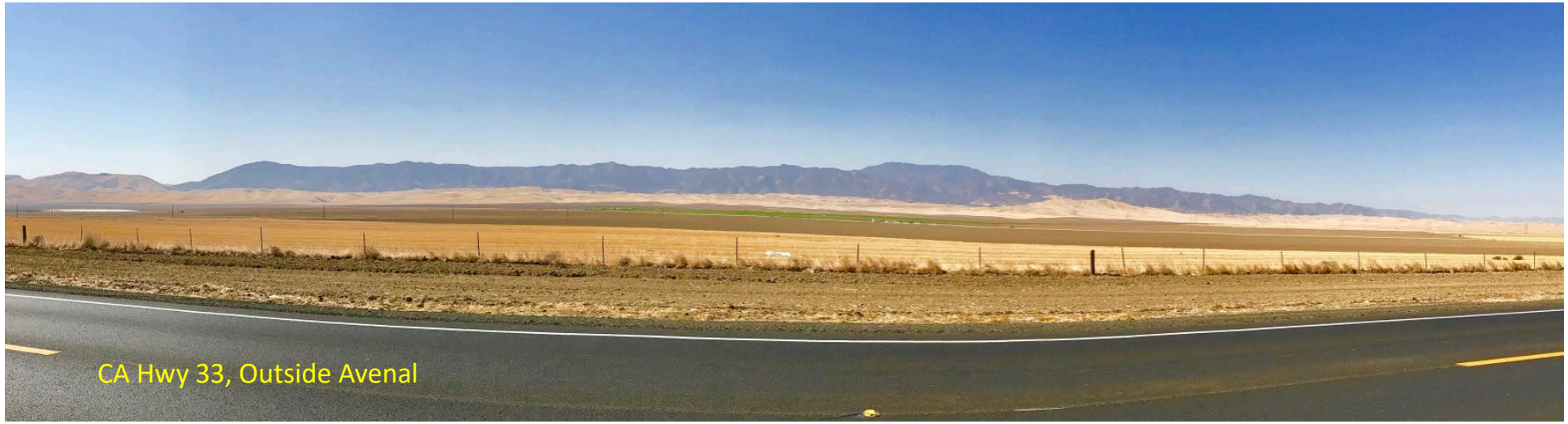
Environmental background and significance

John W. Taylor
UC Berkeley
jtaylor@berkeley.edu

November 2022



CALIFORNIA

- UC Berkeley
- Rob Wagner
- Lily Montoya
- Justin Remais
- Jennifer Head-Zhutenneger

UC San Francisco
Anita Sil

UC Berkeley
Rachel Brem

ARIZONA

Northern Arizona University
Bridget Barker

University of Arizona
John Galgiani

NEW MEXICO

University of New Mexico
Paris Salazar-Hamm
Don Natvig

Environmental background and significance

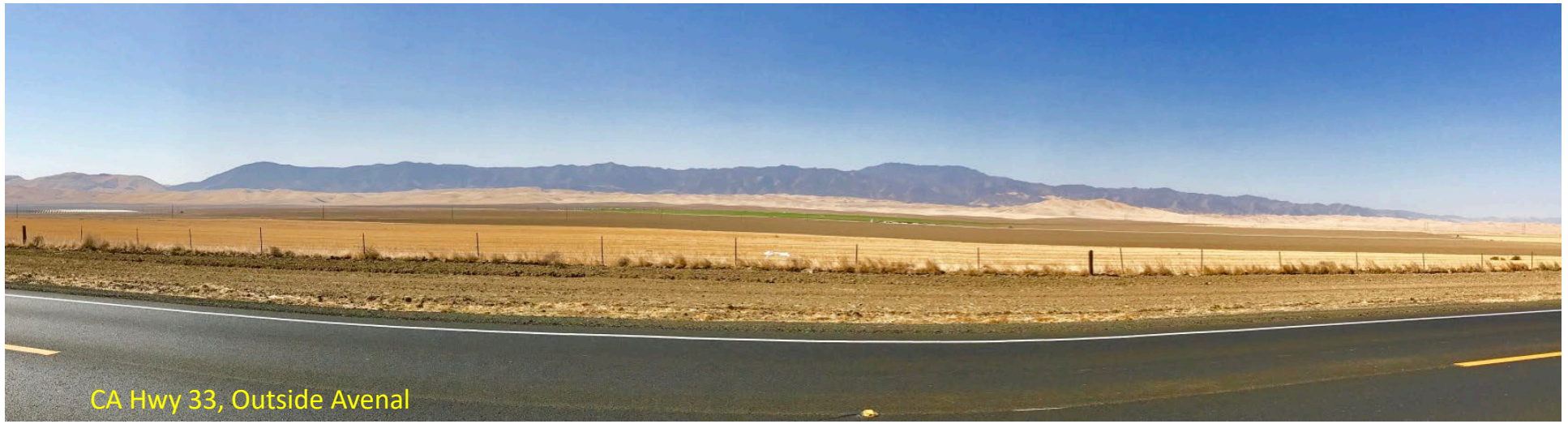
Pioneering studies

Traditional Environmental Cycle

Genomics

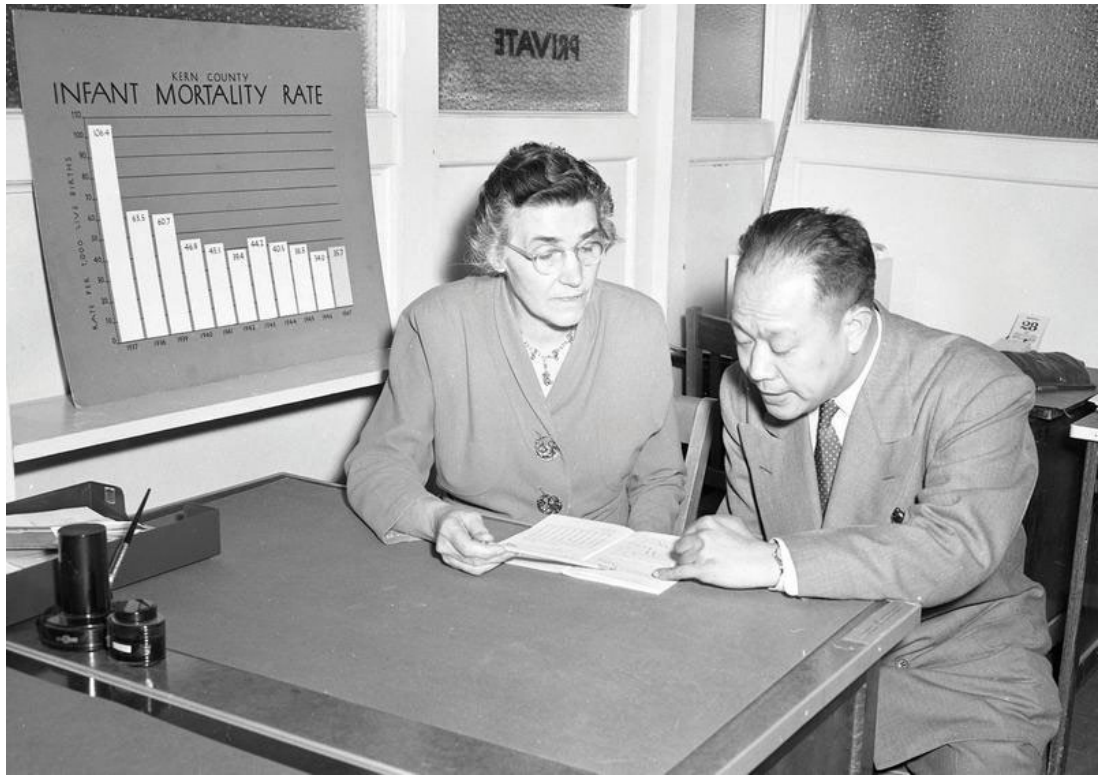
Revisionist Environmental Cycle

Hypothesis testing



Myrnie Gifford, 1938

Coccidial granuloma = San Joaquin Valley Fever

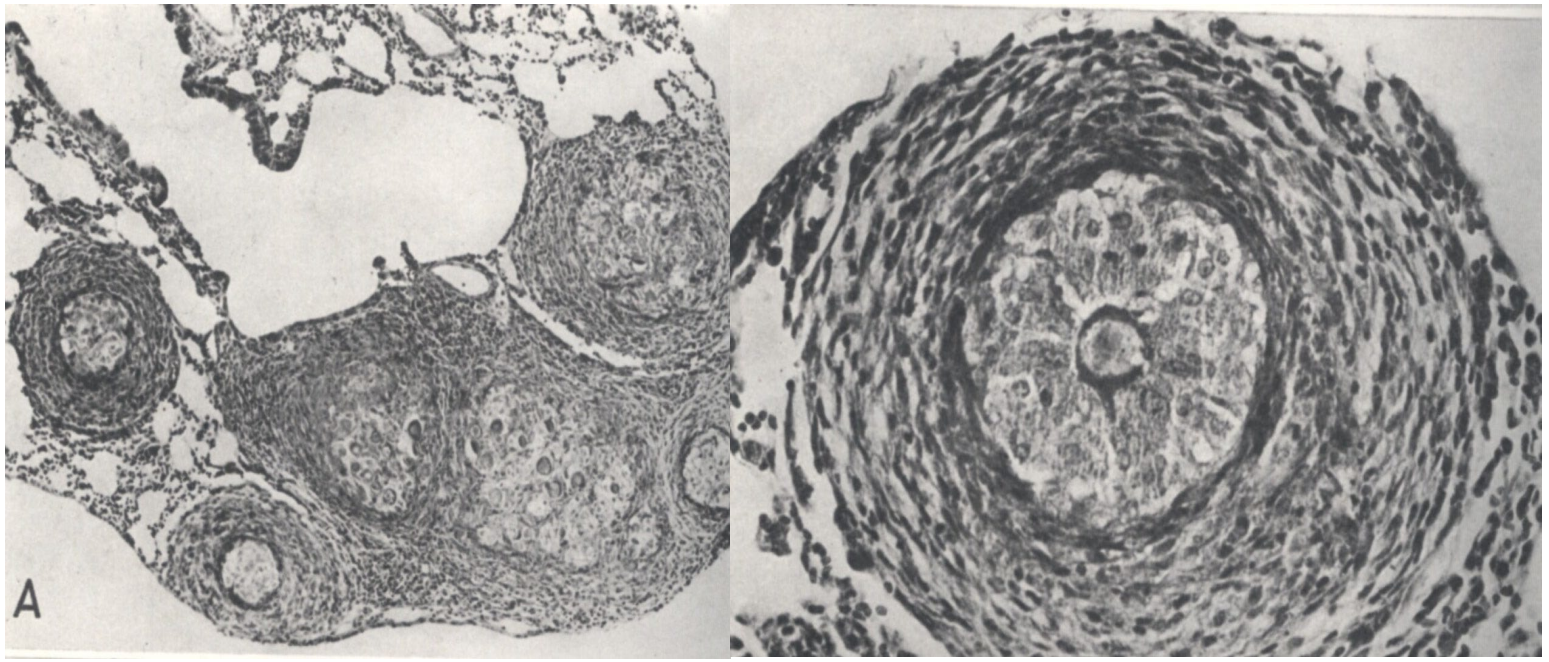


1830 1850 1870 1890 1910 1930 1950 1970 1990 2010

Coccidioides in granuloma in mouse lung

1942

Chester W. Emmons



Ashburn and Emmons 1942. *Archives of Pathology* 34:791-800.

Emmons and Ashburn, 1942

Public Health Reports

Vol. 57 • NOVEMBER 13, 1942 • *No. 46*

THE ISOLATION OF *HAPLOSPORANGIUM PARVUM* N. SP. AND *COCCIDIOIDES IMMITIS* FROM WILD RODENTS. DIOIDOMYCOSIS [1 2]

L. L. ASHBURN, *Passed Assistant c Health Service*

Pocket Mouse

Kangaroo Rat

	Total trapped	Lesions	Only *C. immitis* isolated	Only *H. parvum* isolated	*C. immitis* and *H. parvum* isolated	Total animals	
Perognathus	124	Seen	11	18	5	34	13%
		Not seen	1	60	2	63	
Dipodomys	29	Seen	3	1	2	6	17%
		Not seen		5		5	
	10	Seen		5		5	
		Not seen					
	27	Seen	1			1	
		Not seen		1		1	
	113	Seen					
		Not seen		2		2	
Total	303		16	92	9	*117	

*Cultures from 11 additional animals were contaminated and the pathogens, if present, were lost.

Emmons, 1943

Journal of Bacteriology, 1943, 45:306

WASHINGTON BRANCH
ONE HUNDRED AND TWENTY-NINTH MEETING
GEORGE WASHINGTON MEDICAL SCHOOL
JANUARY 26, 1943

A RESERVOIR OF COCCIDIOIDOMYCOSIS IN WILD RODENTS. C. W. EMMONS
Emmons, National Institute of Health, U. S. Public Health Service. Pulmonary

. . . it may be primarily a disease of rodents . . . certain species of rodents constitute a natural reservoir of coccidioidomycosis . . .

Plunkett and Swatek, 1957

Ecological studies of *Coccidioides immitis.*
Orda A. Plunkett and F. E. Swatek
In: Ajello, L. et al. 1957. Proc. Symp. Coccidioidomycosis.
Public Health Service Publication 575.

May 1954, outbreak with 5 UCLA anthropology students

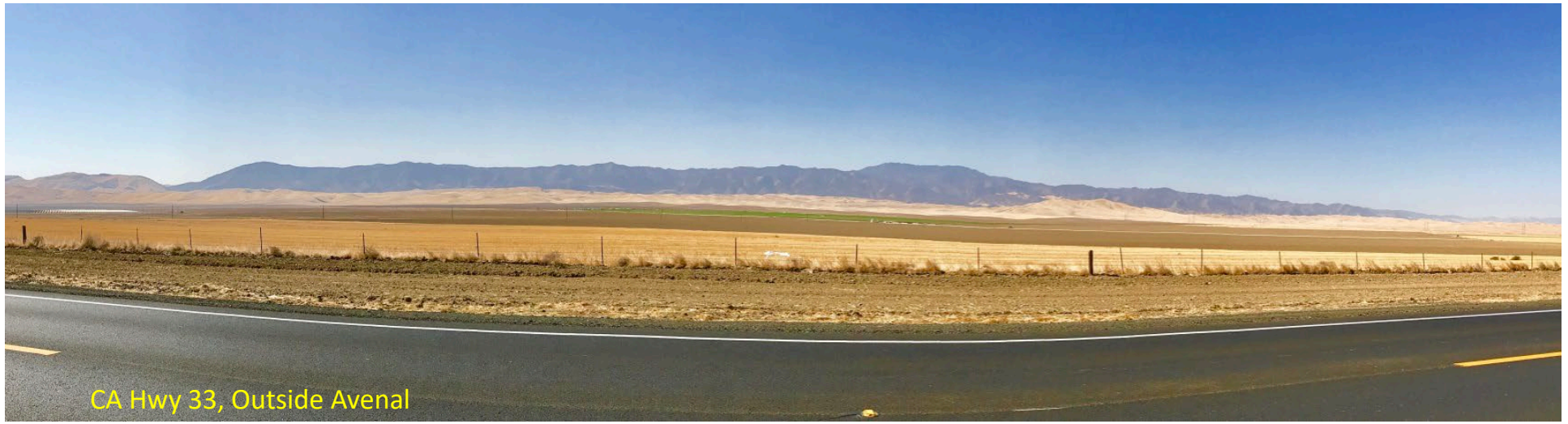
Soil Samples from the midden -- positive.

80 burrow samples taken near the midden – all negative.

440 native rodents near the midden -- all negative.

Environmental background and significance

- Pioneering studies
- **Traditional Environmental Cycle**
- Genomics
- Revisionist Environmental Cycle
- Hypothesis testing



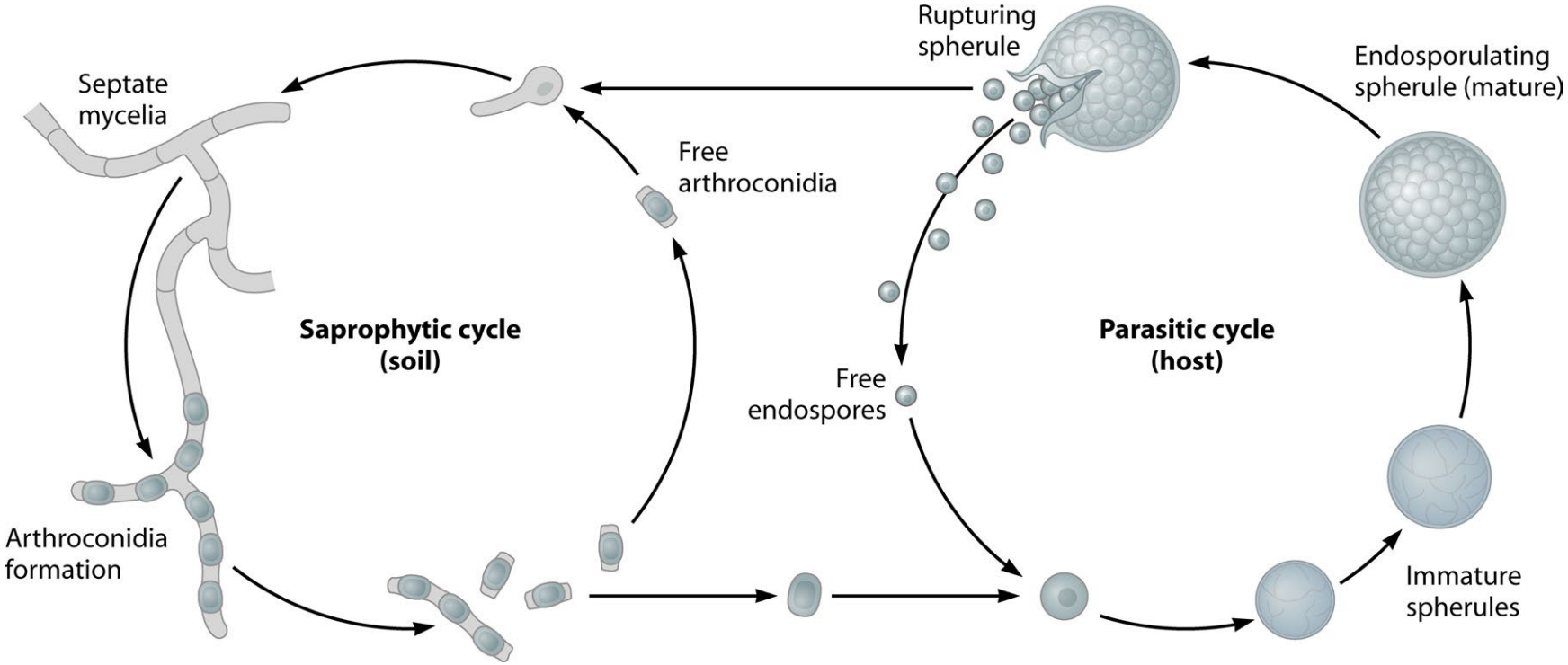
Nguyen et al. 2013

Clinical Microbiology Reviews

Recent Advances in Our Understanding of the Environmental, Epidemiological, Immunological, and Clinical Dimensions of Coccidioidomycosis

Chinh Nguyen, Bridget Marie Barker, Susan Hoover, David E. Nix, Neil M. Ampel, Jeffrey A. Frelinger, Marc J. Orbach and John N. Galgiani

Clin. Microbiol. Rev. **2013, 26(3):505. DOI: 10.1128/CMR.00005-13.**



Soil

Human Host

Nguyen et al. 2013

Clinical Microbiology Reviews

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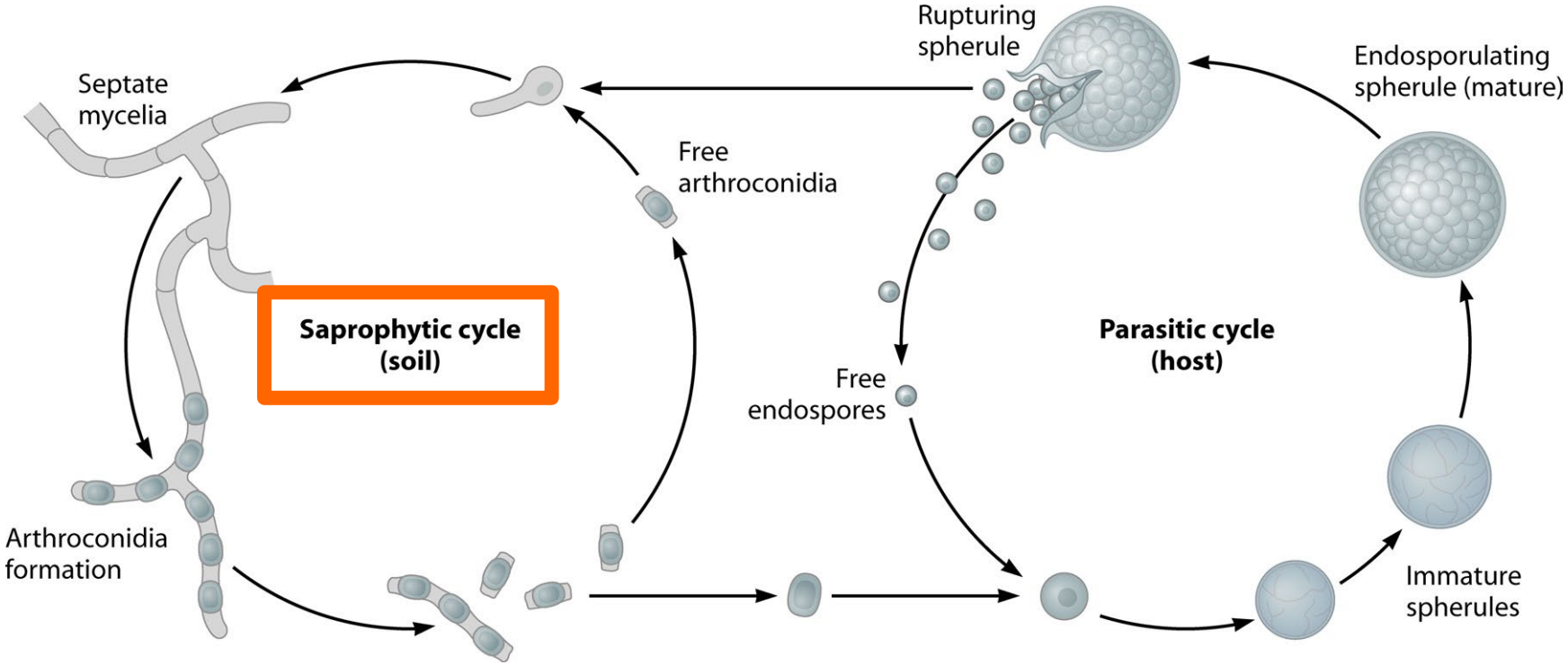


Saprophyte Soil Human Host

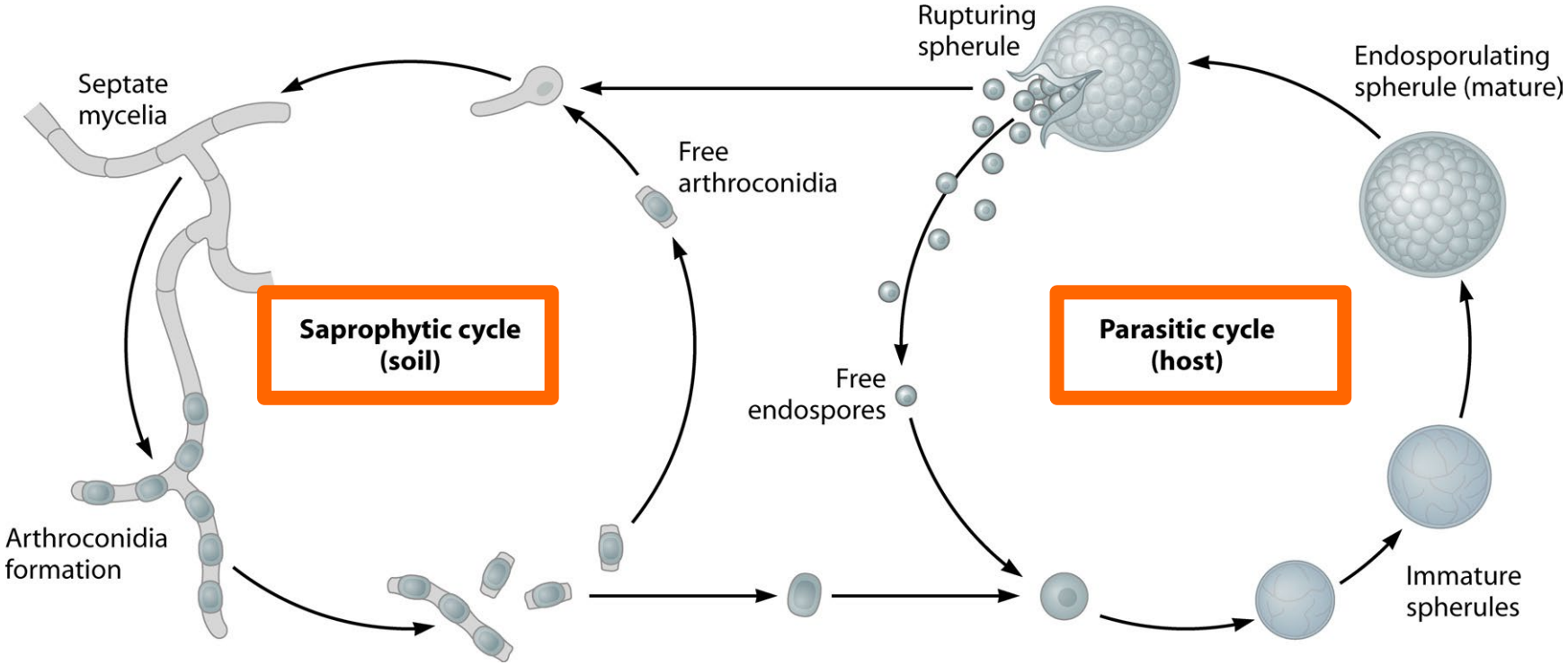
Nguyen et al. 2013

Clinical Microbiology Reviews

Recent Advances in Our Understanding of the Environmental, Epidemiological, Immunological, and Clinical Dimensions of Coccidioidomycosis

Chinh Nguyen, Bridget Marie Barker, Susan Hoover, David E. Nix, Neil M. Ampel, Jeffrey A. Frelinger, Marc J. Orbach and John N. Galgiani

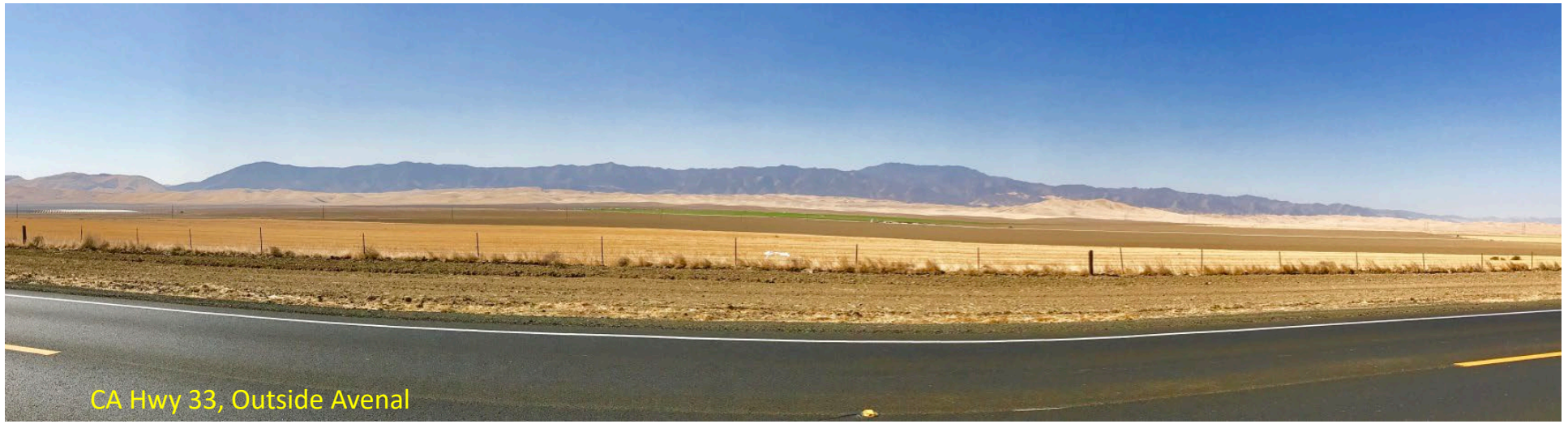
Clin. Microbiol. Rev. 2013, 26(3):505. DOI: 10.1128/CMR.00005-13.



Saprophyte Soil Human Host Parasite

Environmental background and significance

- Pioneering studies
- Traditional Environmental Cycle
- **Genomics**
- Revisionist Environmental Cycle
- Hypothesis testing



CA Hwy 33, Outside Avenal

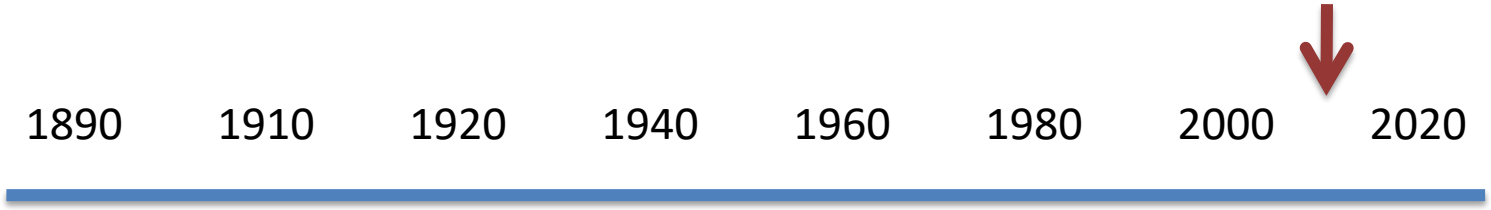
Sharpton, Stajich et al. 2009, *Comparative Genomics*

CSH PRESS GENOME RESEARCH

Letter

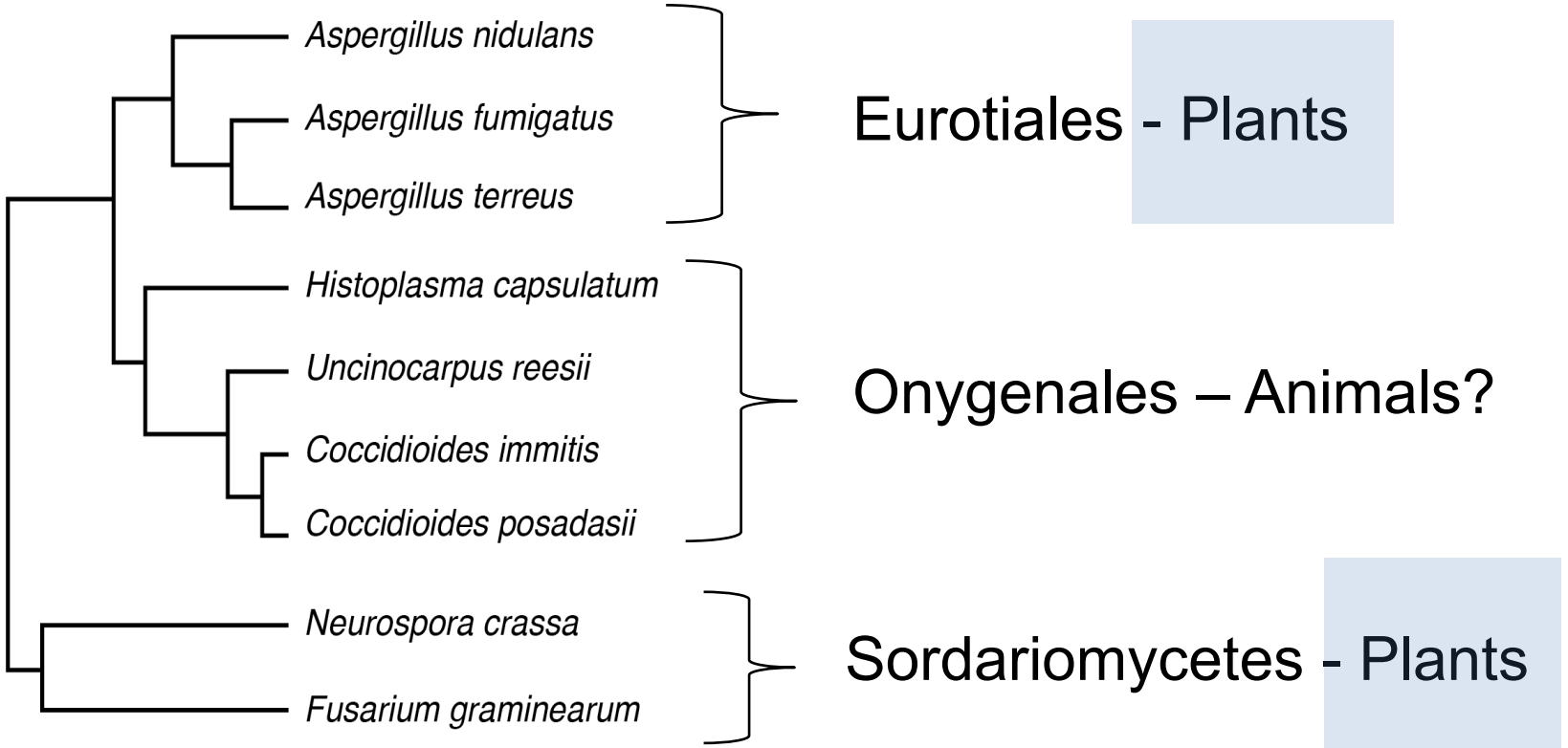
Comparative genomic analyses of the human fungal pathogens *Coccidioides* and their relatives

Thomas J. Sharpton,[1,11] Jason E. Stajich,[1] Steven D. Rounsley,[2] Malcolm J. Gardner,[3] Jennifer R. Wortman,[4] Vinita S. Jordar,[5] Rama Maiti,[5] Chinnappa D. Kodira,[6] Daniel E. Neafsey,[6] Qiandong Zeng,[6] Chiung-Yu Hung,[7] Cody McMahan,[7] Anna Muszewska,[8] Marcin Grynberg,[8] M. Alejandra Mandel,[2] Ellen M. Kellner,[2] Bridget M. Barker,[2] John N. Galgiani,[9] Marc J. Orbach,[2] Theo N. Kirkland,[10] Garry T. Cole,[7] Matthew R. Henn,[6] Bruce W. Birren,[6] and John W. Taylor[1]



Sharpton, Stajich et al. 2009, *Comparative Genomics*

Evolution of Gene Family Size



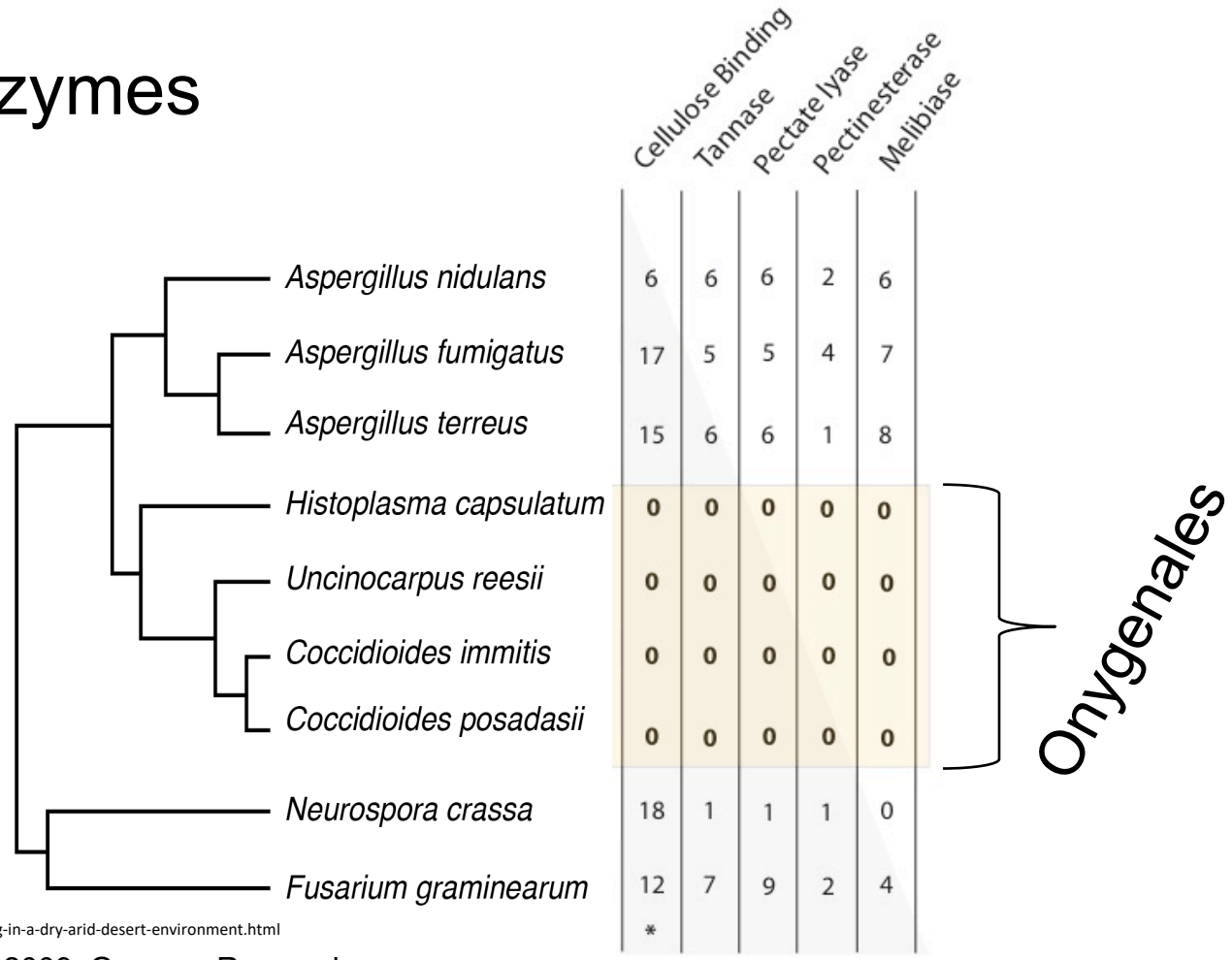
Sharpton, Stajich et al. 2009. Genome Research

Sharpton, Stajich et al. 2009, *Comparative Genomics*

Gene Family Reductions:

Genes coding enzymes that digest plants

https://www.123rf.com/photo_27279678_dried-out-dead-plants-lying-in-a-dry-arid-desert-environment.html



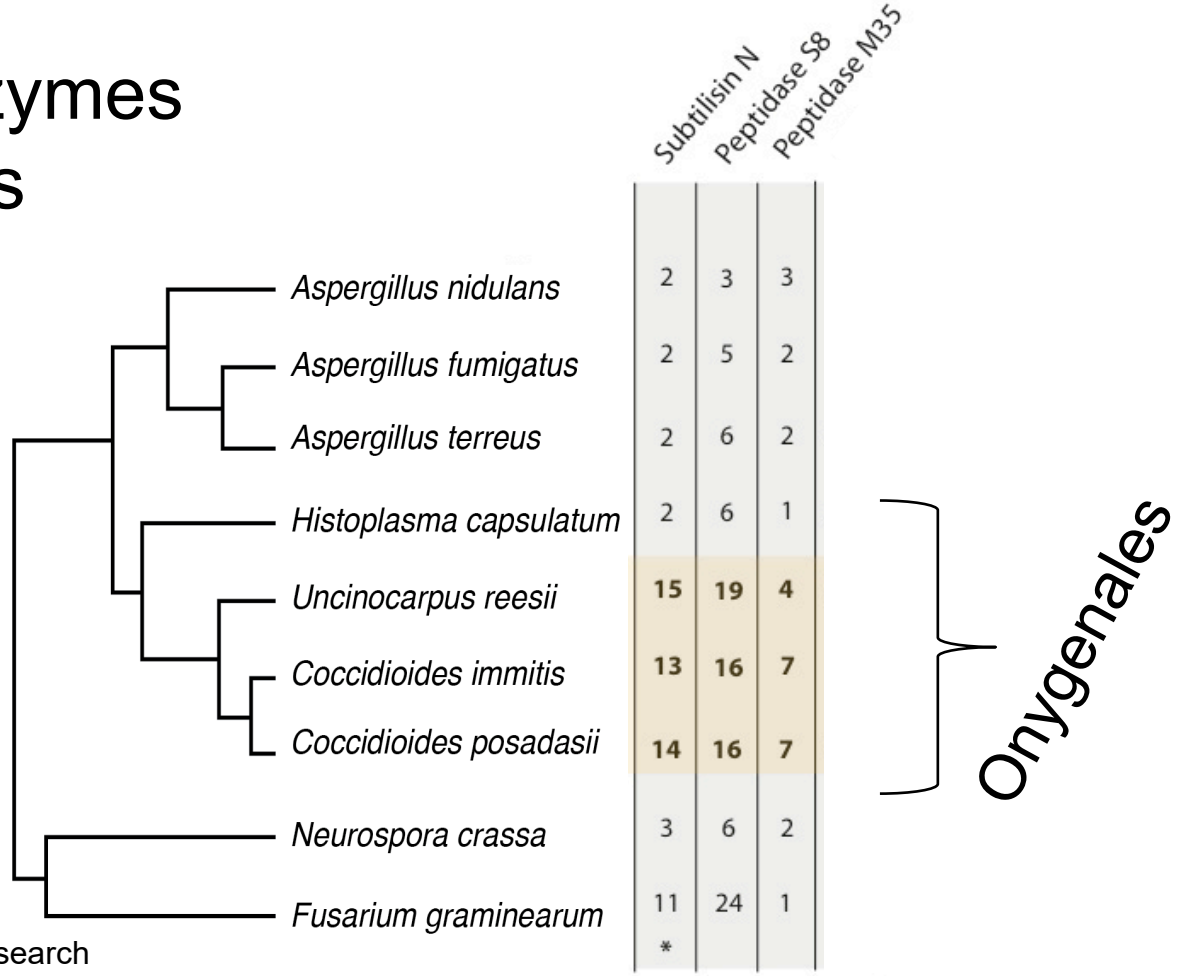
Sharpton, Stajich et al. 2009. Genome Research

Sharpton, Stajich et al. 2009, *Comparative Genomics*

Gene Family Expansion:

Genes coding enzymes that digest animals

Perognathus longimembris



Sharpton, Stajich et al. 2009. Genome Research

Jonah Evans, Texas. Parks and Wildlife Department, http://www.inaturalist.org/photos/407437

Wet protein in a dry desert

Environmental background and significance

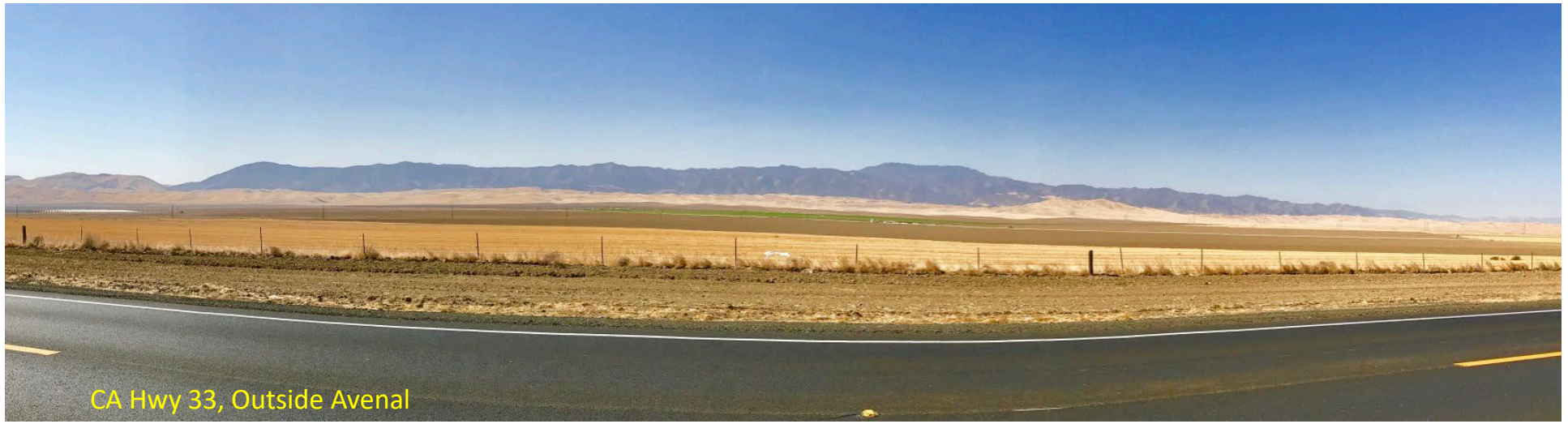
Pioneering studies

Traditional Environmental Cycle

Genomics

Revisionist Environmental Cycle

Hypothesis testing



CA Hwy 33, Outside Avenal

ISHAM
INTERNATIONAL SOCIETY FOR
HUMAN AND ANIMAL MYCOLOGY

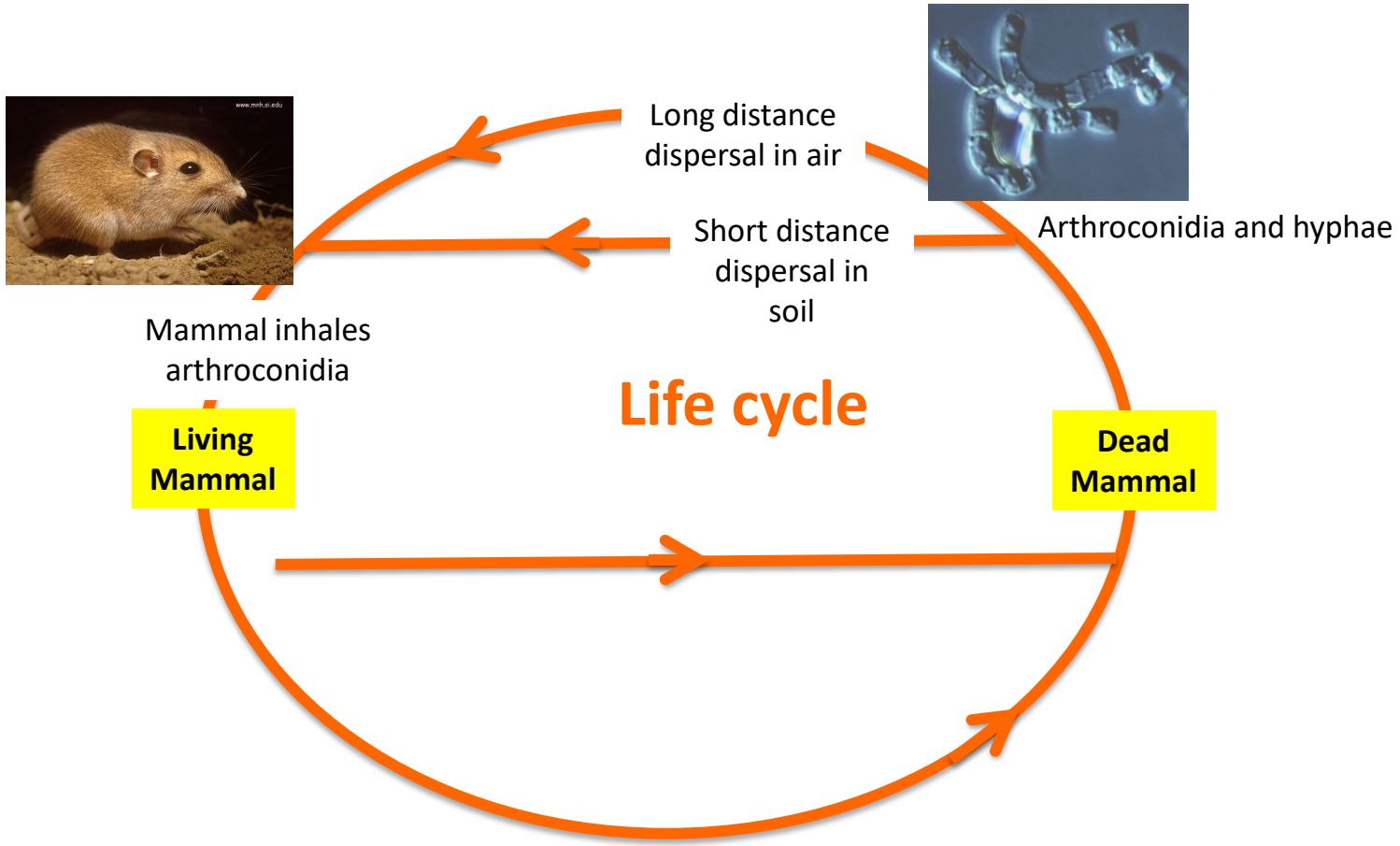
2018

Medical Mycology, 2018, 0, 1–5
doi: 10.1093/mmy/myy039
Advance Access Publication Date: 0 2018
Review Article

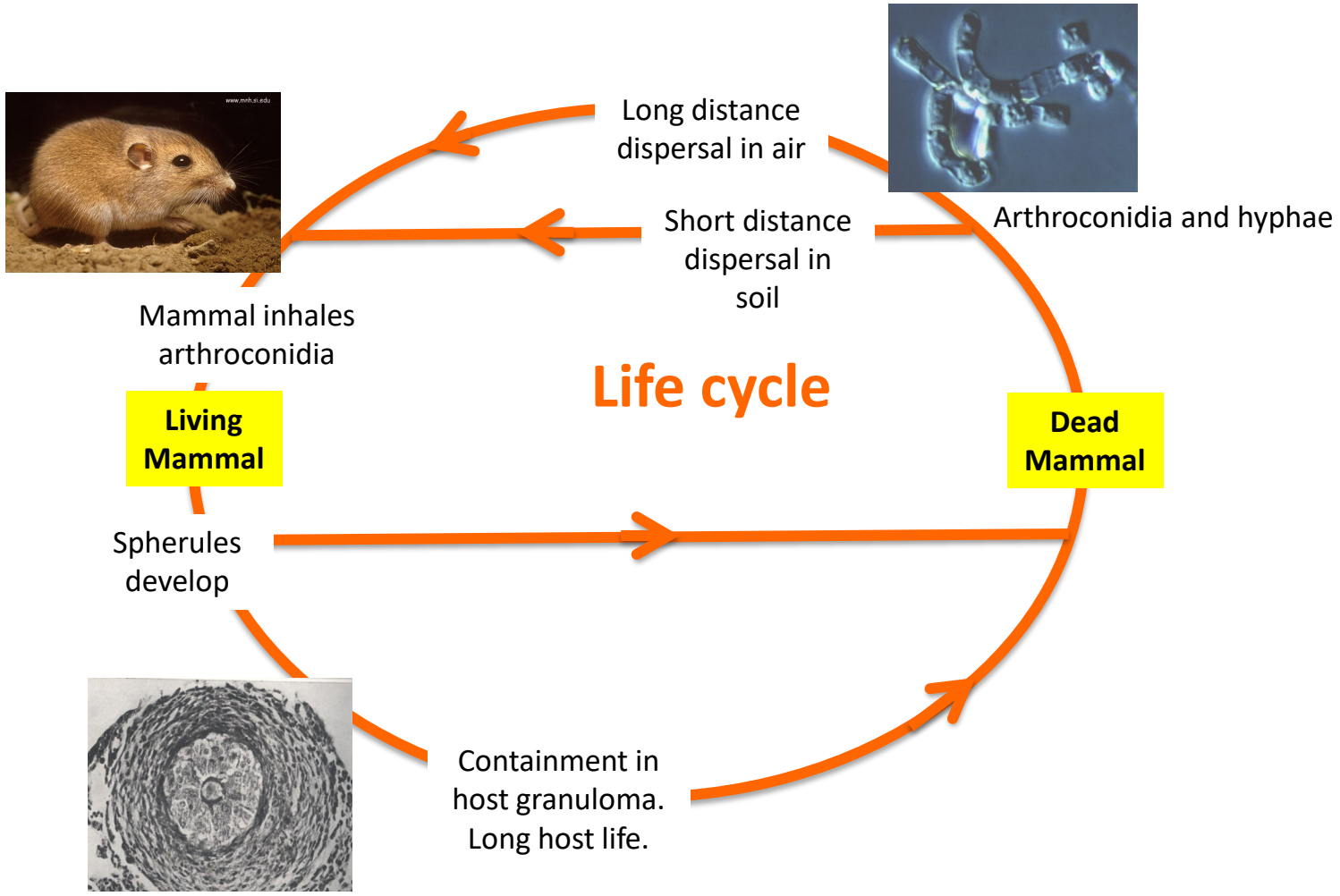
Review Article

The endozoan, small-mammal reservoir hypothesis and the life cycle of *Coccidioides* species

John W. Taylor[1,*] and Bridget M. Barker[2]



Taylor and Barker 2018, *Medical Mycology*



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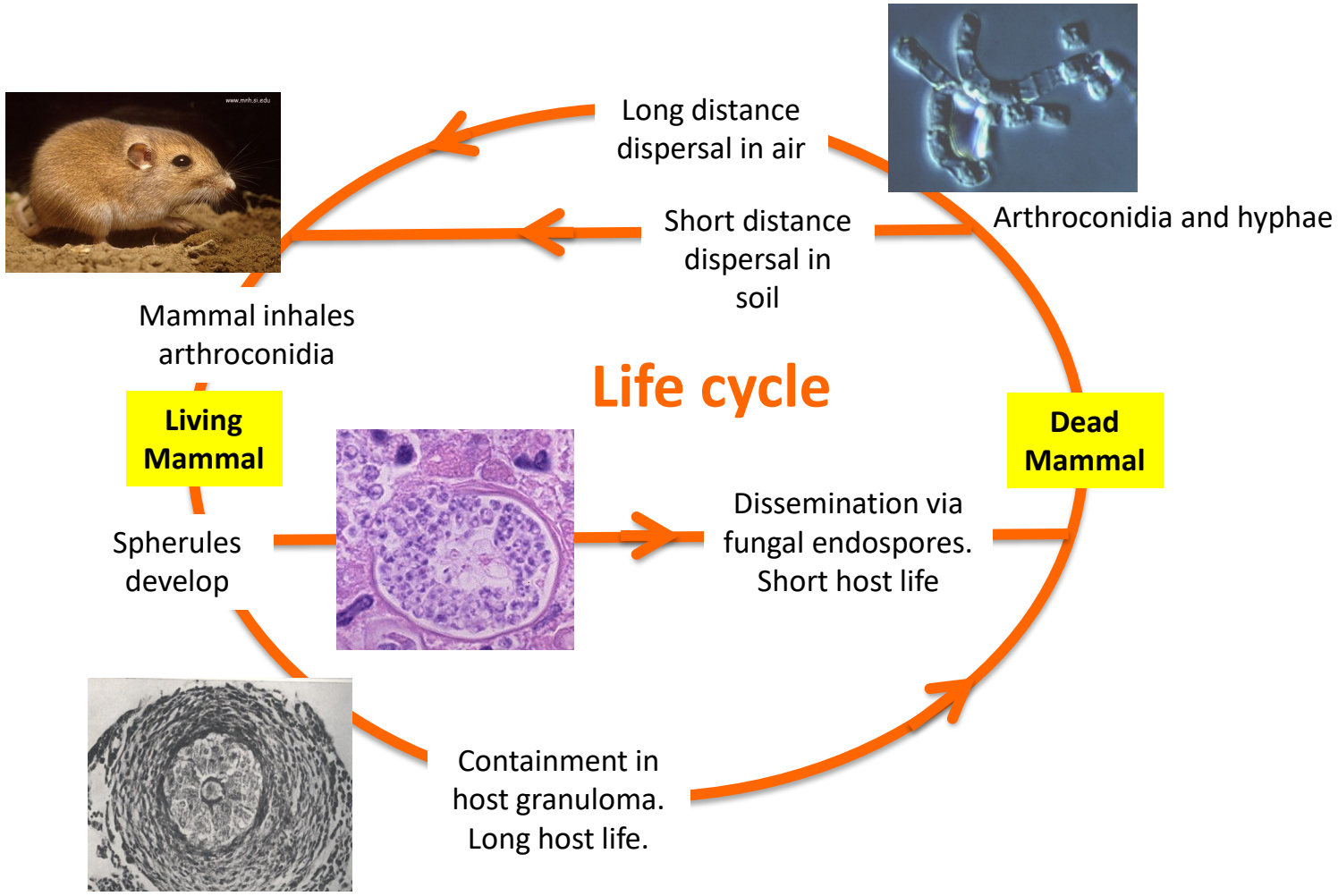
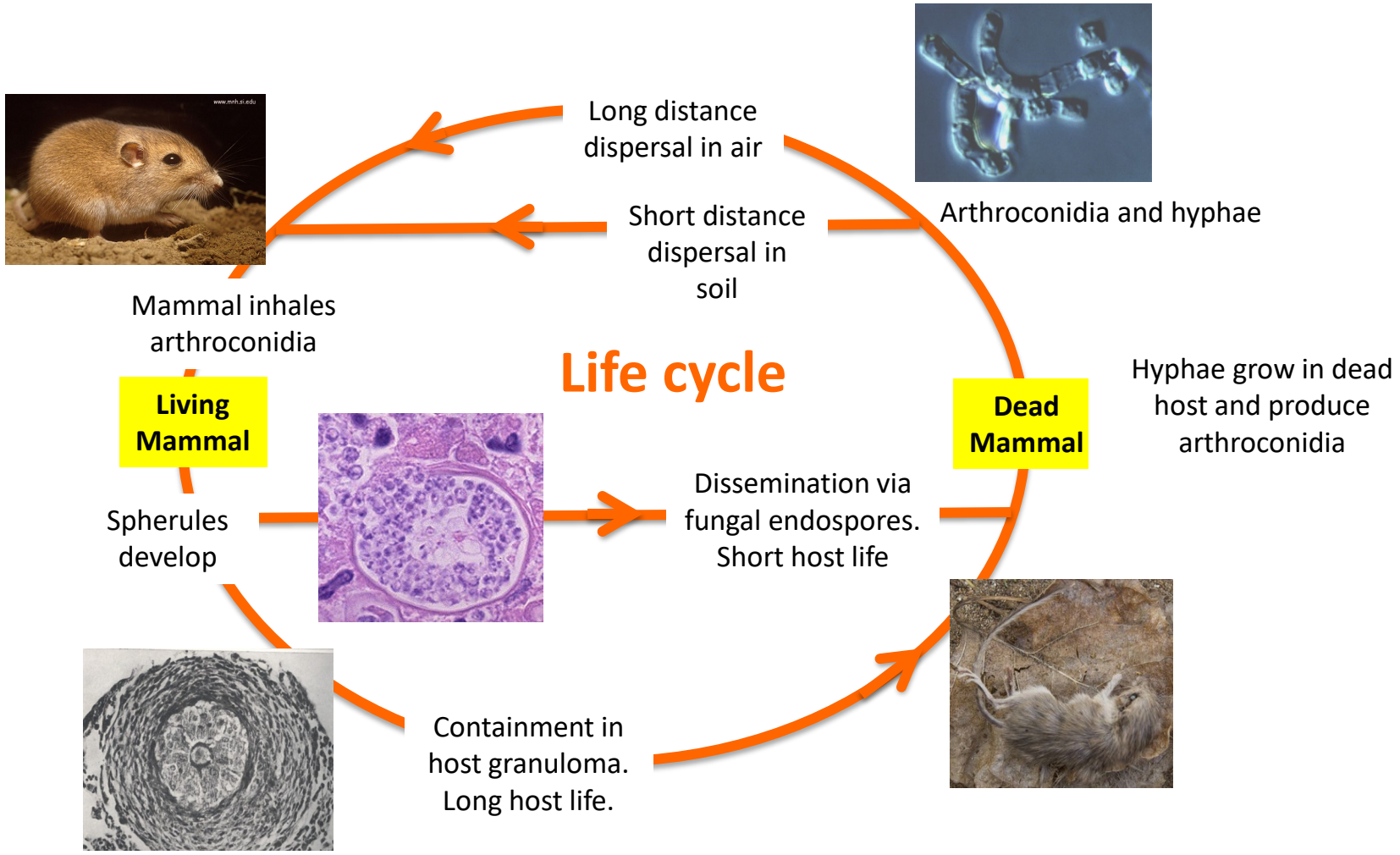


Taylor and Barker 2018, *Medical Mycology*



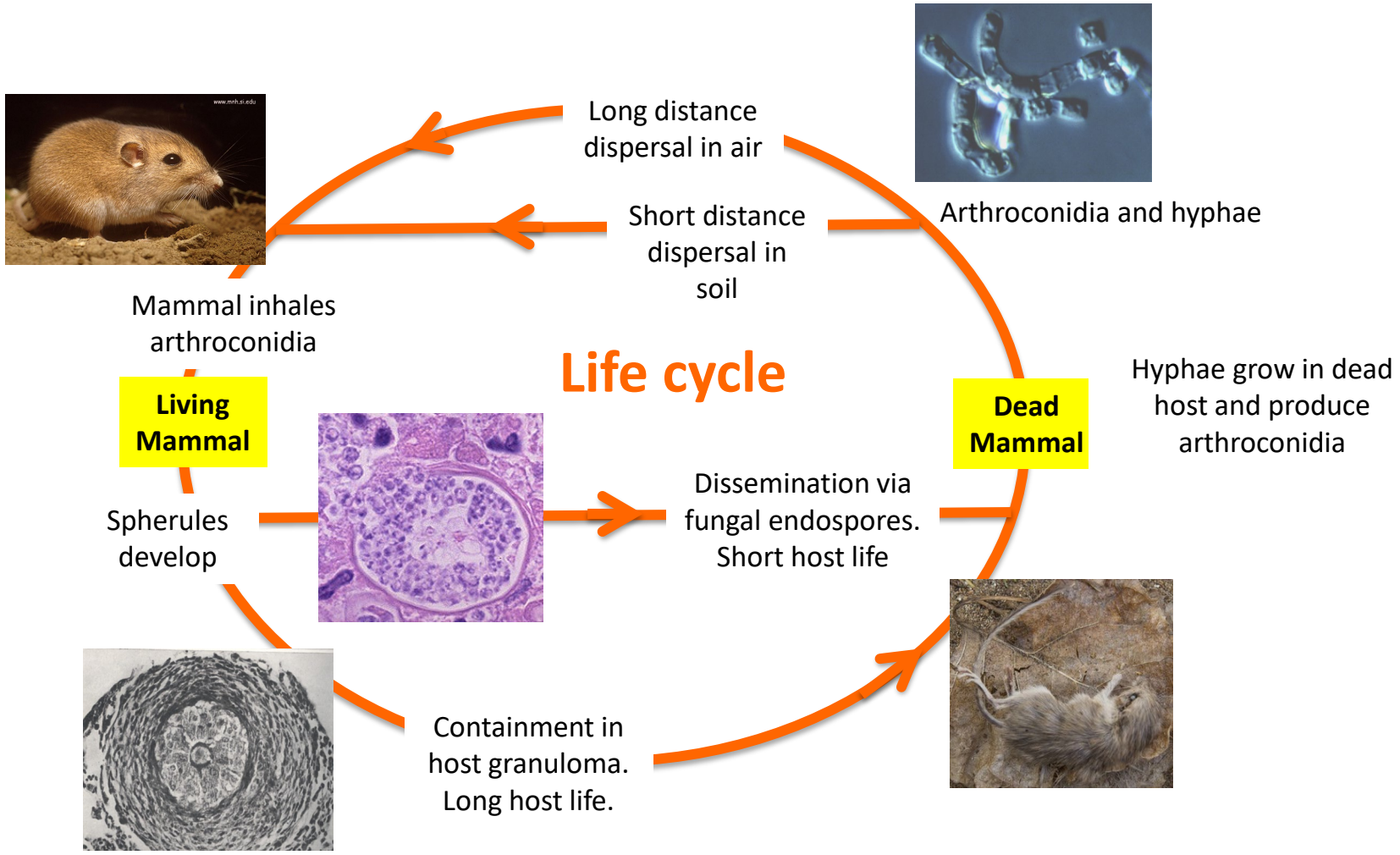
Taylor and Barker 2018, *Medical Mycology*

Coccidioides environmental cycle.

No saprophyte

No soil

No human host



Taylor and Barker 2018, *Medical Mycology*

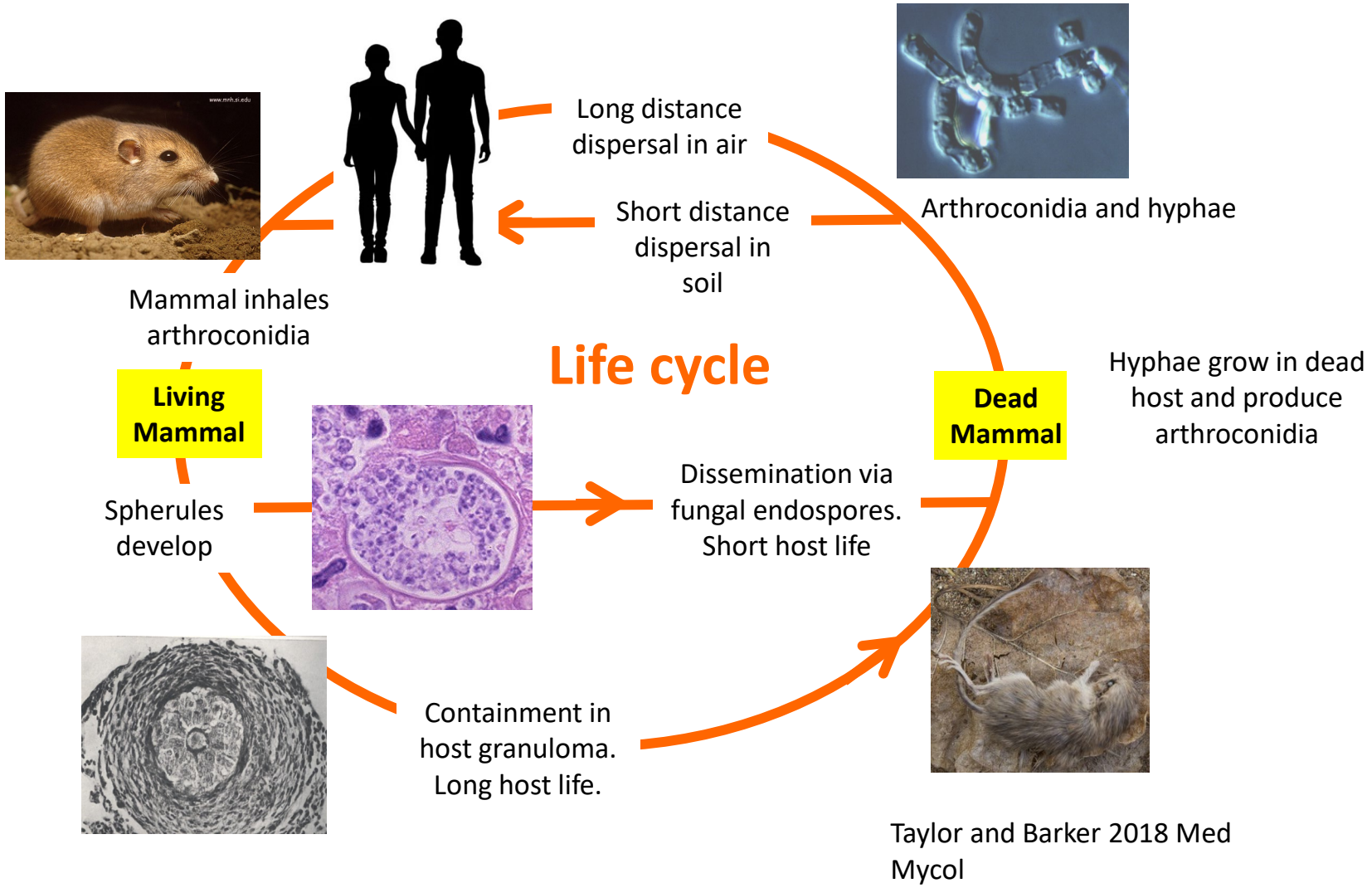
Humans are a dead end for *Coccidioides*

Coccidioides environmental cycle.

No saprophyte

No soil

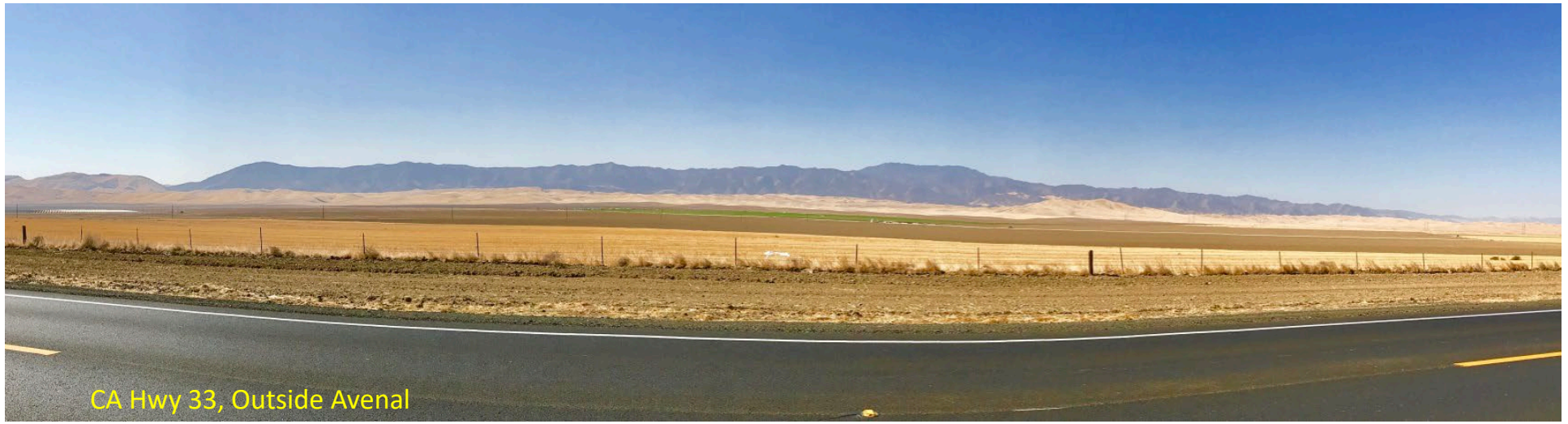
No human host



Taylor and Barker 2018, *Medical Mycology*

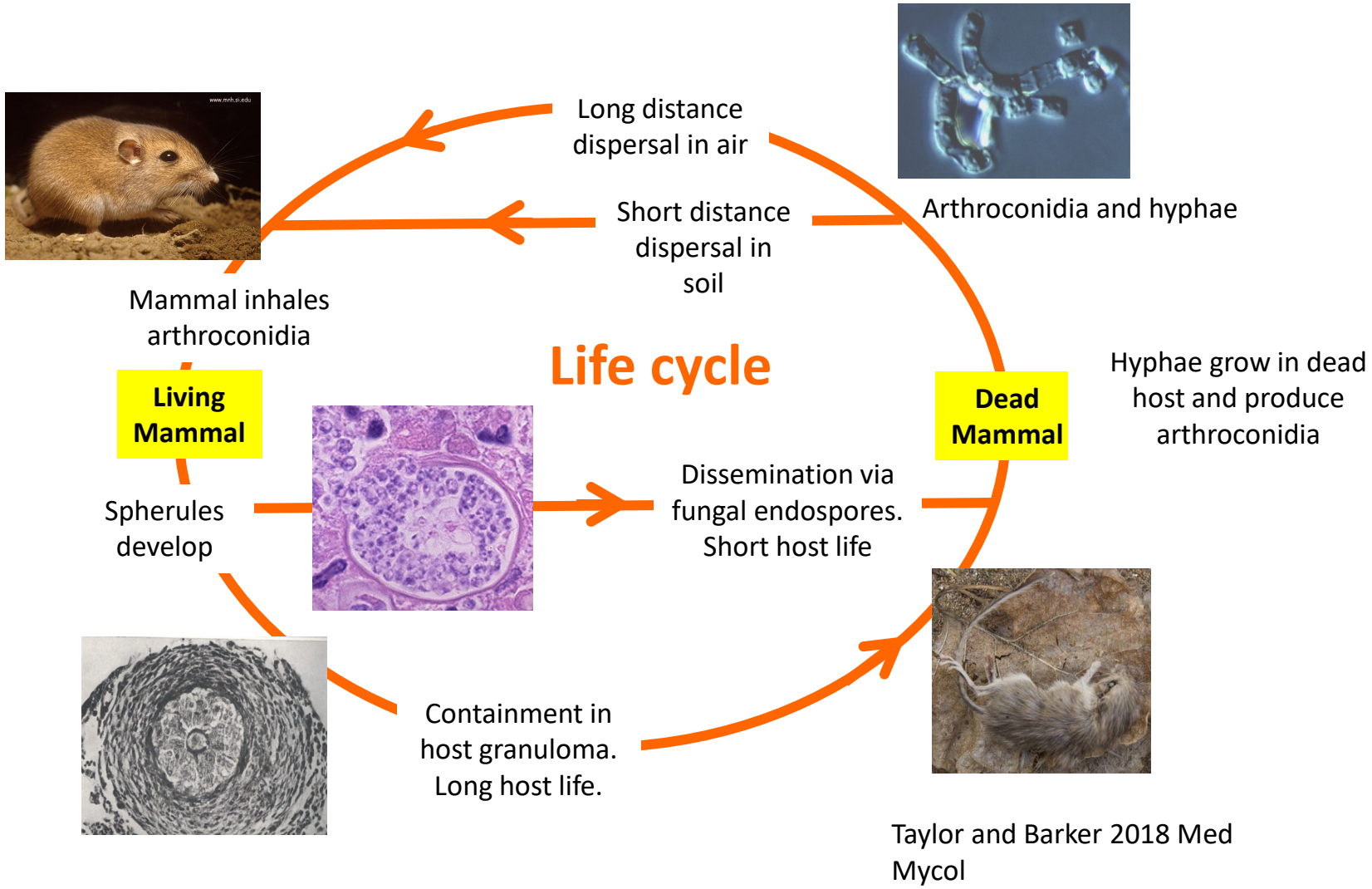
Environmental background and significance

- Pioneering studies
- Traditional Environmental Cycle
- Genomics
- Revisionist Environmental Cycle
- **Hypothesis testing**



CA Hwy 33, Outside Avenal

If this cycle is correct, native rodents should harbor *Coccidioides*



Taylor and Barker 2018, *Medical Mycology*

Emmons, again

1942

Emmons and Ashburn, 1942

Public Health Reports

Vol. 57 • NOVEMBER 13, 1942 • *No. 46*

THE ISOLATION OF *HAPLOSPORANGIUM PARVUM* N. SP. AND *COCCIDIOIDES IMMITIS* FROM WILD RODENTS. DIOIDOMYCOSIS [1] [2]

L. L. ASHBURN, *Passed Assistant c Health Service*

Pocket Mouse

Kangaroo Rat

	Total trapped	Lesions	Only *C. immitis* isolated	Only *H. parvum* isolated	*C. immitis* and *H. parvum* isolated	Total animals	
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Total	303		16	92	9	*117	

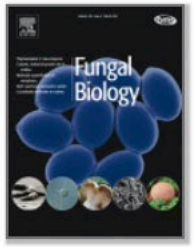
*Cultures from 11 additional animals were contaminated and the pathogens, if present, were lost.

Catalán-Dibene et al. 2014, Meritxell Riquelme's lab at CICESE in Ensenada, Baja California

ELSEVIER

Fungal Biology

Volume 118, Issue 3, March 2014, Pages 330-339



Detection of coccidioidal antibodies in serum of a small rodent community in Baja California, Mexico

Jovani Catalán-Dibene [a, d, 1], Suzanne M. Johnson [b], Ricardo Eaton [c], Adriana L. Romero-Olivares [d, 2], Raúl C. Baptista-Rosas [a, e, 3], Demosthenes Pappagianis [b], Meritxell Riquelme [d]

Location	Native Rodents	*Coccidioides*	Percentage
Val de las Palmas	40	3	7.5%

Paris Salazar-Hamm et al. 2022 from Don Nativig's lab at the University of New Mexico

frontiers | Frontiers in Fungal Biology
26 September 2022

Breathing can be dangerous: Opportunistic fungal pathogens and the diverse community of the small mammal lung mycobiome

Paris S. Salazar-Hamm[1]*, Kyana N. Montoya[1], Liliam Montoya[2], Kel Cook[1], Schuyler Liphardt[1], John W. Taylor[2], Joseph A. Cook[1,3] and Donald O. Natvig[1]

[1]Department of Biology, University of New Mexico, Albuquerque, NM, United States, [2]Department of Plant and Microbial Biology, University of California, Berkeley, Berkeley, CA, United States, [3]Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM, United States

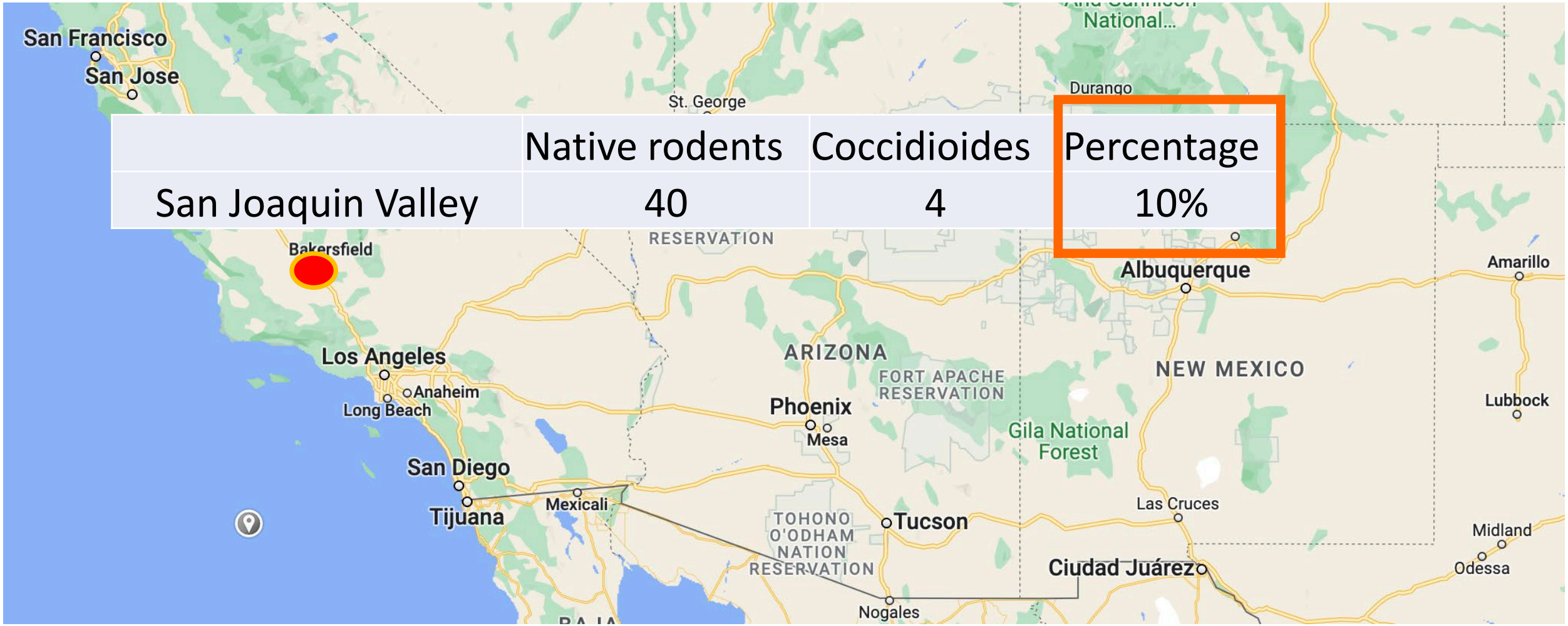
Paris Salazar-Hamm et al. 2022 from Don Nativig's lab at the University of New Mexico

Lungs of 200 rodents in NM, AZ, CA, tested for *Coccidioides*.

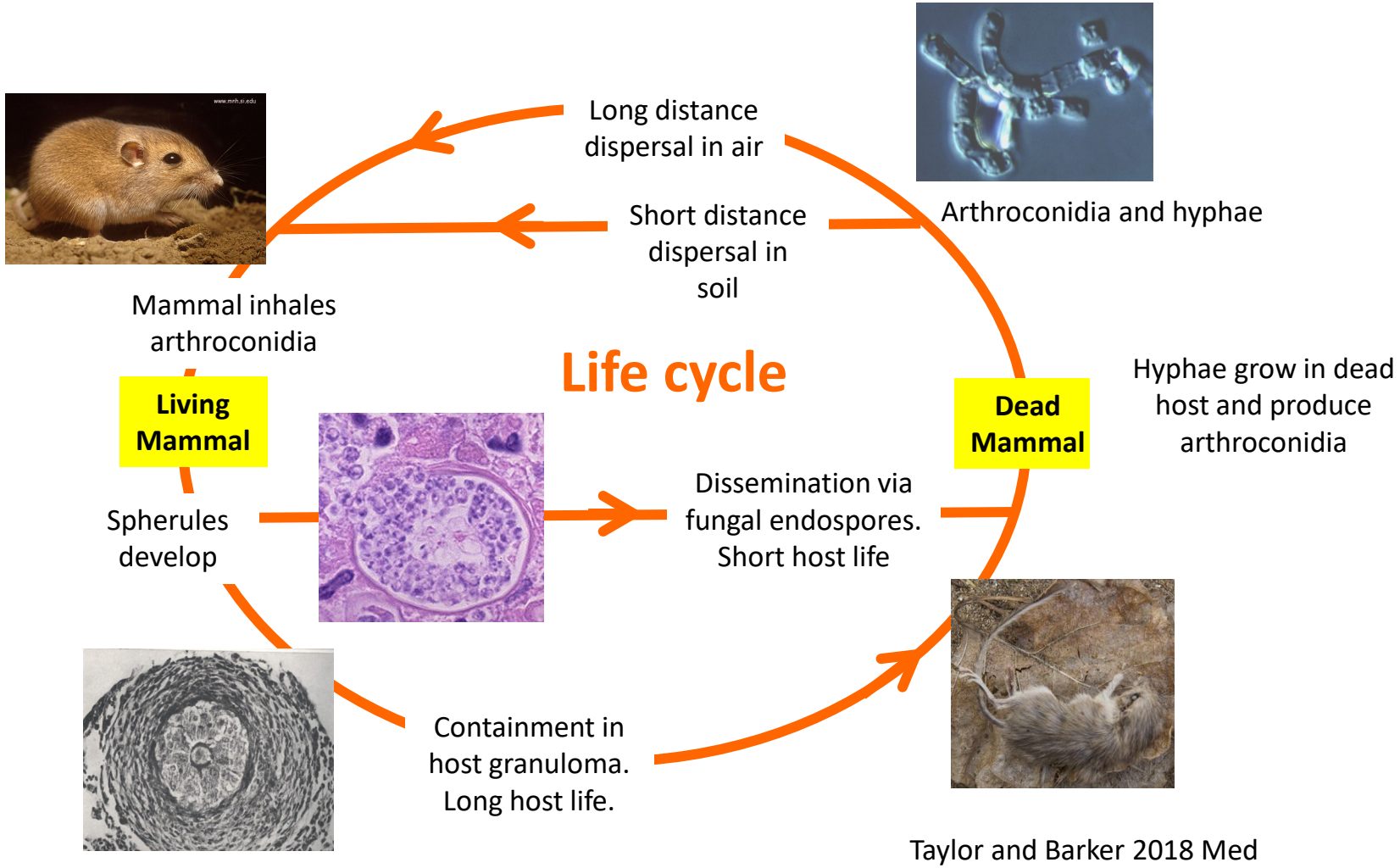
Paris Salazar-Hamm et al. 2022 from Don Nativig's lab at the University of New Mexico

Lungs of 200 rodents in NM, AZ, CA, tested for *Coccidioides*.

	Native rodents	Coccidioides	Percentage
San Joaquin Valley	40	4	10%

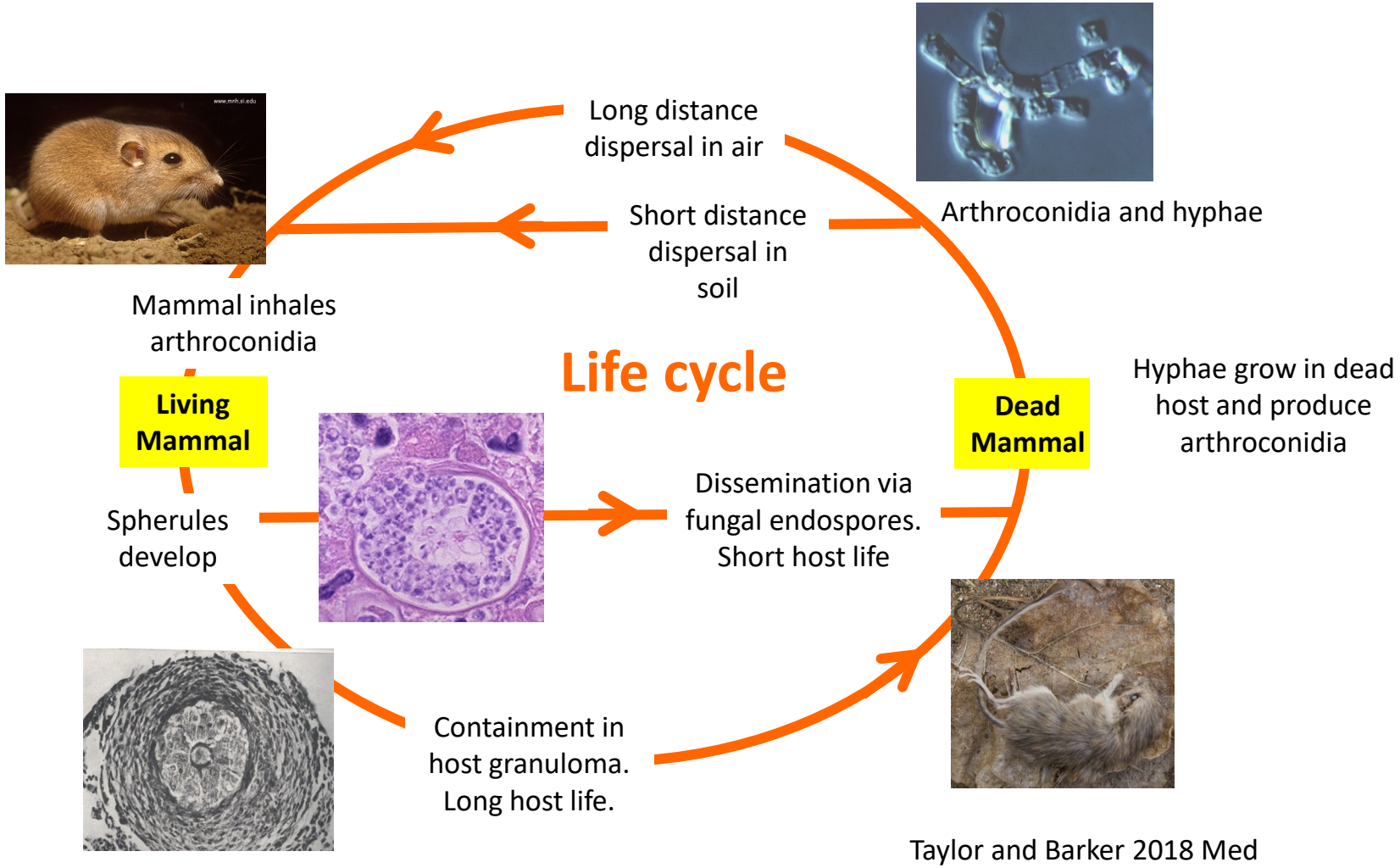


Native rodents harbor *Coccidioides*



Taylor and Barker 2018 Med Mycol

If this cycle is correct, rodent burrows should contain *Coccidioides*



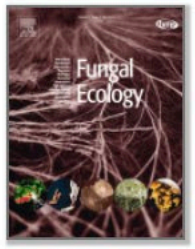
Taylor and Barker 2018 Med Mycol

Baptista-rosas et al. 2012, Meritxell Riquelme's lab at CICESE in Ensenada, Baja California

ELSEVIER

Fungal Ecology

Volume 5, Issue 2, April 2012, Pages 177-190



Molecular detection of *Coccidioides* spp. from environmental samples in Baja California: linking Valley Fever to soil and climate conditions

Raúl C. Baptista-rosas [a, b], Jovani Catalán-dibene [b], Adriana L. Romero-olivares [b], Alejandro Hinojosa [c], Tereza Cavazos [d], Meritxell Riquelme [e]

Location	Burrows	Coccidioides	Percentage
Val de las Palmas	50	17	34%
San Jose de la Zorra	13	3	23%

Kollath et al. 2020 in Bridget Barker's lab at Northern Arizona University

2020

Mycopathologia (2020) 185:145–159
https://doi.org/10.1007/s11046-019-00391-2

Check for updates

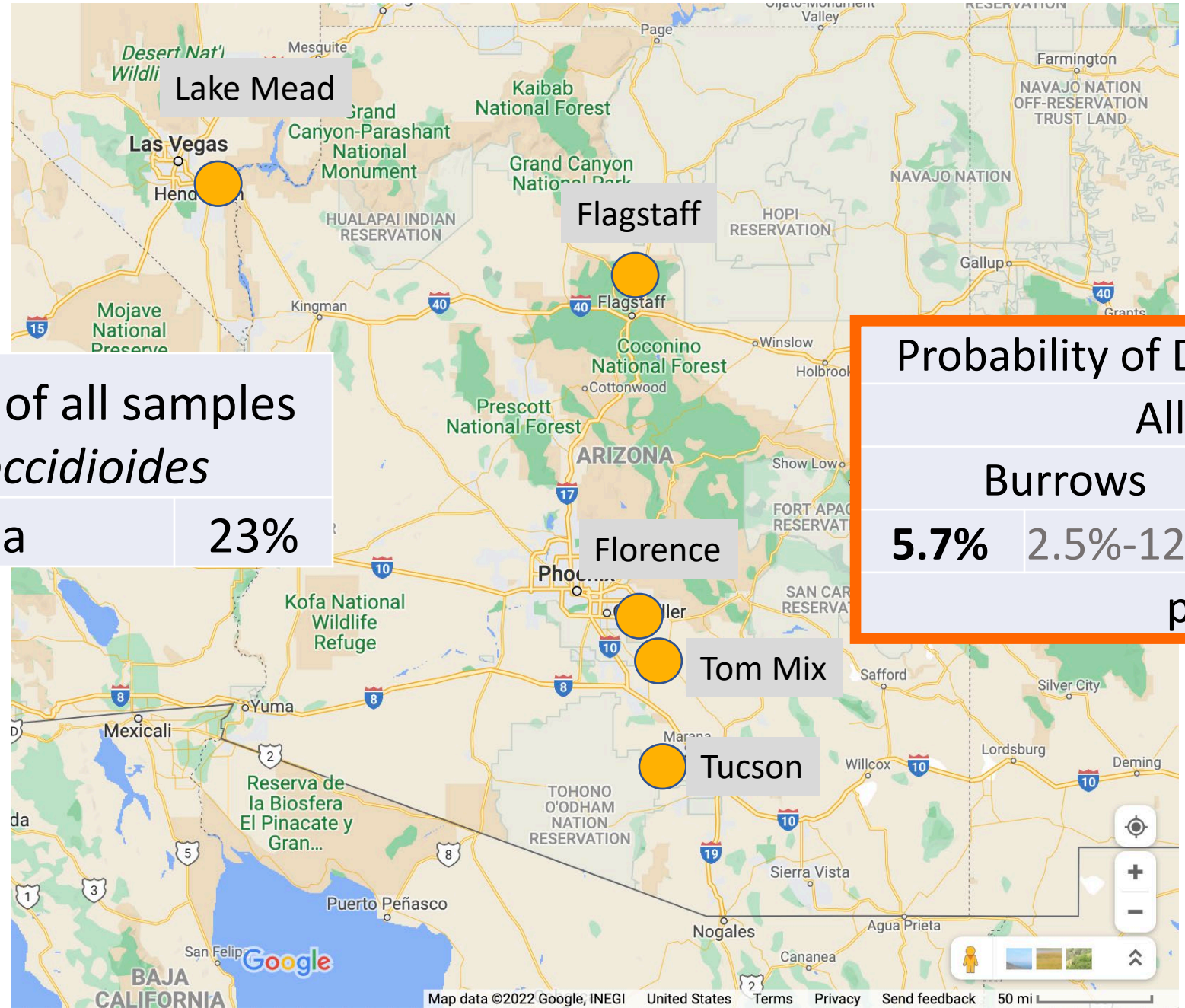
ORIGINAL PAPER

Investigating the Role of Animal Burrows on the Ecology and Distribution of *Coccidioides* spp. in Arizona Soils

Daniel R. Kollath · Marcus M. Teixeira · Aubrey Funke · Karis J. Miller · Bridget M. Barker

456 soil samples, 5 sites in Arizona

Kollath et al. 2020 in Bridget Barker's lab at Northern Arizona University



Percentage of all samples with *Coccidioides*	
Arizona	23%

Probability of Detecting Coccidioides			
All Five Sites			
Burrows		Outside Burrows	
5.7%	2.5%-12.5%	**2.01%**	0.5%-6.8%
p = 0.015			

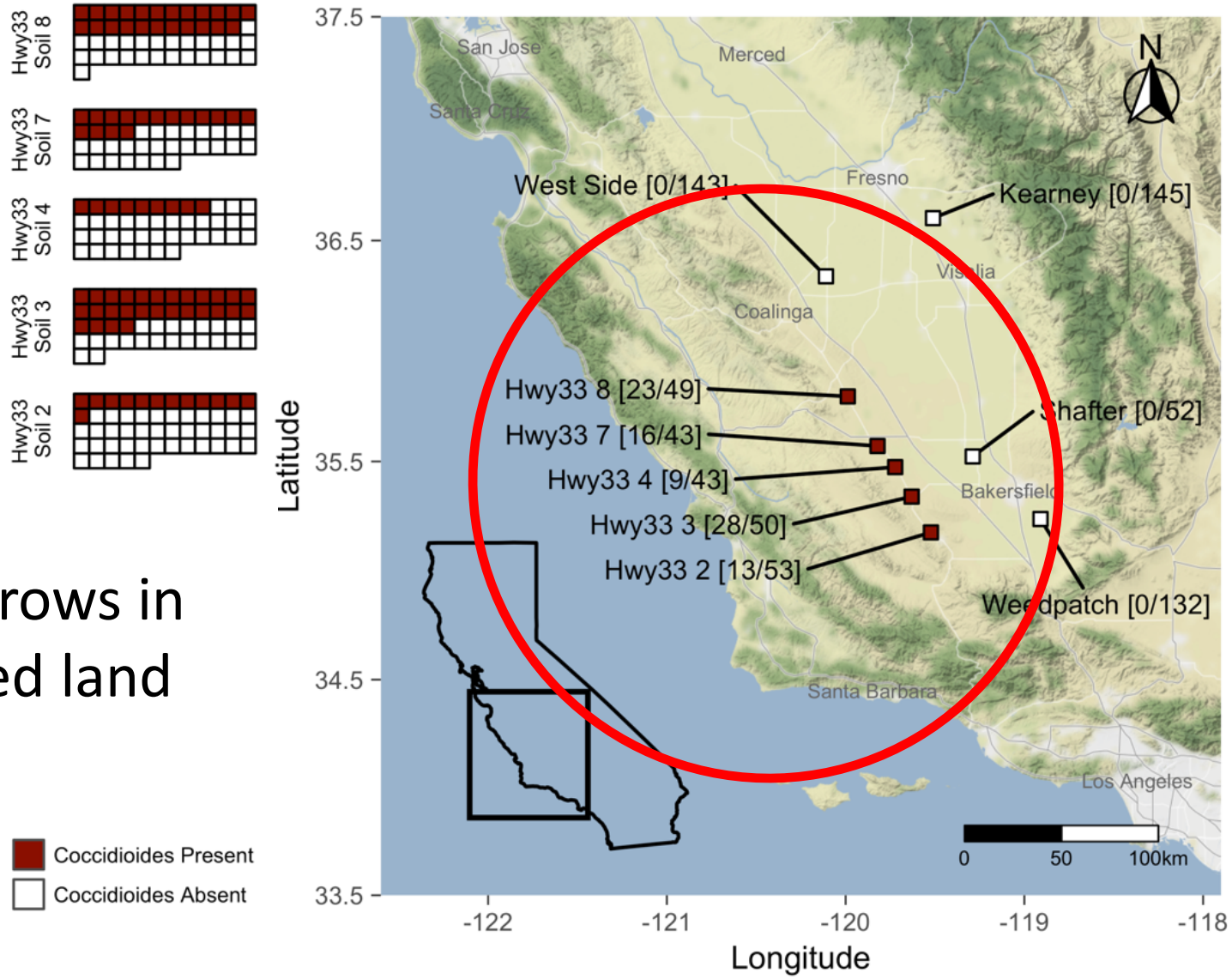
Robert Wagner, Liliam Montoya, Jennifer R. Head, Simon Campo, Justin Remais, John W. Taylor. Manuscript 2023.

Coccidioides in undeveloped and agricultural soils

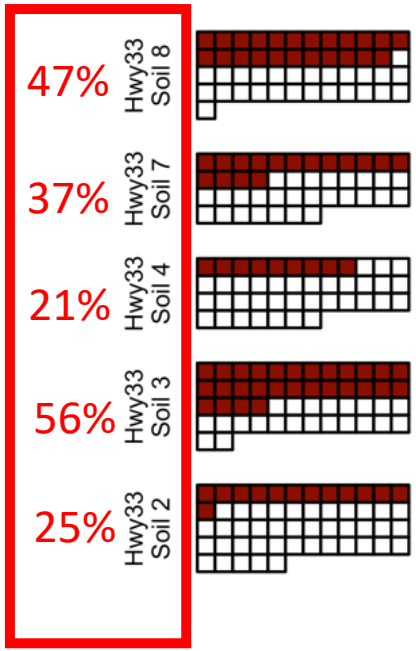
238 soil samples from 5 sites with monthly sampling over one year

Robert Wagner, Liliam Montoya, Jennifer R. Head, Simon Campo, Justin Remais, John W. Taylor. Manuscript 2023.

Rodent burrows in undeveloped land

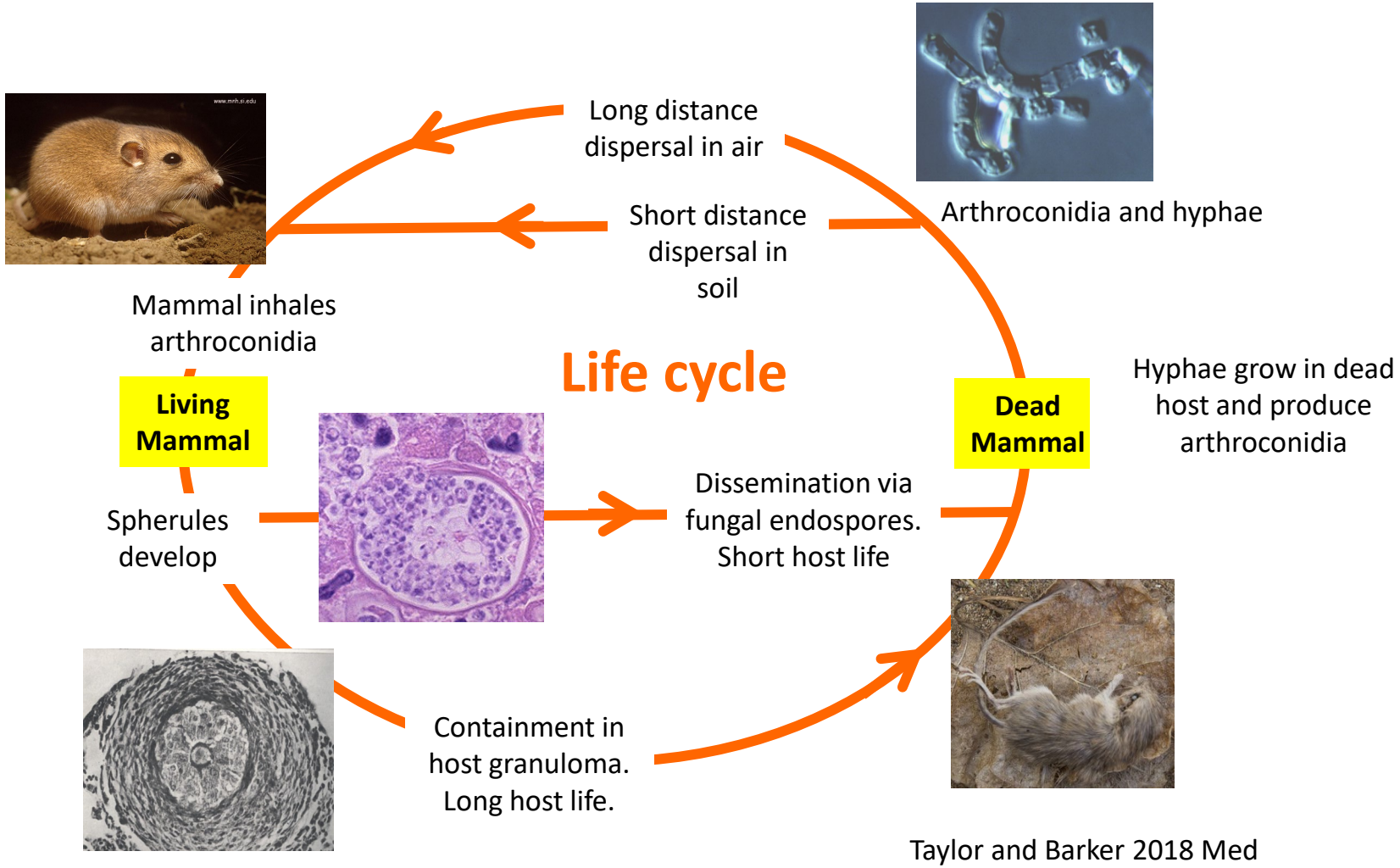


Robert Wagner, Liliam Montoya, Jennifer R. Head, Simon Campo, Justin Remais, John W. Taylor. Manuscript 2023.



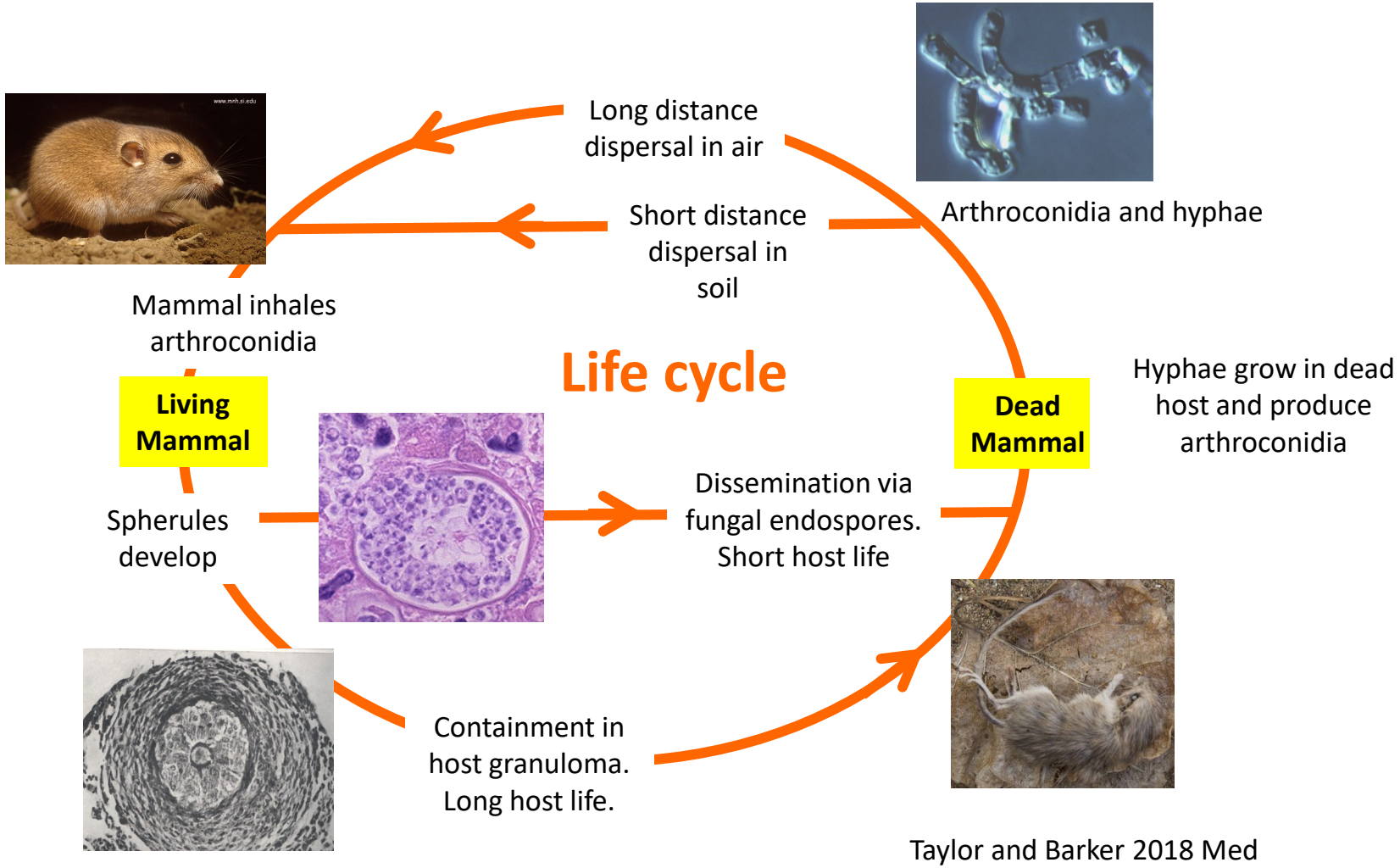
Rodent burrows in undeveloped land

Rodent burrows do contain *Coccidioides*



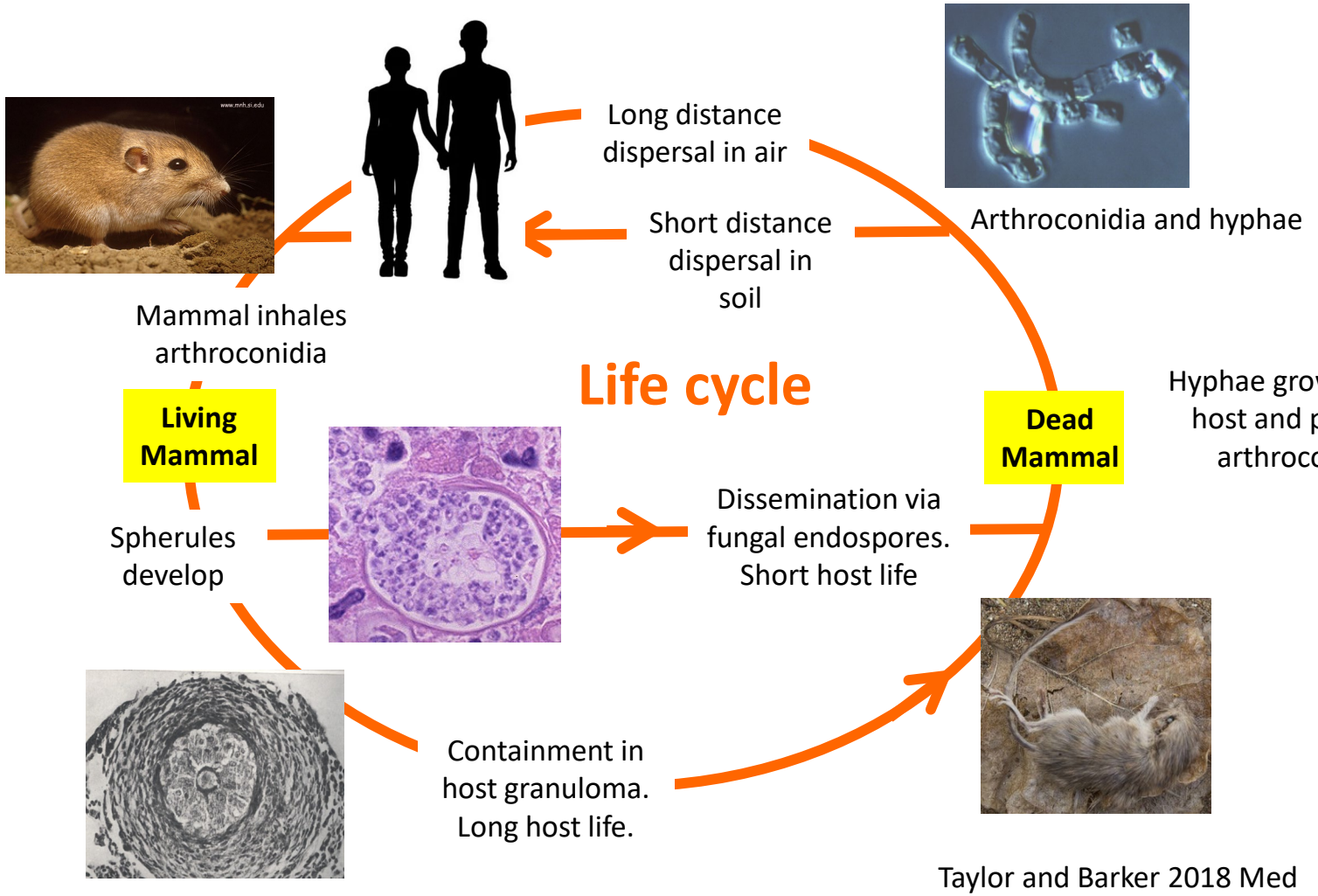
Taylor and Barker 2018 Med Mycol

Transmission of *Coccidioides* among rodents



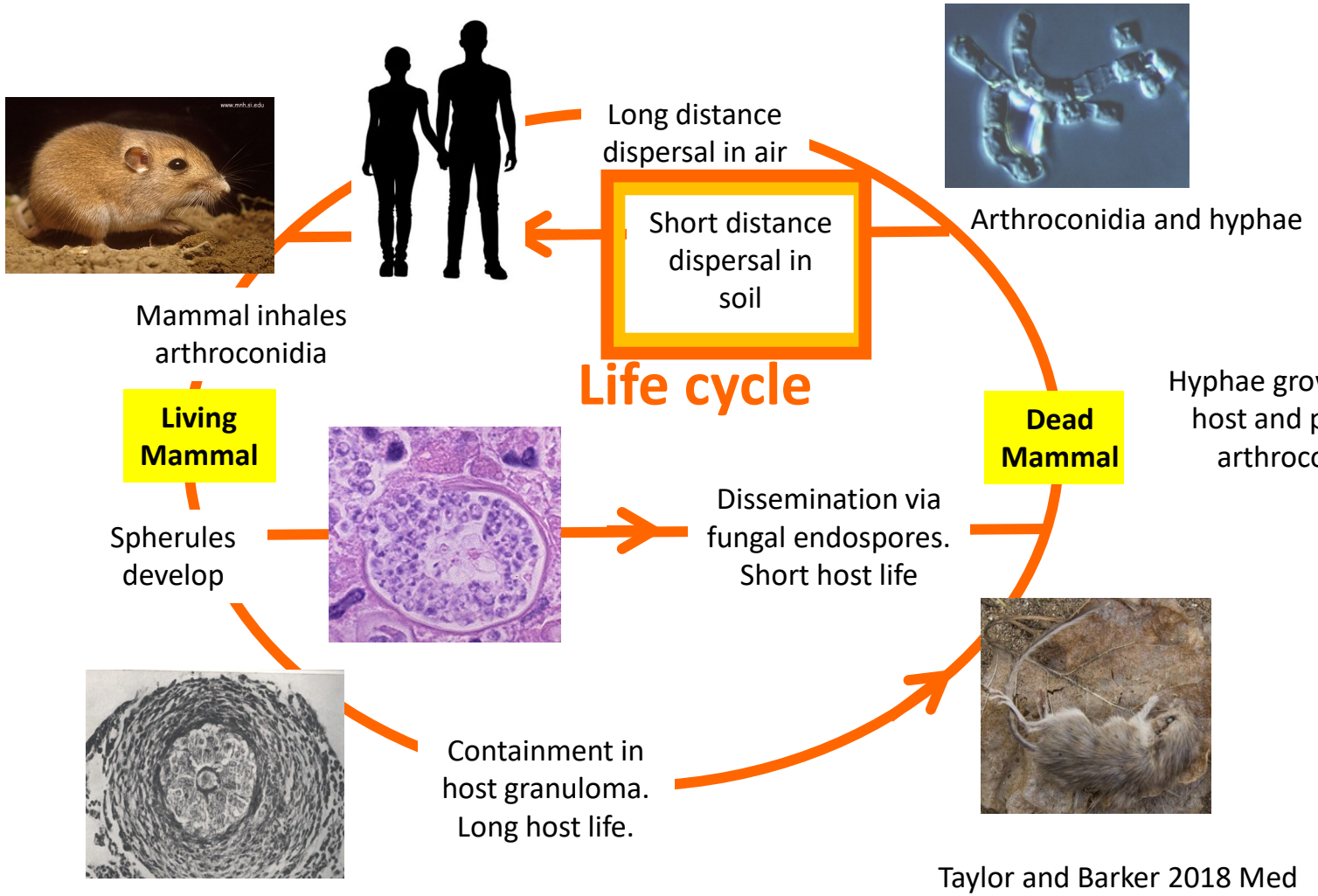
Taylor and Barker 2018 Med Mycol

Transmission to humans from the environment



Taylor and Barker 2018 Med Mycol

Transmission to humans from the environment



Taylor and Barker 2018 Med Mycol

Risk of coccidioidomycosis to workers.

Outbreaks (2 or more cases at the same time and place) reported for:

Highway construction workers – Caltrans loses $12M lawsuit

Solar Panel installers – Wilkin et al. 2015 EID, Laws et al. 2018 MMWR

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All outbreaks are on undisturbed land.

No outbreaks reported for agricultural workers,
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Emerg Infect Dis. 2020 Jul; 26(7): 1430–1437.
doi: 10.3201/eid2607.200024

PMCID: PMC7323545
PMID: 32568046

Risk for Coccidioidomycosis among Hispanic Farm Workers, California, USA, 2018

Stephen A. McCurdy, Catherine Portillo-Silva, Carol L. Sipan, Heejung Bang, Kirt W. Emery

Self-reported dust exposure	Cases	Controls	Adjusted Odds Ratio
Never or sometime	32	41	1, reference
Halftime or more	78	52	1.9

RESEARCH

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Can Coccidioides be detected in agricultural land?

RESEARCH

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Lauer et al., 2020, International J Environmental Research and Public Health

International Journal of
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MDPI

Article

Valley Fever: Environmental Risk Factors and Exposure Pathways Deduced from Field Measurements in California

Antje Lauer [1,*], Vicken Etyemezian [2], George Nikolich [2], Carl Kloock [1], Angel Franco Arzate [1], Fazalath Sadiq Batcha [1], Manpreet Kaur [1], Eduardo Garcia [1], Jasleen Mander [1] and Alyce Kayes Passaglia [1]

5 samples from non-Agricultural land –

13 samples from Agricultural land –

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5 samples from non-Agricultural land – *Coccidioides* detected

13 samples from Agricultural land - Undetected

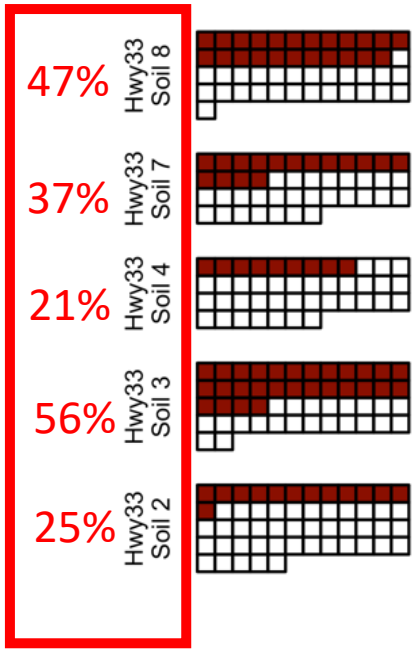
Robert Wagner, Liliam Montoya, Jennifer R. Head, Simon Campo, Justin Remais, John W. Taylor. Manuscript 2023.

Coccidioides in undeveloped and agricultural soils

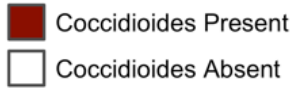
472 agricultural soil samples collected in summers of 2016, 2017, 2018 and 2021.

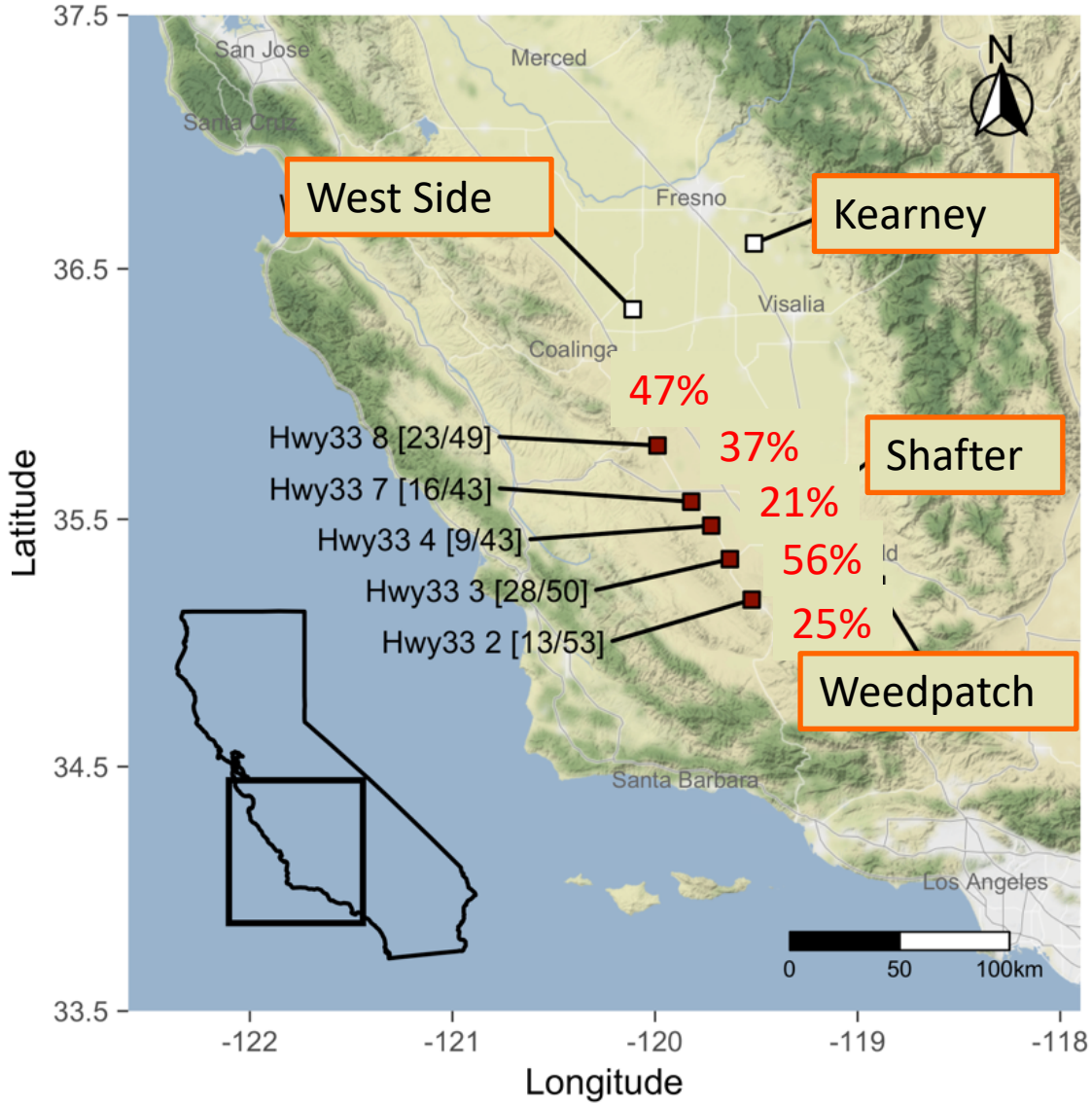
238 undisturbed soil samples collected monthly in 2017-2018,

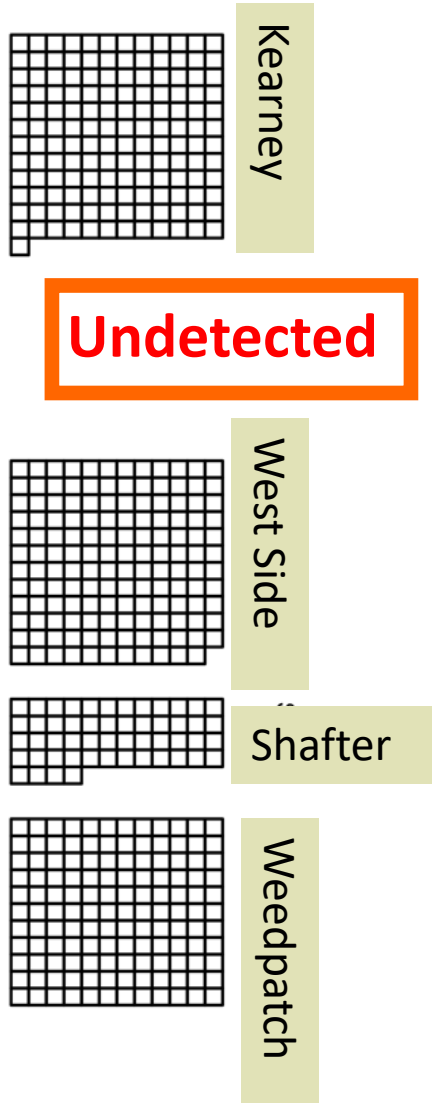
Robert Wagner, Liliam Montoya, Jennifer R. Head, Simon Campo, Justin Remais, John W. Taylor. Manuscript 2022.



Rodent burrows in undeveloped land







Agricultural workers are at risk for Valley Fever.

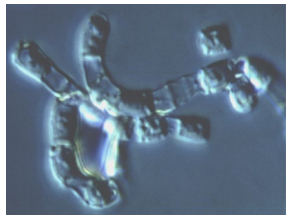
Coccidioides undetected in agricultural soils

Another source could be airborne *Coccidioides* spores.

Transmission to humans from the environment

Long distance dispersal in air

Short distance dispersal in soil

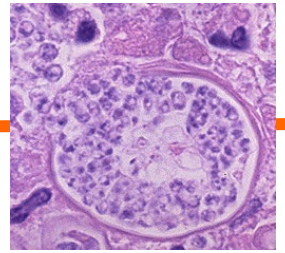


Arthroconidia and hyphae

Mammal inhales arthroconidia

Life cycle

Living Mammal

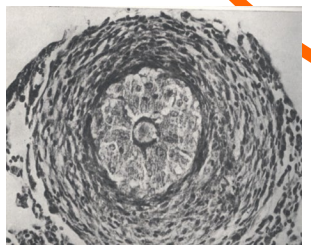


Spherules develop

Dissemination via fungal endospores. Short host life

Dead Mammal

Hyphae grow in dead host and produce arthroconidia



Containment in host granuloma. Long host life.

Taylor and Barker 2018 Med Mycol

Taylor and Barker 2018 Med Mycol

Wagner et al. 2022 Molecular Ecology

Molecular Ecology / Volume 31, Issue 19 / p. 4962-4978

ORIGINAL ARTICLE | Open Access

The air mycobiome is decoupled from the soil mycobiome in the California San Joaquin Valley

Robert Wagner, Liliam Montoya, Cheng Gao, Jennifer R. Head, Justin Remais, John W. Taylor

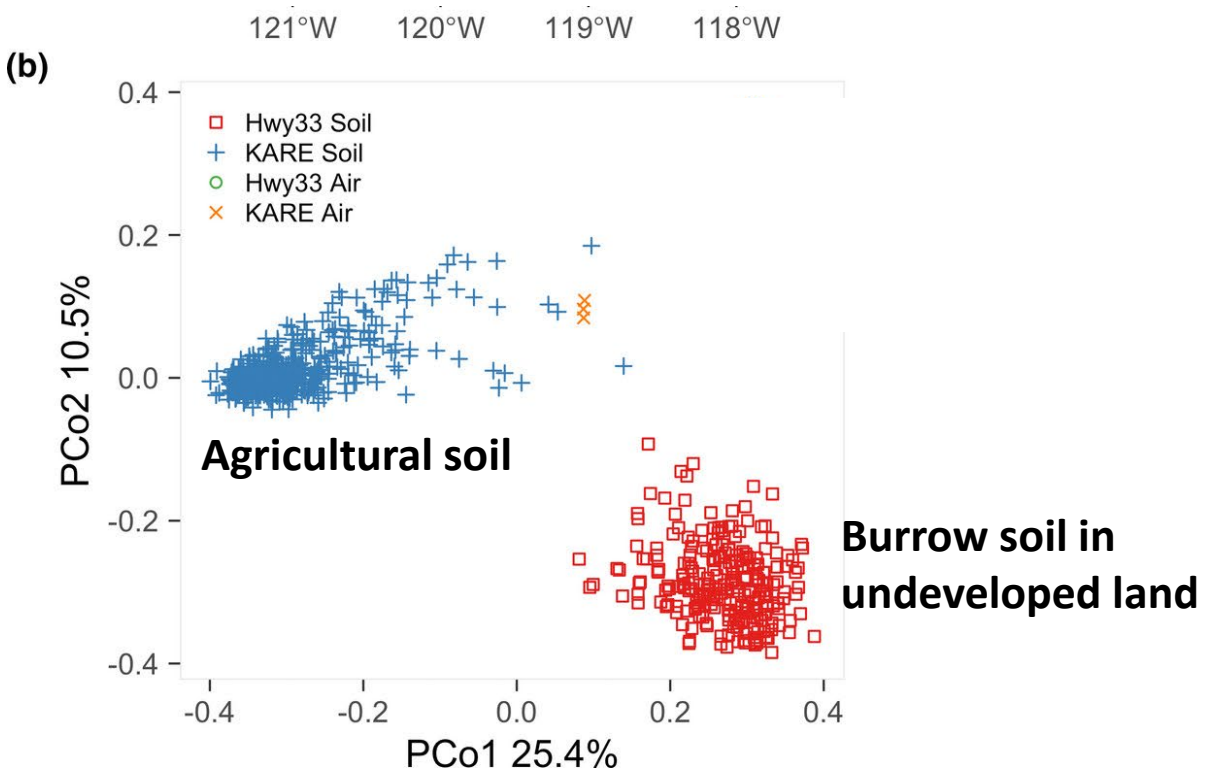
First published: 07 August 2022

https://doi.org/10.1111/mec.16640

1001 samples

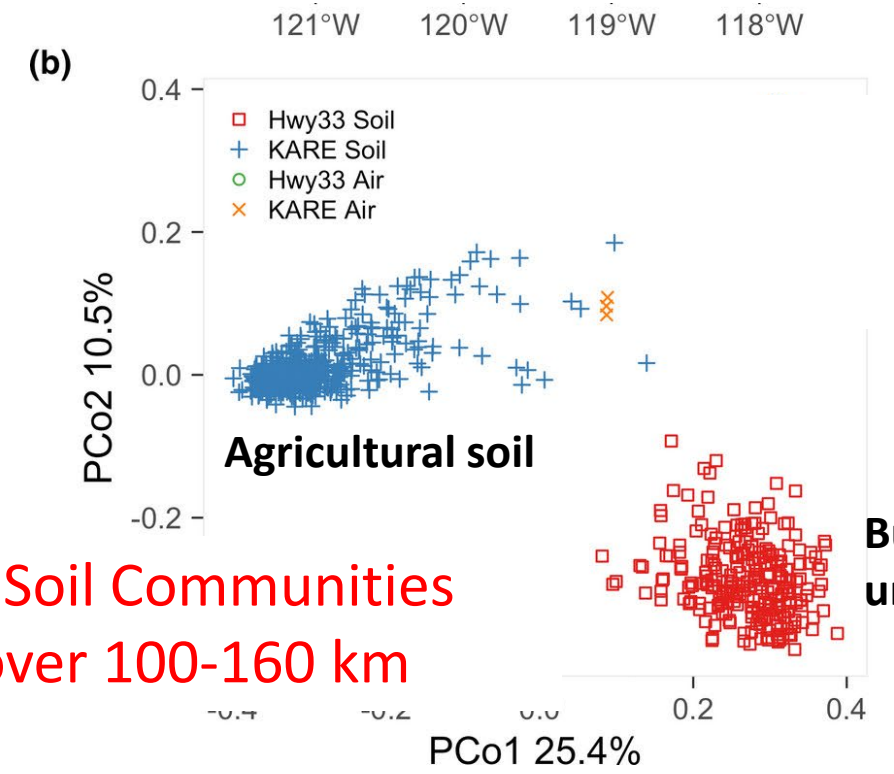
Land	Soil	Air
Undisturbed, 5 sites	238	175
Agricultural, KARE	498	90

Ordination of Fungal Communities



Burrow soil in undeveloped land

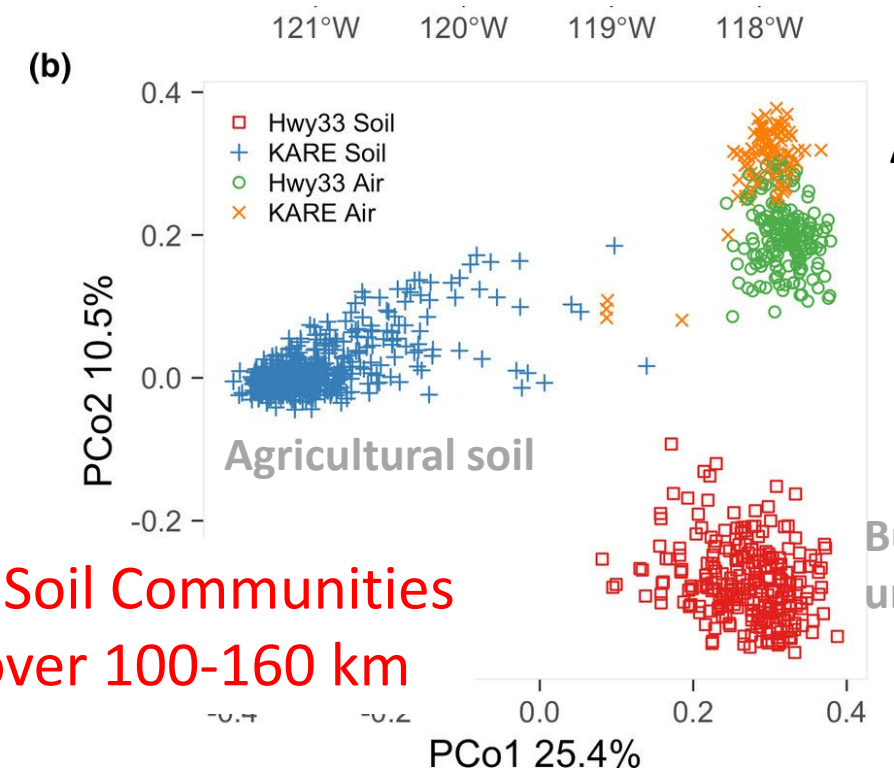
Ordination of Fungal Communities



Burrow soil in undeveloped land

Fungal Soil Communities differ over 100-160 km

Ordination of Fungal Communities



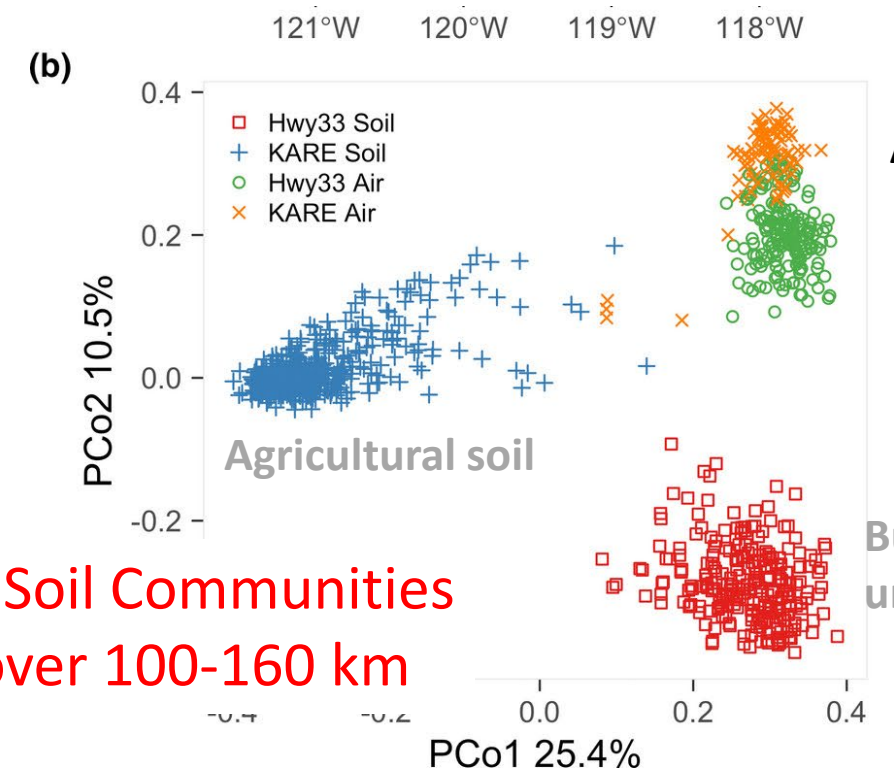
Air 50cm above agricultural land

Air 50cm above undeveloped land

Burrow soil in undeveloped land

Fungal Soil Communities differ over 100-160 km

Ordination of Fungal Communities



Fungal Air Assemblages **do not** differ over 100-160 km

Air 50cm above agricultural land

Air 50cm above undeveloped land

Burrow soil in undeveloped land

Fungal Soil Communities differ over 100-160 km

Do agricultural workers acquire Valley Fever from airborne spores?

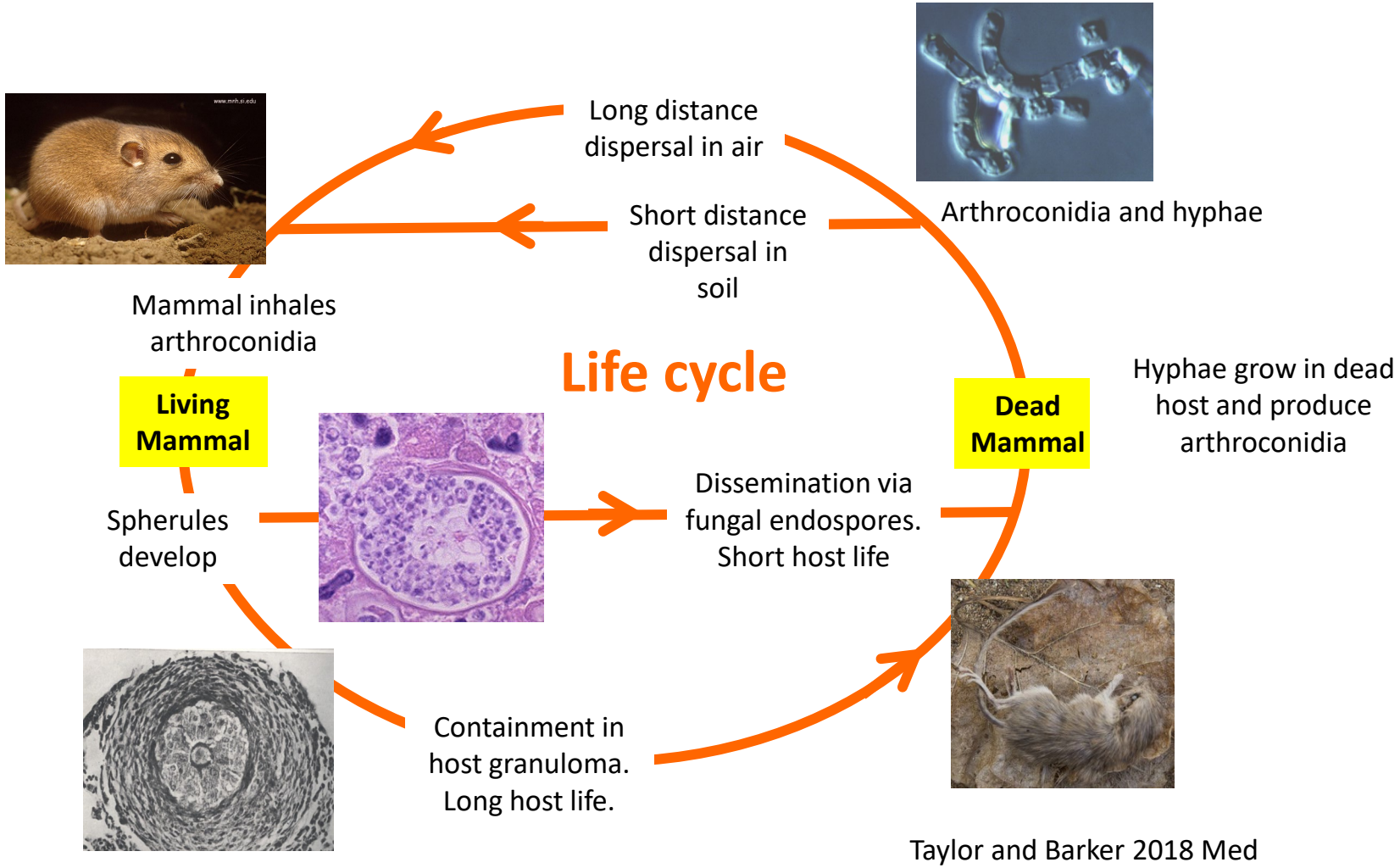
Do agricultural workers acquire Valley Fever from airborne spores?

We don’t know.

We have not detected *Coccidioides* in passively settled dust samples.

First Grand Challenge:
Effective air sampling for *Coccidioides*.

Second Grand Challenge:
Transmission of *Coccidioides* among native rodents.



Taylor and Barker 2018 Med Mycol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