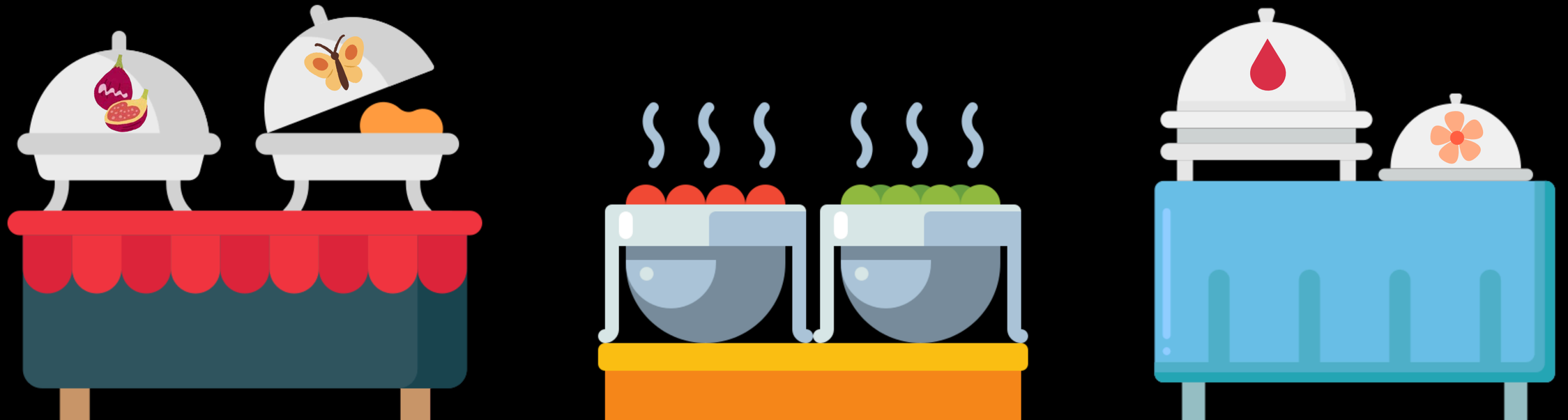
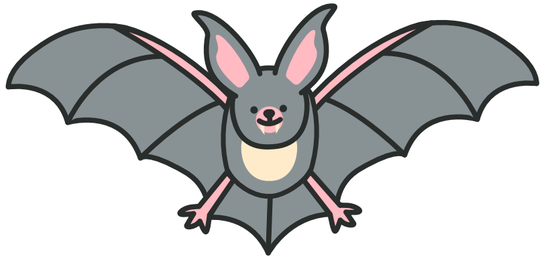
Buffet for Bats: A Feast of Dietary Diversity

Andrea Bernal-Rivera



About me

Colombia



8 years

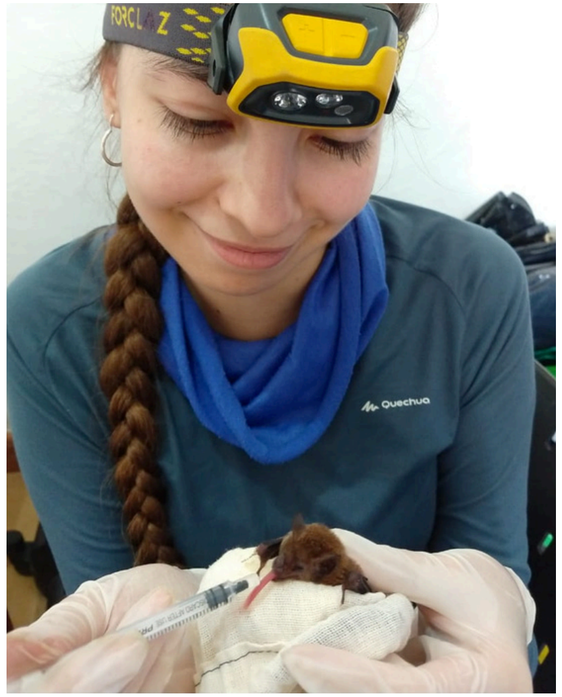
Ecophysiology

Calima Foundation

University of Washington

Global Union of Bat Diversity Networks

My work

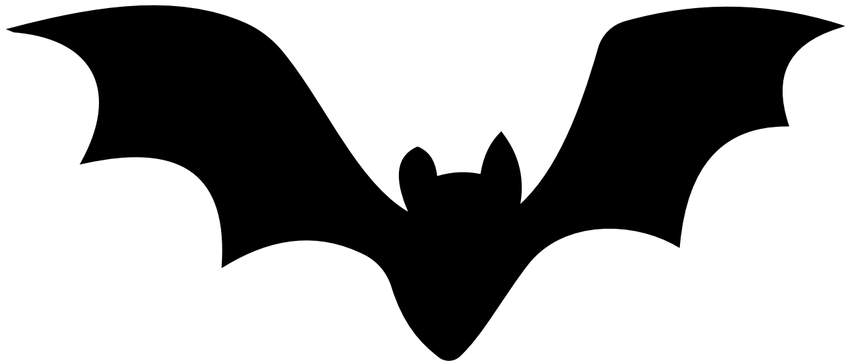


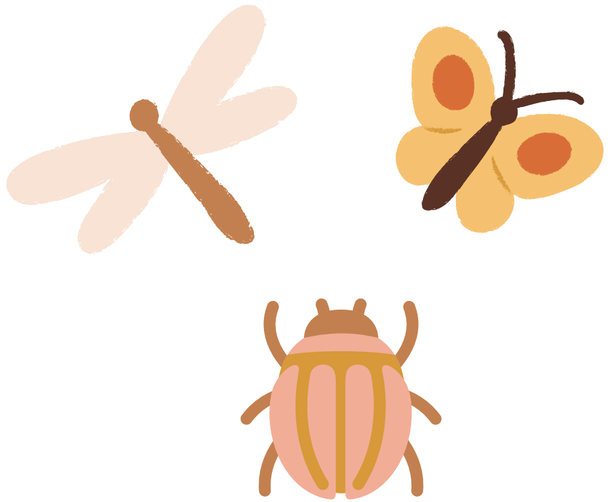
Agenda

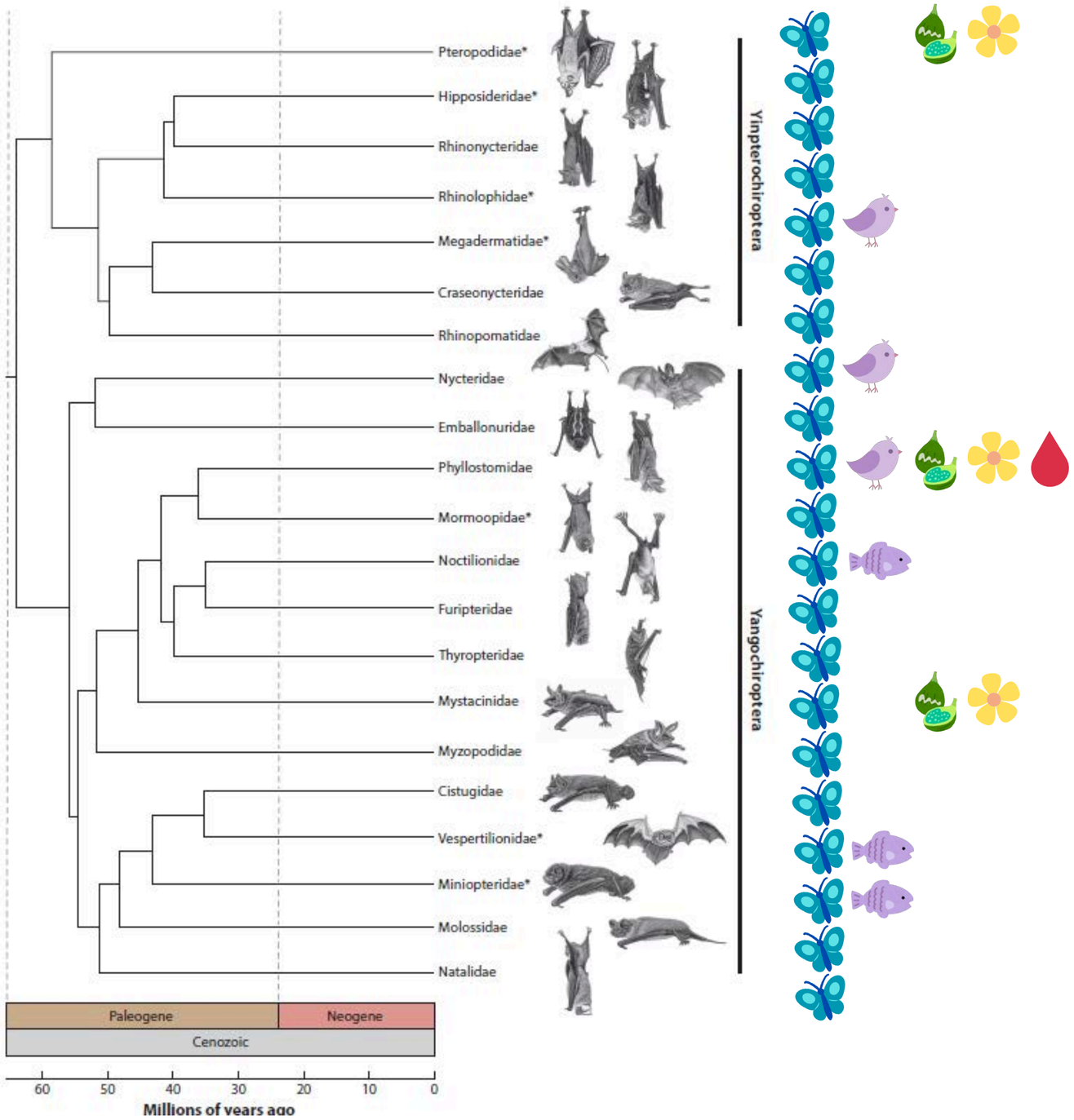
1. Bat dietary diversity
2. Ecosystem services
3. Adaptations to diet
- Morphology
- Sensory system
- Behavior
- Physiology
4. My research

Dietary evolution of bats

Ancestor

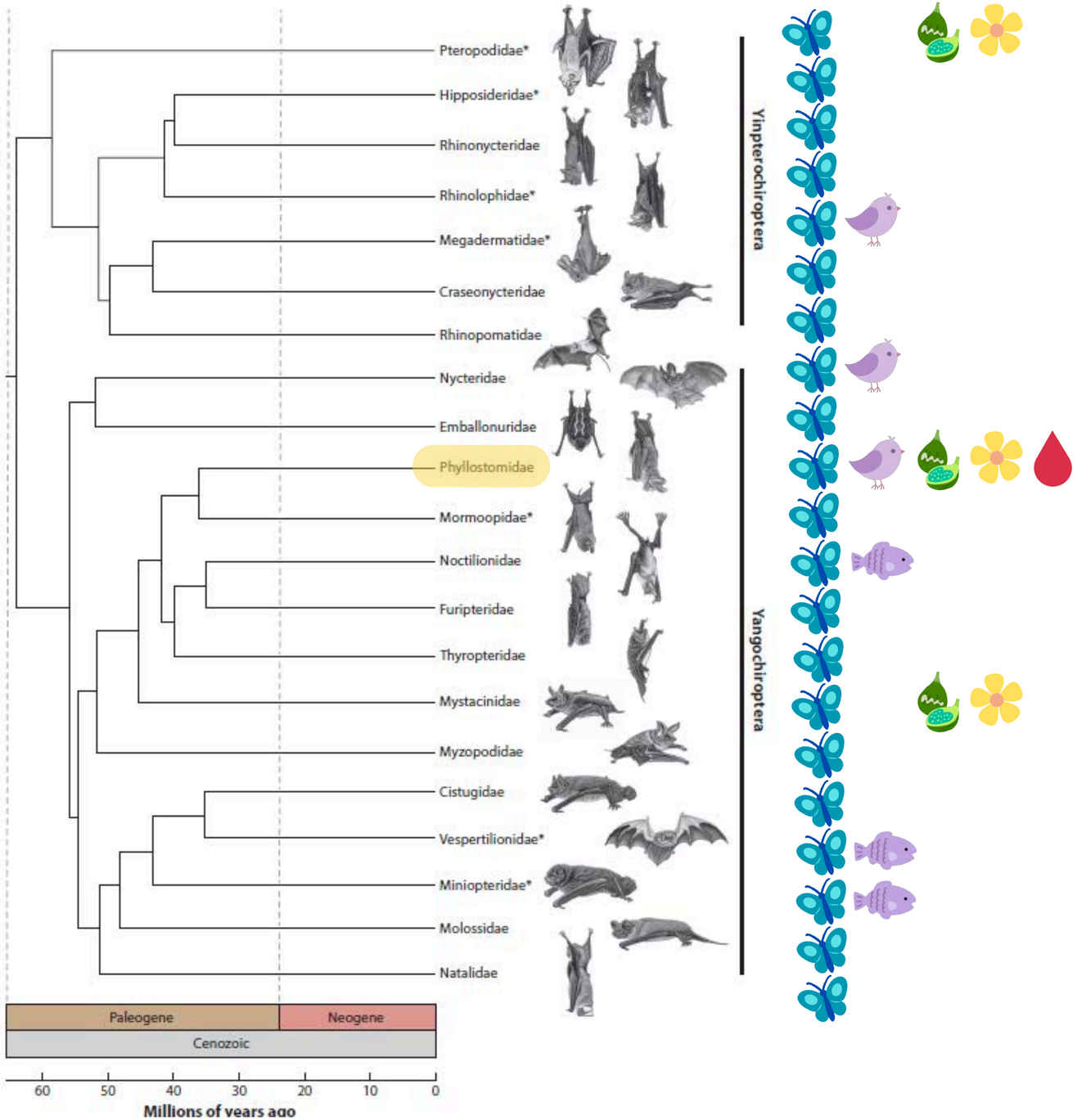






Bats exhibit a huge dietary diversity

Teeling et al. 2018

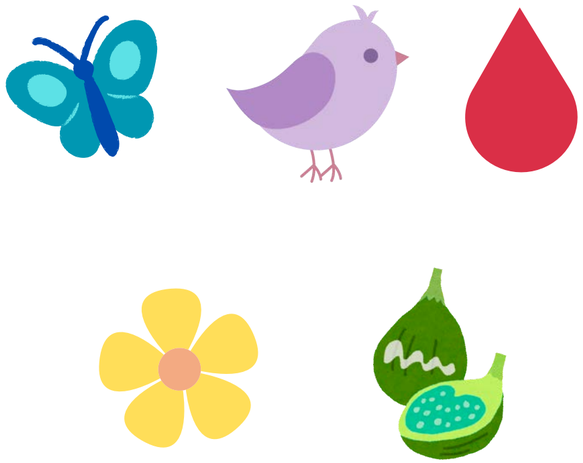


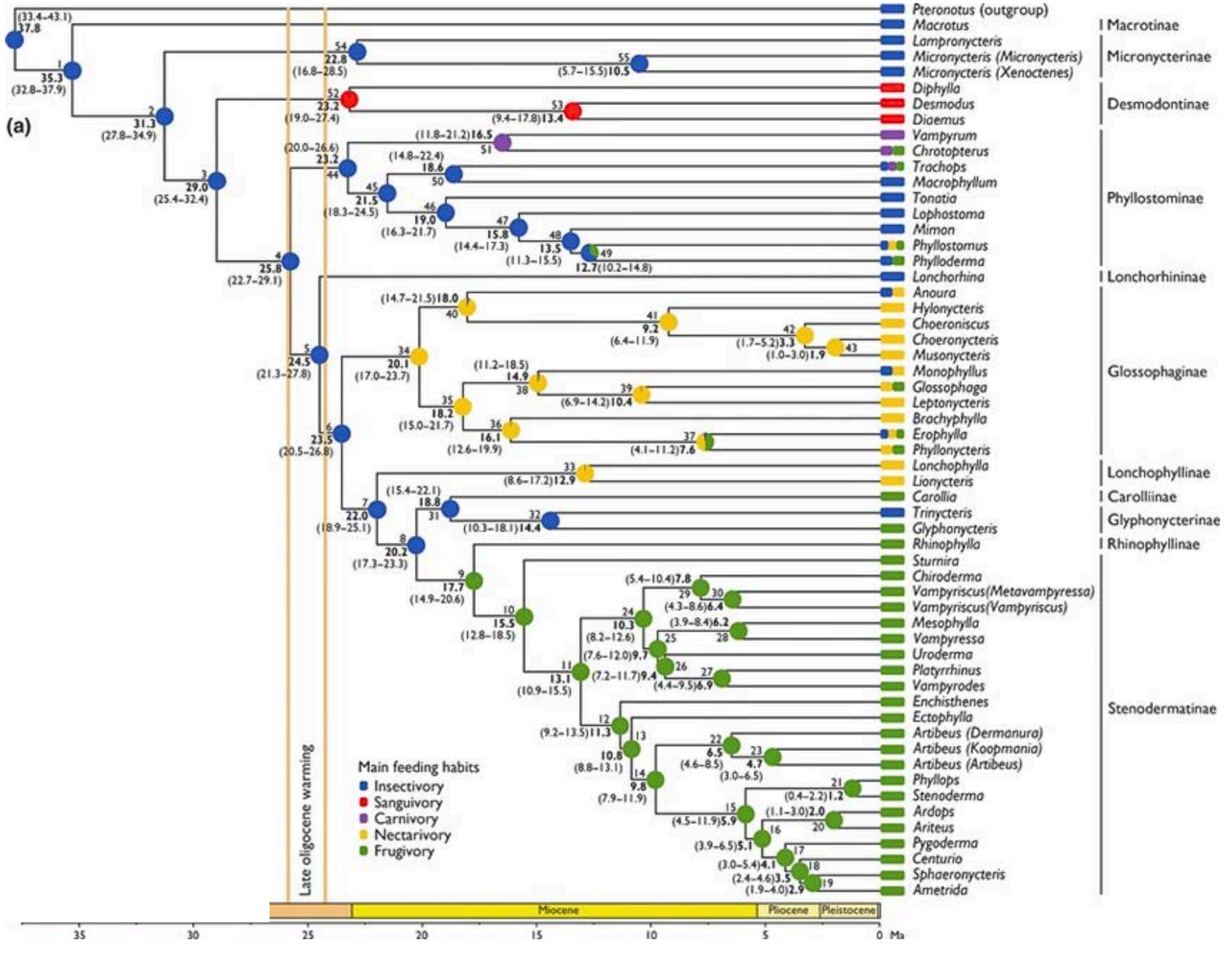
Bats exhibit a huge dietary diversity

Teeling et al. 2018

Bats exhibit a huge dietary diversity

Phyllostomidae





Rojas et al. 2011

Bat dietary diversity

> 1400 Bat species

~ 70% insectivores
50-100% of their body weight in insects

Only 3 species feed on blood

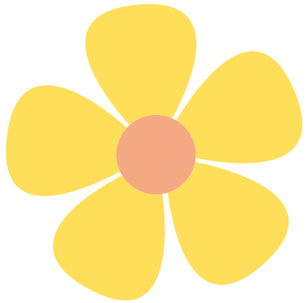
Photos:
merlintuttle.org

Diet is a continuum

Broad categories

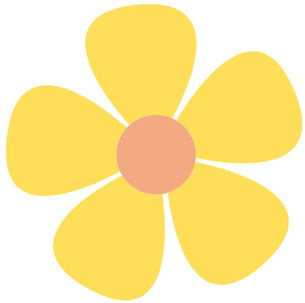
Diet is a continuum

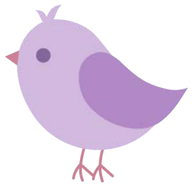
Broad categories

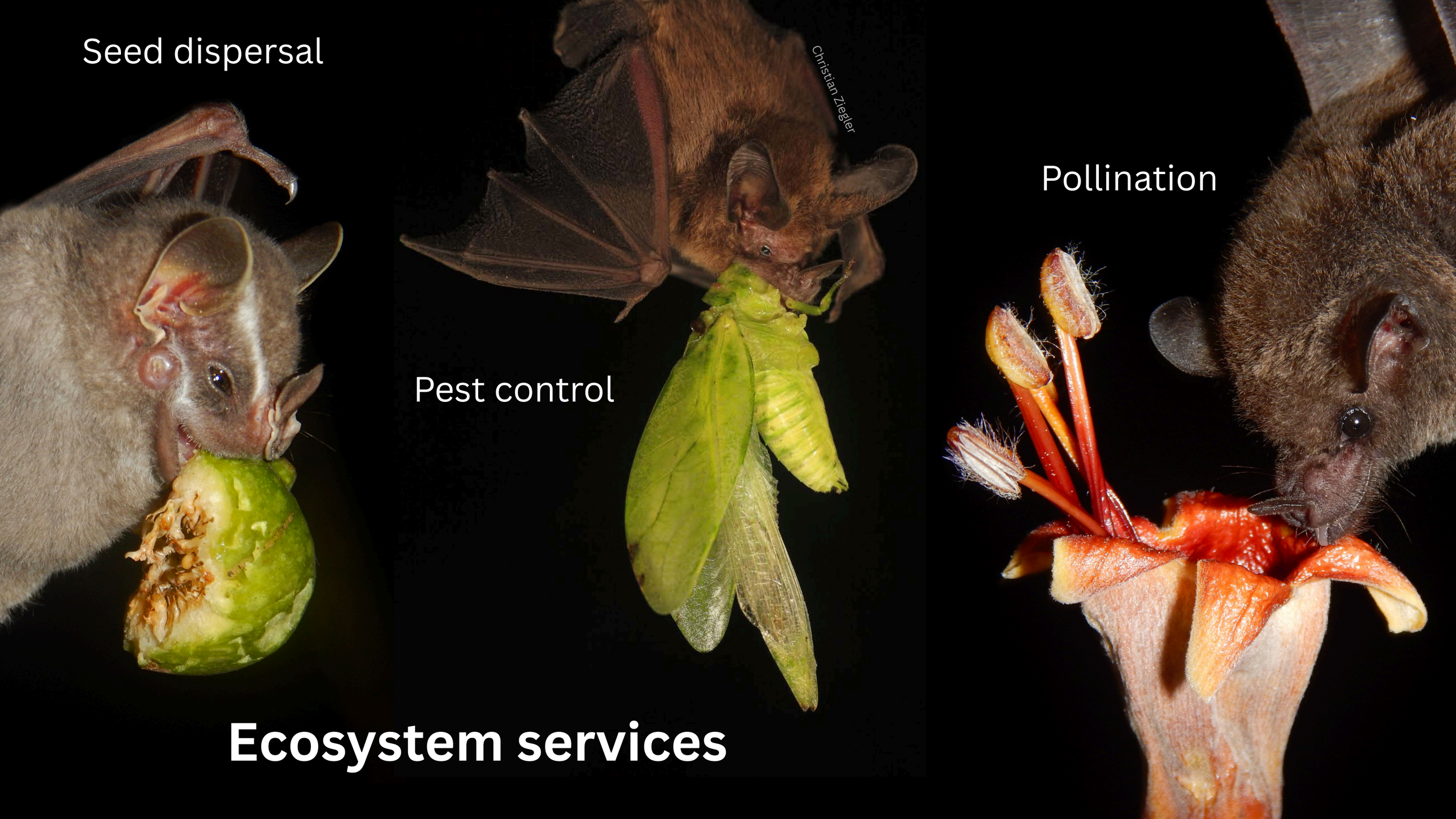


Diet is a continuum

Broad categories







Ecosystem services

Bats in action

with Austin Bat Refuge

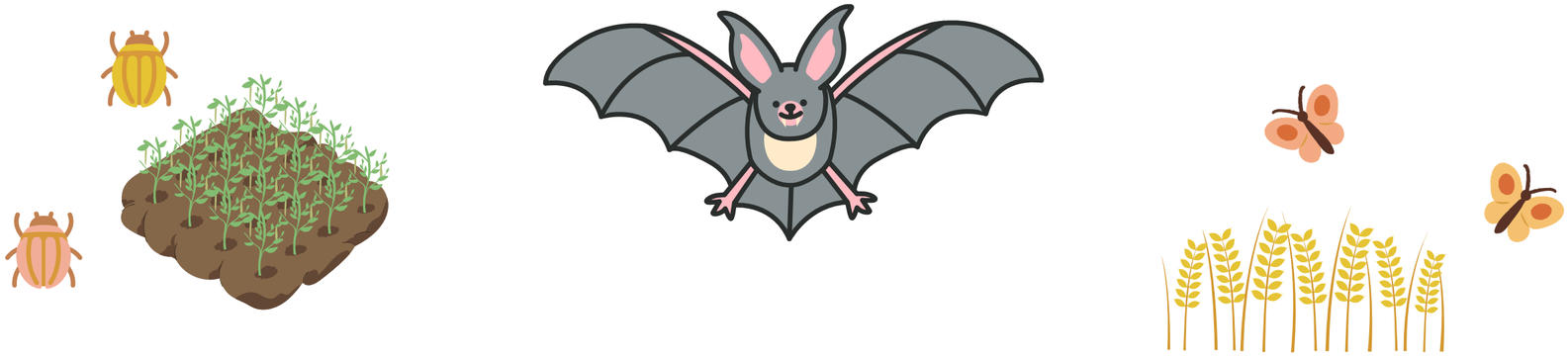
with INCIVA

with Nathan Muchhala

Ecosystem services measured

> 500 plant species depend on bats for their pollination

Pest control estimated to be over 3.7 billion dollars per year in the US



Enormous contribution of bats to the ecosystems and to our lives:

https://www.fightwns.org/bat-alphabet/

Example of ecosystem services and bats used for conservation purposes

Inform restoration with native plants

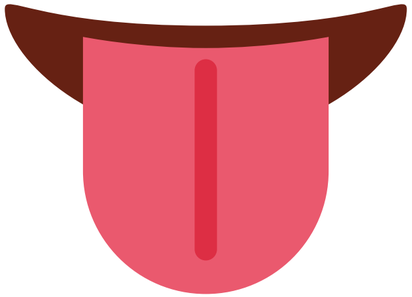
Conservation values (CVs)

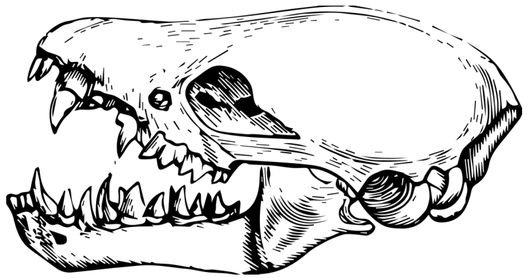
Protected areas

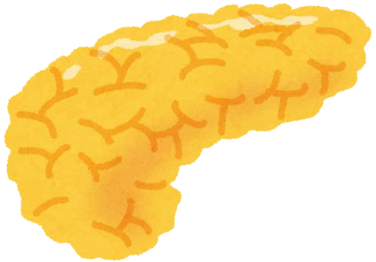
Adaptations of bats to their diet

- Morphology
- Sensory system
- Behavior
- Physiology

Morphology

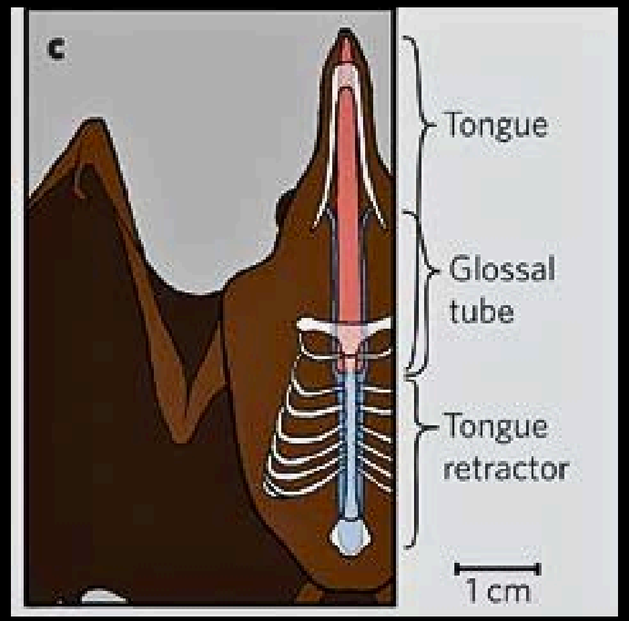






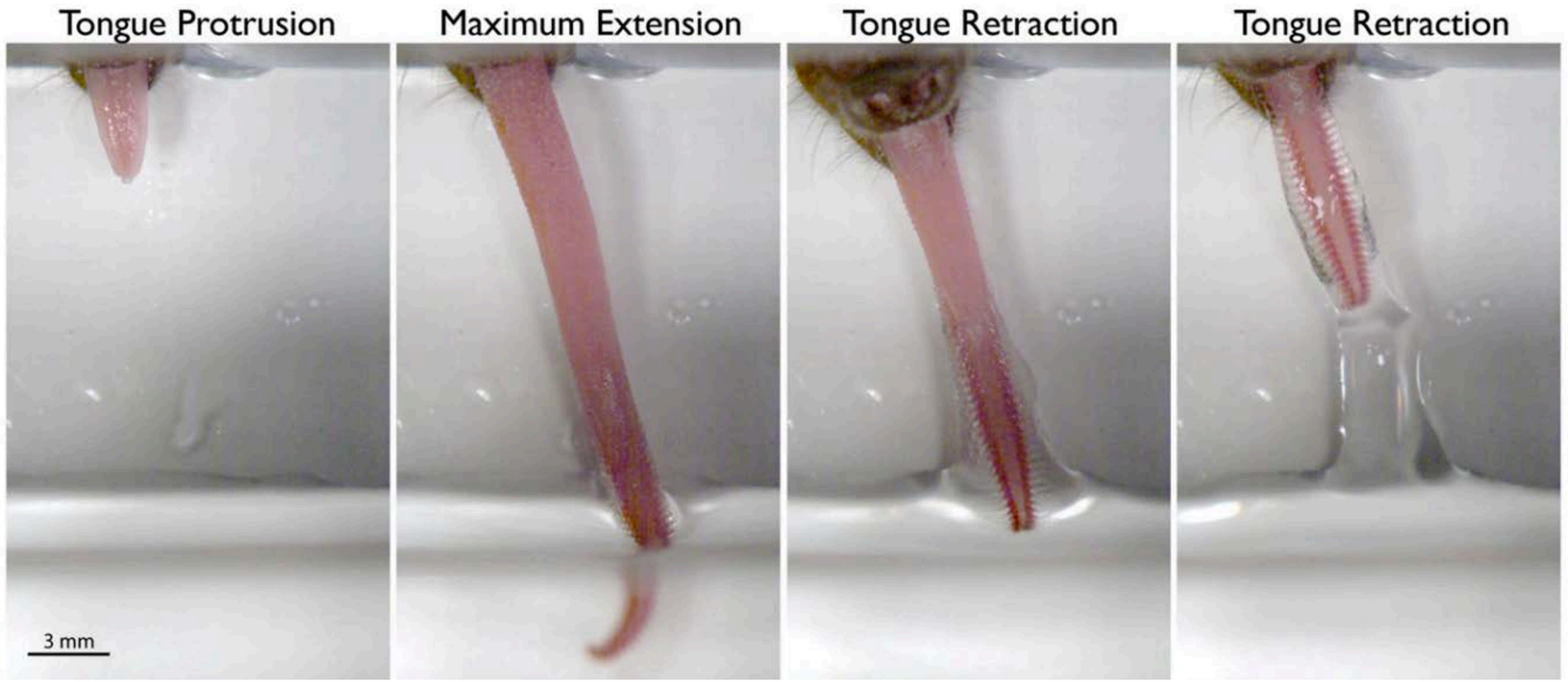
Diet

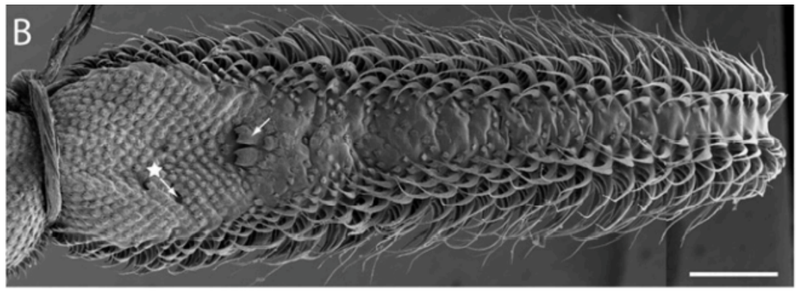
Tongue in nectarivorous bats

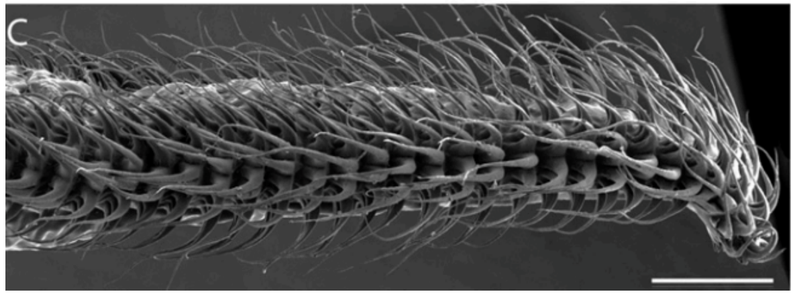


Muchhala et al. 2006

Tongue in nectarivorous bats

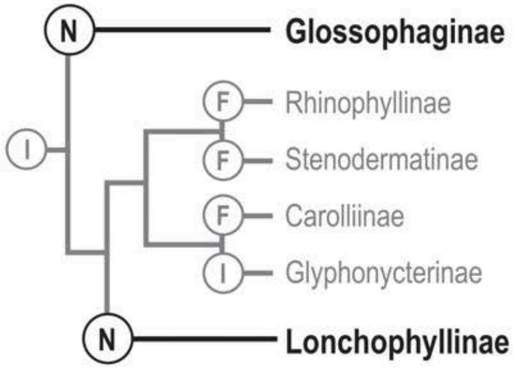


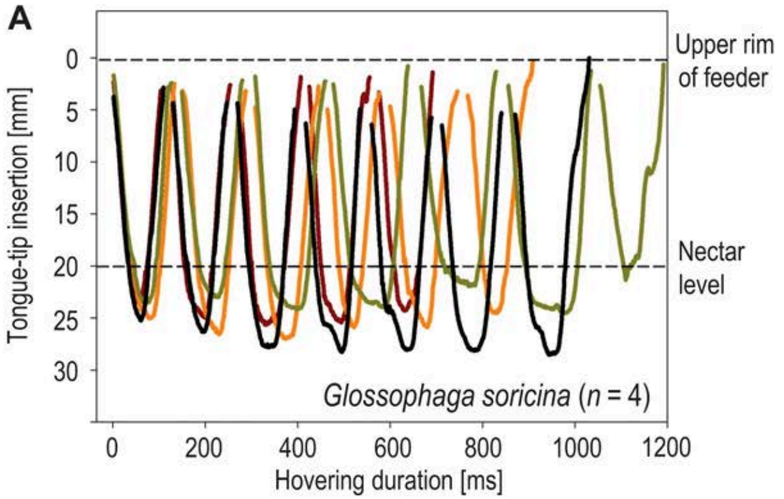


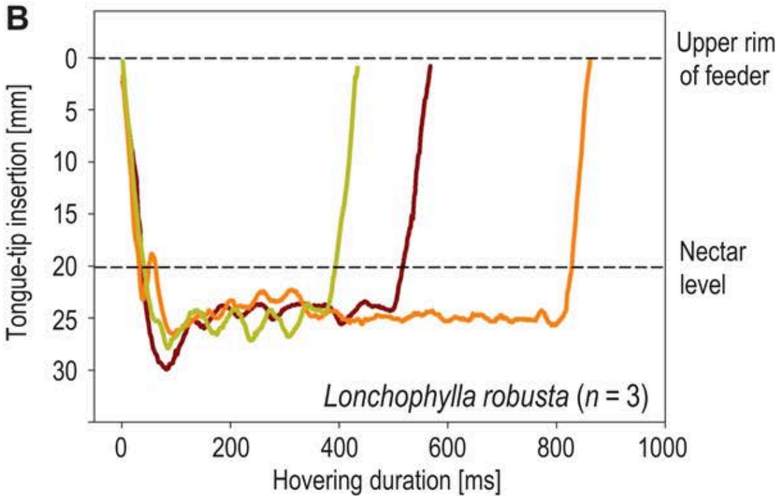


Harper et al. 2013

Tongue in two lineages of nectarivorous bats

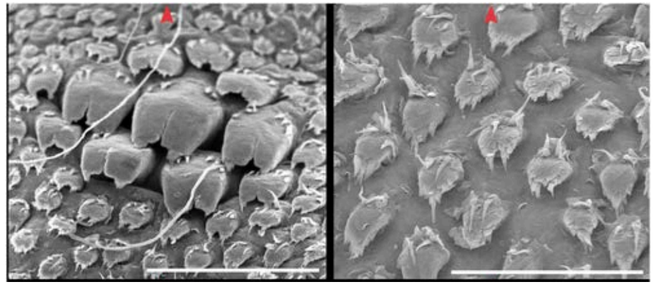


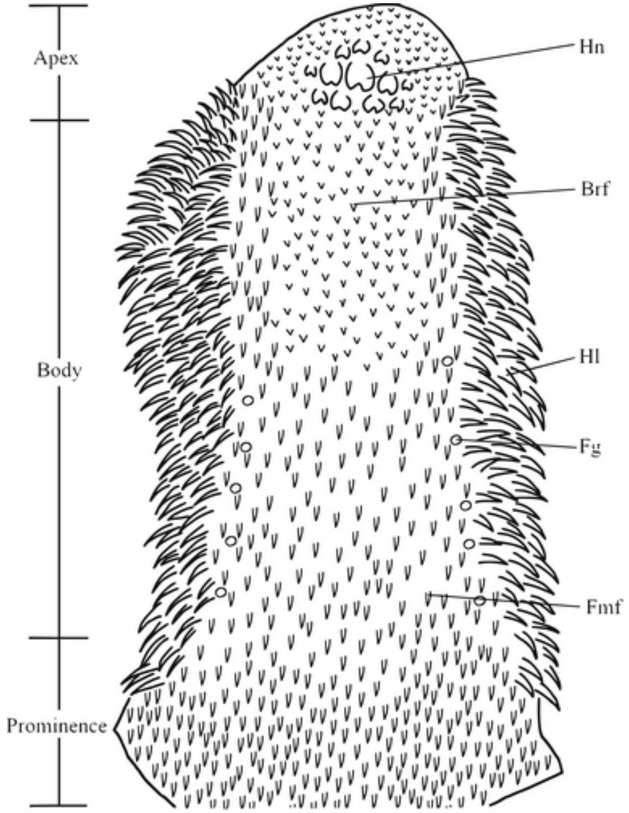




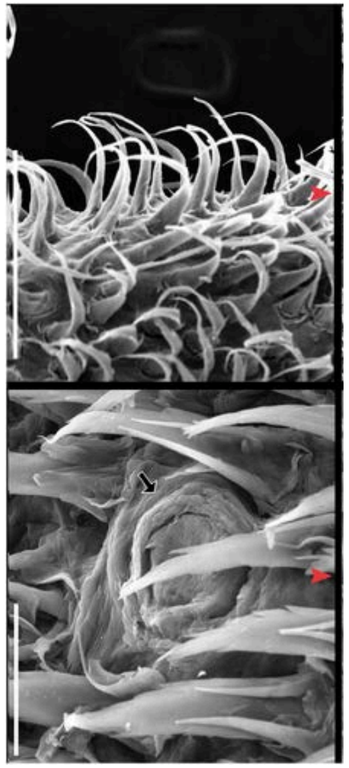
Tschapka et al. 2015

More tongues

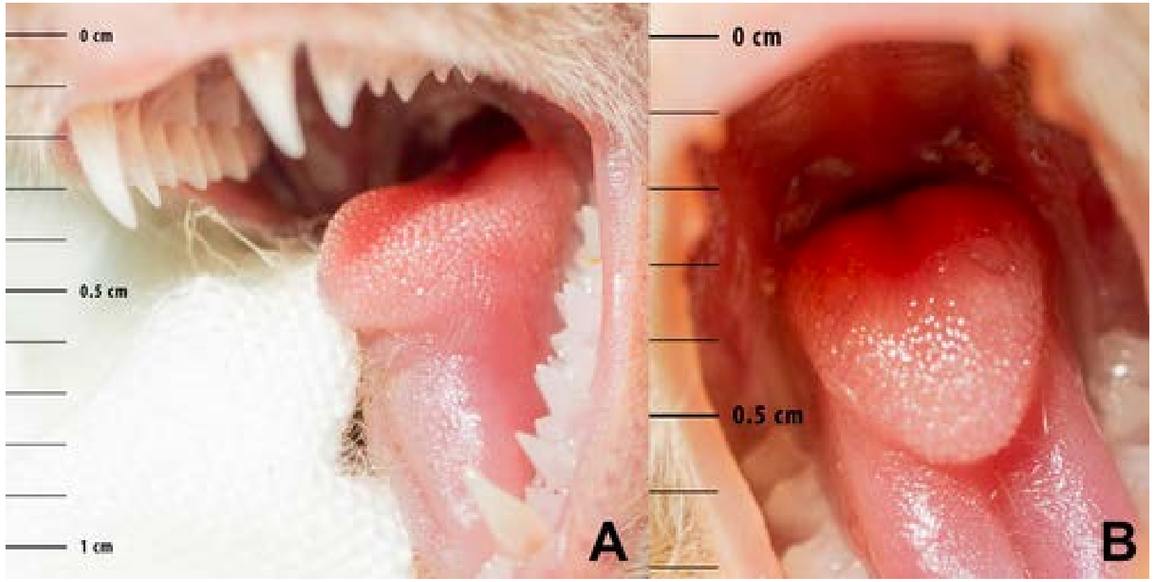




Quinche et al. 2022

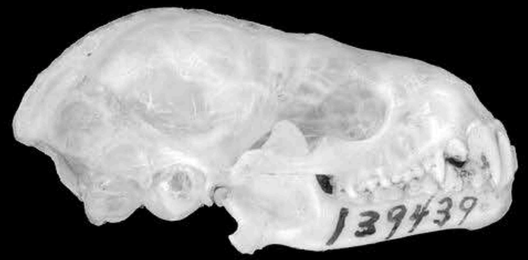


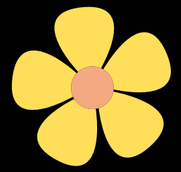
Russo et al. 2025



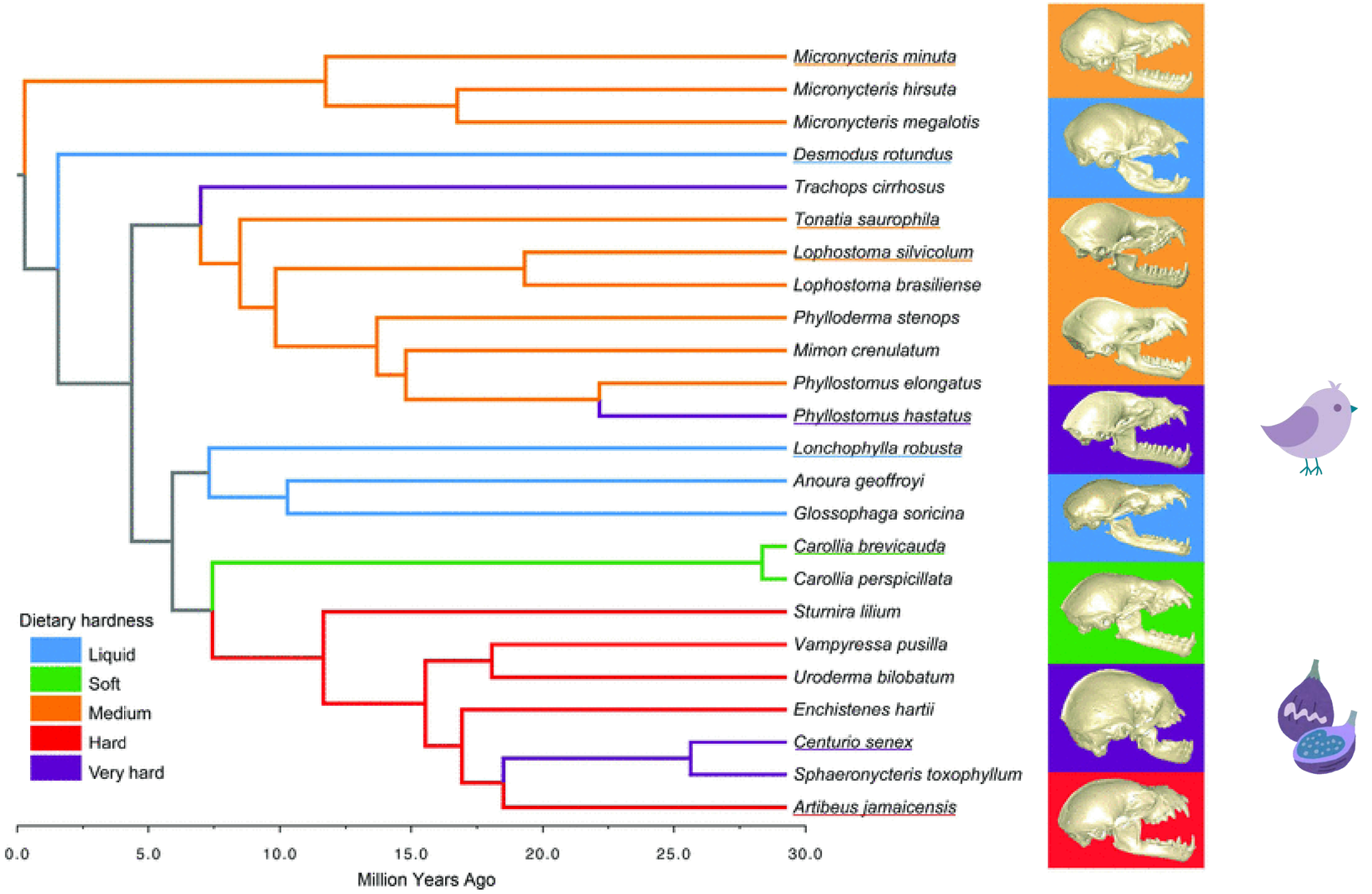
Skull morphology and diet

Elizabeth Dumont



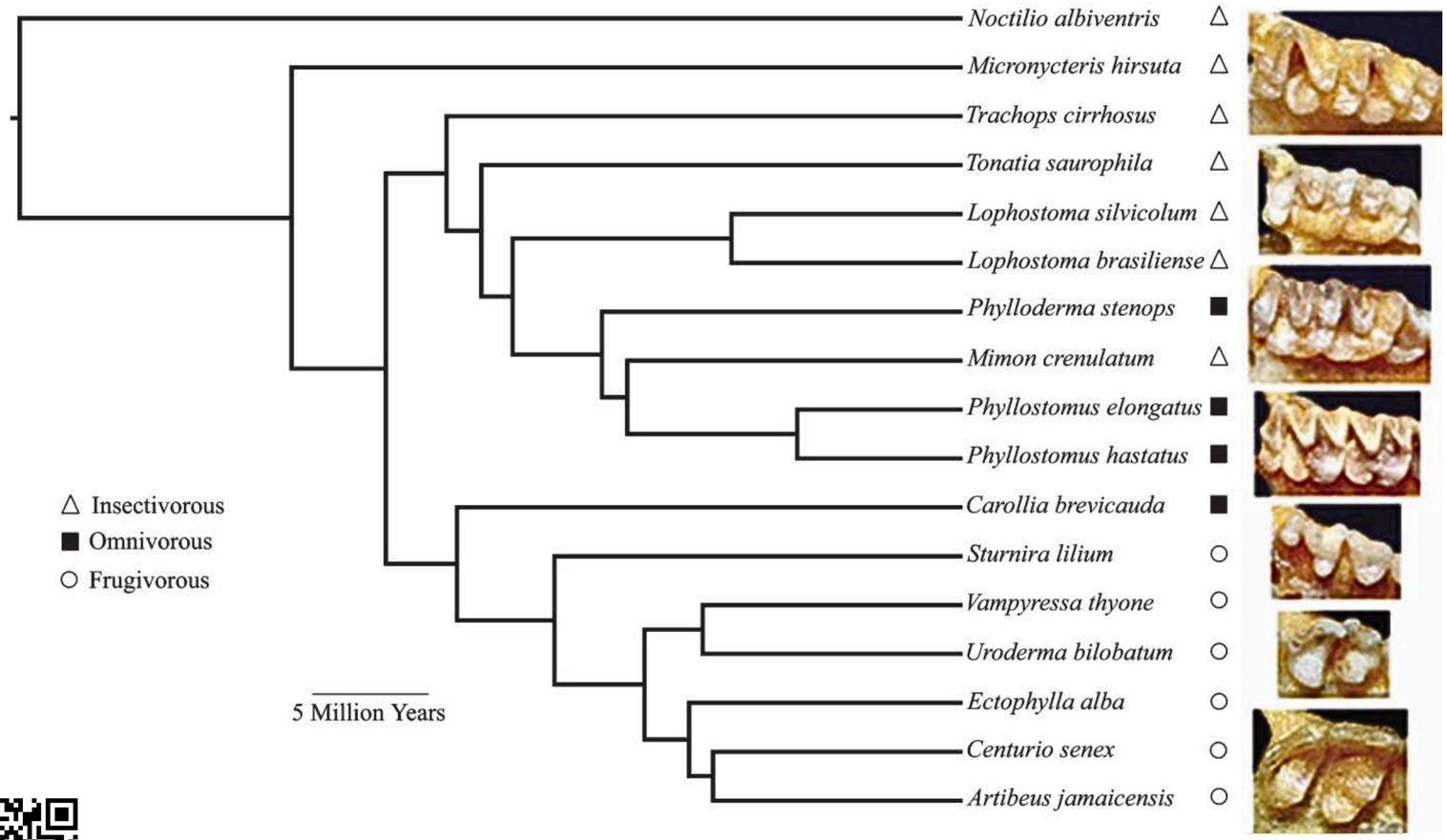


Skull and dietary hardness



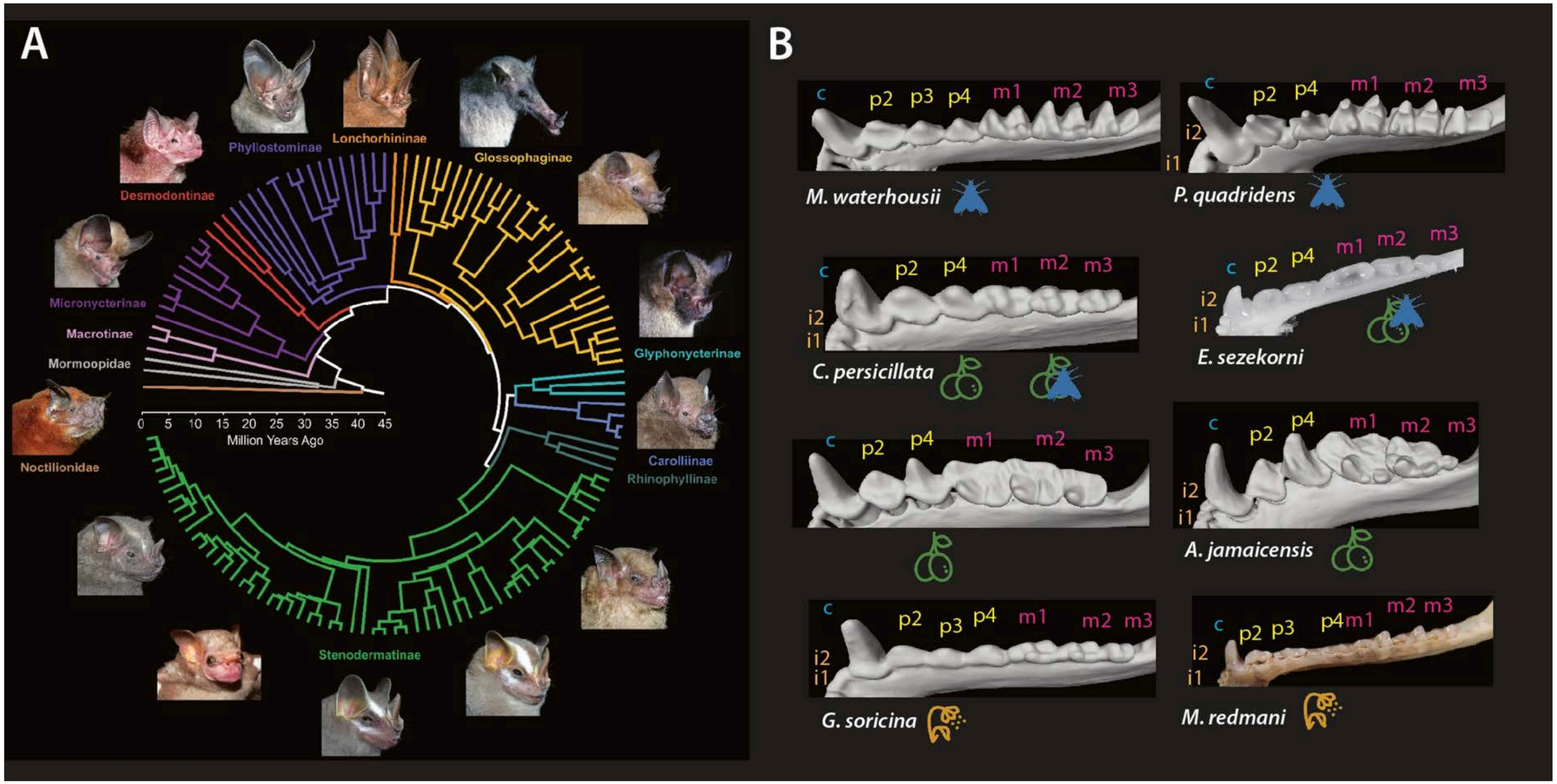
Santana et al. 2012

Molar morphology reflects bat diet



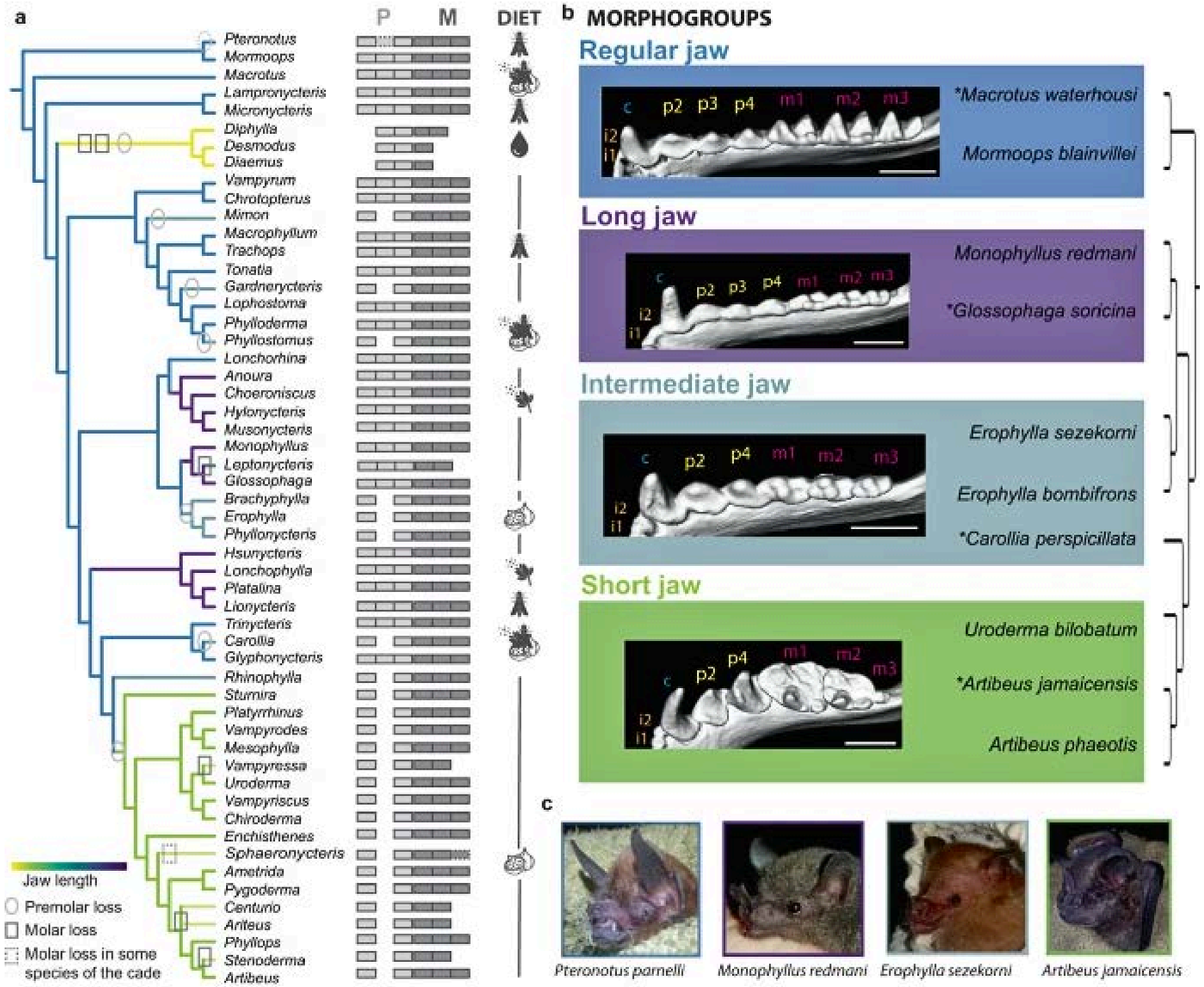
Santana et al. 2012

Teeth morphology reflects bat diet



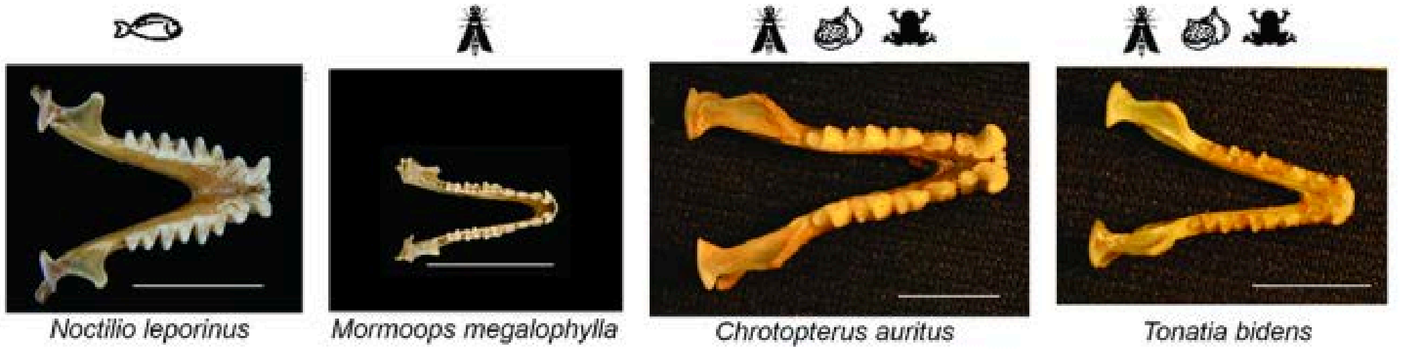
Dumont et al. 2011

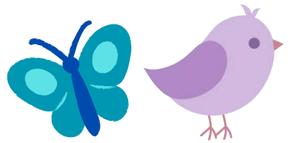
Sadier et al. 2023

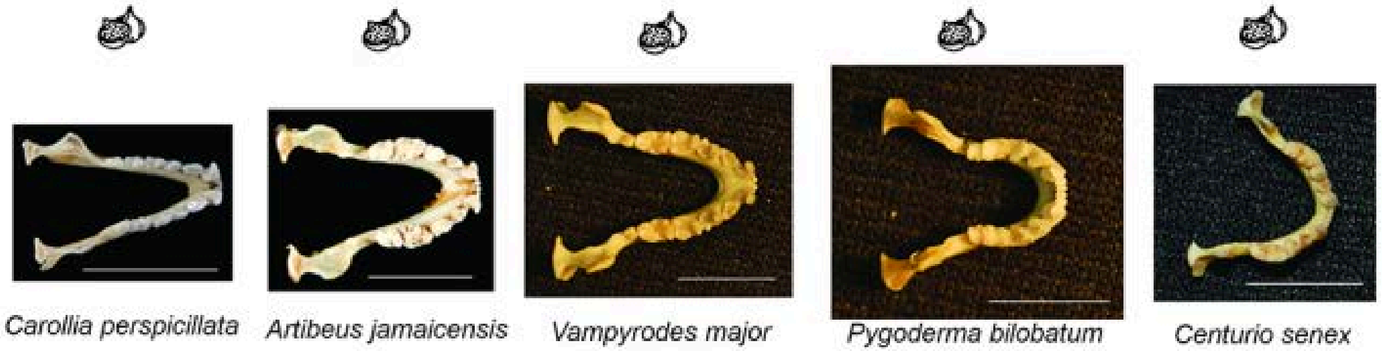


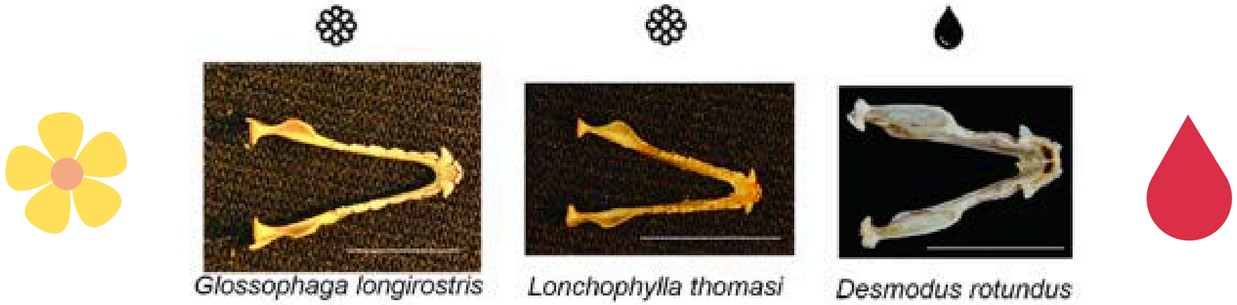
Jaw length and teeth loss are also related to diet

Sadier et al. 2023





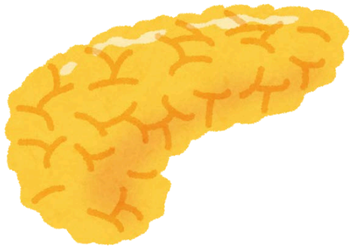




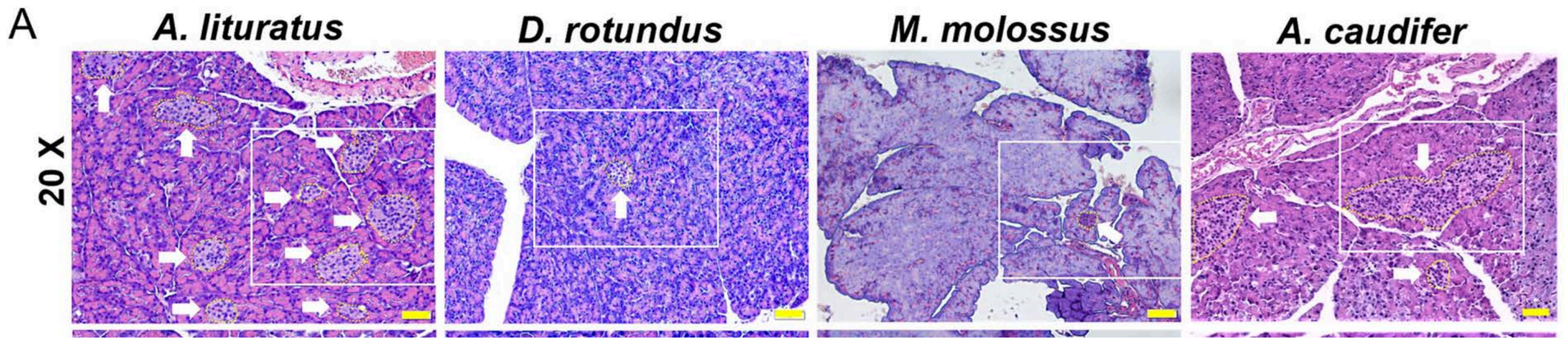
Jaw shape diversity and diet

Sadier et al. 2021

Bonus: Fishing bat



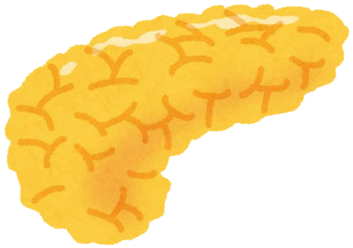
Pancreas morphology



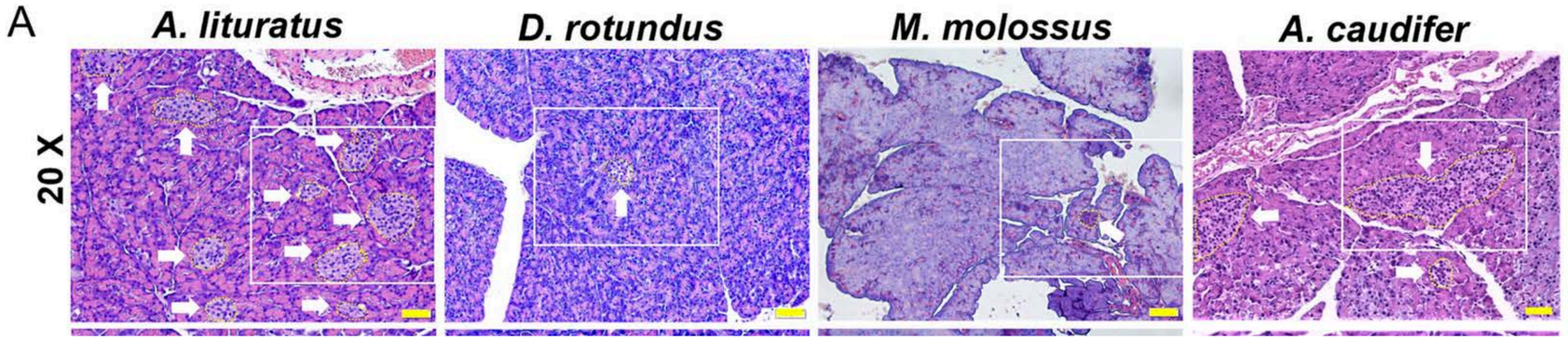
Pancreas islets

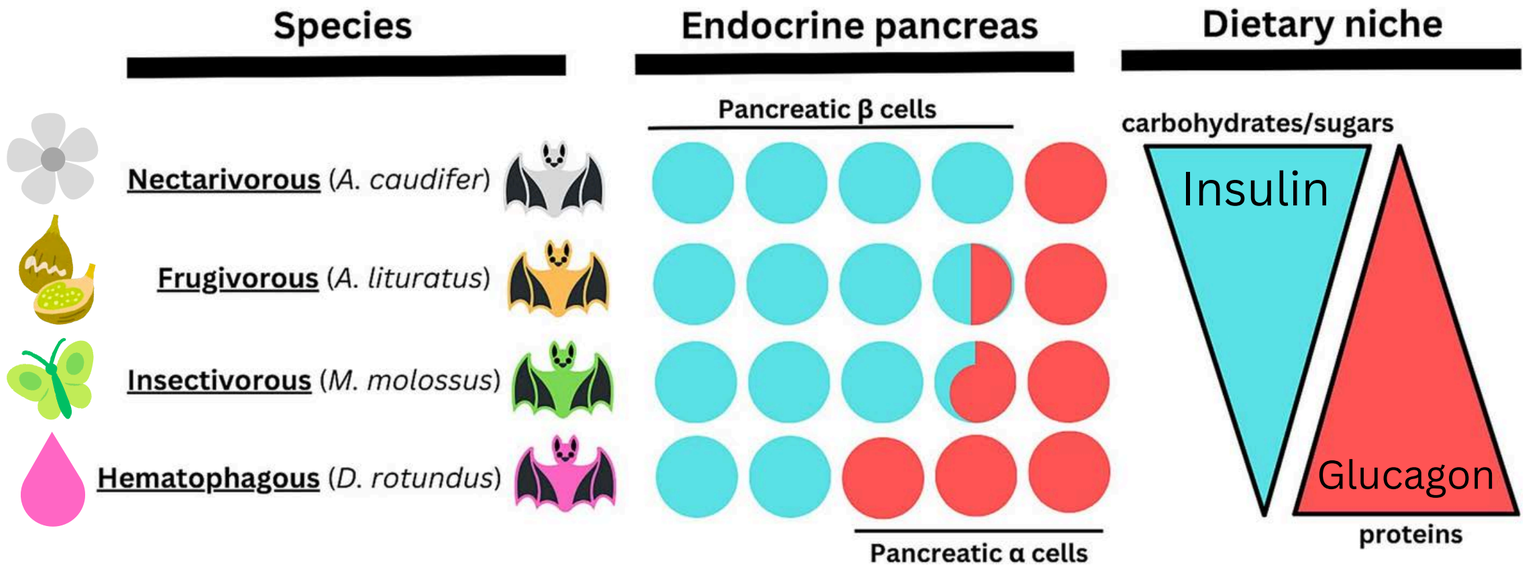
Production of hormones that are crucial for nutrient metabolism

Cotini et al. 2024



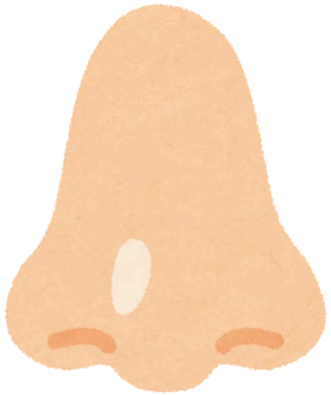
Pancreas morphology

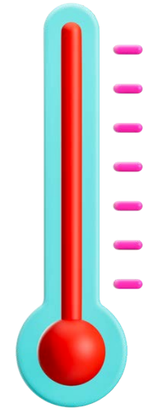




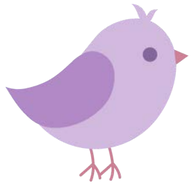
Cotini et al. 2024

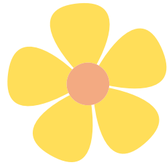
Sensory system



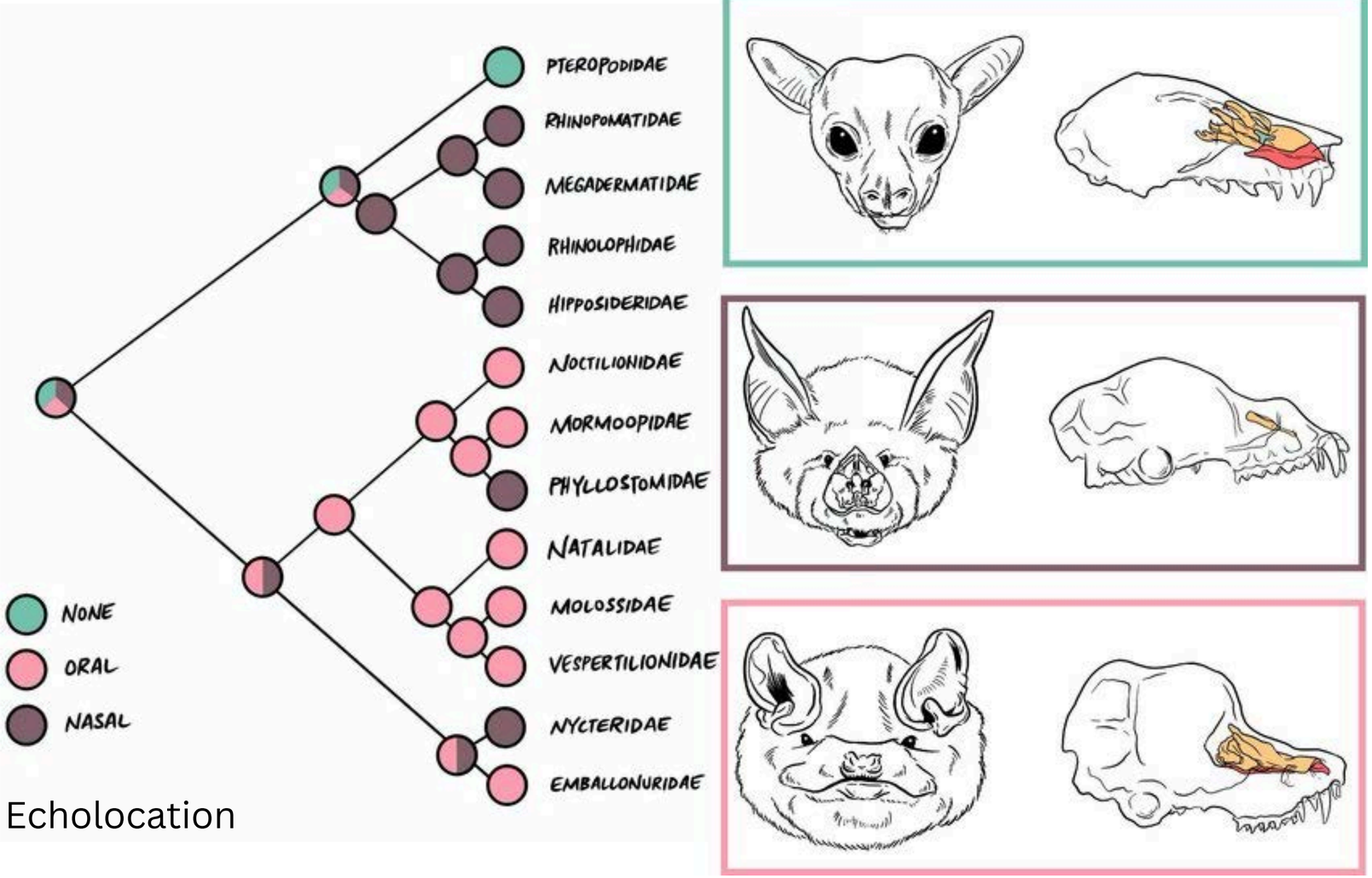



Find different food resources




Different ways to locate sources and navigate

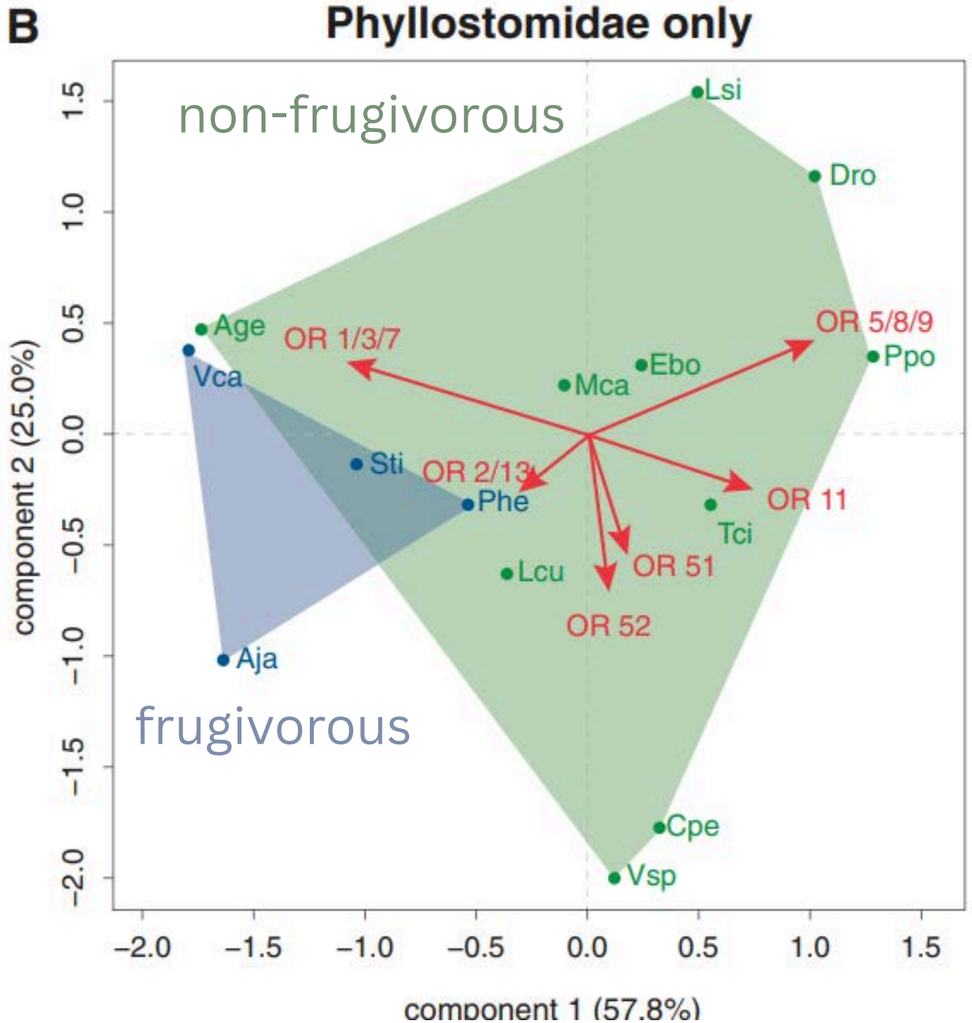


Echolocation

Dzal & Gillam, 2023

Odor perception

OR genes



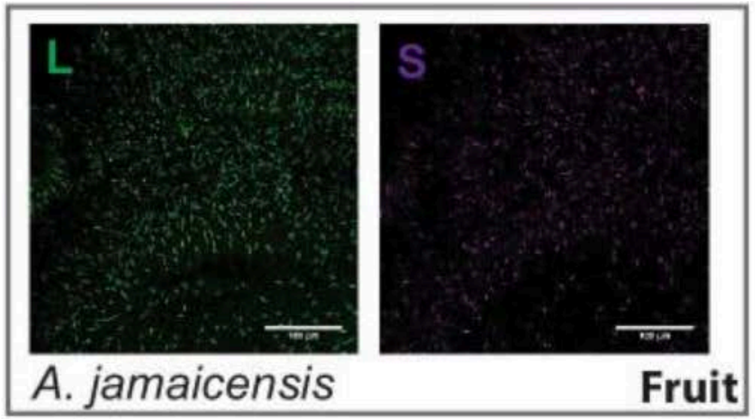
Olfactory receptors (OR)

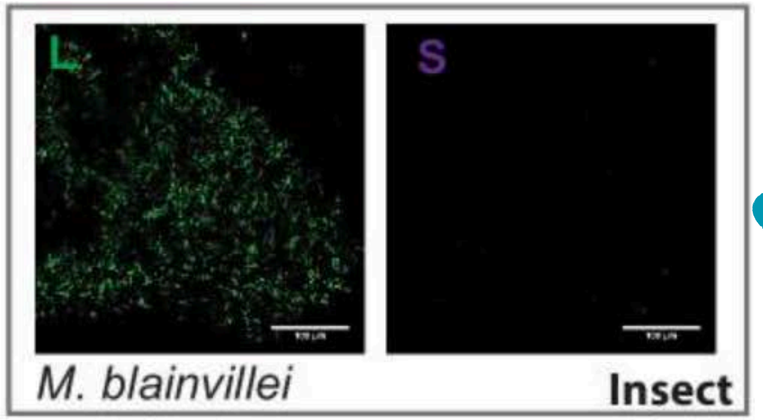
Unique OR pattern linked to the frugivorous diet of New World fruit-eating bats

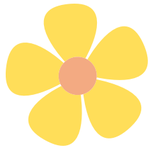
Strong association between niche specialization and OR diversity

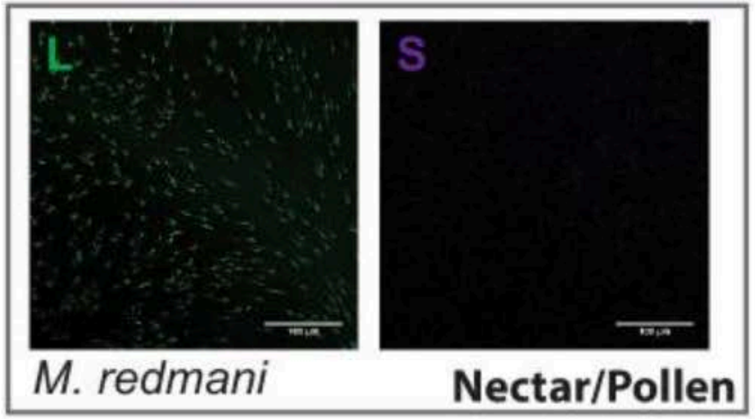
Hayden et al. 2014

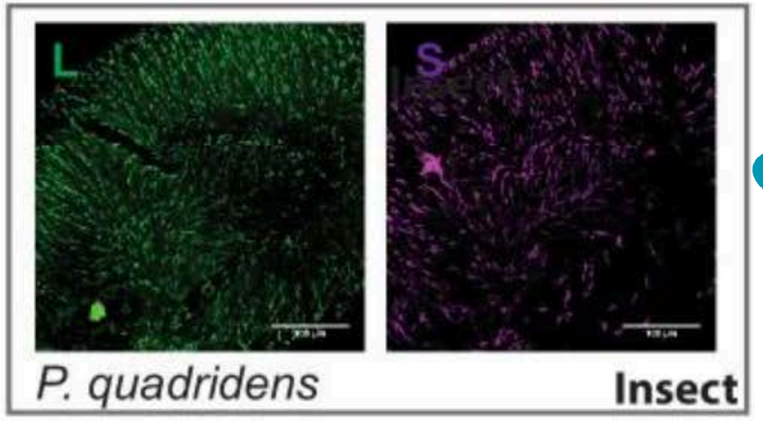
Dichromatic and UV-vision











Vision is a highly evolvable trait that repeatedly and rapidly changes in response to diverse selective demands

Sadier et al. 2018

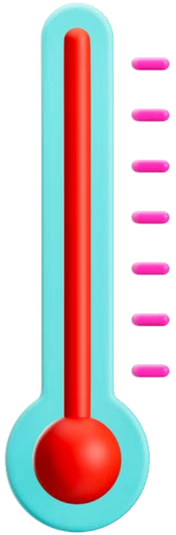
Thermoperception

Nasal pits

Kürten & Schmidt, 1982

Detection of infrared radiation

Vampire bat

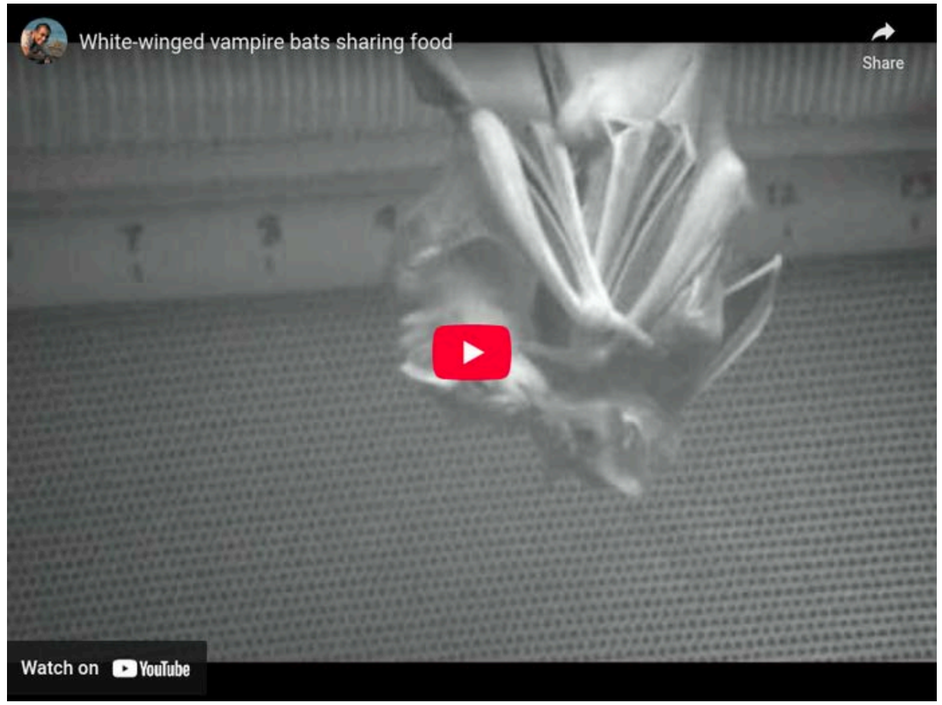


Heat detection
in preys’ body

Behavior

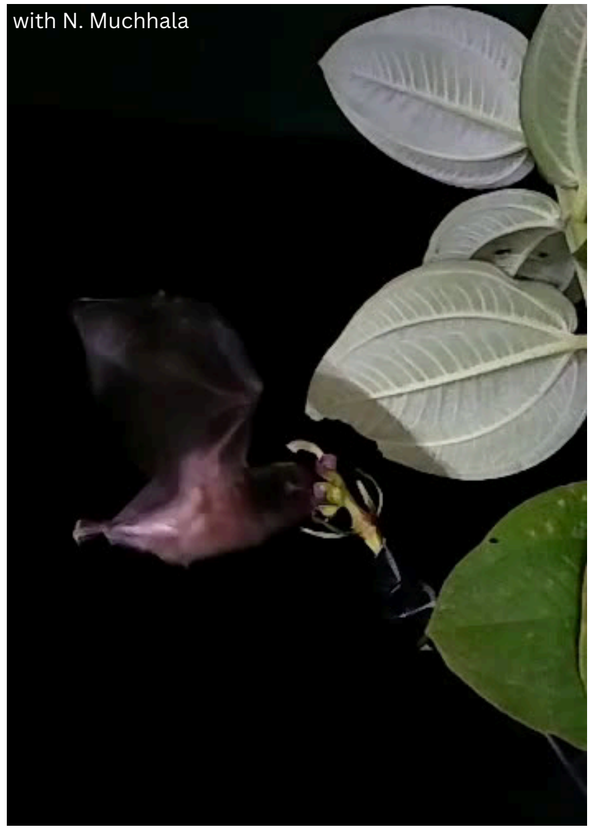
Jumping (vampire bat)

Food sharing (vampire bat)



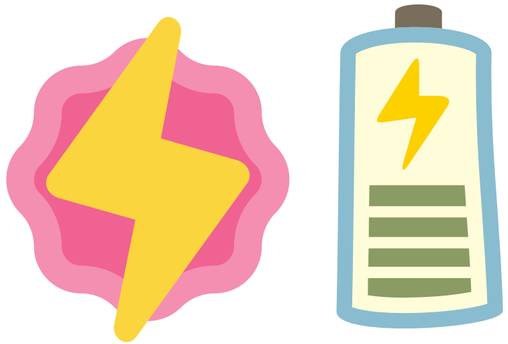
Behavior

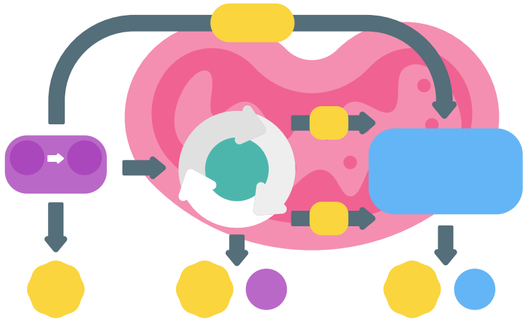
Hovering (nectar bats)



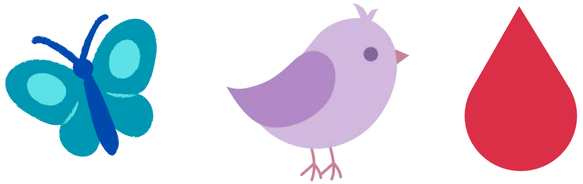
To go food
frugivores, carnivores

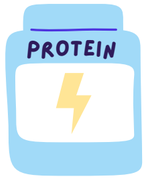
Physiology



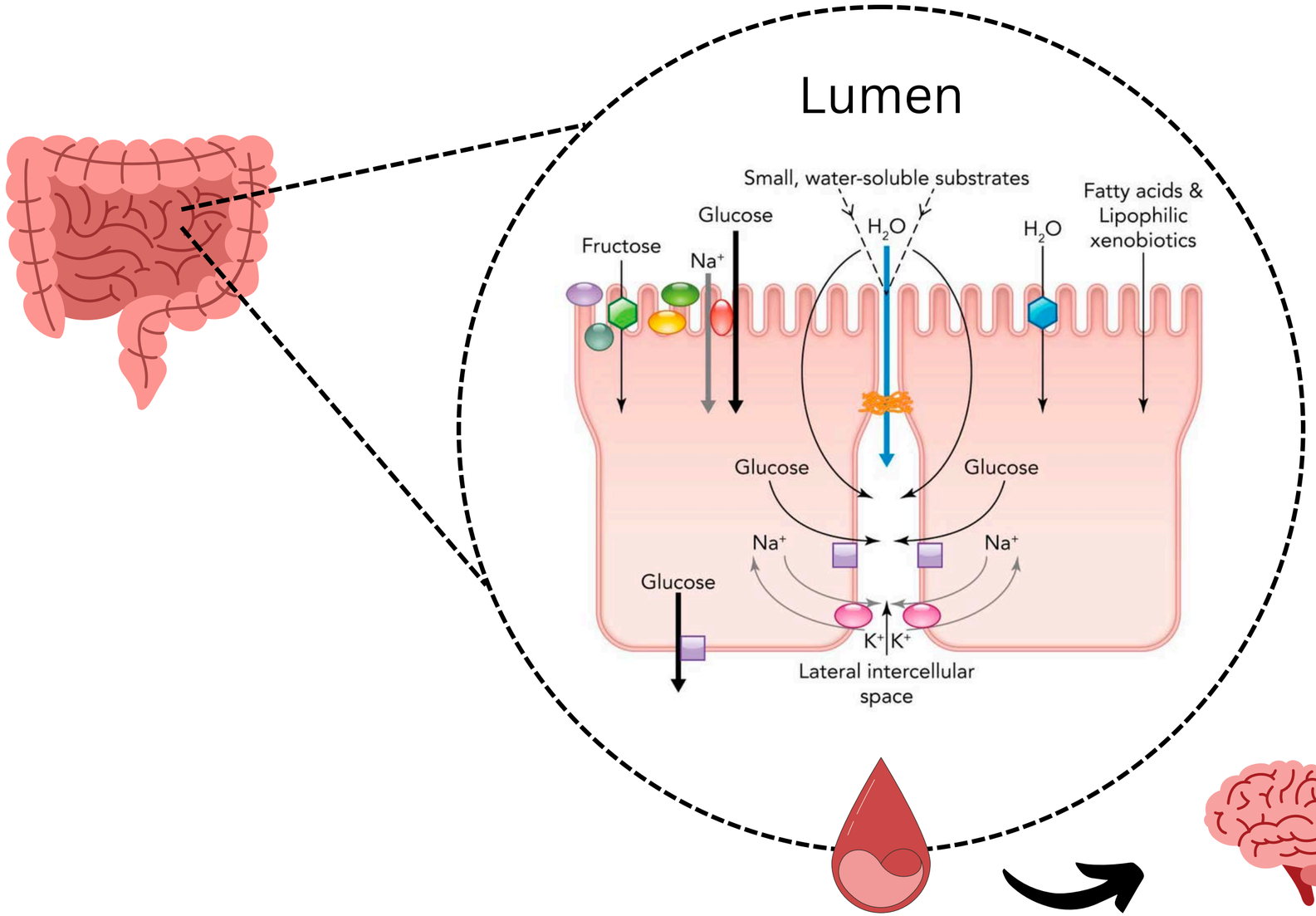


Nutrient assimilation



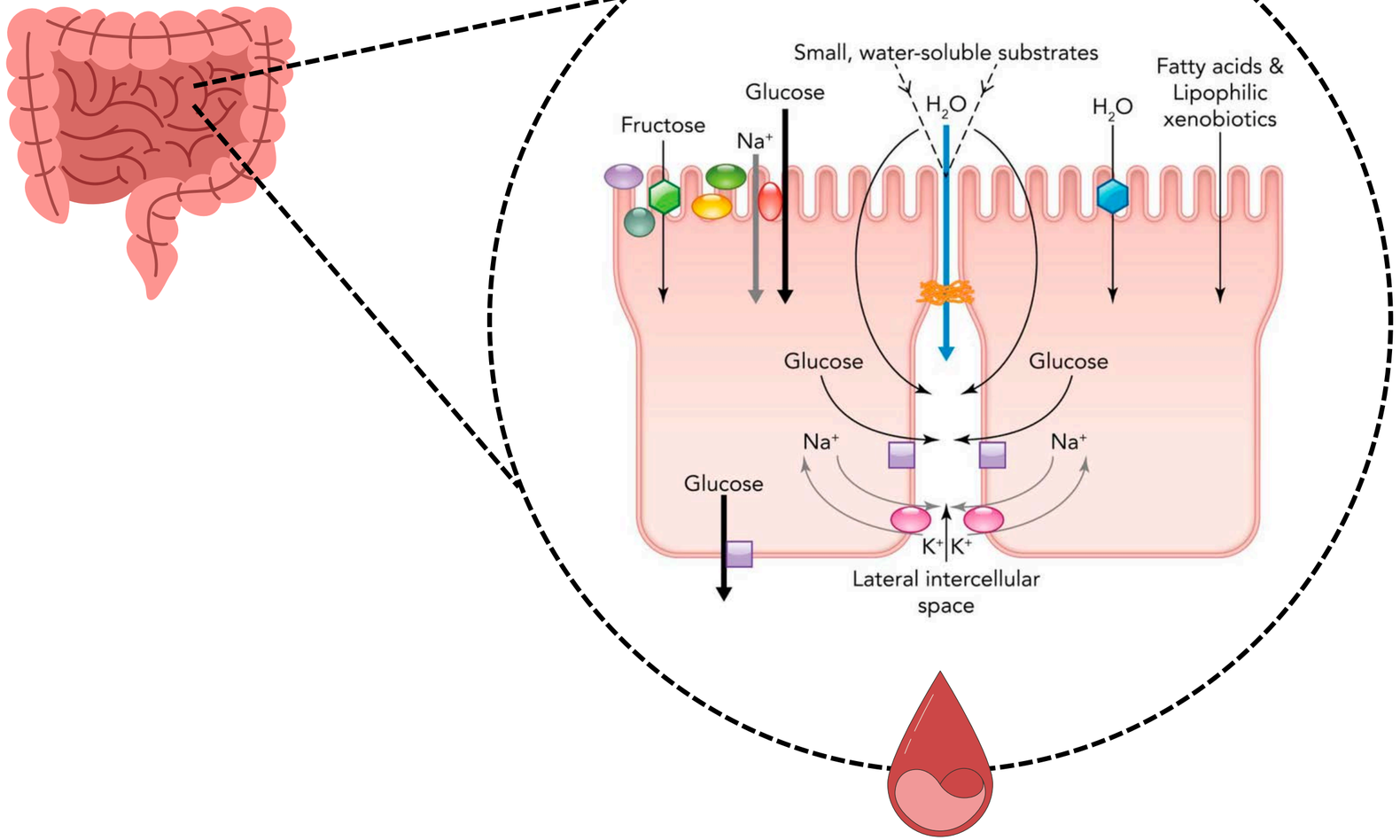


Nutrient digestion



Price et al. 2015

Nutrient digestion



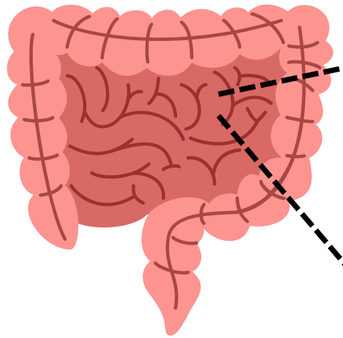
Brush border enzymes
- Sucrase
- Maltase
- Aminopeptidase-N

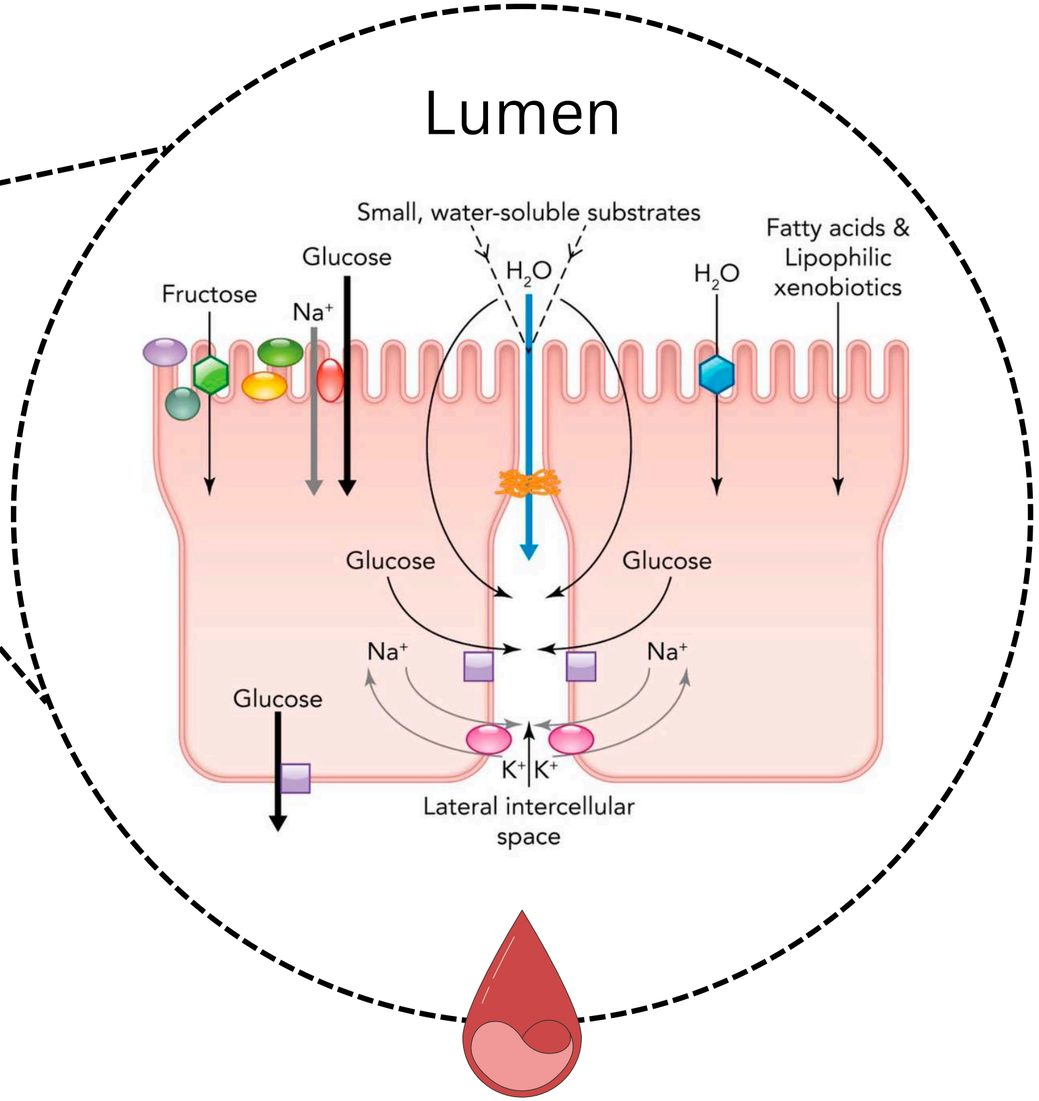
Tight junction

Transporters
- SGLT1
- GLUT2
- GLUT5
- Na+/K+ ATPase
- Aquaporins
- Amino acid transporter(s)

Price et al. 2015

Nutrient digestion





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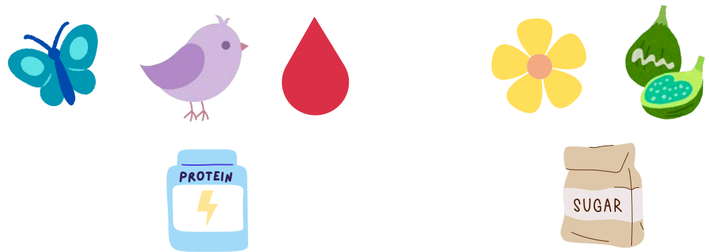
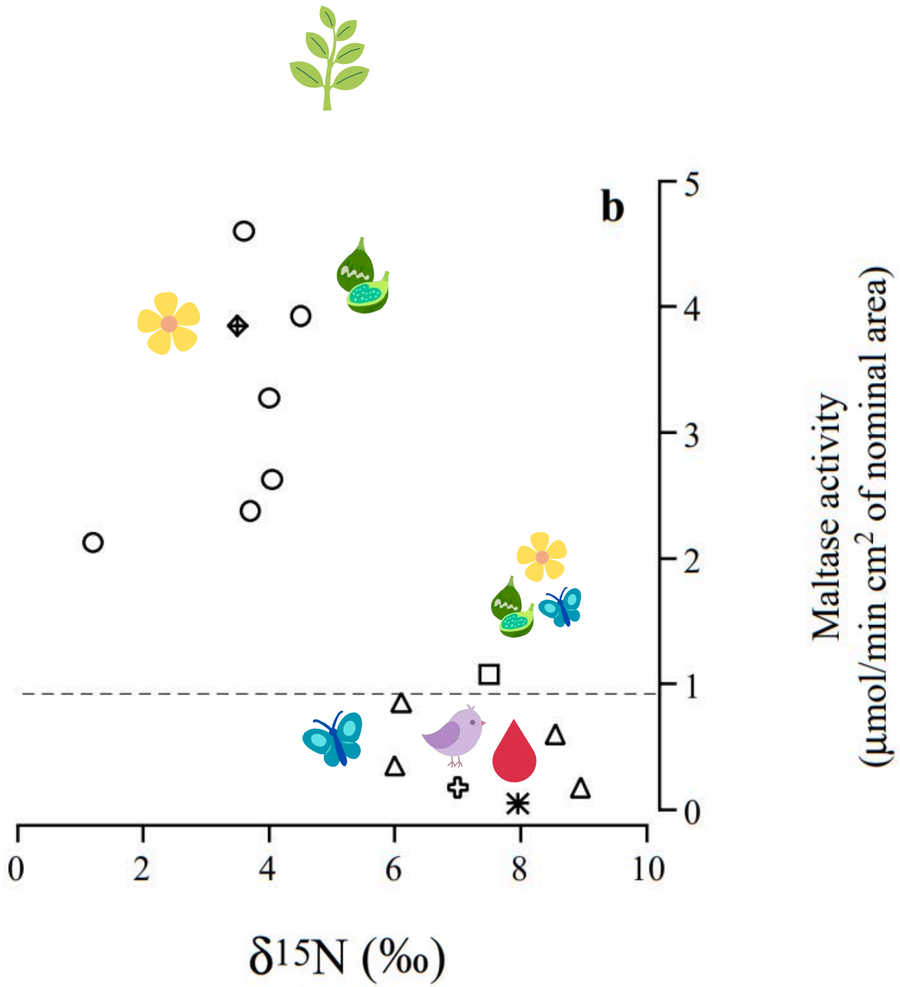


Price et al. 2015; Camacho & Bernal-Rivera et al. 2024

Enzyme activity

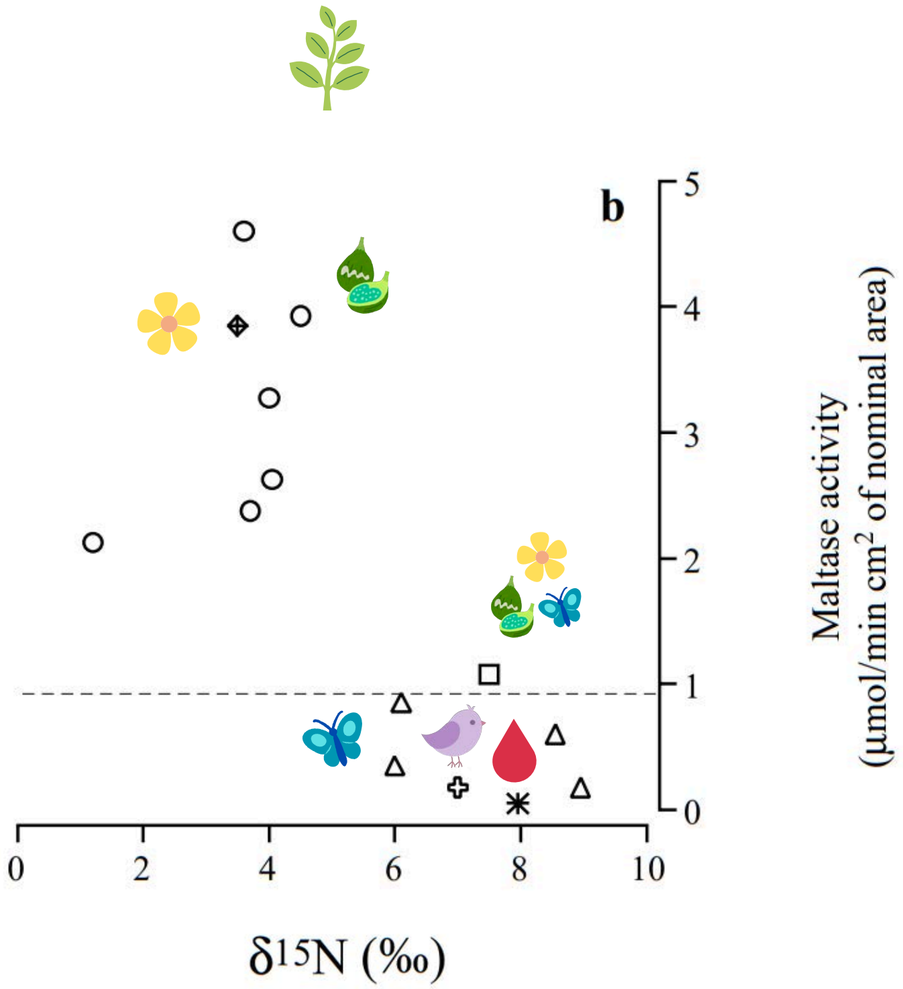
Maltase → starch breakdown



Schondube et al. 2001

Enzyme activity changes are related to diet

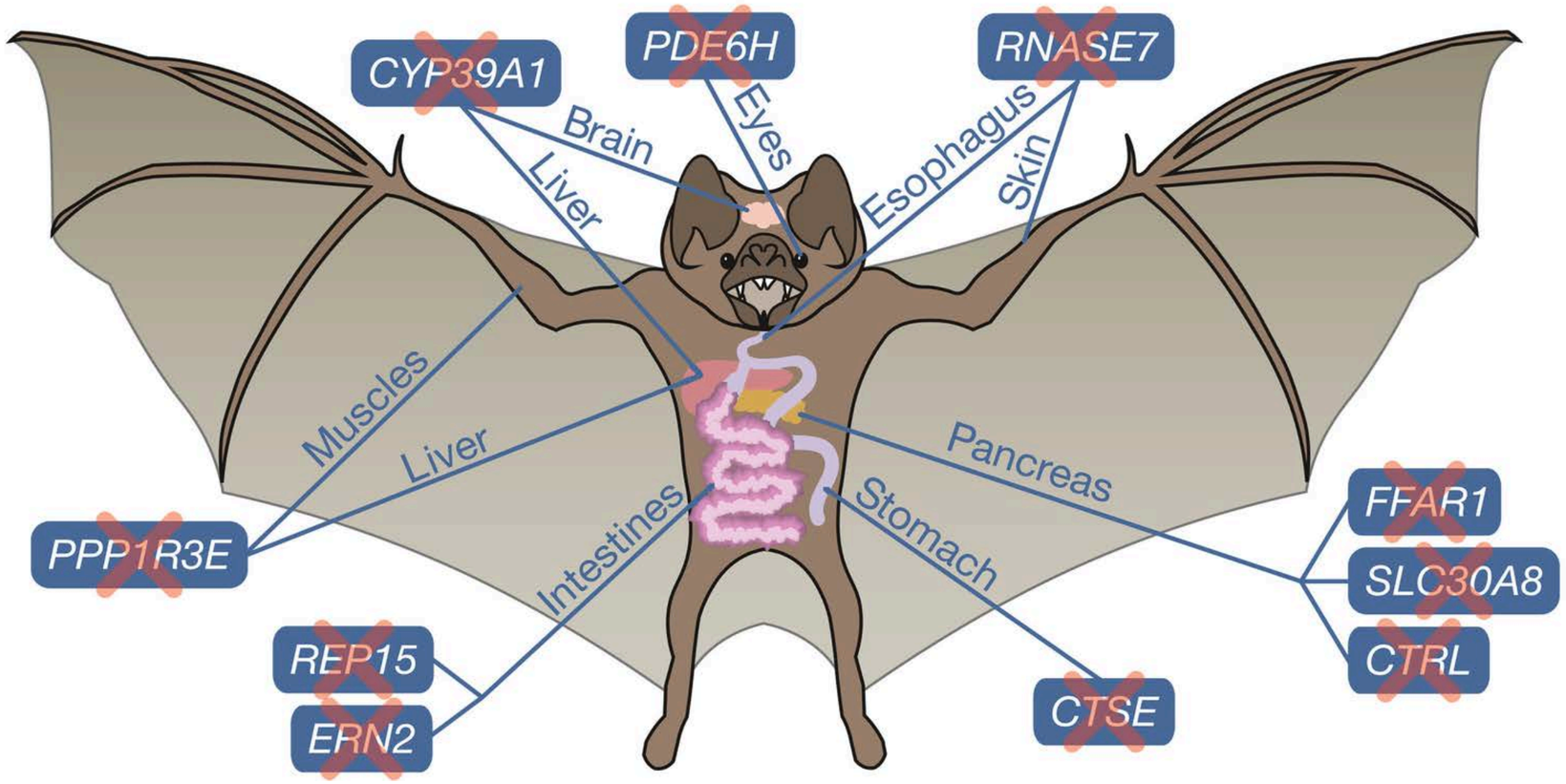
Maltase → starch breakdown



	Maltase	Sucrase	Trehalase	Amino-peptidase-N	RMT
Change in Diet:					
Insects to Blood	– (–)	– (–)	– (–)	0 (0)	0 (0)
Insects to Nectar	+ (+)	+ (+)	– (–)	0 (0)	– (–)
Insects to Omnivore	+ (+)	+ (+)	0 (0)	0 (0)	0* (–)
Insects to Meat	0 (0)	0 (0)	– (–)	0 (0)	0 (0)
Insects to Fruit	+ (+)	+ (+)	– (–)	0 (0)	– (–)

Schondube et al. 2001

Molecular adaptations to specialized diets

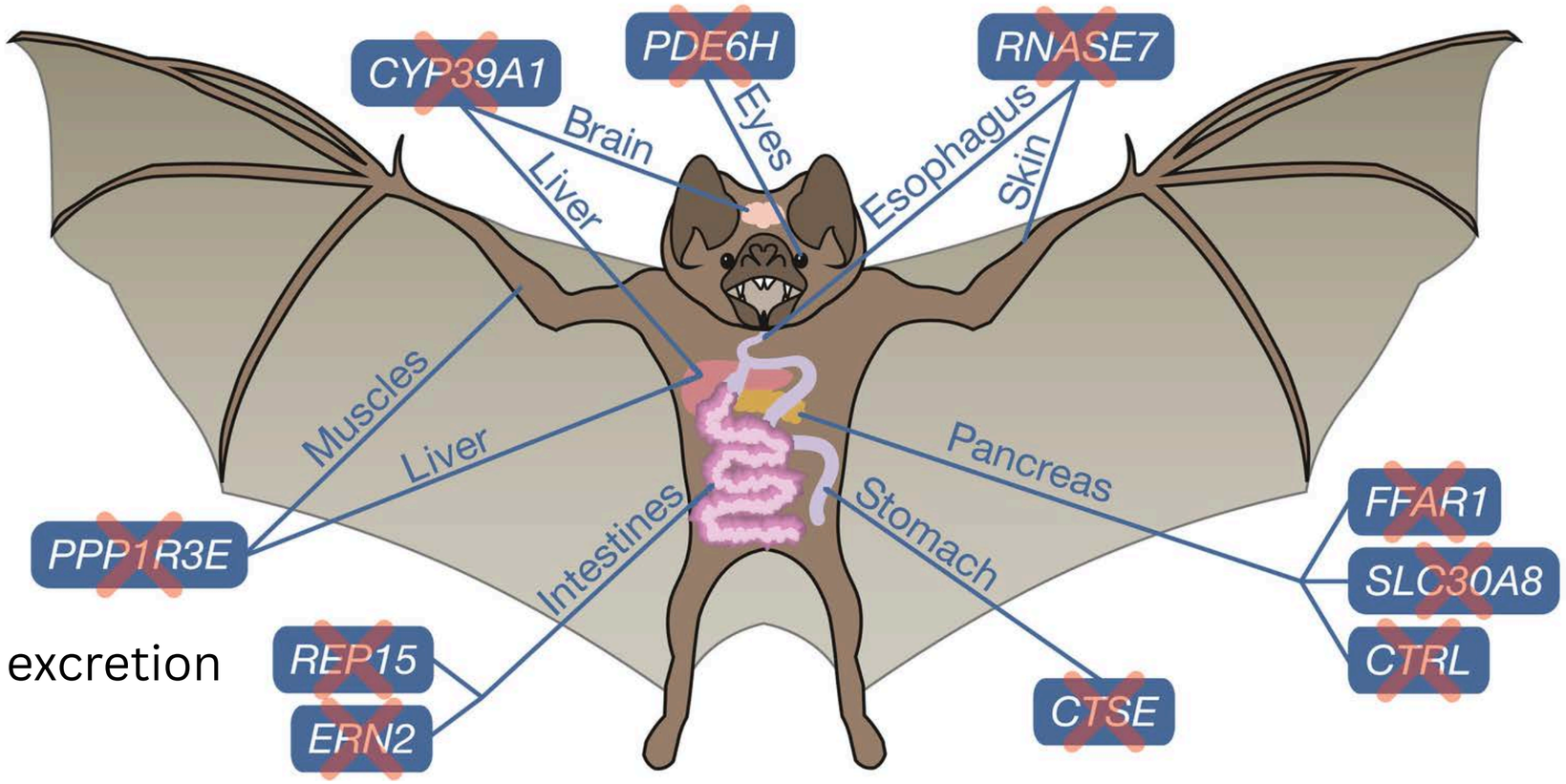


Gene losses

Hematophagy:
Vampire bats

Blumer et al. 2022

Molecular adaptations to specialized diets



Gene losses

↑ iron excretion

Hematophagy:
Vampire bats

Blumer et al. 2022

JOURNAL ARTICLE

Dietary Diversification and Specialization in Neotropical Bats Facilitated by Early Molecular Evolution

Joshua H T Potter ✉ , Kalina T J Davies , Laurel R Yohe , Miluska K R Sanchez , Edgardo M Rengifo , Monika Struebig , Kim Warren , Georgia Tsagkogeorga , Burton K Lim , Mario dos Reis ... Show more

Molecular Biology and Evolution, Volume 38, Issue 9, September 2021, Pages 3864–3883, https://doi.org/10.1093/molbev/msab028

Published: 04 March 2021

› Curr Biol. 2021 Oct 25;31(20):4667-4674.e6. doi: 10.1016/j.cub.2021.08.018. Epub 2021 Sep 2.

Nectar-feeding bats and birds show parallel molecular adaptations in sugar metabolism enzymes

Joshua H T Potter [1], Rosie Drinkwater [2], Kalina T J Davies [2], Nicolas Nesi [2], Marisa C W Lim [3], Laurel R Yohe [4], Hai Chi [5], Xiaoqing Zhang [6], Ilya Levantis [2], Burton K Lim [7], Christopher C Witt [8], Georgia Tsagkogeorga [2], Mario Dos Reis [2], Yang Liu [5], William Furey [9], Matthew J Whitley [9], Dunja Aksentijevic [10], Liliana M Dávalos [11], Stephen J Rossiter [12]

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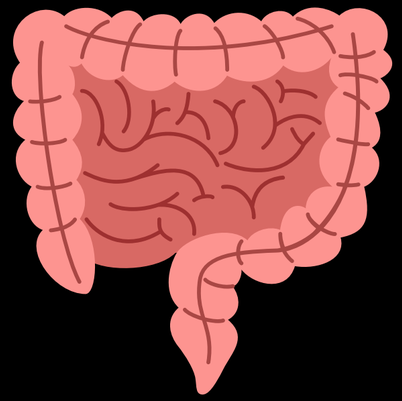
PMID: 34478643 DOI: 10.1016/j.cub.2021.08.018

Free article

My research

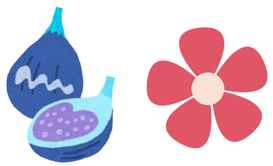
Sugar assimilation in bats with different diets

Interplay physiology-morphology



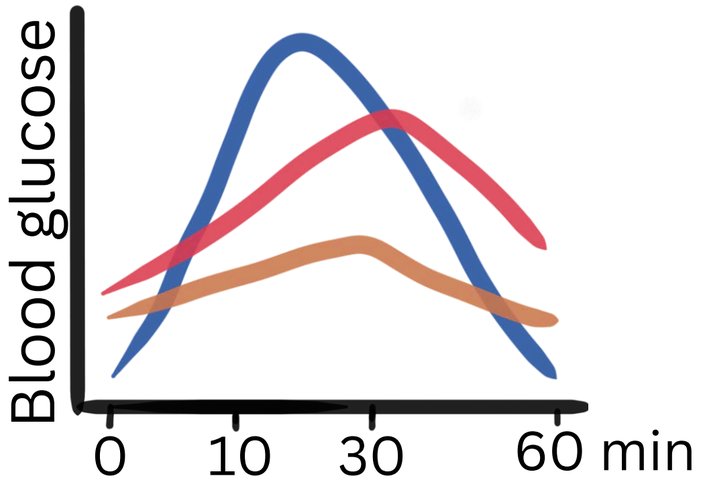
In vivo physiology

Glucose & Sucrose



Trehalose

3

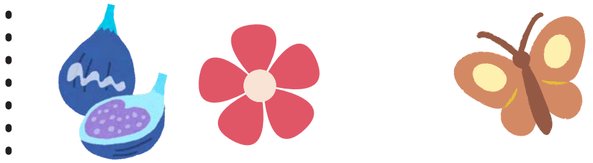


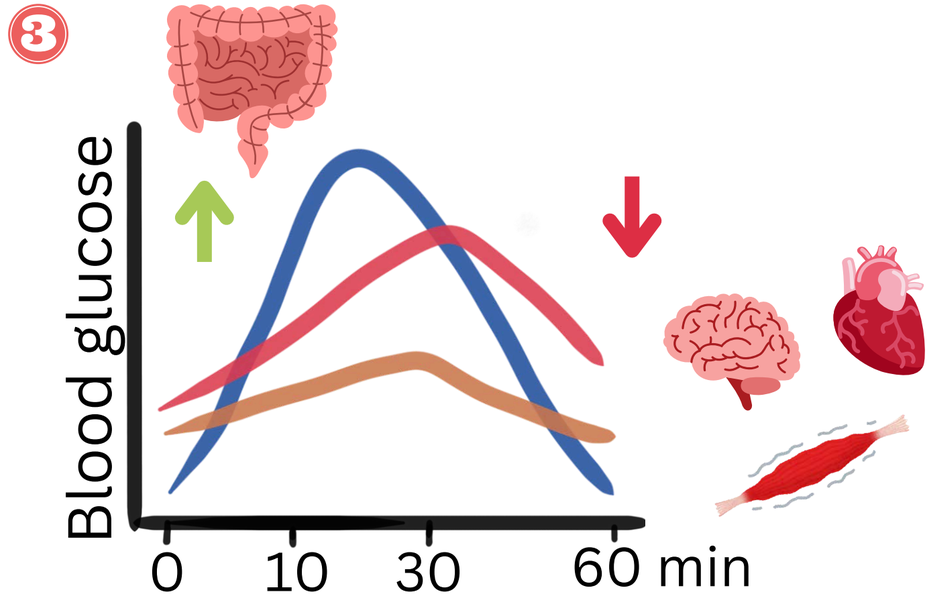
Sugar tolerance curves

In vivo physiology

Glucose & Sucrose

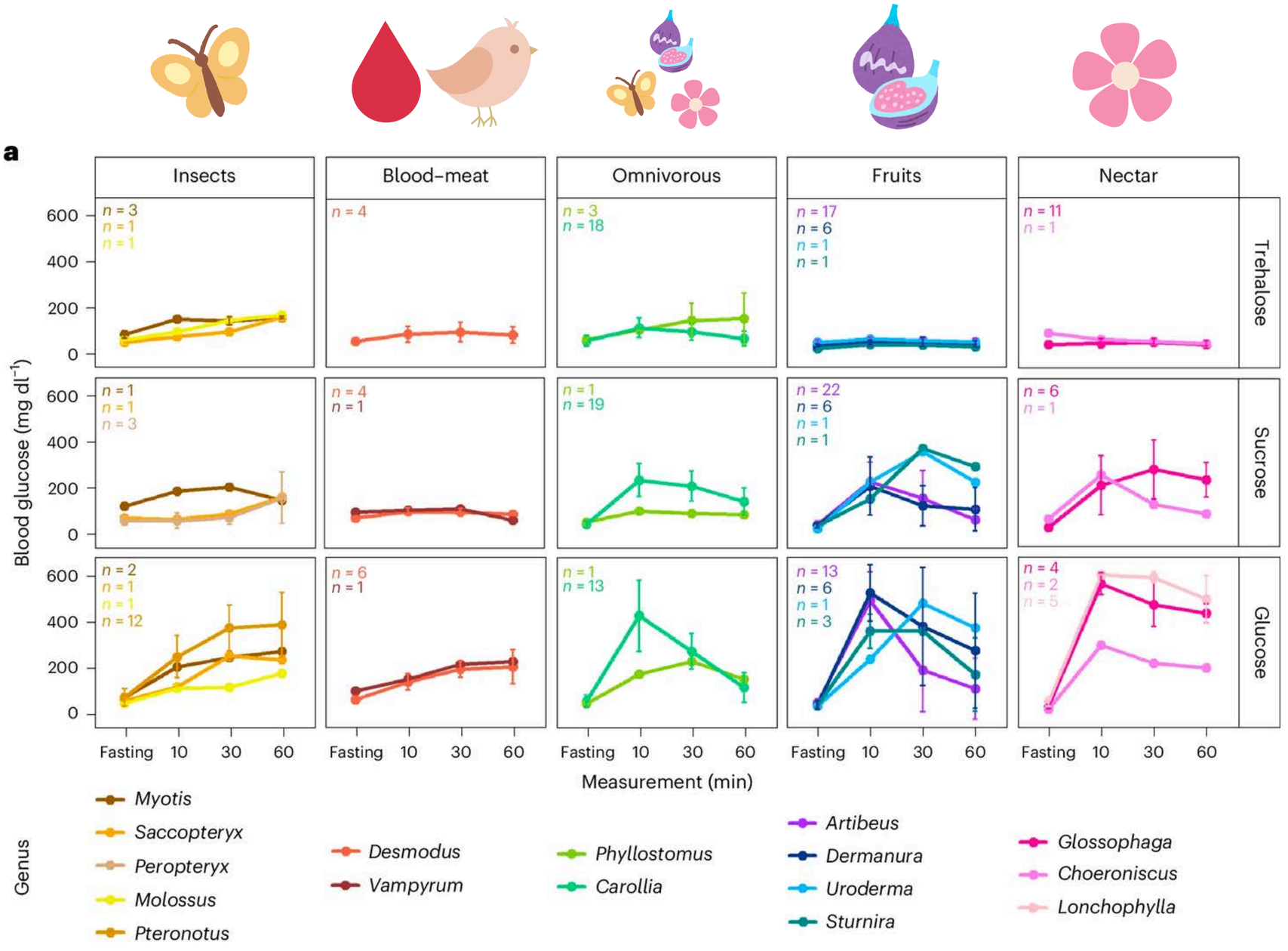
Trehalose



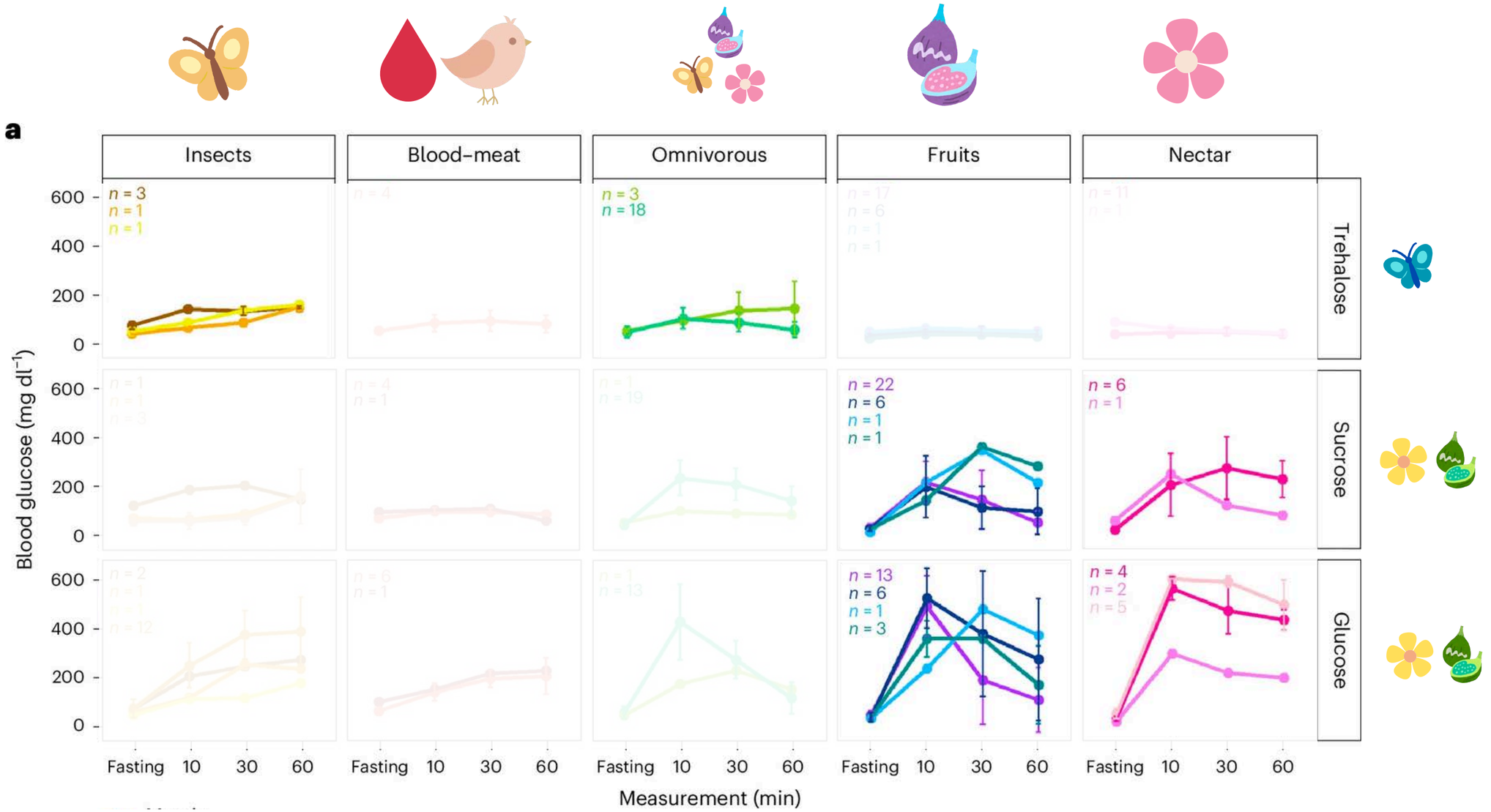


Sugar tolerance curves

Bats better assimilate the sugars predominantly found in their natural diet

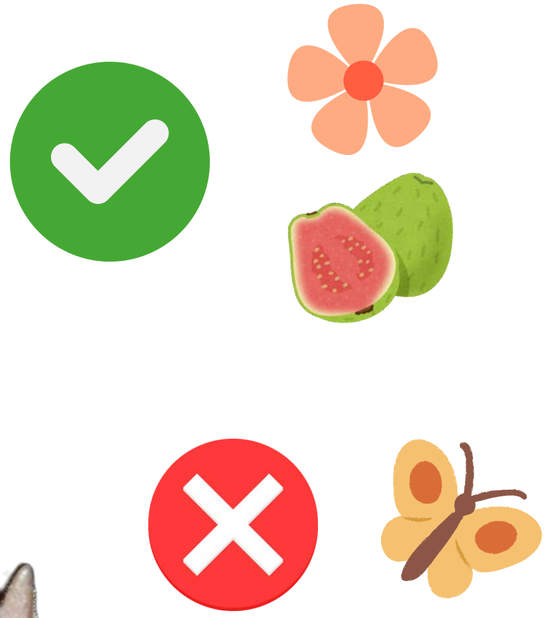


Camacho & Bernal-Rivera et al. 2024



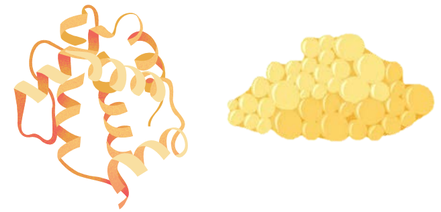
Camacho & Bernal-Rivera et al. 2024

Nectarivorous and frugivorous bats are great at assimilating the sugar found in nectar and fruits



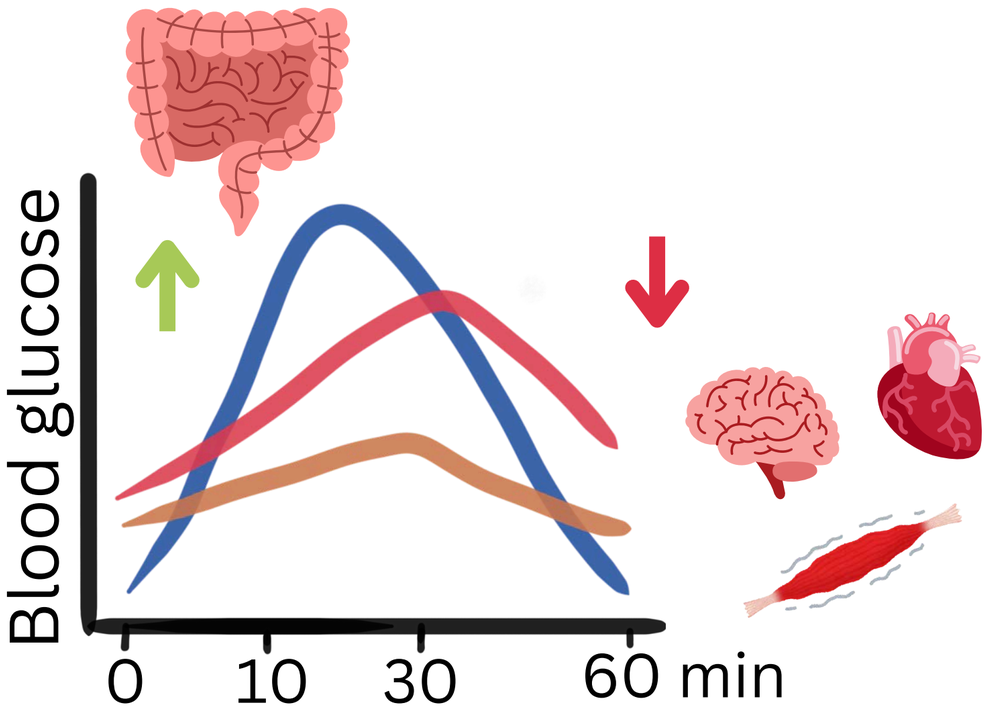
Camacho & Bernal-Rivera et al. 2024

Insectivorous bats can assimilate the sugar found in insects



Camacho & Bernal-Rivera et al. 2024

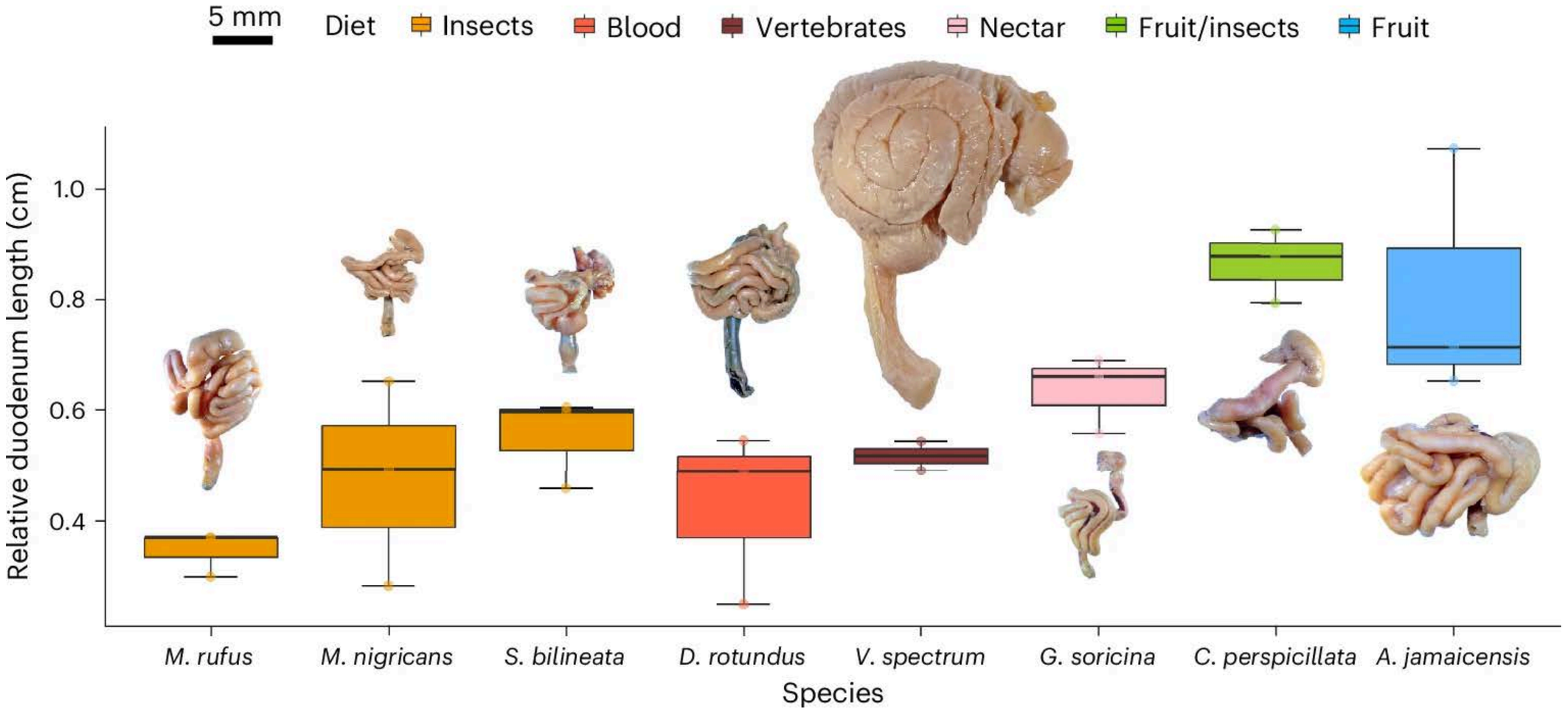
What is happening at the intestinal level?



Stowers Institute

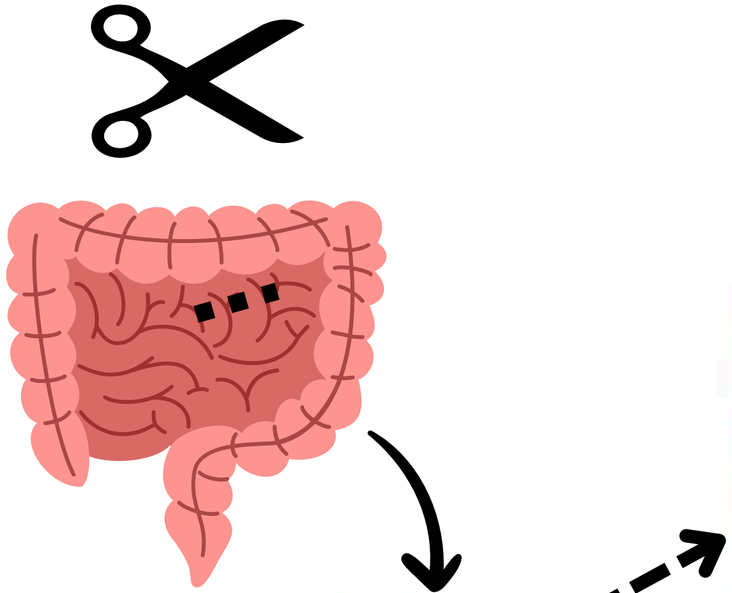
Camacho & Bernal-Rivera et al. 2024

Longer duodenum in bats with rich-sugar diets

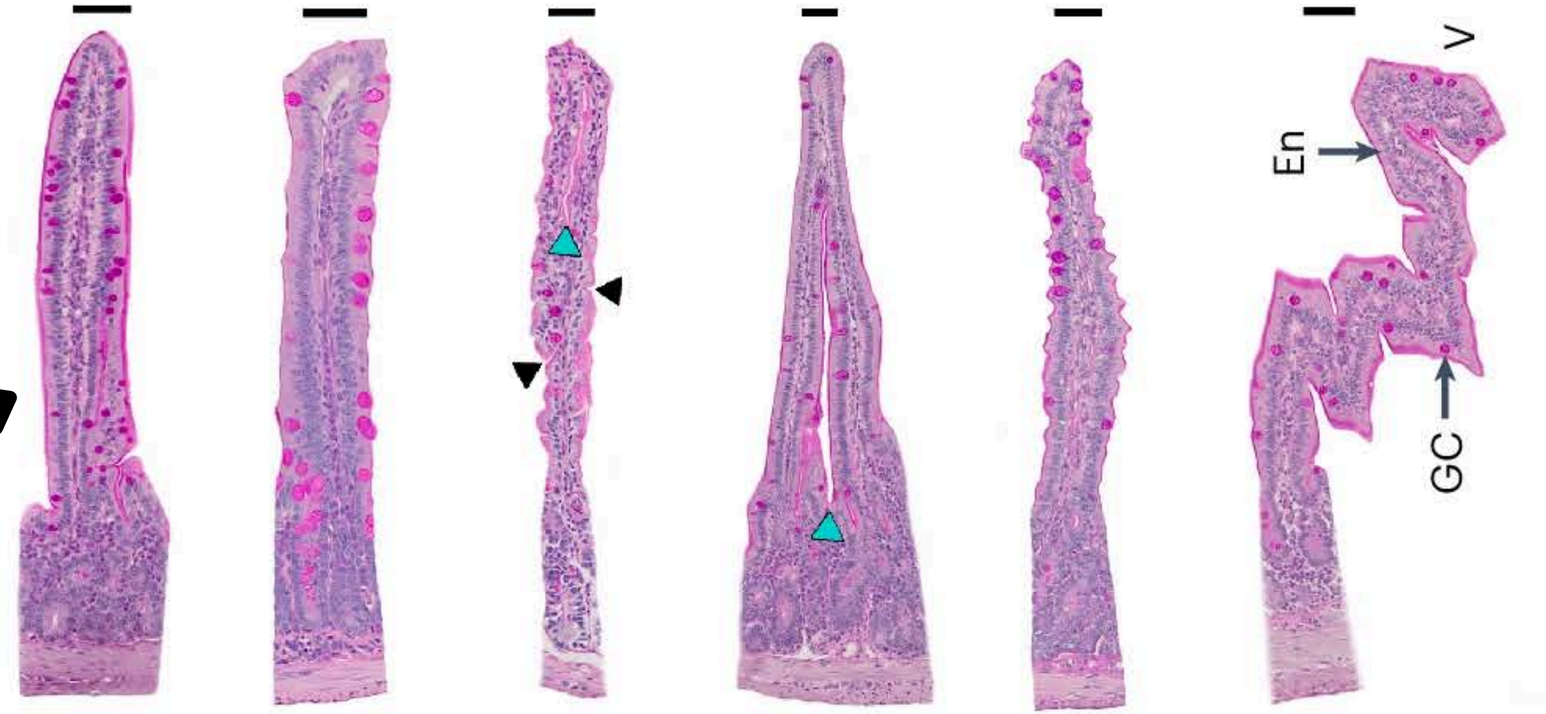


Camacho & Bernal-Rivera et al. 2024

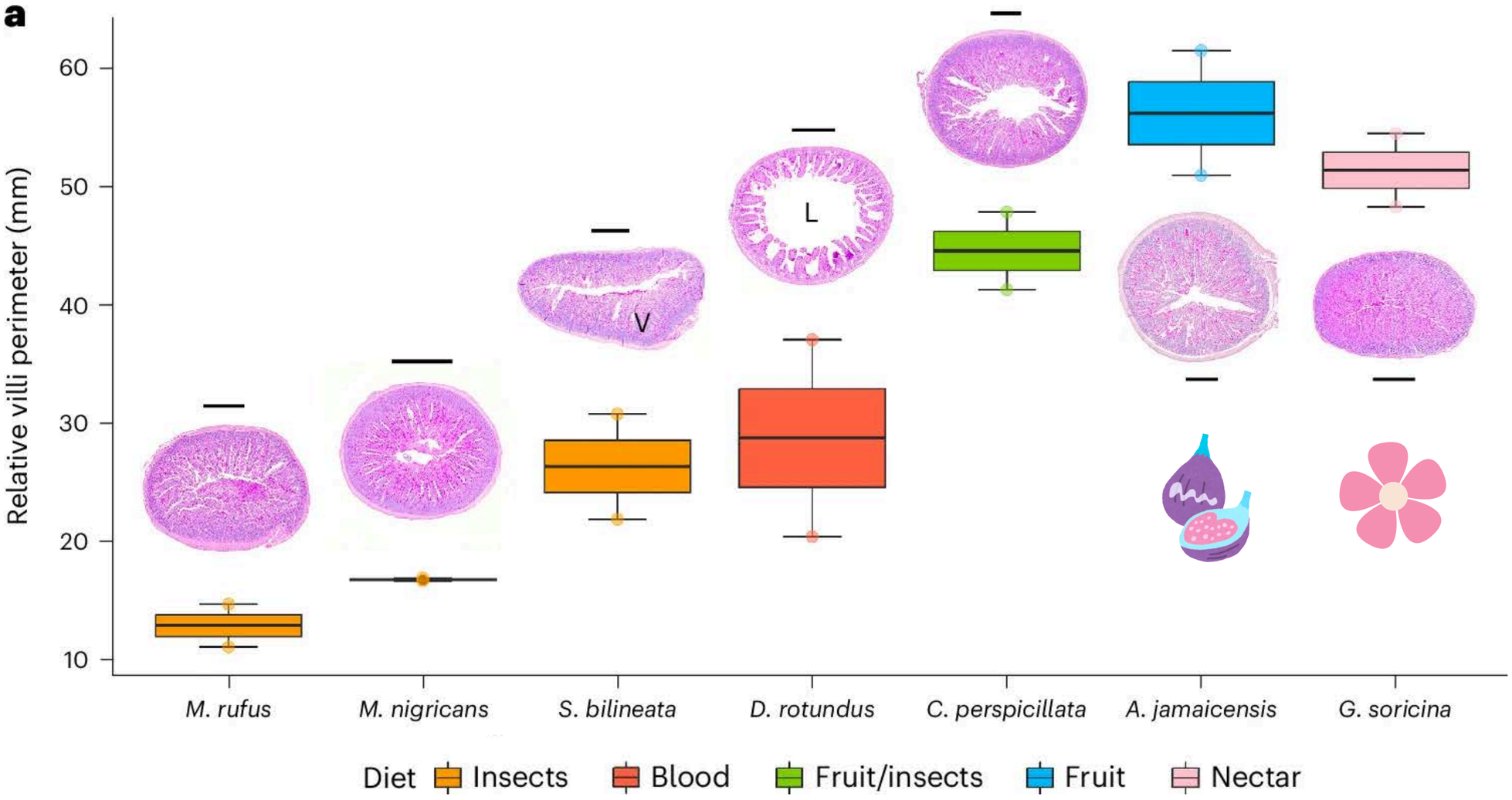
Differences in epithelial cell arrangement

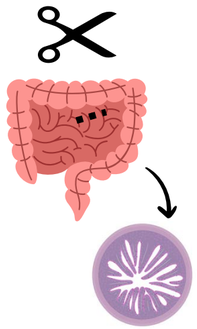


villi



Higher absorptive area in the duodenum of bats with rich-sugar diets





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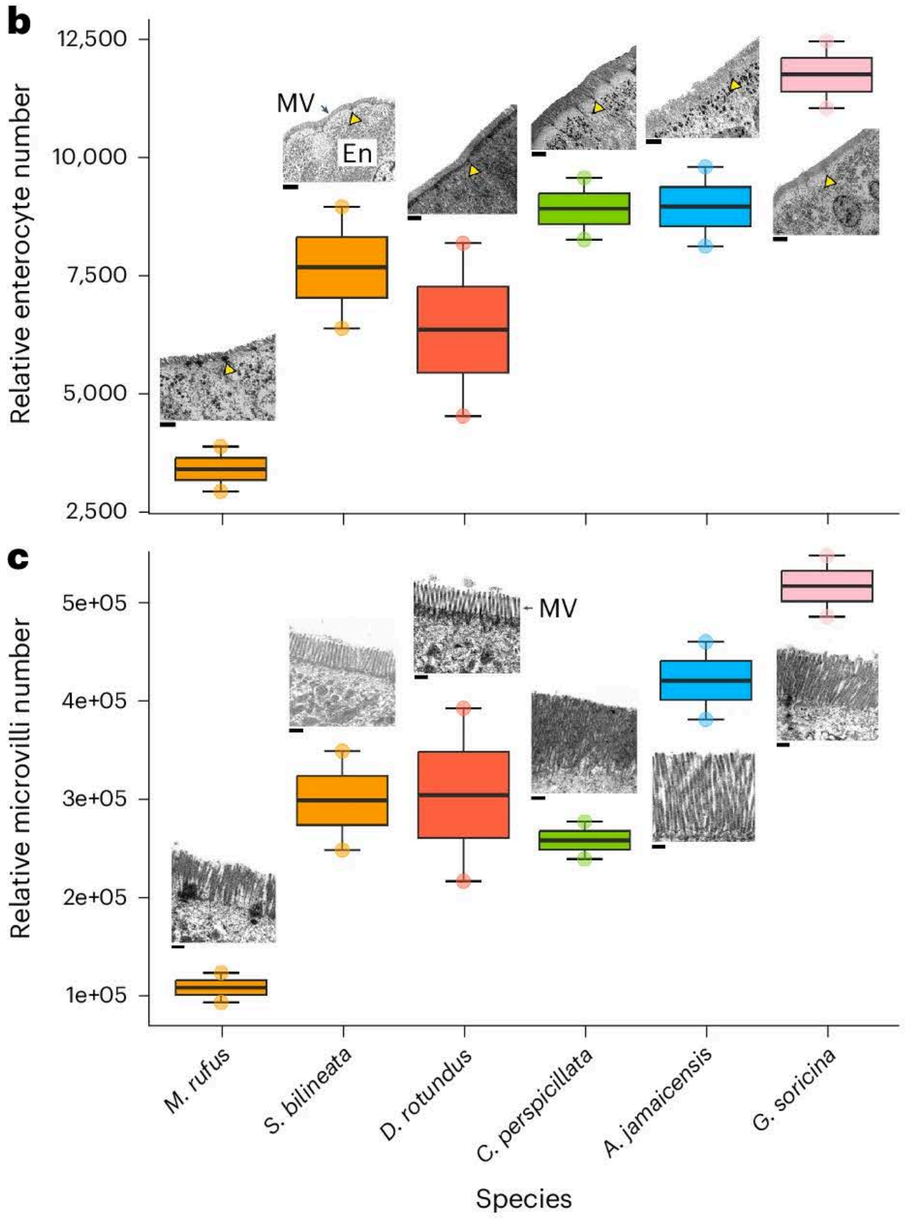
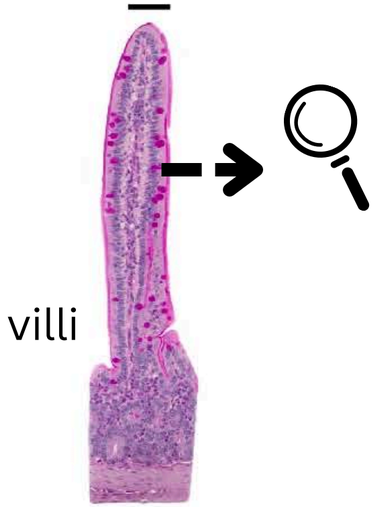
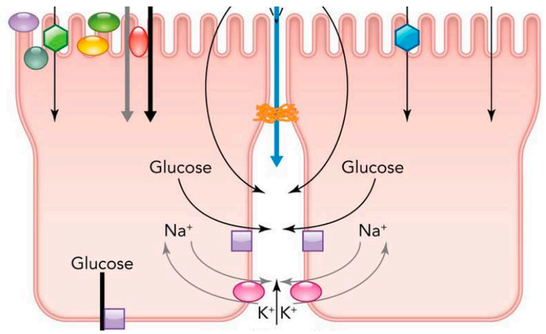




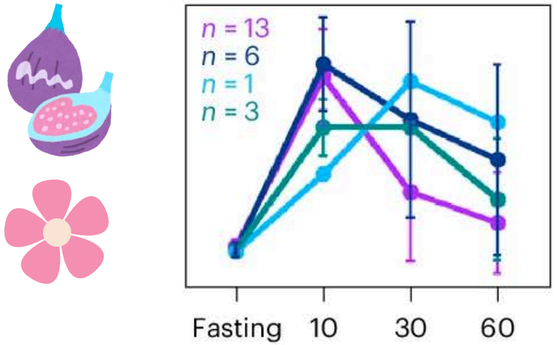


microvilli

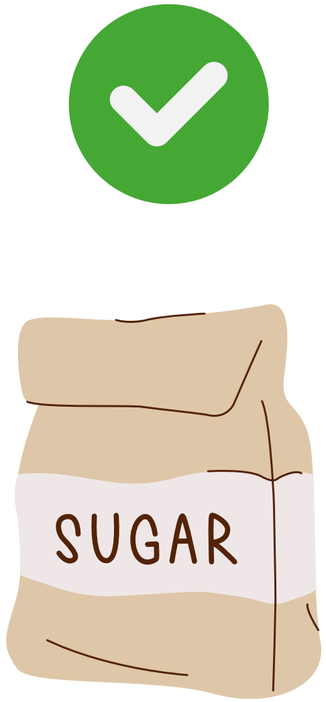
enterocyte

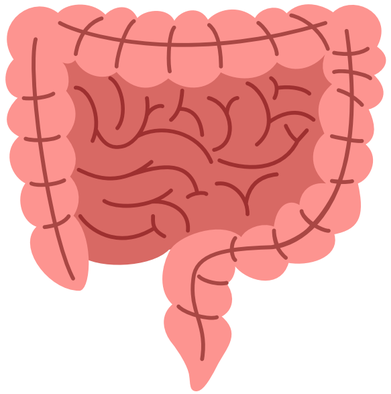
More villi and microvilli in the duodenum of bats with rich-sugar diets

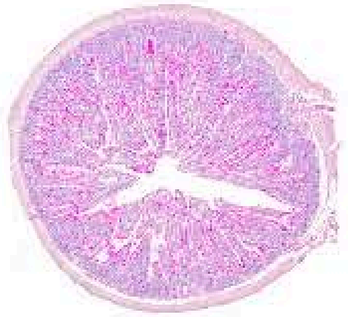
In vivo physiology matching intestine morphology



↑ glucose assimilation







↑ intestinal absorptive area

Thank you!

Questions?