

# A microbial consortia approach is crucial for understanding human health

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**African Microbiomes hold the key to the  
future of microbiome research!**

# Roadmap to expanding microbiome research in Africa

nature reviews microbiology

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## African microbiomes matter

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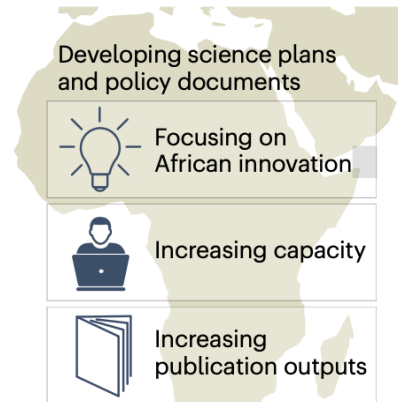
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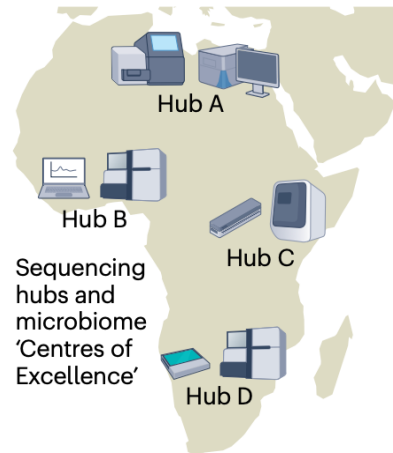
**Coordinated research networks**  
Continental microbiome research networks



**Policy interventions**  
Coordinated continental science plans to advance microbiome research



**Infrastructure development**  
Urgent need to establish the sequencing capacity and research infrastructure




## Comment

<https://doi.org/10.1038/s41591-024-03026-2>

## Microbiome research in Africa must be based on equitable partnerships

Ovokeraye H. Oduaran, Moréniké Oluwátóyin Foláyan, Arox W. Kamng'ona, Annetee Nakimuli, Lamech M. Mwapagha, Mathabatha E. Setati, Michael Owusu, Nicola Mulder, Thulani P. Makhalanyane & Soumaya Kouidhi

 Check for updates

**Table 1 | Pillars of an implementation framework for African microbiome research**

Pillar	Rationale
Local research leadership	Empowering local scientists and scholars ensures consideration of cultural and contextual relevance in research efforts, fostering community-engaged research and network strengthening.
Contextualized global research	Addressing locally relevant public health priorities and public health research priorities, while aiming for globally applicable solutions, is crucial to the advancement of microbiome research on the continent.
Ethical and equitable partnerships	Fair engagement practices with shared goals and objectives, clear guidelines on samples and data ownership, along with future-minded initiatives bode well for long-lasting, mutually beneficial collaborations.
Standardized microbiome protocols	Standardized procedures suitable for the African setting, ranging from sample collection and storage practices to laboratory and analytical approaches, will facilitate reproducibility and consistency in research efforts.
Governmental involvement	The role of national governments is vital for policy development, enabling conducive regulatory research environments, and can lead to coordinated efforts to tackle public health priorities.

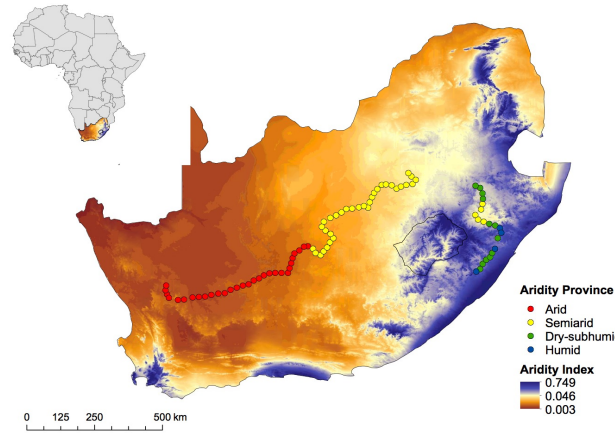
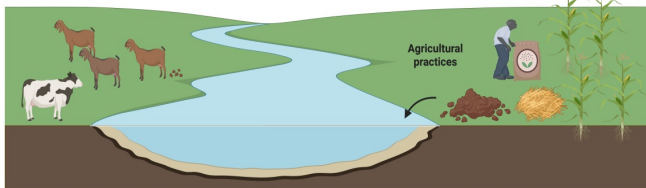
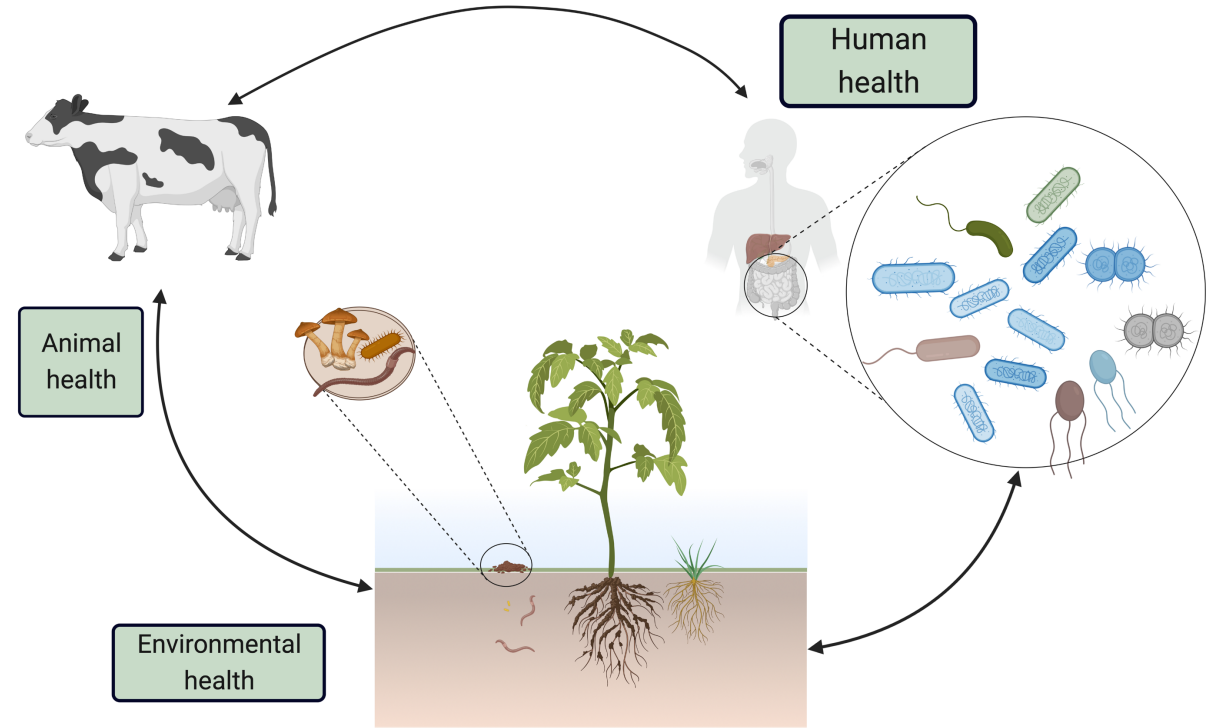
# Research focus

1 Microbial diversity

2 Evolutionary adaptation

3 Microbial interactions

Connection between **plants, animals and humans**





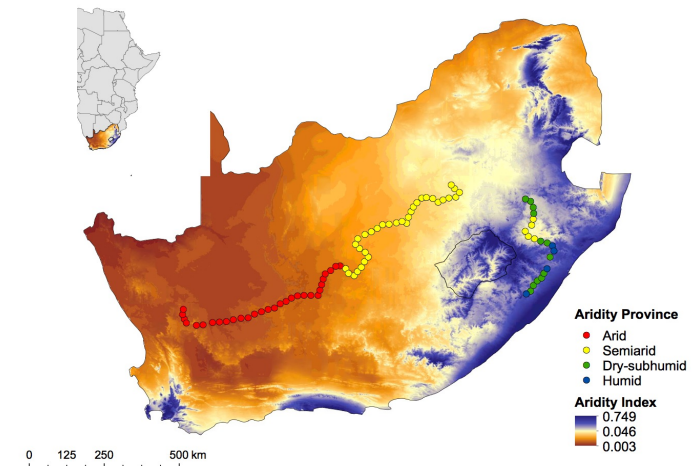
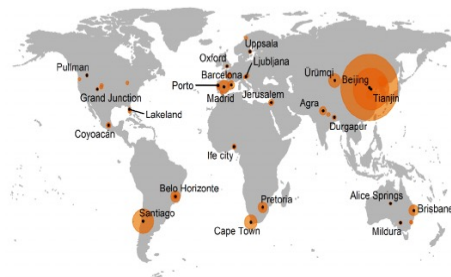
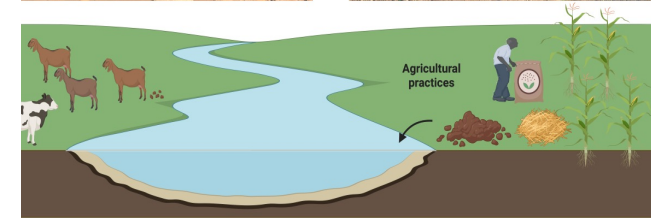
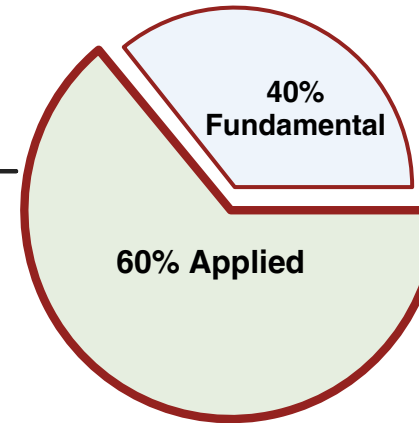
# African Microbiome Group@SUN thematic research areas

- THEME 1**  
*African Microbiome Discovery and Innovation*
- THEME 2**  
*Training the next Generation of African Microbiome Scientists*
- THEME 3**  
*Microbiome Services and Support*
- THEME 4**  
*Coordinating Microbiome Policy and Education*
- THEME 5**  
*Strengthening Regional and International Networks*

## African Microbiome Discovery and Innovation

- 1 Dynamics of African microbiomes
- 2 Climate change effects on African microbiomes
- 3 Microbiome environmental surveillance
- 4 Microbiomes and health

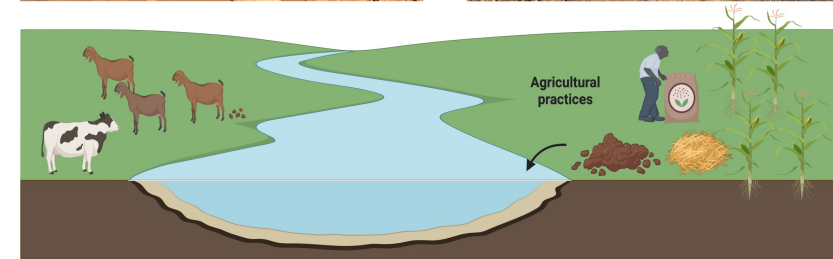
### Applied vs Fundamental Research



# Current funded projects



1. Establishing genetic, phylogenetic and functional Mechanisms that shape microbiomes (NRF/NSF)
2. Microbiomes as sentinels of change in coastal and marine environments (NRF)
3. Leapfrogging the discovery of microbial bioproducts using machine learning
4. Understanding the persistence and transmission of antimicrobial resistance genes in African wastewater and freshwater environments.





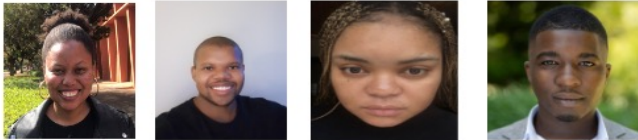


# African Microbiome Group Members



Dr. Girish Nair    Dr. Sam Leareng    Dr. Nonsikelelo Mthethwa    Dr. Peter Montso

## Postdoctoral Fellows



Nosipho Hlalukana    Keith Dube    Nombuso Sithole    Runesu Bakasa

## SU New PhD students



Mayibongwe Buthelezi    Phillip Mawire    Benjamin Abraham    Johan Paul Makumbi

## UP registered students committed to their degrees



Zak Claassen    Elizabe Malan    Michelle Bekker    Mancha Mabaso

## UP registered students who wouldn't leave their moms and boyfriends





# New Honours students and projects



**Nobuhle Kambunga**

Antimicrobial resistance in children living in informal housing



**Louis Burger**

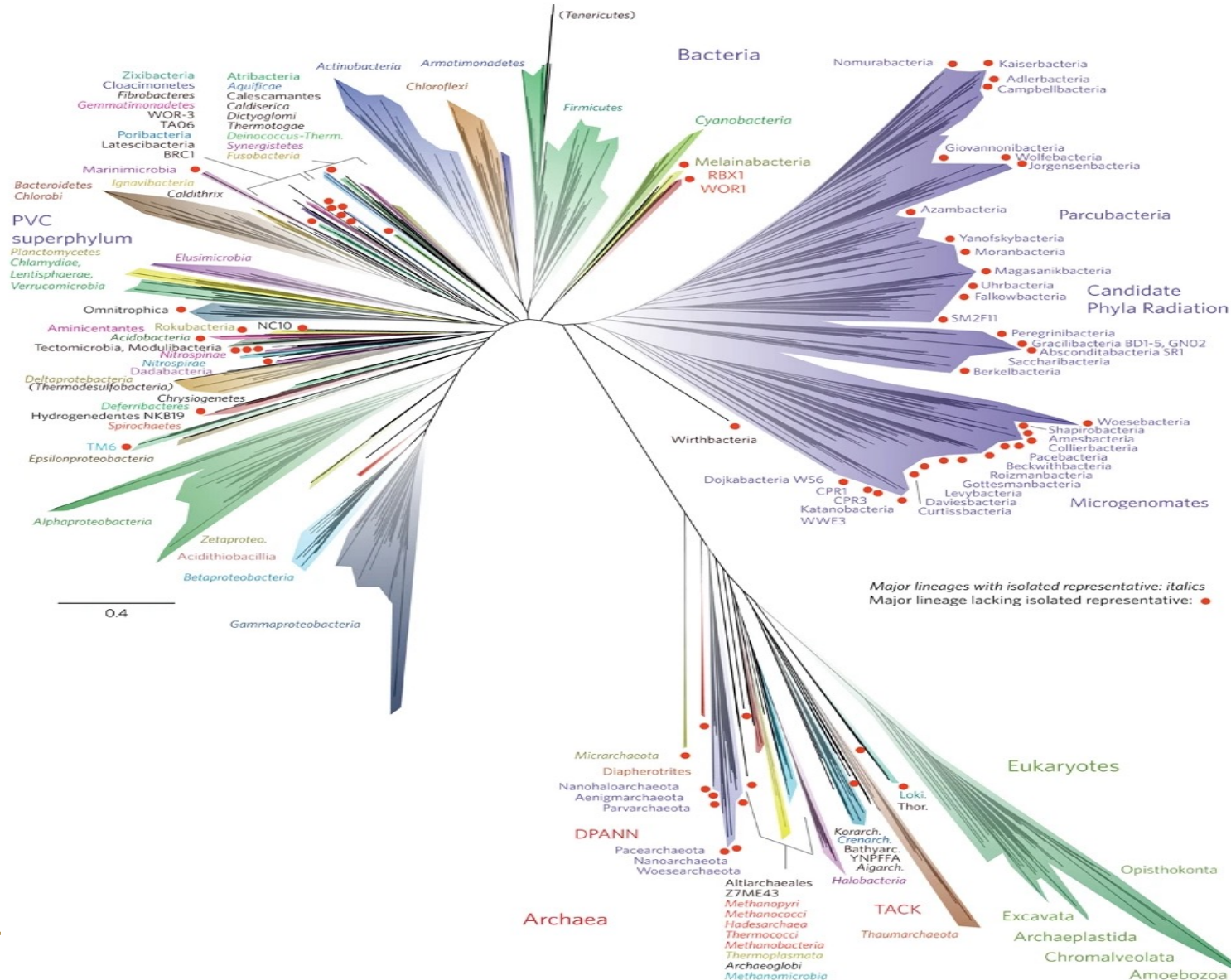
The role of the gut microbiome in long covid



**Isabella Blumeris**

Childhood stunting in children born from HIV positive mothers

# A new view of microbial diversity



1. Role in human **health**
2. Role in **biochemical** cycling
3. Impact on **climate** change

Hug et al. "A new view of the tree of life." *Nature microbiology* 1.5 (2016): 1-6.

# The complexity of studying microbiomes: Polar and Marine environments as model ecosystems

1

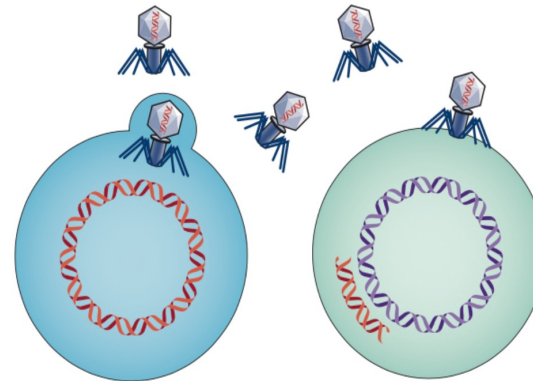
Microbial communities are **numerous**

Marine sediment

$7.85 \times 10^3$  to  $6.10 \times 10^5$  (**bacteria**)  
and  
 $3.28 \times 10^4$  to  $2.46 \times 10^6$  (**archaea**)

2

Widespread **horizontal gene transfer**, **gene loss** and **convergent evolution** may confound the relationship between traits and phylogeny




REVIEWS

3

**Environmental conditions** disproportionately **shape phylogeny**

 Examining horizontal gene transfer in microbial communities

*Ilana Lauren Brito* 

4

**Microbes in polar and marine environments** are excellent **models** for understanding the effects of change

The ISME Journal (2018) 12:2470–2478  
<https://doi.org/10.1038/s41396-018-0158-1>

 **ISME**

ARTICLE



**A strong link between marine microbial community composition and function challenges the idea of functional redundancy**

Pierre E. Galand <sup>1</sup> · Olivier Pereira<sup>1</sup> · Corentin Hochart<sup>2</sup> · Jean Christophe Auguet<sup>3</sup> · Didier Debroas<sup>2</sup>



# Five lessons from studying environmental microbiomes

1. Ecological context matters
2. Microbial interactions are more consequential than single microbes
3. High diversity leads to community stability
4. Microbial communities are subject to succession
5. Changes in environmental conditions influence microbial evolution and adaptation

nature climate change

Article

<https://doi.org/10.1038/s41558-023-01646-z>

## Biogenic factors explain soil carbon in paired urban and natural ecosystems worldwide

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 Check for updates

Manuel Delgado-Baquerizo<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Pablo Mark A. Bradford<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Tadeo Sáez-Sandino<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Yu-Rong Liu<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Sebastian Abades<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Adebola R. Bamigboye<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, José L. Blanco-Pastor<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Jorge Durán<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Tine Grebenc<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Thulani P. Makhhalanyane<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Tina U. Nahberger<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Gabriel F. Peñaloza-I<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Alexandra Rodríguez<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Christina Siet<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Pankaj Trivedi<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Jay Prakash Verma<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, L. Tianxue Yang<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Eli Zaady<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>, Xiaobing Z<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>



RESEARCH ARTICLE



## Bacteria and Archaea Regulate Particulate Organic Matter Export in Suspended and Sinking Marine Particle Fractions

Choaro D. Dithugoe,<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup> Oliver K. I. Bezuidt,<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup> Emma L. Cavan,<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup> William P. Froneman,<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup> Sandy J. Thomalla,<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup> Thulani P. Makhhalanyane<sup>1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100</sup>

Article

## Global hotspots for soil nature conservation

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# How do the gut microbiomes of healthy individuals in urban and rural areas of South Africa differ, and what are the functional implications of these differences?



Vhembe district, Limpopo



Pretoria, Gauteng

# Studies on African gut microbiomes

ARTICLE

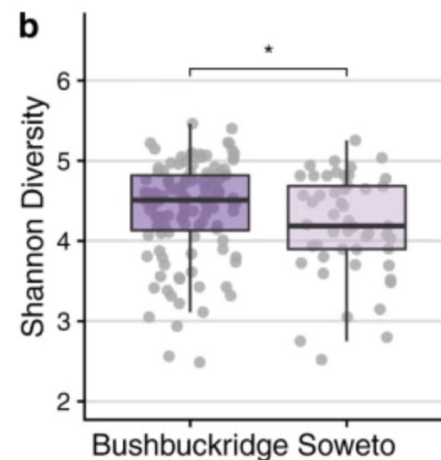
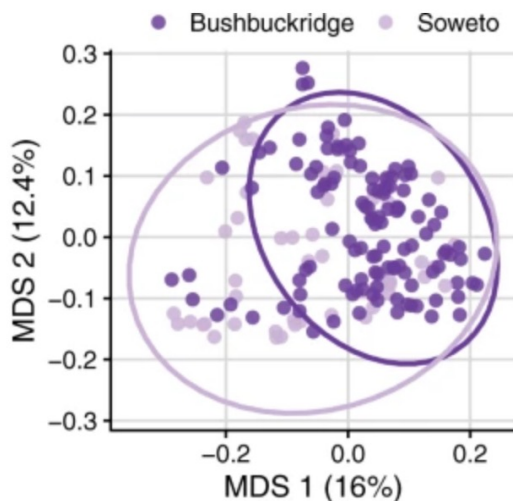


<https://doi.org/10.1038/s41467-021-27917-x>

OPEN

## Short- and long-read metagenomics of urban and rural South African gut microbiomes reveal a transitional composition and undescribed taxa

Fiona B. Tamburini<sup>1</sup>, Dylan Maghini<sup>1</sup>, Ovokeraye H. Oduaran<sup>2</sup>, Ryan Brewster<sup>3</sup>, Michaella R. Hulley<sup>2,4</sup>, Venesa Sahibdeen<sup>4</sup>, Shane A. Norris<sup>5,6</sup>, Stephen Tollman<sup>7,8</sup>, Kathleen Kahn<sup>7,8</sup>, Ryan G. Wagner<sup>7,8</sup>, Alisha N. Wade<sup>7</sup>, Floidy Wafawanaka<sup>7</sup>, F. Xavier Gómez-Olivé<sup>7,8</sup>, Rhian Twine<sup>7</sup>, Zané Lombard<sup>4</sup>, H3Africa AWI-Gen Collaborative Centre, Scott Hazelhurst<sup>2,9,11</sup> & Ami S. Bhatt<sup>1,3,10,11</sup>



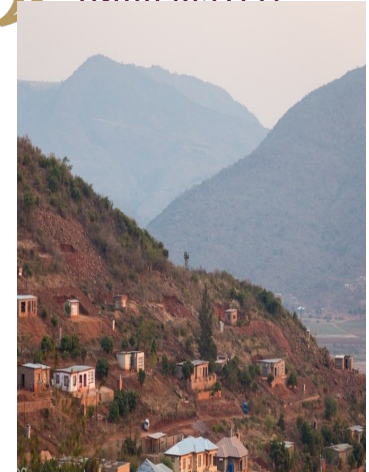
- Comparatively **few studies** on African gut microbiomes
- Some evidence showing that the **gut microbiome of South Africans does not conform to a simple “western-nonwestern” axis** and contains undescribed microbial diversity.
- Due to differences in diets, vital to expand these studies including **different regions**

# Studies on African gut microbiomes

## SA Gut team (past and present)



1. Elucidate gut **microbiomes** of healthy **SA individuals**
2. We collected stool samples from **Venda** and **Pretoria** (n=100)
3. Amplicon sequencing using **16S** and **ITS rRNA** gene markers
4. **Shotgun metagenomic** analysis



Vhembe district, Limpopo



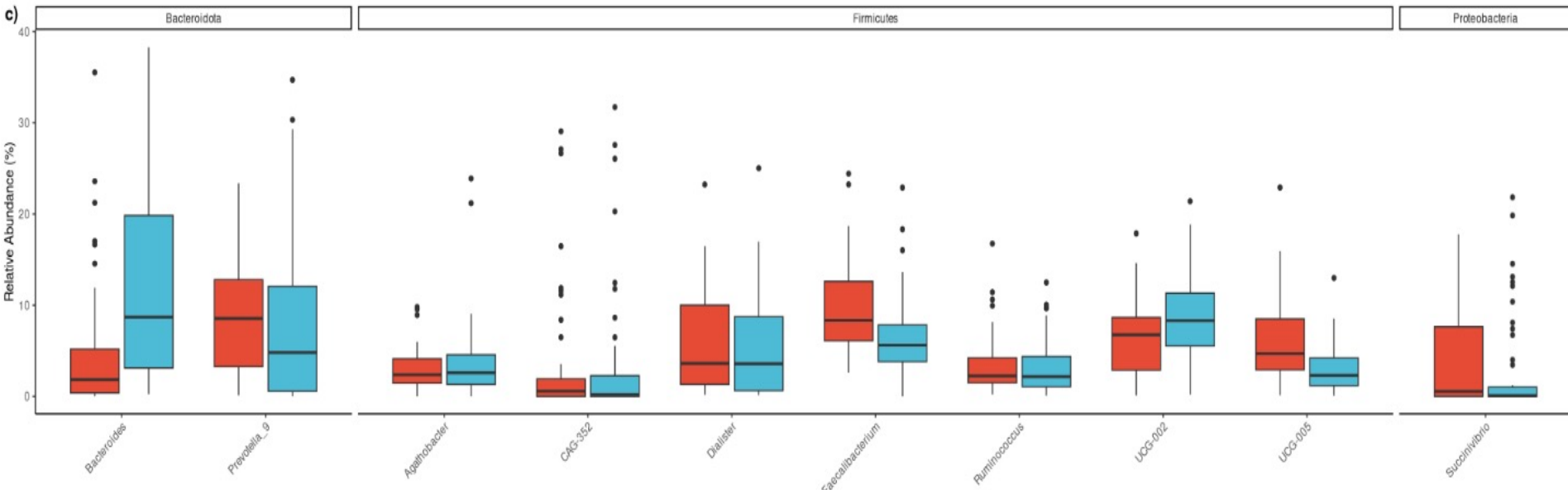
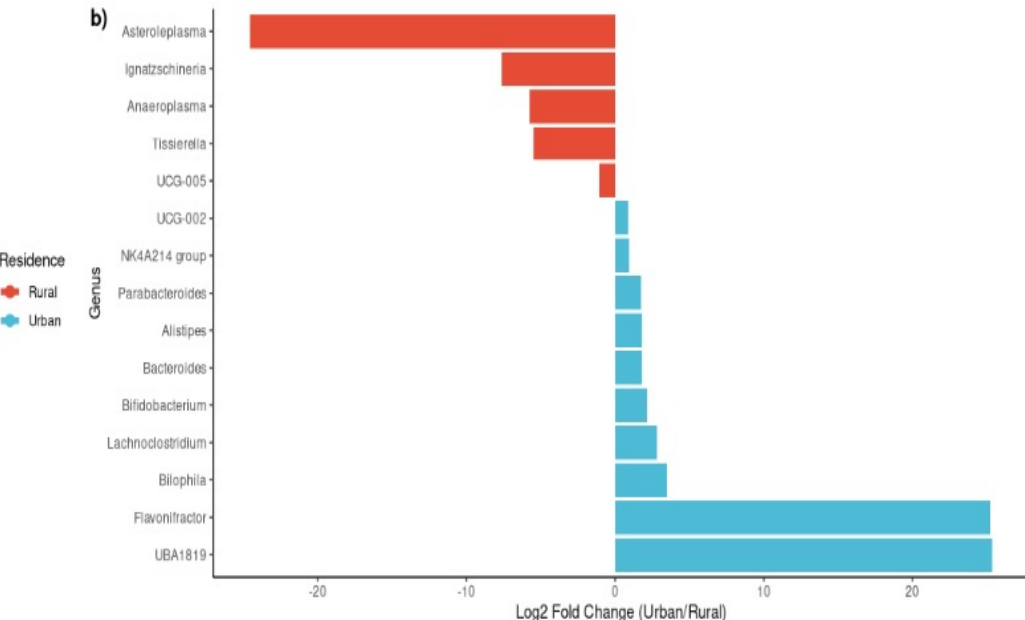
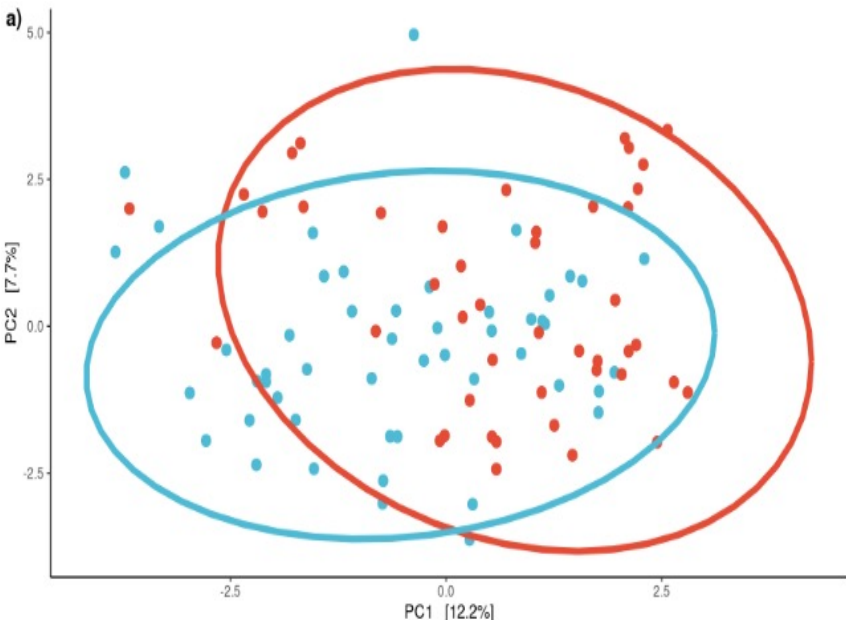
Pretoria, Gauteng



# Structural patterns of bacterial communities

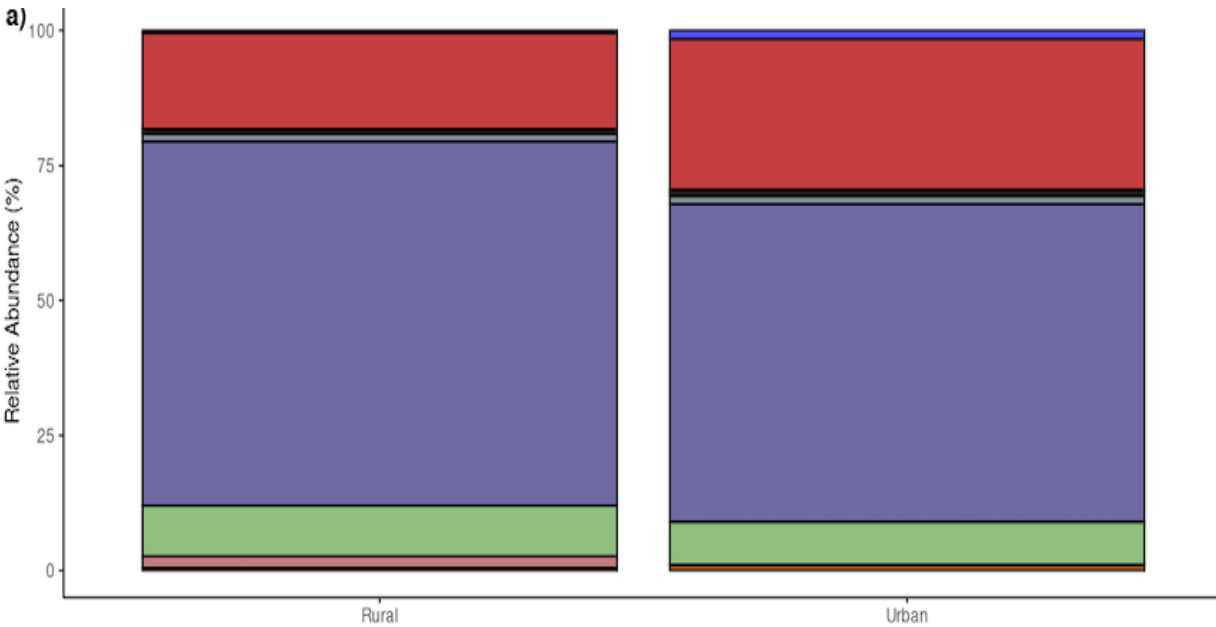


Bars in red and blue indicate the urban and rural populations, respectively.



## The 10 most abundant genera in rural and urban samples

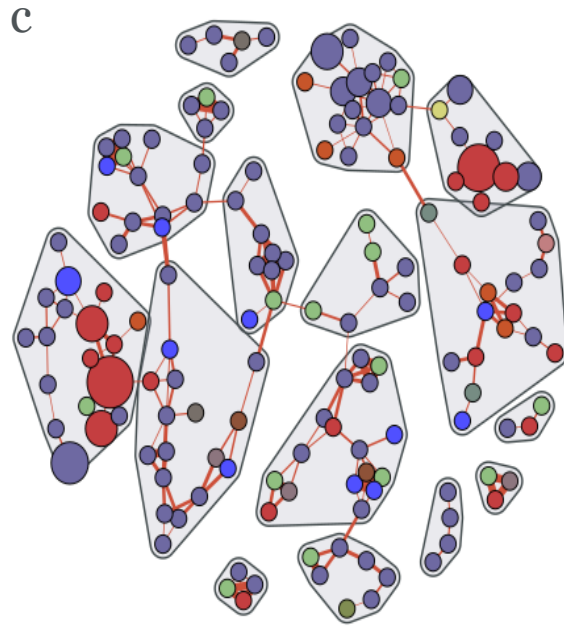
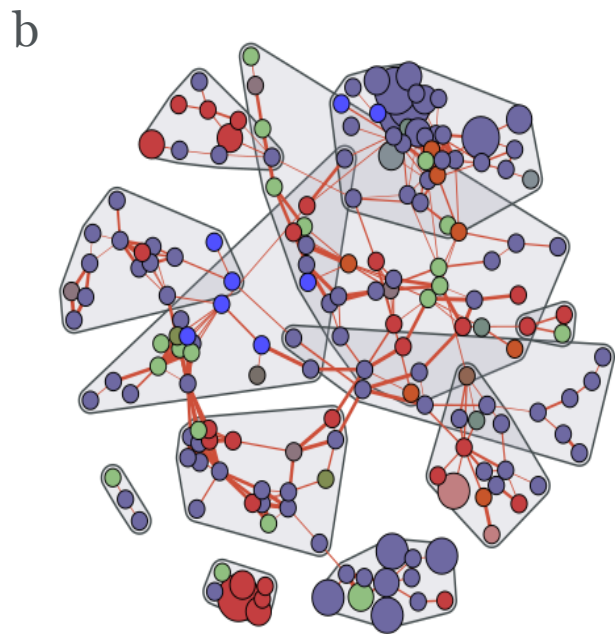
# Gut microbiomes of rural South Africans more diverse and connected



- Actinobacteriota
- Bacteroidota
- Campylobacterota
- Cyanobacteria
- Desulfobacterota
- Elusimicrobiota
- Euryarchaeota
- Firmicutes
- Fusobacteriota
- Proteobacteria
- Spirochaetota
- Synergistota
- Thermoplasmatota
- Verrucomicrobiota

Rural

Urban



**Alpha diversity shows that rural microbiomes more diverse**

**Rural networks are more connected suggesting increased cooperativity in these microbiota**

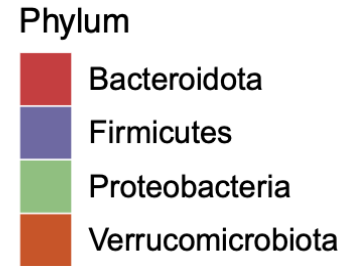
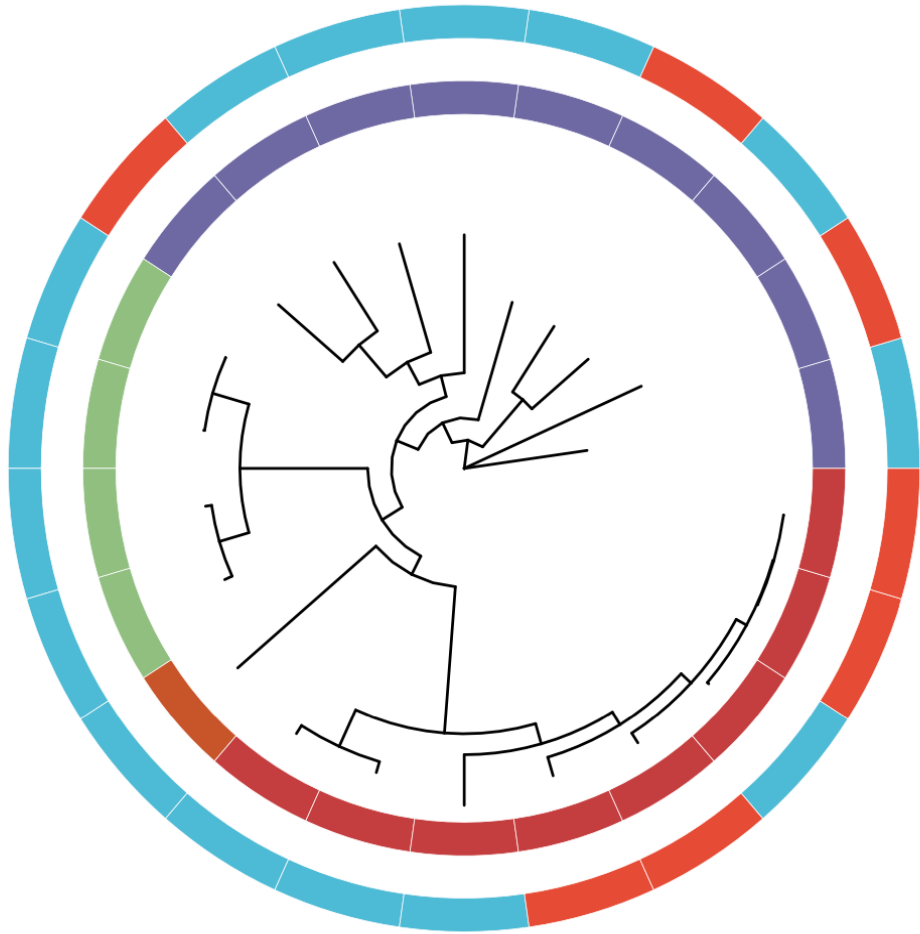


# Metagenomic analysis reveals over 380 diverse high to medium quality genomes

Phylum	Rural	Urban	Total
Actinobacteriota	1	8	9
Bacteroidota	56	41	97
Desulfobacterota	0	1	1
Elusimicrobiota	0	2	2
Firmicutes	125	125	250
Methanobacteriota	0	2	2
Proteobacteria	10	9	19
Spirochaetota	2	0	2
Verrucomicrobiota	0	2	2

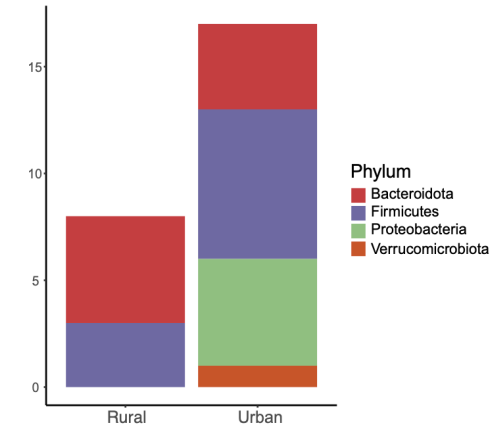
# South African gene catalogue shows high diversity and ARGs abundant in urban individuals

a



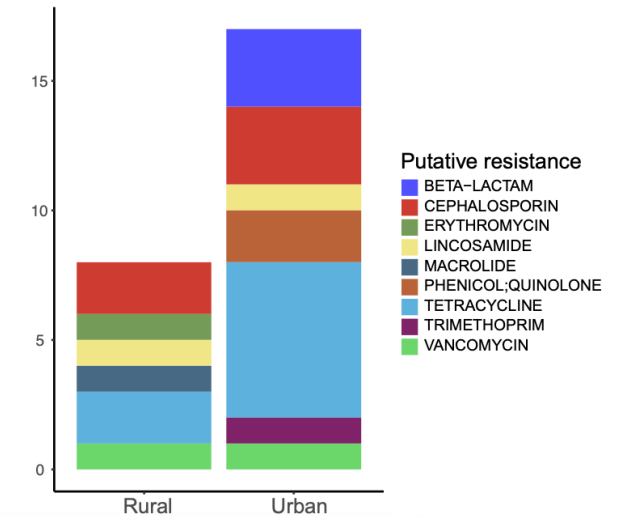
**Genomes with antimicrobial resistance genes**

b



**Two phyla with ARGs in rural vs four in urban**

c



**Putative antimicrobial resistance higher in urban**

- While previous studies have shown the difference between high-income countries and traditional communities, our data suggests some clear **differences in urban and rural Africans**
- **Urban** and **rural** South Africans harbor **highly similar** gut microbiota
- Results from co-occurrence networks suggest clear differences in the **stability** of **rural and urban microbiota**
- These differences may explain the considerably **varied functional profiles** (based on ARGs)

# Conclusion and future directions

1. Studies on environmental ecosystems have provided remarkable insights on microbial evolution
2. There are significant gaps in microbiome studies
3. A need to build collaborations and partnerships



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Computational Thinking



## Housing study Core team

1. **Ronelle Burger (SU)**
2. Marisa von Fintel (SU)
3. Dumisani Hompashe (UFS)
4. Vuyiswa Dlamini (SU)
5. Kuhle Ndyonda (SU)
6. **Lauren Tavener-Smith (SU)**
7. Renate Campher (SU)
8. Eigelaar-Meets (SU)



## Siyakhula project team

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Thank you  
Enkosi  
Dankie