Uso de precursores de glucosa como suplemento energético para máximizar la producción de leche

Ph.D. Barry Bradford

Titulación académica:

- Posee dos títulos de licenciatura en la Universidad Estatal de Lowa y un doctorado en nutrición animal en la Universidad Estatal de Michigan

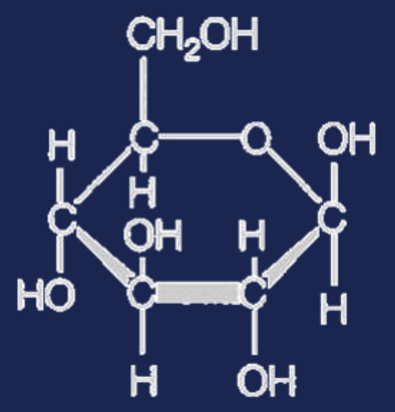
En su experiencia laboral se destaca por:

- Formó parte del cuerpo docente de la Universidad Estatal de Kansas desde 2006 hasta 2019, y en 2020 regresó a la Universidad Estatal de Michigan como Presidente Clint Meadows en Gestión Láctea. La investigación de Bradford se centra en la nutrición y el metabolismo del ganado lechero, con un énfasis particular en intentar traducir hallazgos novedosos en fisiología metabólica fundamental a aplicaciones prácticas en la agricultura animal

Además:

- Bradford ha contribuido a más de 130 publicaciones revisadas por pares y ha compartido esos hallazgos en más de 200 presentaciones invitadas.

Glucose precursors at the liver level – with strategies to improve diet efficiency.



Barry Bradford, PhD

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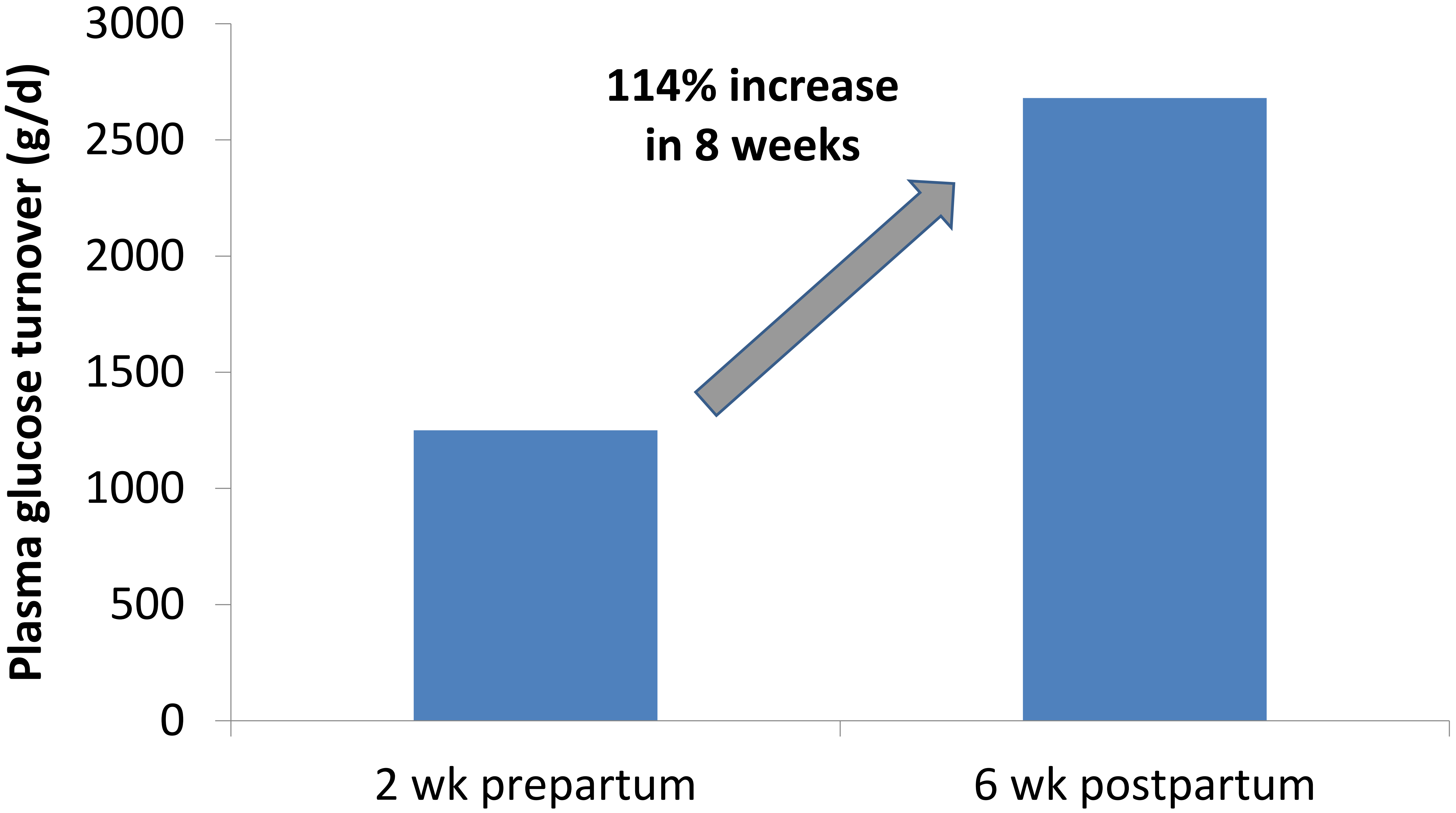
Overview

- Why is glucose production important?
- What determines the rate of glucose production in lactating cows?
- Sources of glucose precursors and impacts on the body
- Promoting glucose production during the transition period

Lactation requires a lot of glucose!



Schulze et al., 1991

How does the cow meet her glucose needs?

What is the glucose supply in the diet?

Assuming:

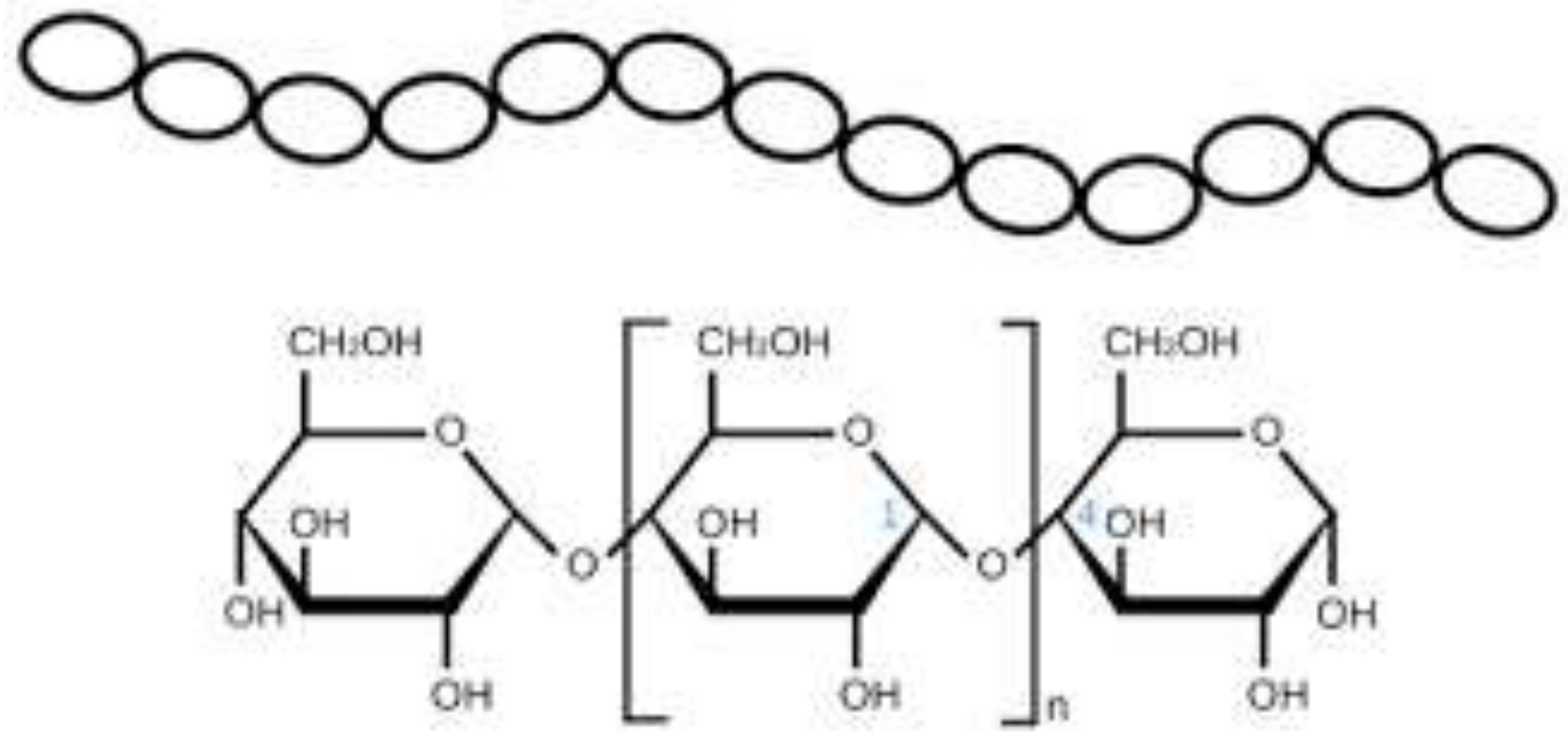
The cow eats 20 kg of dry matter per day

The diet is 70% carbohydrate

Starch is composed of 100% glucose

Fiber is composed of 90% glucose

→ **The cow consumes about 13 kg of glucose monomers per day!**



How does the cow meet her glucose needs?

What are the glucose requirements for a lactating cow?

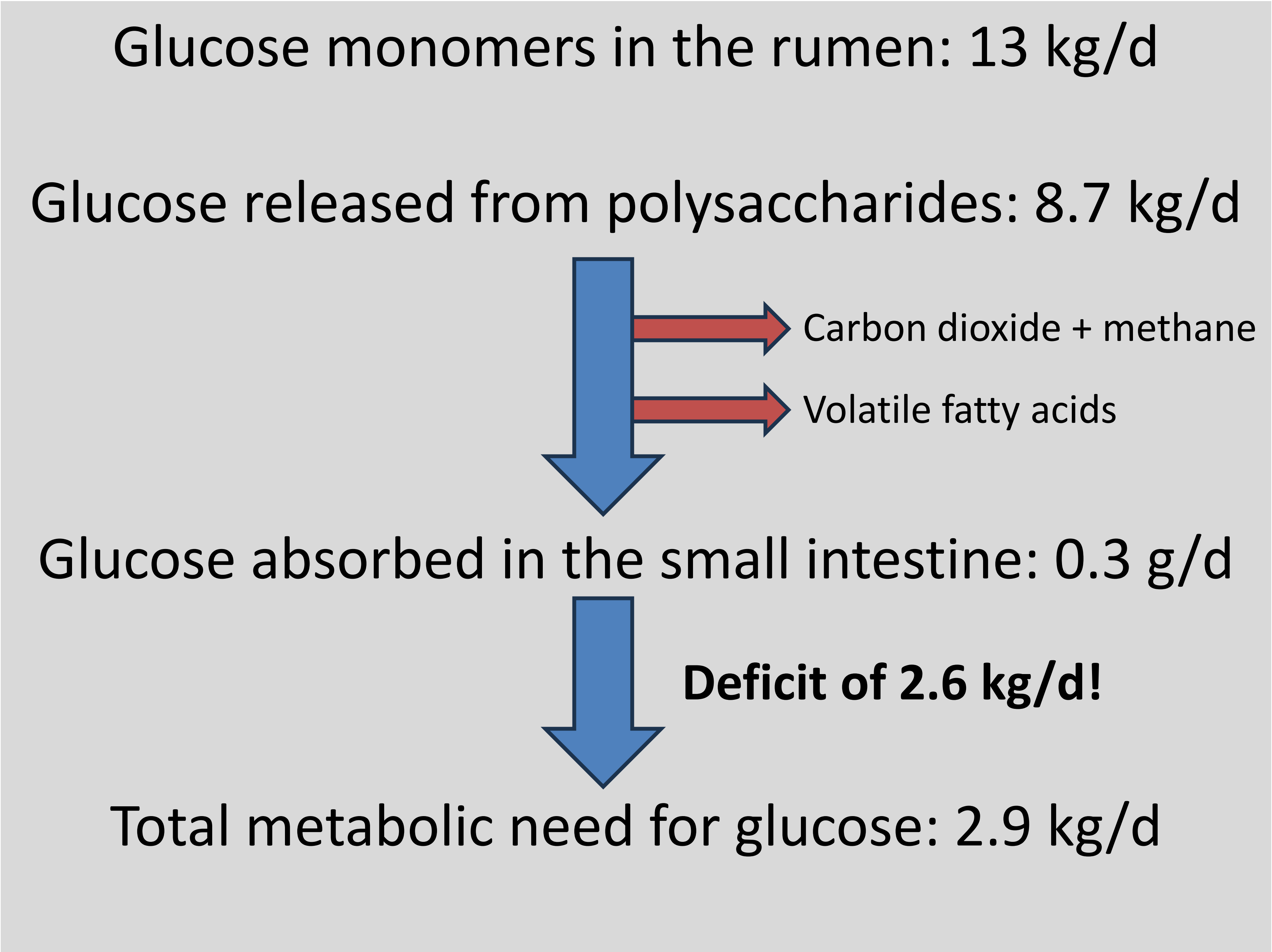
Assuming:

The cow produces 30 kg/d of milk with 4.8% lactose

Lactose synthesis accounts for 67% of mammary glucose use

Mammary use accounts for 75% of total glucose use

→ **The cow uses about 2.9 kg of glucose per day**



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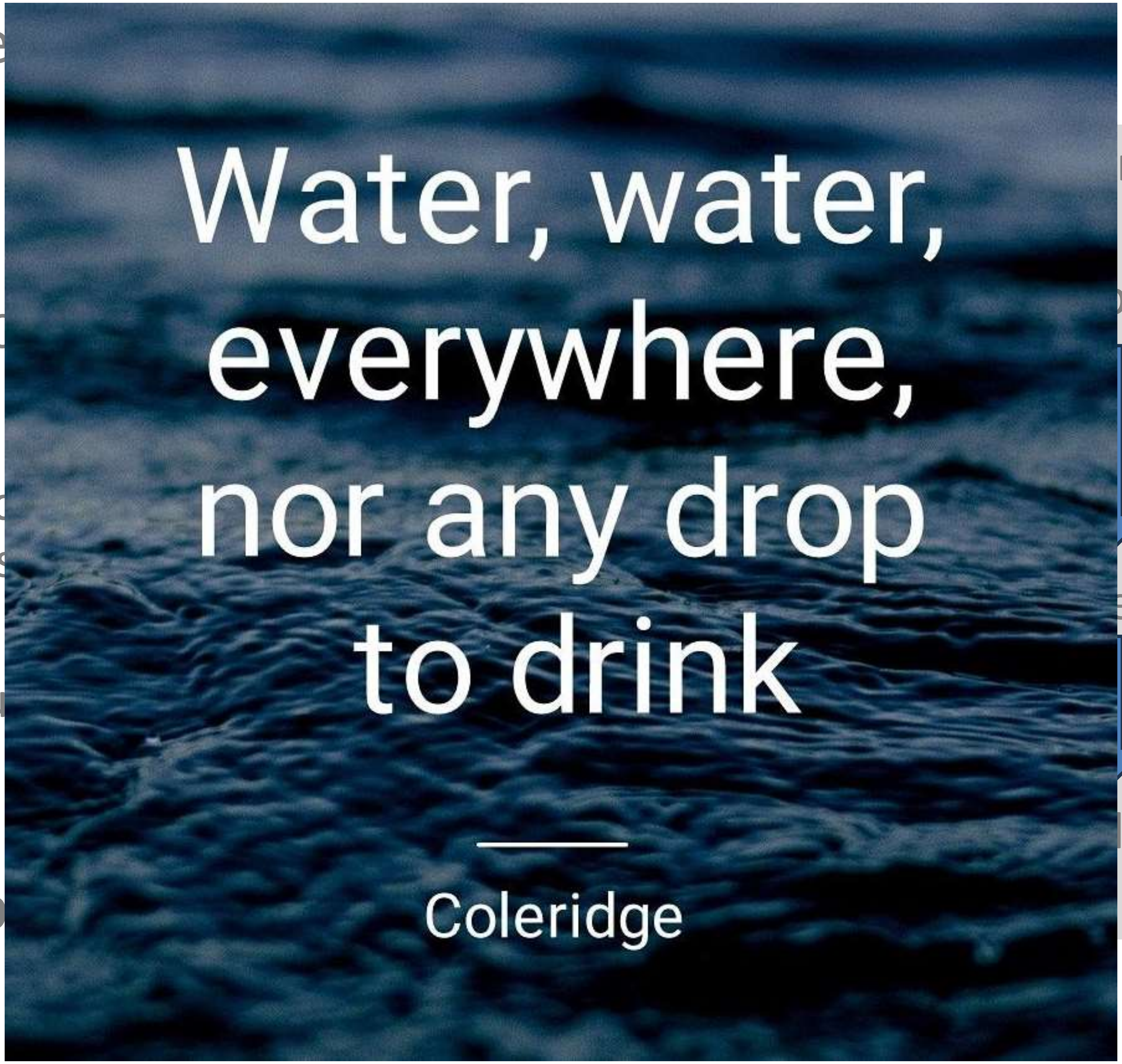


n the rumen: 13 kg/d

polysaccharides: 8.7 kg/d

Carbon dioxide + methane

Volatile fatty acids

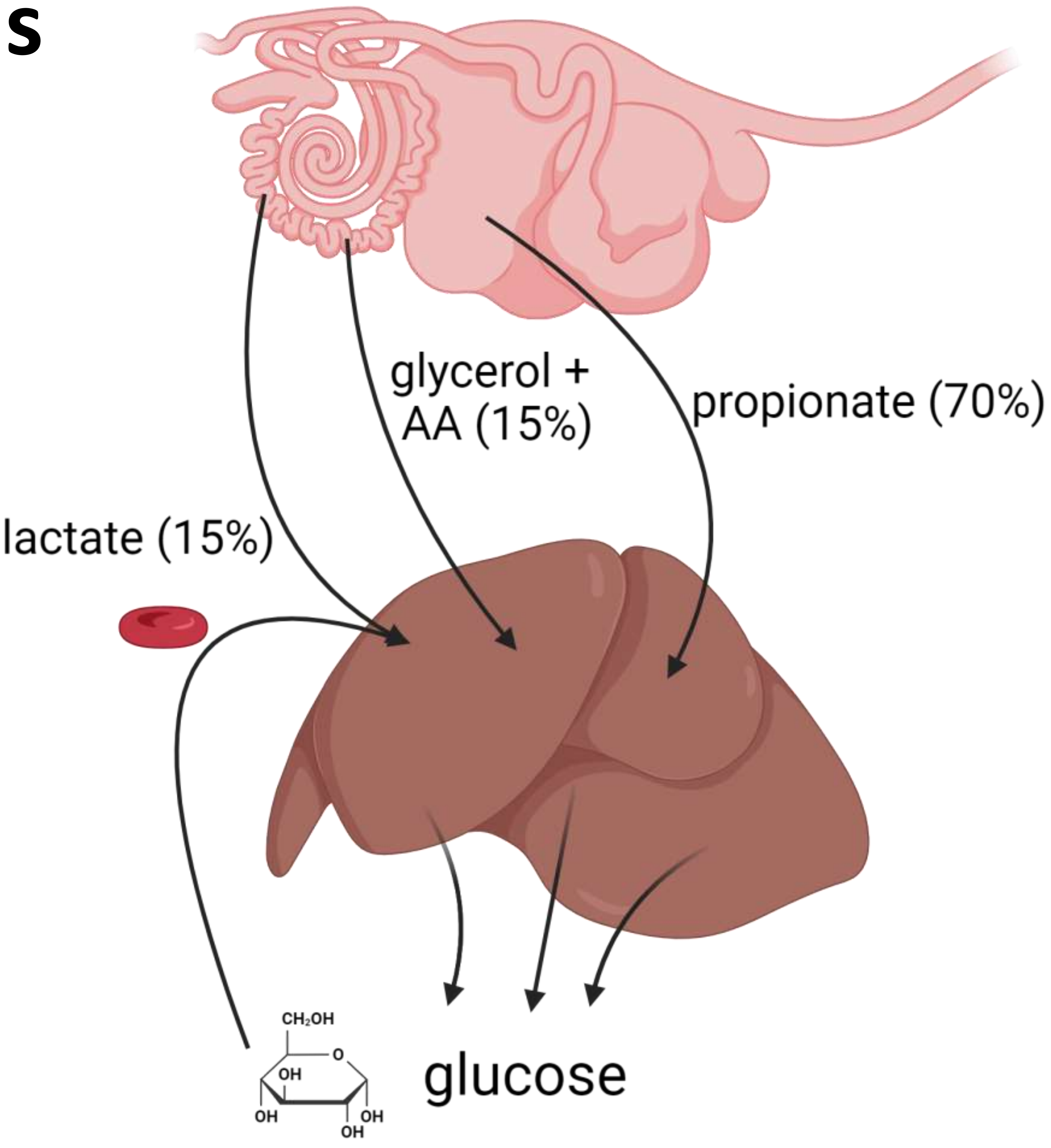
e small intestine: 0.3 g/d

Deficit of 2.6 kg/d!

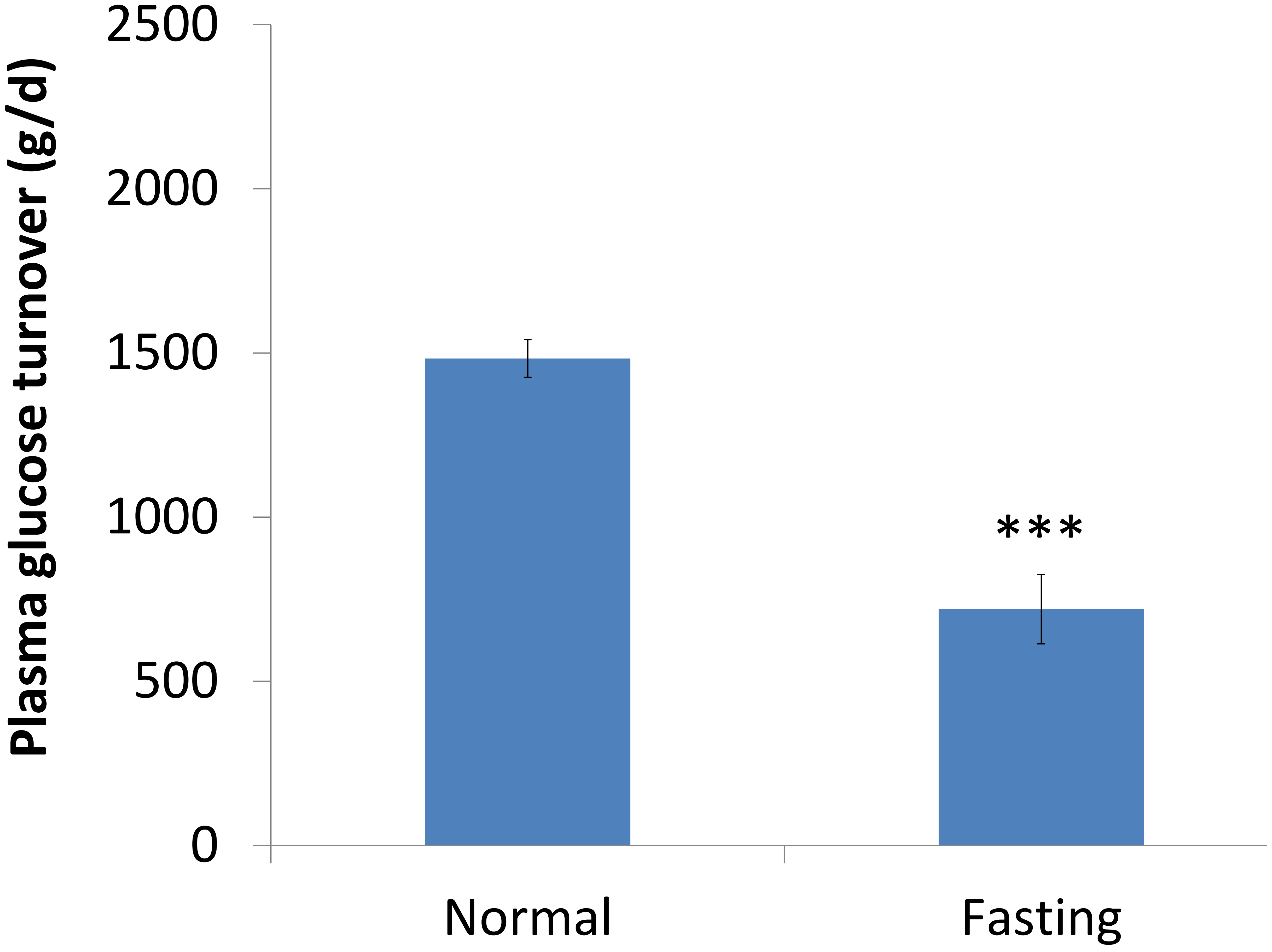
l for glucose: 2.9 kg/d

The solution: gluconeogenesis

- Gluconeogenesis is the process of synthesizing “new” glucose from other substrates
- The liver is thought to account for more than 80% of glucose synthesis (the kidneys are a secondary site)
- Glucose can only be synthesized from certain metabolites; this does NOT include fatty acids or ketones.

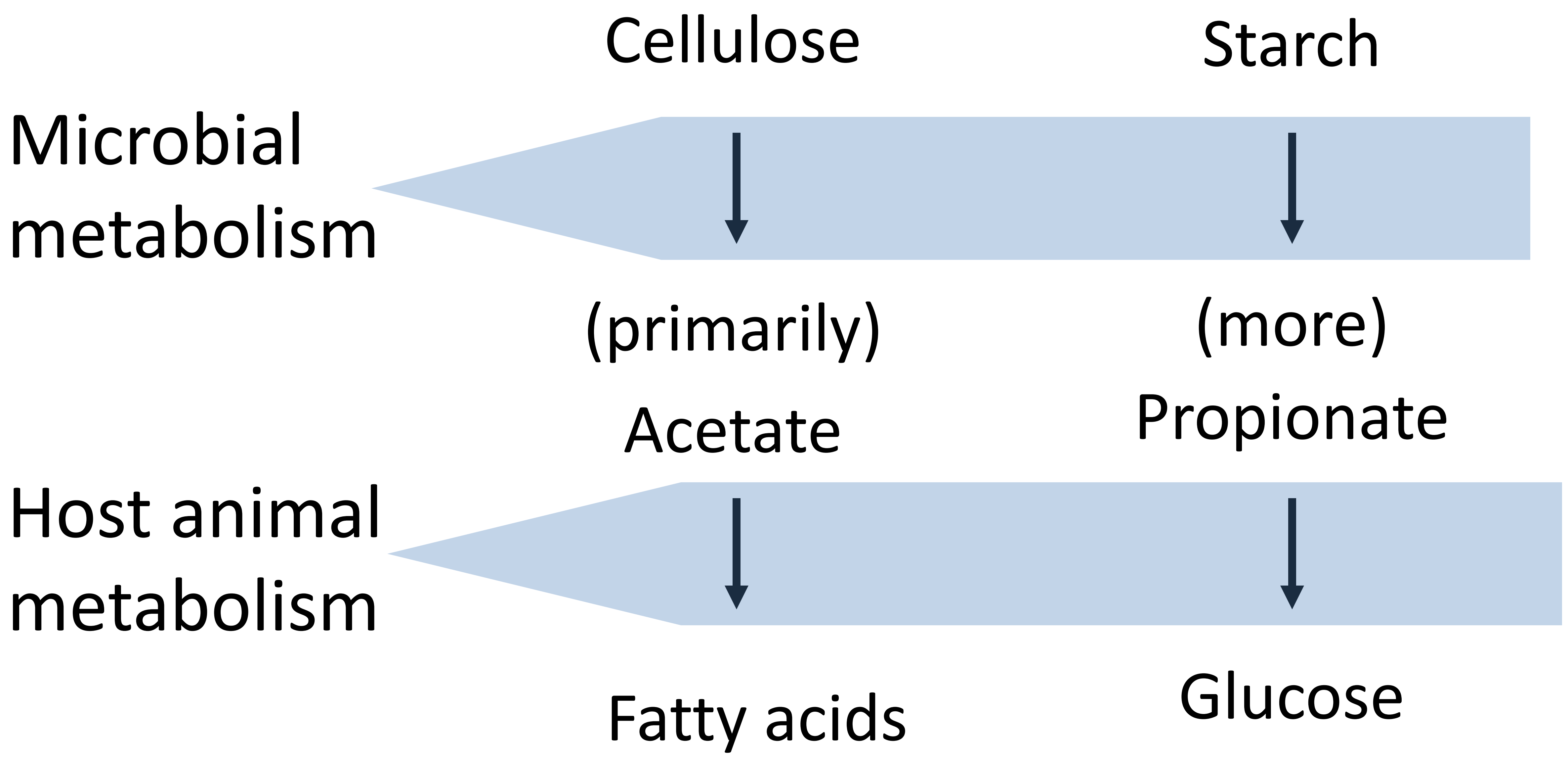


Glucose production depends on substrate supply

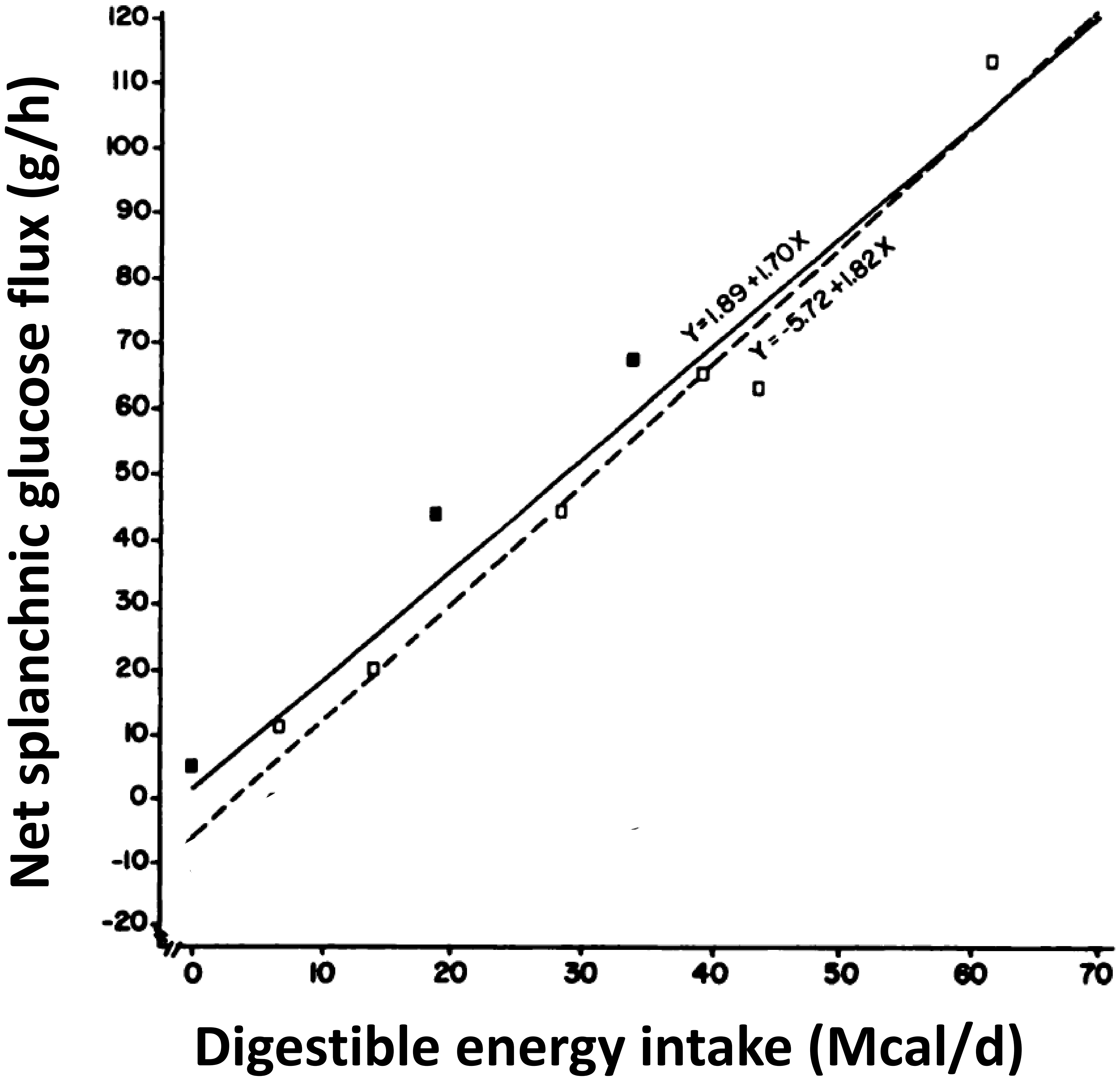


Kronfeld and Raggi, 1964

Different volatile fatty acids play different roles



Low energy diets can limit glucose production



Physical and chemical composition of the diets—main experiment

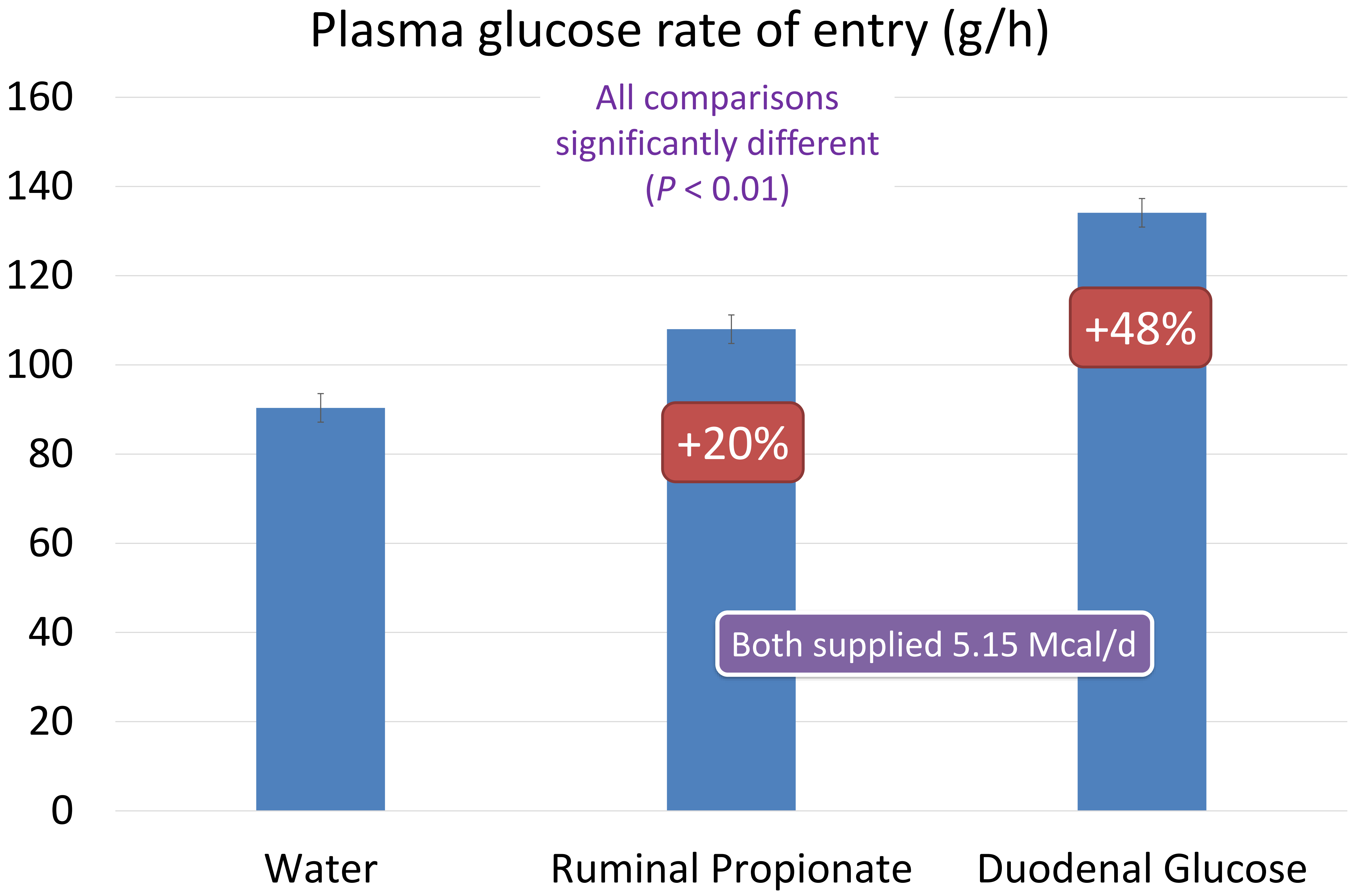
Ingredient	High concentrate	High forage
	% of diet dry matter	
Chopped alfalfa/timothy hay[1]	20.0	65.0
Cracked corn	58.4	29.5
Soybean meal	19.2	4.9
Trace mineral salt[2]	0.4	0.4
Limestone	1.8	—
Phosphorus supplement	—	0.3

Wieghart et al., 1986

When highly digestible diets are not an option…what to do?

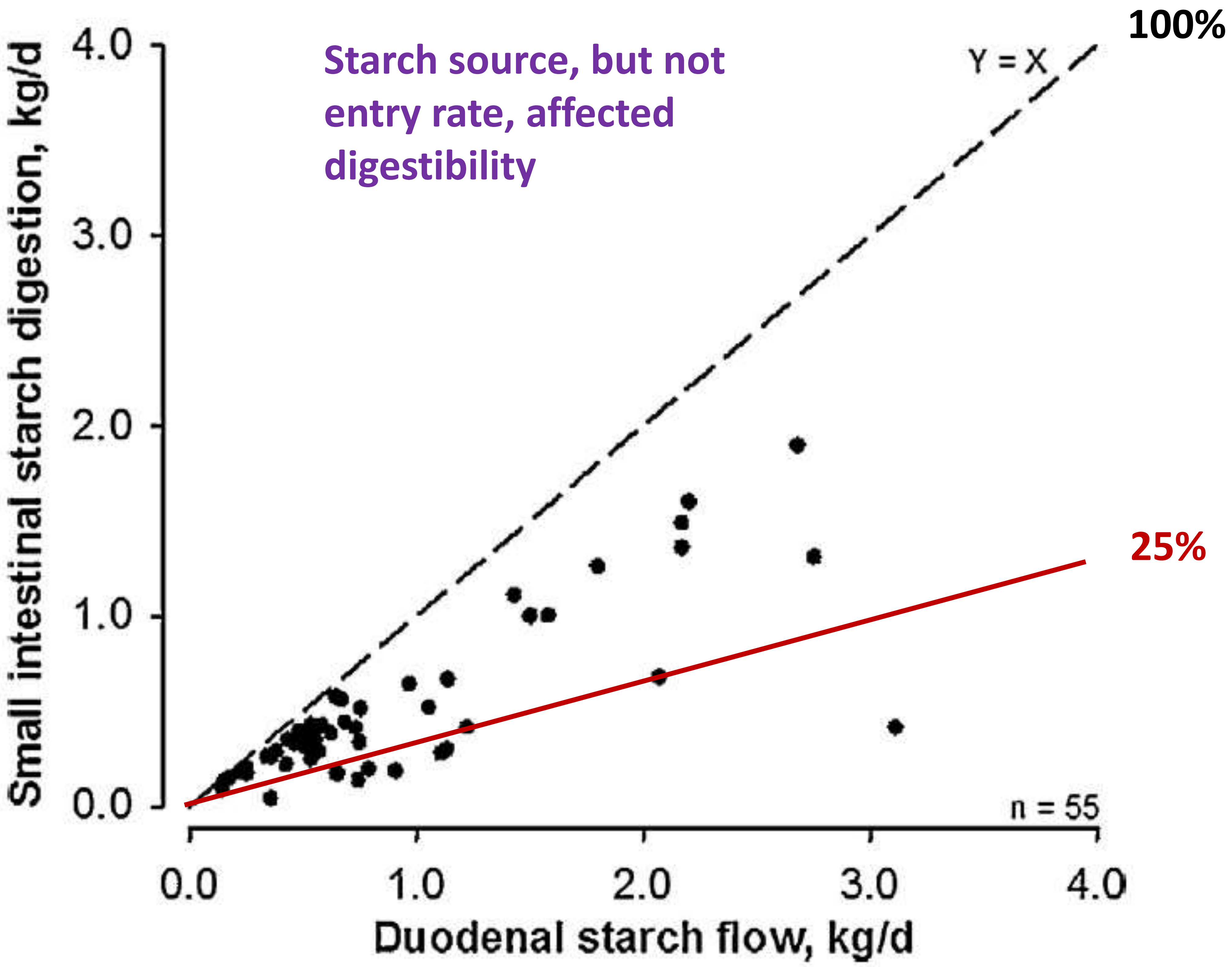
We can use gluconeogenesis or bypass it

- Cows consuming 15.5 kg DM/day, producing 24 kg/d milk
- Infused 1.34 kg/d Na propionate in the rumen OR
- Infused 1.39 kg/d glucose into the duodenum
- No milk response in this case



Lemosquet et al., 2009

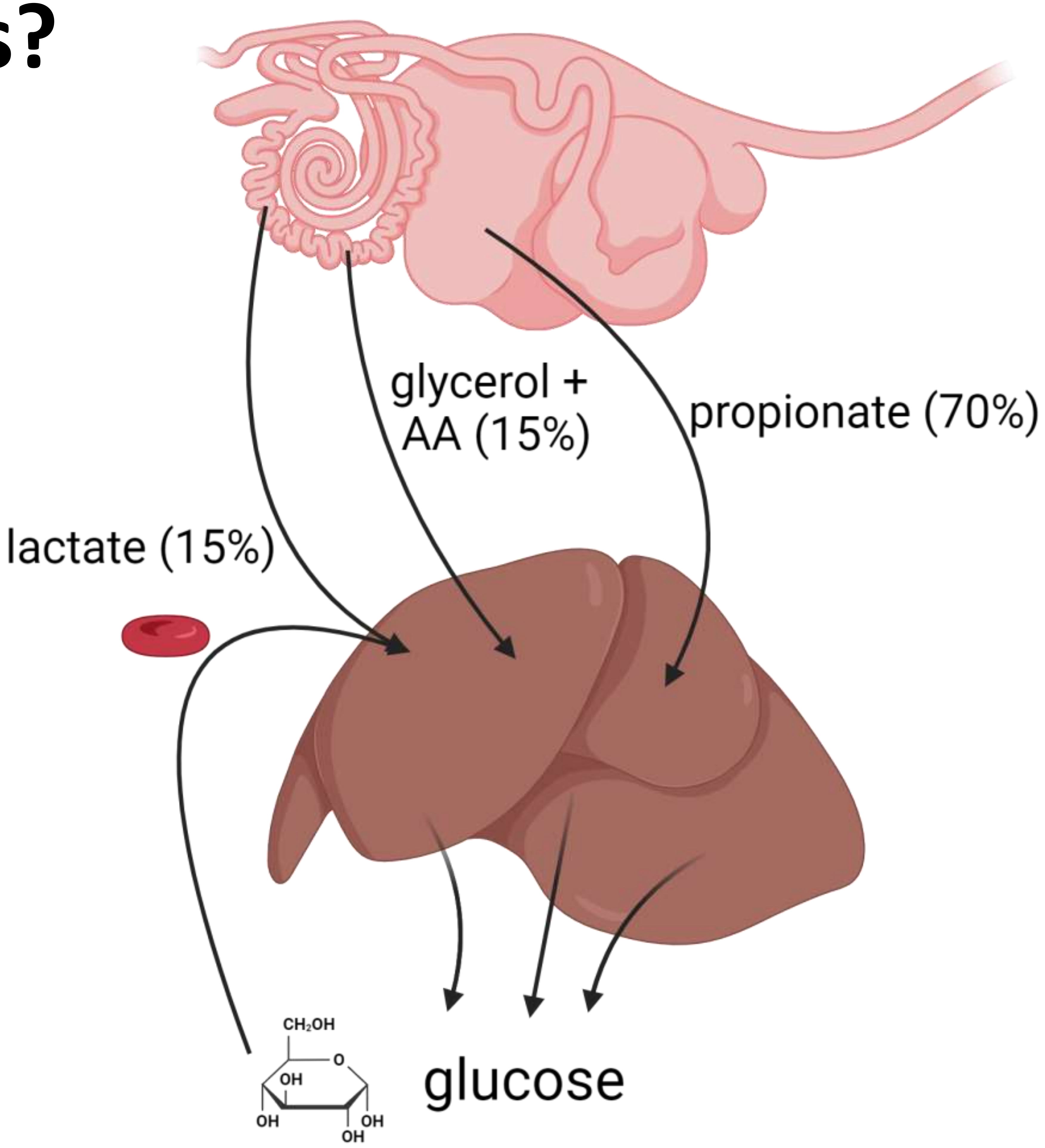
Small intestinal digestion of starch is a means to supply glucose



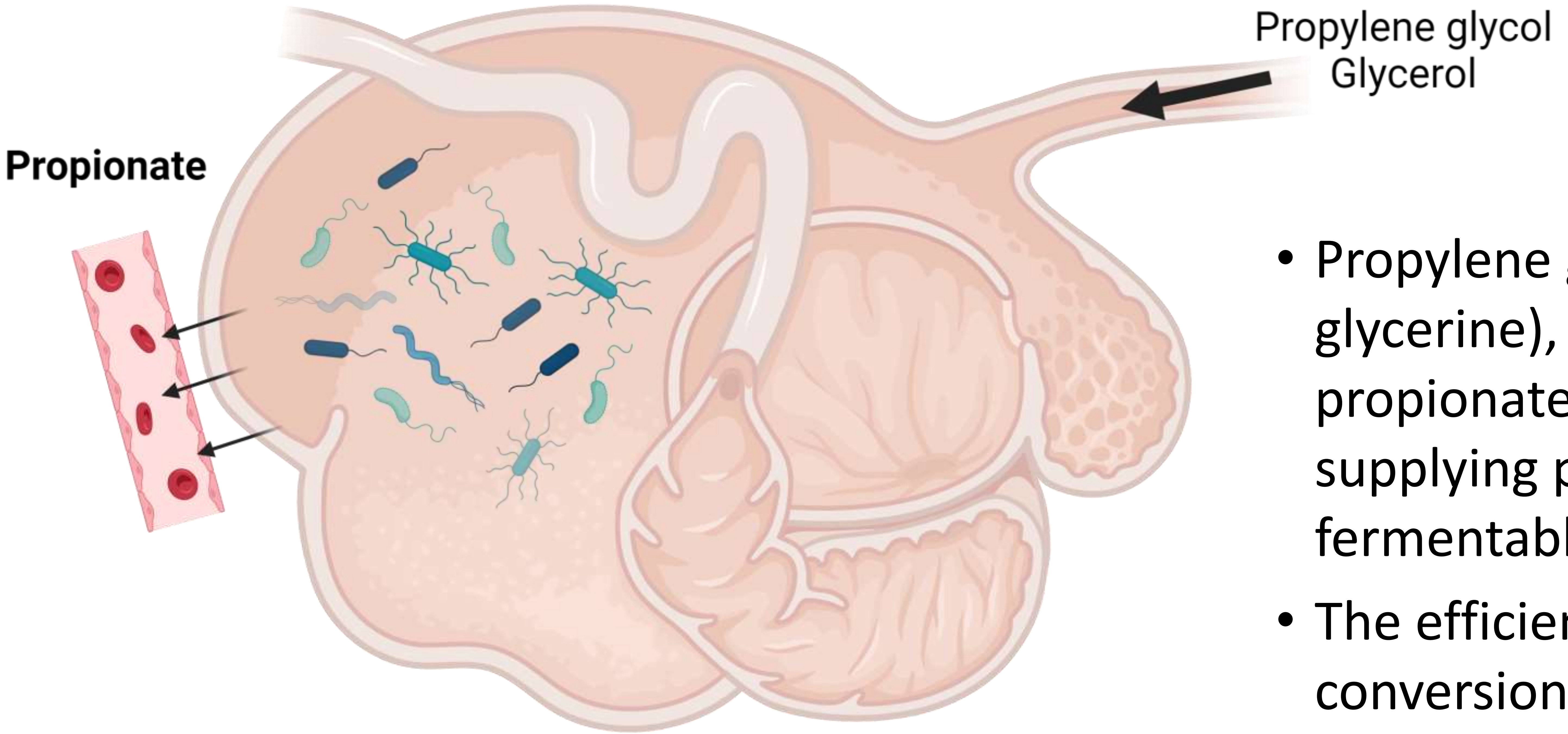
Moharrery et al., 2014

Enhance supply of precursors?

- The substrates at right are produced through digestion and intestinal metabolism of typical feed ingredients.
- However, specialty feeds – including some industrial byproducts – can also be used to supplement these glucose precursors.
- Does feeding these ingredients aid in providing glucose to the cow?

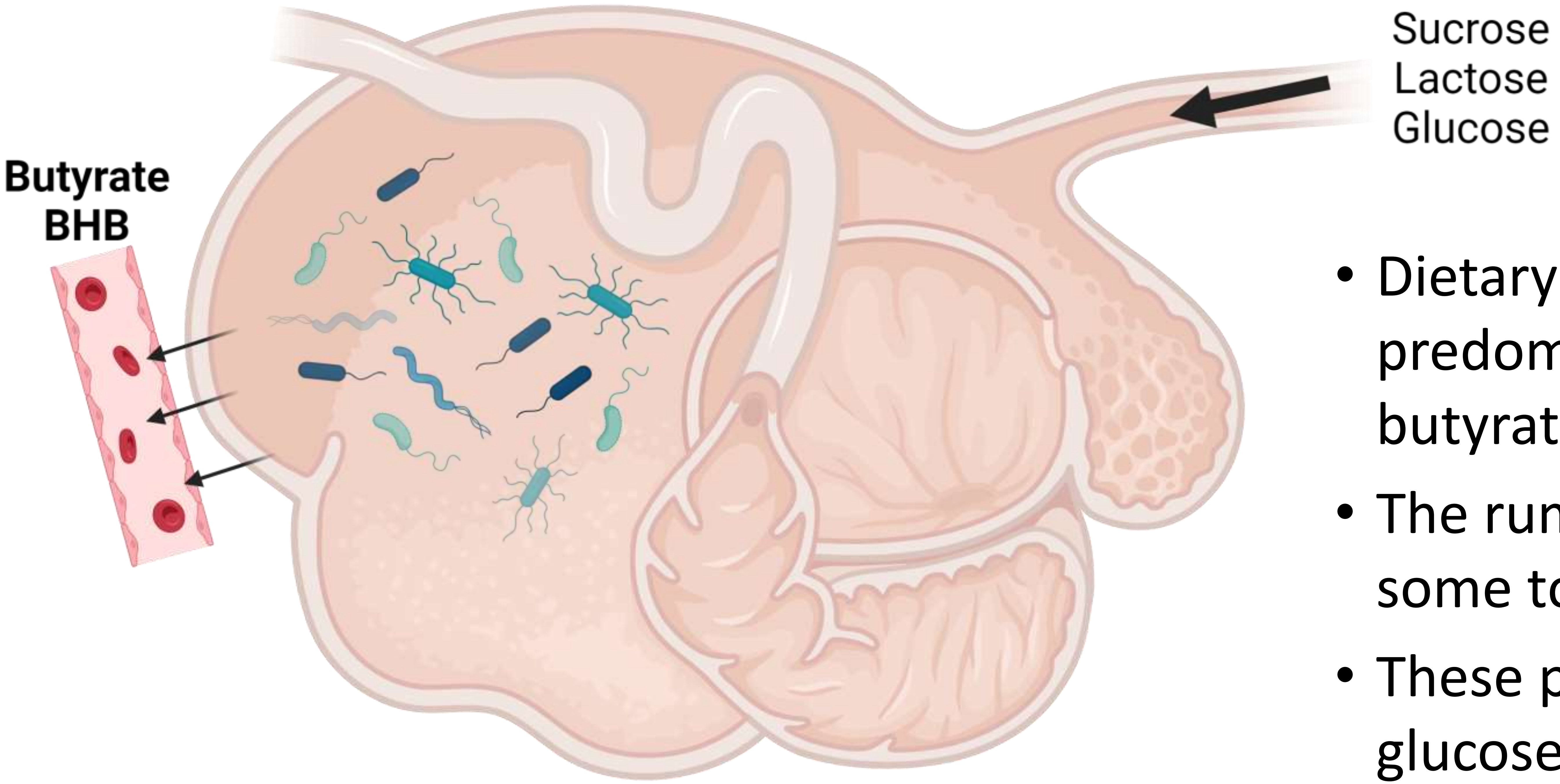


Enhance supply of precursors?



- Propylene glycol, glycerol (or glycerine), and calcium propionate all end up supplying propionate, like fermentable carbohydrates.
- The efficiency of substrate conversion to propionate differs by product.
- Drenching changes things...

Enhance supply of precursors?



- Dietary sugars are predominantly converted to butyrate.
- The rumen wall converts some to β-hydroxybutyrate.
- These products are NOT glucose precursors.

How to provide glucose precursors?

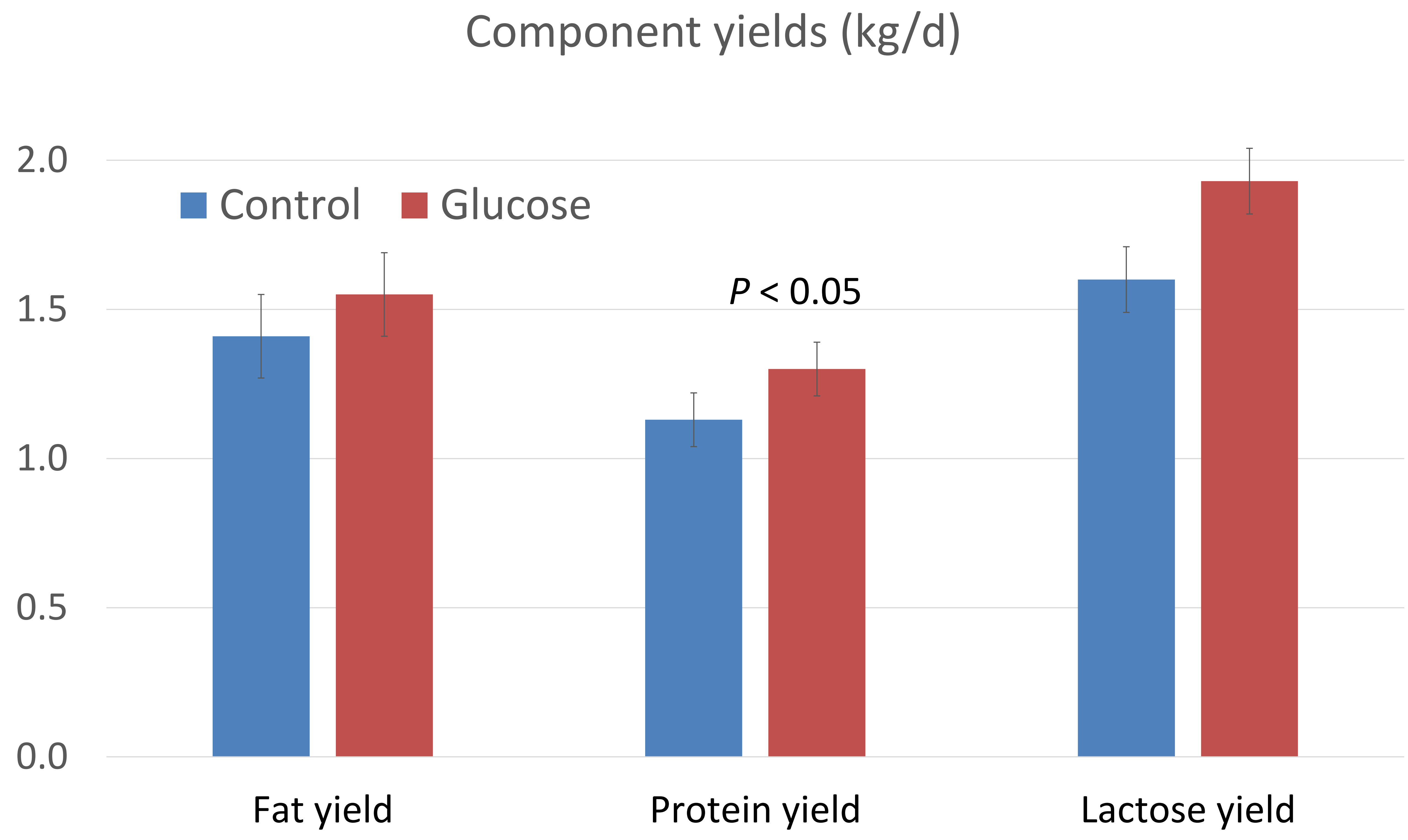
1. Balance fermentable carbohydrate to promote adequate feed intake and **propionate** supply
2. Rumen-bypass starch (e.g. dry corn grain) can provide **glucose** directly to the small intestine
3. Calcium/sodium **propionate**, **propylene glycol**, or **glycerol** can increase propionate supply from the rumen
4. Dietary sugar is mostly fermented to butyrate, not propionate – so it does <u>not</u> contribute to glucose production.

Optimal strategies for using glucose precursors

1. Increasing glucose supply does not always improve milk yield, but it is more likely in low-energy diets

Feed restricted cows respond to glucose infusion

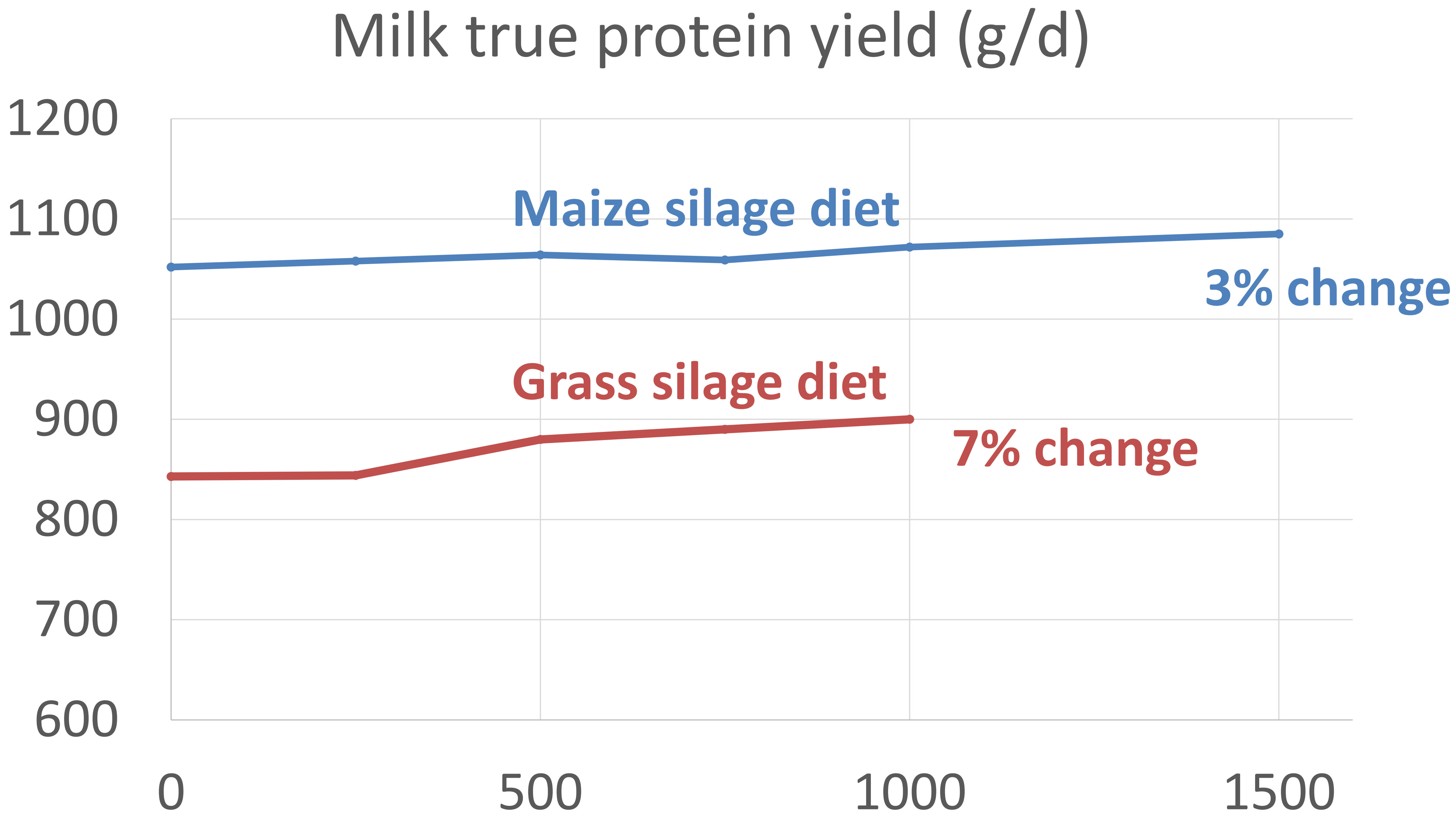
- Cows restricted to 85% of *ad libitum* feed intake
- Glucose infused into the abomasum at 817 g/d



Danes et al., 2020

Basal diet determines impact of glucose infusion

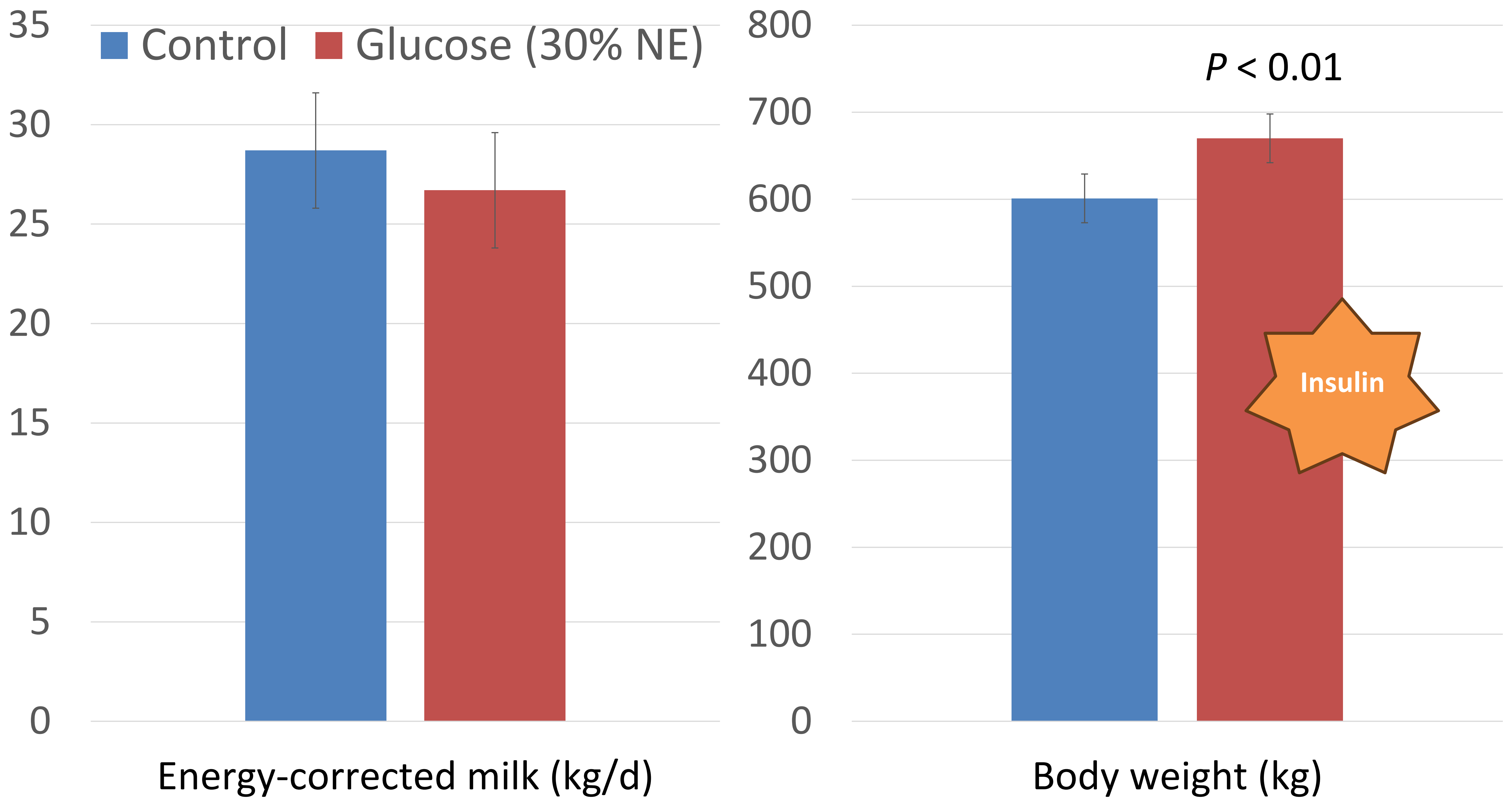
- Cows were fed a diet with 50% maize silage or 40% grass silage
- Glucose infused into the duodenum at increasing doses



Hurtaud et al., 1998 & 2000

Glucose infusions promote body fat, not milk, in post-peak cows

- Cows were at ~200 DIM
- Glucose infused into the jugular vein for 28 days
- Glucose dose slowly increased to 30% of energy requirements by day 24



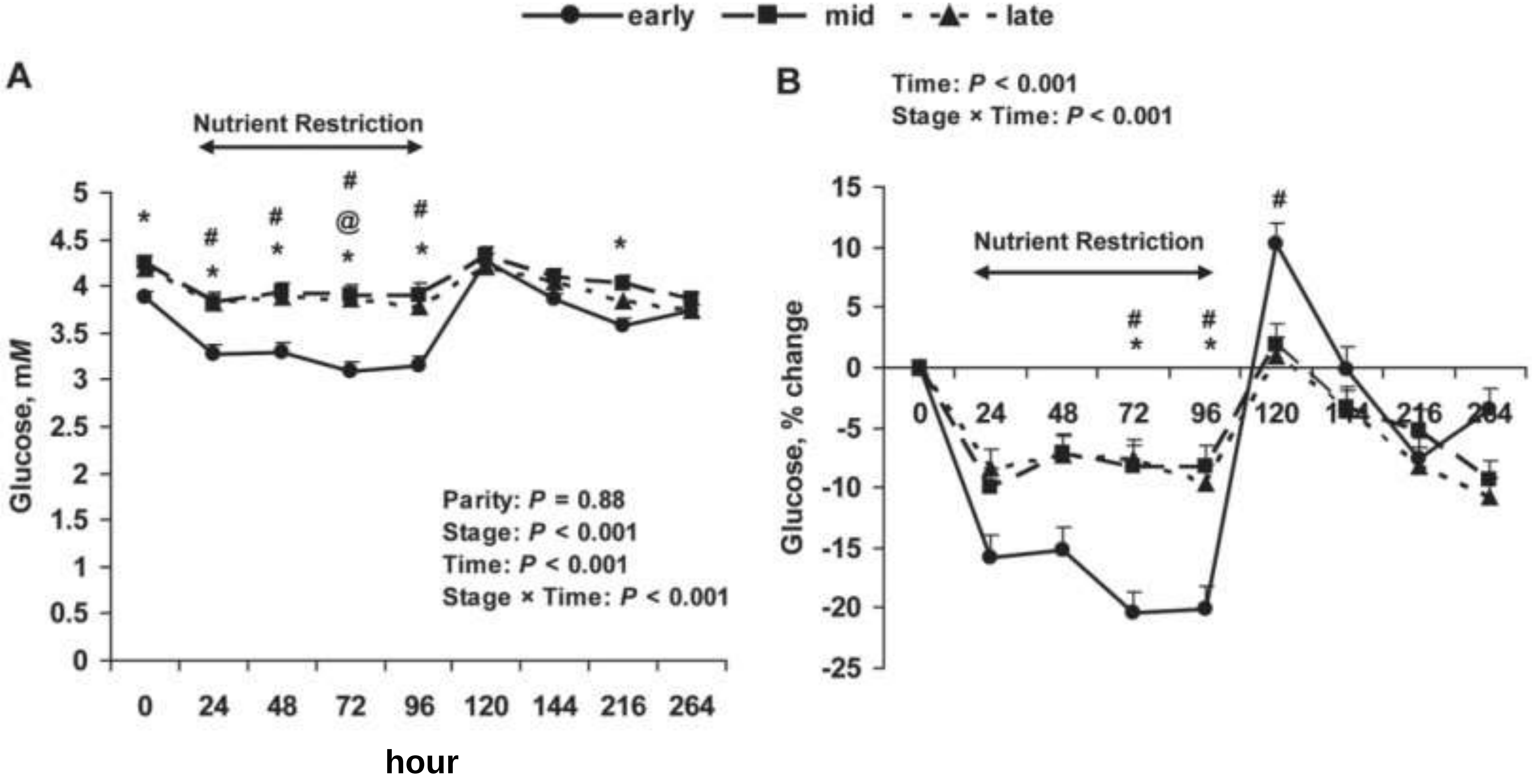
Al-Trad et al., 2009

Optimal strategies for using glucose precursors

1. Increasing glucose supply does not always improve milk yield, but it is more likely in low-energy diets
2. Likely to be most effective in early and peak lactation

Impact of nutrient restriction on glucose homeostasis

- Early: 49 DIM
- Mid: 159 DIM
- Late: 273 DIM
- Diet was diluted with 60% wheat straw for 96 hours

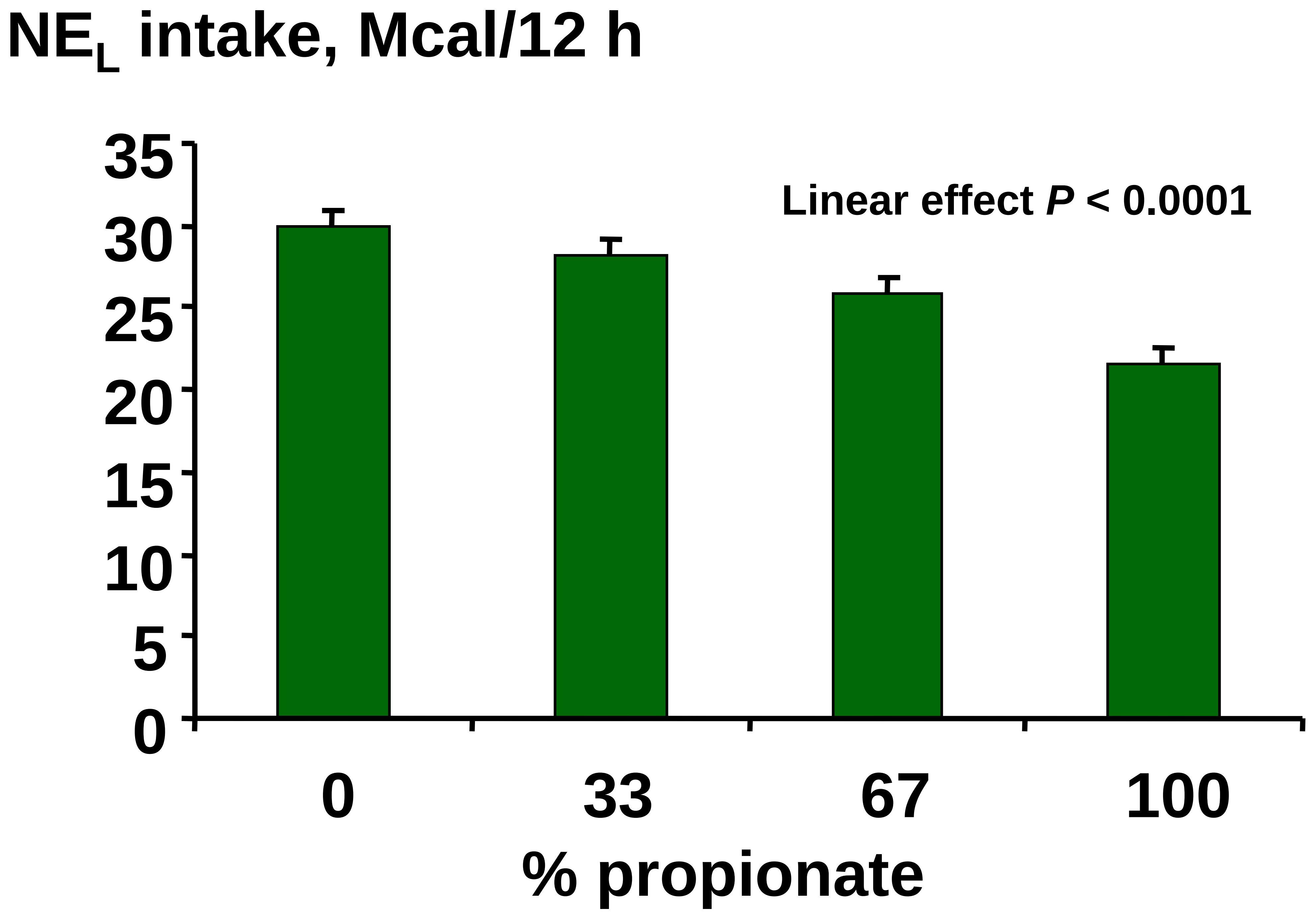


Bjerre-Harpoth et al., 2012

Optimal strategies for using glucose precursors

1. Increasing glucose supply does not always improve milk yield, but it is more likely in low-energy diets
2. Likely to be most effective in early and peak lactation
3. Excessive supply of propionate can suppress appetite and may backfire

Propionate has unique effects on appetite

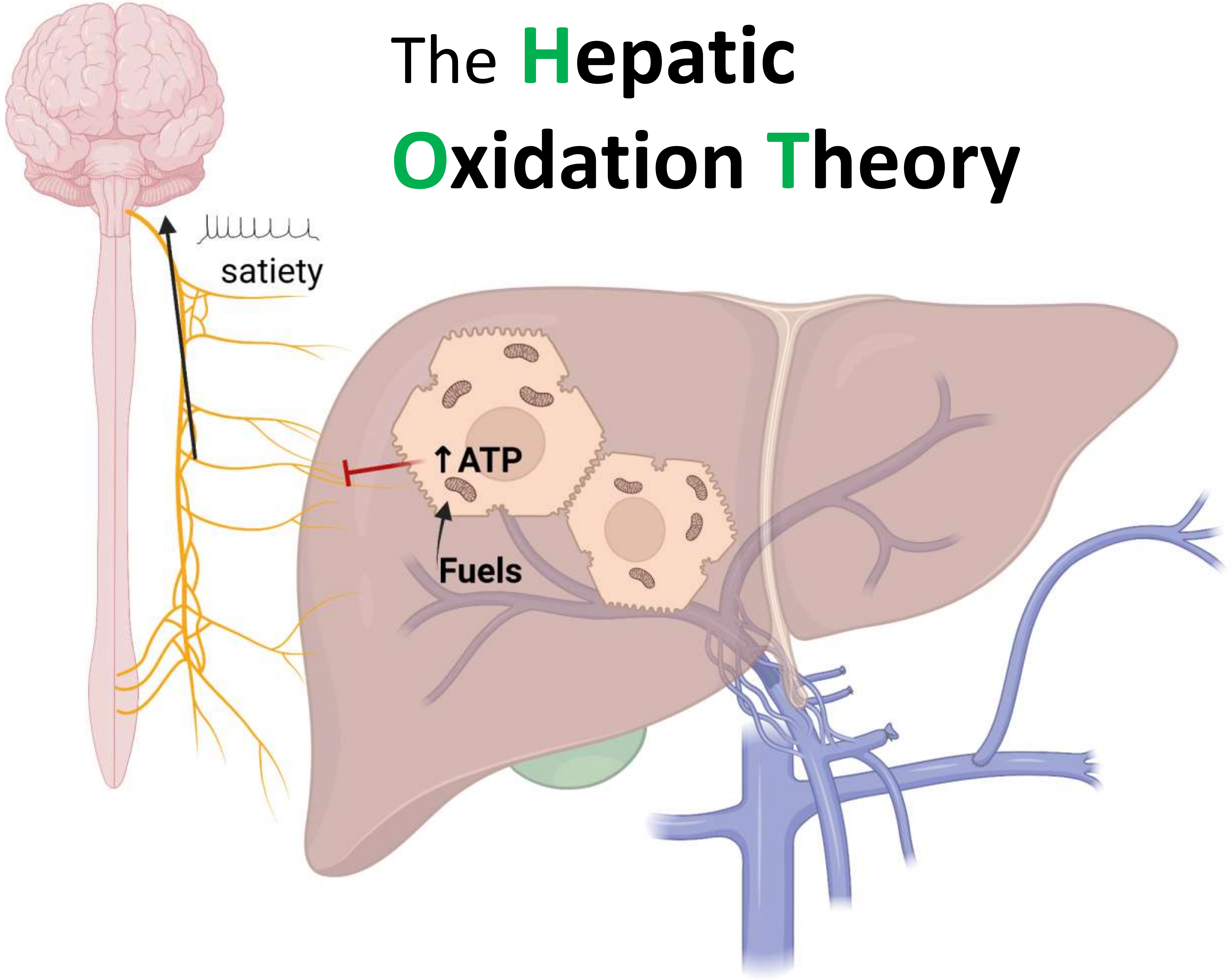


Continuous ruminal infusion of mixtures of propionate and acetate at 1.5 mol/h from 2 h before feeding until 12 h after feeding

NE$_L$ intake = feed + VFA

Oba and Allen, 2003 J. Nutr. 133:1094

The Hepatic Oxidation Theory



- ✓ The liver is in an optimal anatomic location to monitor incoming nutrients.
- ✓ In ruminants, propionate is almost all taken up by the liver from the portal blood flowing from the gut.
- ✓ Propionate that exceeds the rate of use for glucose production can be oxidized, rapidly generating ATP that contributes to the cow feeling full.
- ✓ This results in shorter meals and lesser feed intake.

Optimal strategies for using glucose precursors

1. Increasing glucose supply does not always improve milk yield, but it is more likely in low-energy diets
2. Likely to be most effective in early and peak lactation
3. Excessive supply of propionate can suppress appetite and may backfire
4. Consider impacts of substrate on digestion of other feeds
   - Any risk of negative impacts on digestion of base diet?
   - Is nitrogen the main limitation? Urea may drive more propionate by allowing for better fiber digestion.

Optimal strategies for using glucose precursors

1. Increasing glucose supply does not always improve milk yield, but it is more likely in low-energy diets
2. Likely to be most effective in early and peak lactation
3. Excessive supply of propionate can suppress appetite and may backfire
4. Consider impacts of substrate on digestion of other feeds
5. Assess carefully whether specialty feeds are more cost-effective than cereal grains


Thank you!
Questions?

Su opinión
es muy valiosa para nosotros

Llene una breve encuesta y quede participando en la rifa de un obsequio de nuestros patrocinadores

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