

Are there microbes in venom, and why characterizing them matters for our fundamental understanding of systems biology



De León et al. 2025 Symbiosis [in press]

Larry Mays Seminar Series in Bioinformatics
Sabah Ul-Hasan, PhD
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Acknowledgements

[alphabetical] Anthony Saviola, Clarissa Nobile, Daniel Petras, Eduardo Fox, Eduardo Rodriguez-Roman, Jason Macrander, Justin Yeager, *Marina De León*, Natasha Varona, Nick Keiser, Ronald Jenner, Sara Dunaj, Samantha Nixon, Steven Trim, *Timothy Colston*, Volker Herzig



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Land Acknowledgement: Tiwa Territory

Overview

- **10 min: Background**
 - Microbiology
 - Venom as a microenvironment
- **20 min: Venom microbiomics as a Field**
 - Review: De León et al. 2025 Symbiosis [in press]
 - Ties to systems biology, informatics, and theory
- **10 min: Summary**
 - Does diversity matter in science? Impacts of iVAMP, my path
 - What does this mean for those in computing and bioinformatics, why care?

Background

What is the impact of microbiology as a field to biology, and even informatics?

<https://pollev.com/sabahulhasan789>

Since the characterization of the human gut microbiome (Gill et al. 2006), rank how the expansion of microbiology as a field has influenced the most vs least?

Our understanding of biodiversity and the "Tree of Life"



1st

Biomedical applications, such as findings on antibiotic resistance and small molecules



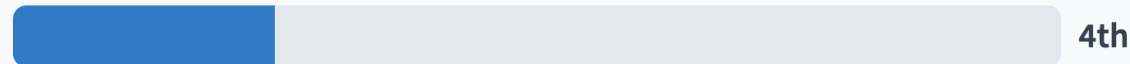
2nd

Fundamental theory, such as: Holobiont theory, game theory, etc



3rd

Next Generation Sequencing (NGS) technologies



4th

Microbiology significantly contributes to understanding biology

[nature](#) > [the journal of antibiotics](#) > [review articles](#) > [article](#)

Review Article | Published: 09 January 2009

Review Article

Microbial drug discovery: 80 years of progress

[Arnold L Demain](#)  & [Sergio Sanchez](#)

[The Journal of Antibiotics](#) **62**, 5–16 (2009) | [Cite this article](#)

Cell



Volume 172, Issue 6, 8 March 2018, Pages 1181-1197

Perspective

Major New Microbial Groups Expand Diversity and Alter our Understanding of the Tree of Life

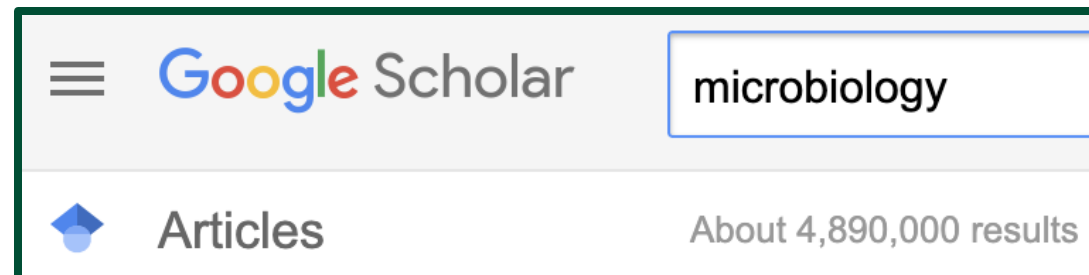
[Cindy J. Castelle](#) ^{1 2 3}, [Jillian F. Banfield](#) ^{1 2 3 4 5 6}  

Commentary | [Open access](#) | Published: 30 June 2020

Microbiome definition re-visited: old concepts and new challenges

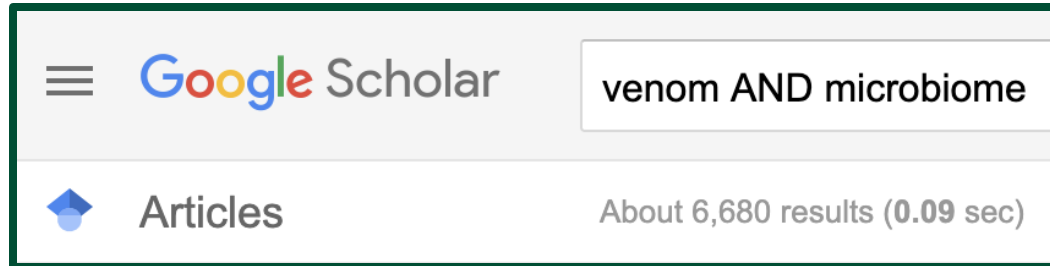
[Gabriele Berg](#) , [Daria Rybakova](#), [Doreen Fischer](#), [Tomislav Cernava](#), [Marie-Christine Champomier Vergès](#), [Trevor Charles](#), [Xiaoyulong Chen](#), [Luca Cocolin](#), [Kellye Eversole](#), [Gema Herrero Corral](#), [Maria Kazou](#), [Linda Kinkel](#), [Lene Lange](#), [Nelson Lima](#), [Alexander Loy](#), [James A. Macklin](#), [Emmanuelle Maguin](#), [Tim Mauchline](#), [Ryan McClure](#), [Birgit Mitter](#), [Matthew Ryan](#), [Inga Sarand](#), [Hauke Smidt](#), [Bettina Schelkle](#), ... [Michael Schlöter](#)  [+ Show authors](#)

[Microbiome](#) **8**, Article number: 103 (2020) | [Cite this article](#)



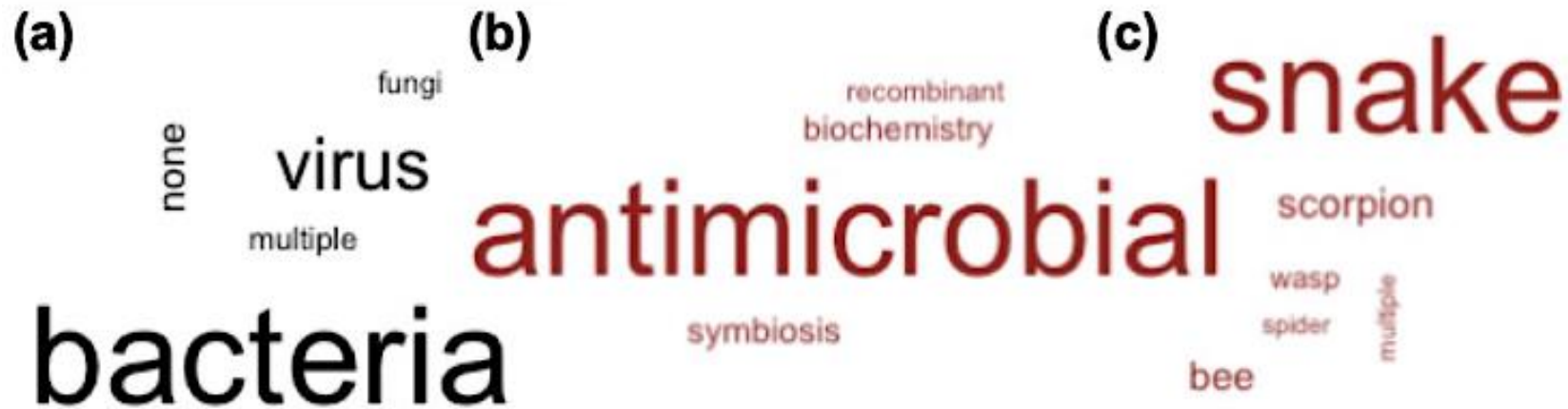
- vs 7,210,000 results for “biology”
- 1,430,000 are “microbiome”
- 674,000 since 2006 (~47%)

Microbes in venom: Review of literature shows bias

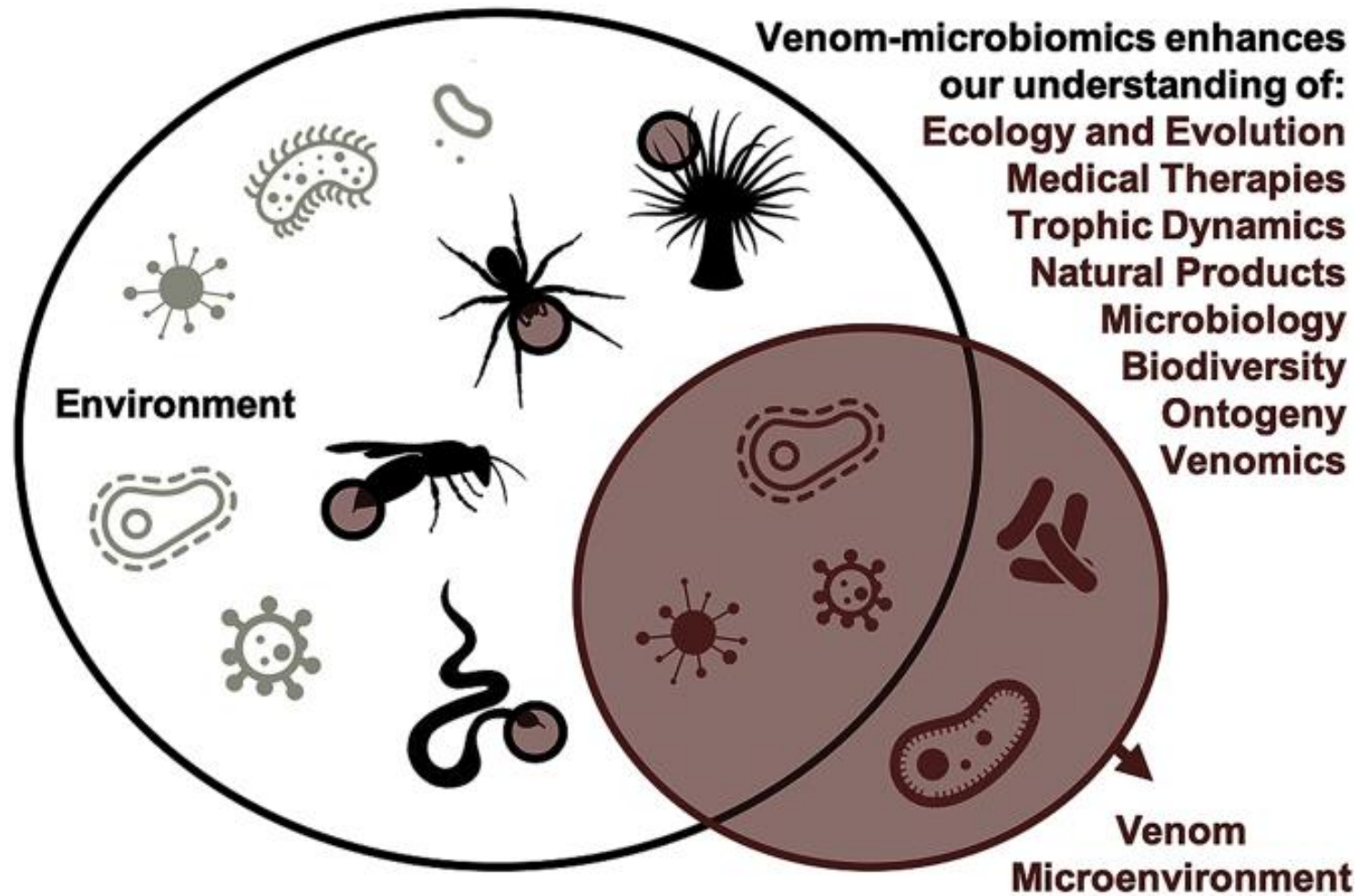


< 0.05% of all results for “microbiome”

Majority are identifications of antimicrobials derived from venom, so much less



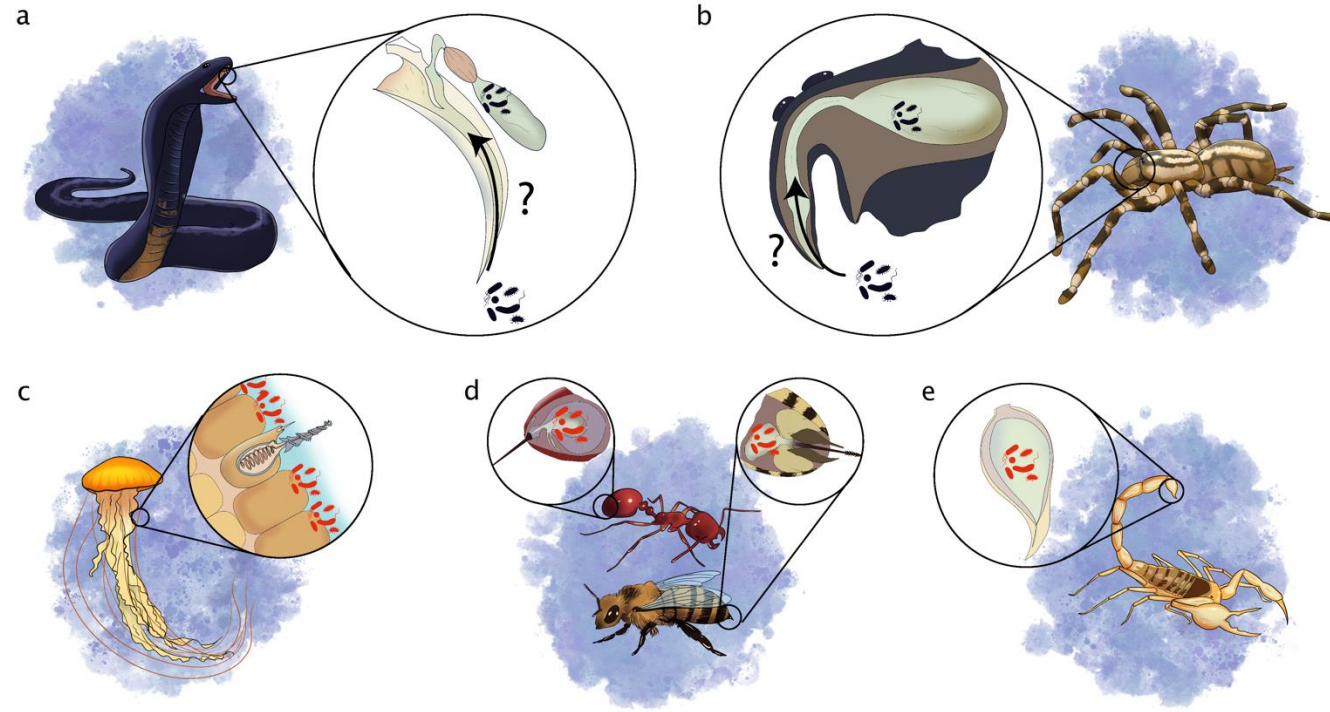
Venom: A relatively untouched reservoir for microbial discovery



Ul-Hasan et al. 2019 Toxicon: X

Venom Microbiomes

A review of the venom microbiome and its utility in ecology and evolution including future directions for emerging research



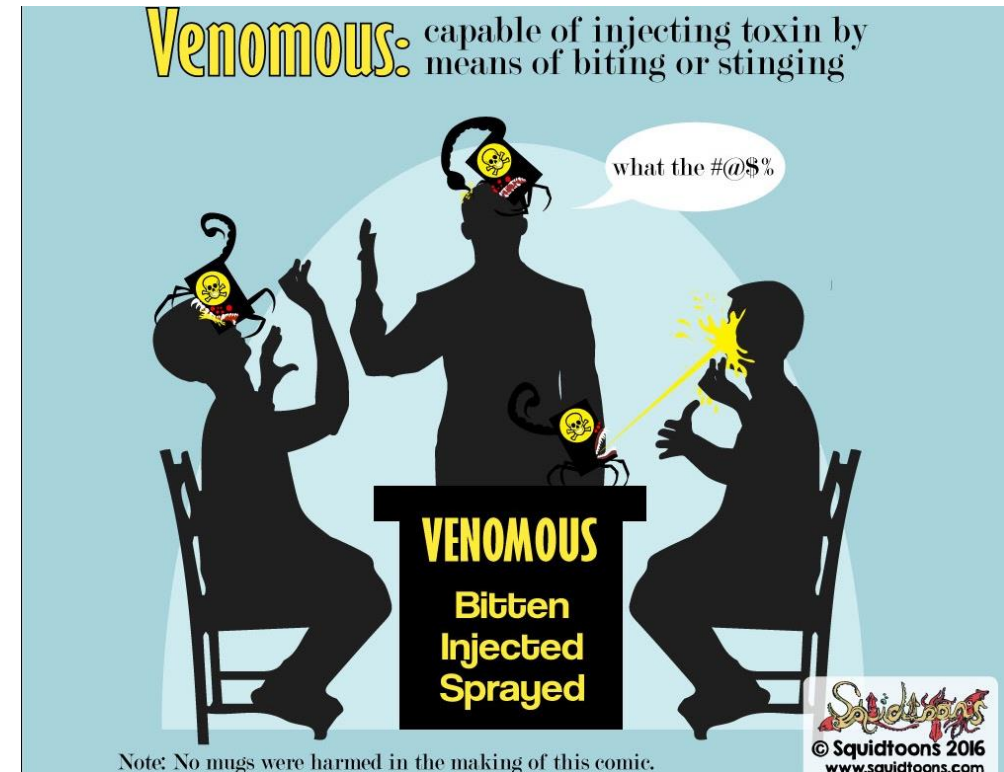
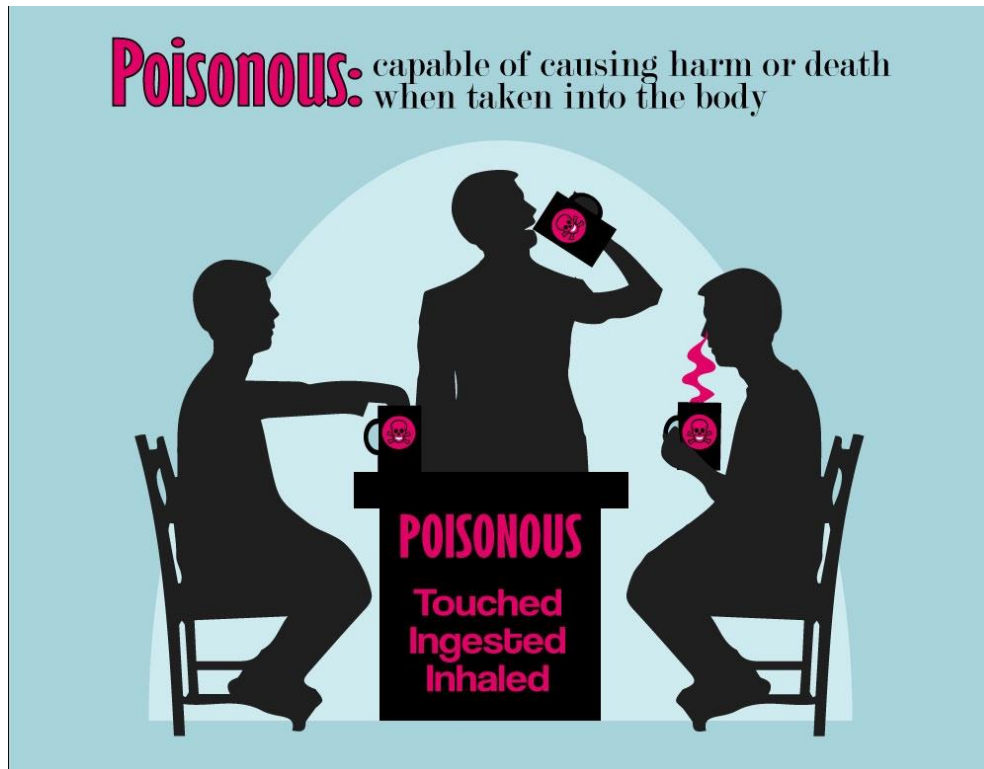
- Convergently evolved, sophisticated and specialized systems over hundreds of millions of years
- Variations in microbial colonization of the host, venom composition, host-microbe interaction, etc

Publications of confirmed bacteria presence in venom

Host species (microbial taxa identified)	Publication	ID method	Cultured in Petri dish	Isolated from
<u>Wasp</u> <i>Comperia merceti</i> (1)	Lebeck 1989; Gibson & Hunter 2009	Light & electron microscopy	yes	venom gland & other tissue
<u>Bee</u> <i>Apis mellifera</i> (1)	Copley & Jabaji 2012	qPCR of dissected glands	yes	venom gland & other tissue
<i>Myrmeleon bore</i> (1)	Yoshida et al. 2001	Not specified	yes	venom
<u>Ants</u> <i>Solenopsis invicta</i> (5) <i>Solenopsis geminata</i> (6) <i>Diacamma rugosum</i> (4)	Yang et al. 2021	16S rRNA sequencing	no	venom gland
<u>Scorpions</u> <i>Smeringurus mesaensis</i> (7) <i>Hadrurus arizonensis</i> (7)	Shimwell et al. 2023	16S rRNA sequencing clones telson libraries	no	telson (bulbous segment of tail)
<i>Vaejovis smithi</i> (1)	Tonalli García-Santibañez et al. 2022	Combined PacBio and Illumina metagenome assembly	no	telson (bulbous segment of tail)
<u>Spiders</u>				
<i>Lasiadora parahybana</i> (1)	Esmaeilishirazifard et al. 2022	Isolate culture: Whole Genome Sequencing (WGS)	yes	venom
<i>Poecilotheria regalis</i> (1)	Esmaeilishirazifard et al. 2022	Isolate culture: Whole Genome Sequencing (WGS)	yes	venom
<i>Parasteatoda tepidariorum</i> (22)	Dunaj et al. 2020	RNA-seq + 16s rRNA seq	no	venom
<i>Latrodectus hesperus</i> (20)	Dunaj et al. 2020	RNA-seq + 16s rRNA seq	no	venom
<i>Steatoda grossa</i> (22)	Dunaj et al. 2020	RNA-seq + 16s rRNA seq	no	venom
<i>Steatoda nobilis</i> (5)	Dunbar et al. 2020	16s rRNA sequencing	no	Chelicerae (mouth region)
<u>Snakes</u>				
<i>Naja nigricollis</i> (1)	Esmaeilishirazifard et al. 2022	Isolate culture: Whole Genome Sequencing (WGS)	yes	venom
<i>Naja nigricollis</i> (21)	Esmaeilishirazifard et al. 2022	16S rRNA sequencing	no	venom
<i>Bitis arietans</i> (21)	Esmaeilishirazifard et al. 2022	16S rRNA sequencing	no	venom
<i>Bothrops atrox</i> (21)	Esmaeilishirazifard et al. 2022	16S rRNA sequencing	no	venom
<i>Oxyuranus scutellatus</i> (21)	Esmaeilishirazifard et al. 2022	16S rRNA sequencing	no	venom
<i>Crotalus atrox</i> (21)	Esmaeilishirazifard et al. 2022	16S rRNA sequencing	no	venom

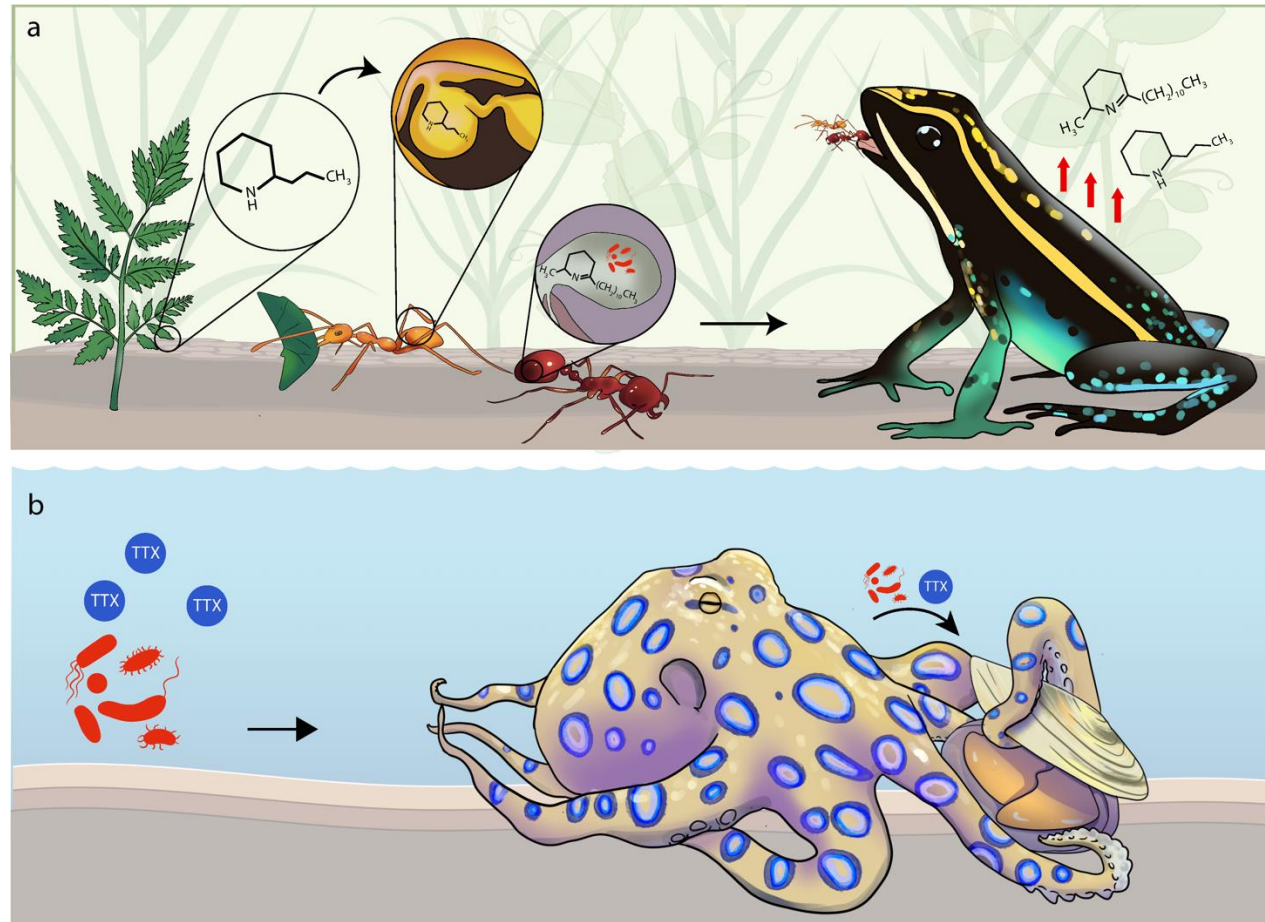
How does the bacteria colonize the host?

Looking to our understanding of poisonous animals for answer



Note: No mugs were harmed in the making of this comic.

Looking to our understanding of poisonous animals for answer
Transfer of toxins (and microbes?) across trophic levels



De León et al. 2025 Symbiosis [in press]

Venom microbiomics as a field

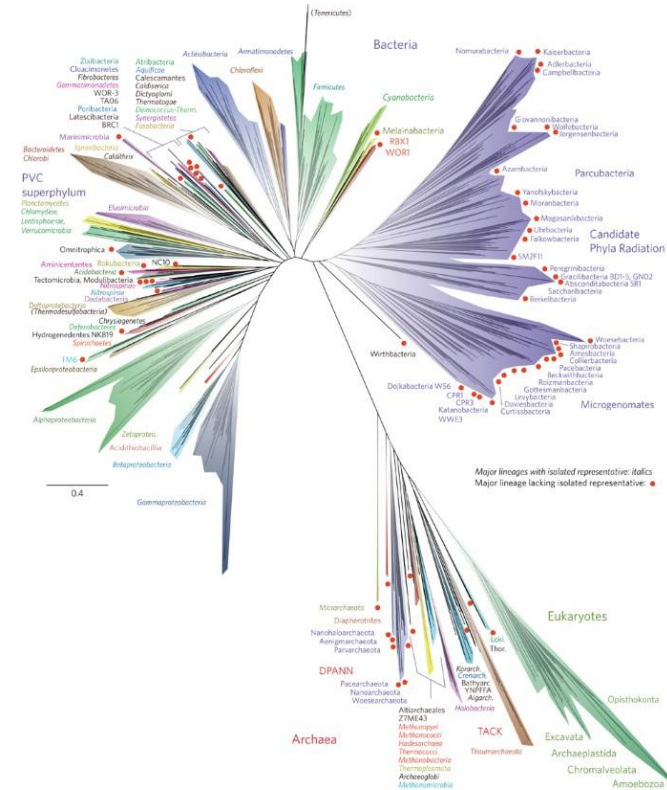
- What is the venom microbiome beyond bacteria?
- Is there a core venom microbiome across species?
- How may this venom microbiome vary across life stages?
- Which venomous hosts post as strong model systems, and why?

Methods and Approaches to Understanding Venom Microbiomes					
Focus	Technique	Taxonomic classification	Functional data	Advantages	Primary considerations
Venom Microbiome Exploration	Metagenomics	YES	NO	Biomarker discovery, Comparative analysis	Contamination risk, dissection, library preparation
Venom production and regulation	Transcriptomics	NO	YES	Gene expression pattern, Key genes, Comparatives analysis with microbial genes	Difficulty in RNA extraction and processing, transcript sorting
Protein composition, Protein family exploration	Proteomics	NO	YES	Detect protein interactions or levels, Functional potential	Complex biological samples, database searches, statistical analysis
Chemical profiling and pathways	Metabolomics	NO	YES	Metabolite profiling, Comprehensive, Functional	Interdisciplinary collaboration, compound identification
Host health, Ecology, Selection	Isolate Cultures	YES	NO	Selective, Strain identification, AMR testing	Technical expertise, careful planning, contamination risk

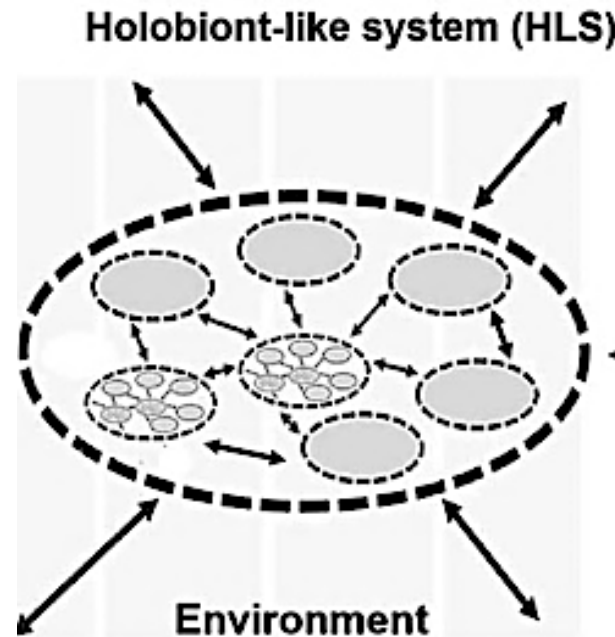
De León et al. 2025 Symbiosis [in press]

Venom microbiome characterization and contributions to theory

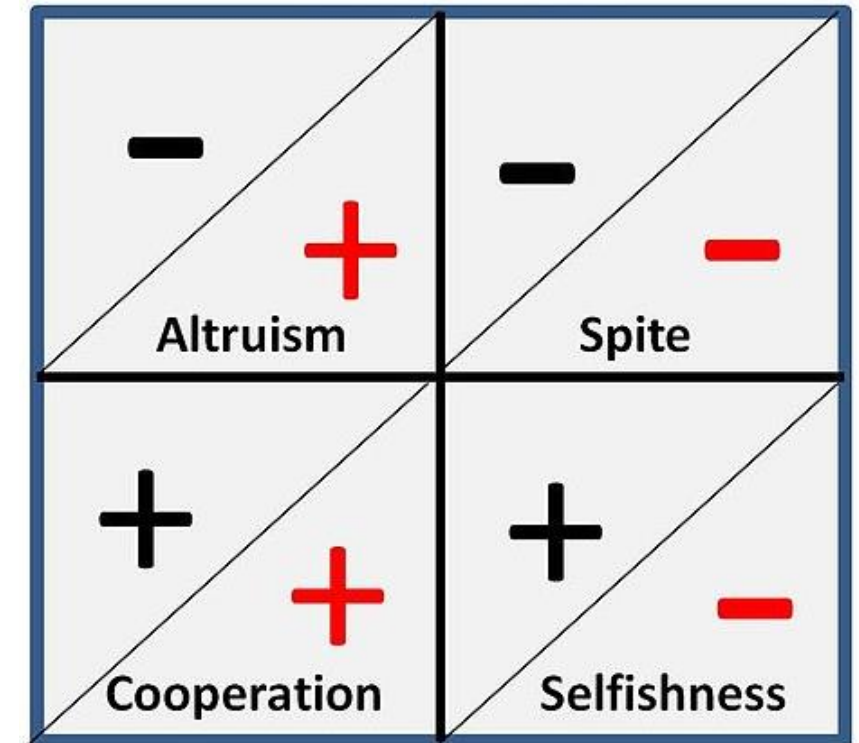
- Biomedical applications and understanding of evolution as a result of microbial discovery
- Expanded case study examples for our understanding of both systems and holobionts
- More variables for modeling game theory schema: When we have species A, what is the likelihood of species B being pathogenic? Mutualistic? Etc



Hug et al. 2016 Nature



Progress in Botany Vol 83

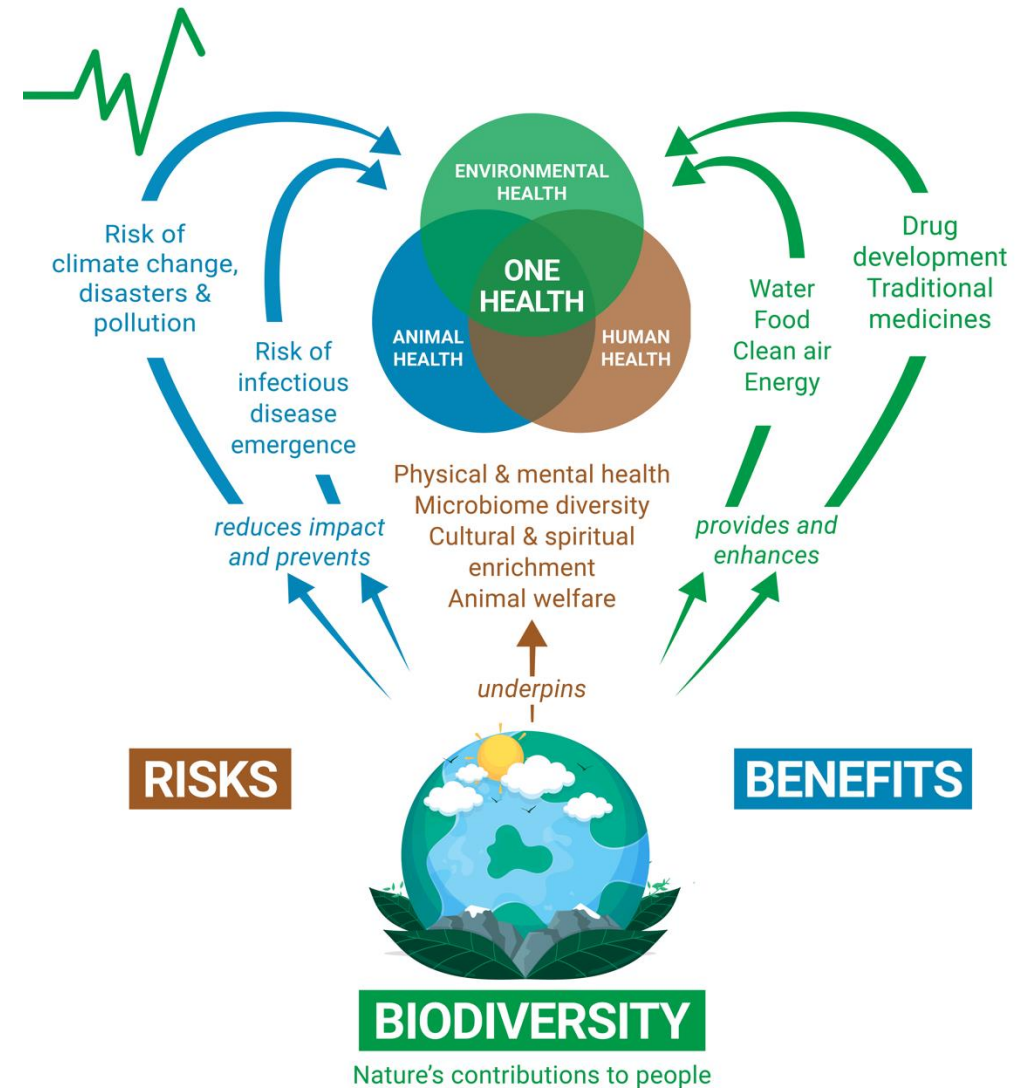


Evolutionary Game Theory

Summary

Why care about diversity?

- Healthy ecosystems are strongly rooted in biodiversity



SUSTAINABLE DEVELOPMENT GOALS



Convention on
Biological Diversity

Why care about diversity?

- Healthy ecosystems are strongly rooted in biodiversity
- Diversity in the workplace = innovation and productivity

What are the benefits of diversity in the workplace?

19%

higher innovation
revenues

35%

performance
advantage over those
that are homogenous

36%

more profitable
(companies in top 25% for
ethnic and cultural diversity
vs bottom 25%)

Source: Harvard Business Review & McKinsey

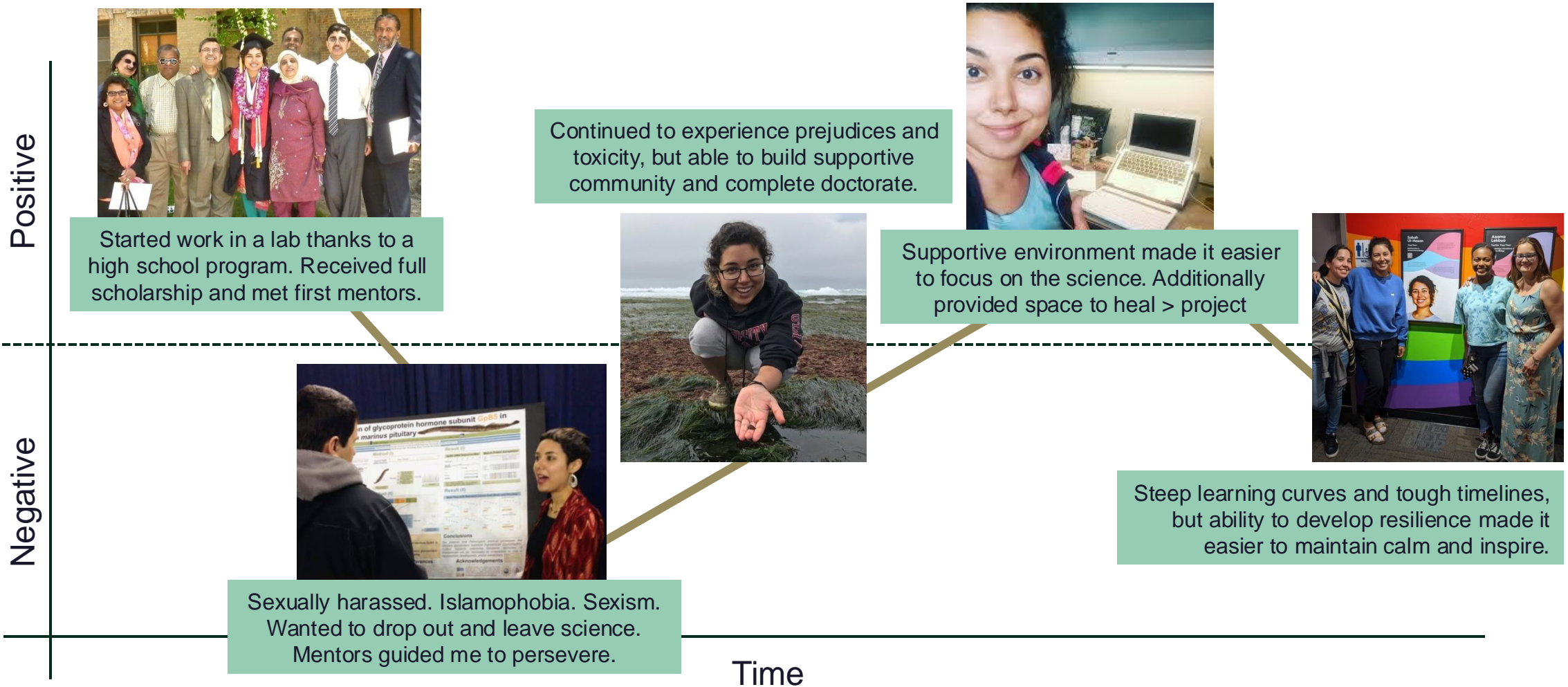


Caring about diversity, equity, & inclusion means better science

We cannot be objective as scientists without understanding and acknowledging the subjective.
We need "DEI" to be successful, as a species, and we all need to fight for it.

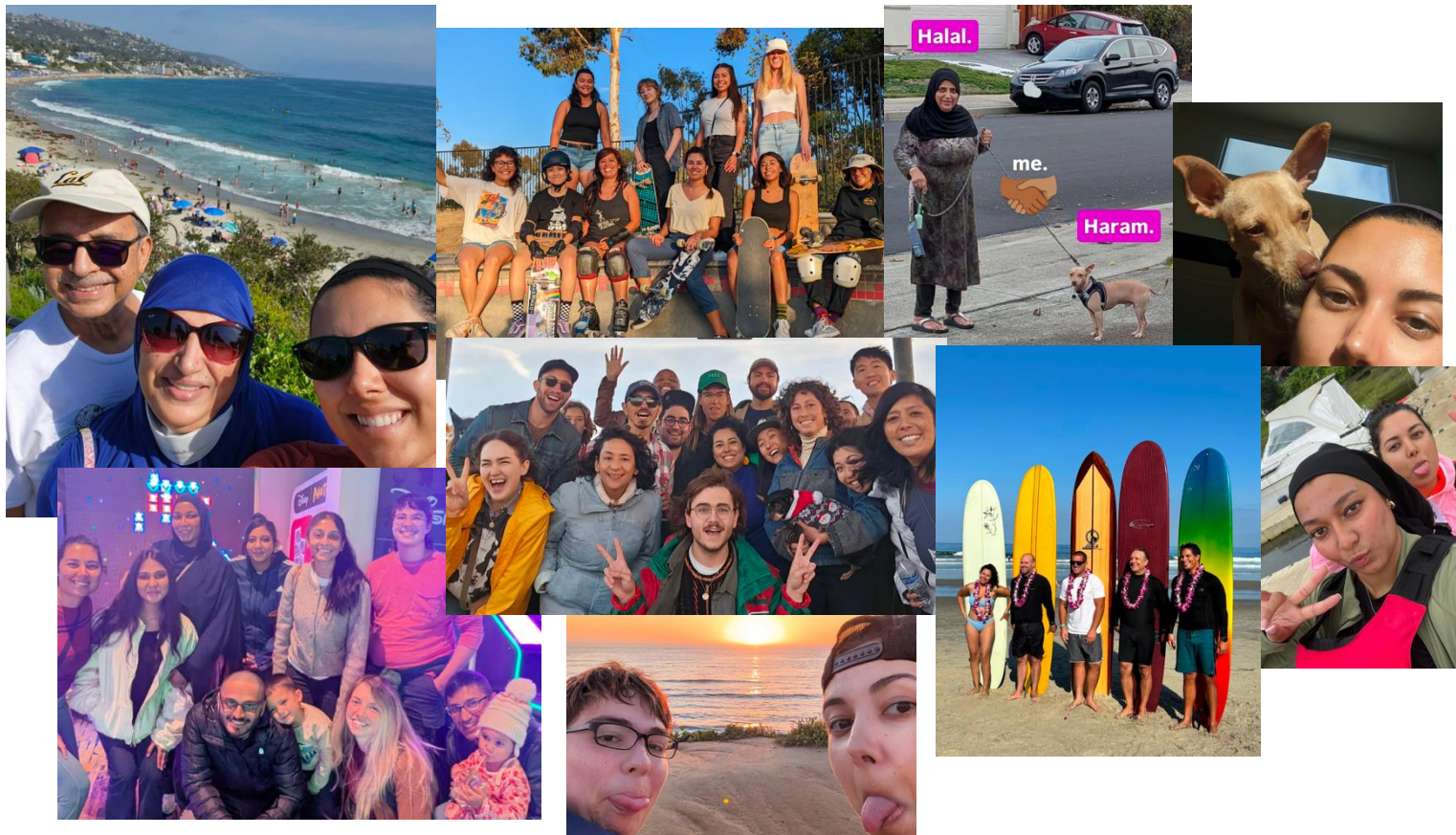


Life is ups and downs: Know your worth, stay resilient.



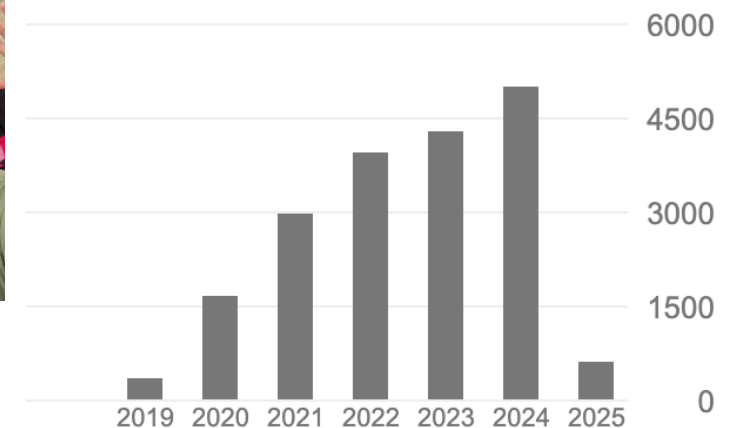
Normalize rest: Existing is enough.

- The "leaky pipeline", or a shift in priorities? Finite time with family
- During the pandemic: Evaluation of what (and who) is important to me
- There will be plenty of opportunities to succeed later, ~30+ more years to "produce"



Cited by

	All	Since 2020
Citations	18965	18501
h-index	12	10
i10-index	12	11



Takeaways: Venom microbiomes for informatics

- Large data sets of complex biological systems and interactions for analytics and modeling
"The ultimate objective of iVAMP is to cultivate a collaborative network aimed at developing predictive models, leveraging a comprehensive understanding spanning from host metadata to the interactions of microorganisms within venom."
De León et al. 2025 Symbiosis [in press]
- Approximately ~30% of venom microbe taxa are uncharacterized, which can serve as good case study examples for further development of next generation technologies
- Identification of bias in datasets and filling those gaps, much like the biases that may be within ourselves, can push and advance our understanding of fundamentals

Publish or perish... or a new paradigm? **Putting science first.**

Were they thinking about publication counts in Nature and Science?

