The Metabolism and Productive Responses to Heat Stress
PART ONE

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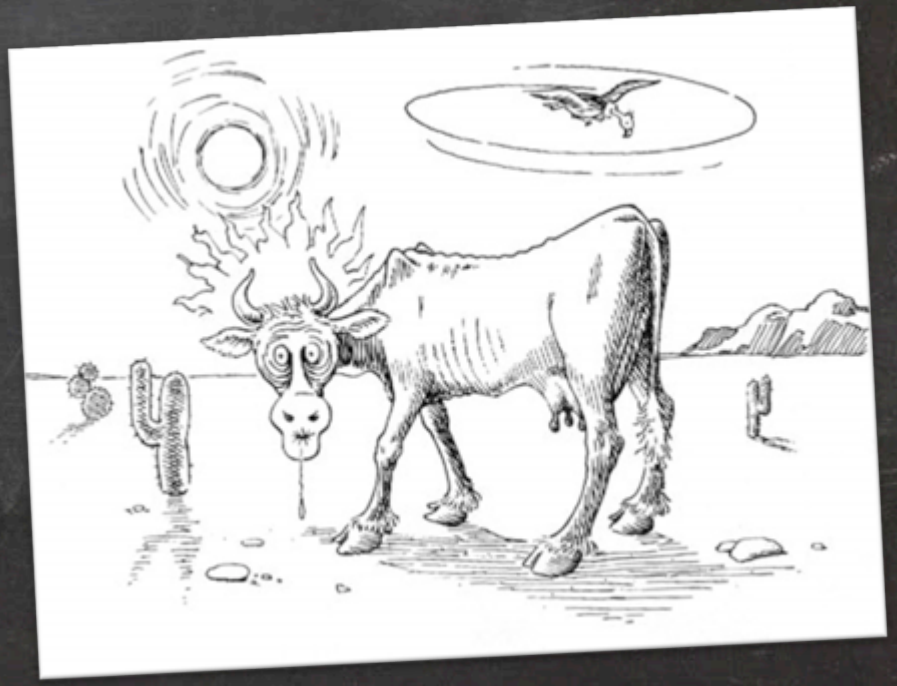
The Metabolism and Productive Responses to Heat Stress: Potential Nutritional Strategies

Heat Stress is not Fever

When environmental temperature nears the animal's body temperature, the animal's cooling mechanisms are impaired.

- Fever vs. Hyperthermia
- Very different biology



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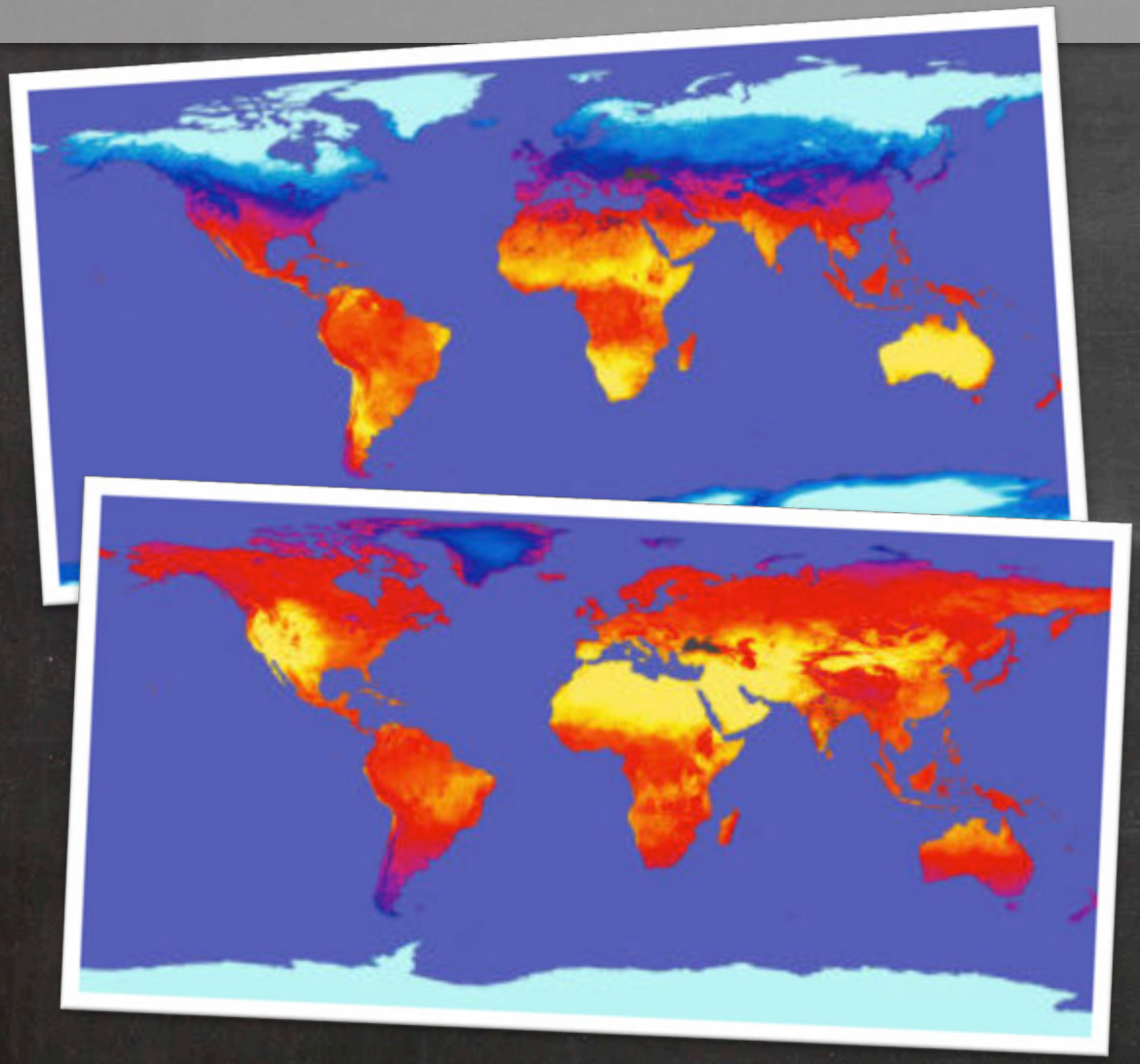
Heat Stress is a Global Problem



January 2003
NASA

July 2003
NASA

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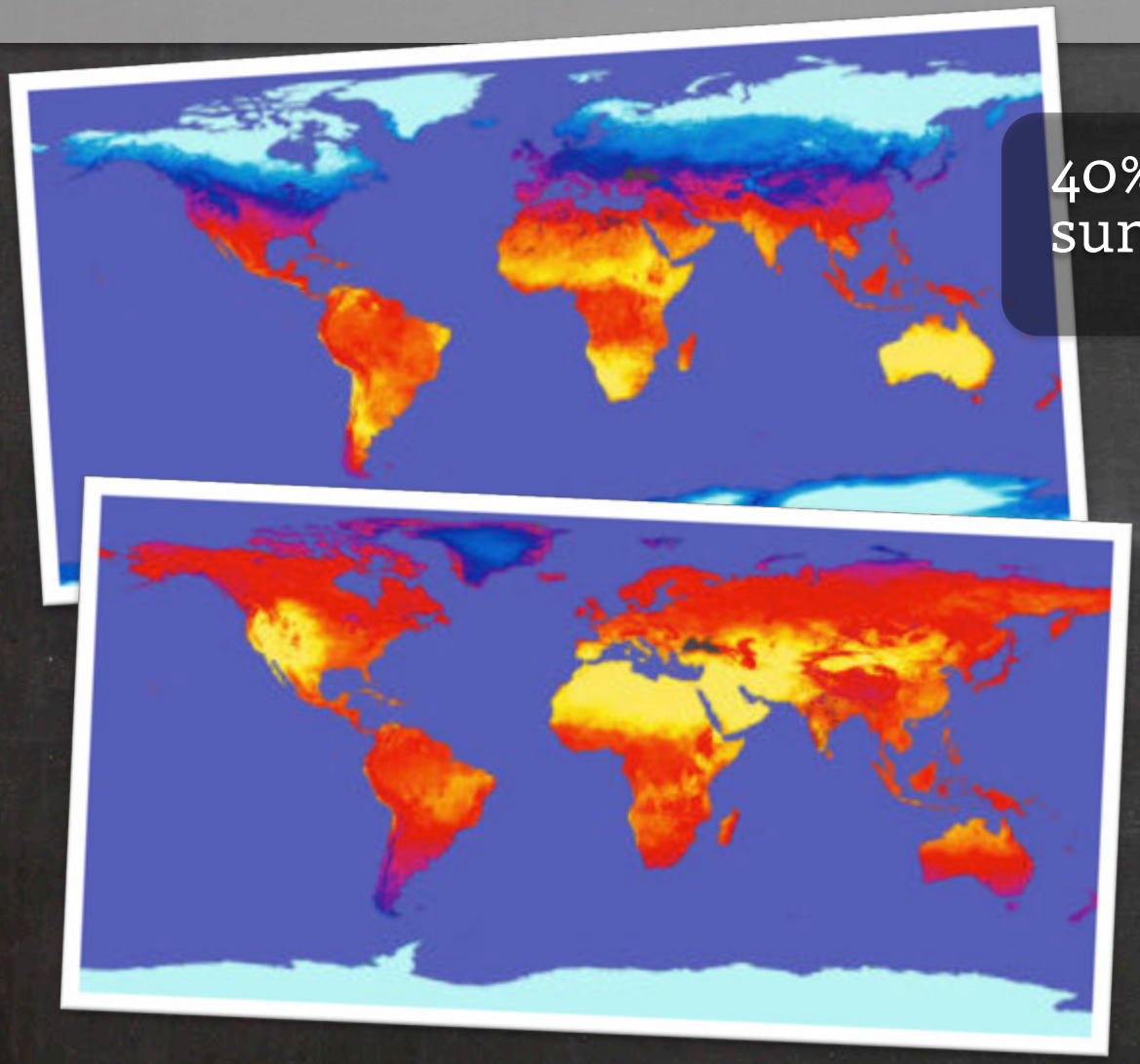
Heat Stress is a Global Problem



40% of W. Canadian summer days THI > 72

Ominski et al., 2002

January 2003

NASA

July 2003

NASA

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Heat Stress: Economics and Food Security

Cost: (lost productivity, mortality, product quality, health care etc.)

- American Agriculture: > $4 billion/year
- Global Agriculture: > $150 billion/year

It will get worse in the future if:

- Climate change continues as predicted
- Genetic selection continues to emphasize milk synthesis, lean tissue accretion, piglets/sow etc..
  - — Heat producing processes

St. Pierre et al., 2003; Baumgard and Rhoads, 2013

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Heat Stressed Cow

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Metabolism Review

Ad Libitum Intake

- ⬆ Insulin
- ⬇ NEFA
- ⬇ Catabolic hormones

Restricted Intake

- ⬇ Insulin
- ⬆ NEFA
- ⬆ Catabolic hormones

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Heat Stress Questions

- Does the decrease in feed intake explain the reduced milk yield during heat stress?

Indirect vs. Direct Effects of Heat

- If we have a better understanding of the biological reasons **WHY** heat stress reduces production, we'll have a better idea of how to alleviate it.

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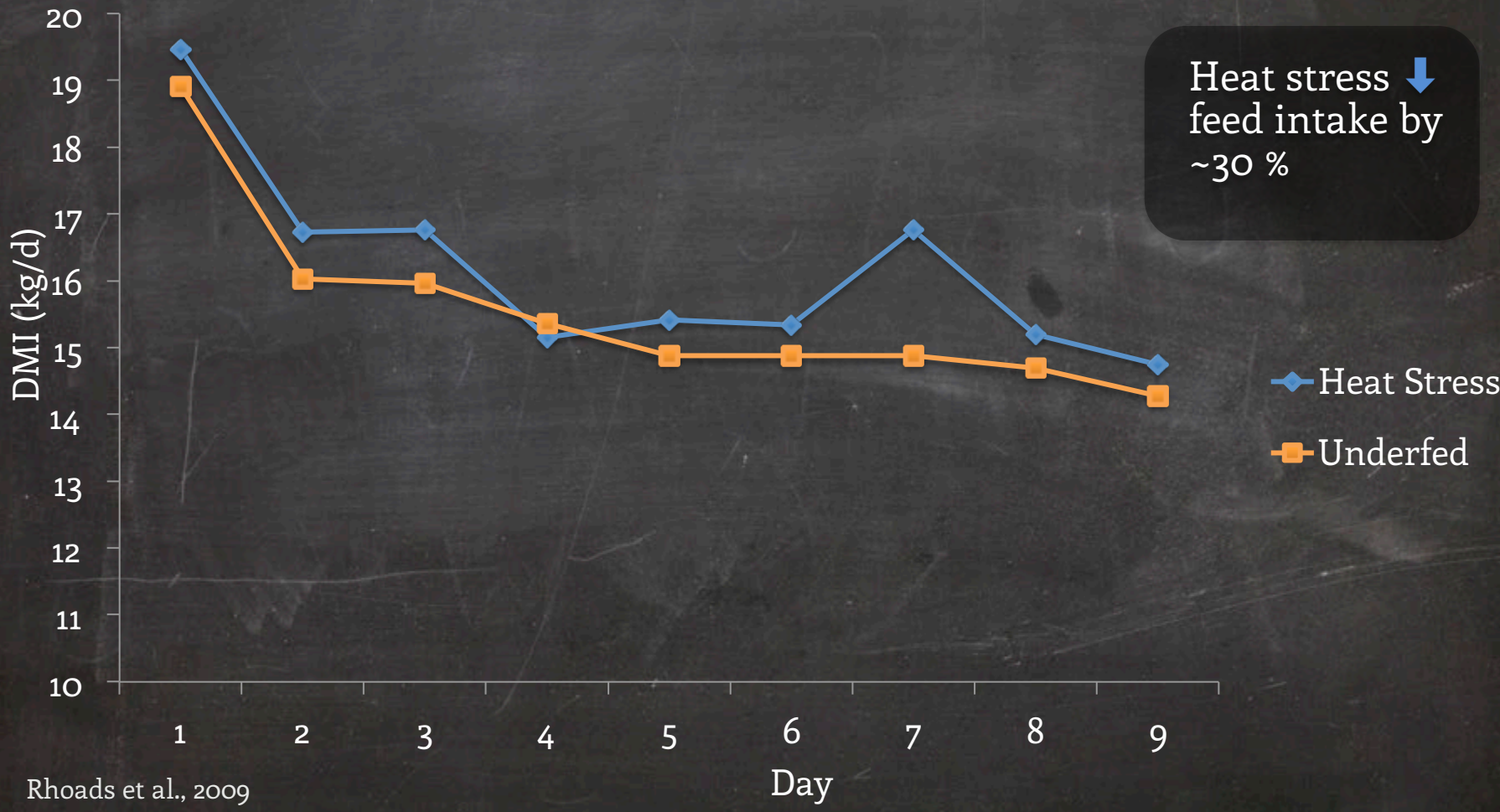
Lactation: Effects of Heat Stress on Feed Intake



Rhoads et al., 2009

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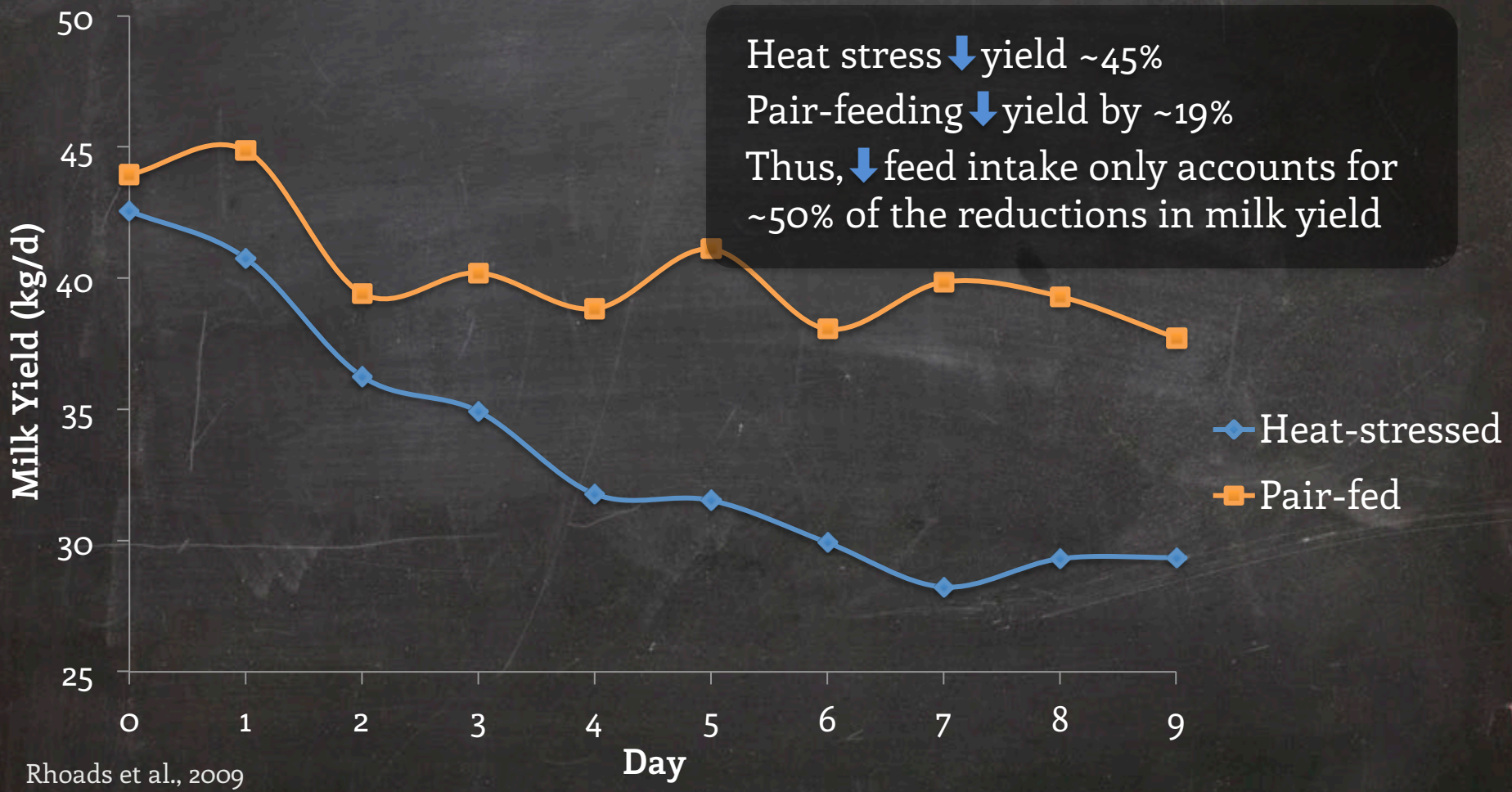
Effects of Environment on Milk Yield



Rhoads et al., 2009
Wheetlock et al., 2014

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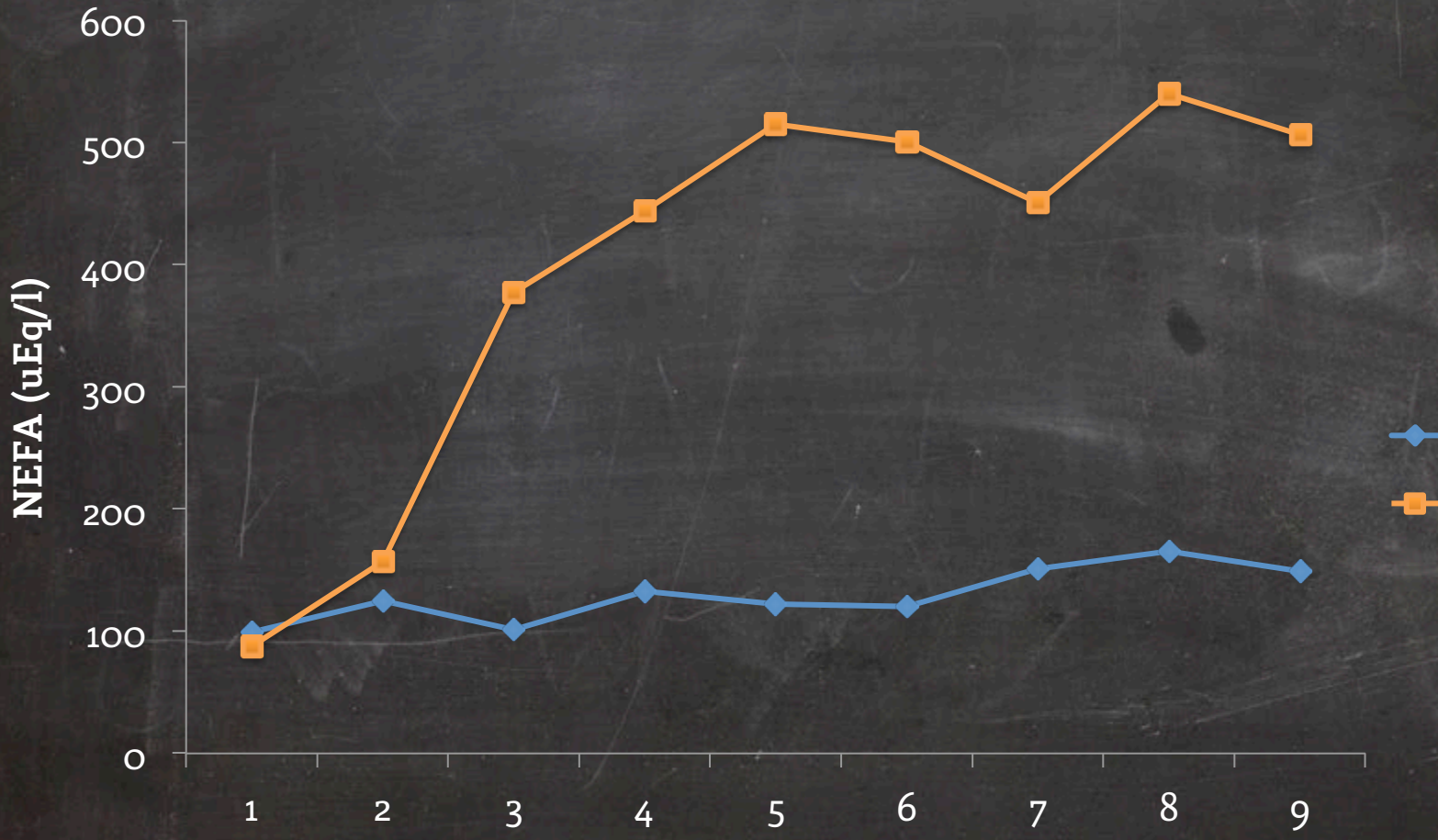
Effects of Heat Stress on Adipose Tissue Mobilization: Cattle



Rhoads et al., 2009

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Circulating Insulin in Cattle

Wheelock et al., 2010

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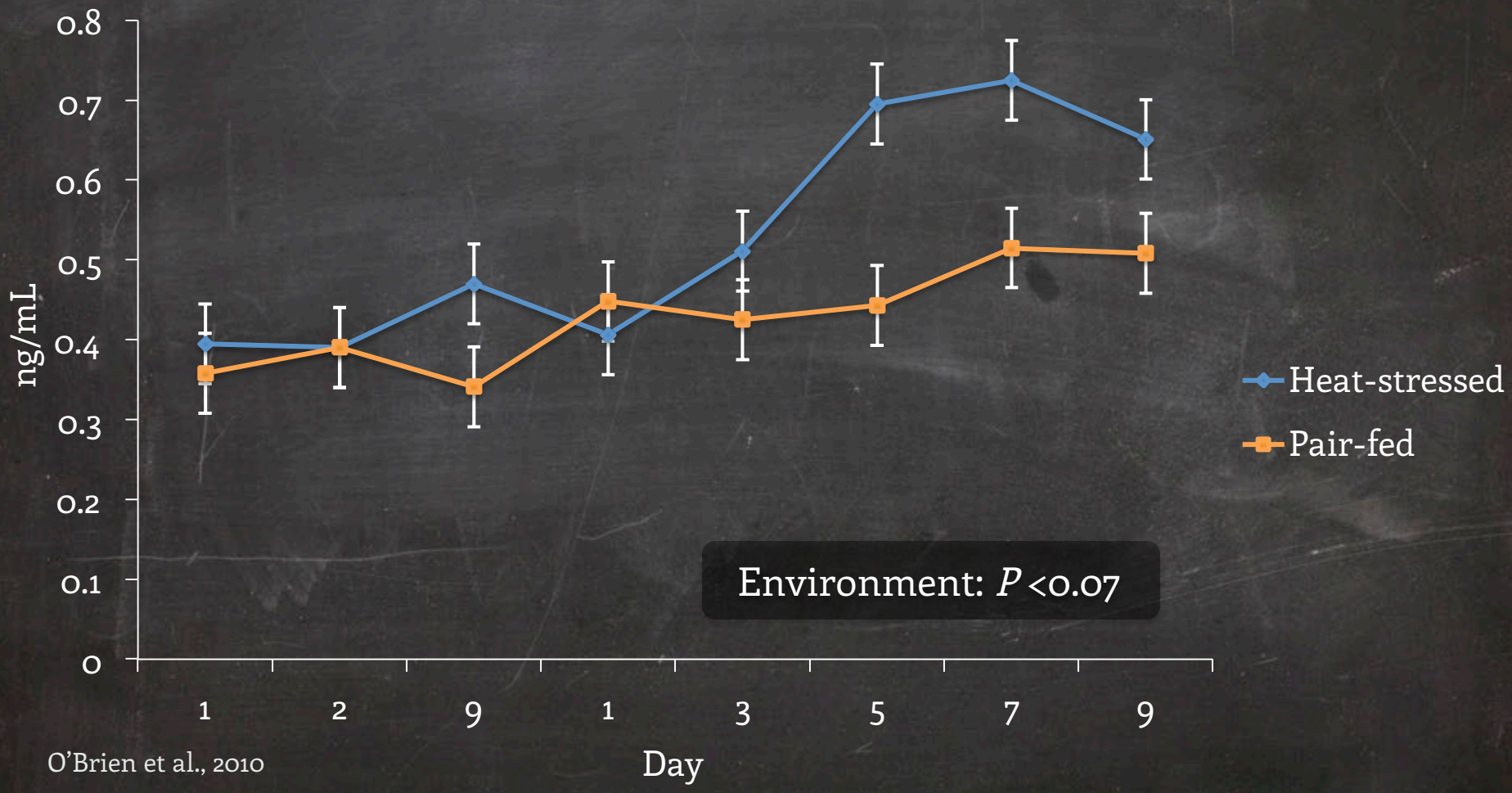
Basal Insulin in Growing Steers



O'Brien et al., 2010

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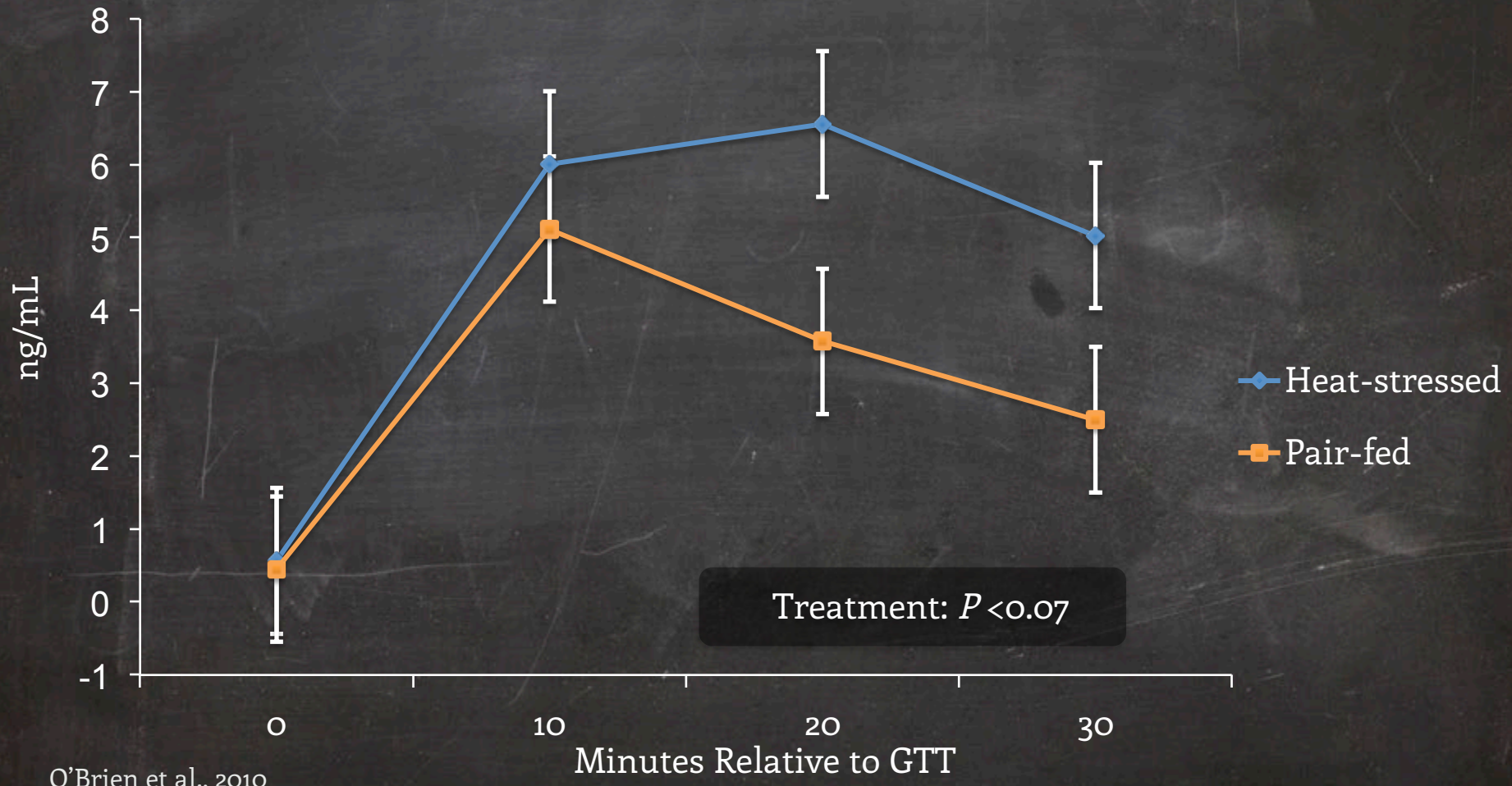
Insulin Response to the GTT



O'Brien et al., 2010

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Potential Fuels for Ruminants

- VFA (acetate)
  - Contribution is presumably decreased b/c DMI is reduced
- NEFA
  - Do not increase during heat stress
- Amino Acids
  - Efficiency of capturing ATP is low
- **Glucose**
  - By process of elimination, glucose contribution to whole animal energetics may be increased?

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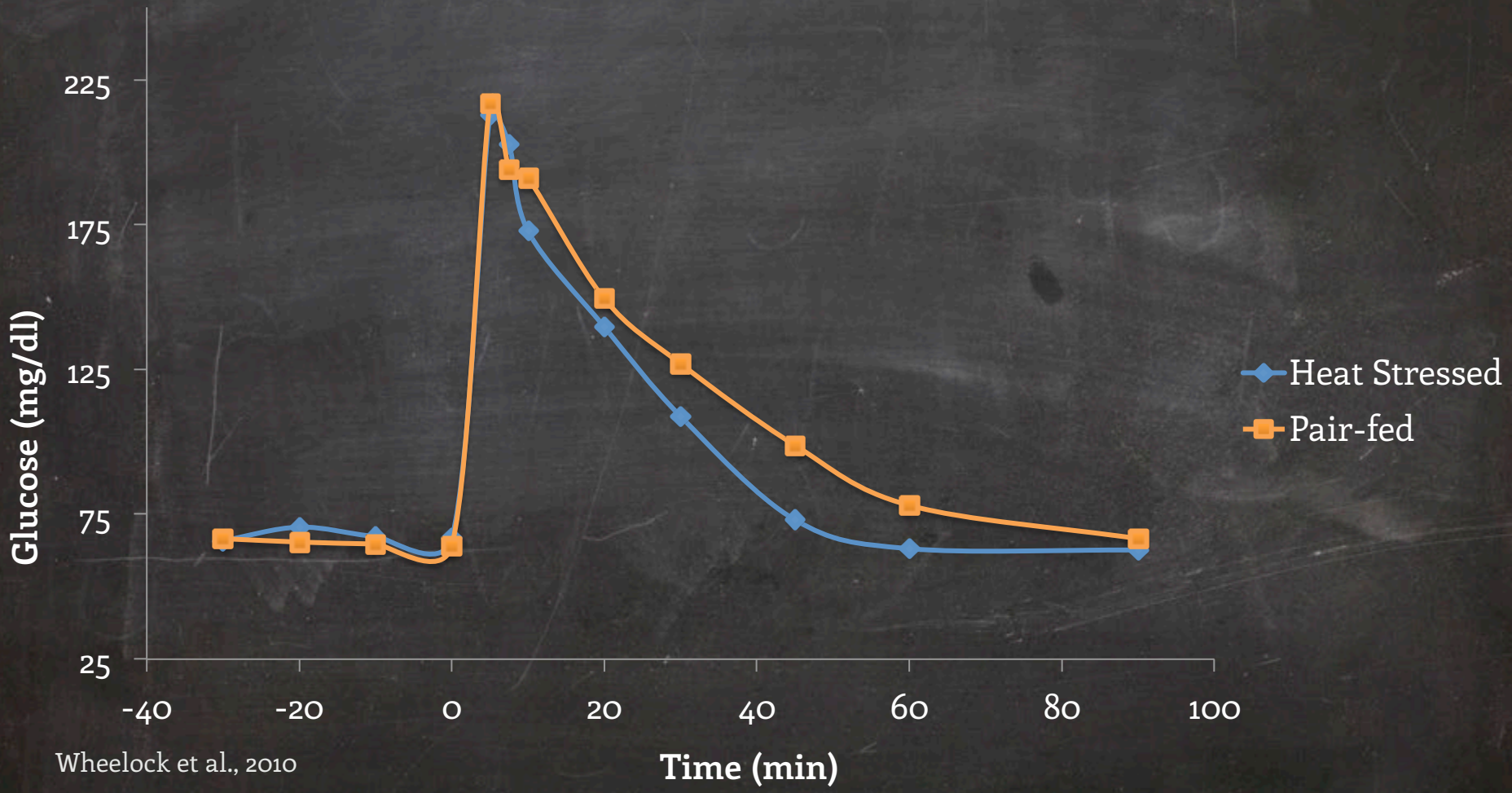
Glucose Tolerance Test



Wheelock et al., 2010

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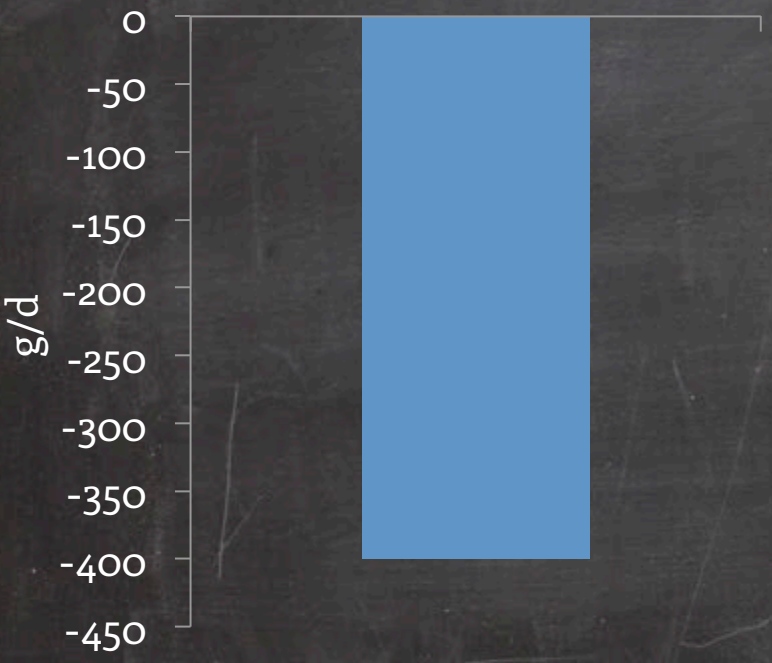
Lactose: Heat Stress vs. Pair-Fed Thermal Neutrals



Heat Stress Cows Secrete
~400 g **less** lactose/day than Pair-Fed Thermal Neutral Controls

Is the liver producing ~ 400 g less glucose/day????
or is extra-mammary tissues utilizing ~400 g more/day

Rhoads et al., 2009
Wheetlock et al., 2014

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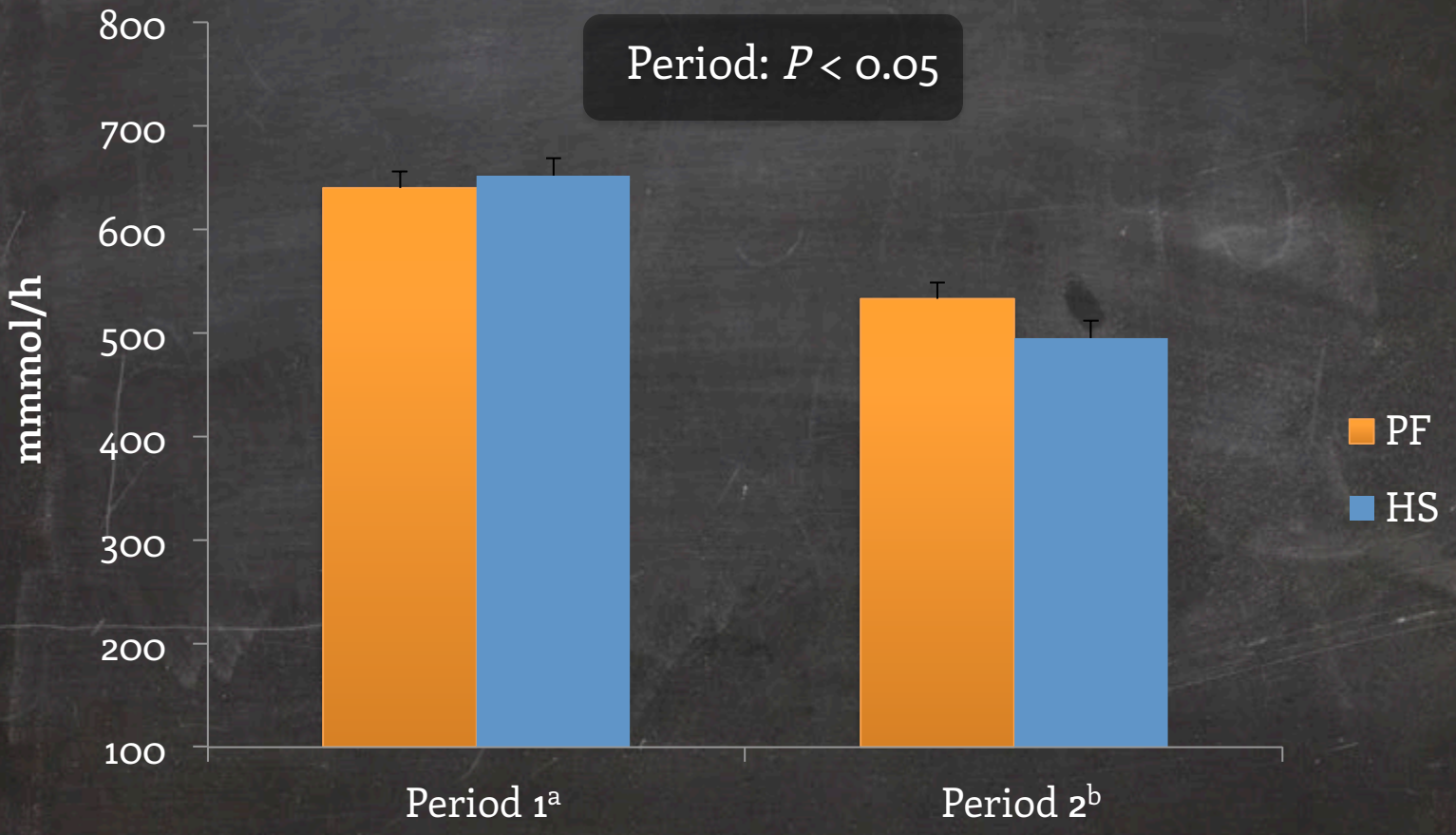
Whole Body Glucose Production



Baumgard et al., 2011

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Whole Body Glucose Production

Extra mammary tissues utilize ~ 400 g **more** glucose/day during heat stress.

Indicates glucose is preferentially being utilized for processes other than milk synthesis (ostensibly by insulin-responsive tissues, or the immune system) during heat stress.

Baumgard et al., 2011

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Energetic Summary

- Decreased feed intake only accounts for ~50% of the reductions in milk yield
- Tissue differences in sensitivity to catabolic and anabolic signals
- Heat-stressed cows have increased insulin action
  - Decreased NEFA
  - Increased glucose disposal
- Heat-stressed cows require extra energy
  - Especially glucose

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Why Increased Insulin??

- Direct or Indirect effects of heat?
- Indirect: associated/caused by heat compromised gastrointestinal track barrier function?

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