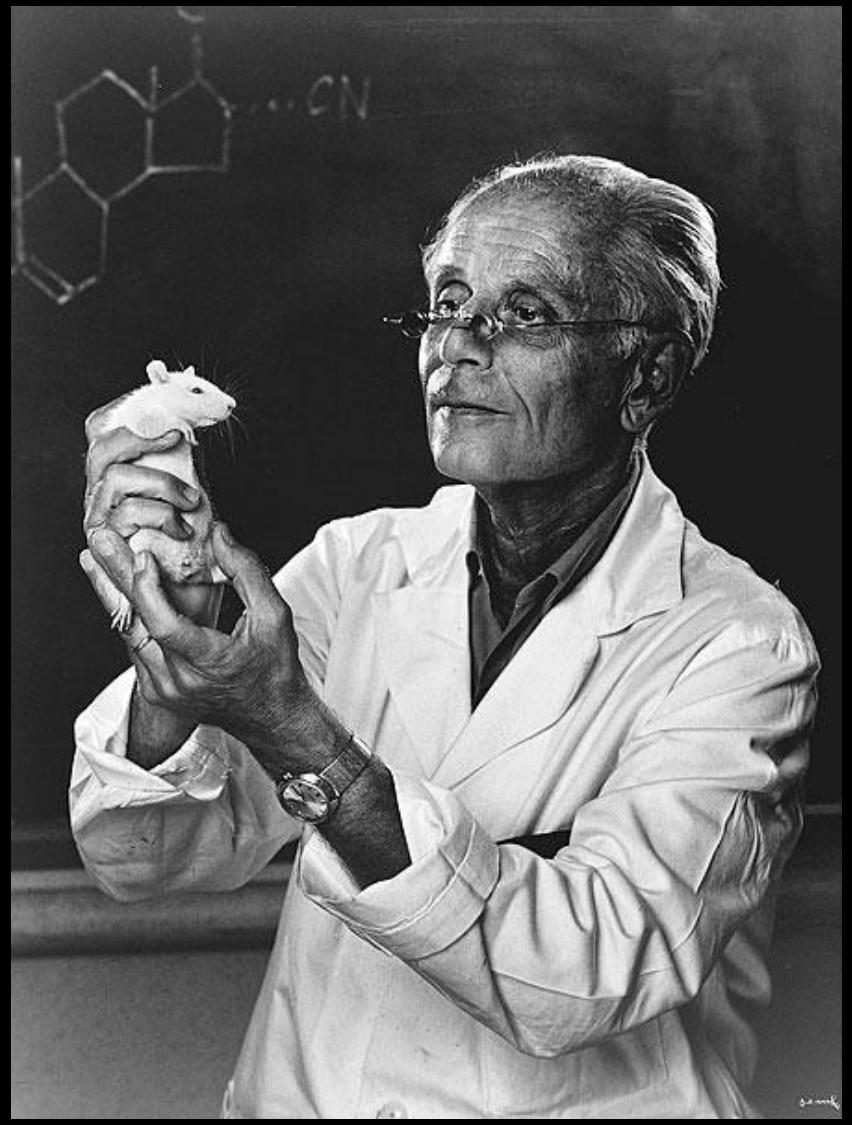
Stress refers to the force applied to a material per unit area, while strain is a deformation or change in the shape of the material that results from the applied force.



Stress versus strain

Hans Selye
Father of stress physiology





Stress versus strain

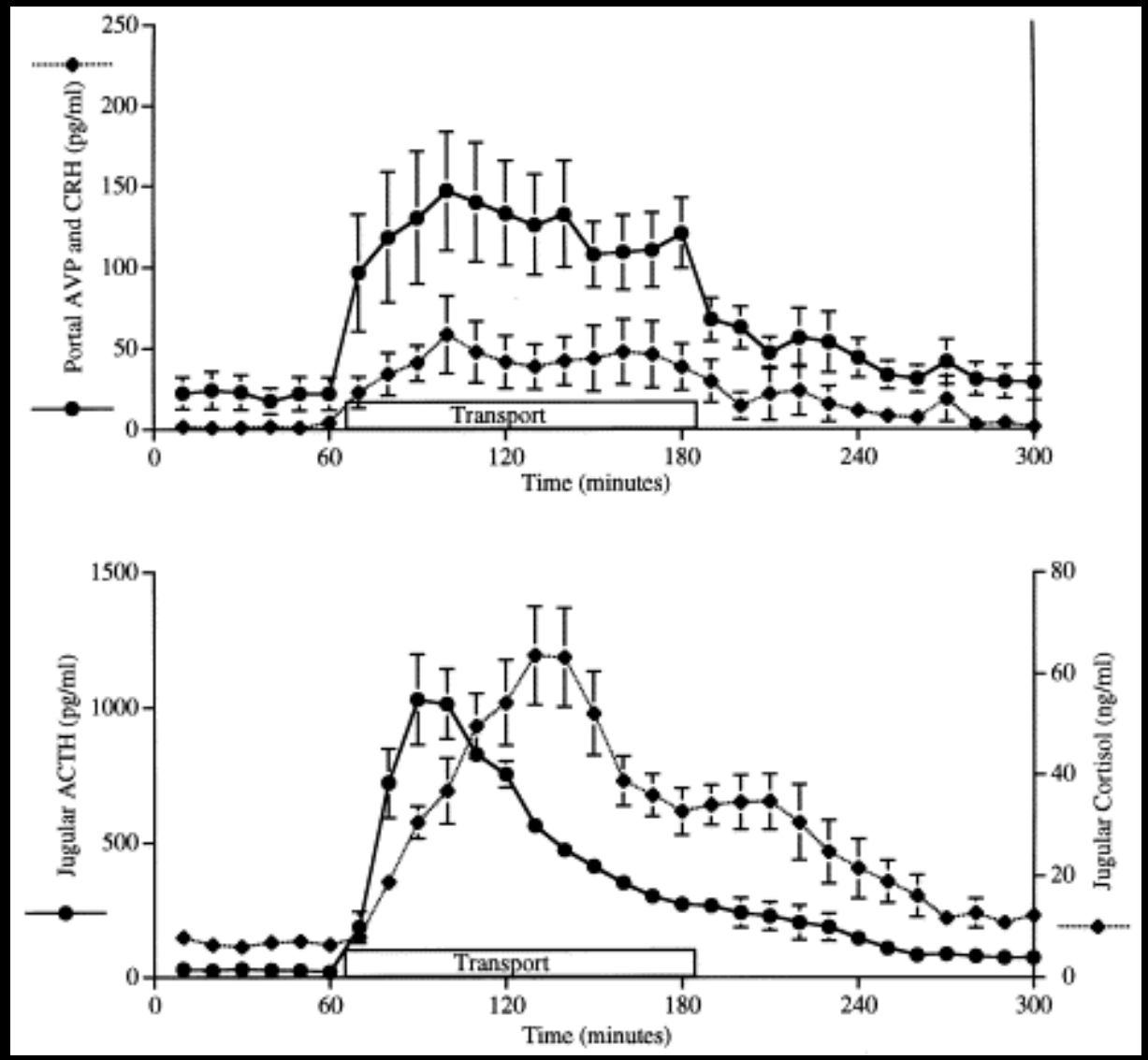
What is stress?

What is stress, and how does it affect reproduction?

Hilary Dobson and R. F. Smith

Department of Veterinary Clinical Science and Animal Husbandry, University of Liverpool, Leahurst, Neston, Wirral, CH64 7TE, UK

Anim Reprod Sci. 2000 Jul 2;60-61:743-52.



What is stress?

Stress versus strain

0021-972X/96/$03.00/0
Journal of Clinical Endocrinology and Metabolism

Vol. 81, No. 5
Printed in U.S.A.

Time Kinetics of the Endocrine Response to Acute Psychological Stress*

STEFAN D. RICHTER, THOMAS H. SCHÜRMEYER, MANFRED SCHEDLOWSKI, ANDREAS HÄDICKE, UWE TEWES, REINHOLD E. SCHMIDT, AND THOMAS O.F. WAGNER

Divisions of Endocrinology (S.D.R., T.H.S., A.H., T.O.F.W.), Medical Psychology (M.S., U.T.), and Clinical Immunology (M.S., R.E.S.), Hannover Medical School, 30623 Hannover, Germany

ABSTRACT

A first-time parachute jump was chosen as a model to evaluate the endocrine response to acute psychological stress. In 43 inexperienced tandem parachutists, blood was drawn continuously from 2 h before to 1 h after the jump and analyzed at 10-min intervals for plasma concentrations of epinephrine (E), norepinephrine (NE), cortisol, GH, PRL, and TSH. In addition, heart rate was recorded throughout the experiment. There was a significant increase in heart rate and E concentrations during the jump itself. NE, cortisol, GH, PRL, and TSH peaked with a latency of 10–20 min. Apart from cortisol and TSH concentrations, which were still elevated 1 h after the stress event, plasma levels of the other endocrine variables normalized within 1 h following the jump. Statistically significant cross-correlations could be observed between E and NE ($r = 0.60$, no time lag) and between E and PRL ($r - 0.58$, 10-min time lag) only. Even in a very homogenous group of subjects and under well-controlled conditions, endocrine responses to acute psychological stress show considerable variations. (*J Clin Endocrinol Metab* **81:** 1956–1960 1996)

Stress versus strain

What is stress?

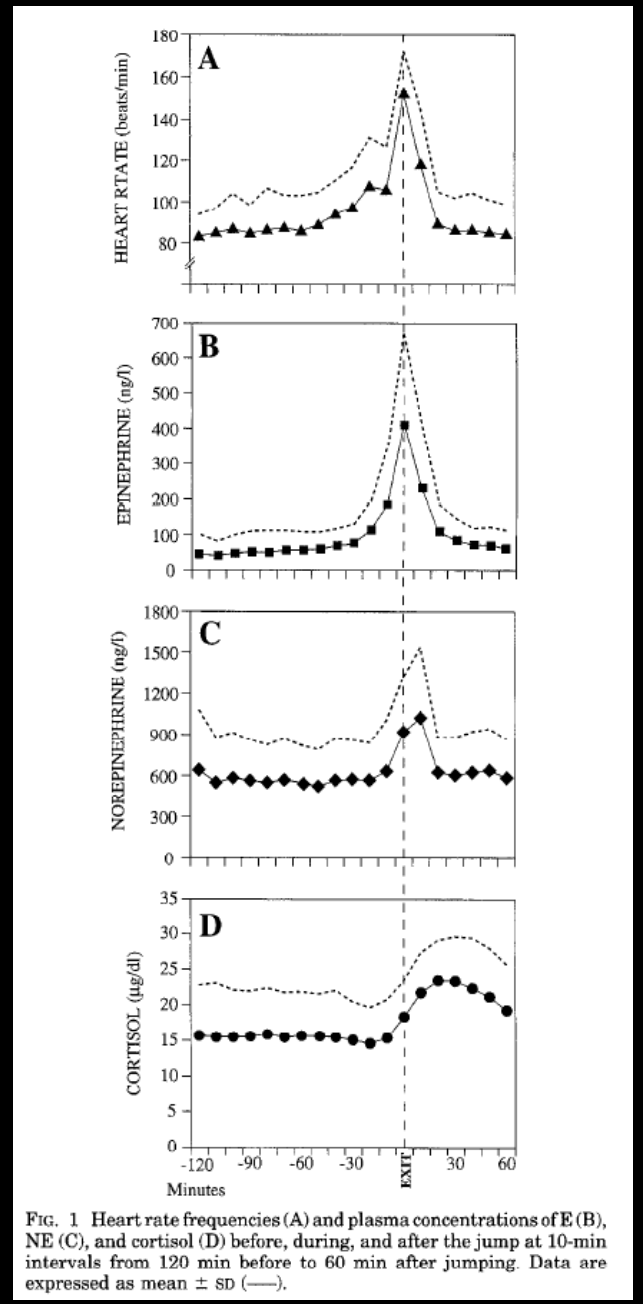


FIG. 1 Heart rate frequencies (A) and plasma concentrations of E (B), NE (C), and cortisol (D) before, during, and after the jump at 10-min intervals from 120 min before to 60 min after jumping. Data are expressed as mean ± SD (——).

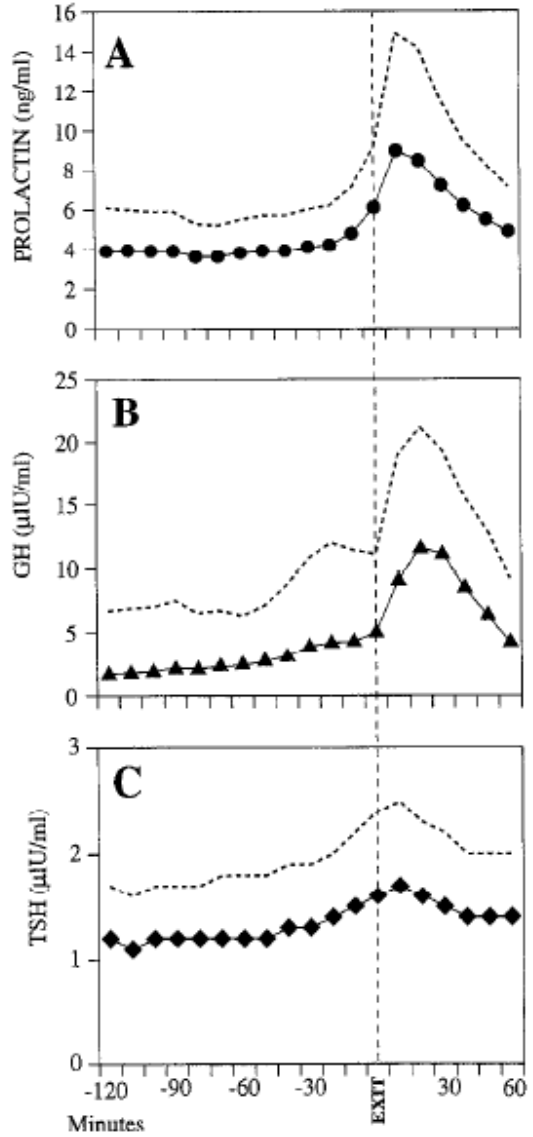
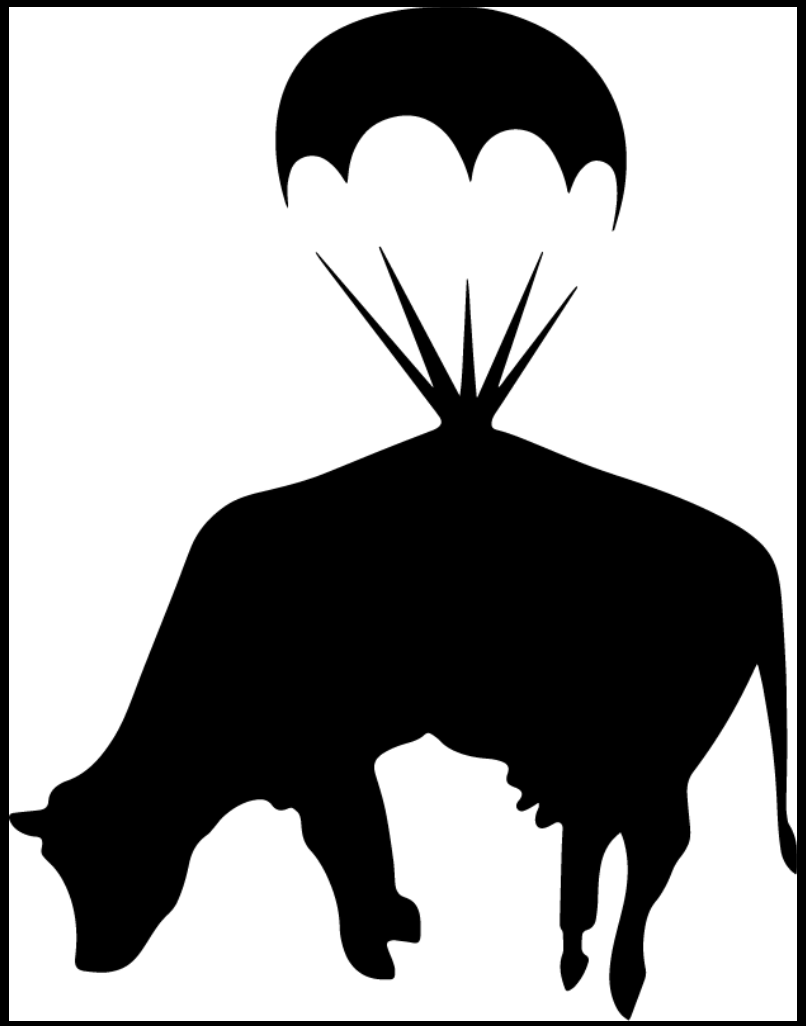


FIG. 2 Plasma concentrations of PRL (A), GH (B) and TSH (C) before, during, and after the jump at 10-min intervals from 120 min before to 60 min after jumping. Data are expressed as mean ± SD (——).

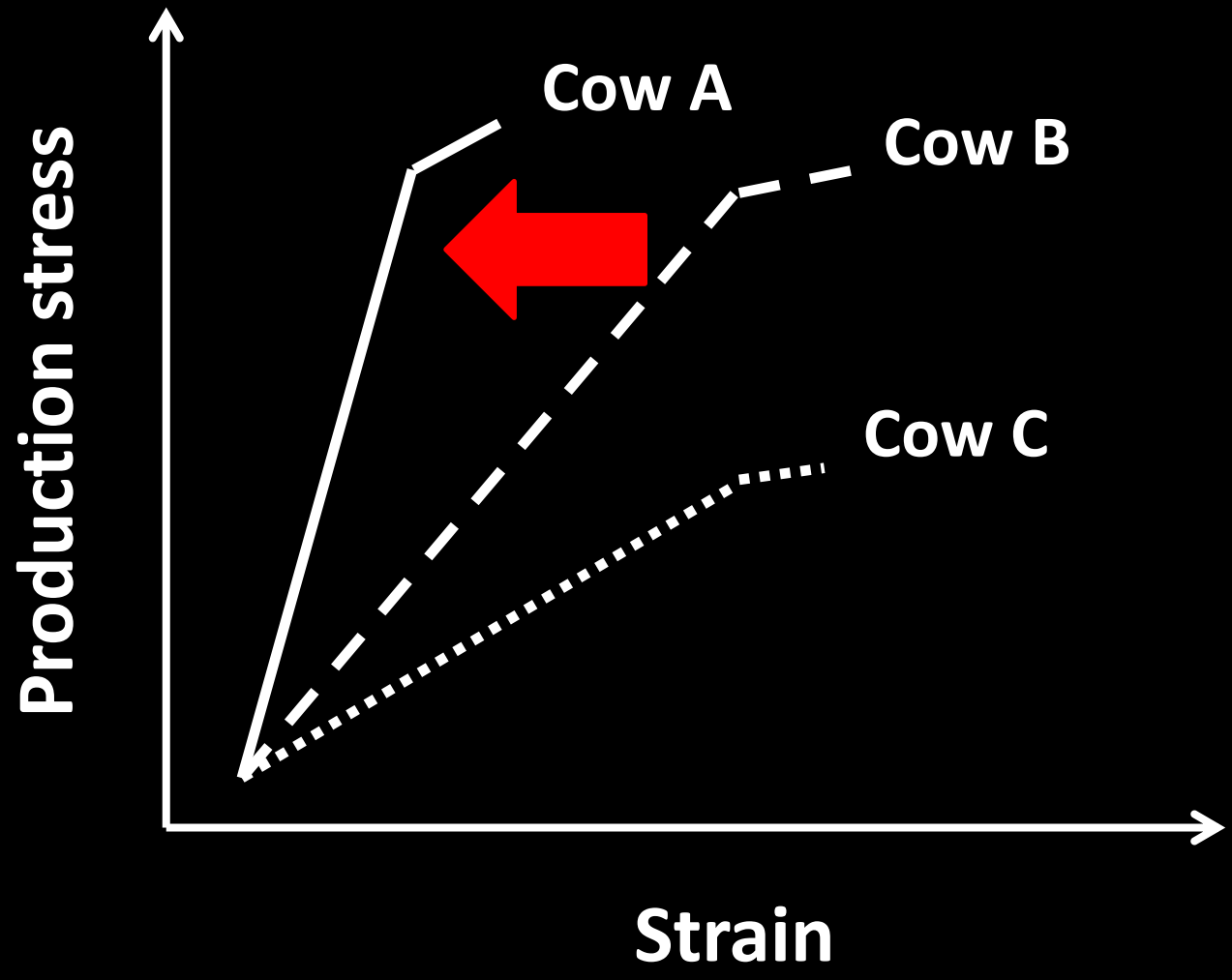
A "Resilient" cow is stressed but she shows little strain response to the stress.



Bansky image

Stress versus strain

Stress and Strain (Dairy Example)



Why are cows culled (examples of strain)?

Data from Dr. Scott Poock (University of Missouri Extension)

Reason for Cull	# of Culls
Mastitis	692
Lame	497
"Disease"	450
Reproductive	731
Poor Production	889
Died	653
Average herd Size	1066
Data from 40 herds	
Years: 2017-2021	

Stress and Strain

STRESSES	MEDIATORS OF STRESS ON THE WHOLE ANIMAL	STRAIN
Psychological • Pens and pen moves • Overcrowding • Time in headlocks	Activation of the HPA axis	Mastitis
Environmental Heat and humidity	Elevated body temperature	Lameness
Calving	Infection	“Disease”
Milk production	Inflammation	Low production
	Metabolic and hormonal imbalance	Infertility
	Immune dysfunction	Death

Lucy (2019) Anim Reprod 16(3):455–464

Stress and Strain

To reduce the strain, you need to either:

- Reduce the magnitude of the stress
- Manage the whole animal mediators of the stress

The extent to which we can do or want to do
this varies with the individual stressors

Stress ("easy" fixes)

STRESSES	MEDIATORS OF STRESS ON THE WHOLE ANIMAL	STRAIN
Psychological • Pens and pen moves • Overcrowding • Time in headlocks	Activation of the HPA axis	Mastitis
Environmental Heat and humidity	Elevated body temperature	Lameness
		"Disease"
		Low production
		Infertility
		Death

Lucy (2019) Anim Reprod 16(3):455–464

Stress (less "easy" fixes)

STRESSES	MEDIATORS OF STRESS ON THE WHOLE ANIMAL	STRAIN
Psychological • Pens and pen moves • Overcrowding • Time in headlocks	Activation of the HPA axis	Mastitis
Environmental Heat and humidity	Elevated body temperature	Lameness
Calving	Infection	"Disease"
	Inflammation	Low production
		Infertility
		Death

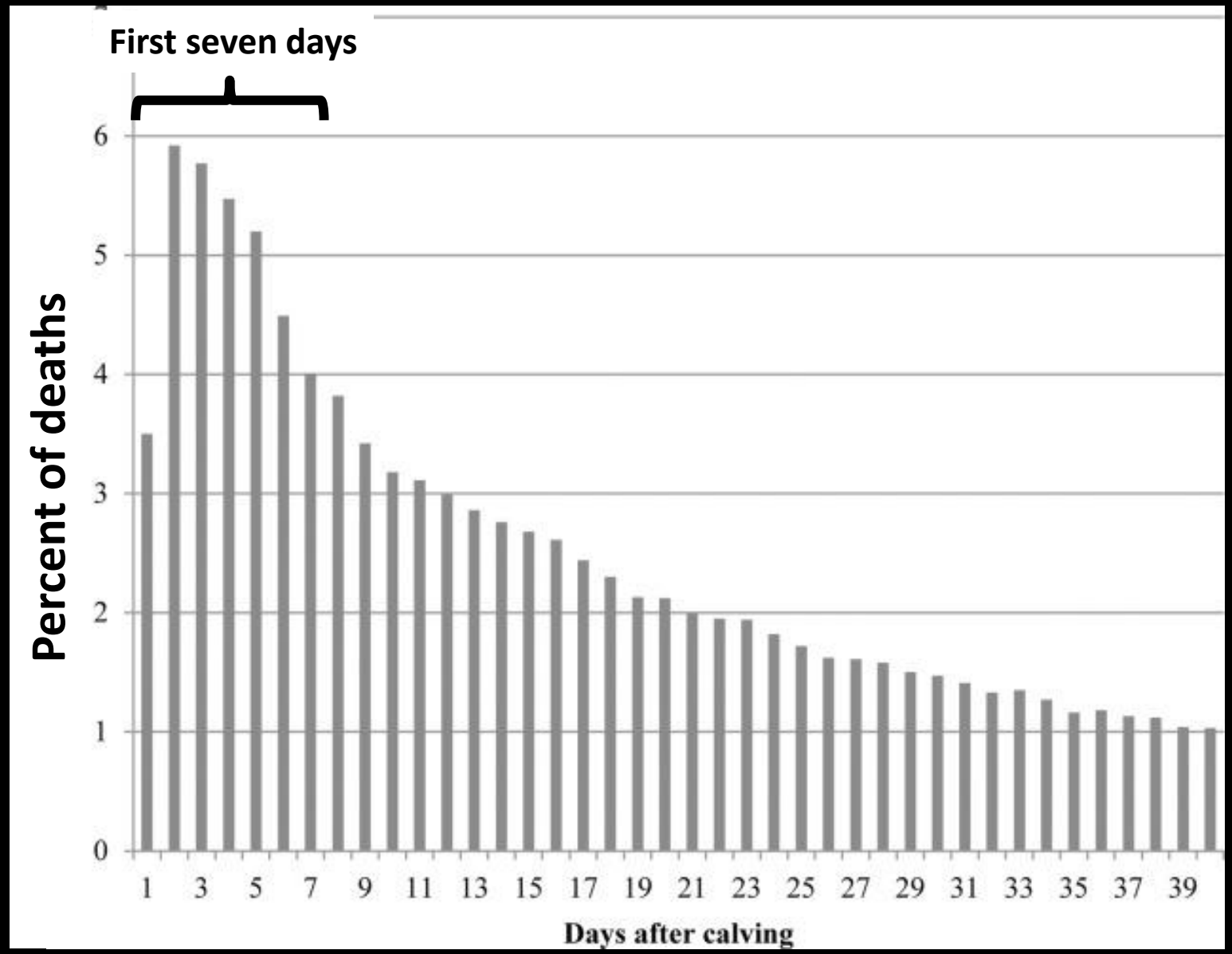
Lucy (2019) Anim Reprod 16(3):455–464

When do cows die on a dairy farm?

Overall, expect 5% annual death rate on farm.

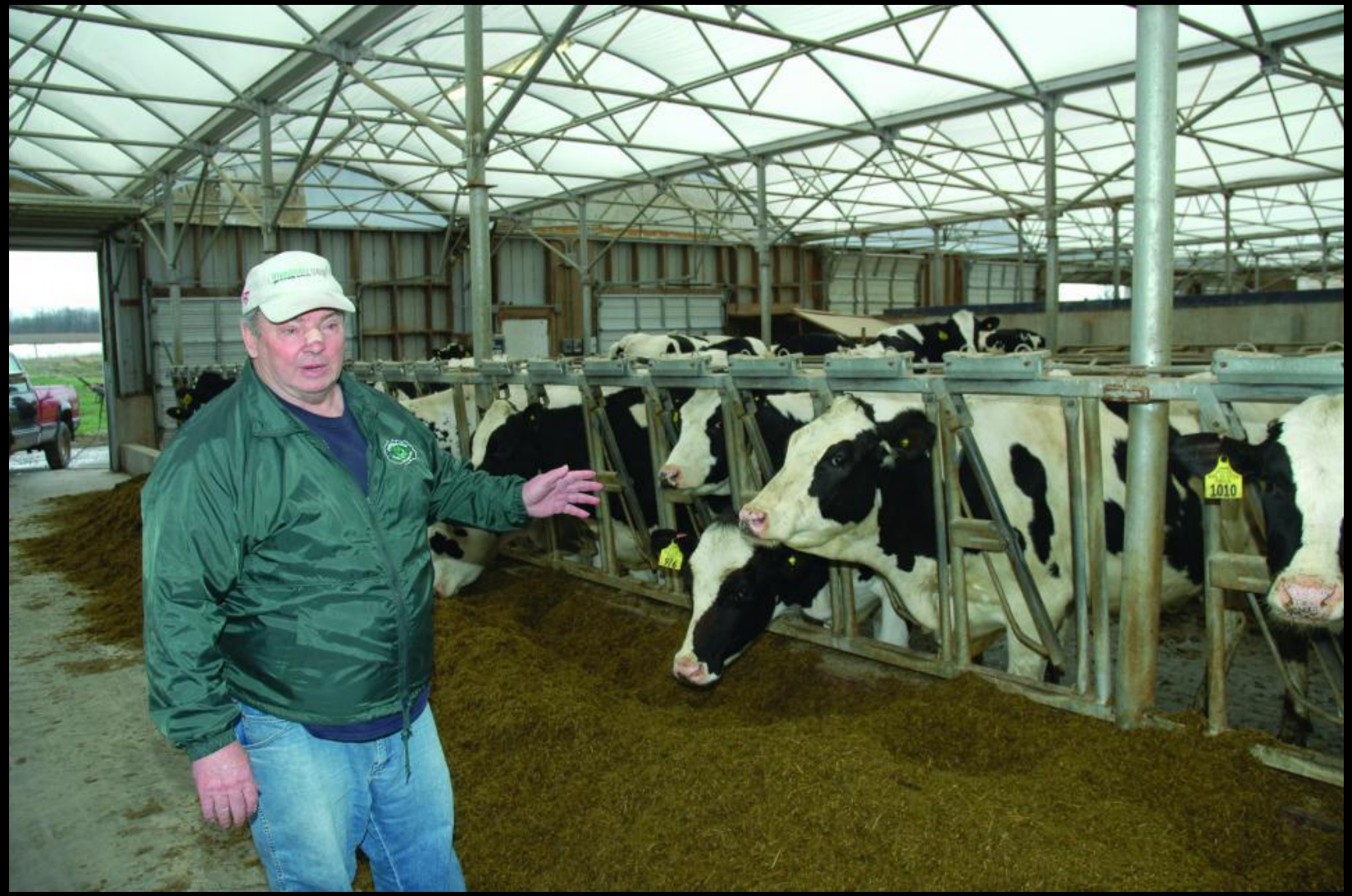
Most cows die within the first month of lactation.

Many cows die during week 1.



Shahid et al. (2015) J. Dairy Sci.

“The two worst days in a cow’s life is the day she calves and the day you dry her off”



Tom Kestell, Ever-Green Holsteins
Dairy Herd Management Photo

Reducing the "stress" at calving (some examples)

- Managing BCS during late lactation and in the dry cow pen
- Feeding diets that reduce the risk of postpartum hypocalcemia
- Using X-sorted semen and calving ease sires

Do everything possible to reduce the incidence of postpartum disease, particularly metritis and endometritis, after calving

A clean environment is important and should reduce the incidence of metritis.

Photo: Drost Project

The deathrate from "childbed fever" was 18% in women before doctors recognized that they should wash their hands before delivering babies.

1850's Vienna

Nature (2023): 620:269

Science in culture

Books & arts

Medical drama shines spotlight on antisepsis pioneer

Pride and tragedy stymied ideas about how infections spread, suggests a show about nineteenth-century doctor Ignaz Semmelweis. **By Georgina Ferry**

How do great scientific discoveries make it into the mainstream, and who gets credit? A play now showing in London tells the story of the Hungarian physician and obstetrician Ignaz Semmelweis, who in the mid-nineteenth century radically reduced rates of death in childbirth at Vienna General Hospital – the largest hospital in Europe at the time. His practice – a strict hand-washing regime for doctors and nurses – was remarkably effective. Yet his ideas were rejected. Unlike French chemist Louis Pasteur, British surgeon Joseph Lister and German physician Robert Koch, who made their discoveries between the 1860s and 1880s, he is barely given a footnote in the history of antiseptic procedures and the germ theory of disease.

Why did his ideas fail to catch on? That question is at the core of *Dr Semmelweis*, a fascinating play produced by the UK National Theatre, and created by the writer Stephen Brown with the actor Mark Rylance, who plays Semmelweis. They powerfully capture the personal

SIMON ANNAND

Dr Ignaz Semmelweis (Mark Rylance) and Ferdinand von Hebra (Felix Hayes).

Cleanliness is critical but some stress at calving is difficult or beyond our control (for now)

- Inflammation
- Effect of parity
- Where do the “bad guys” really come from?

Systemic inflammation

Bradford et al. (2015) J. Dairy Sci. 98:6631-6650

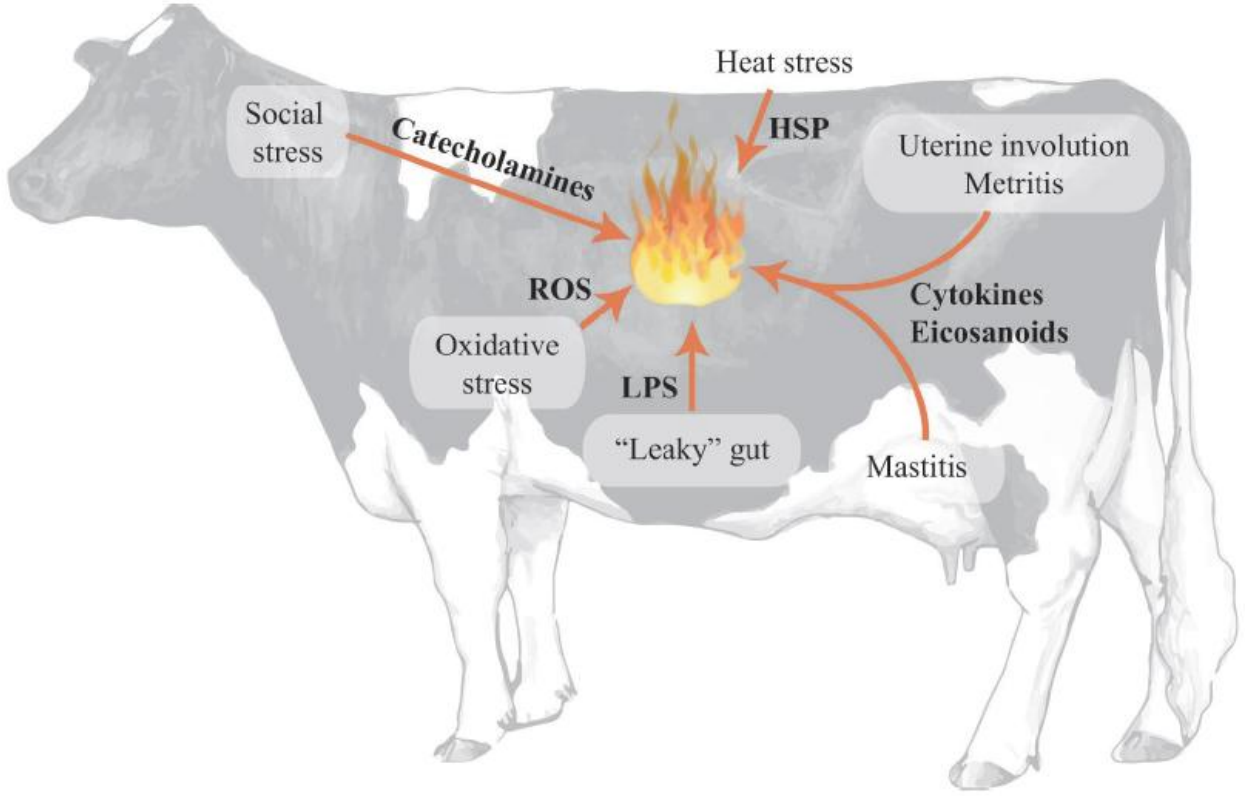
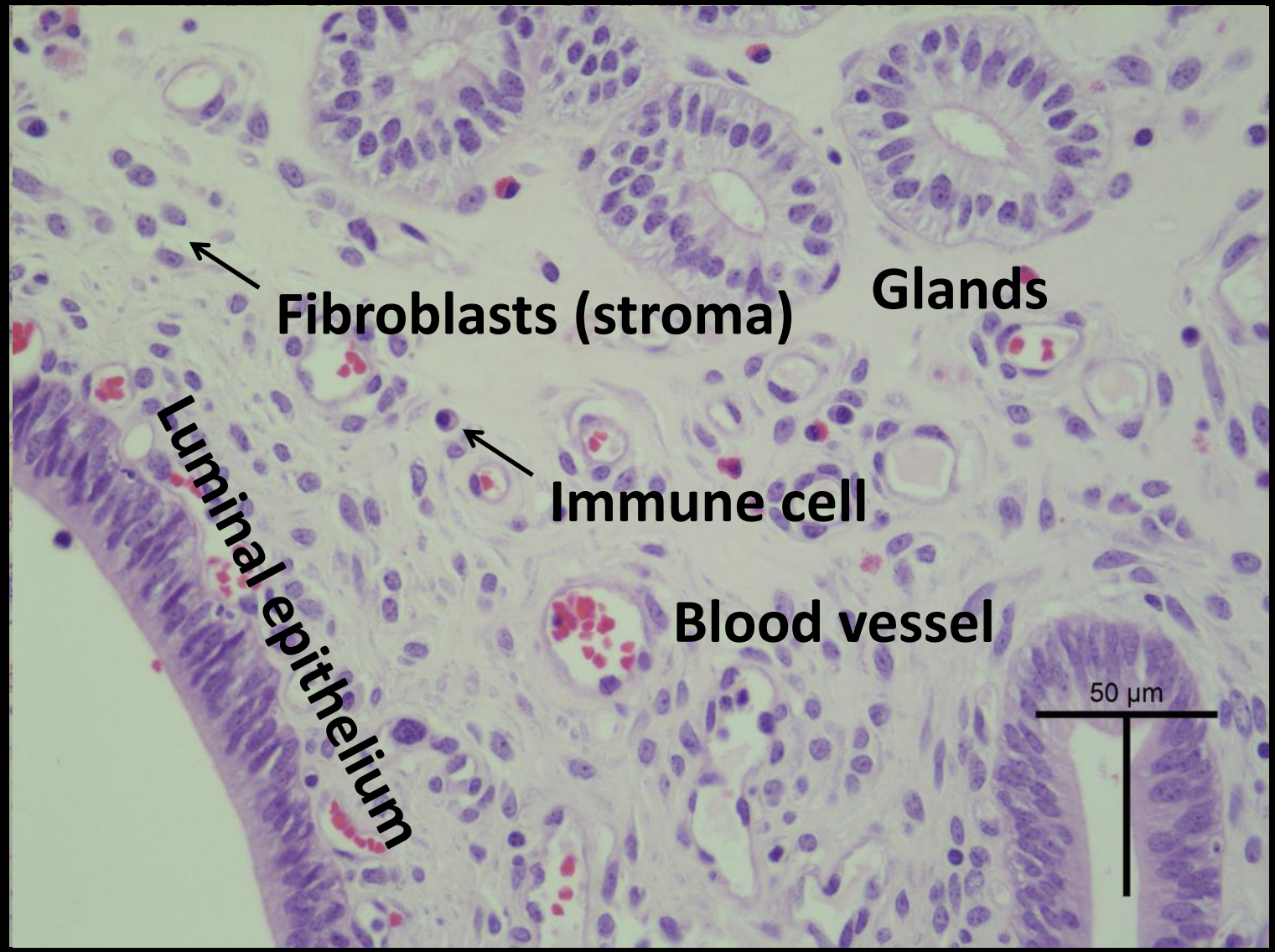


Figure 2. Diverse stressors may contribute to systemic inflammation. The wide variety of signals that converge to drive inflammatory processes (Figure 1) is derived from a broad list of systemic stressors. Social stress and heat stress can promote inflammatory transcription patterns via autonomic catecholamine release and bloodborne heat shock proteins (HSP), respectively. Tissue damage associated with parturition and subsequent uterine involution, as well as infections such as metritis and mastitis, result in leukocyte activation and release of inflammatory cytokines and eicosanoids. Various dietary and environmental conditions can decrease barrier function of the gut, allowing translocation of LPS into the bloodstream. Excess circulating lipids and low antioxidant status are associated with oxidative stress, which occurs when free radicals cause chain reactions, thus producing reactive oxygen species (ROS) that promote inflammation. Color version available online.

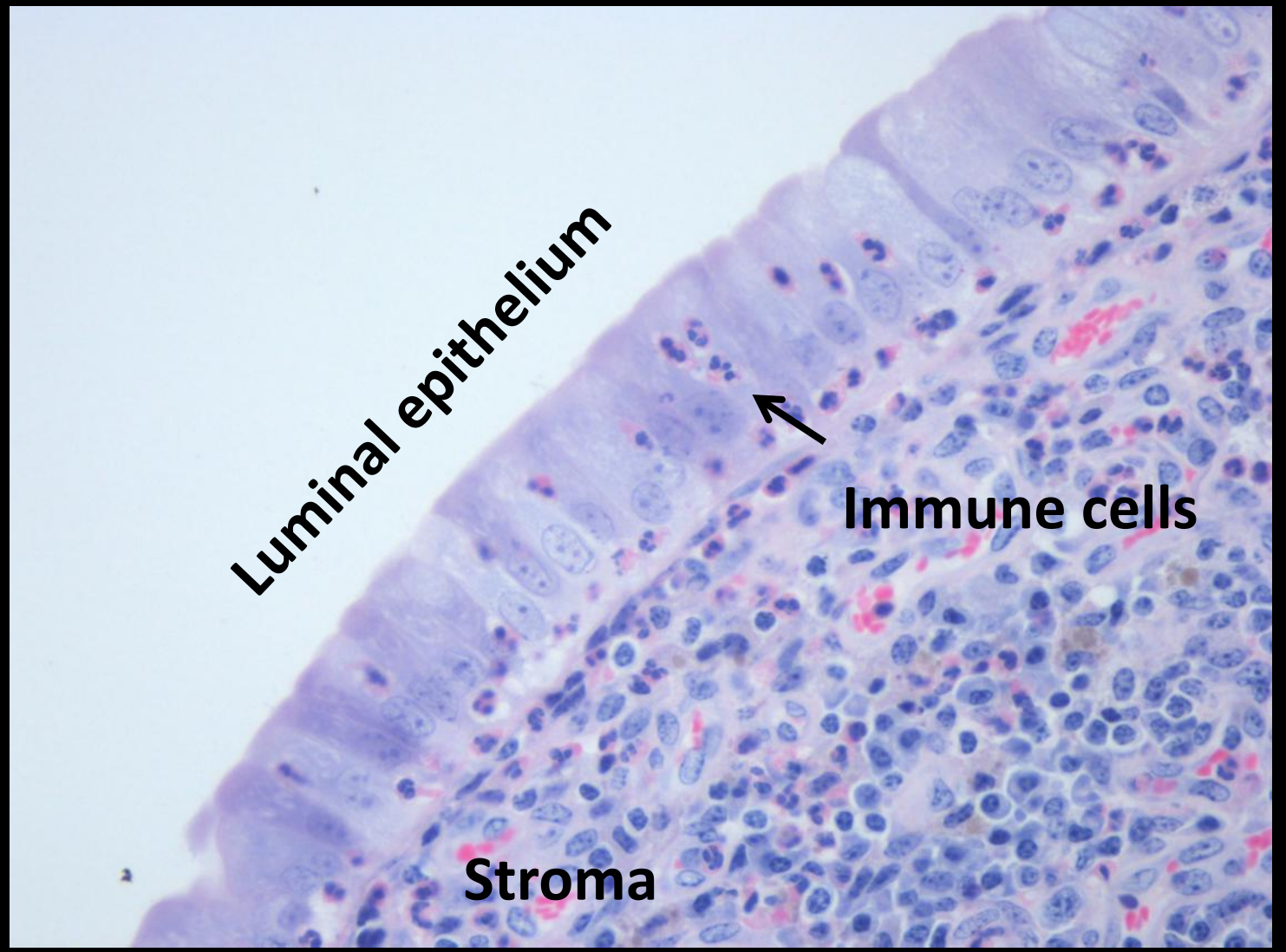
Journal of Dairy Science Vol. 98 No. 10, 2015

Endometrium and luminal epithelium - heifer



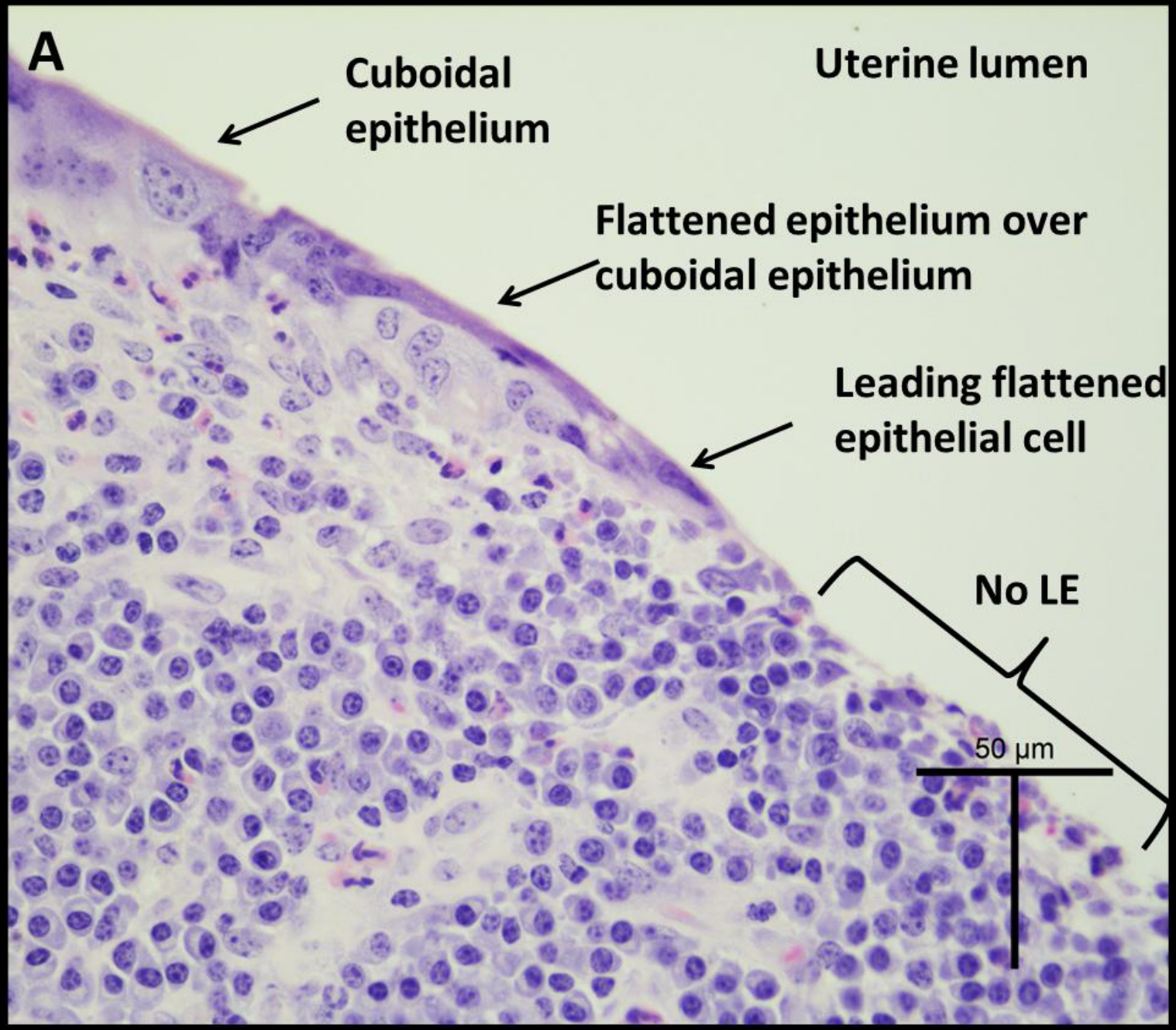
Lucy and Waldron (unpublished photo)

Luminal Epithelium of the bovine uterus at 25 dpp



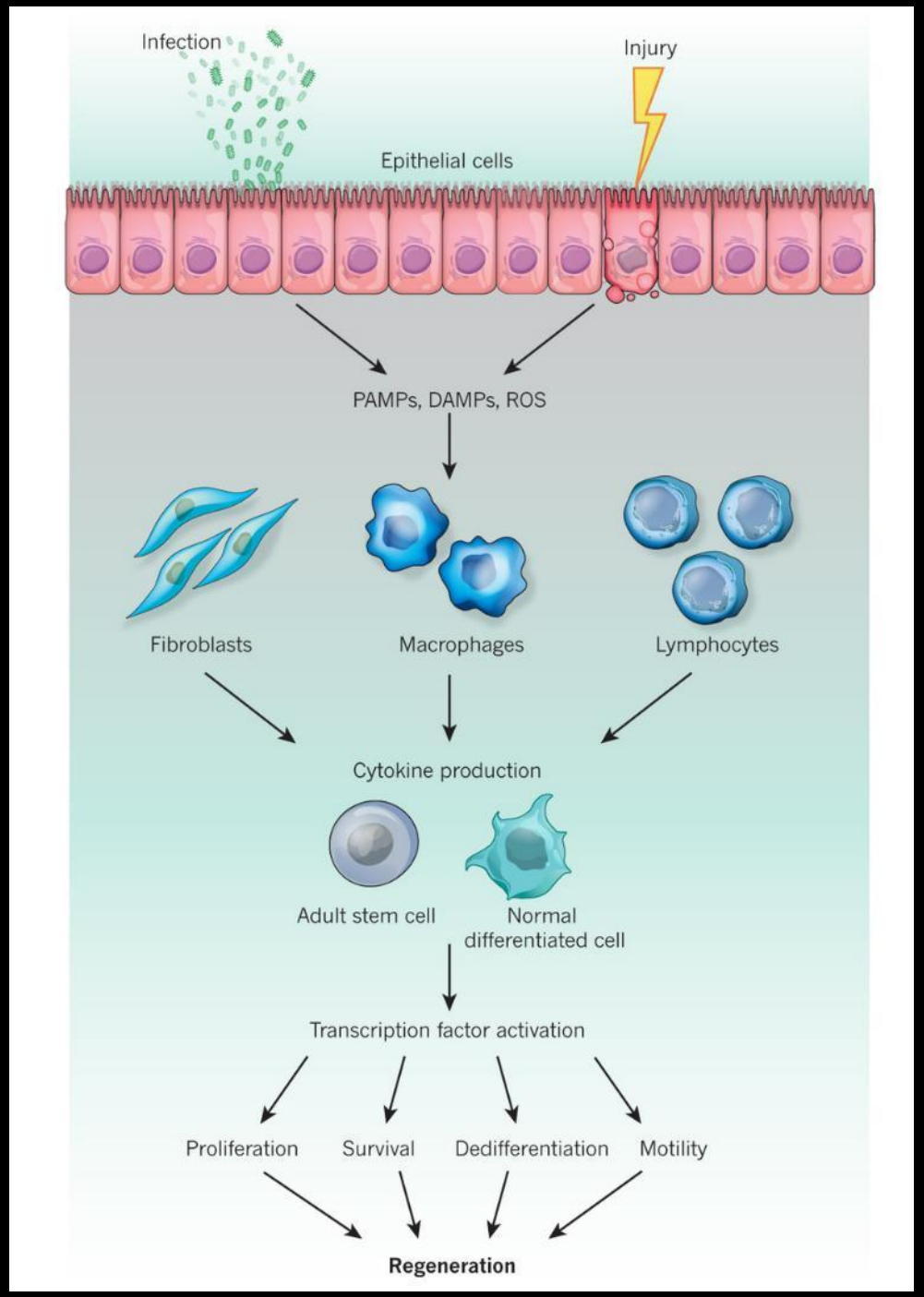
Lucy and Waldron (unpublished photo)

What is endometritis (inflammation in the uterus)



Reparative inflammation and tissue regeneration

Michael Karin and Hans Clevers
Nature 2016; 529:307-315



Inflammation

Resolution of inflammation

Bradford et al. (2015) J. Dairy Sci. 98:6631-6650

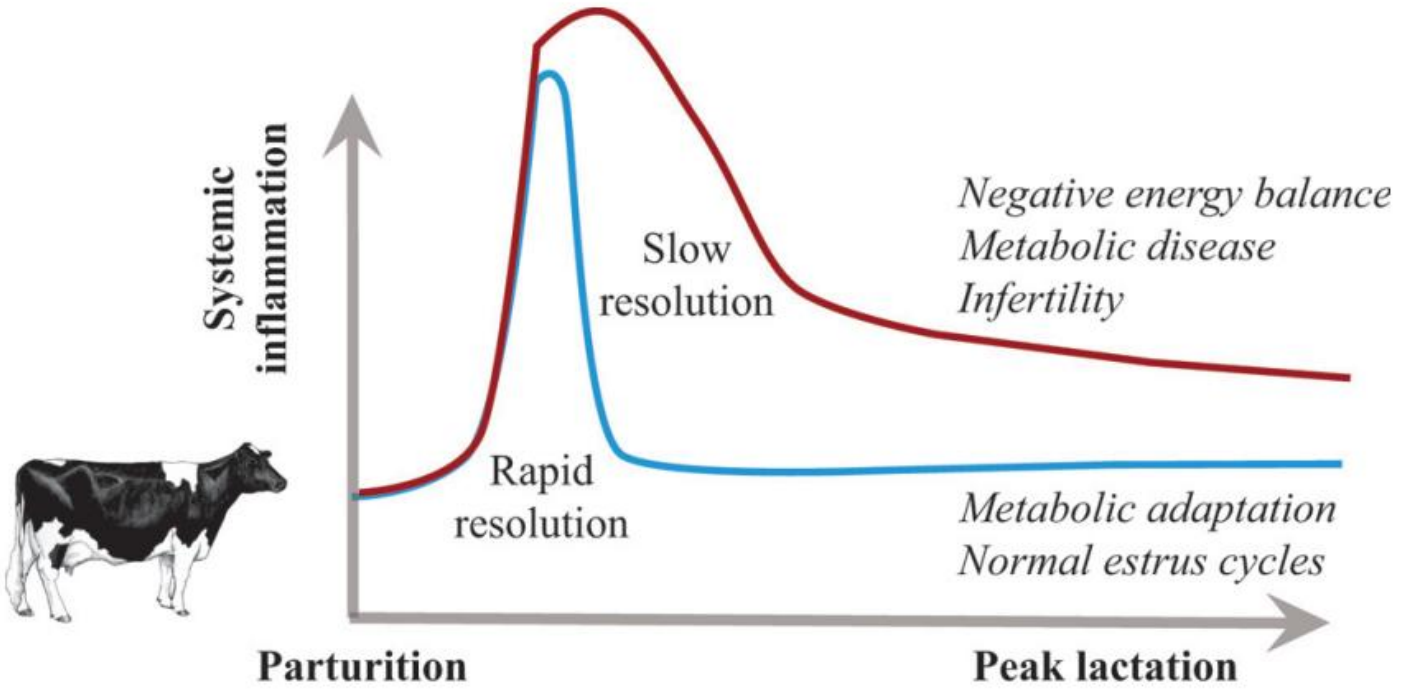


Figure 4. Hypothesized responses to resolved and unresolved inflammation in early-lactation dairy cows. Visualization of typical time courses of slowly resolved or quickly resolved inflammation, along with proposed production outcomes resulting from these different profiles.

Inflammatory memory

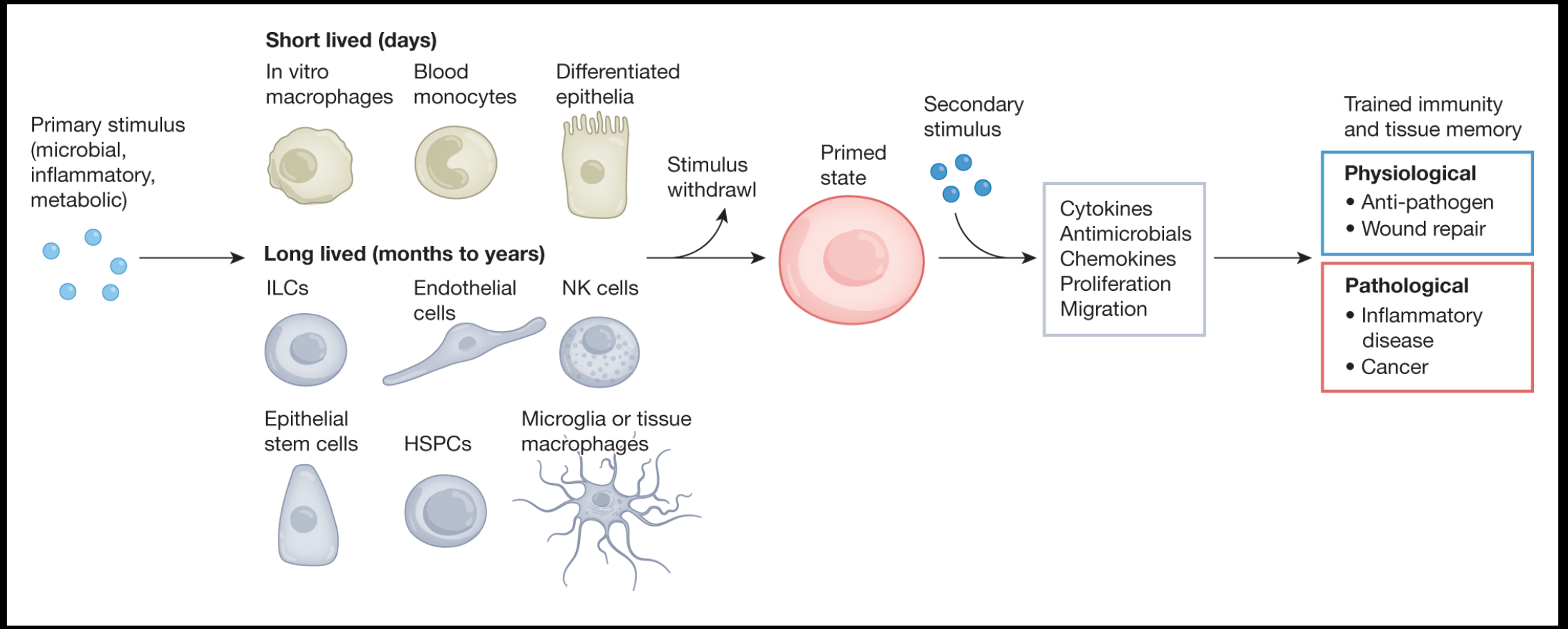


Figure 1 from: Naik, S., Fuchs, E. Inflammatory memory and tissue adaptation in sickness and in health. *Nature* 607, 249–255 (2022).

Inflammatory memory

Cell
Leading Edge
CellPress

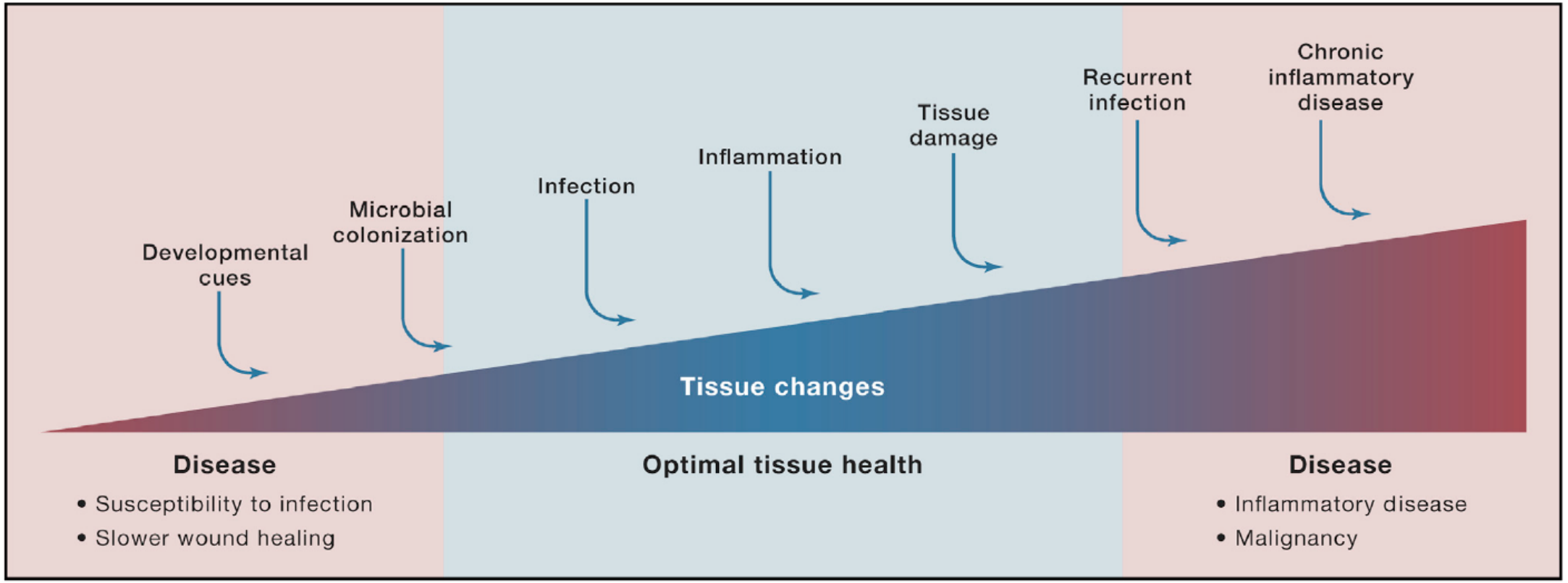


Figure 3. A spectrum of tissue adaptation

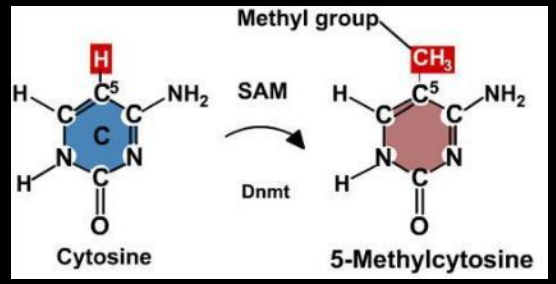
Cells within barrier epithelial tissues experience diverse exposures to inflammatory stimuli over a lifetime. Whether memories or adaptations might accumulate is a fascinating possibility as yet unexplored. In a model where they do so, tissue adaptation would be expected to occur on a spectrum represented by the red and blue triangle. In this model, a paucity of normal developmental cues and inflammatory exposures might render tissues vulnerable to infection or poor tissue recovery following injury. By contrast, when a tissue is perpetually exposed to excessive inflammatory signals, this may drive chronic inflammation and cancer via accumulation of tissue "memories."

Epigenetic Regulation

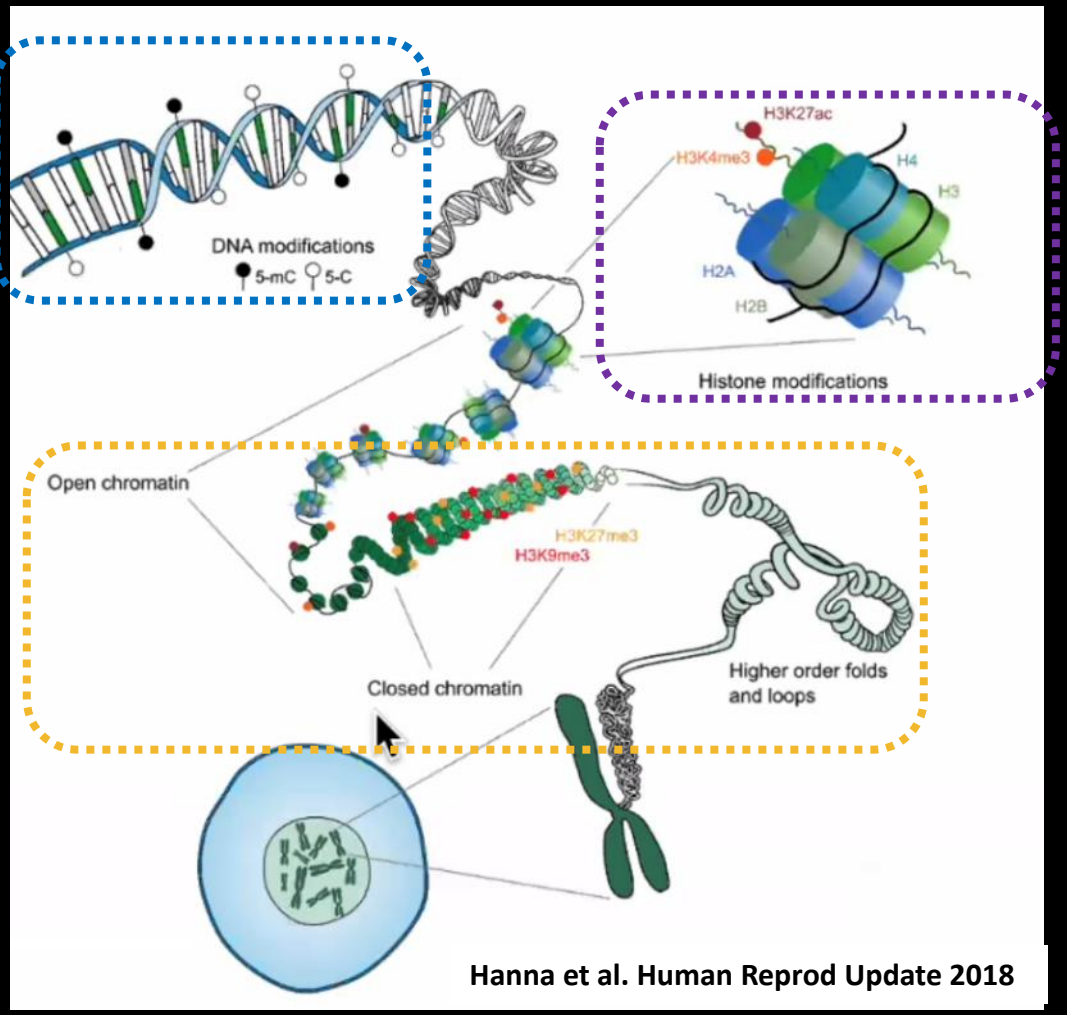
DNA Modifications

Hydroxy-methylation

Methylation



Primarily happens at CpG sites



Histone Modifications

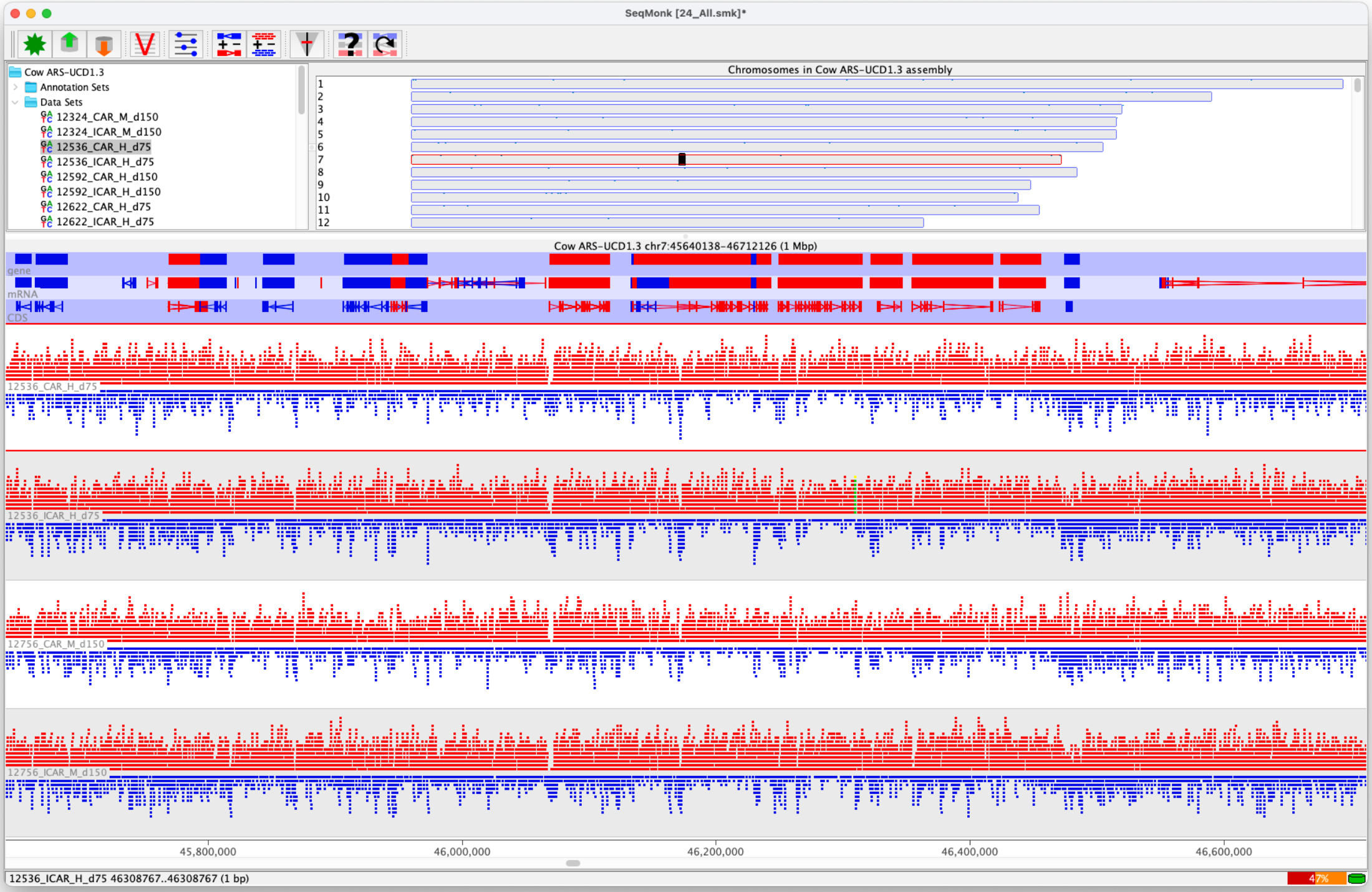
Histone Methylation

Acetylation

Phosphorylation

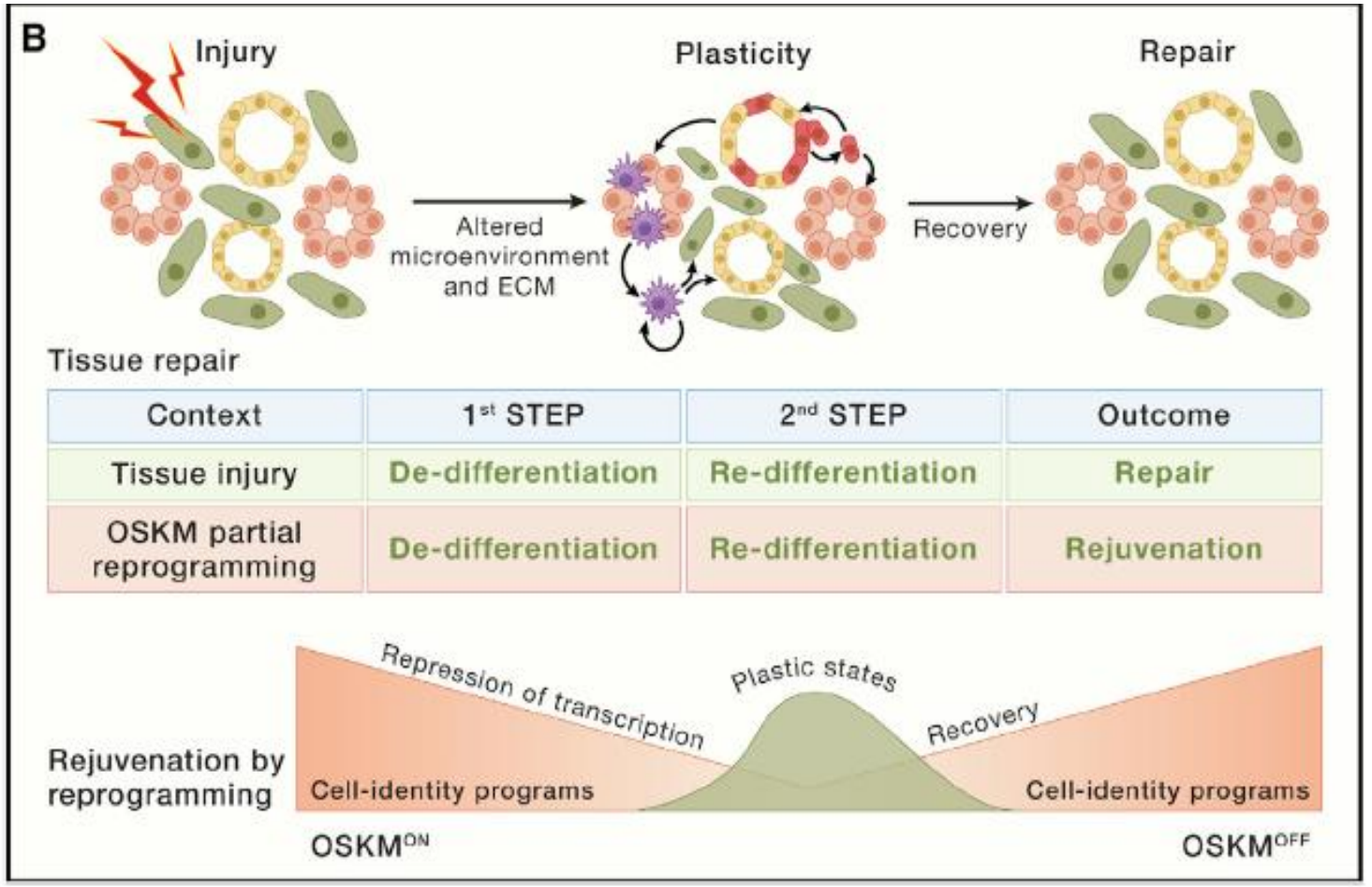
Chromatin Remodeling

Current research - Cellular memory



Partial reprogramming repairs and rejuvenates damaged tissues.

Cell
Review



Experimental studies for induction of metritis

- **Primiparous cows: (Silva et al. Animals (Basel). 2023 Sep 8;13(18):2852)**
  - 36 cows -> no predisposing factors (RP, still birth, twins)
  - Challenge administered within 24h of parturition;
    - **Control:** Sterile saline solution;
    - **Dose:** 10^6 CFU each of *E. coli, T. pyogenes*, and *F. necrophorum*;

- **Multiparous cows: (Silva et al. J Dairy Sci. 2023 Jan;106(1):607-623)**
  - 36 cows -> no predisposing factors (RP, still birth, twins)
  - Challenge administered within 24h of parturition;
    - **Control:** Sterile saline solution;
    - **Dose:** 10^6 CFU each of *E. coli*, *T. pyogenes,* and *F. necrophorum.*

Silva and Lucy (2025) *JDS Communications* 6:362-367.

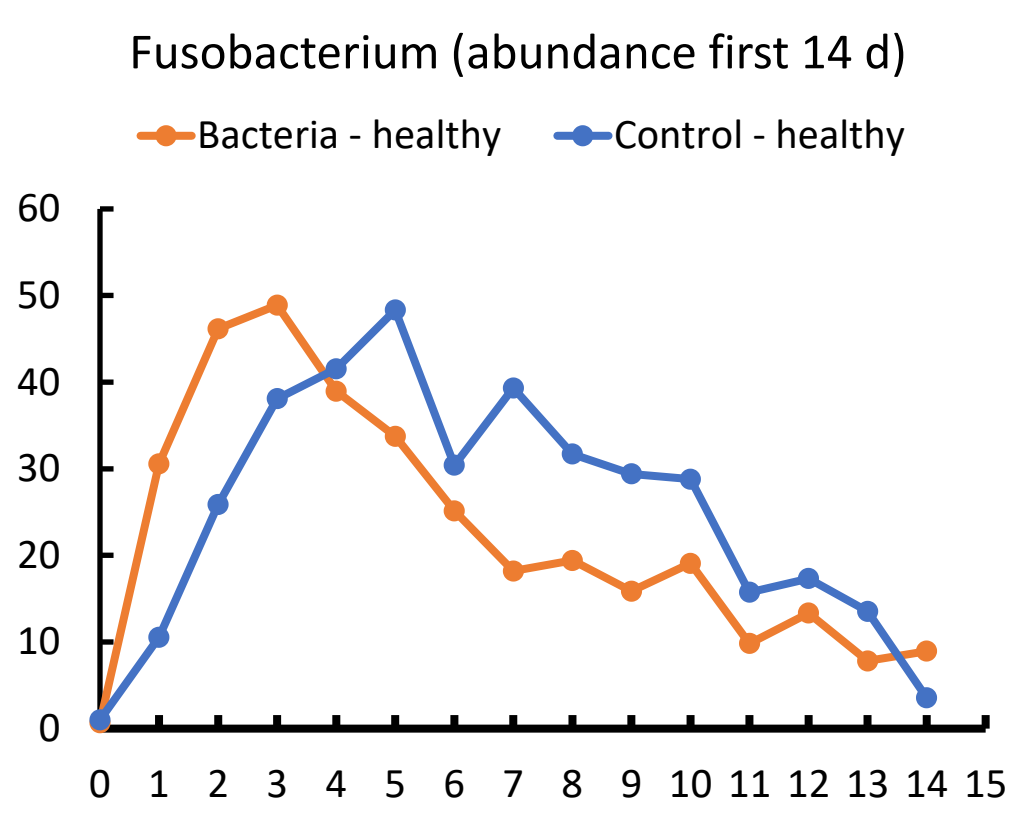
Resolution of infection

First calf heifers vs. older cows

First calf heifers that stayed healthy

Bacterial challenge: 4 out of 11

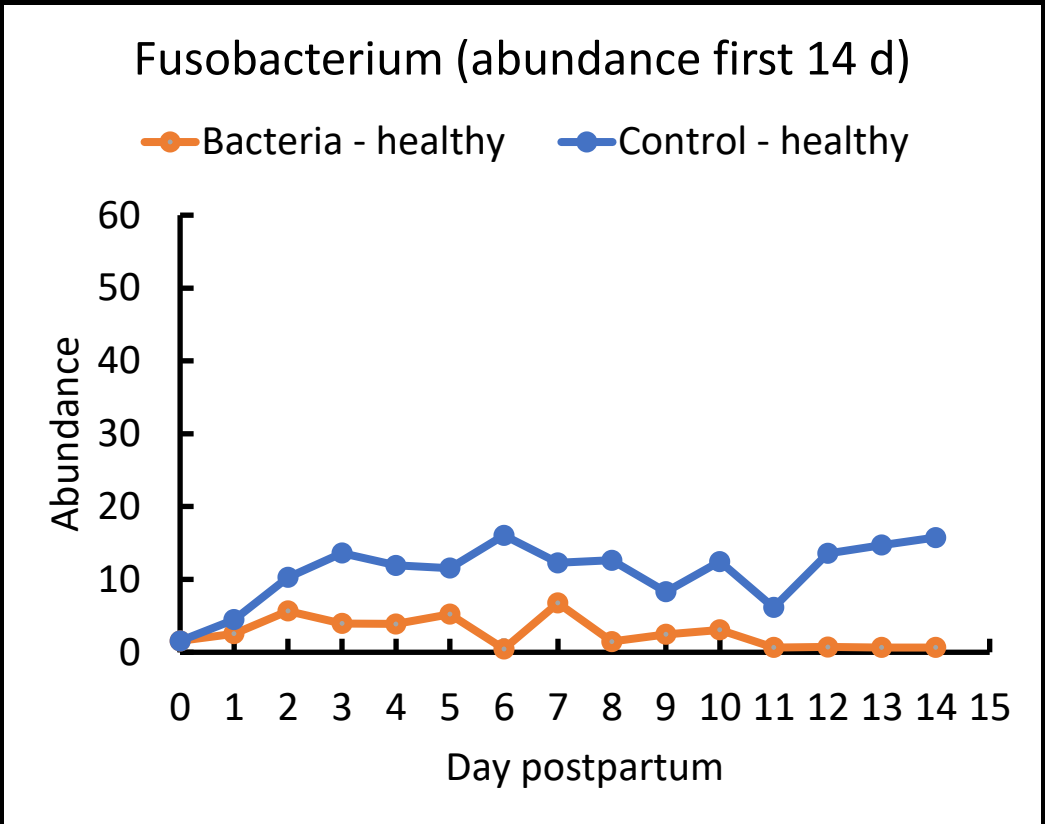
Control: 8 out of 12



Older cows that stayed healthy

Bacterial challenge: 2 out of 12

Control: 11 out of 12



Silva and Lucy (2025) *JDS Communications* 6:362-367.

We are living in interesting times

Aging and lifespan in dairy cows

The 13-year-old Registered Holstein cow is in her tenth lactation and broke the record with her lifetime milk production record of 478,200 pounds of milk, 14,447 pounds of fat, and 12,576 pounds of protein. Chrome-View Charles 3044, owned by Mason's Chrome View farm in Nottingham, PA.

Where do the "bad-guys" come from?

The microbiome of the pregnant uterus in Holstein dairy heifers and cows assessed by bacterial culture and 16S ribosomal RNA gene sequencing

Joao G. N. Moraes[1], Tamara Gull[2], Aaron C. Ericsson[2], Scott E. Poock[2], Monica O. Caldeira[3] and Matthew C. Lucy[3]*

[1]Department of Animal and Food Sciences, Oklahoma State University, Stillwater, OK, United States, [2]College of Veterinary Medicine, University of Missouri, Columbia, MO, United States, [3]Division of Animal Sciences, University of Missouri, Columbia, MO, United States

Conclusion: There are a small number of viable bacteria in the pregnant uterus. The 16S rRNA gene sequencing detected a microbial community within the pregnant uterus but with a low biomass. These results are consistent with recent studies of the pregnant bovine uterus and leave open the question of whether there is adequate microbial mass to significantly affect the biology of the normal healthy bovine pregnancy.

Moraes et al. (2024) *Frontiers in Microbiology* May 15, 2024

AMERICAN SOCIETY FOR MICROBIOLOGY | Microbiology Spectrum

Check for updates

| Open Peer Review | Microbial Ecology | Research Article

Characterizing the prevalence of *Fusobacterium necrophorum* subsp. *necrophorum*, *Fusobacterium necrophorum* subsp. *funduliforme*, and *Fusobacterium varium* in bovine and ovine semen, bovine gut, and vagino-uterine and fetal microbiota using targeted culturing and qPCR

Justine Kilama,[1] Carl R. Dahlen,[2] Mina Abbasi,[3] Xiaorong Shi,[3] T. G. Nagaraja,[3] Matthew S. Crouse,[4] Robert A. Cushman,[4] Alexandria P. Snider,[4] Kacie L. McCarthy,[5] Joel S. Caton,[2] Samat Amat[1]

Conclusions

Among the *Fusobacterium* spp. screened, FNF was the most prevalent subspecies, particularly in bull semen and bovine maternal ruminal fluids. The second most frequently identified *Fusobacterium* spp. across screened different samples were FNN. All three *Fusobacterium* spp. were present in bull semen, vaginal, and uterine samples.

Kilama et al. (2025) *Microbiology Spectrum* 13:1-21.

Bacteria found in liver abscesses are also those found in cows with metritis and are believed to come from the rumen.

"Of the predominant OTU (top 10 as a % of reads), three OTU (*Fusobacteria necrophorum*, *Bacteroides* spp., and *Trueperella pyogenes*) were shared across both abscessed and non-abscessed livers. *Fusobacterium necrophorum* was the dominant OTU regardless of liver score, and the single most abundant OTU, even among non-abscessed livers."

Stotz et al. (2021) J. Anim. Sci. 99(10):1-11.

DAIRY HERD / NEWS / EDUCATION

Researchers Zero in on Liver Abscesses for Beef-on-Dairy

Liver abscesses remain a singular, dark cloud over the otherwise sunny segment of dairy-beef-cross cattle. Several entities are performing research to try to solve this frustrating industry obstacle.

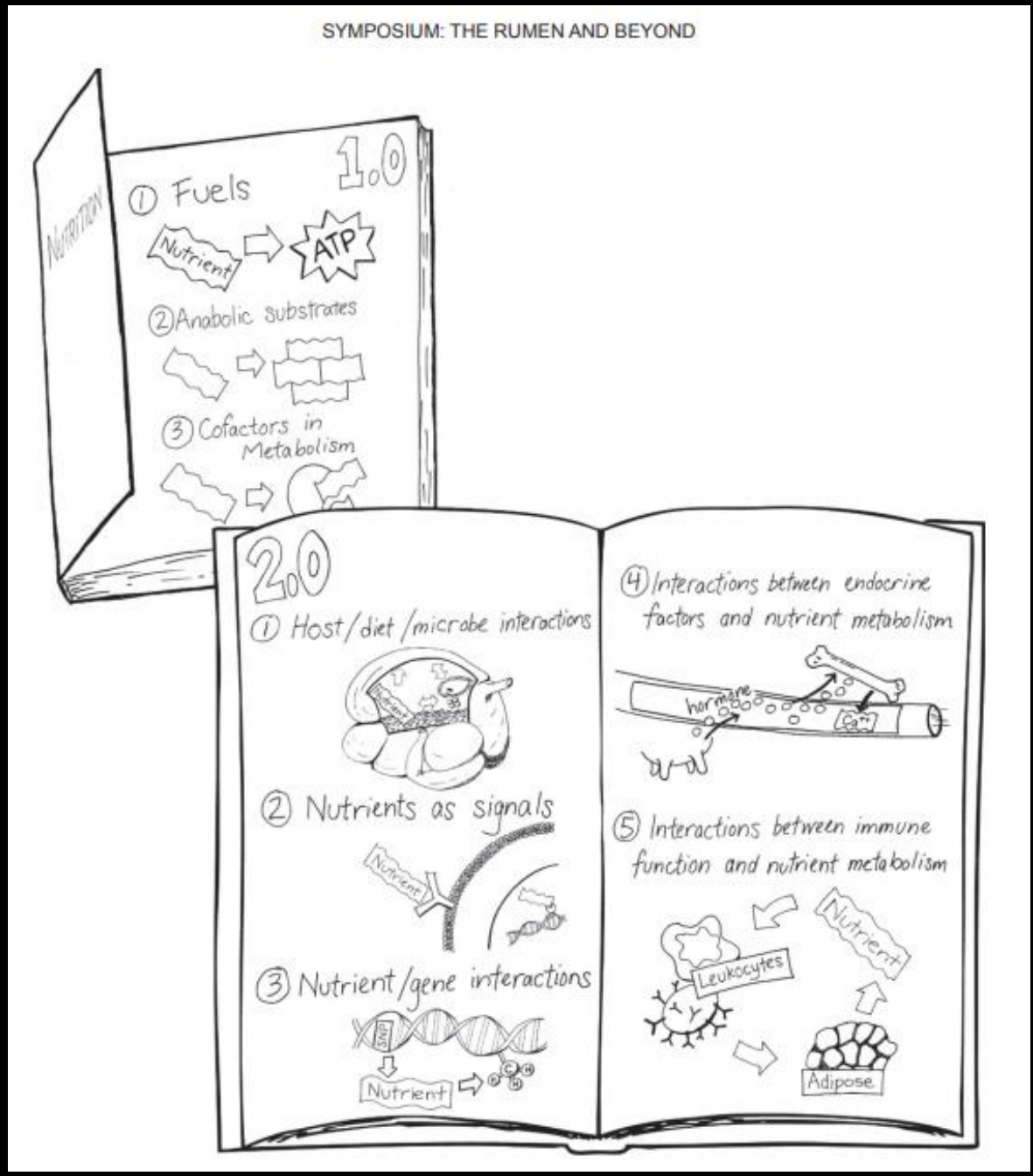
By **Maureen Hanson**
Updated April 09, 2024 07:00 AM

Feedlot Beef-on-Dairy (Adobe Stock)

Nutrition 2.0

Barry Bradford
Michigan State University

- Control inflammation
- Support immune function
- Slow down the aging process



Bradford et al. (2016)
J. Dairy Sci. 99:4983–4996

Stress and Strain

STRESSES	MEDIATORS OF STRESS ON THE WHOLE ANIMAL	STRAIN
Psychological • Pens and pen moves • Overcrowding • Time in headlocks	Activation of the HPA axis	Mastitis
Environmental Heat and humidity	Elevated body temperature	Lameness
Calving	Infection	“Disease”
Milk production	Inflammation	Low production
	Metabolic and hormonal imbalance	Infertility
	Immune dysfunction	Death

Lucy (2019) Anim Reprod 16(3):455–464

Holstein Record!

Selz-Pralle Aftershock 3918

Selz-Pralle Dairy

Humbird, WI

How many lbs of milk per day at peak ?

~114 kg or 250 lbs

How much glucose per day does Selz-Pralle Aftershock 3918 require?

72 g of glucose to produce 1 kg milk

Approximately 115 kg milk per day at peak

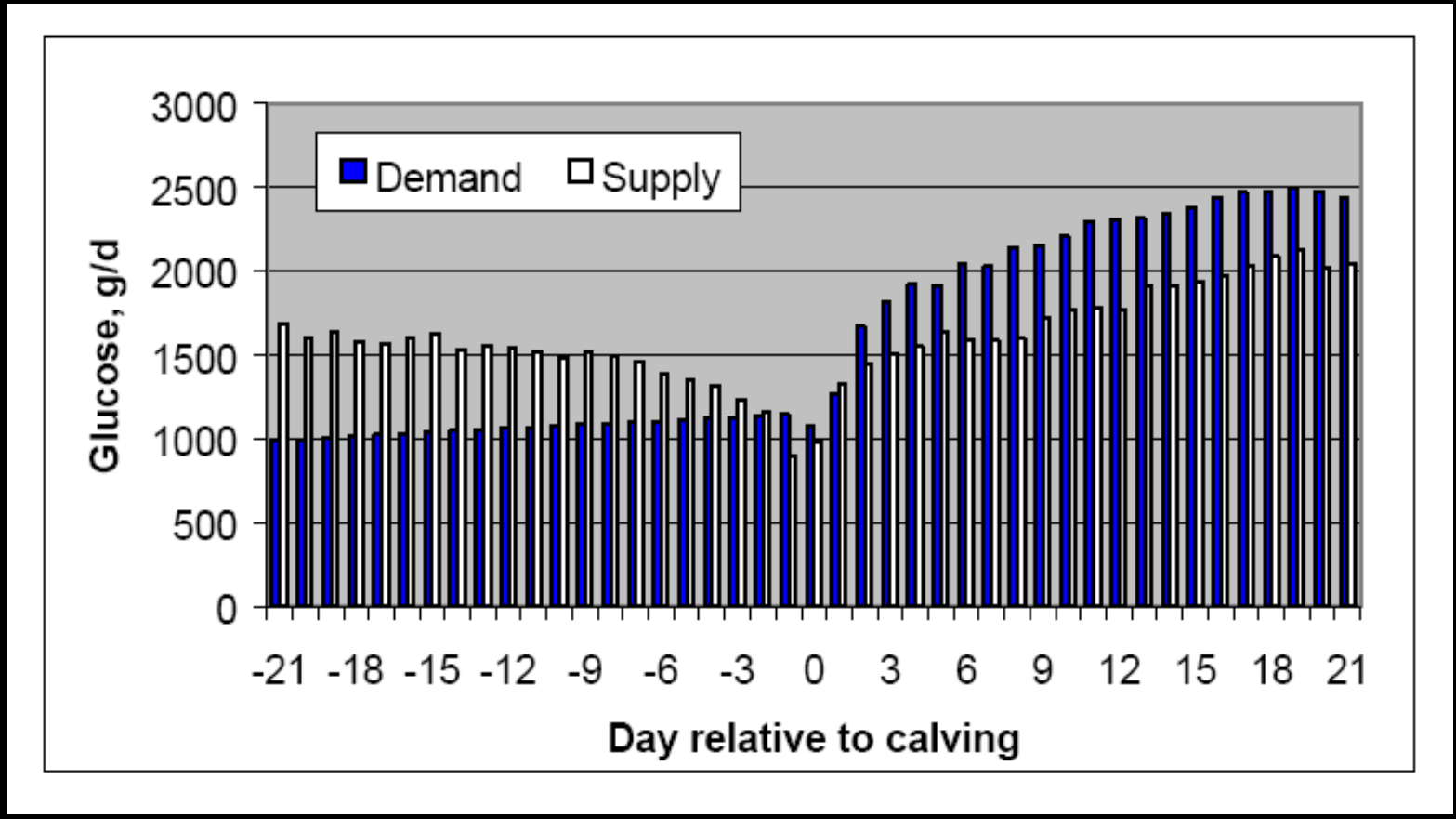
8.3 kg glucose per day

And if she gets a case of metritis or mastitis?

The acutely activated immune system consumes >2 kg of glucose in one day

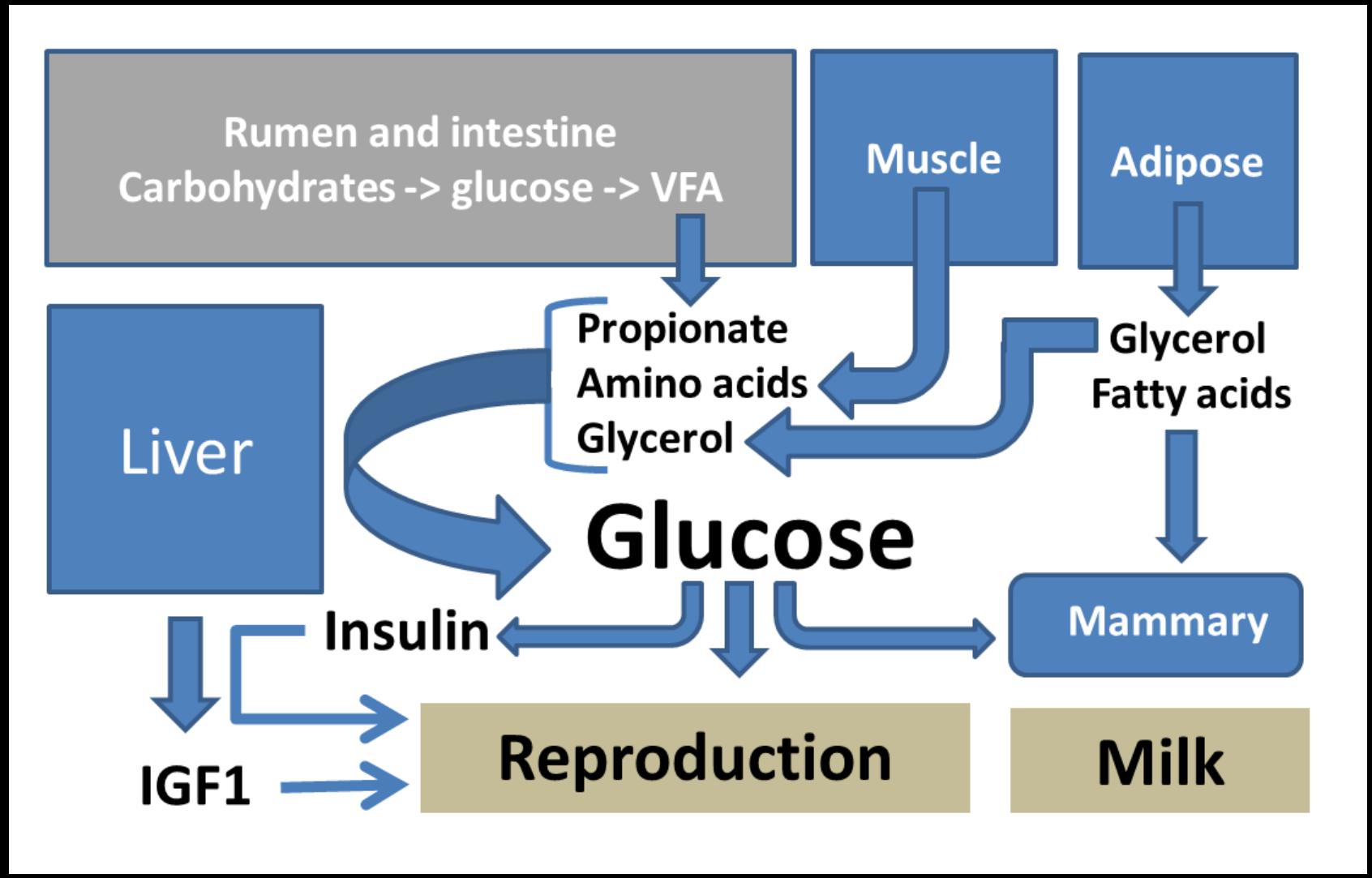
Kvidera et al. (2017)
J. Dairy Sci. 100:2630-74

Glucose supply and demand: Prepartum and early lactation



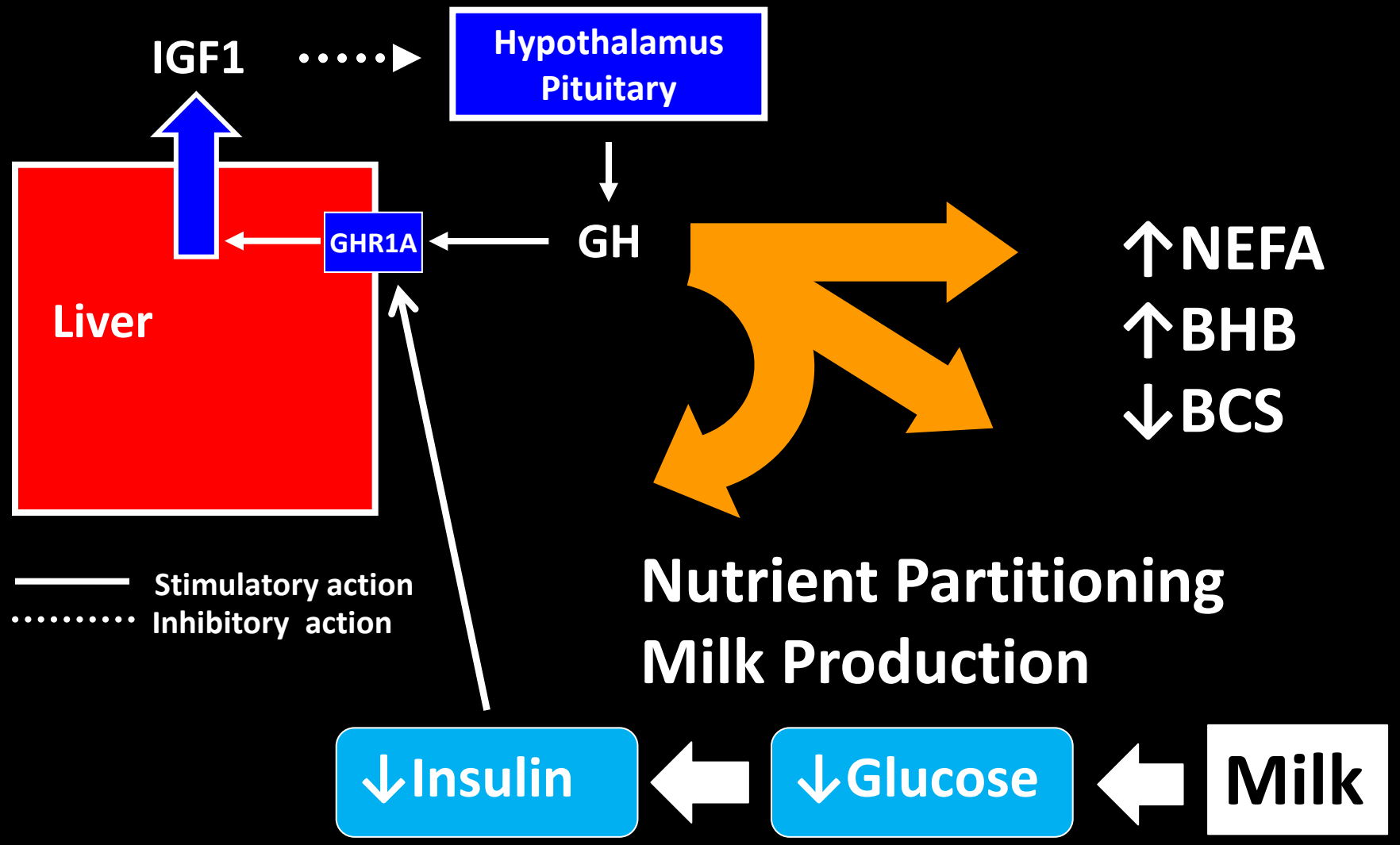
Division of Animal Sciences
University of Missouri

Overton (2001)
Western Canadian Dairy Seminar

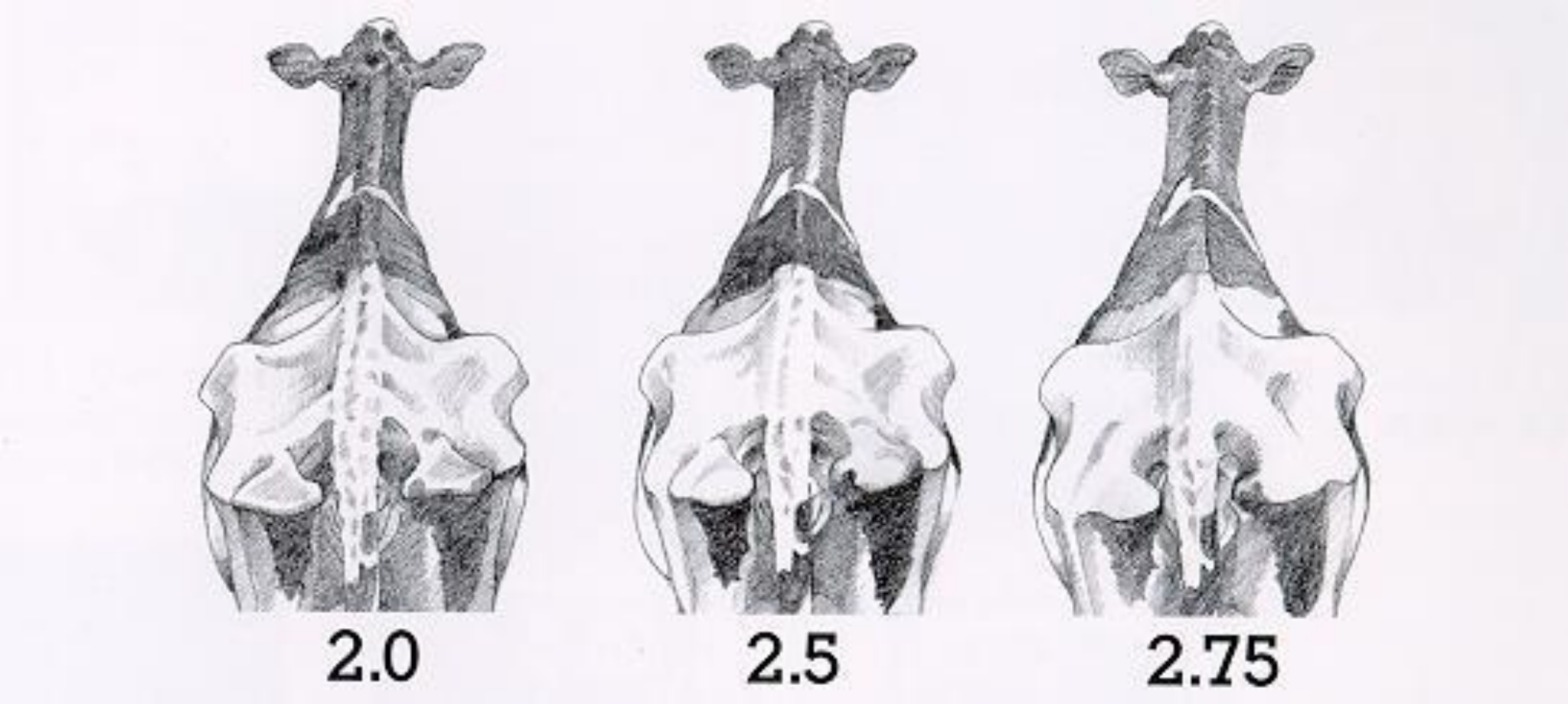


Lucy et al. (2014) Animal 28:1-9

GH, GHR1A, IGF1, and insulin in Postpartum Cows



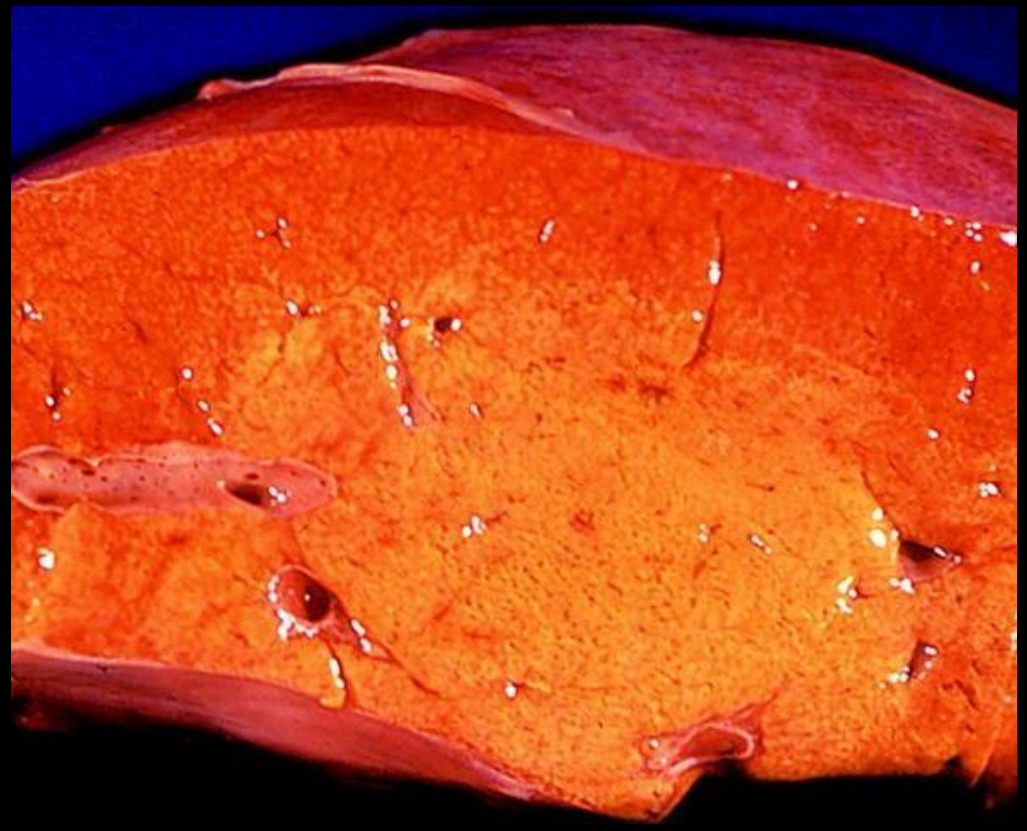
Body condition matters
Low BCS = low reproductive rates



Picture courtesy of Elanco Animal Health

Fatty liver leads to inflammation and poor performance or death in early lactation cows

NEFA → Liver
+ Glycerol
Triglycerides



Fatty liver

ARTIFICIAL BREEDING

by Chad Dechow

Hoard's Dairyman
October 2024

Is high type a killer?

OUR sire evaluations now include over 50 different traits, which can be challenging to sort through without the help of a selection index. If you are like me, there are a handful of key traits you focus on when viewing a sire's or cow's genetic evaluation. One of the traits I pay the most attention to is livability. Livability is a measure of how well a cow avoids on-farm death during their lifetime.

Currently, about 85% of Holsteins avoid dying on the farm. We could also state that approximately 15% of Holsteins will eventually die on the farm during their lifetime. That may sound like a high number, but it is quite common for herds to have a 5% annual mortality rate for lactating cows. If a typical cow lasts for three lactations, then we can see that a 15% lifetime mortality rate is normal.

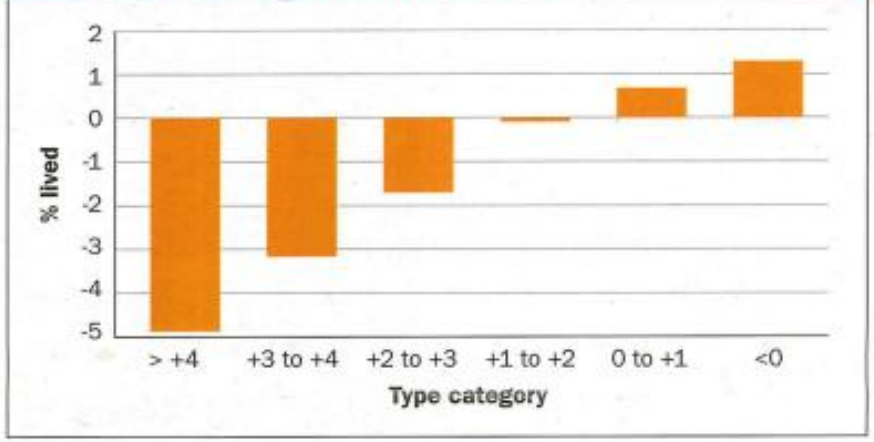
Dechow

The reason I place a lot of weight on livability is because it is a clean measure of longevity and fitness. Many place more emphasis on productive life, which measures how long a cow survives in the lactating insemination company. These four traits were selected because they tend to be the most strongly related to livability. On the other hand, udder and leg traits have a more neutral relationship.

Table 1. Correlation of type traits with livability and productive life for Holstein A.I. bulls born since 2015

	Livability	Productive life
PTA type	-0.46	-0.16
Stature	-0.53	-0.39
Body depth	-0.59	-0.47
Dairy form	-0.42	-0.11

Figure 1. Average livability by type category



As you can see, there is a strong relationship between PTA type category and average PTA for livability. There were 13 bulls with 0 to +1, +1 to +2, +2 to +3, +3 to +4, and over +4.

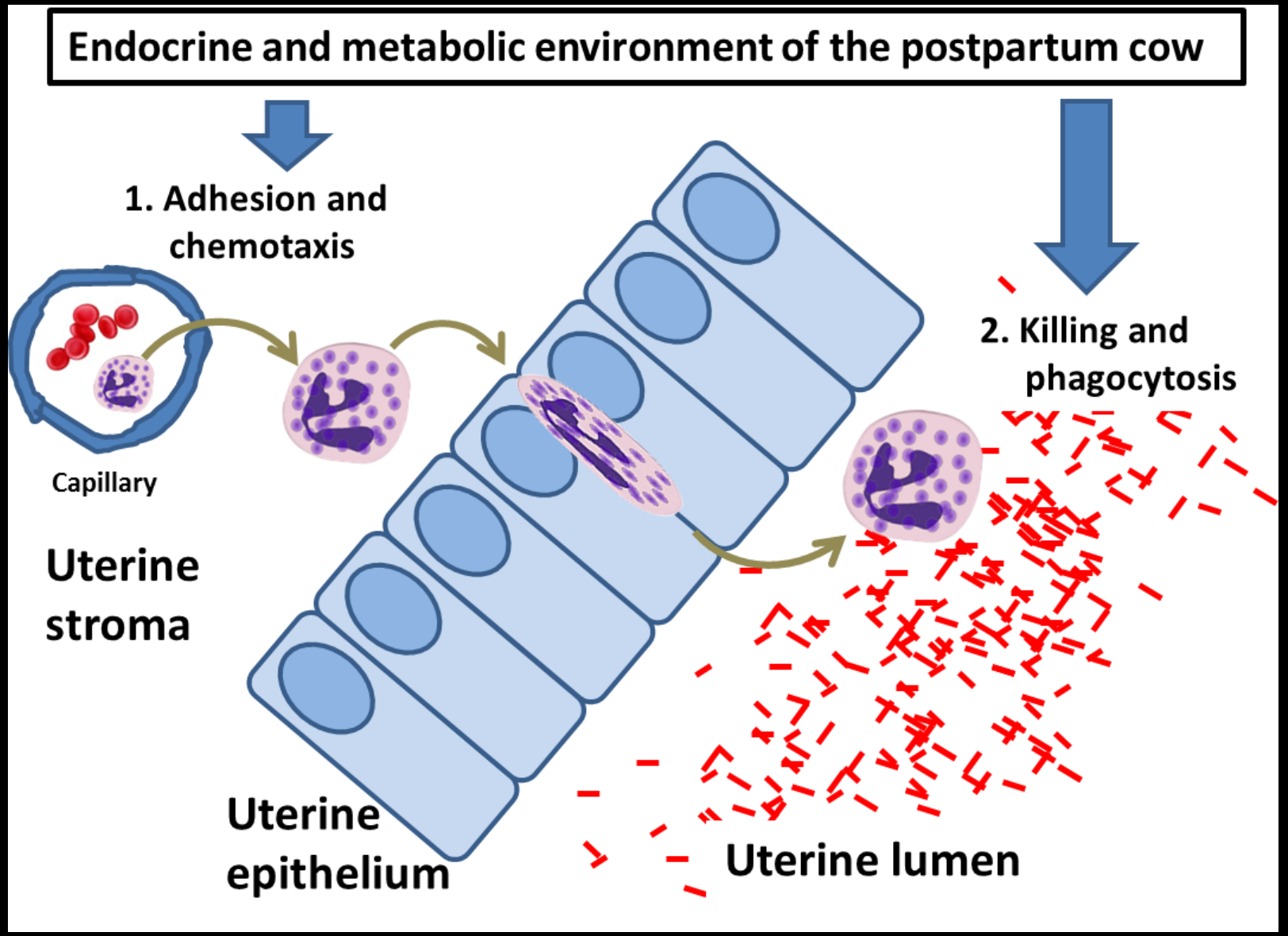
ported by looking at the correlation between PTA type and livability by sire birth year, which is displayed in Figure 2. The relationship was somewhat unfavorable at -0.15 for bulls born between 1995 and 2000; however, that correlation was -0.53 for bulls born since 2019. It is hard to say with certainty why the trend has grown more unfavorable, but we could speculate that we have reached a tipping point for a combination of traits.

This relationship is not as strong for Jersey sires. The overall correlation between type and livability is near zero, but dairy form is an exception. Jersey bulls that are +2 points of dairy form or more on average have a livability of -0.67. Those at the other end of the spectrum at -2 or less have an average livability of +1.06.

Reconsidering strength

I appreciate that cows exhibited in the showring don't necessarily have to look the same as the typical commercial cow. With that said, one would hope that the types of traits we are selecting for in our show cattle would complement the health and fitness abilities needed of cows living in a commercial milk production setting.

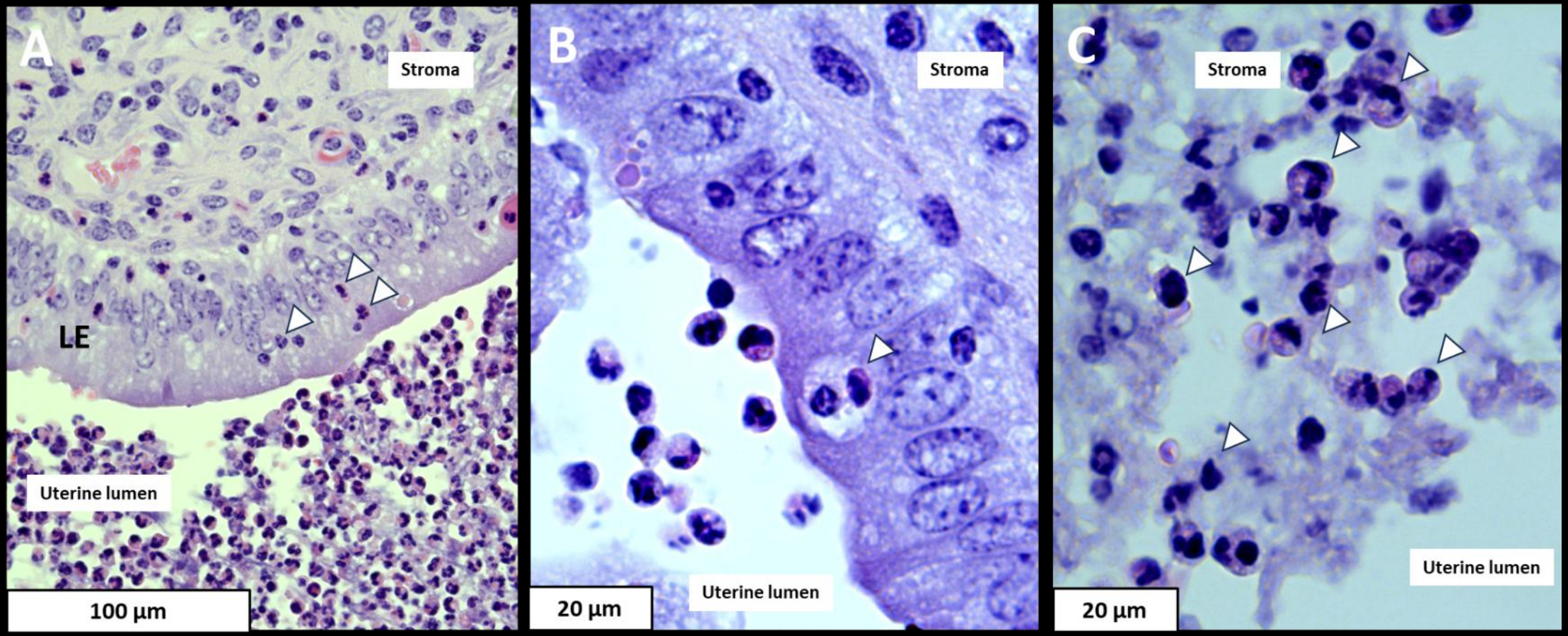
Immune dysfunction



Lucy et al. (2014) Animal 8 Suppl 1:82-90.

Endometritis

What is endometritis (inflammation in the uterus)?



Immune dysfunction

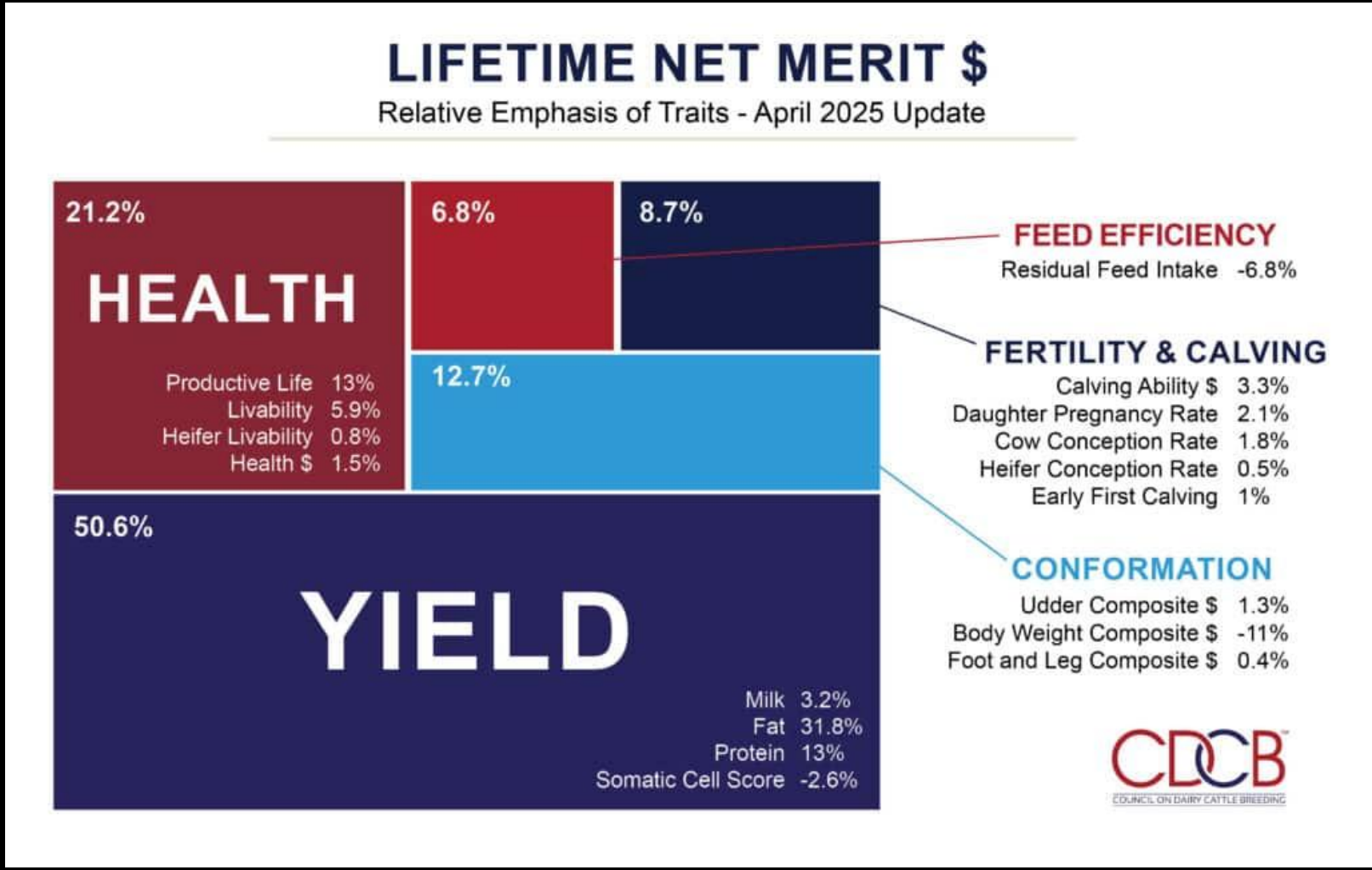
	Known effects on PMN function	Postpartum
Glucose	↑ respiratory burst; ↑ chemotaxis; ↑ phagocytosis (Chou et al., 2010)	low glucose
Insulin	Activates growth factor pathways; ↑ cytokine production; ↑ chemotaxis; ↑ phagocytic activity (Sunahara et al., 2012)	low insulin
IGF1	Cell-survival factor; activation of PI3K (Himpe et al., 2013)	low IGF1
BHB	Inhibits formation of extracellular traps and inhibits bactericidal activity against E. coli. (Grinberg et al., 2008)	high BHB
NEFA	↓ production of reactive oxygen species (ROS) (Ster et al., 2012)	high NEFA

Reducing the "stress" of milk production (examples)

- Start with a clean, healthy cow in good body condition.
- Ideal barn and stall design.
- Feeding the highest quality diet that is balanced for your cow's nutritional requirements.
- Include feed ingredients that minimize BCS loss, stimulate immune function and promote a healthy gut.
- Manage the pen to maximize intake.
    - Feed delivery
    - Push ups
    - Stocking density

Playing the long game with genetics

Selecting for health should mitigate the strain of production



Next Generation herd (Teagasc, Ireland)

J. Dairy Sci. 103:1685–1700
https://doi.org/10.3168/jds.2019-17374

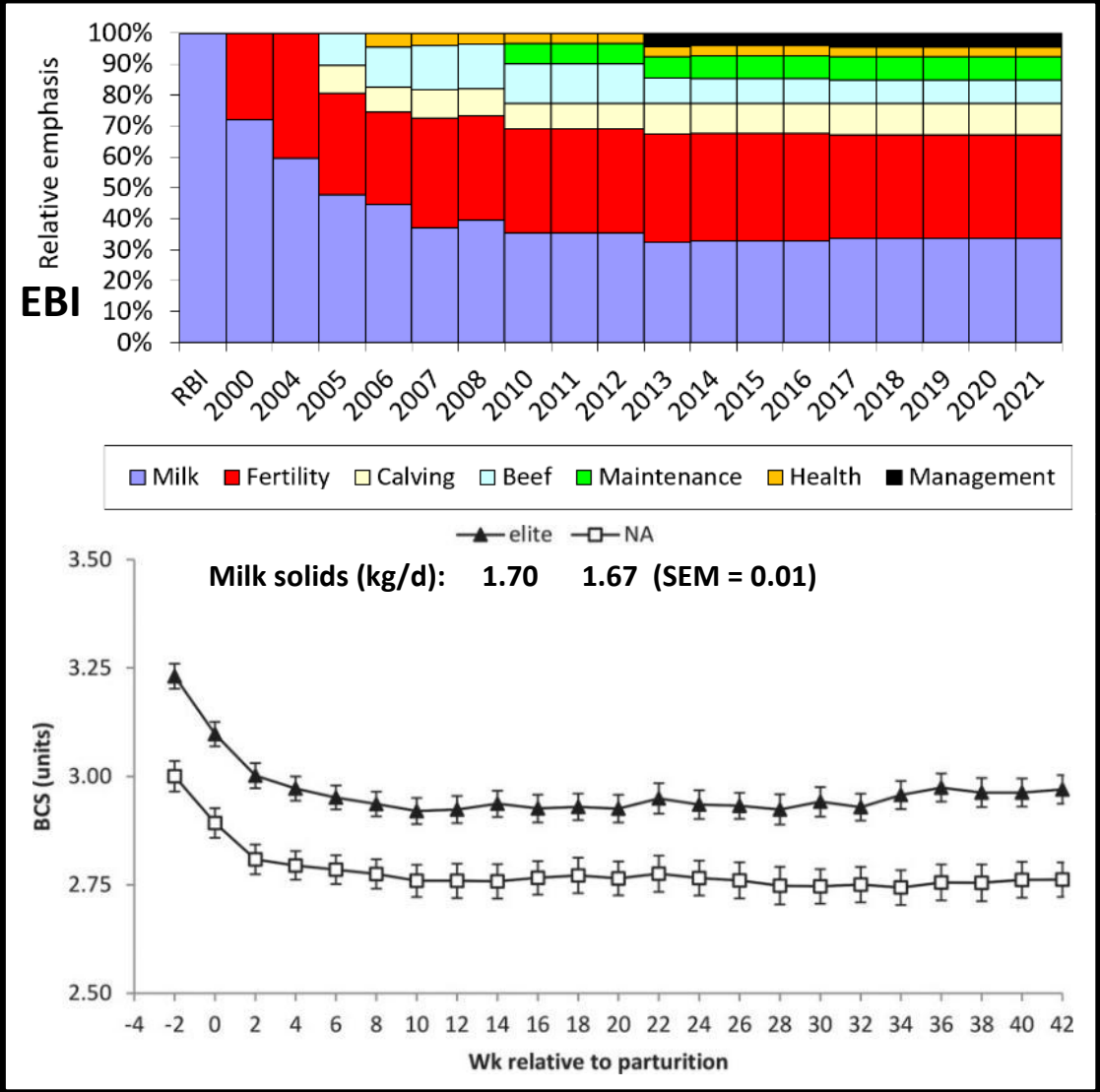
Reproductive efficiency and survival of Holstein-Friesian cows of divergent Economic Breeding Index, evaluated under seasonal calving pasture-based management

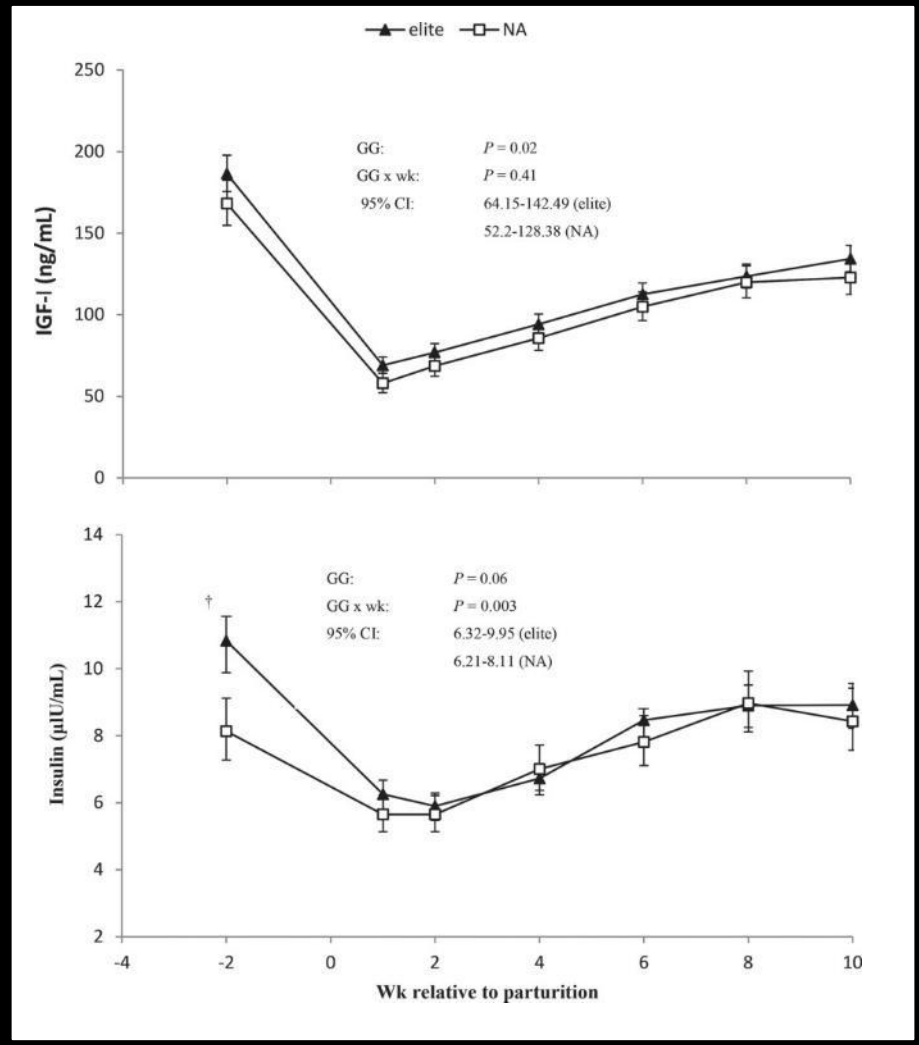
M. O'Sullivan,[1,2] S. T. Butler,[1] K. M. Pierce,[2] M. A. Crowe,[3] K. O'Sullivan,[4] R. Fitzgerald,[1] and F. Buckley[1,2]*
[1]Animal and Grassland Research and Innovation Centre, Teagasc Moorepark, Fermoy, Co. Cork, P61 C997, Ireland
[2]School of Agriculture and Food Science, University College Dublin, Belfield, Dublin, D04 N2E5, Ireland
[3]School of Veterinary Medicine, University College Dublin, Belfield, Dublin, D04 N2E5, Ireland
[4]School of Mathematical Sciences, University College Cork, Cork, T12 XF62, Ireland

Next Generation herd (Ireland)

Genetic selection changes the hormonal and metabolic profile of the early postpartum cow

Results from the Next Generation Herd (Teagasc, Moorepark Ireland)



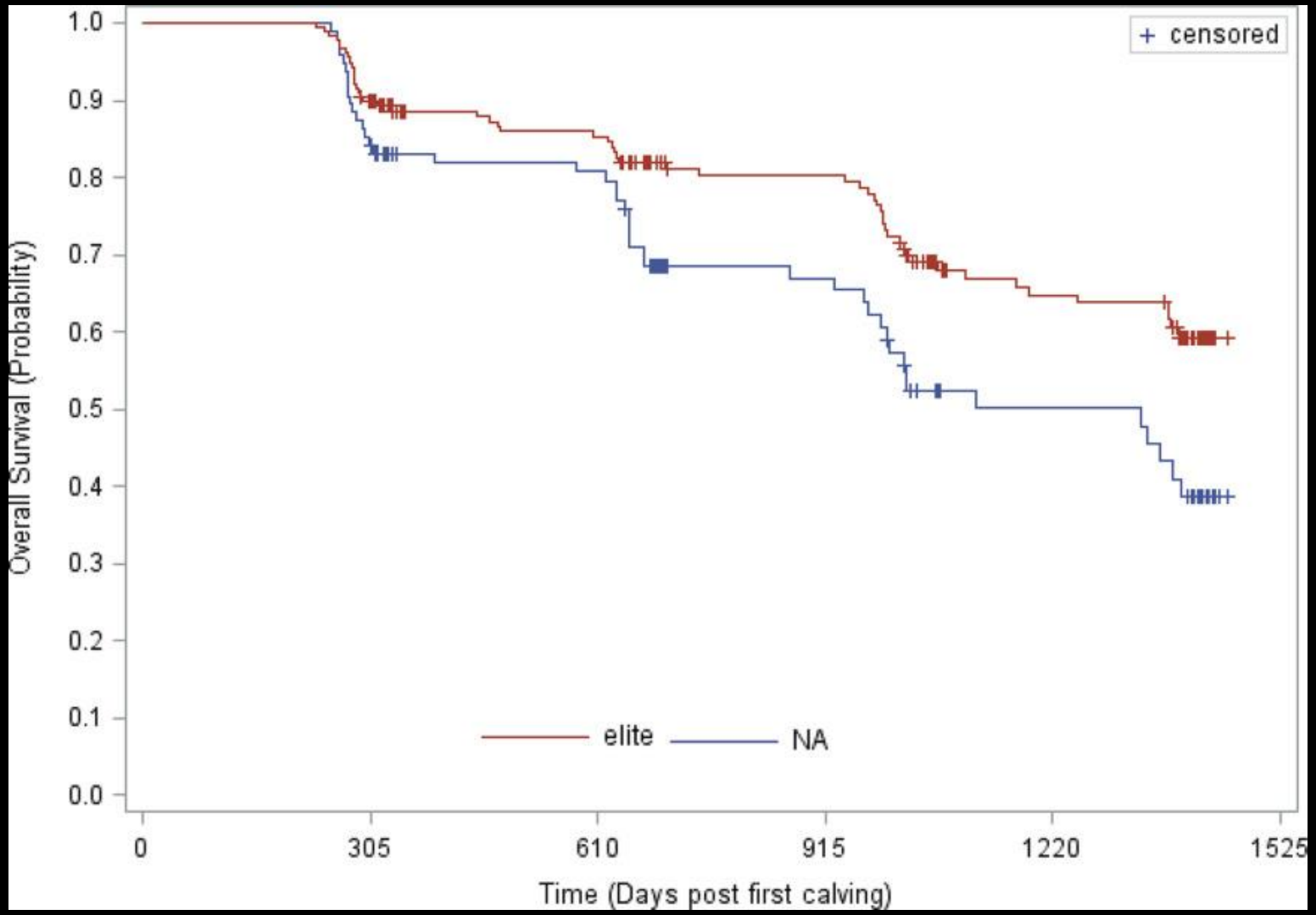


O'Sullivan et al. (2020) J. Dairy Sci. 103:1685-1700.

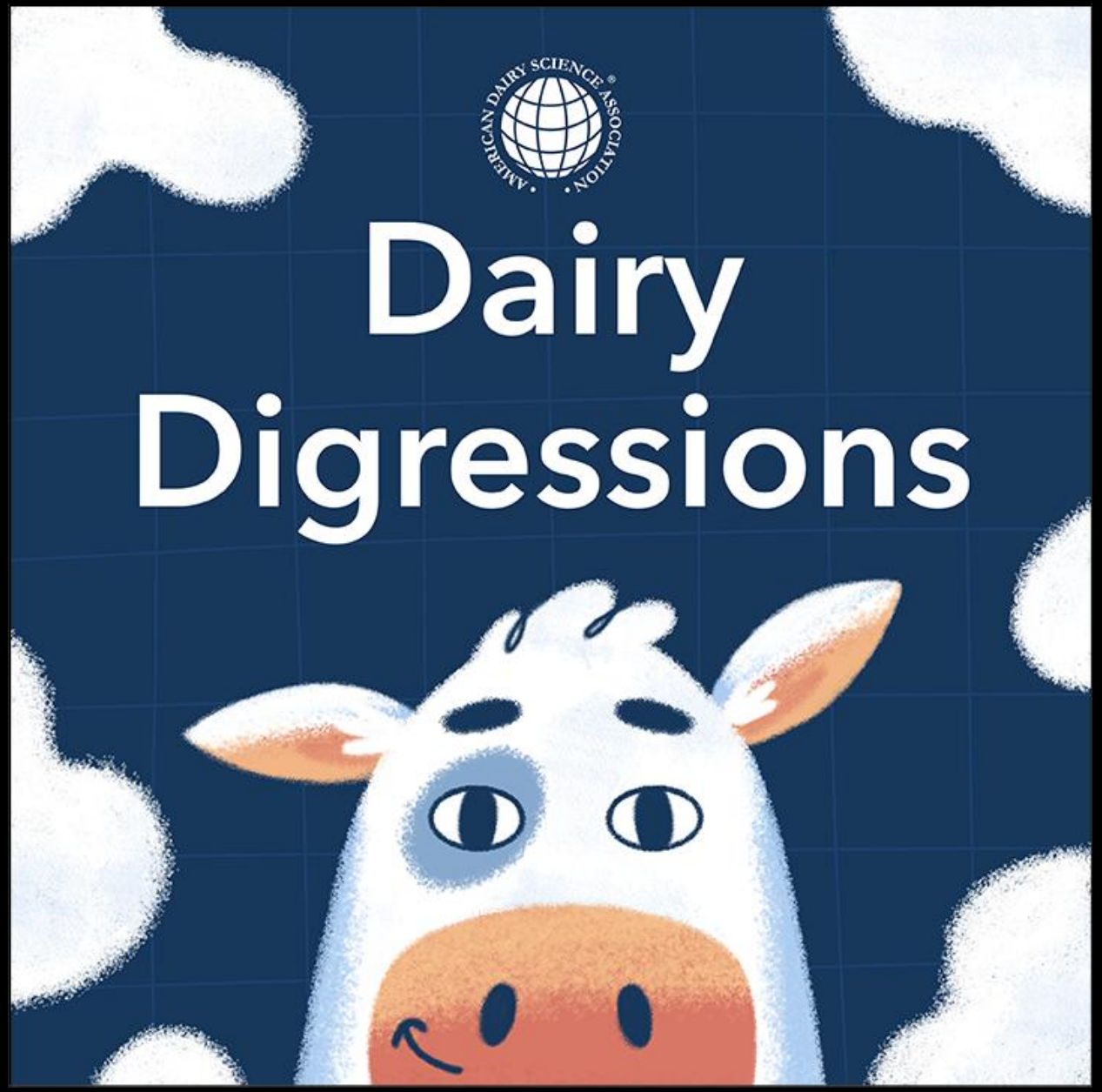
Next Generation herd (Ireland)

Next Generation Herd (Teagasc, Moorepark Ireland)

Survival (four lactations)



O'Sullivan et al. (2020) J. Dairy Sci. 103:1685-1700.



Thank you!

For the latest in dairy science research listen to Dr. Lucy's podcast "Dairy Digressions". We do *science* right!

Matt Lucy
Univ. of Missouri
Columbia, MO
USA
lucym@missouri.edu

SUPPORT - SOLUTIONS - RESULTS

MarSyt

An Agricultural Company
Since 1995

Let's continue the conversation.

Contact Us