



# A crash course in the gut microbiome.

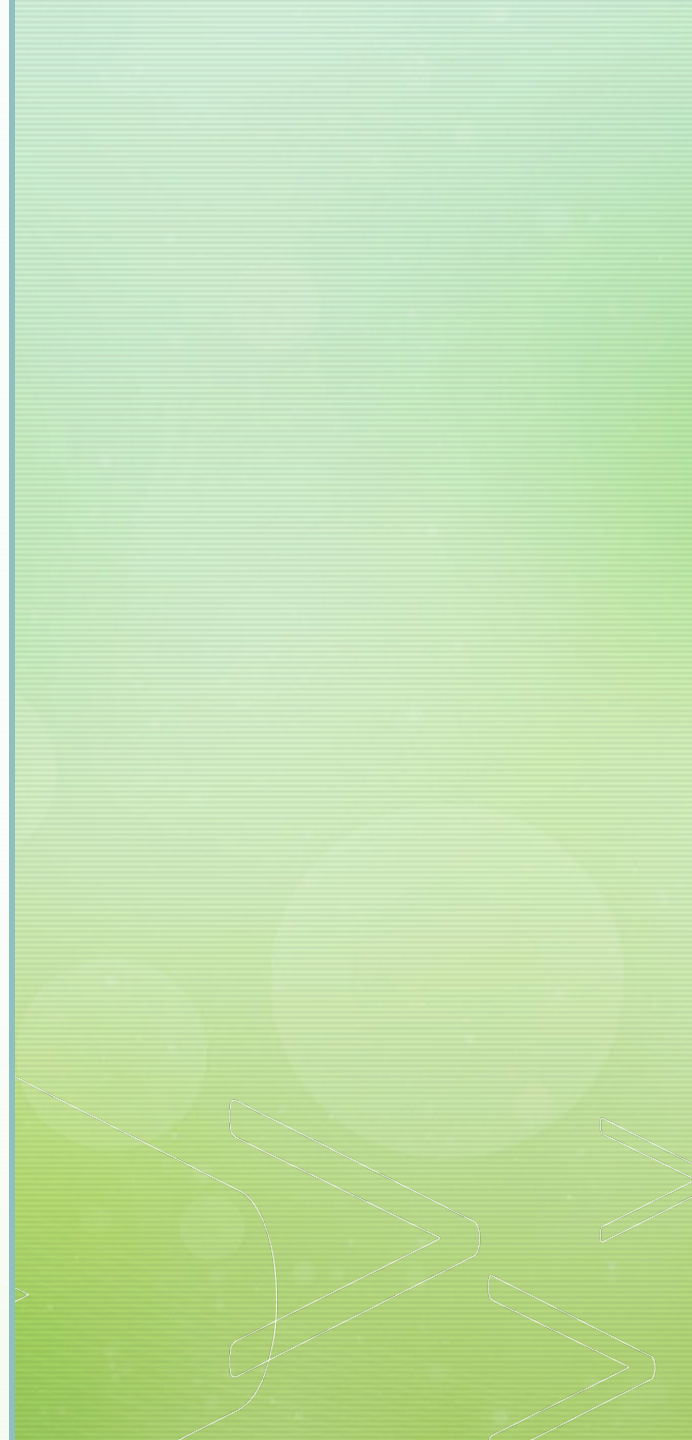
▶ Suzanne (Sue) Ishaq, Ph.D.

University of Maine

Assistant Professor of Animal and Veterinary Sciences

Nov 6, 2020

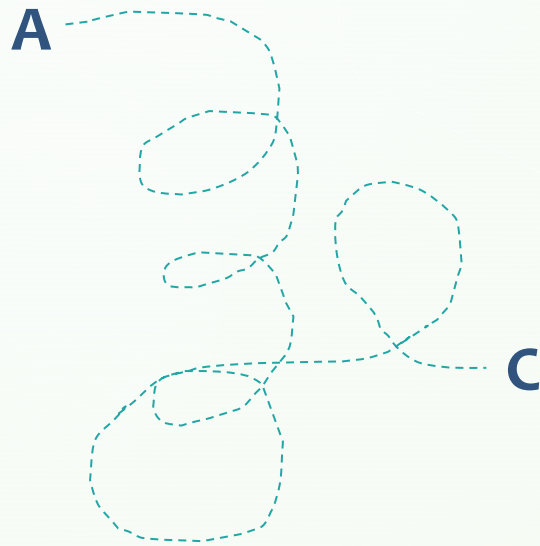
@DrSueIshaq FB, Twitter, Instagram, LinkedIn  
[www.sueishaqlab.org](http://www.sueishaqlab.org)  
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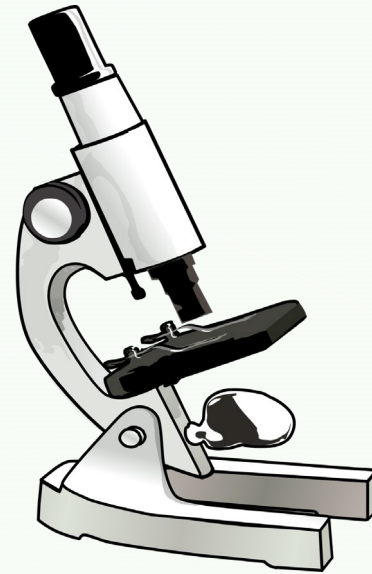


# Overview

## Diversity → Functionality



Trajectory

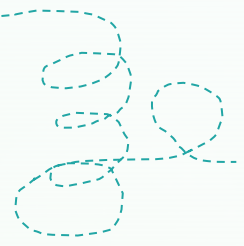


Theory



Community

A



# Career Trajectory

University of Vermont

Montana State University

University of Oregon



# Genomics and Cell Culture Apace, UMaine

Virtual tour:  
[SUEISHAQLAB.ORG/LAB-SPACE/](http://SUEISHAQLAB.ORG/LAB-SPACE/)

# Microbiology Space, UMaine



# Managing microbiomes

Rumen



Rhizosphere



Room





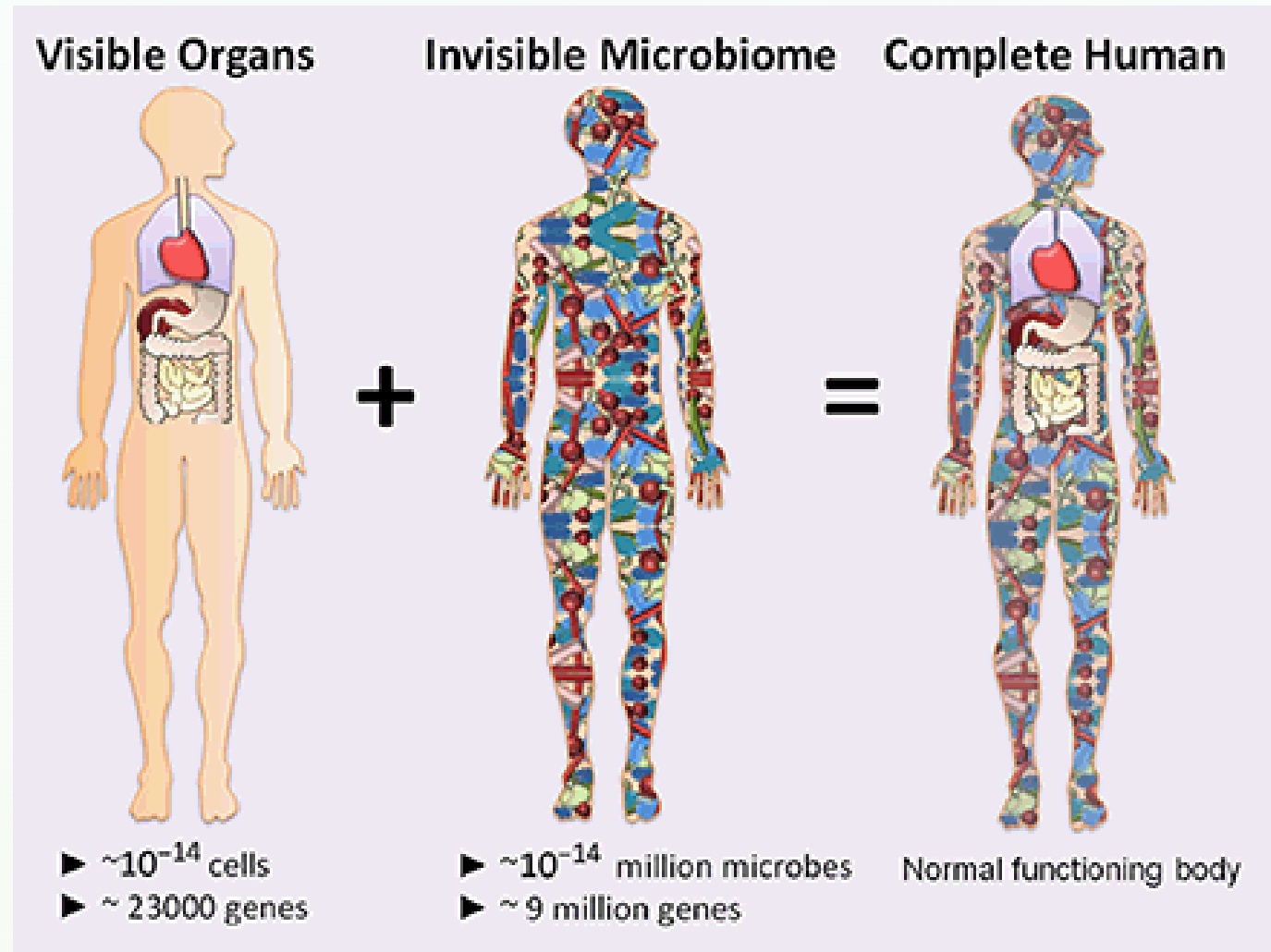
Image Credit: Darryl Leja, NHGRI



Image Credit: Andrew Rae for Quanta Magazine

# MICROBIOME IS TRENDING

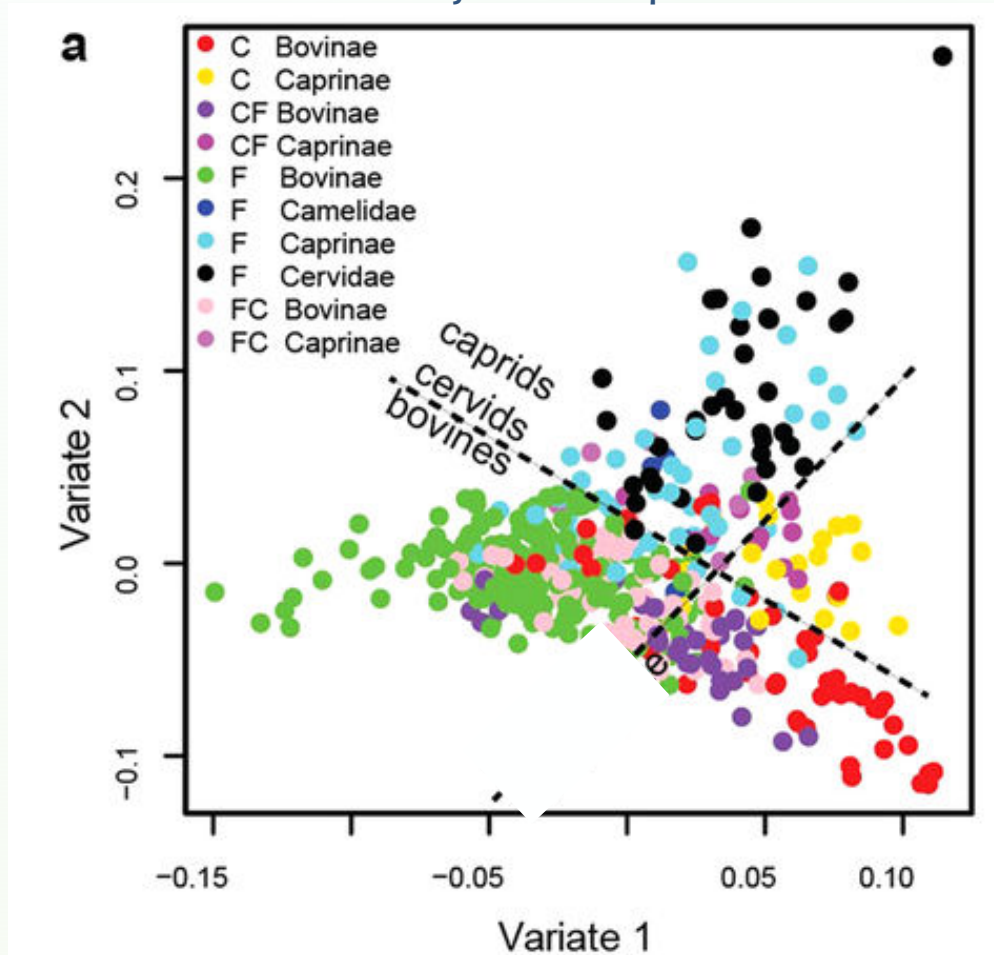
# Don't leave home without your microbiome



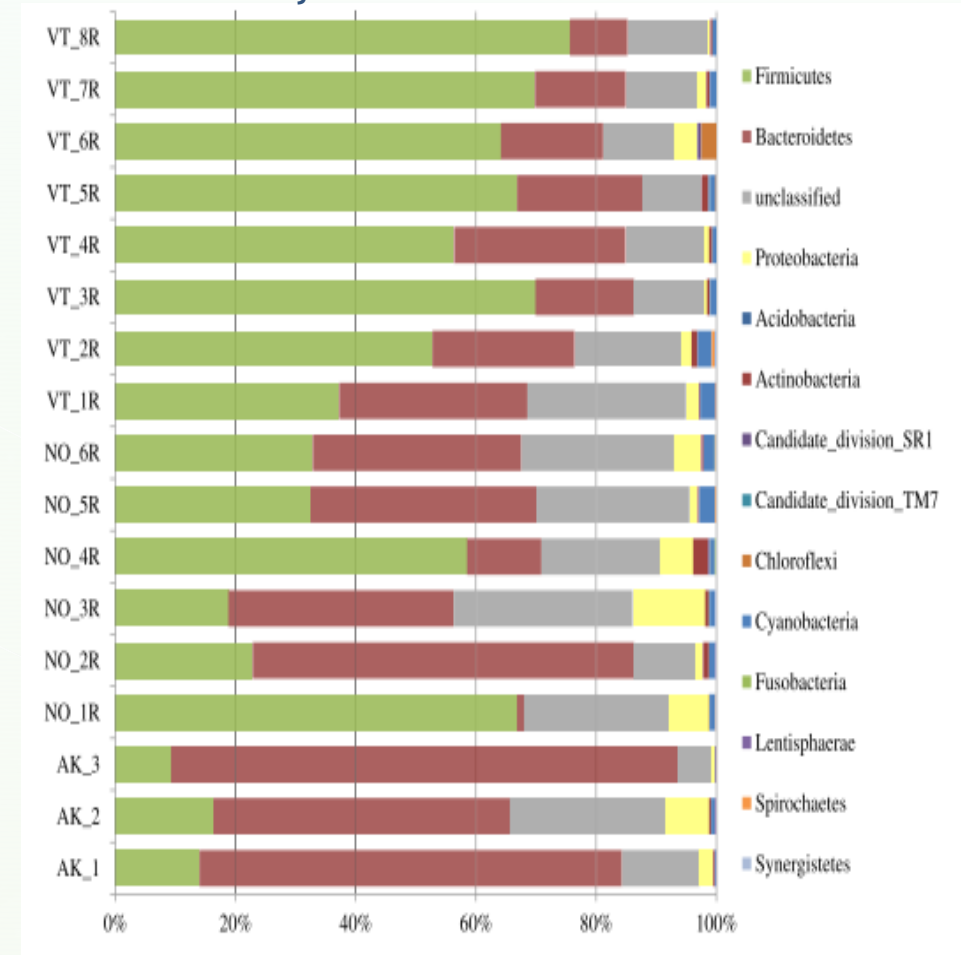
Appanna 2018

# Host-specific research is needed Microbial communities vary by host

By animal species



By individual



Henderson et al. 2015

Ishaq et al. 2014

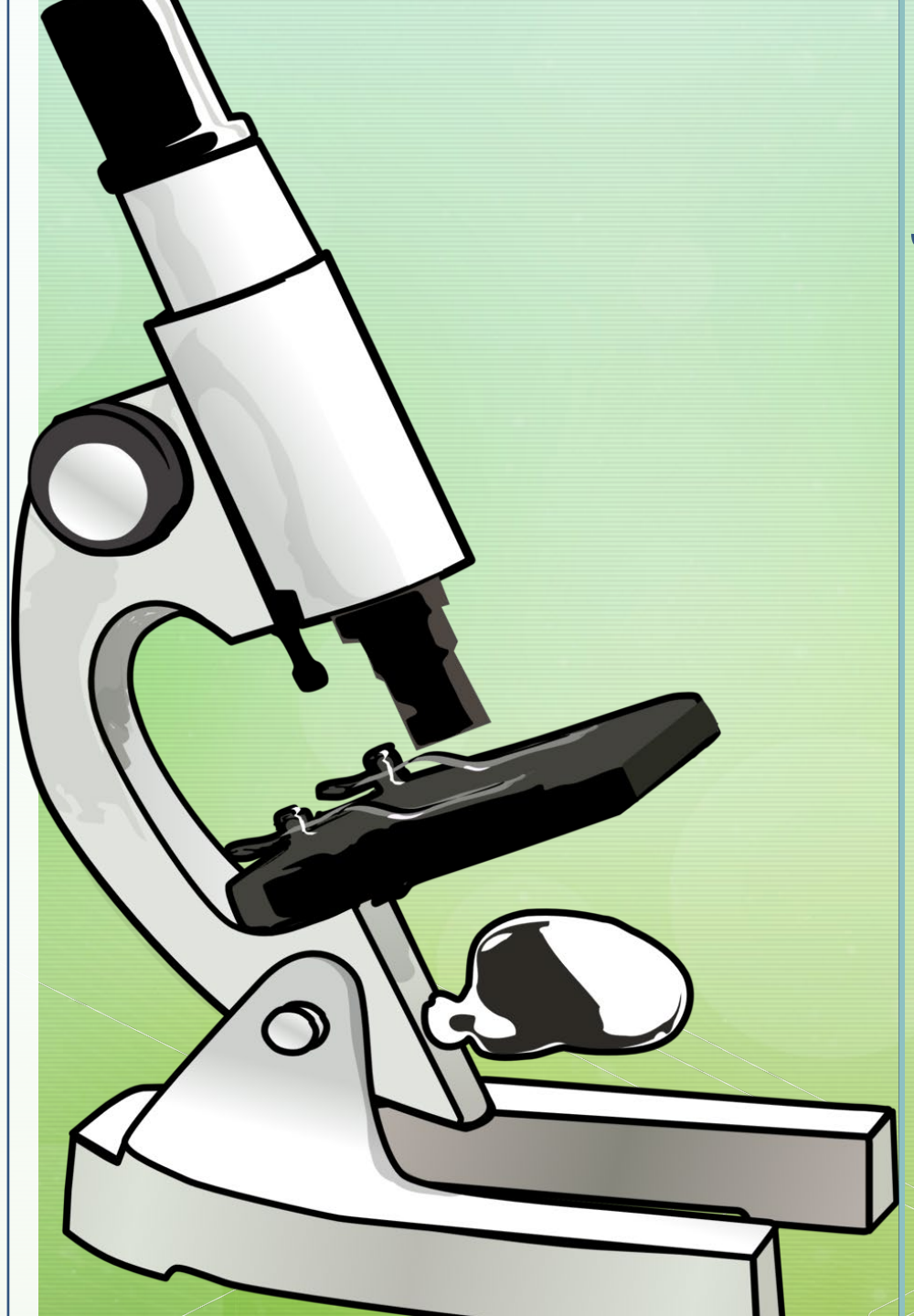


# What does animal microbiome work look like?

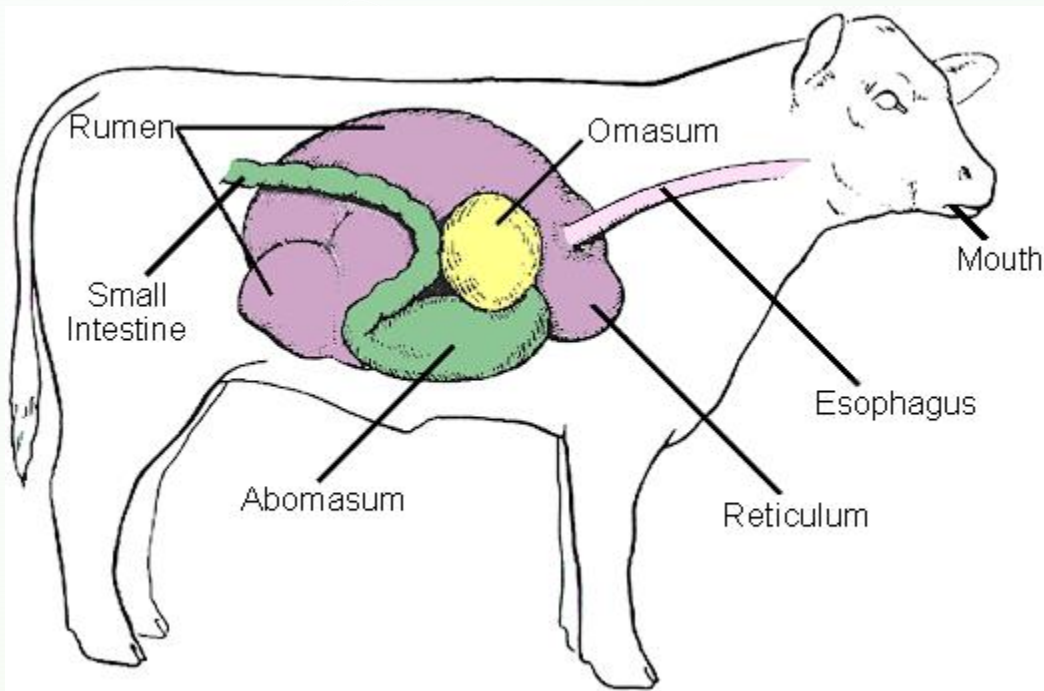
*Spatial*

*Temporal*

*Dynamic*

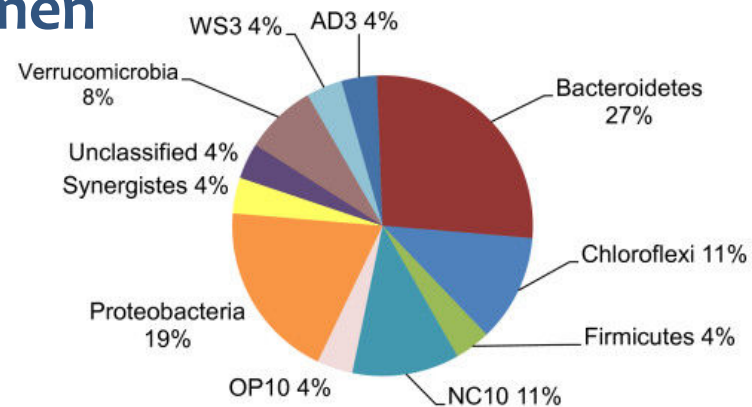


# Does anatomical location matter to microbes?



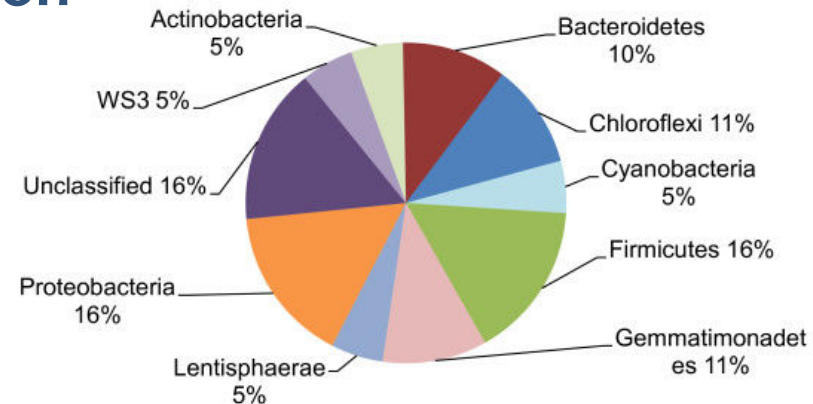
## Rumen

**b**



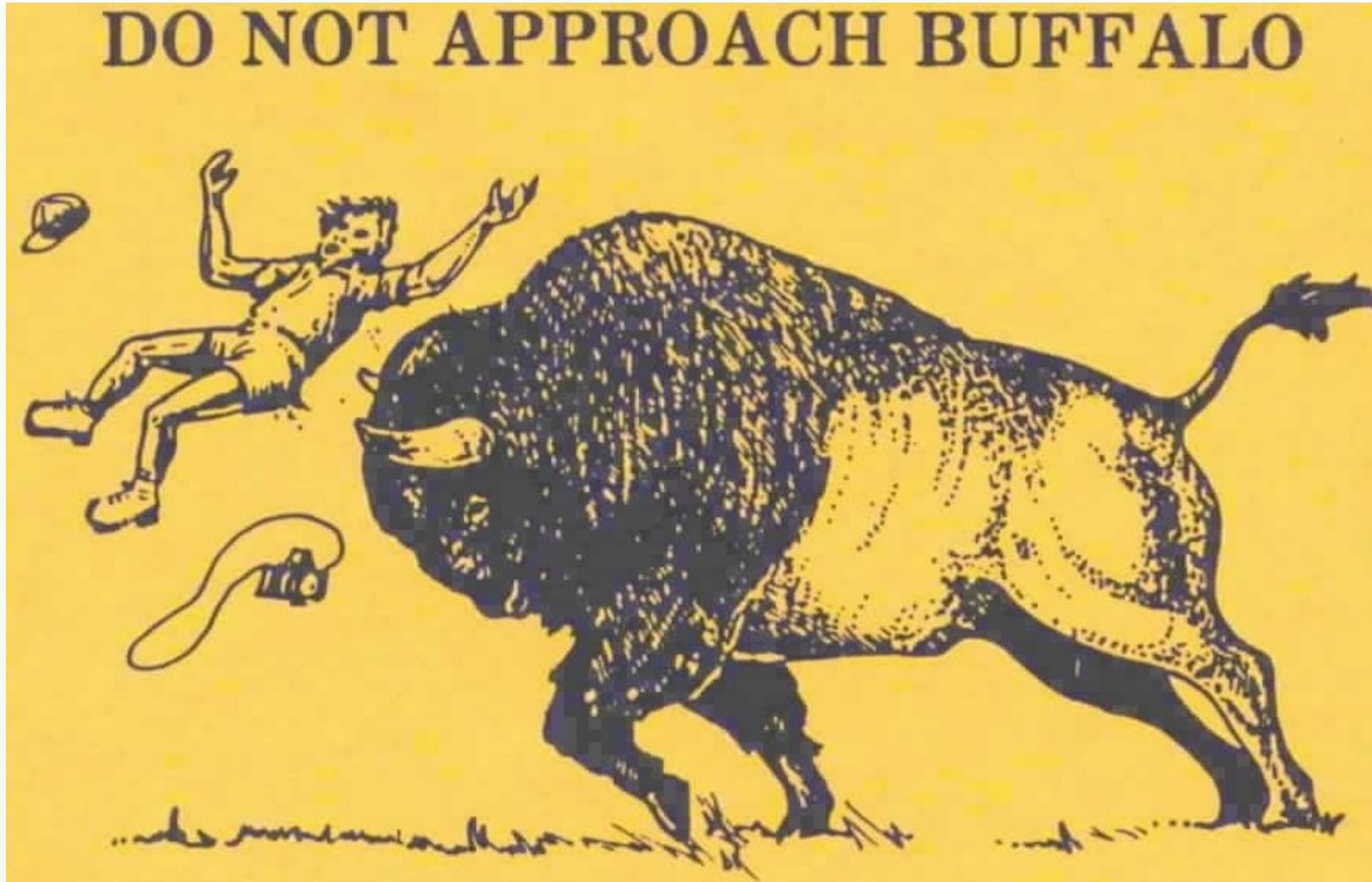
## Colon

**c**



Ishaq and Wright, 2012

▶ Anatomical location matters for sampling



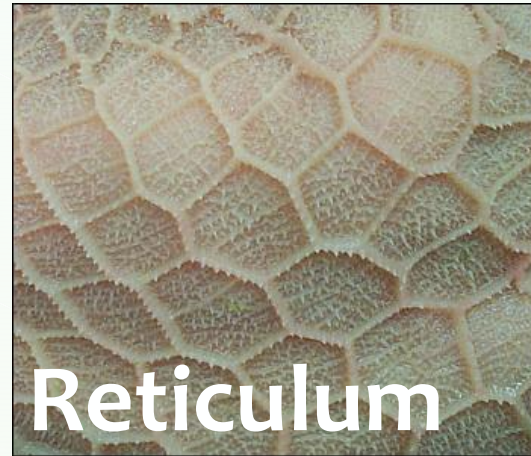
# The gut is a series of ecosystems featuring different microbial communities

vivo.colostate.edu



Rumen

vivo.colostate.edu



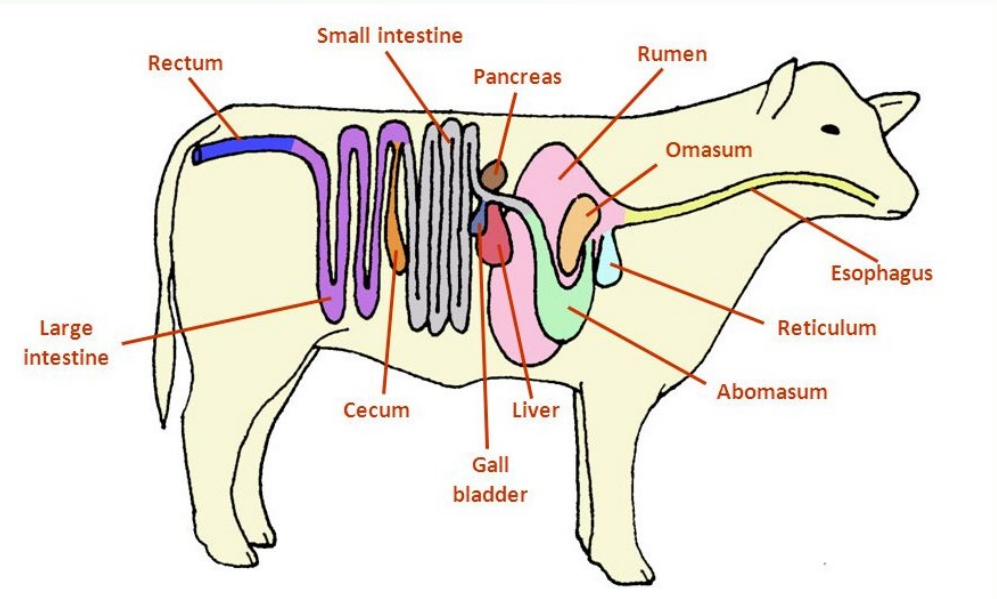
Reticulum



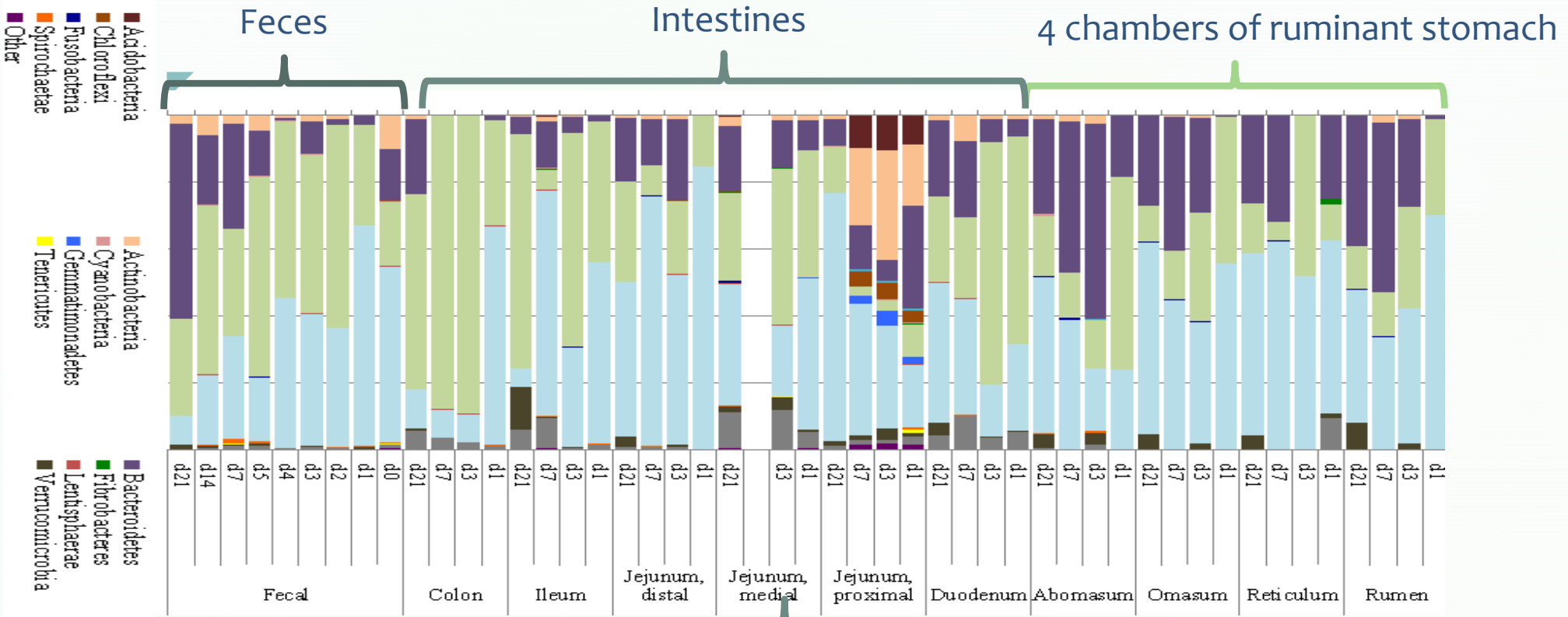
Omasum



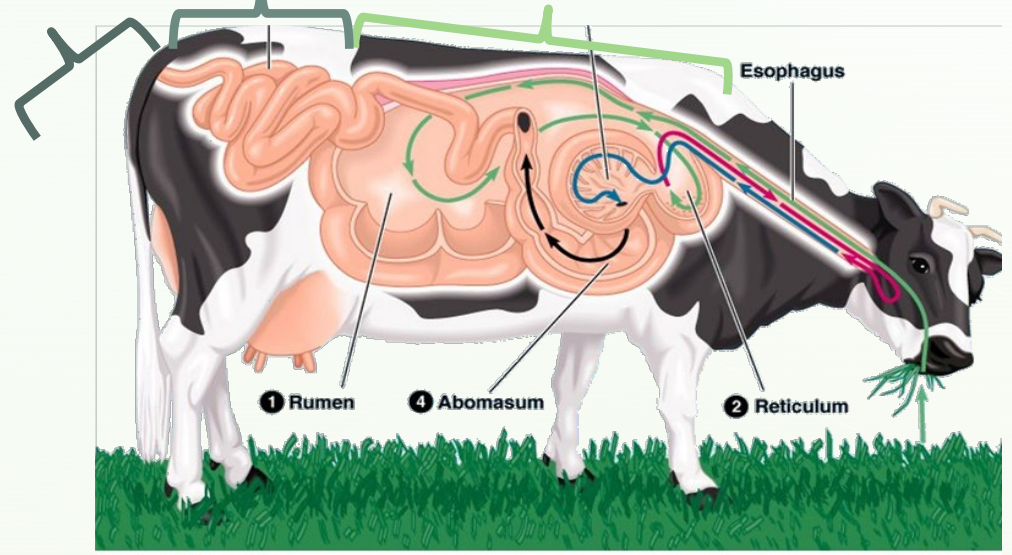
Abomasum



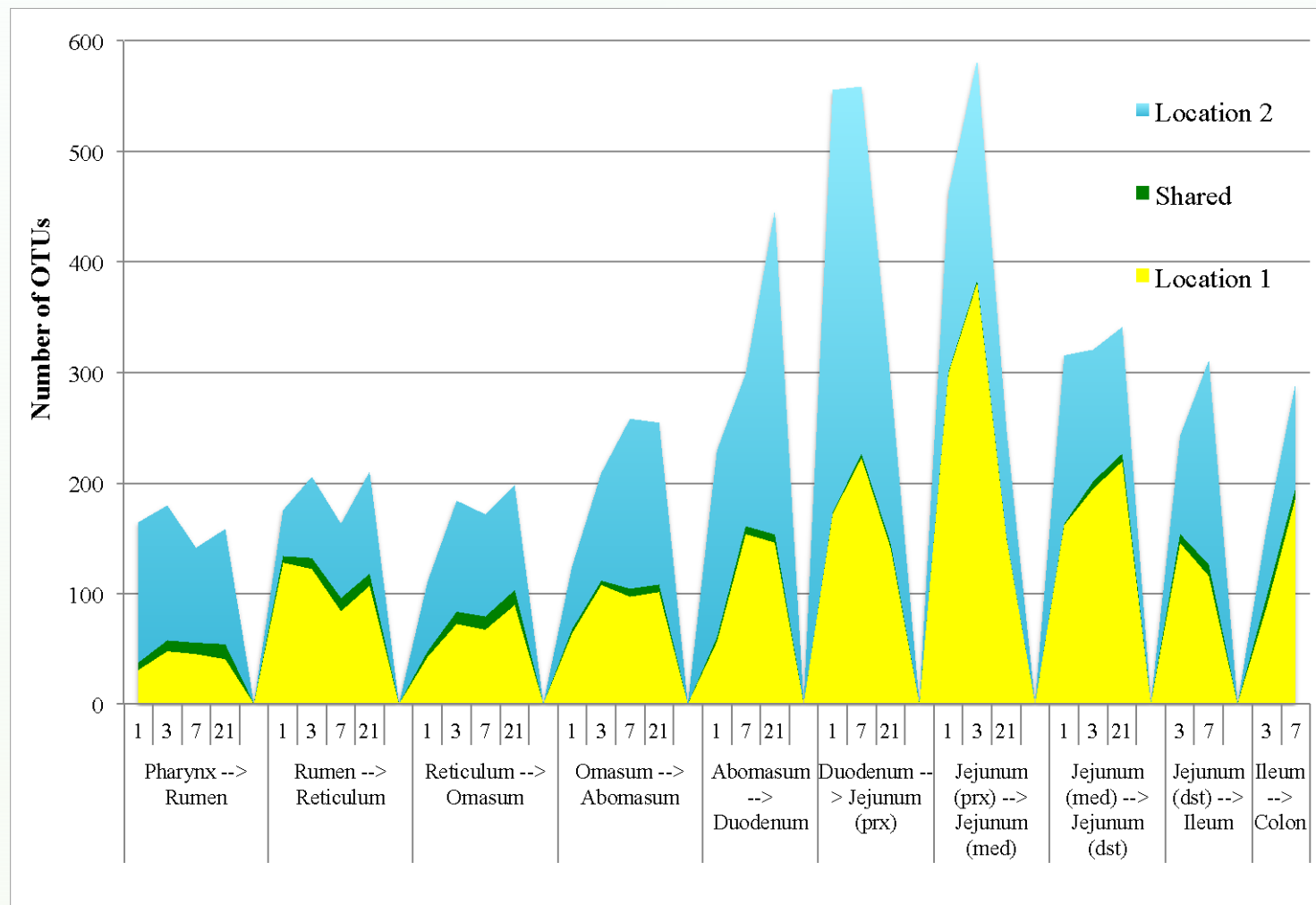
<https://media1.britannica.com/>



Yeoman and Ishaq et al. 2018

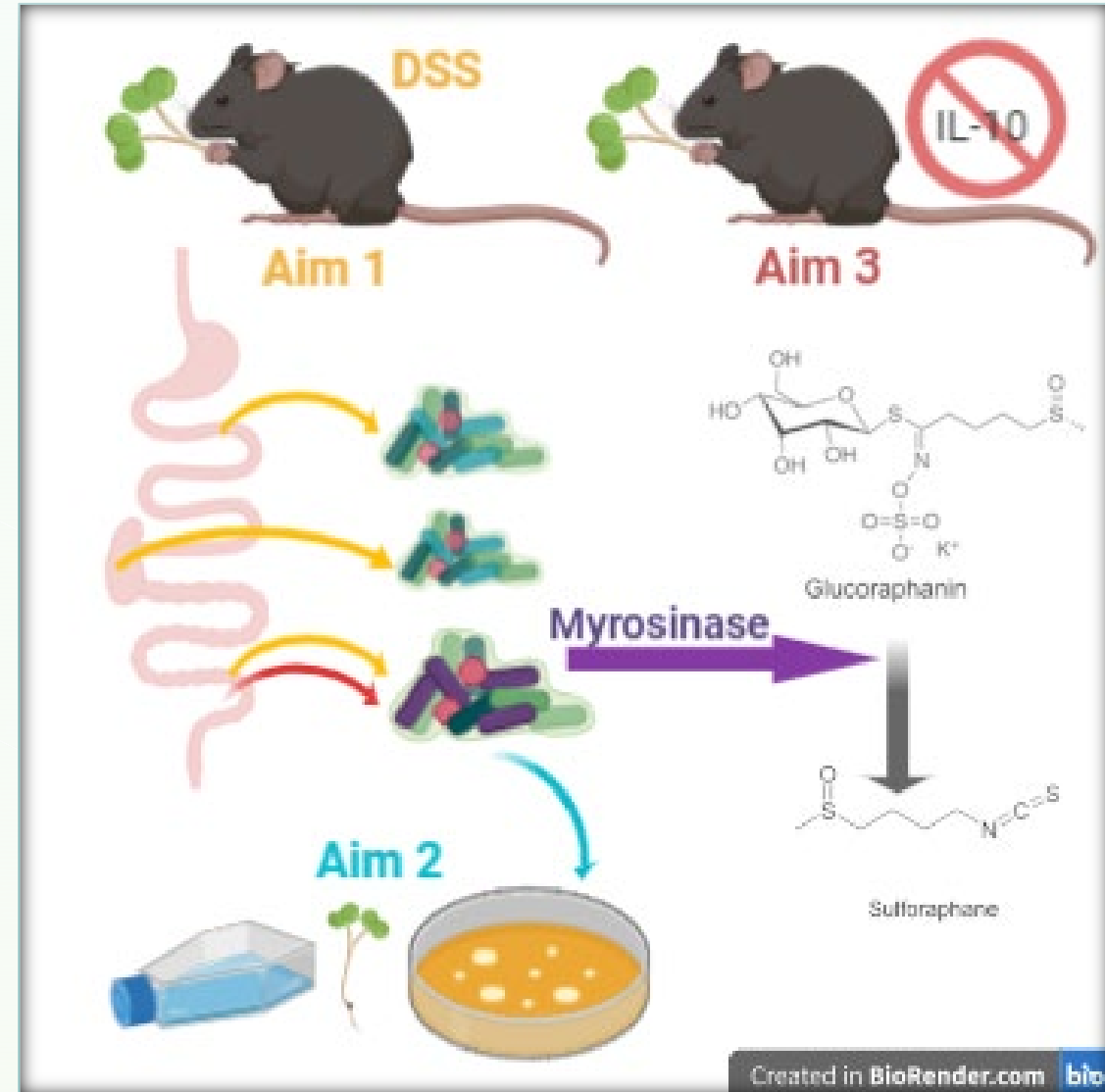


# Bacterial community along GI not source: sink effect



Yeoman and Ishaq et al. 2018

Anatomically-specific gut microbes provide anatomically-specific host benefits



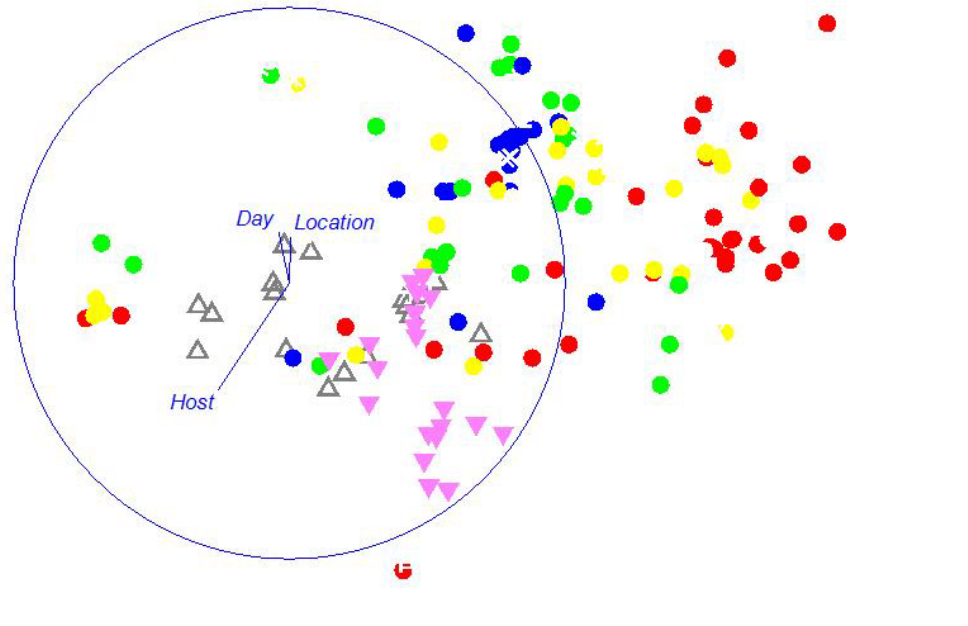
Li, Ishaq, Zhang, Chen, Moses, and Mawe

# Day is strong predictor of community variation in digesta but not mucosal-associated populations

## Digesta

Standardise Samples by Total  
Transform: Square root  
Resemblance: S17 Bray Curtis similarity

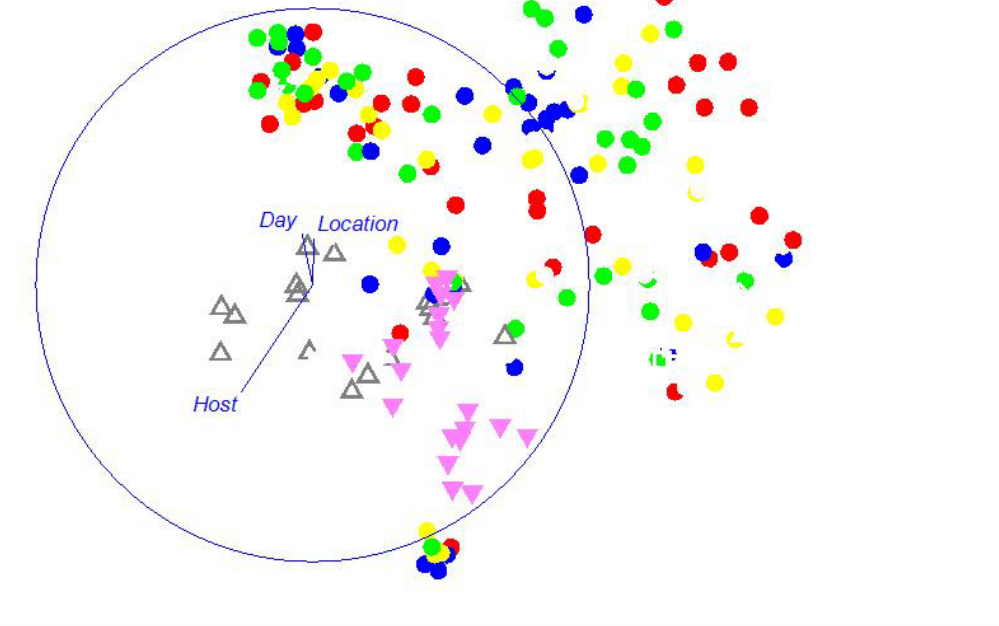
2D Stress: 0.19



## Mucosal-associated

Standardise Samples by Total  
Transform: Square root  
Resemblance: S17 Bray Curtis similarity

2D Stress: 0.19



Yeoman and Ishaq et al. 2018



Dam colostrum



Dam udder and vagina scrapings



Calf Day 0



Calf Day 3



Calf Day 7

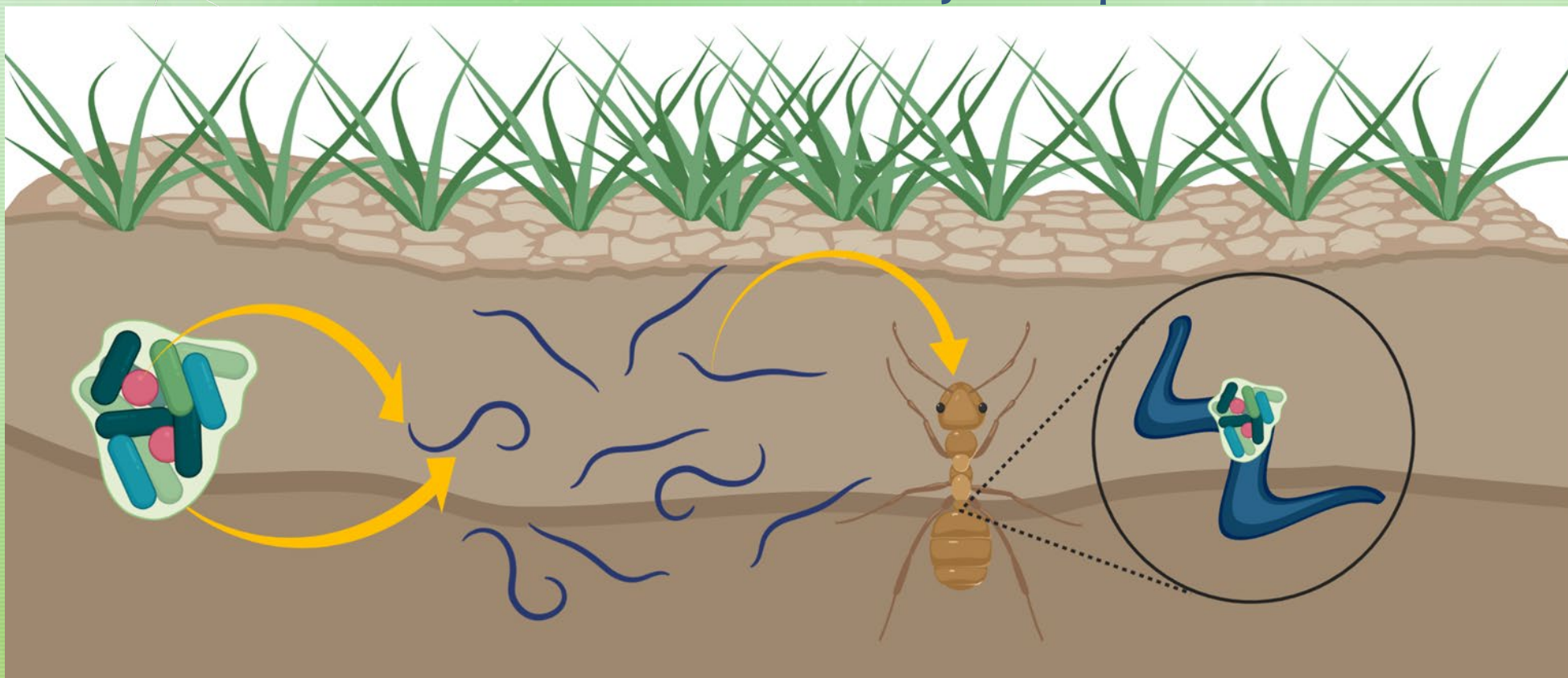


Calf Day 21



## Time can help you trace microbial transfer

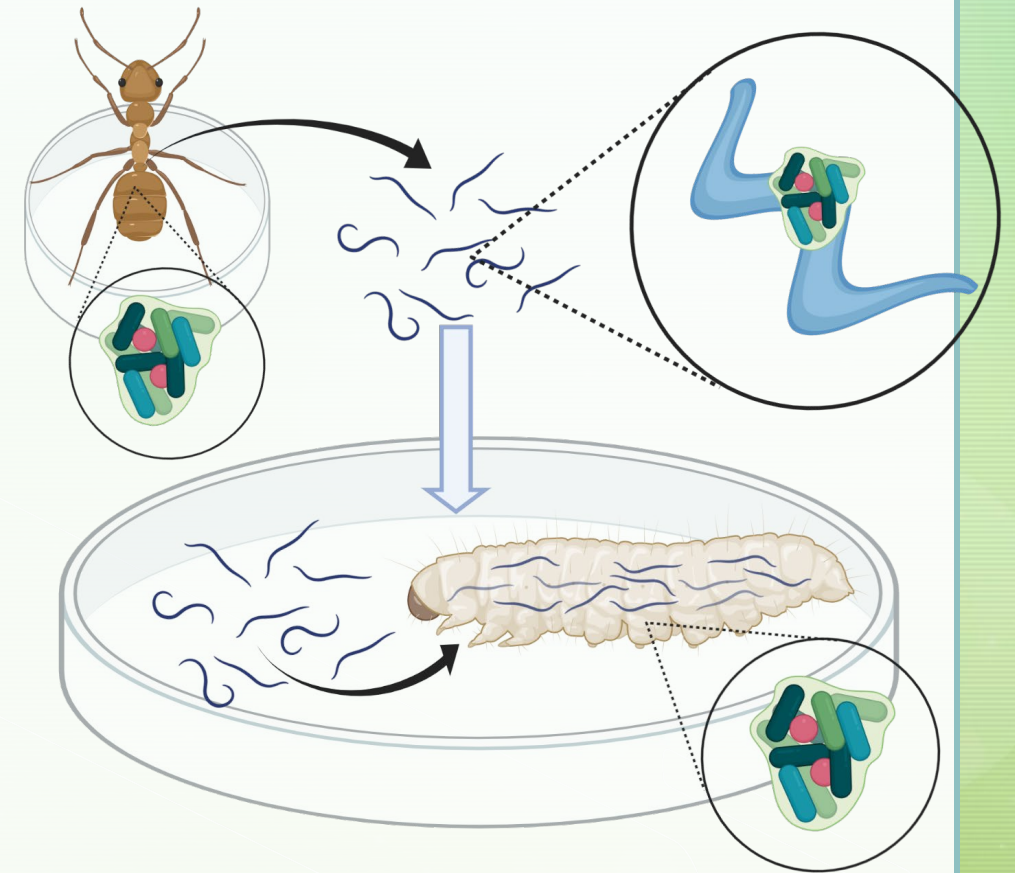
Do necromenic nematodes vector environmental bacteria into invasive ants and contribute to colony collapse?



Ishaq et al. in review

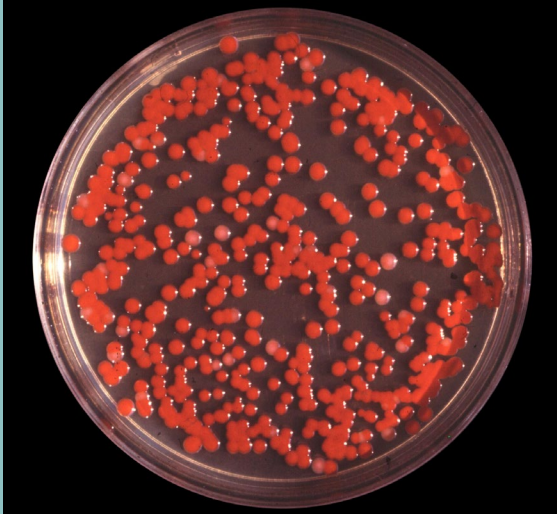
## Patial experimental methods

1. Invasive ants collected from 3 collapsed colonies in coastal Maine
2. Nematodes emerged from ant cadavers
3. Nematodes cultured with *Galleria mellonella* waxworm larvae
4. Bacterial communities identified by 16S rRNA gene, analysis with DADA2 in R
  - Ants
  - Nematodes
  - Infected waxworms
  - Non-infected waxworm controls



Ishaq et al. in review

# Results: 1 *Serratia marcescens* shared across all samples



*Serratia marcescens* previously isolated from field-collected nematodes

Tree scale: 0.1

Field Site

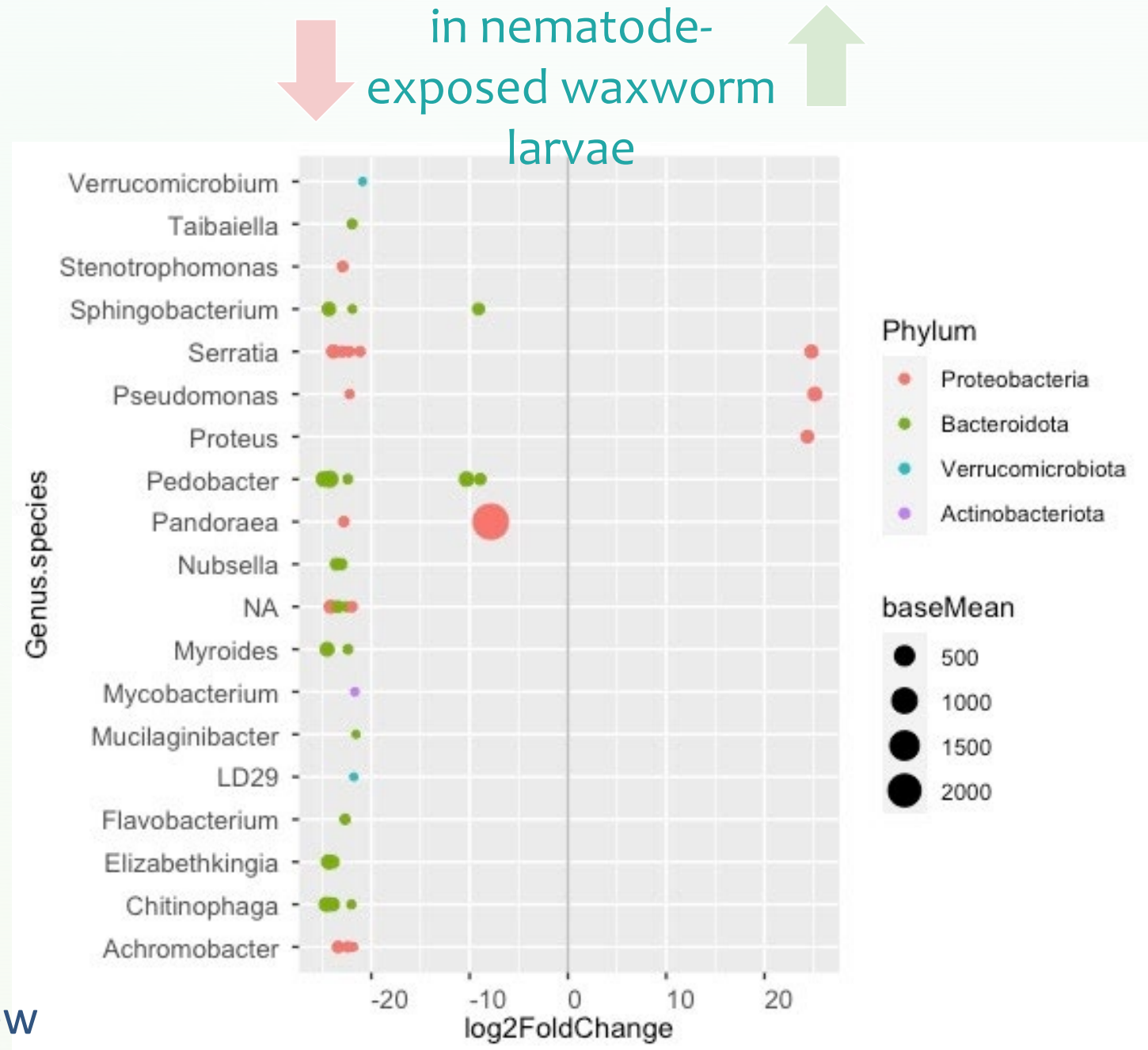
- MGH
- COA
- Shared



[Serratia marcescens - Wikimedia](#)

Ishaq et al. in review

Results:  
nematode  
infection might  
disorder host  
community more  
than transfer  
bacteria



Ishaq et al. in review

## Conclusions

It is plausible that *Pristionchus entomophagus* nematodes vector environmental bacteria to *M. rubra* ants

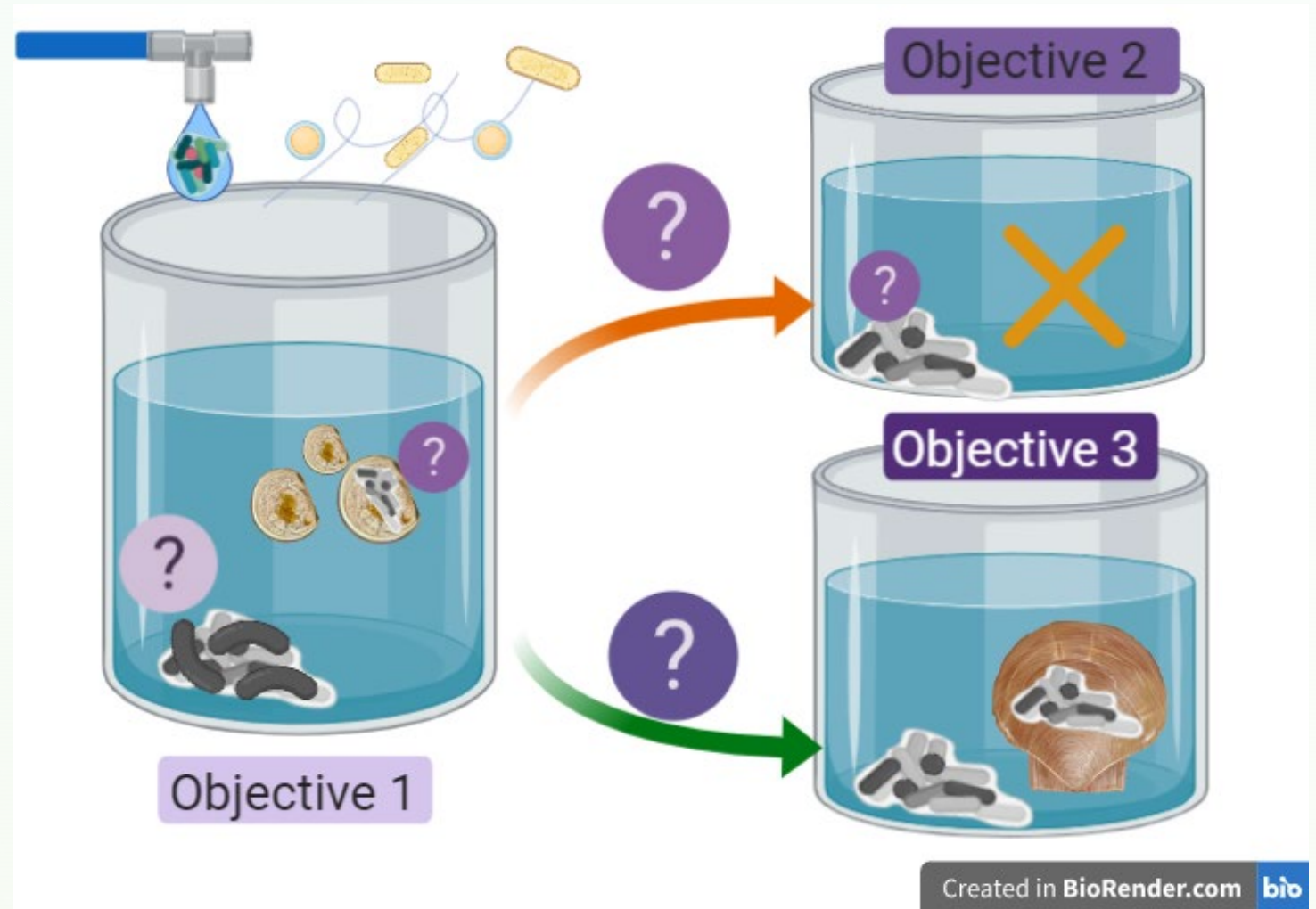
- Shared bacterial sequences
- Transfer of bacteria from media to nematode

It is plausible that nematode infection (and bacterial vectoring) contributed to mortality

- Bacterial identify
- Nematodes caused mortality in larvae

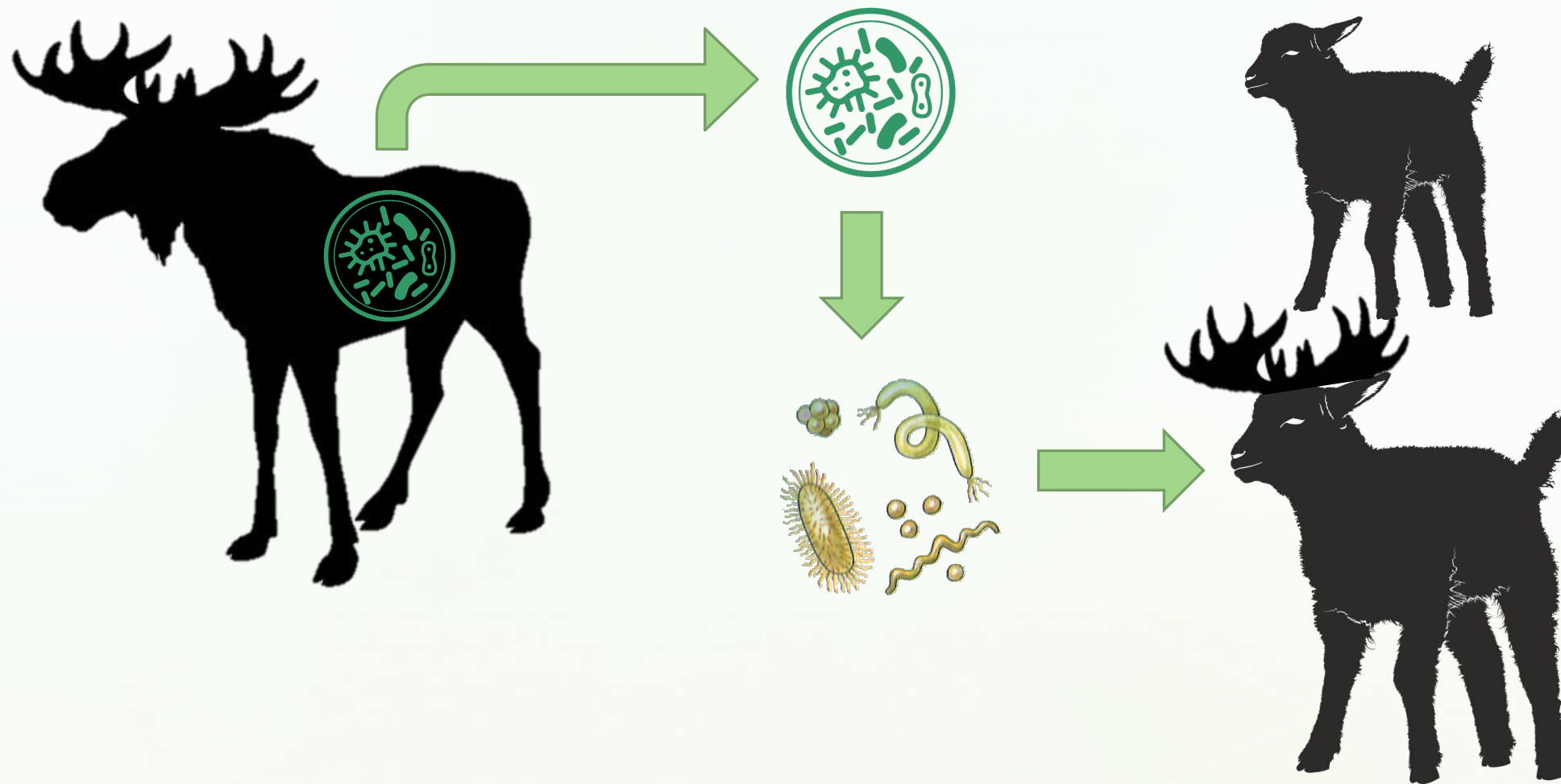
Ishaq et al. in review

Microbial community in and around the host may affect when the host decides to quit



Ishaq, Bowden, Perry, and Beal

What happens when you take microbes from an efficient herbivore and give it to another animal?



## Moose probiotics: Hypotheses



Ishaq et al. 2015

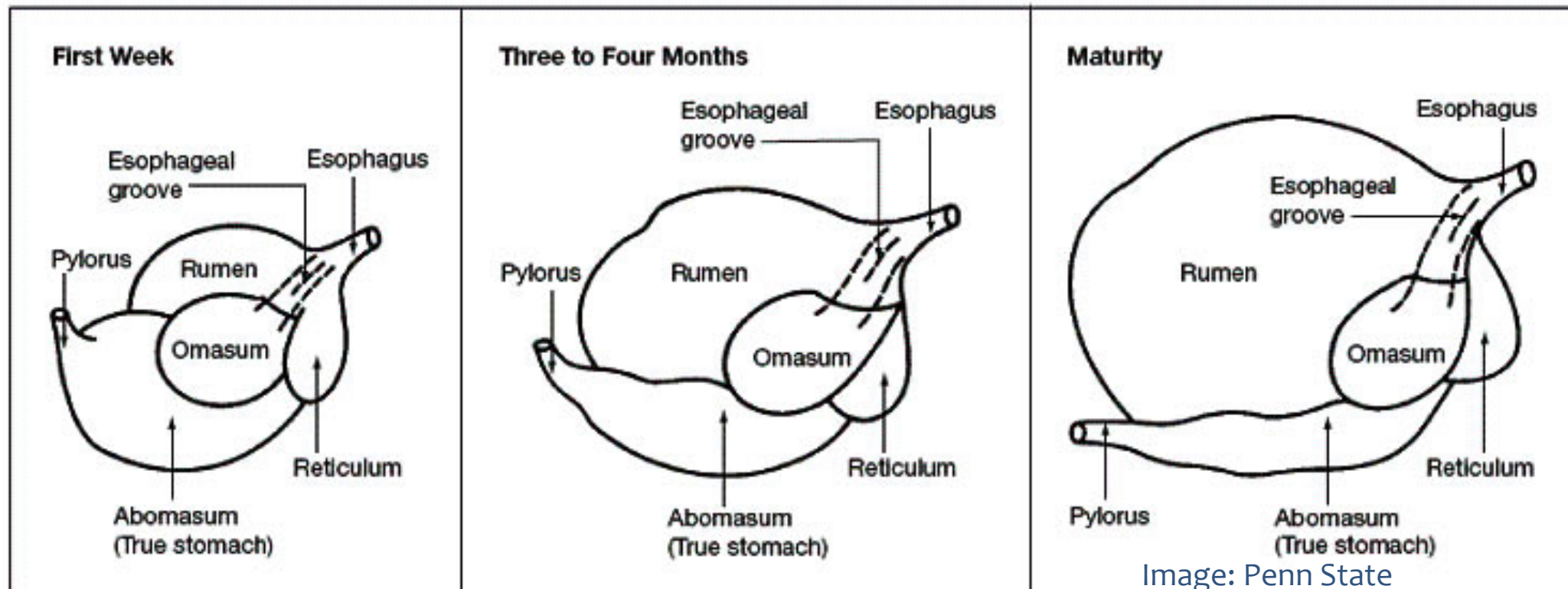
Introducing fibrolytic bacteria from moose to lambs would increase...

- rumen bacterial diversity
- weight gain
- wool growth (length, weight)



Decided to give fibrolytic probiotic during development and before the rumen microbiota has established

Figure 1. Development of bovine stomach compartments from birth to maturity.





Did it work? Sort of.  
Why it didn't work is a more interesting story...

Improved in Probiotic lambs	No Difference
Reduced rearing costs → enough to offset cost of adding probiotic?	Weight
Reduced acetate to propionate ratio → increased dietary efficiency	Couldn't find our probiotic in the rumen
Total wool growth	Most bacterial community metrics
Increased wool diameter (ns) → higher calorie intake or increased dietary efficiency	Methanogen and methanogen density



Ishaq et al. 2015

## Troubleshooting microbial interventions



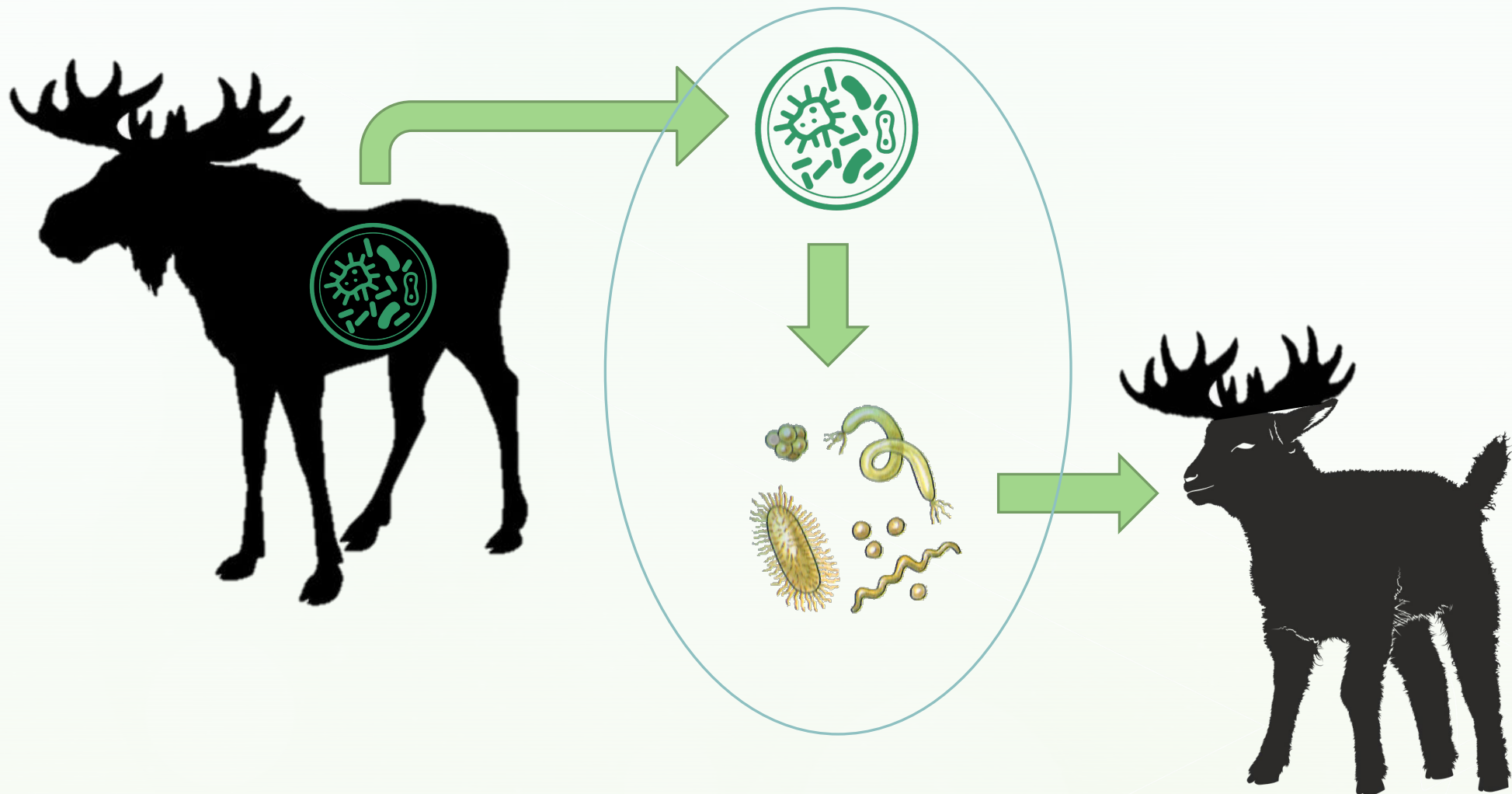
‘Send in the microbes’ doesn’t end up how you expected

How do we define ‘success’ in that host?

How do we pick the probiotic?

- SPATIAL and TEMPORAL context is key

Microbes have preferred hosts, can become lab-associated



“For nothing was simply one thing.”  
— Virginia Woolf, To the Lighthouse

Microbial interactions in the lab



Juggling | [Loris Bottello](#) | [Flickr](#)

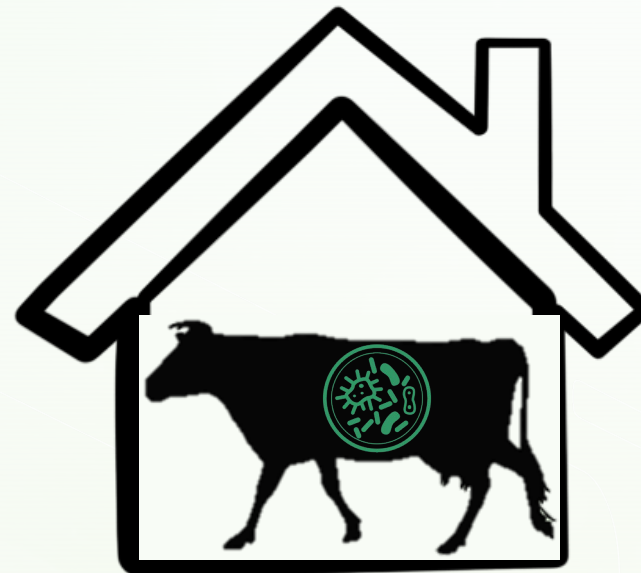
Microbial interactions in the gut



Copyright: Jaap Joris Vens - Super Formosa Photography

## Research vision at UMaine

- Recovering microbial communities in hosts
  - Lifestyle, diet, built environment affect gut diversity
  - Domestic livestock aren't wild-type anymore
- Create dynamic laboratory methods to study this system more accurately





# Building Community





# Teamwork makes the dreamwork



[sueishaqlab.org/team/](https://sueishaqlab.org/team/)





# Affiliation, Collaboration



School of Food and Agriculture  
Biomedical Sciences and Engineering  
Molecular & Biomedical Sciences  
Ecology and Environmental Sciences  
UMaine Medicine

# Community-building



Microbes and Social Equity working group  
Pedagogy in STEMM working group  
Supporting Diversity, Equity, and Inclusion group  
WiSTEMM  
500 Women Scientists, Pod Coordinator for Orono

# Social equity is about fair access

Access to resources gives us

- Access to beneficial microbial interactions
- Reduction in stress
- Improvement in health
- Promotes beneficial host-microbial interactions


▪ <https://en.wikipedia.org/>,  
▪ <https://www.peakpx.com/>,  
▪ <https://www.wallpaperflare.com/>



 OPEN ACCESS

ESSAY

# Framing the discussion of microorganisms as a facet of social equity in human health

Suzanne L. Ishaq , Maurisa Rapp, Risa Byerly, Loretta S. McClellan, Maya R. O'Boyle, Anika Nykanen, Patrick J. Fuller, Calvin Aas, Jude M. Stone, Sean Killpatrick, Manami M. Uptegrove, Alex Vischer, Hannah Wolf, Fiona Smallman, Houston Eymann, Simon Narode, Ellee Stapleton, Camille C. Cioffi, Hannah F. Tavalire [ [view less](#) ]

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## Citations

- Appanna 2018, [https://link.springer.com/chapter/10.1007/978-981-10-7684-8\\_1](https://link.springer.com/chapter/10.1007/978-981-10-7684-8_1)
- Ishaq et al. in review, preprint through Research Square: <https://www.researchsquare.com/article/rs-101817/v1>
- **Ishaq, S.L.**, Wright, A-D.G. 2012. Insight into the bacterial gut microbiome of the North American moose (*Alces alces*). BMC Microbiology, 12:212.
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- **Ishaq, S.L.**, Kim, C.J., Reis, D., Wright, A-D.G. **2015**. Fibrolytic bacteria isolated from the rumen of North American moose (*Alces alces*) and their potential as a probiotic for ruminants. PLoS One, 10:12.
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- Yeoman, C.J. and **Ishaq, S.L.**, Bichi, E., Olivo, S.K., Lowe, J., Aldridge, B.M. **2018**. Biogeographical Differences in the Influence of Maternal Microbial Sources on the Early Successional Development of the Bovine Neonatal Gastrointestinal tract. Scientific Reports 8:3197.