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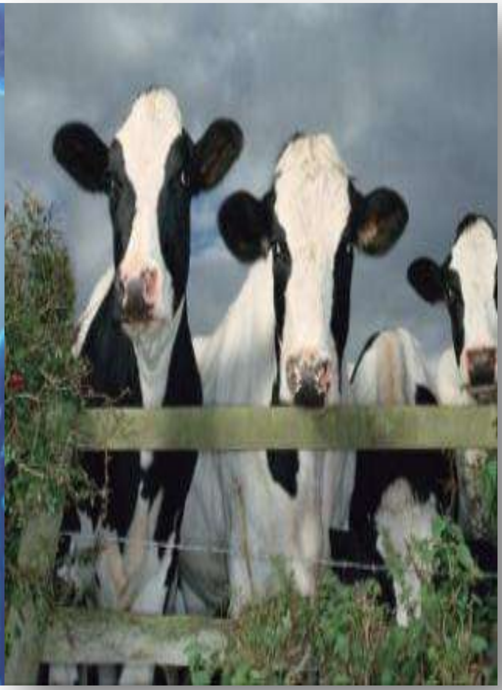
Strategic application of direct-fed microbials to livestock for growth efficiency and production

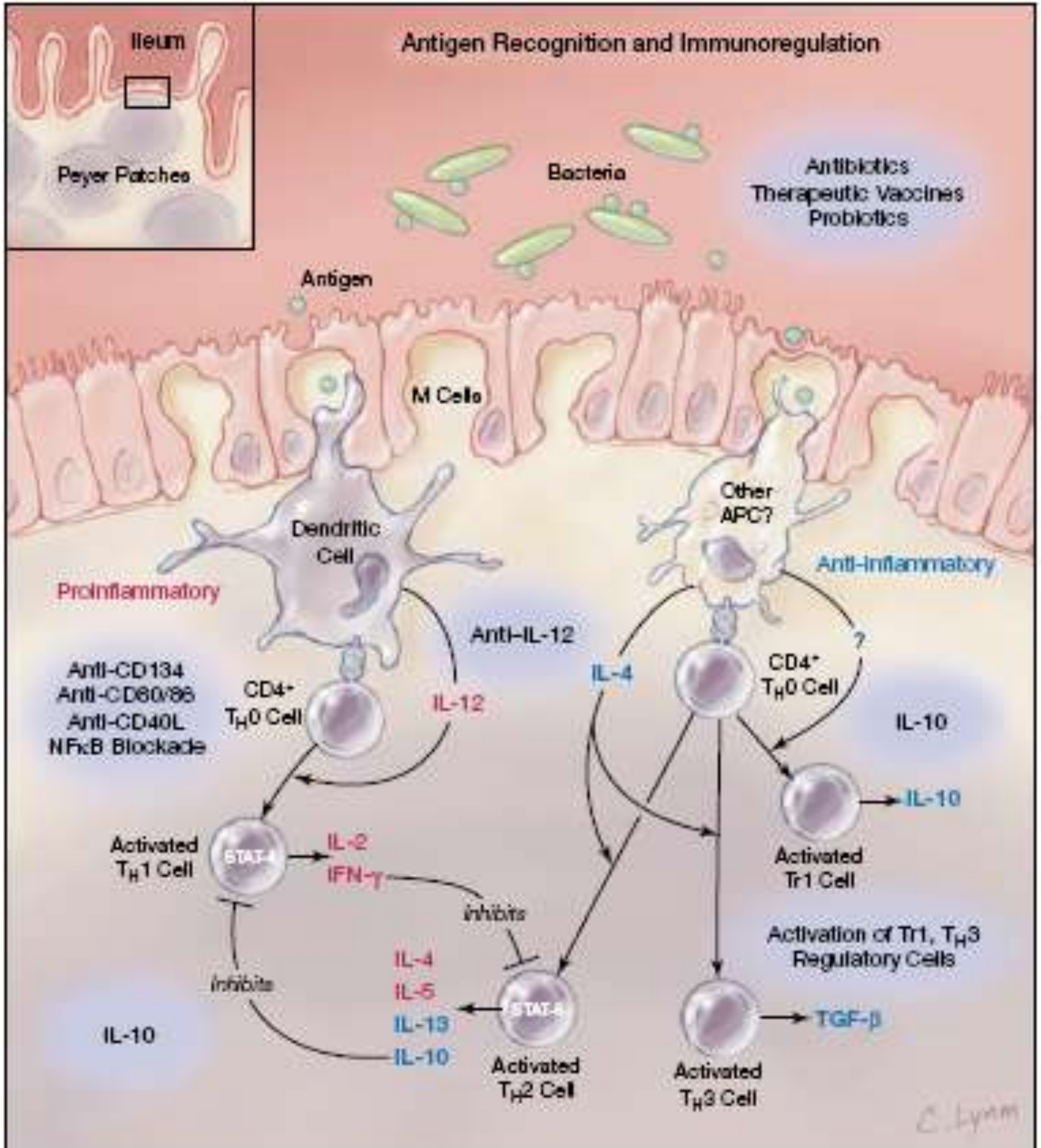
E. Davis and T. Rehberger; Danisco USA; Waukesha, WI, USA





Presentation Outline

- Gastrointestinal Microbiota → Immune Development → Performance
- Direct-fed microbial application and neonatal development
- Direct-fed microbial application in later production
- Importance of strategic selection and application of DFMs



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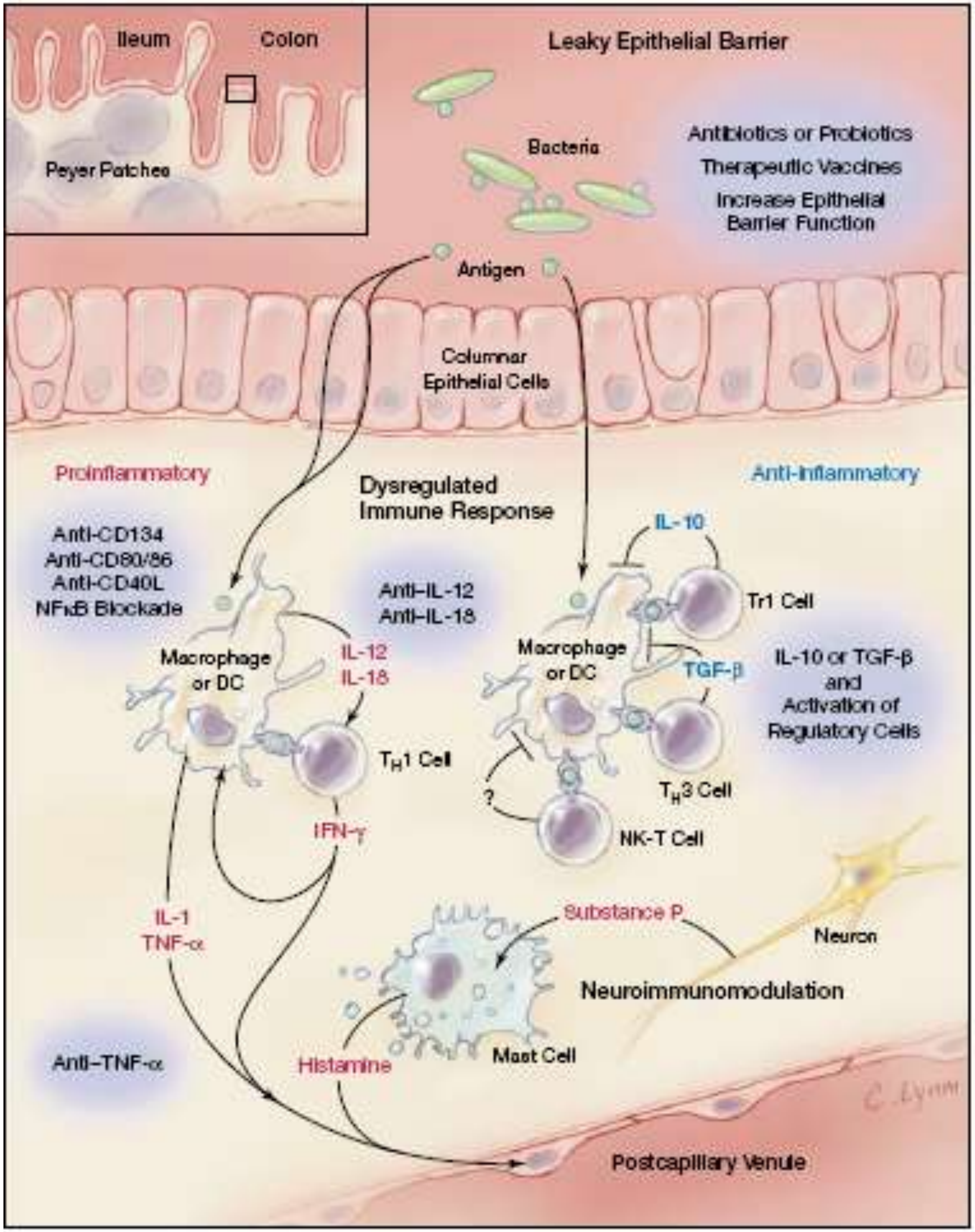

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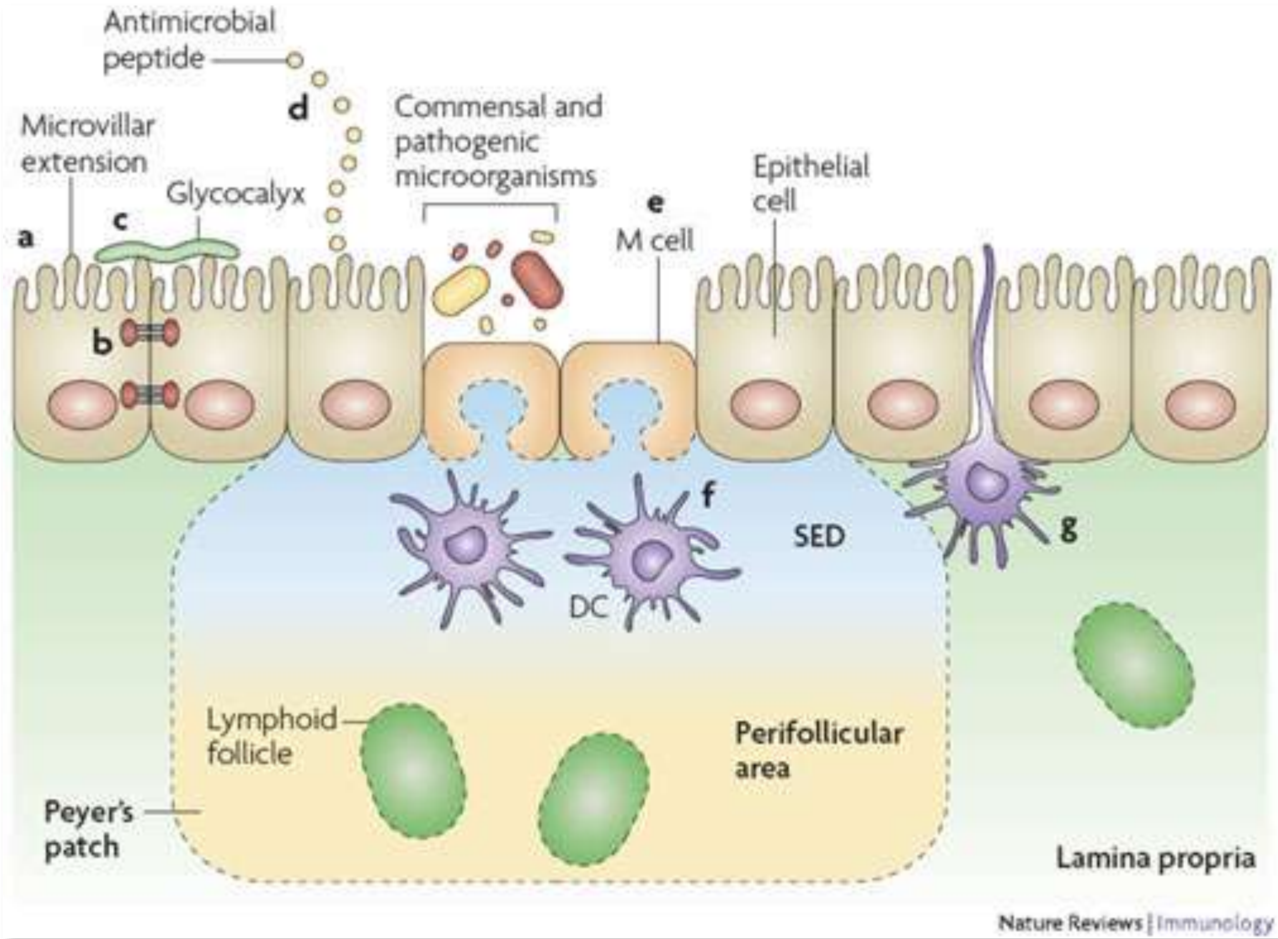
Immune Homeostasis in the Gastrointestinal Tract



Artis, 2008

Growth Performance Association with Intestinal Immune Cell Phenotypes

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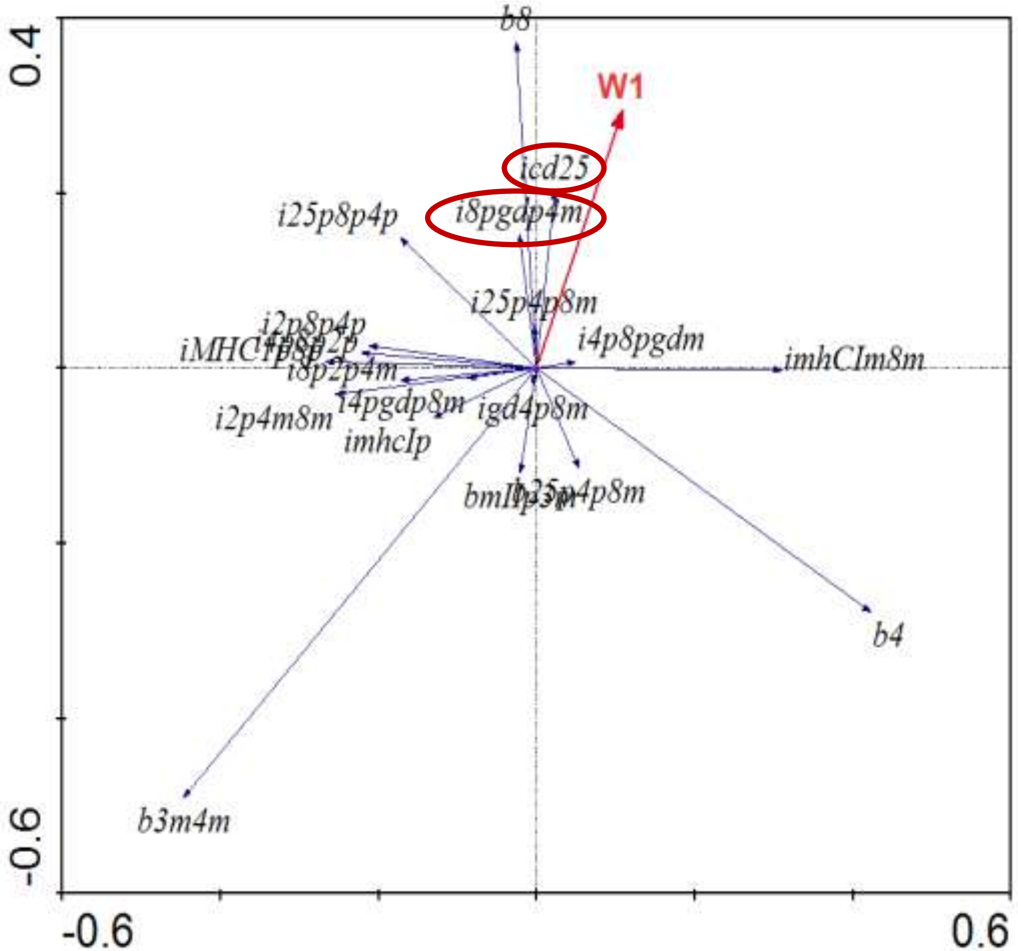
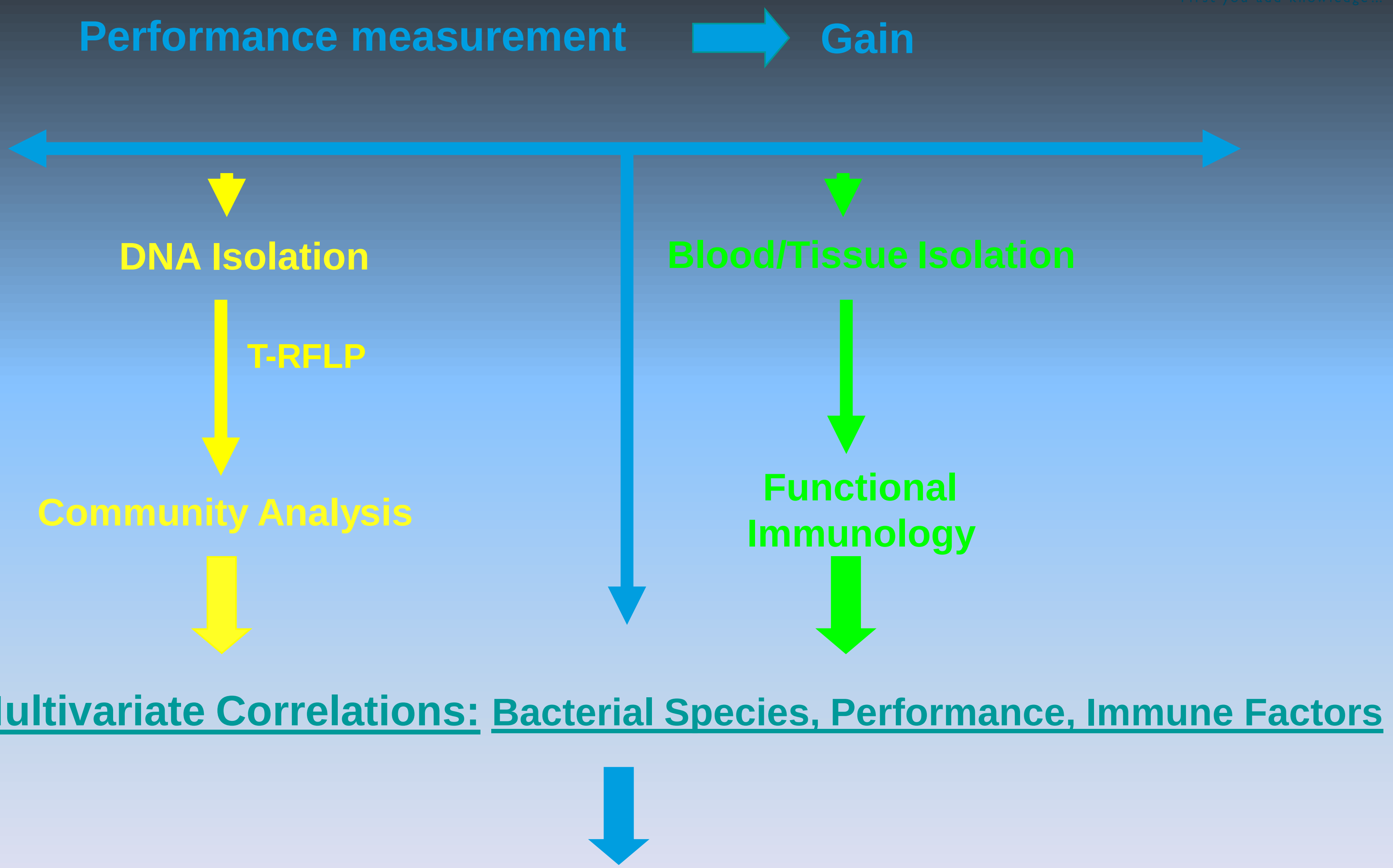
Jejunal intraepithelial lymphocyte phenotypes positively correlated to pig body weight 11 days post-weaning



Immune cell (IEL) phenotype	*P*-value
$CD4^{+}TCR1^{+}CD8^{-}$	0.009
$CD8^{+}TCR1^{+}CD4^{-}$	0.013
$CD4^{+}CD8^{+}CD2^{+}$	0.019
$CD2^{+}CD8^{+}CD4^{+}$	0.023
$TCR1^{+}CD4^{+}CD8^{-}$	0.040
$CD25^{+}$	0.055

Davis et al., 2009; AAI San Diego



Use of molecular approaches in combination with “natural” models to identify important microbial contributors

DFM and Neonatal Development

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- DFM—*Bacillus* strains selected for ability to inhibit clostridia in neonatal pigs
- 208 mixed parity sows housed at a commercial swine research farm
- Diets
  1. Control – Standard corn-soybean meal diet
  2. DFM – Control diet supplemented with *Bacillus* combination (3.75 x 10^5 cfu's feed) fed 6 weeks prior to and throughout lactation
- Characterization of gastrointestinal microbiota

  Samples

  - 21 piglets were euthanized from each sow treatment group on day 3 of lactation
  - 15 piglets were euthanized from each sow treatment group on day 10 of lactation

  Dissection – ileum and colon samples

Litter performance with DFM supplementation to the sow

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	Litter size	Initial litter weight, lbs.	Litter weaning weight, lbs.	Litter ADG lbs.	Weaned litter size	PWM %
DFM	10.99	37.14	136.27	5.01	9.86	10.41
Control	10.95	33.97	128.76	4.74	9.56	12.76
SEM	0.06	1.28	3.15	0.16	0.16	1.54
P value	0.54	0.01	0.02	0.09	0.06	0.12

Administration of a Bacillus-based DFM shifts intestinal microbiota toward specific Lactobacillus populations

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Day 3 Colon

	Peak	P Value	Putative Identification
DFM			
	B423	0.009	*Lactobacillus gasseri, L. johnsonii*
	M187	0.07	*Lactobacillus gasseri, L. johnsonii, L. sakei*
	H330	0.08	*Lactobacillus gasseri, L. johnsonii, L. crispatus*
Control			
	M220	0.003	*Clostridium sp., Eubacterium sp.*
	M495	0.003	*E. coli and other enterics*
	M89	0.01	*Flexibacter sp., Flavobacterium sp., Bacteriodes sp.*
	B387	0.02	*Clostridium ramosum, Mycoplasma sp., Pseudomonas sp., Brevibacillus sp.*
	B518	0.03	*Bacteroides sp., Flavobacterium sp., Prevotella sp.*
	B394	0.04	*E. coli and other enterics*
	M96	0.04	*Bacteroides sp., Prevotella sp.*
	H251	0.04	*Clostridium sp., Mycoplasma sp.*
	M214	0.04	*Clostridium hungatei*
	M486	0.07	*Eubacterium sp., Flavobacterium sp., Pseudomonas sp.*
	M92	0.07	*Bacteriodes sp., Flavobacterium sp., Flexibacter sp., Prevotella sp.*
	H240	0.08	*Eubacterium sp., Paenibacillus alvei*
	M539	0.08	*Mycoplasma sp.*

Administration of a Bacillus-based DFM shifts intestinal microbiota toward specific Lactobacillus populations

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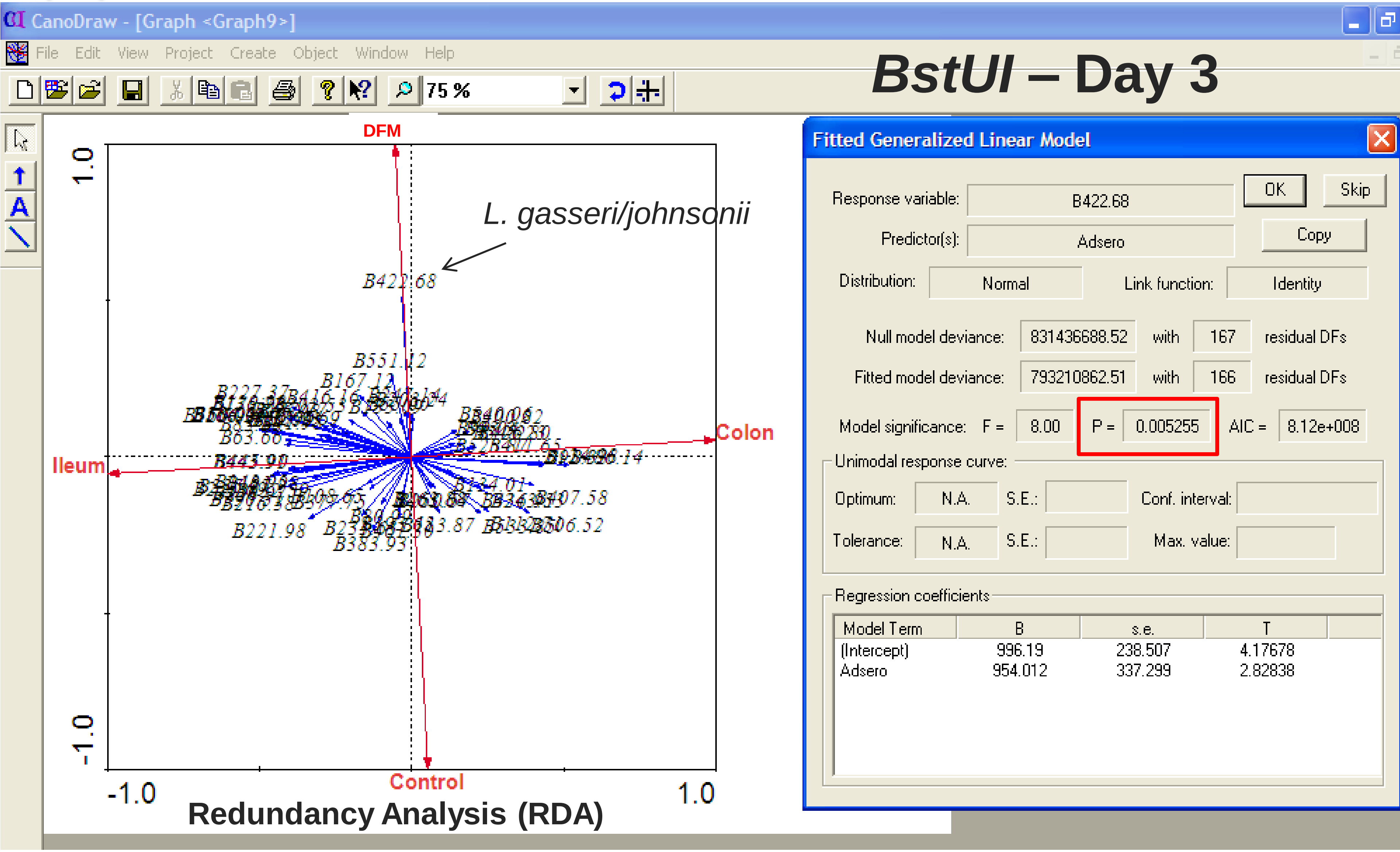
Day 10 Colon

	Peak	P Value	Putative Identification
DFM			
	B417	0.003	*Lactobacillus alimentarus, L. bifermentas*
	H333	0.01	*Lactobacillus sakei, L. hilgardii*
	M280	0.02	*Lactobacillus sp., Bifidobacterium sp., Eubacterium sp., Fusobacterium sp., Microbacterium sp.*
	B423	0.02	*Lactobacillus gasseri, L. johnsonii*
	H330	0.02	*Lactobacillus gasseri, L. johnsonii, L. sakei*
	B247	0.02	*Lactobacillus reuteri*
	H279	0.05	*Lactobacillus brevis, L. delbrueckii, L. salivarius*
	B262	0.05	*Lactobacillus crispatus, L. fructovorans, L. sanfranciscensis, Pediococcus acidilactici*
	B250	0.07	*Lactobacillus acidophilus, L. brevis, L. delbrueckii, L. manihotivorans, L. plantarum, L. salivarius*
	M569	0.07	*Lactobacillus sp.*
Control			
	M134	0.08	*Bacillus sp., Bifidobacterium sp., Mycoplasma sp., Paenibacillus sp.*

Administration of a Bacillus-based DFM shifts intestinal microbiota toward specific Lactobacillus populations



SWC3- and SWC9-defined myeloid cell subsets within the MHC II^{+} immune cell population in colostrum

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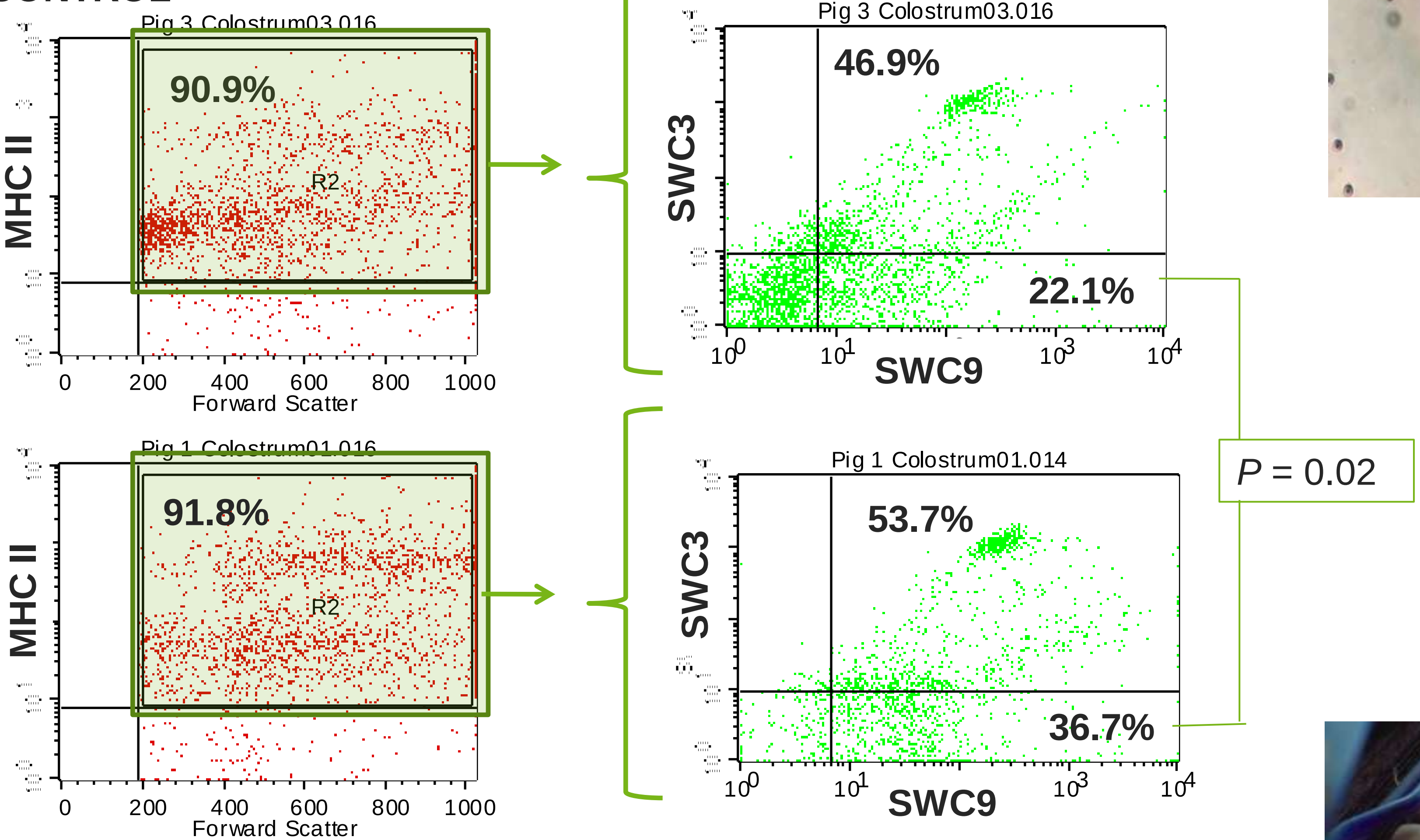
CONTROL



***Bacillus* DFM**

SWC3- and SWC9-defined myeloid cell subsets within the MHC II$^+$ population—piglet PBMC at 3 days of age

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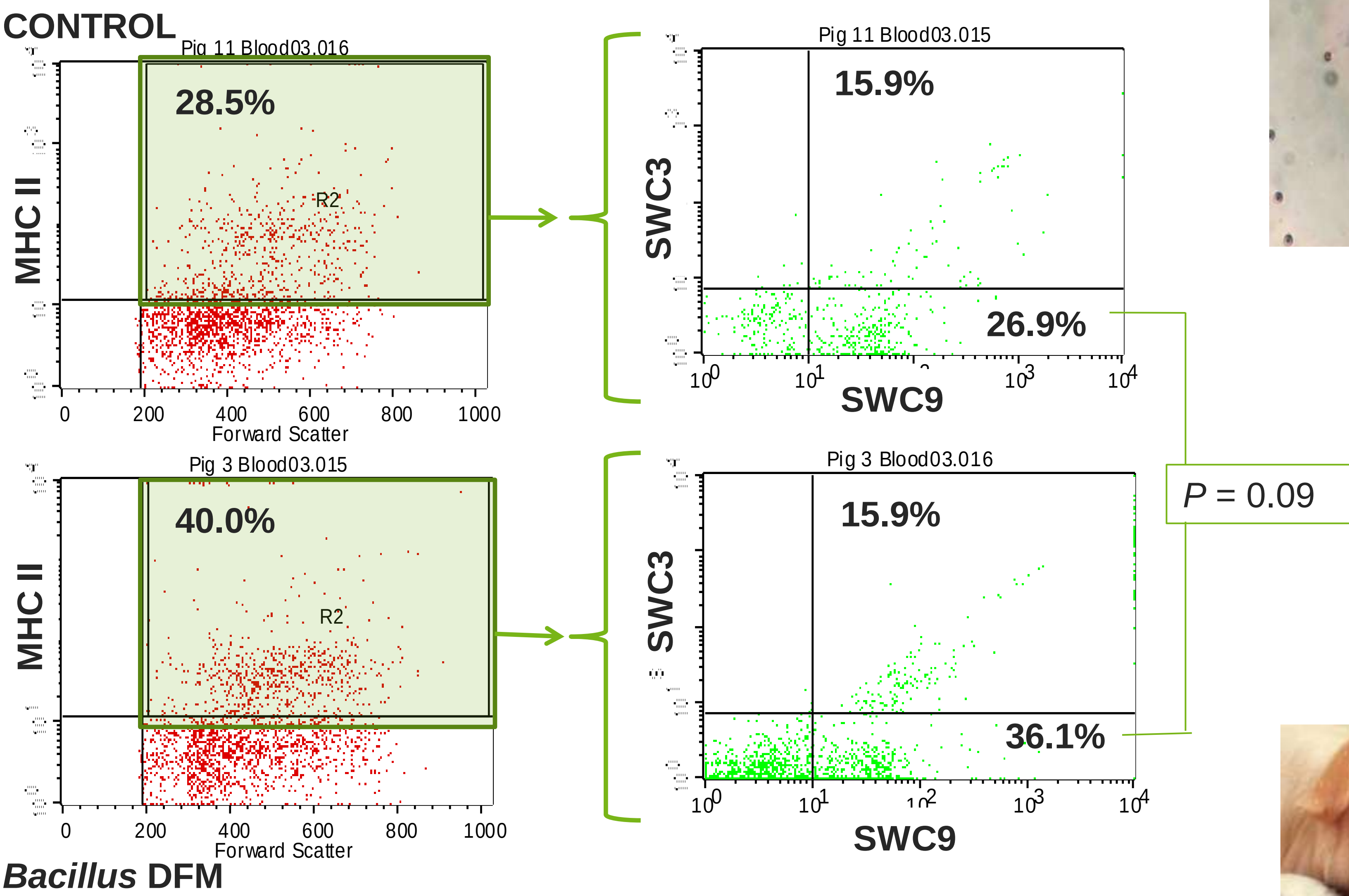
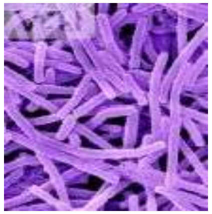


Bacillus-based DFM Application

Sow

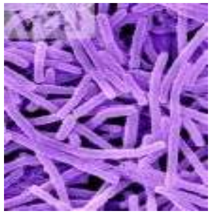
Piglets

Colostrum



Microbial
??

Systemic and
Intestinal
Development



Microbial
Development

DFM Application to Dairy Cows for Increased Milk Production

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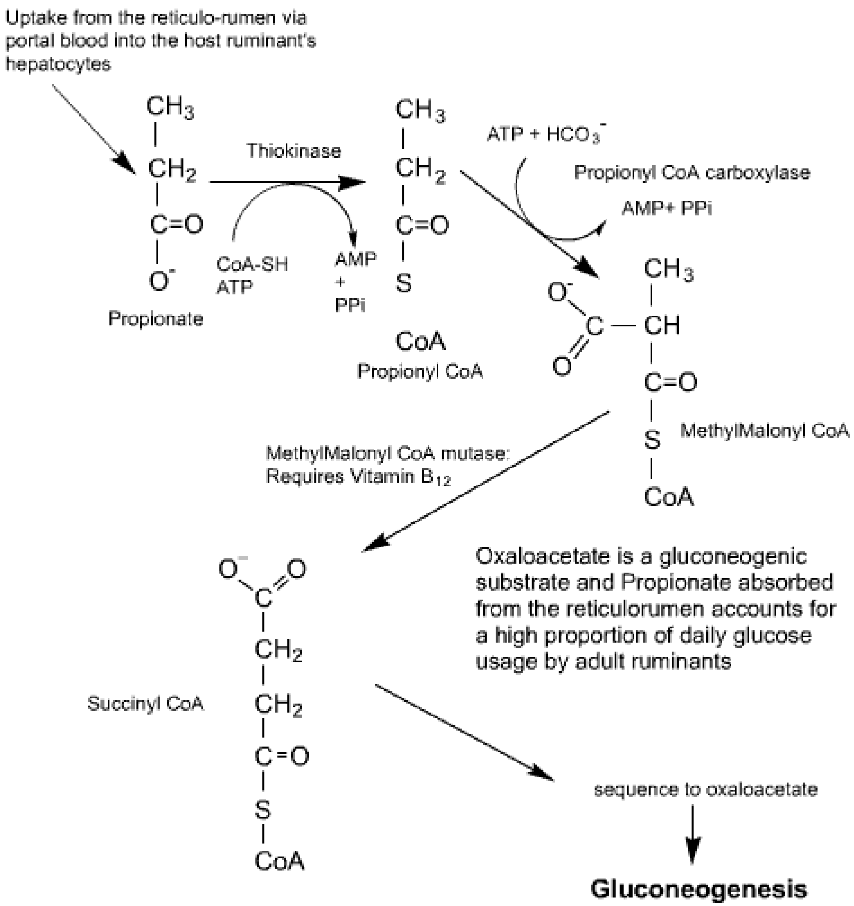
Metabolic Effects of Propionate



- Increase in ruminal propionate production results in:
  - Increased gluconeogenesis
  - Increased plasma insulin
  - Increase plasma leptin
  - Increased feed efficiency
  - Increase milk production
  - Increase reproductive efficiency

Propionibacterium

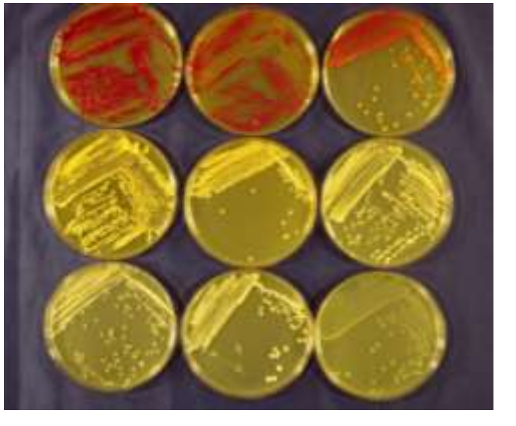
Applications for Dairy Cows

Objectives:

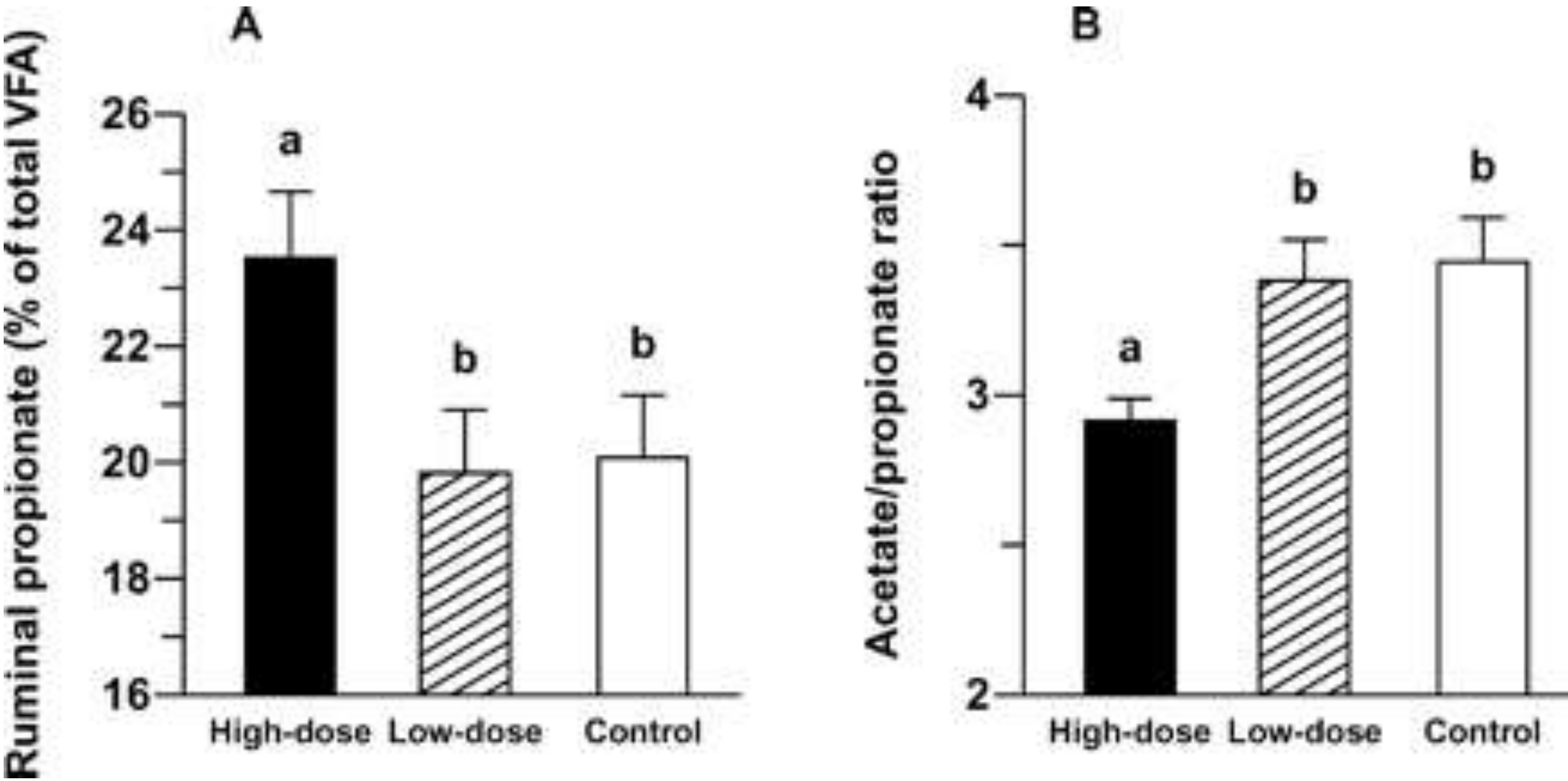
1. *To isolate and characterize native propionibacteria strains from the rumen of dairy cows*

2. *To select propionibacteria strains capable of producing high levels of propionate under typical conditions in the rumen of lactating dairy cows*

***Propionibacterium* Strain P169**

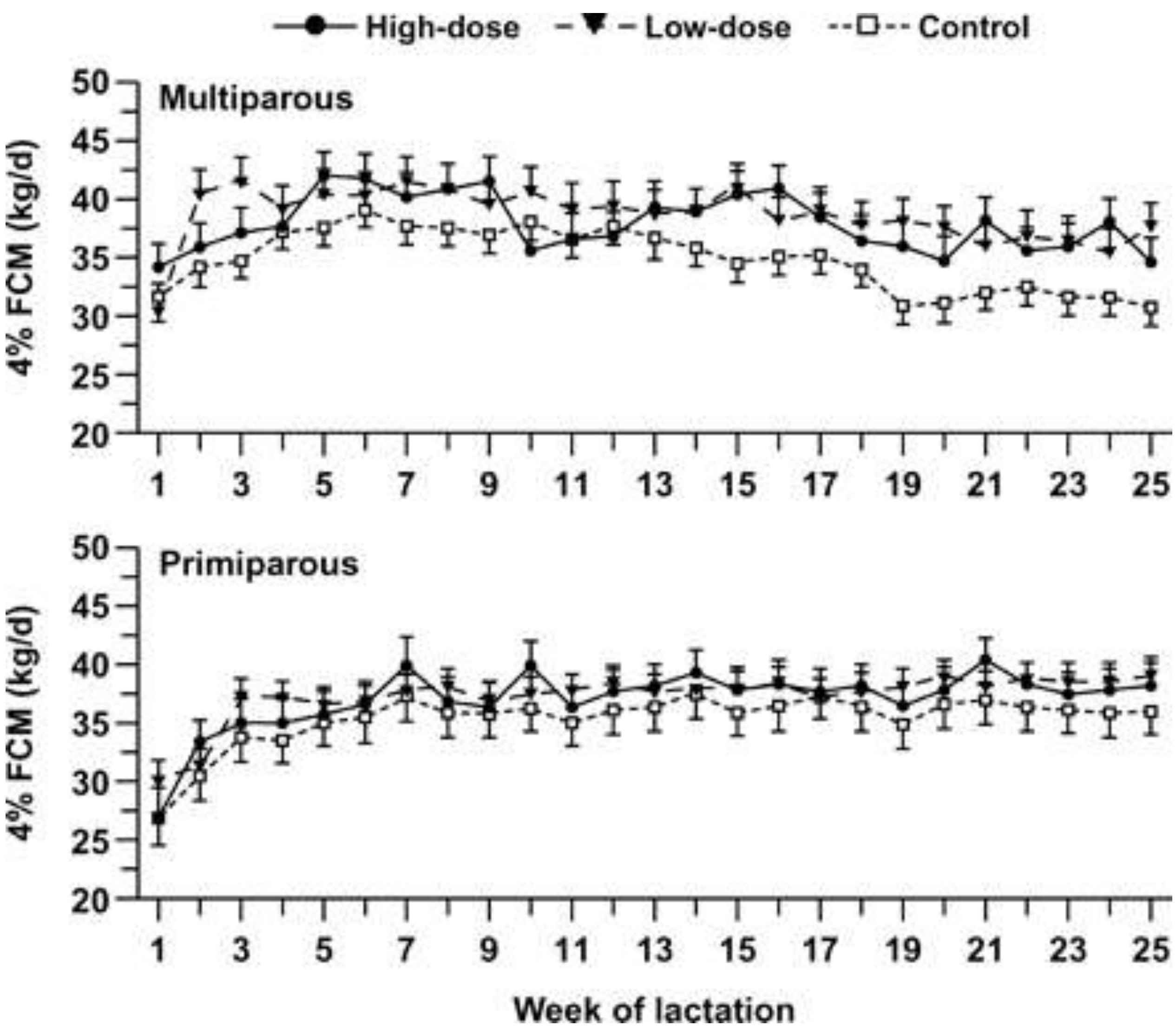


Effects of feeding Propionibacterium strain P169 on Ruminal VFAs



Stein *et al.*, 2006

Effects of feeding Propionibacterium strain P169 on Fat Corrected Milk (FCM)



Stein *et al.*, 2006

Effects of feeding Propionibacteria strain P169 on Milk Lactose

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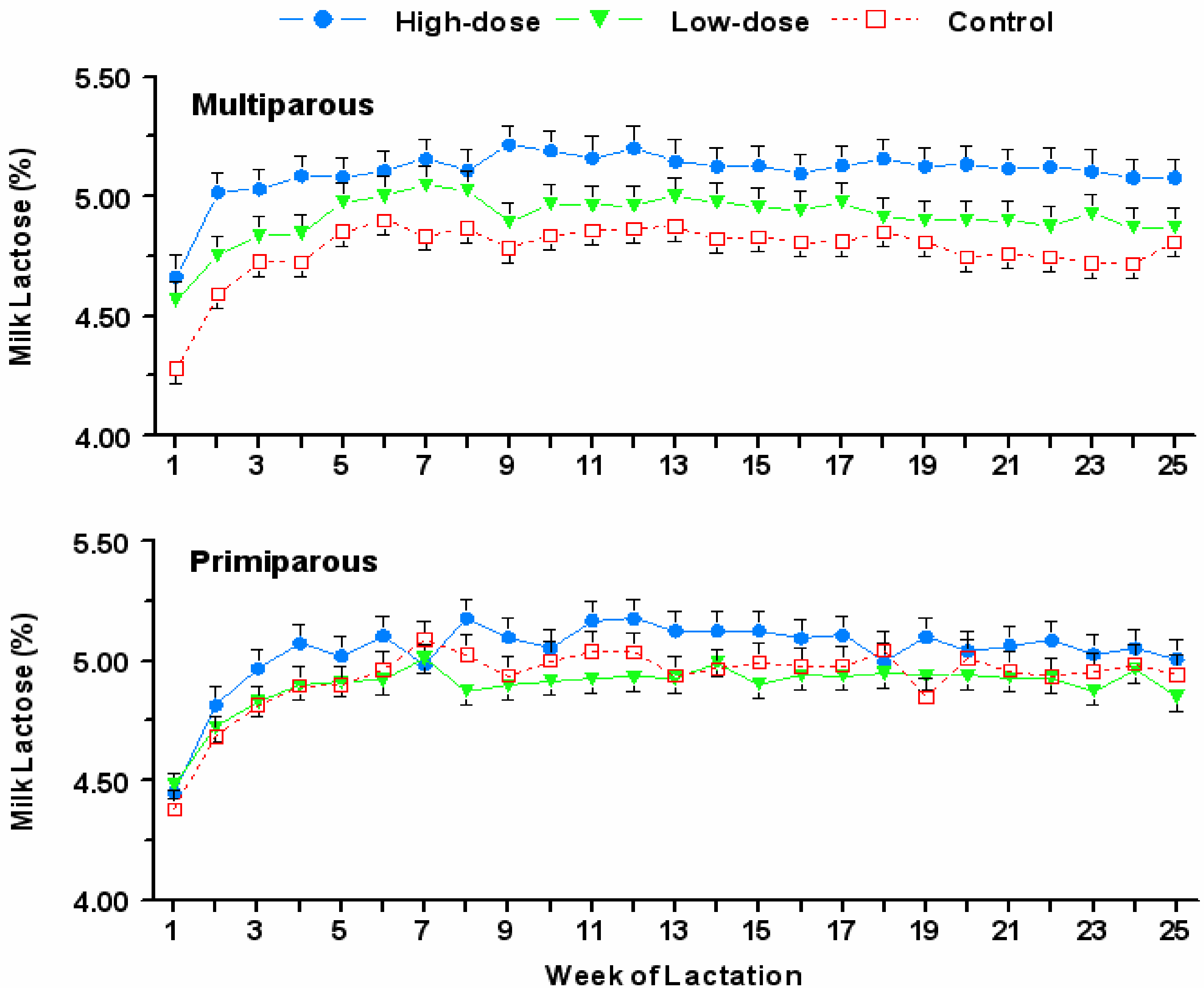
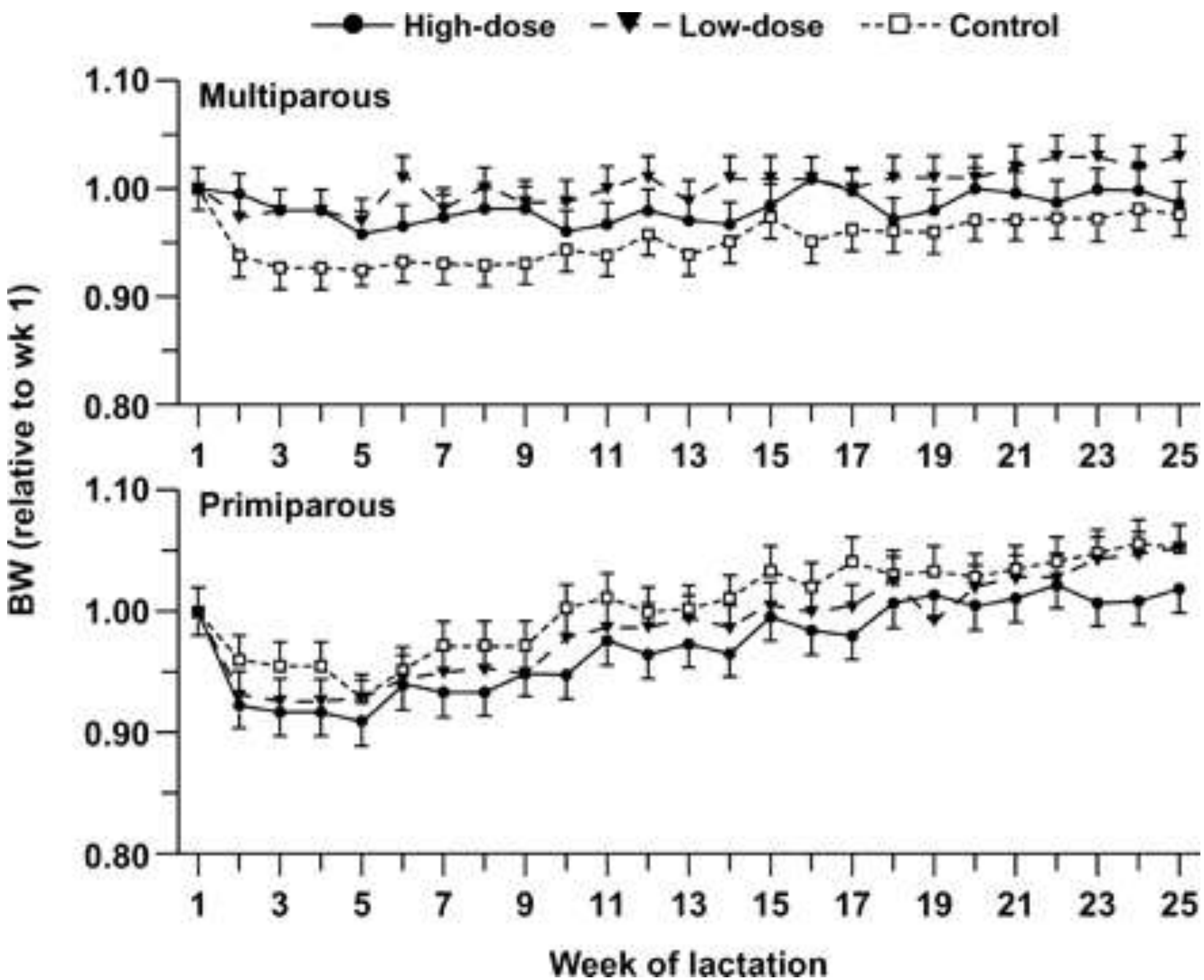
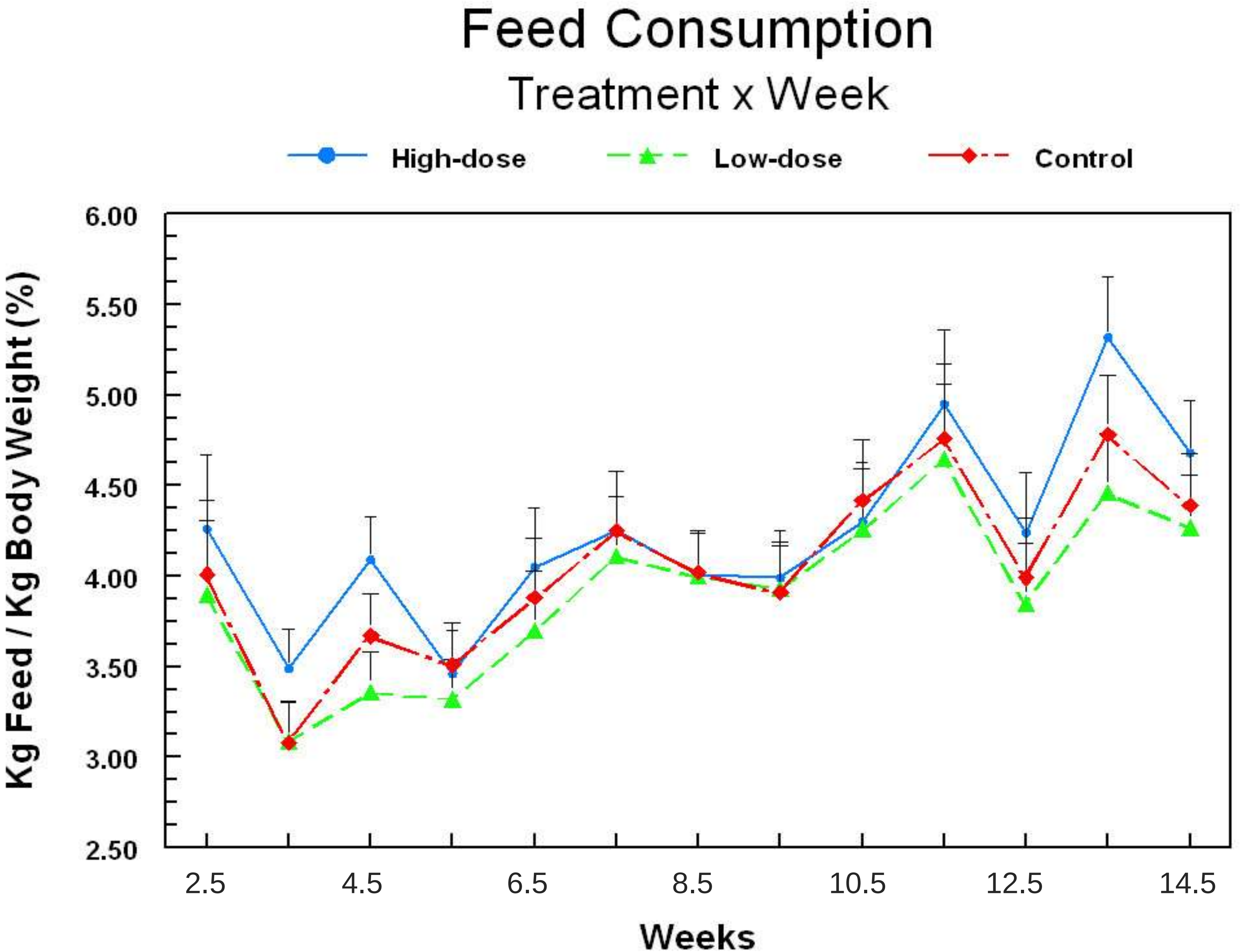


Stein et al., 2006 (J. Dairy Sci. 89:111-125)

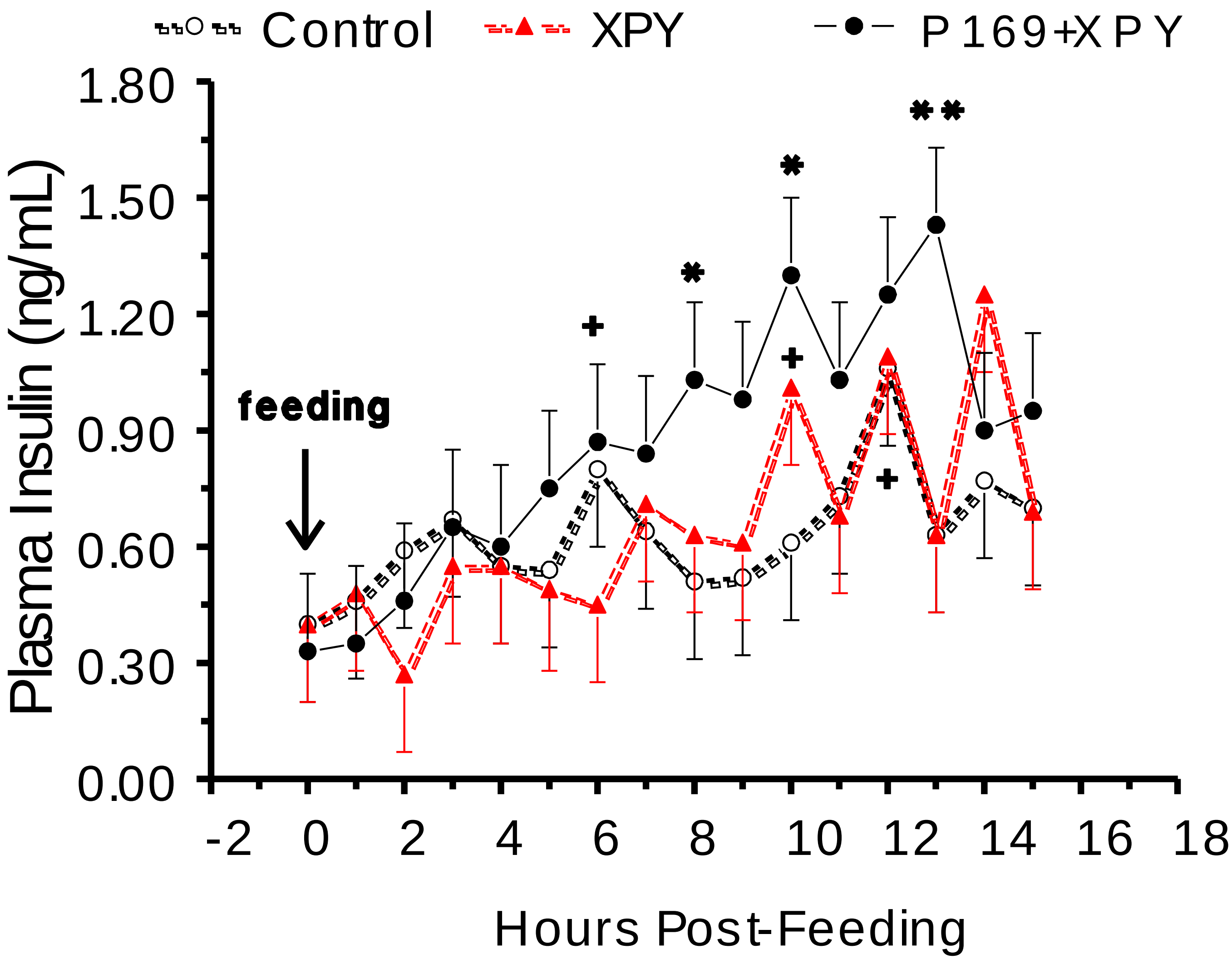
Effects of feeding Propionibacteria strain P169 on Cow BW during 25 wk of lactation



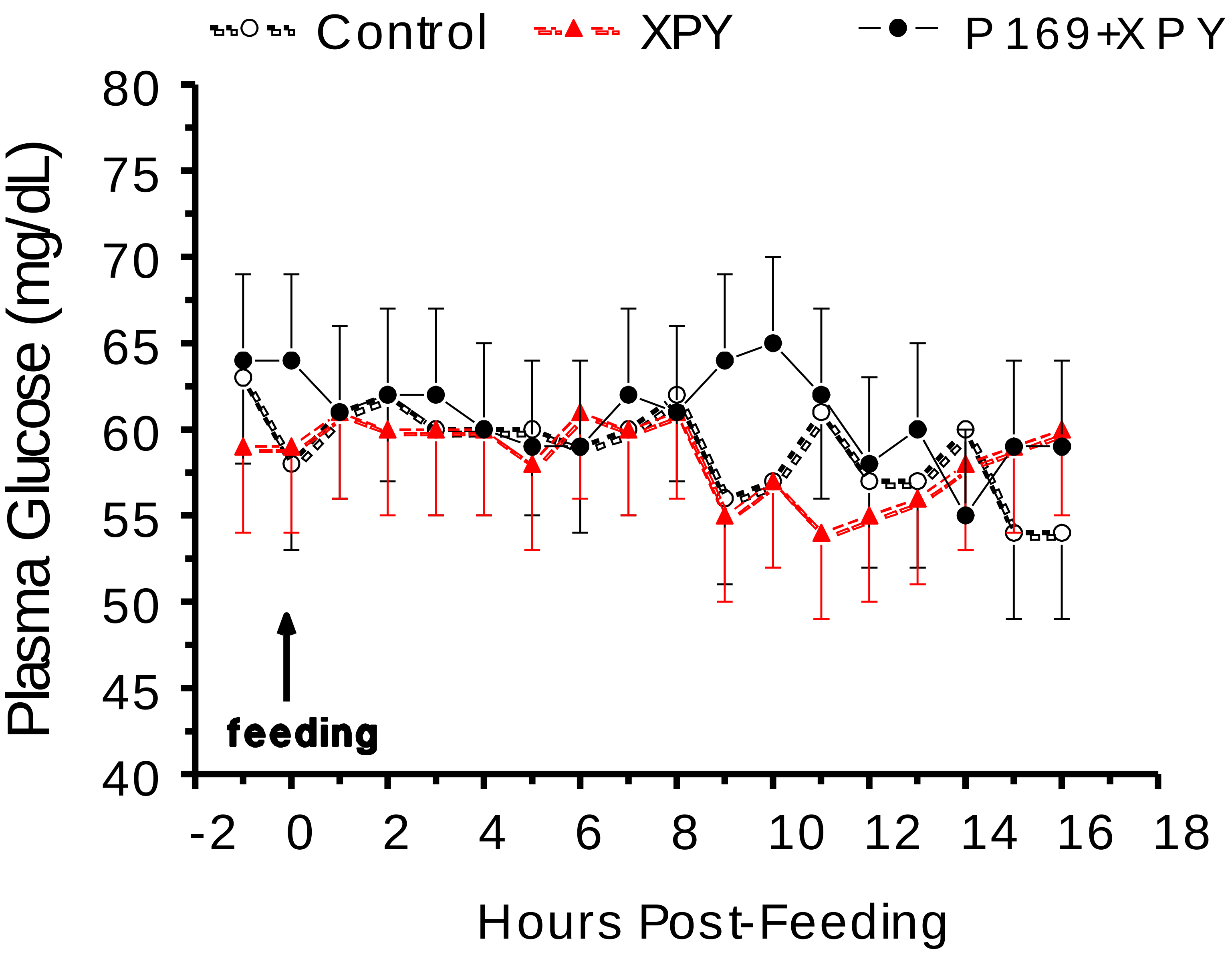
Stein *et al.*, 2006



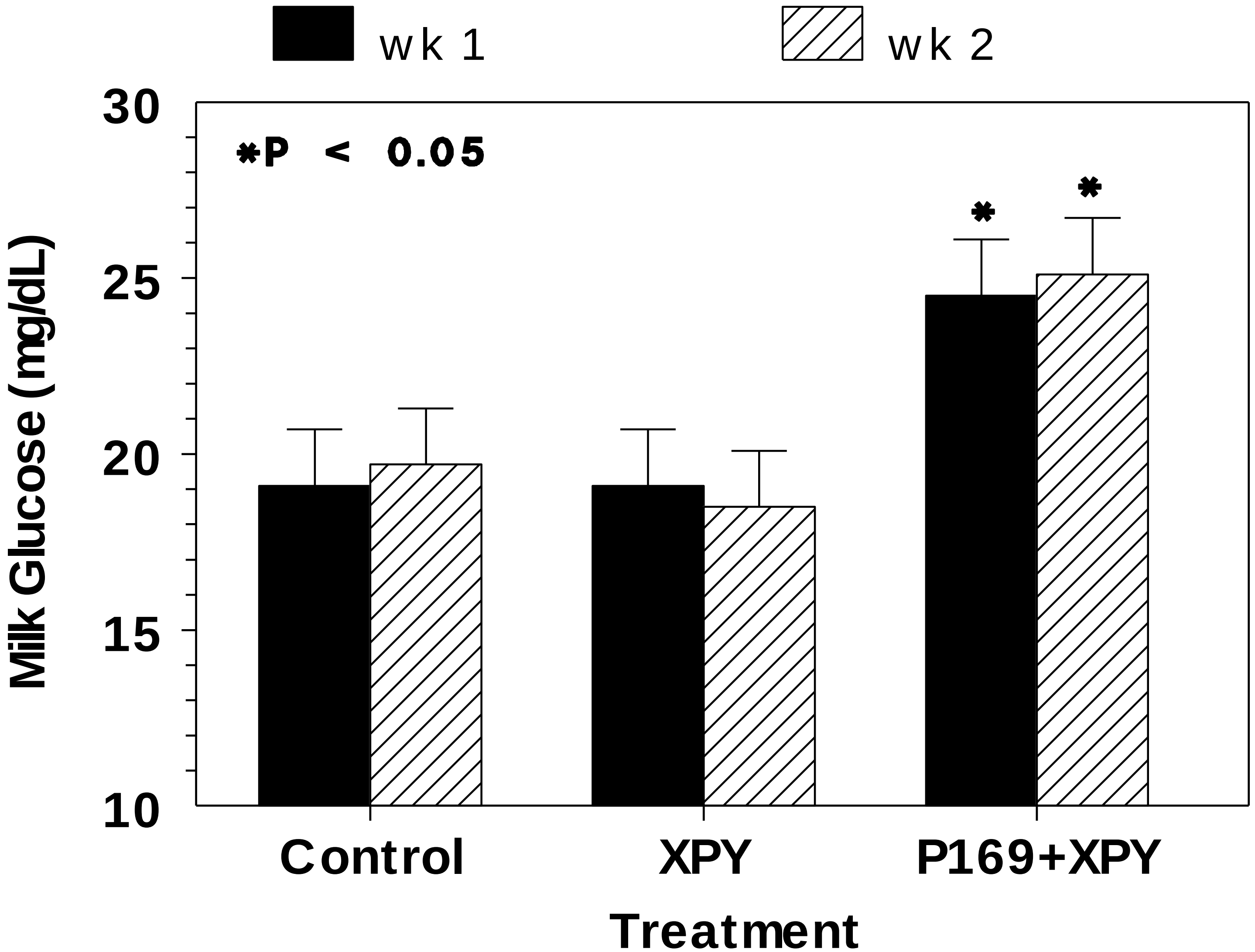
Feed Consumption
Treatment x Week
High-dose
Low-dose
Control
Kg Feed / Kg Body Weight (%)
6.00
5.50
5.00
4.50
4.00
3.50
3.00
2.50
2.5
4.5
6.5
8.5
10.5
12.5
14.5
Weeks



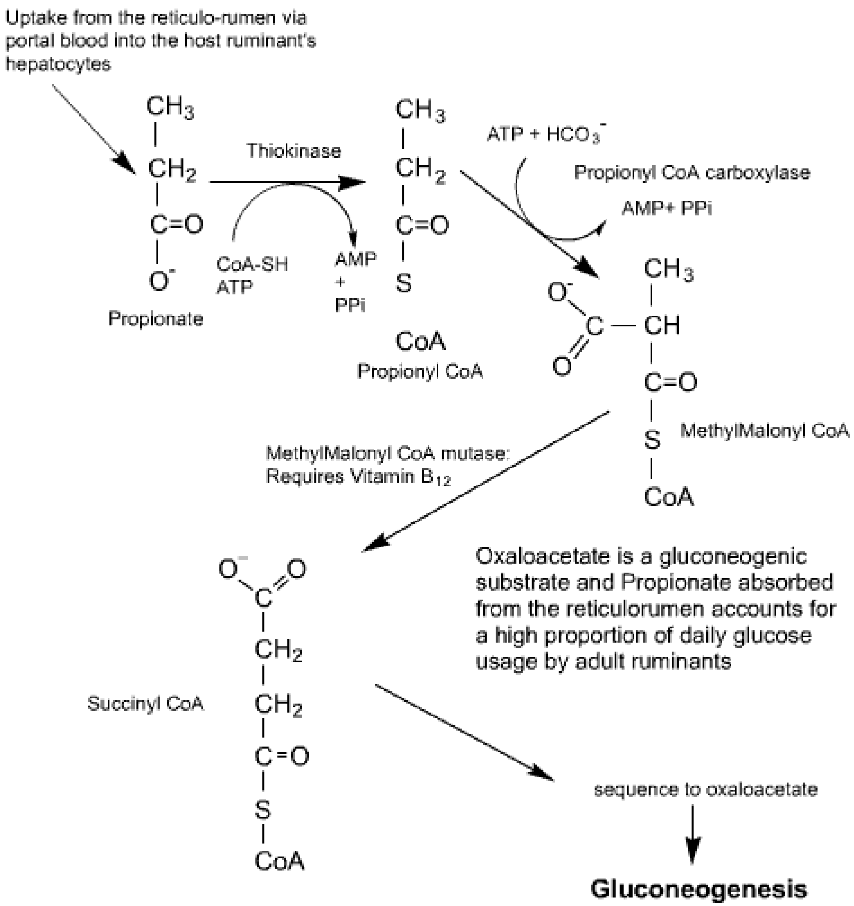
Lehloenya et al., 2006 (unpublished)



Lehloenya et al., 2006 (unpublished)


wk 1
wk 2
*P < 0.05
Milk Glucose (mg/dL)
30
25
20
15
10
*
*
Control
XPY
P169+XPY
Treatment

Metabolic Effects of Propionate



- Addition of *Propionibacterium* P169 to dairy cattle diets results in
  - Increased ruminal propionate
  - Increased insulin
  - Increased milk production
  - Increased milk lactose and glucose
  - Increased feed efficiency

Our microbial consortia have distinct “”personalities”

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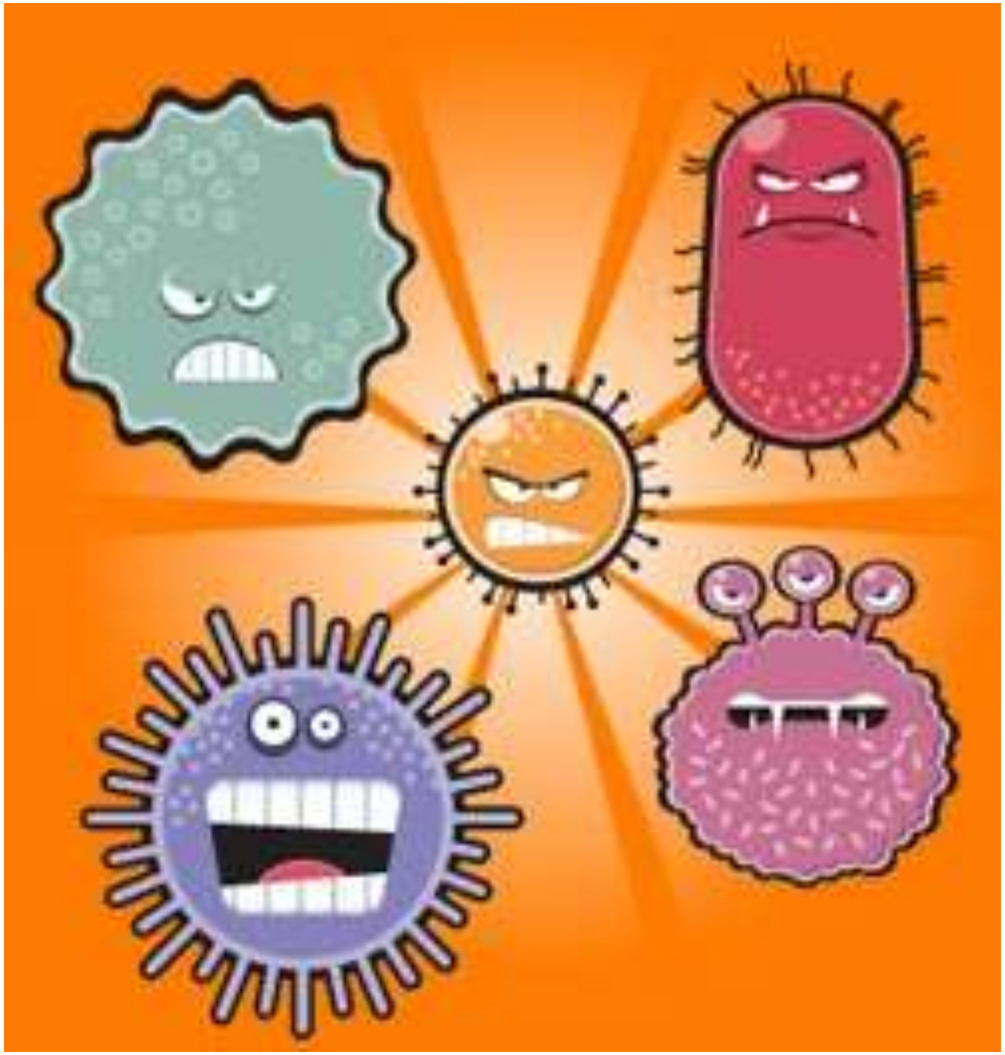
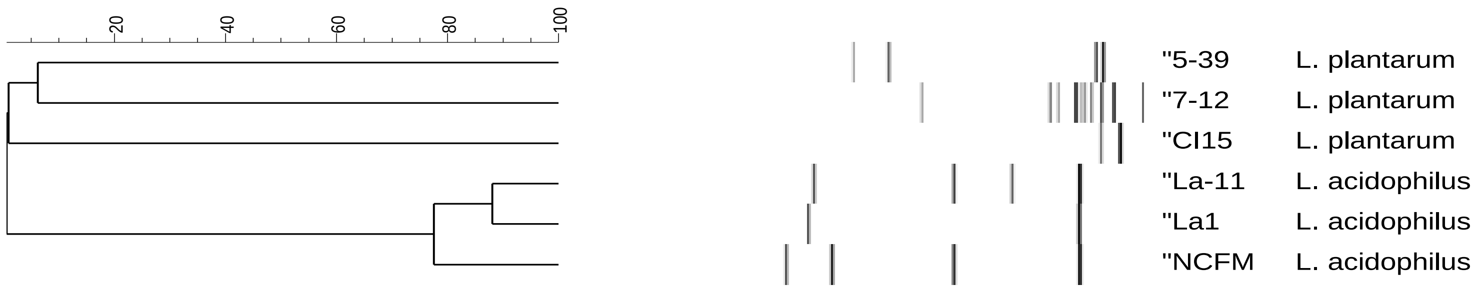
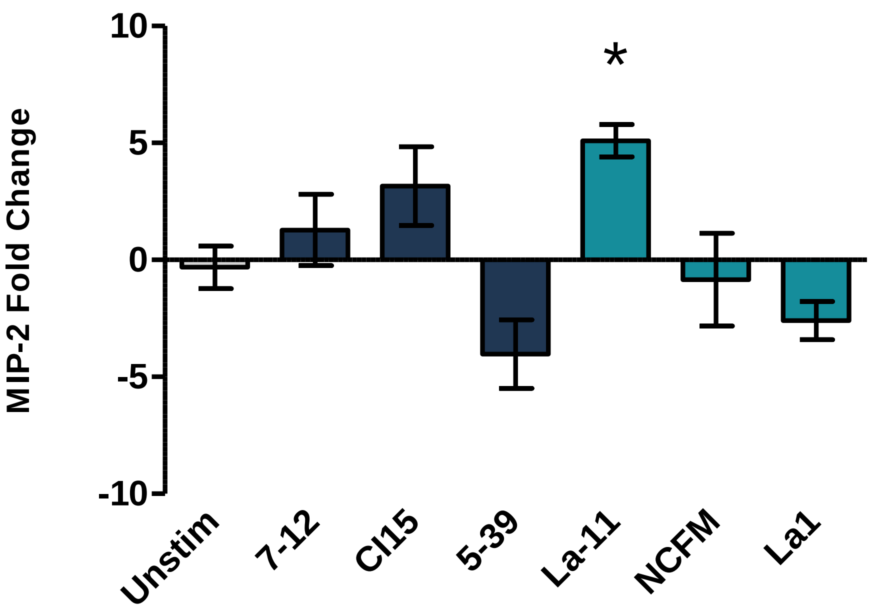
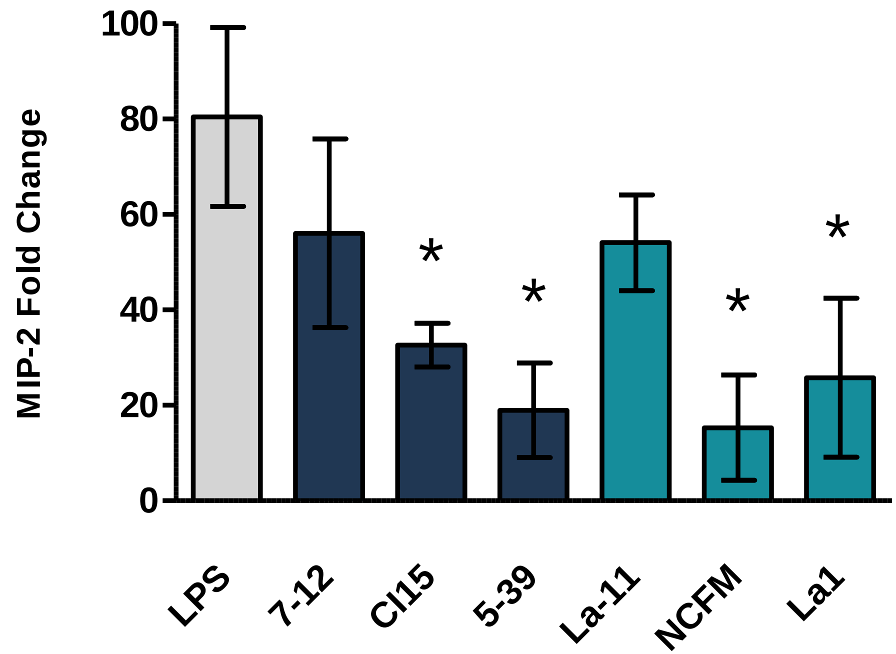


Even within a bacterial species

Fold change in gene expression of macrophage inflammatory protein-2 (MIP-2) in IEC6 cell line







Duersteler et al., 2010; AAI Baltimore

Conclusion

- Strategic application of appropriate DFMs can positively impact neonatal development and production efficiency
- Importance of strategic selection and application of DFMs
- Dictate a portion of the microbial consortia to exert strategic outcome