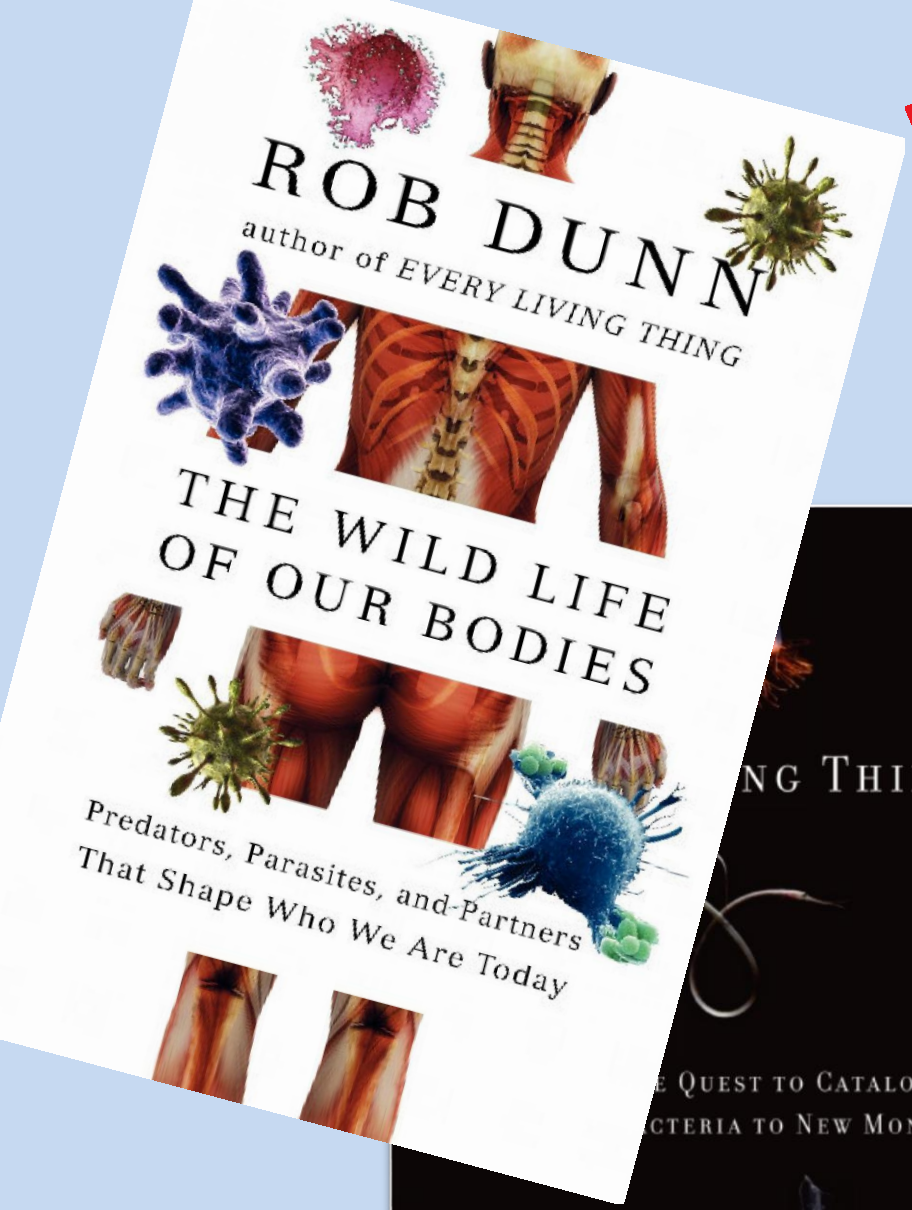
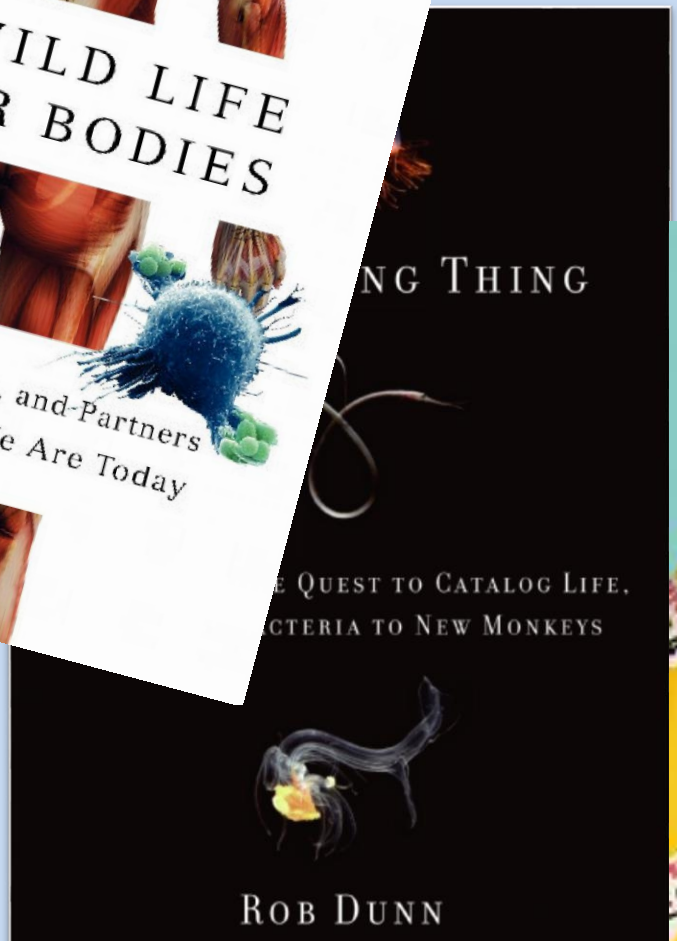
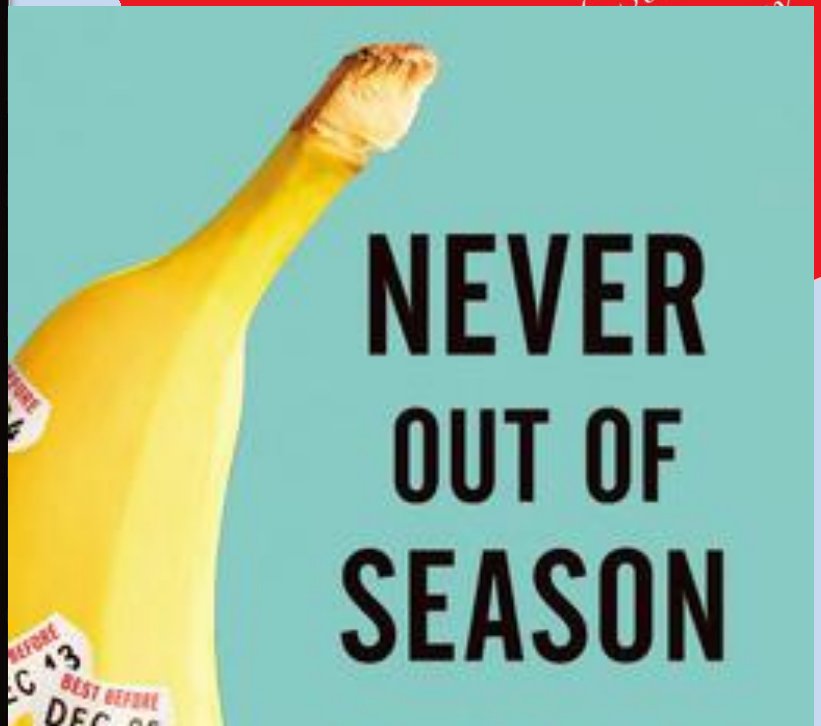
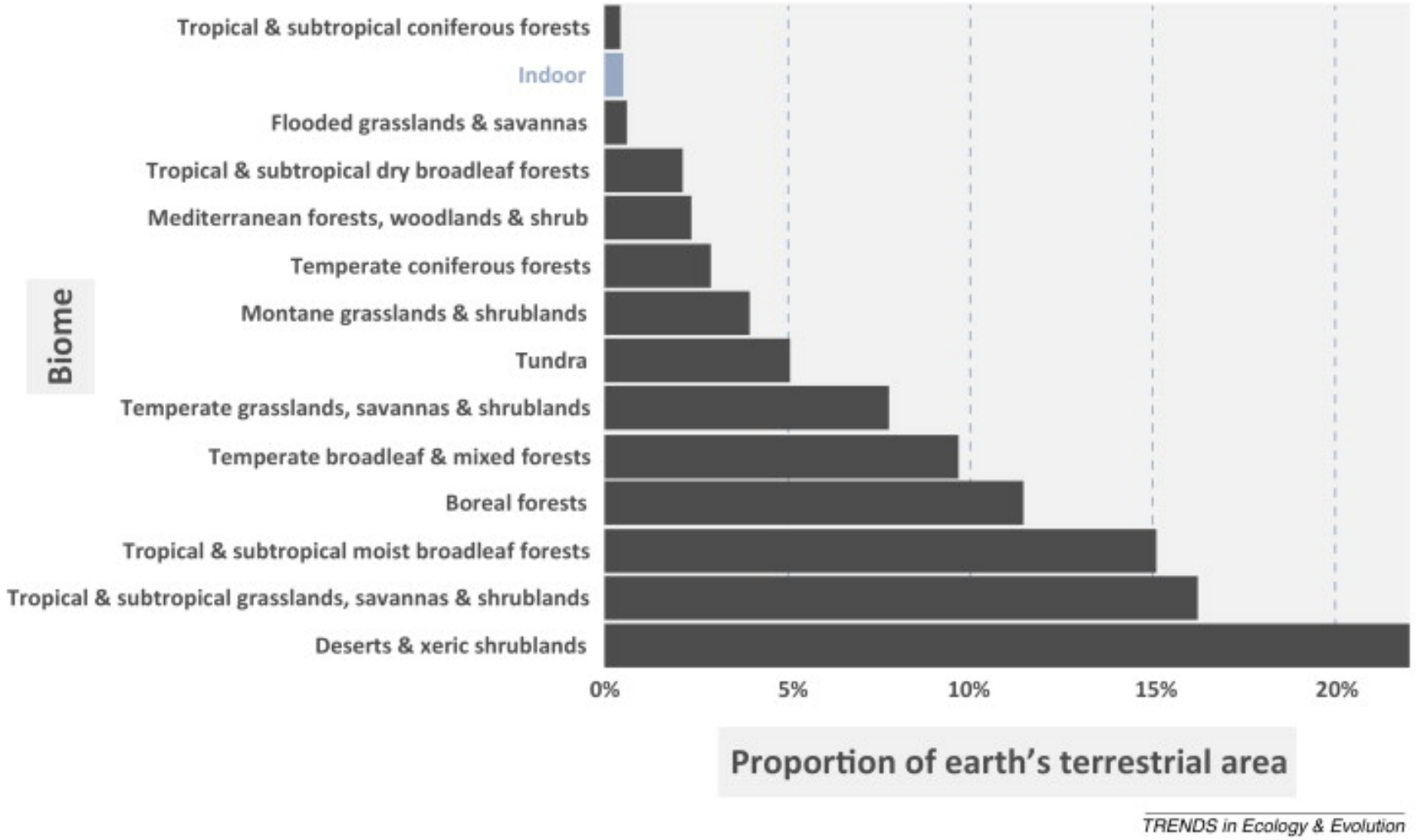

ROB DUNN
author of EVERY LIVING THING
THE WILD LIFE OF OUR BODIES
Predators, Parasites, and Partners That Shape Who We Are Today


THE MAN WHO TOUCHED HIS OWN HEART


NG THING
E QUEST TO CATALOG LIFE,
CTERIA TO NEW MONKEYS
ROB DUNN


NEVER OUT OF SEASON


Tropical & subtropical coniferous forests
Indoor
Flooded grasslands & savannas
Tropical & subtropical dry broadleaf forests
Mediterranean forests, woodlands & shrub
Temperate coniferous forests
Montane grasslands & shrublands
Tundra
Temperate grasslands, savannas & shrublands
Temperate broadleaf & mixed forests
Boreal forests
Tropical & subtropical moist broadleaf forests
Tropical & subtropical grasslands, savannas & shrublands
Deserts & xeric shrublands
Biome
0%
5%
10%
15%
20%
Proportion of earth's terrestrial area
TRENDS in Ecology & Evolution

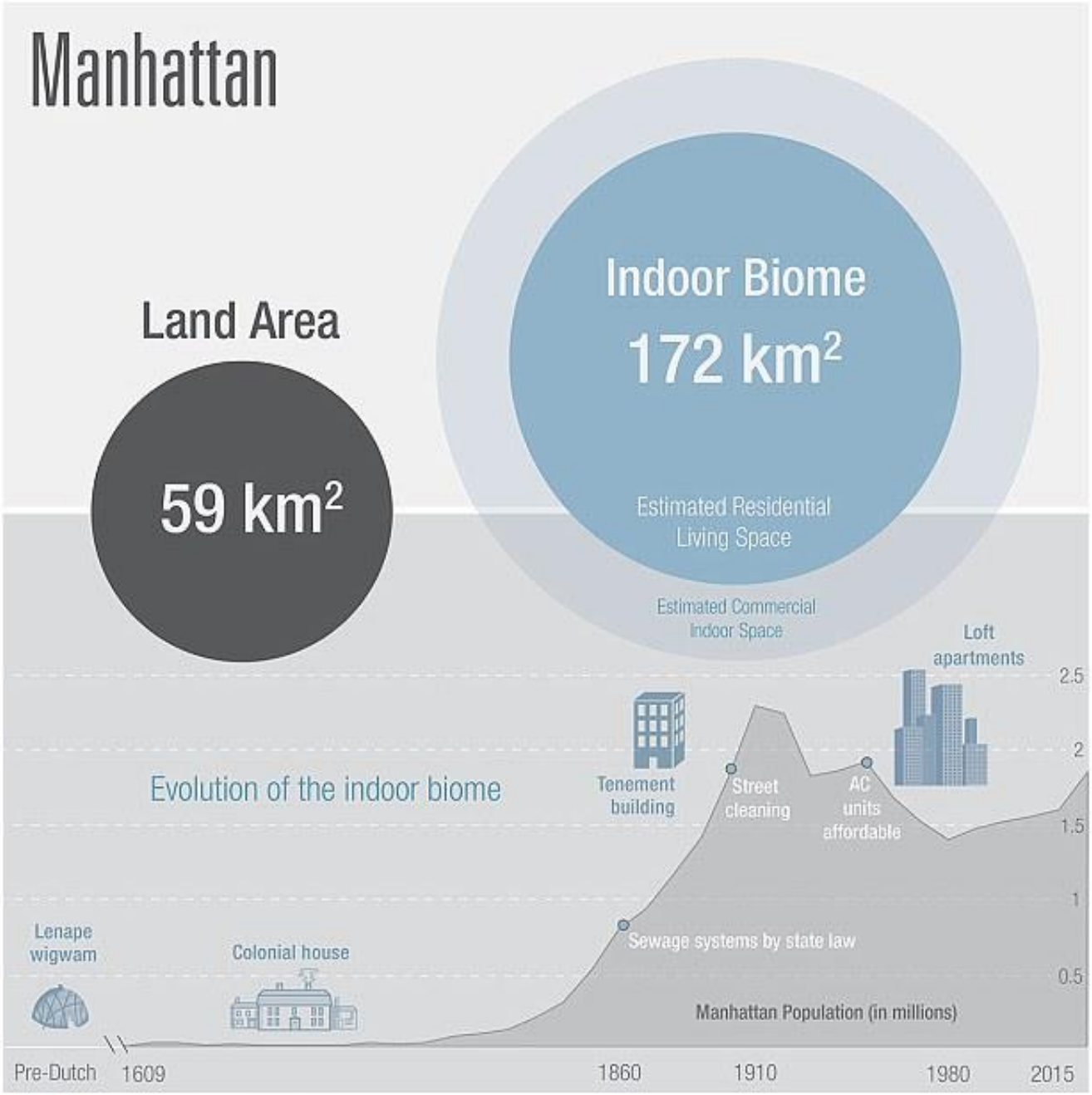
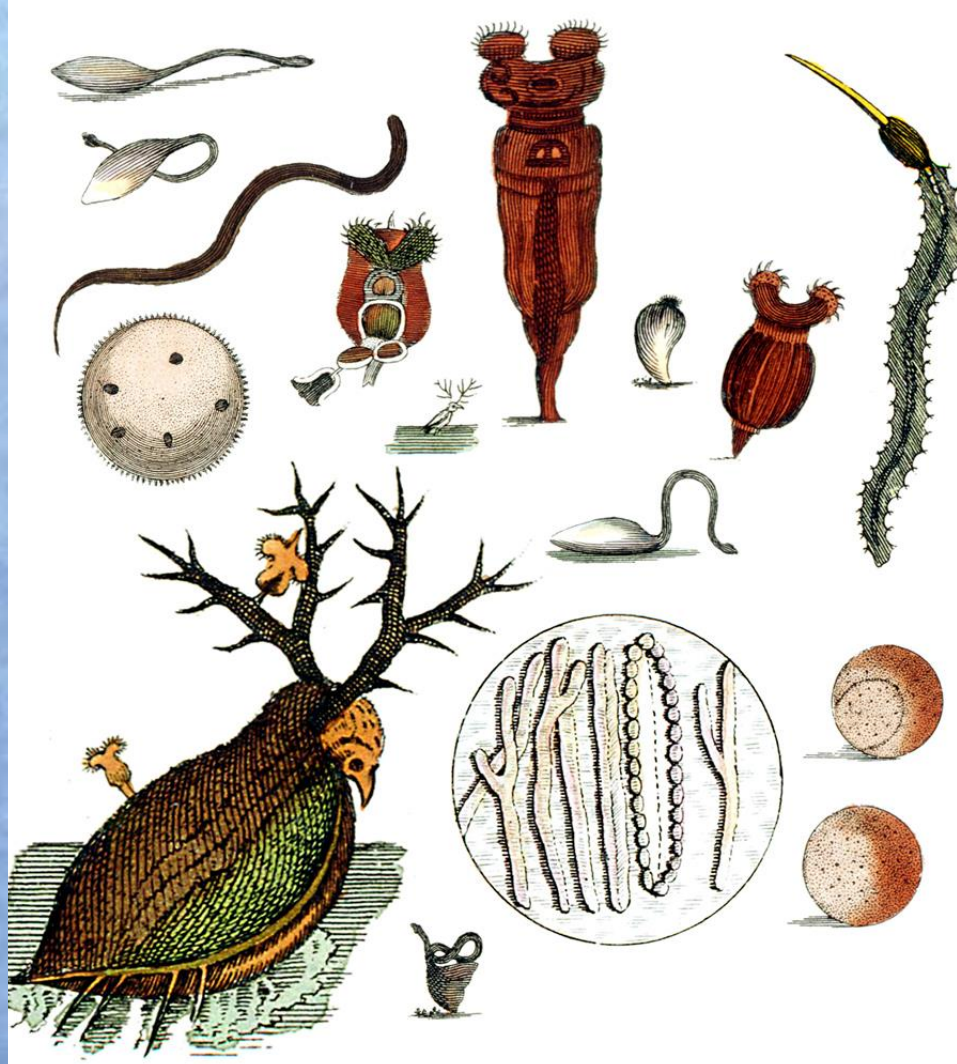


Figure 2: The Manhattan Indoor Biome

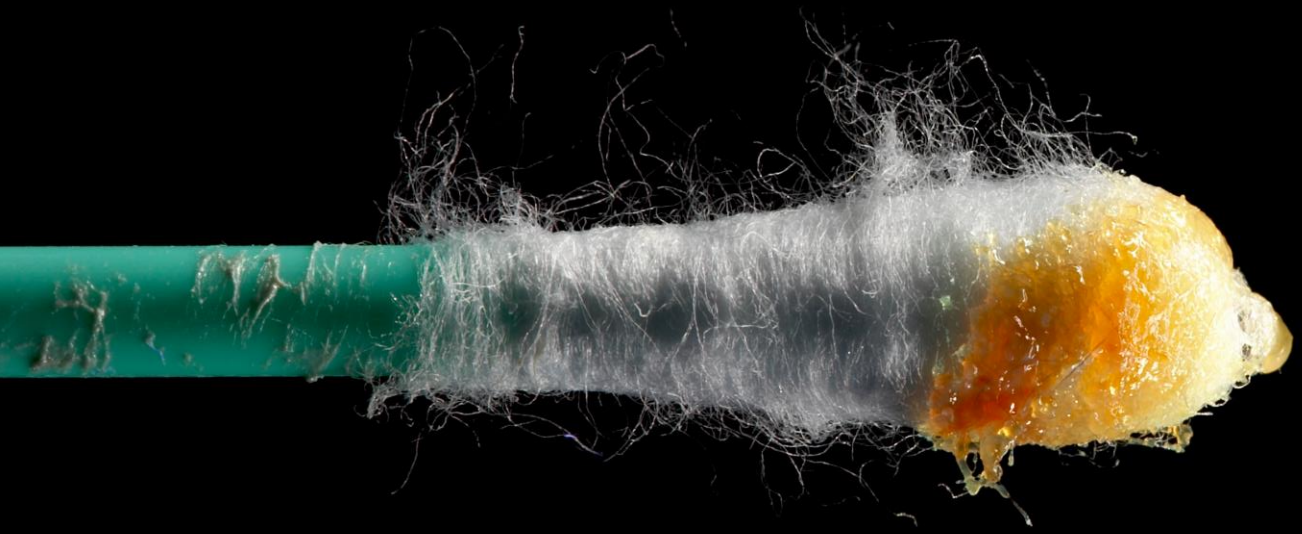
Reproduced from "Evolution of the Indoor Biome" in *TRENDS in Ecology & Evolution* 2015

What should live with us in our homes?

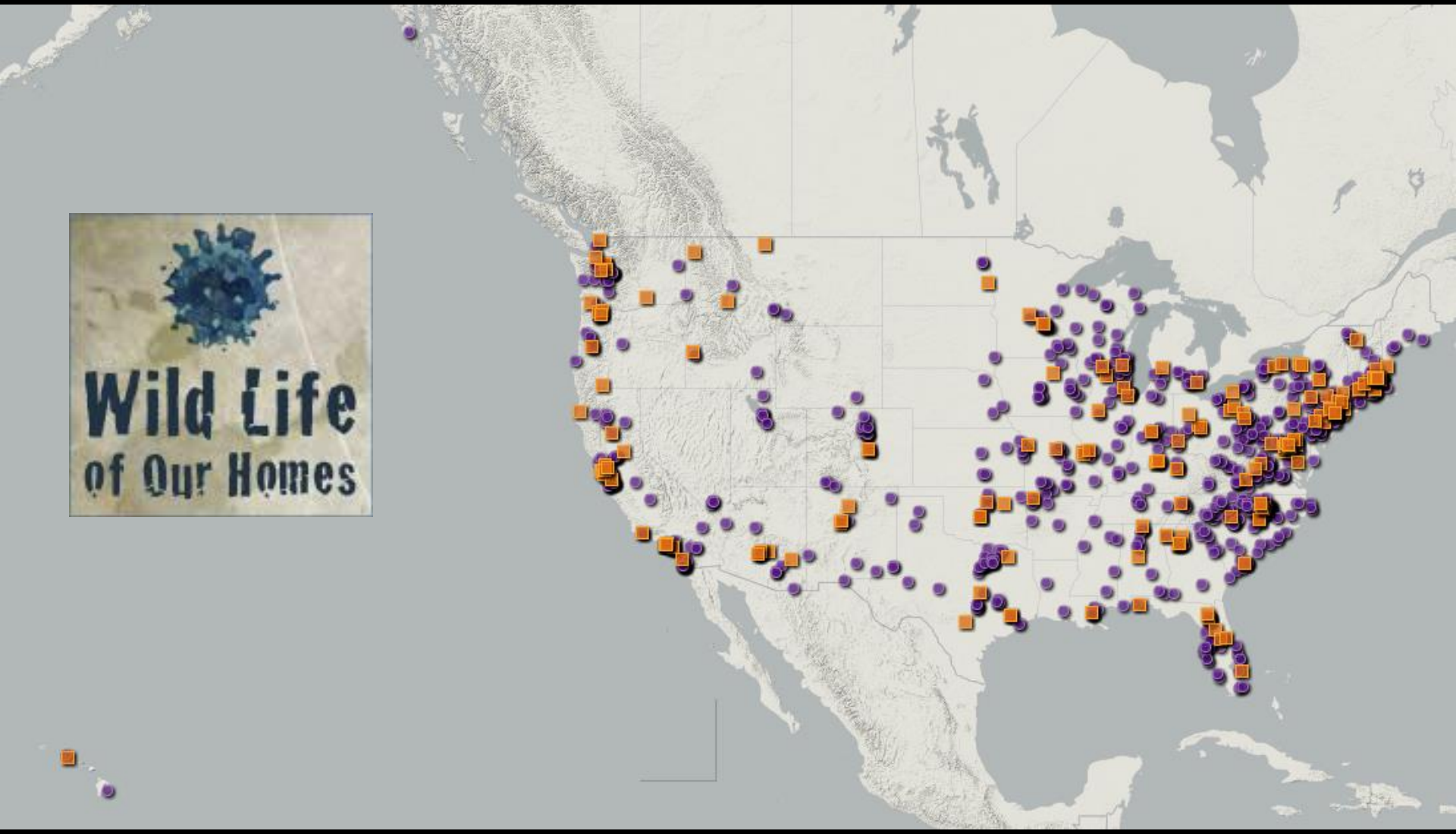
So what do we live with?



So what do we live with?



Subtropical rain forests to tundra

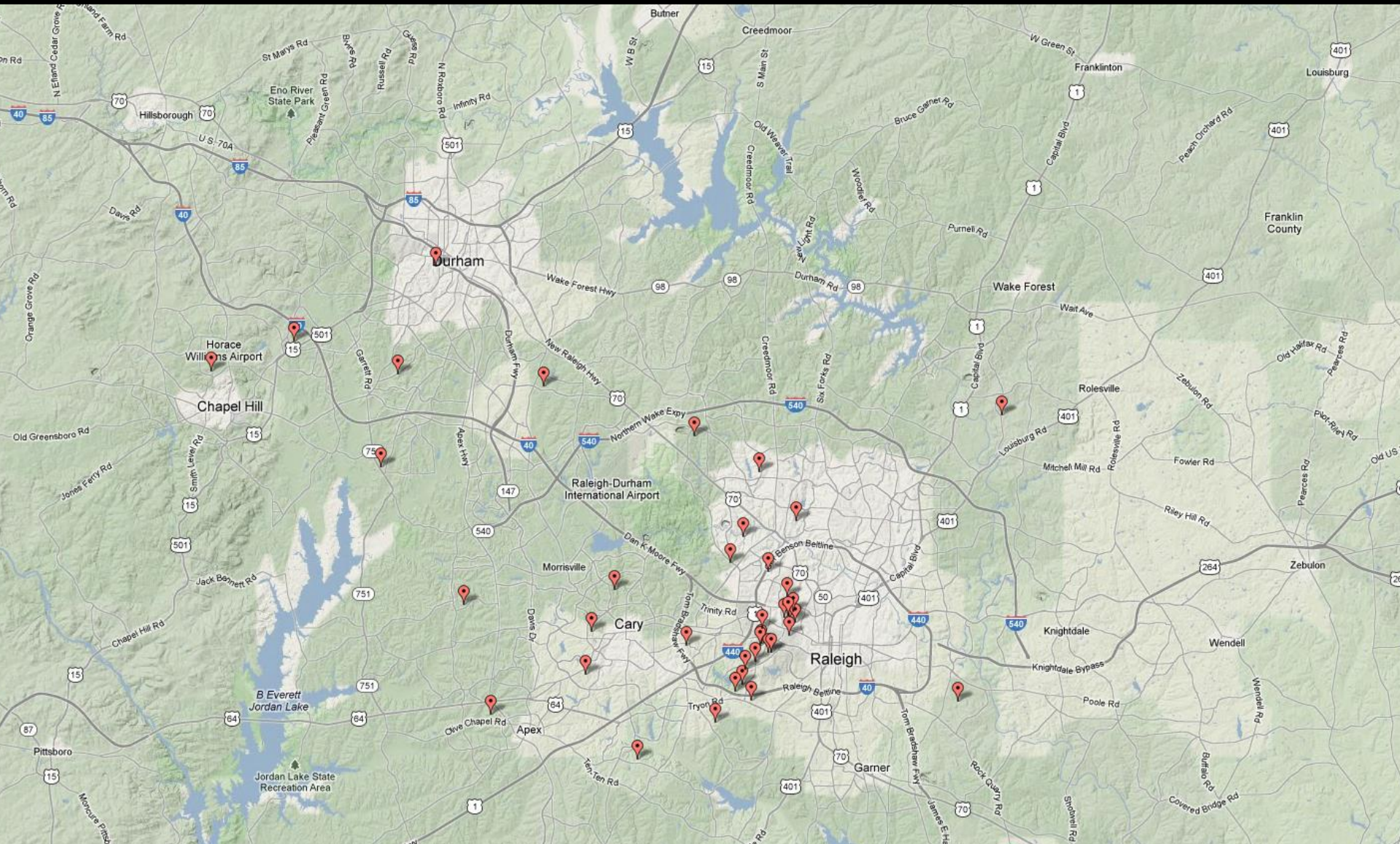


From dust

bacteria, archaea, fungus, plants (pollen) and, we are hoping, animal parts.

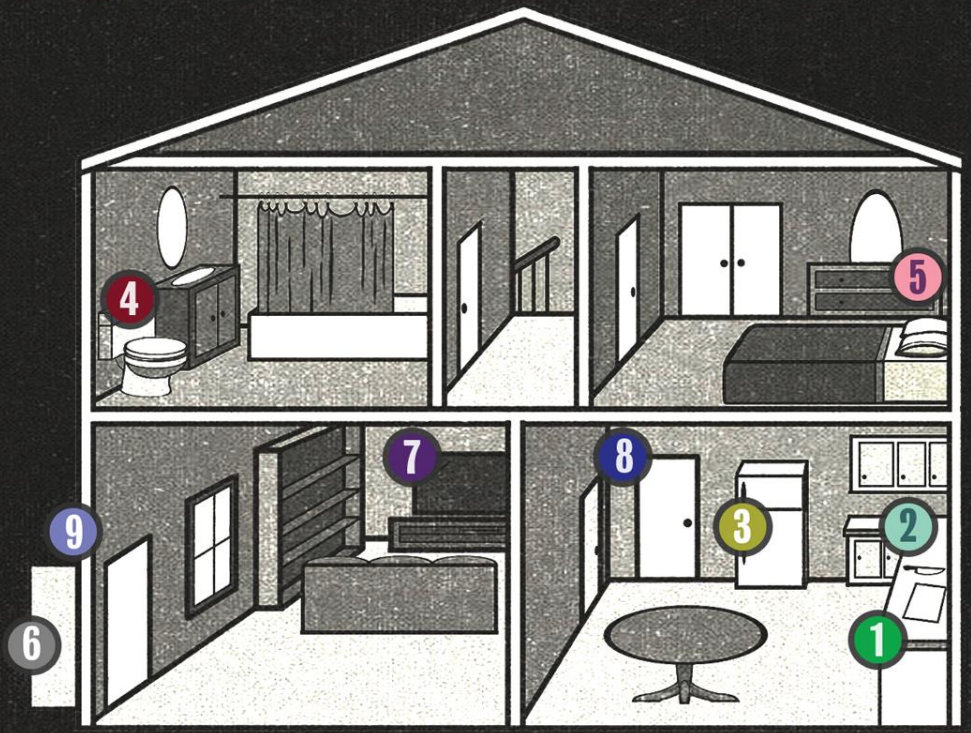

WE
RECYCLE

(An Example) 40 houses, one city

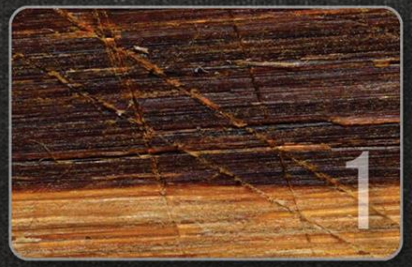


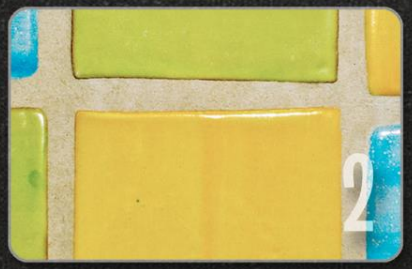
9 STANDARDIZED LOCATIONS SAMPLED PER HOME

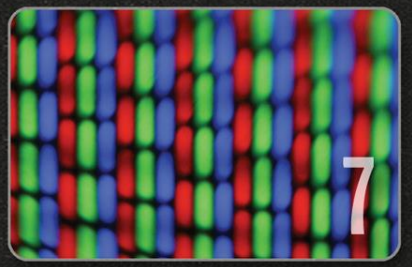
1. CUTTING BOARD
2. KITCHEN COUNTER
3. REFRIGERATOR
4. TOILET SEAT
5. PILLOWCASE
6. DOOR HANDLE
7. TV SCREEN
8. INTERIOR DOOR TRIM
9. EXTERIOR DOOR TRIM



9 SURFACE HABITATS

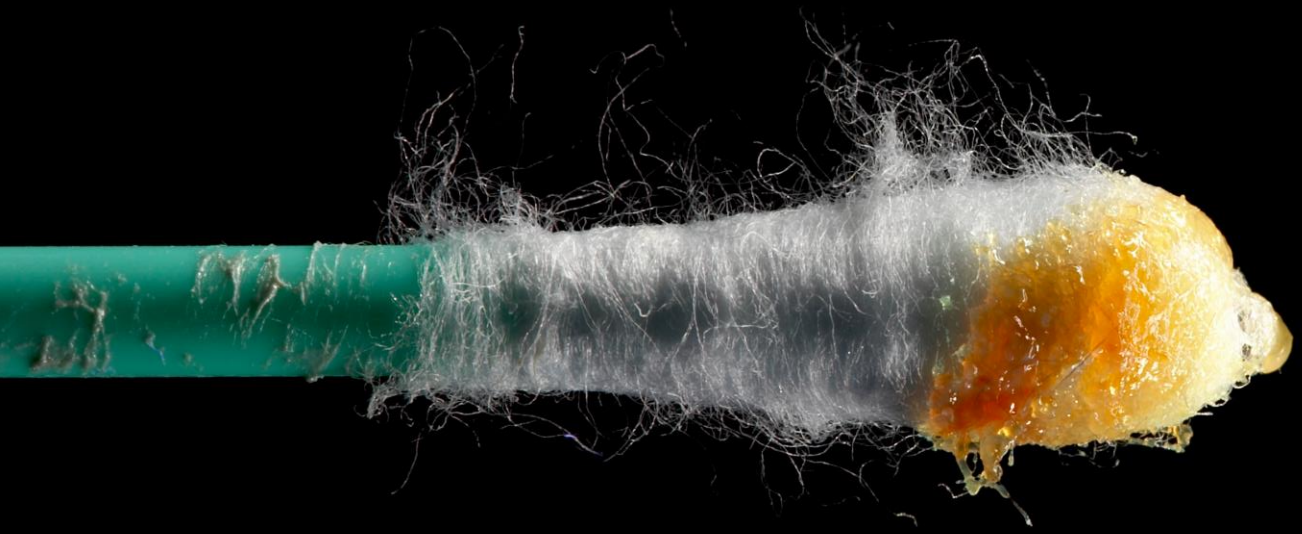




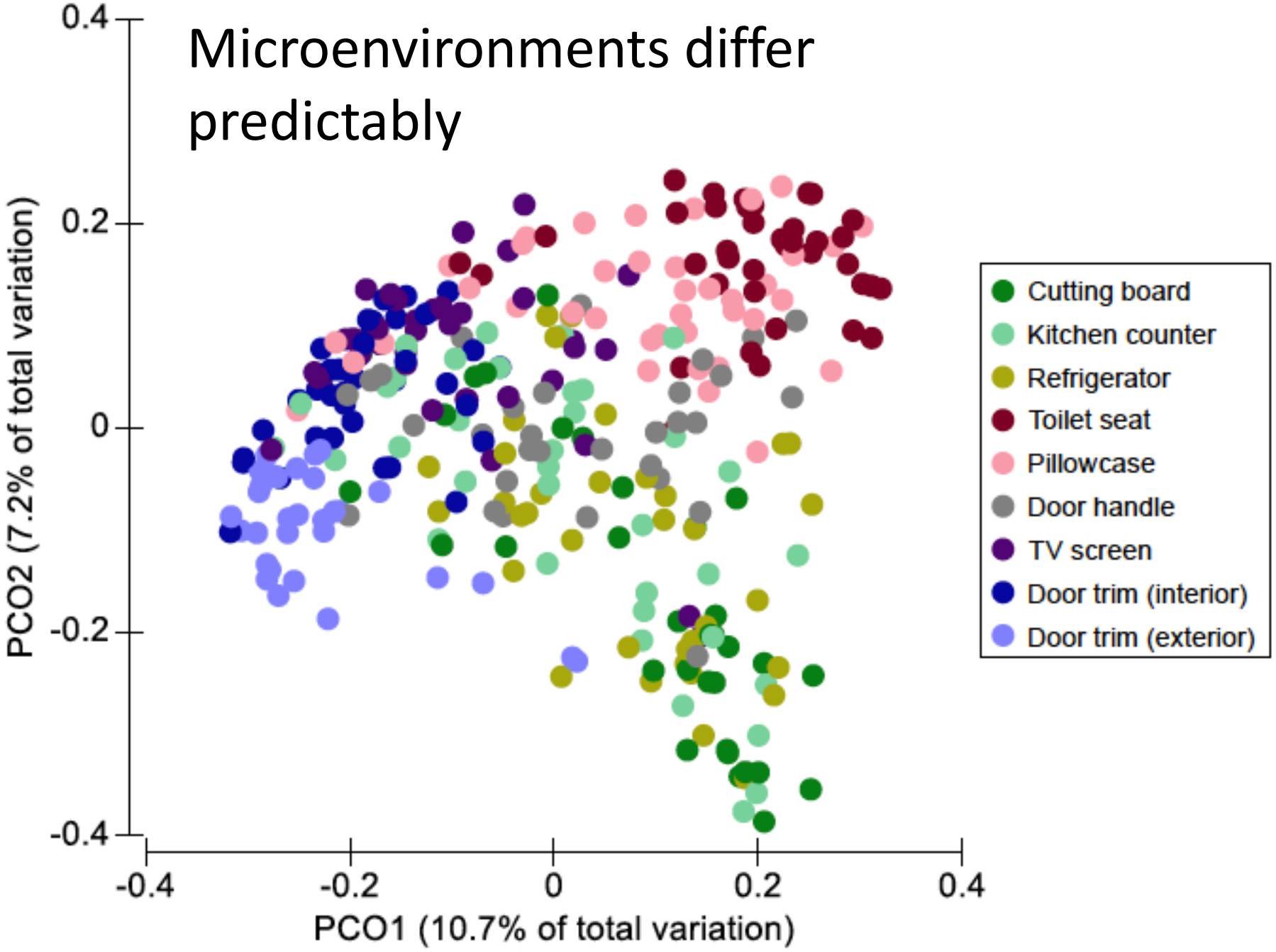


1000s of species of bacteria

not to mention the rest of life

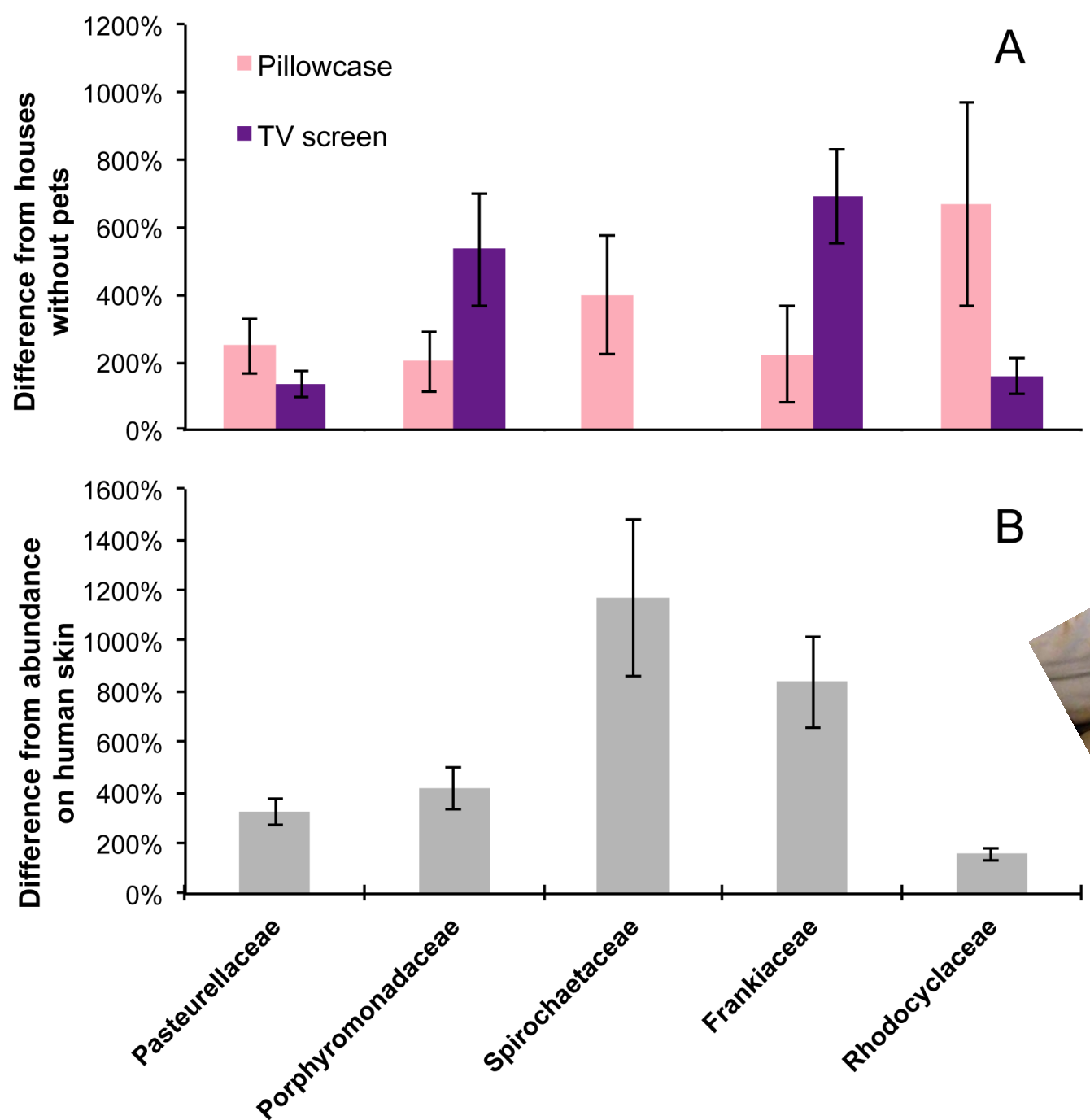


Microenvironments differ predictably



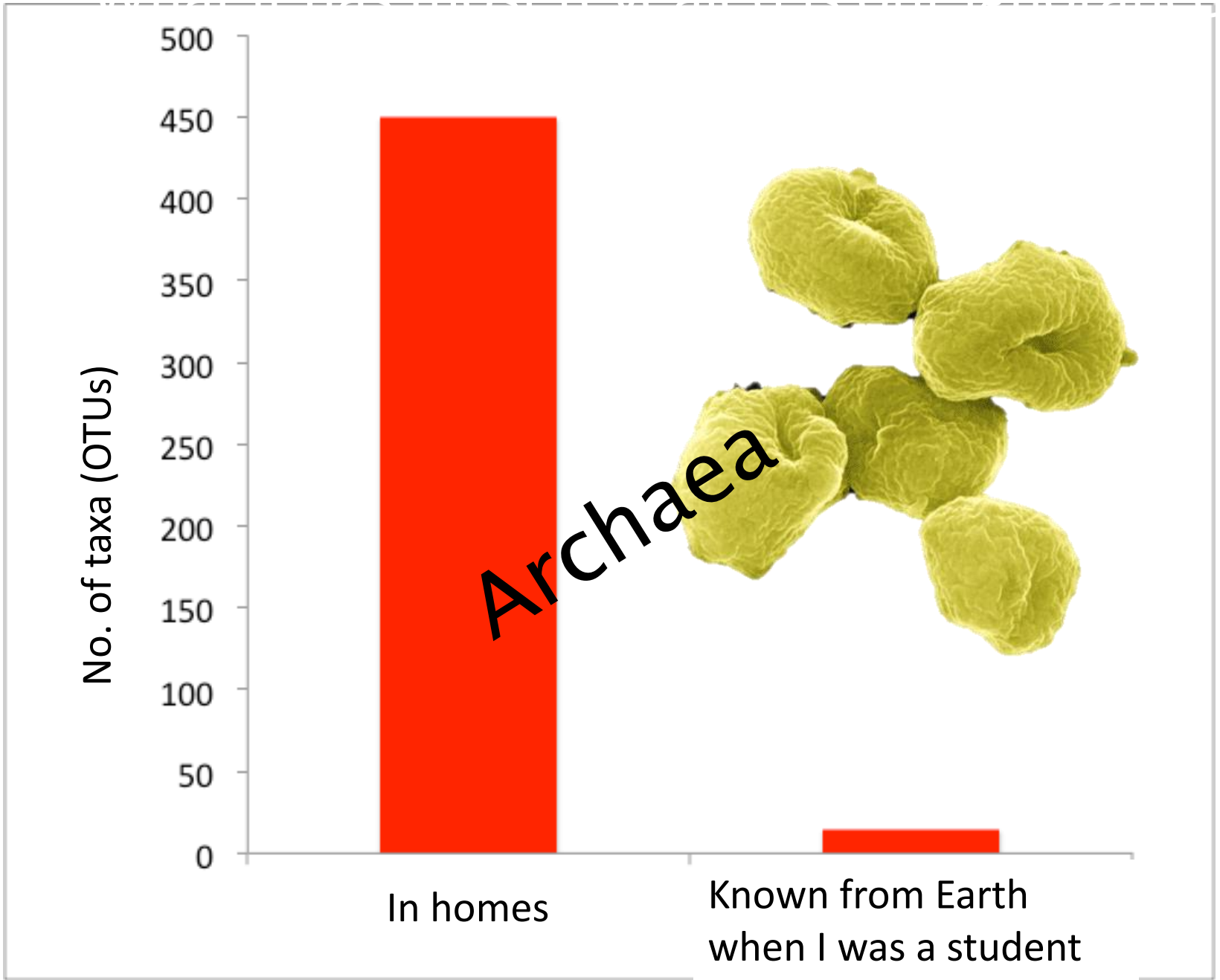
The consequence of poodles?

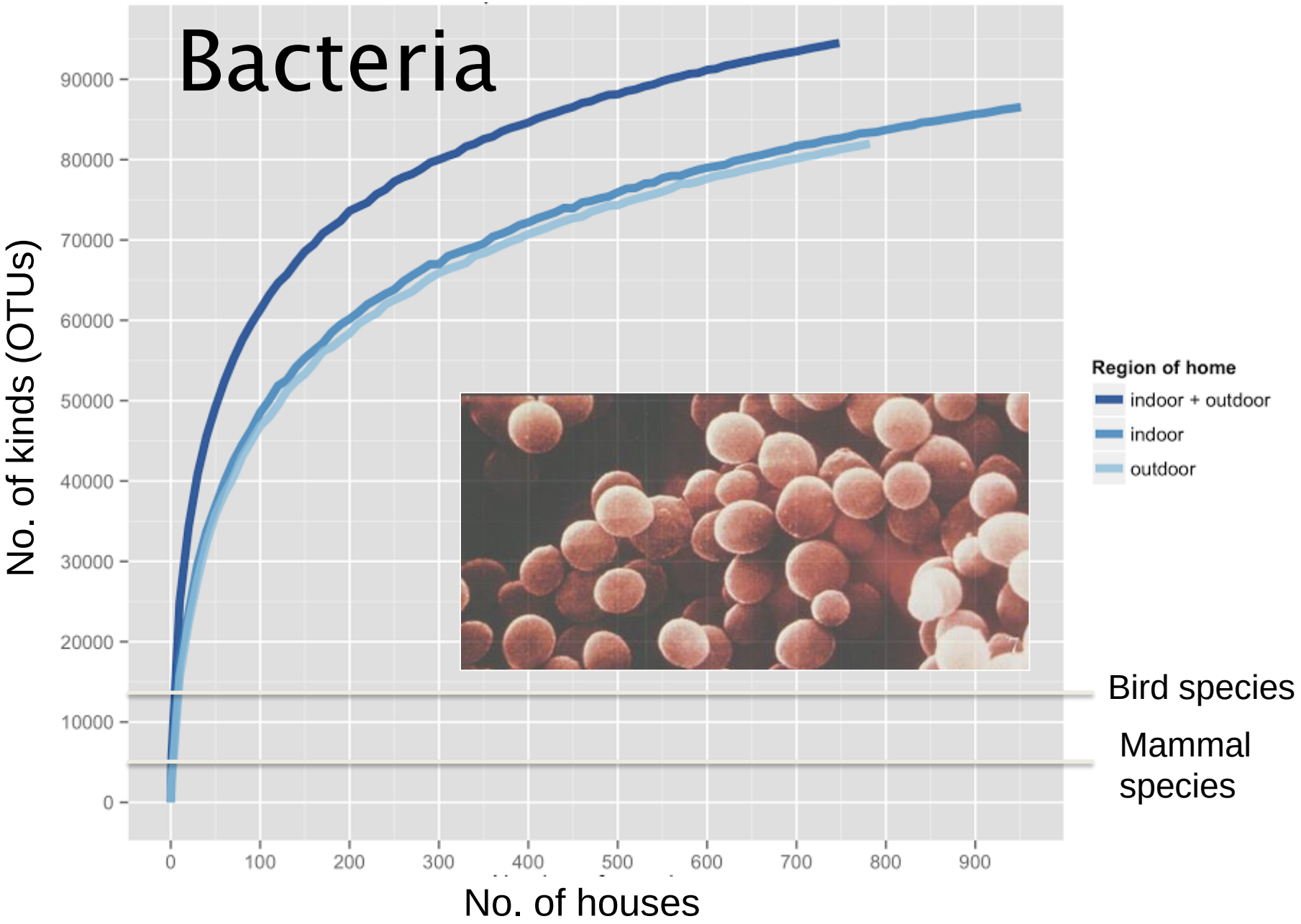
Greater than I would have guessed



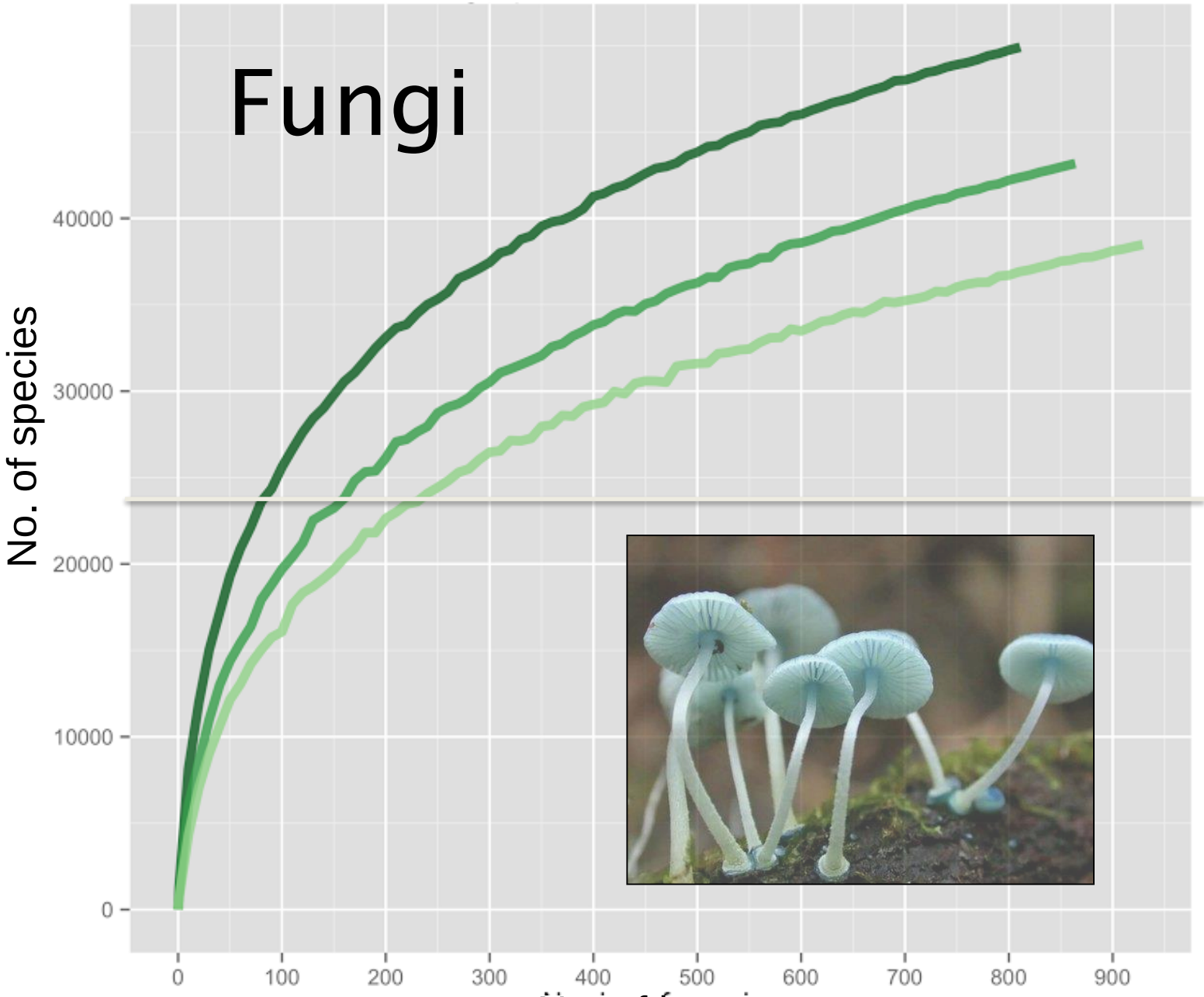
What influences house microbes?

- Ratio of women to men
- The types of pets (yes cats matter too)
- The food you eat (especially live food)
- Ventilation
- **But there is something more, much more really...**


500
450
400
350
300
250
200
150
100
50
0
No. of taxa (OTUs)
Archaea
In homes
Known from Earth
when I was a student

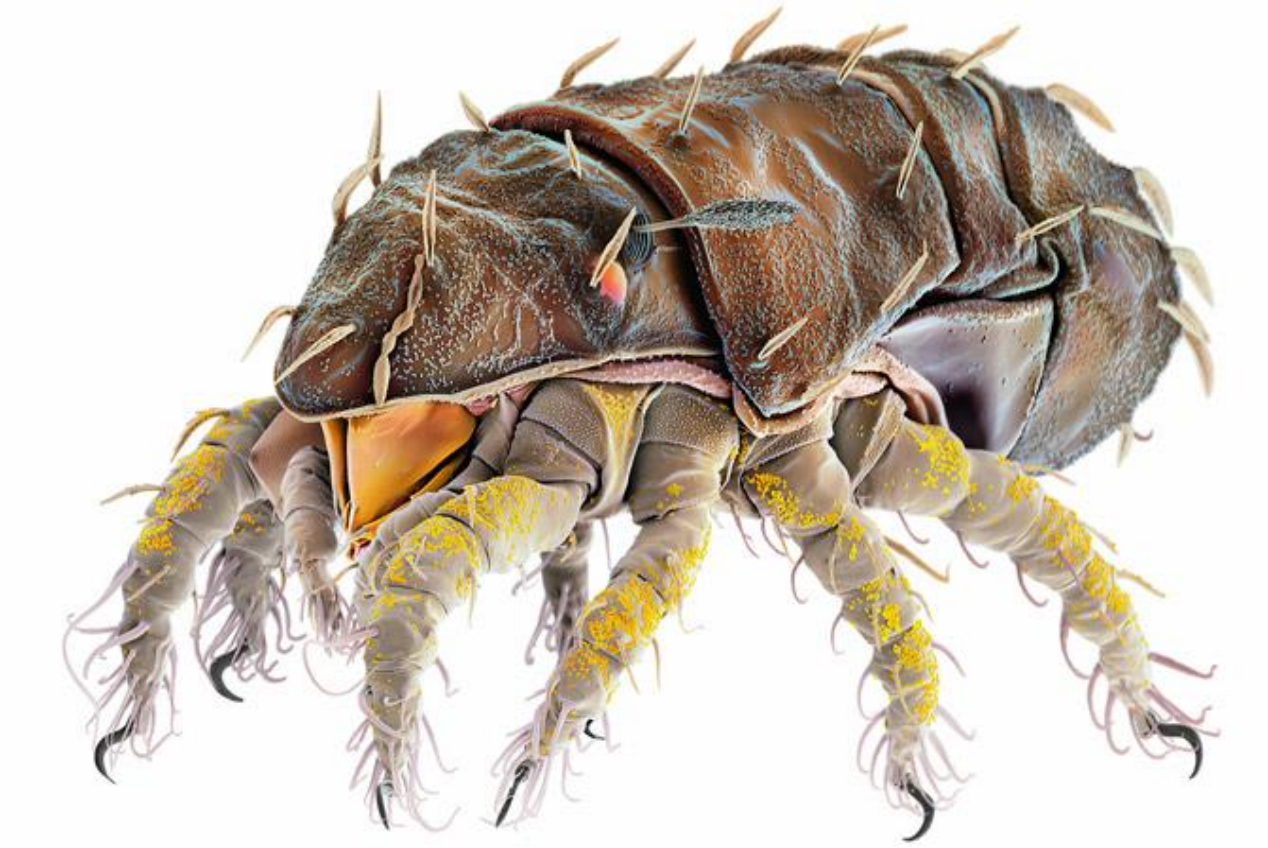

Bacteria
No. of kinds (OTUs)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
0
100
200
300
400
500
600
700
800
900
No. of houses
Region of home
indoor + outdoor
indoor
outdoor
Bird species
Mammal species

Fungi



Approximate no. of named fungal species in North America

Animals



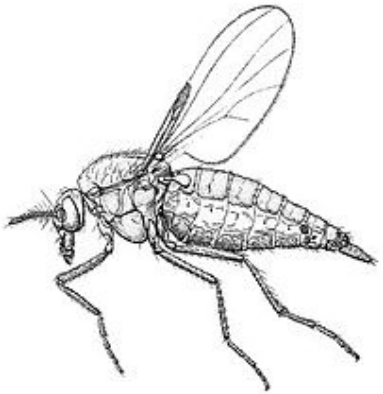
There is a grandeur in this life.

Except for fleeting moments in surgical arenas…

- Sterile conditions do not exist.
- Air is full of life
- Band aides are covered in life
- Clothes IN the laundry are covered in life
- Dispensers of antimicrobials are covered in life
- The key is favoring good, disfavoring bad.

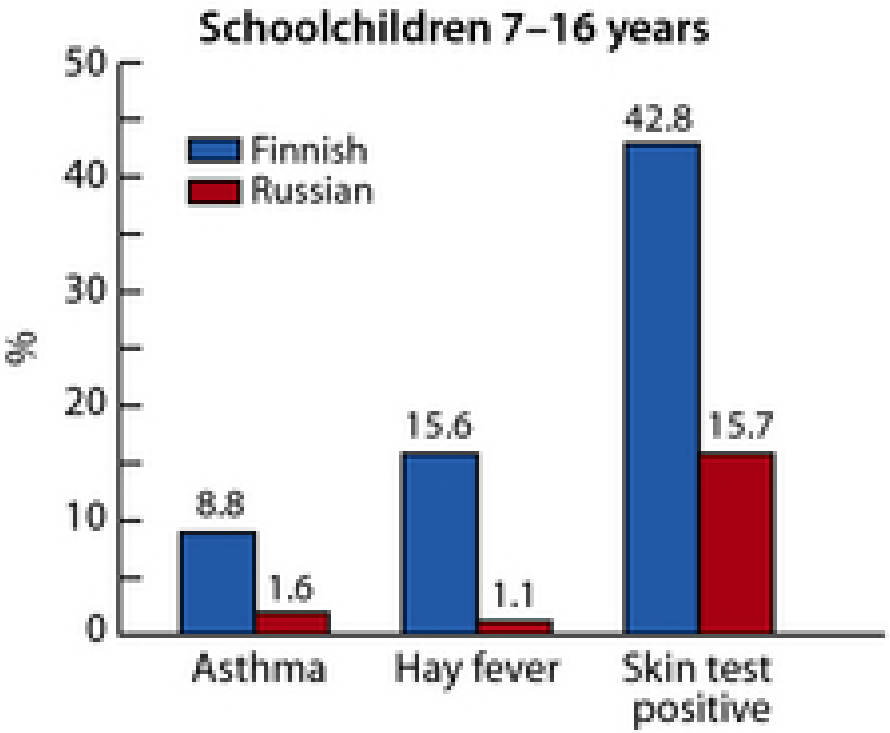
What is Good? What is Bad?

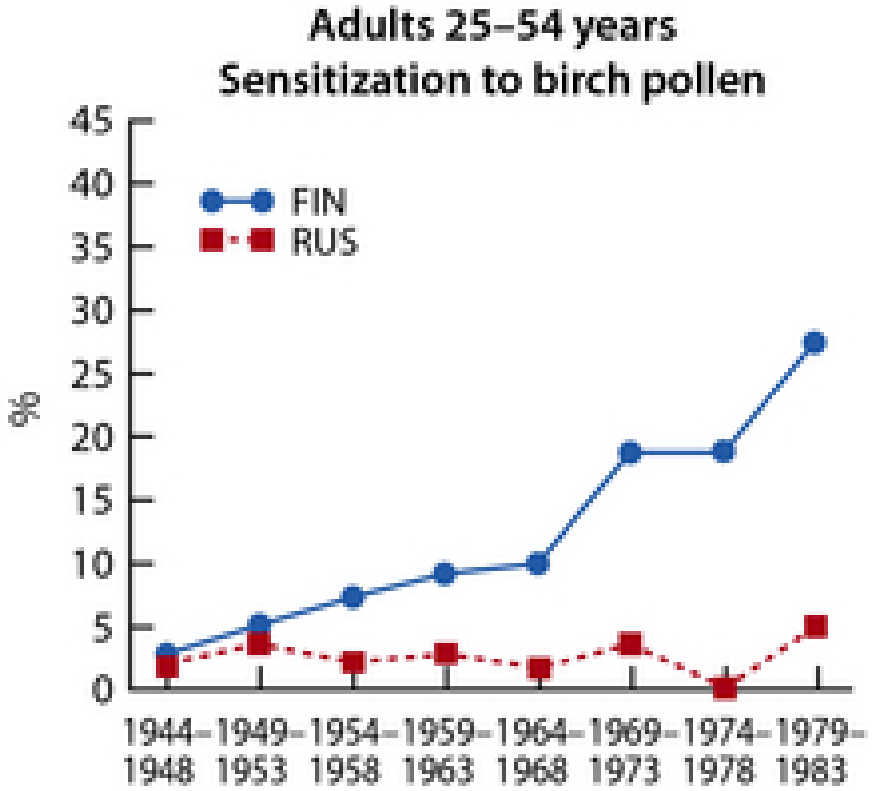
Martin Oegerlli



Something in Russia is Good
(something in Finland is bad, or has gone missing)

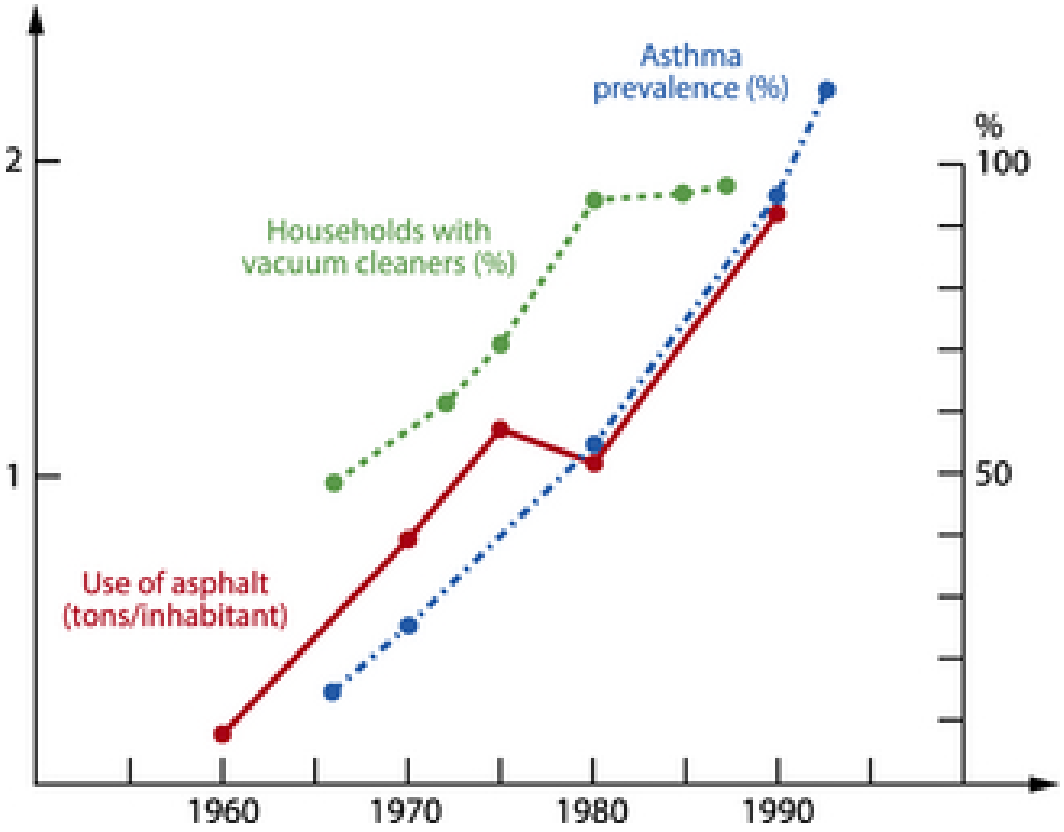
An example comparison





Clinical & Experimental Allergy
Volume 45, Issue 5, pages 891-901, 16 APR 2015 DOI: 10.1111/cea.12527

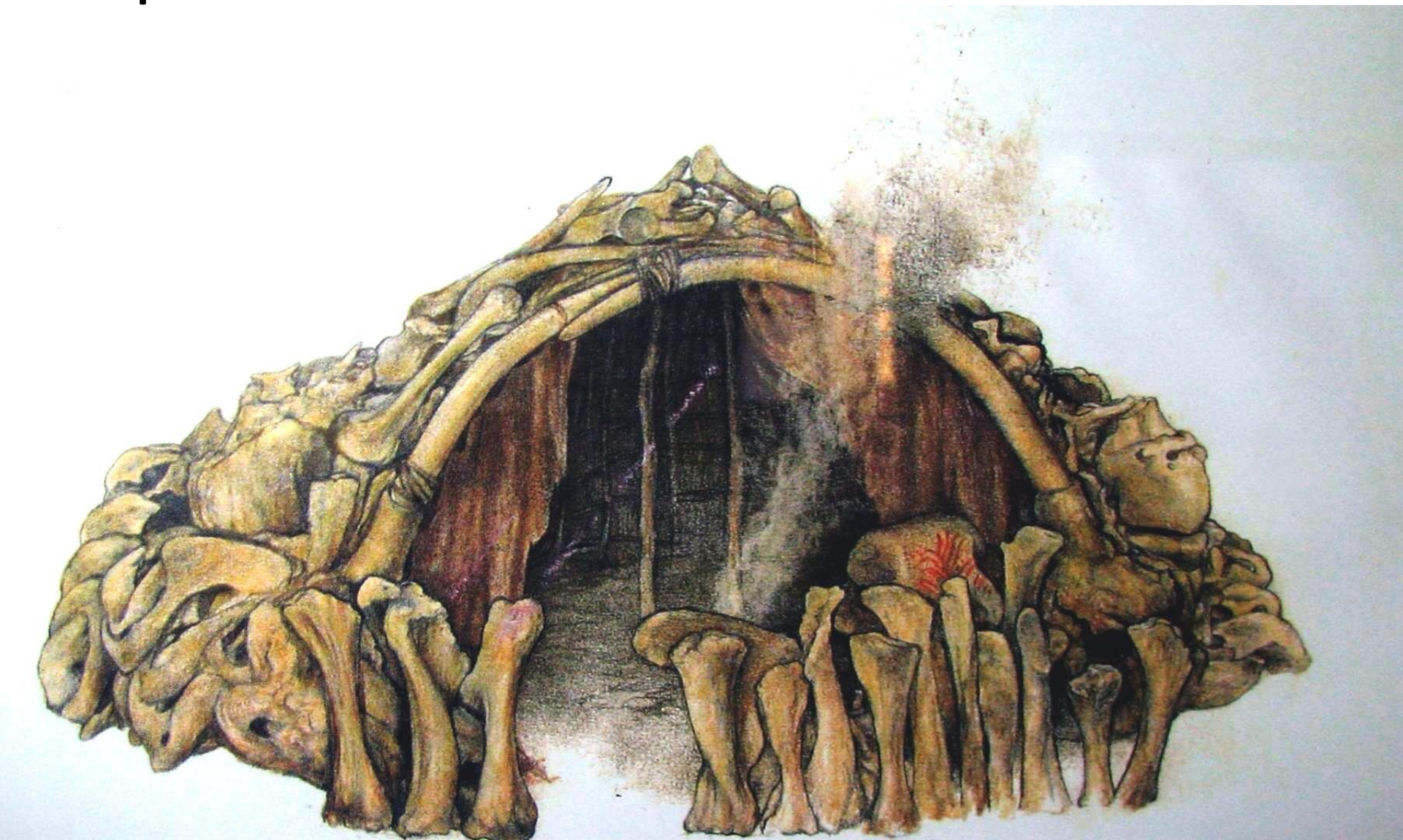
Evolutionary Mismatch



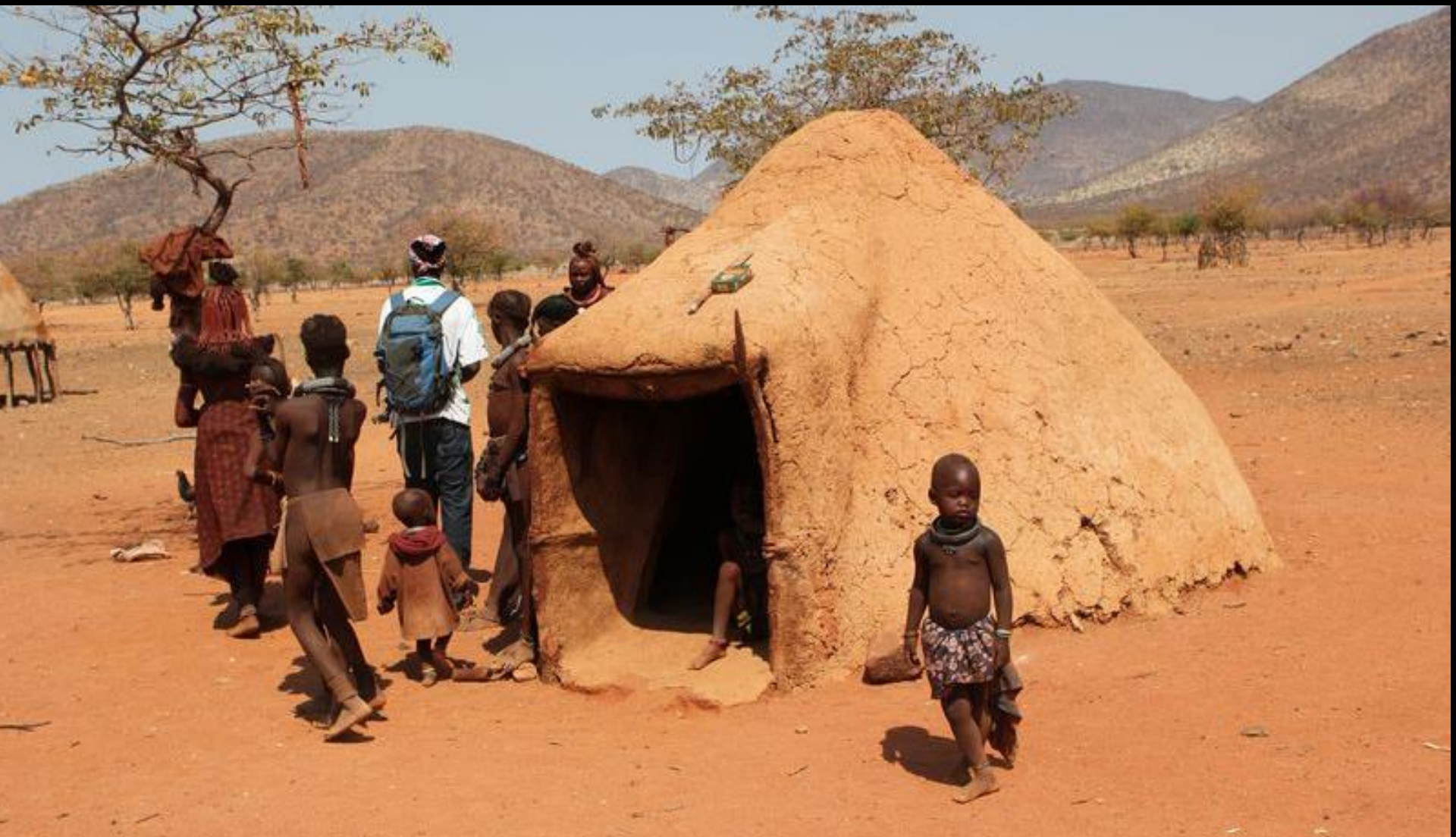
Clinical & Experimental Allergy
Volume 45, Issue 5, pages 891-901, 16 APR 2015 DOI: 10.1111/cea.12527
http://onlinelibrary.wiley.com/doi/10.1111/cea.12527/full#cea12527-fig-0007

A hypothesis: More diversity is good, we have lost diversity, we have also lost specific beneficial species

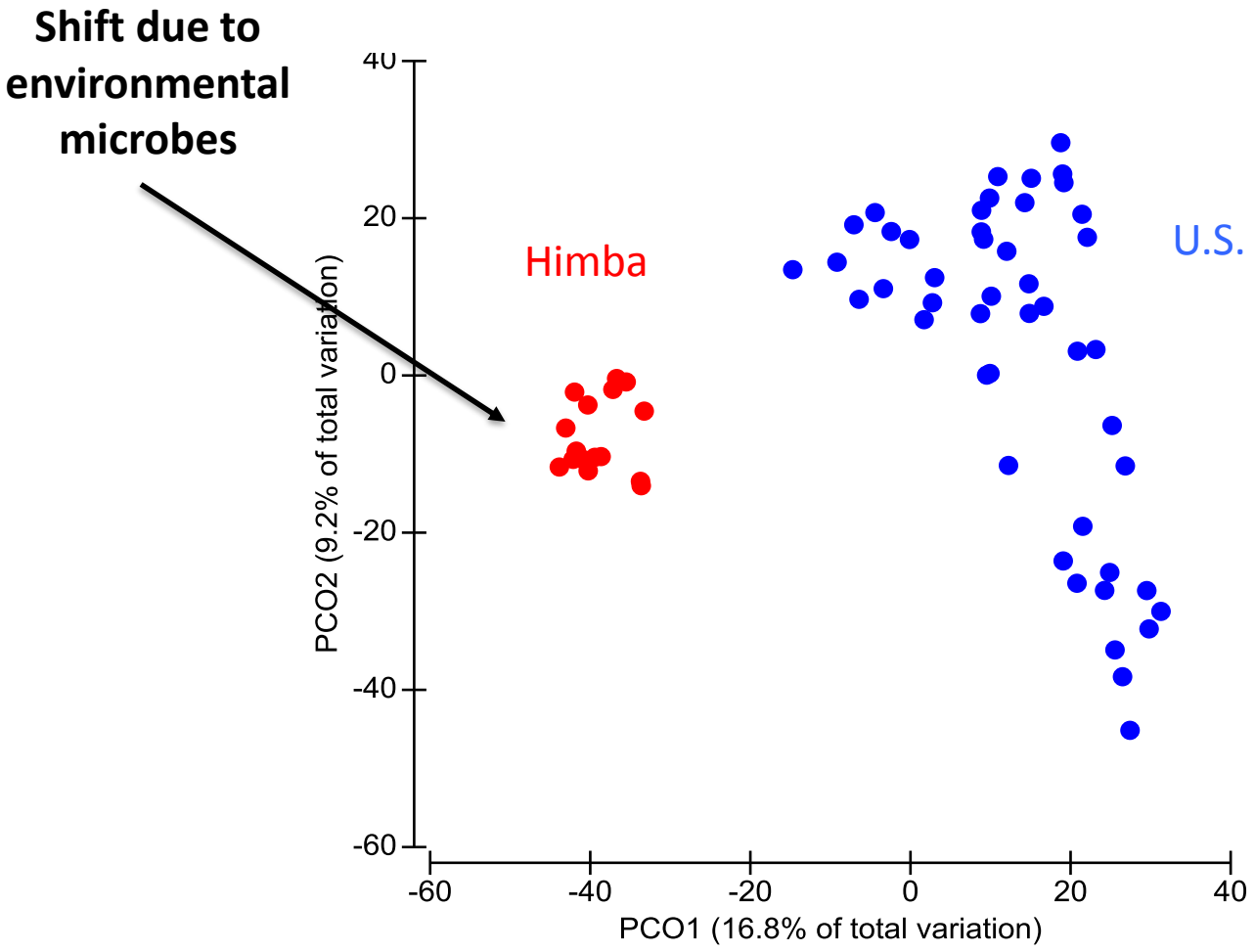
A hypothesis with specific, untested predictions about traditional homes



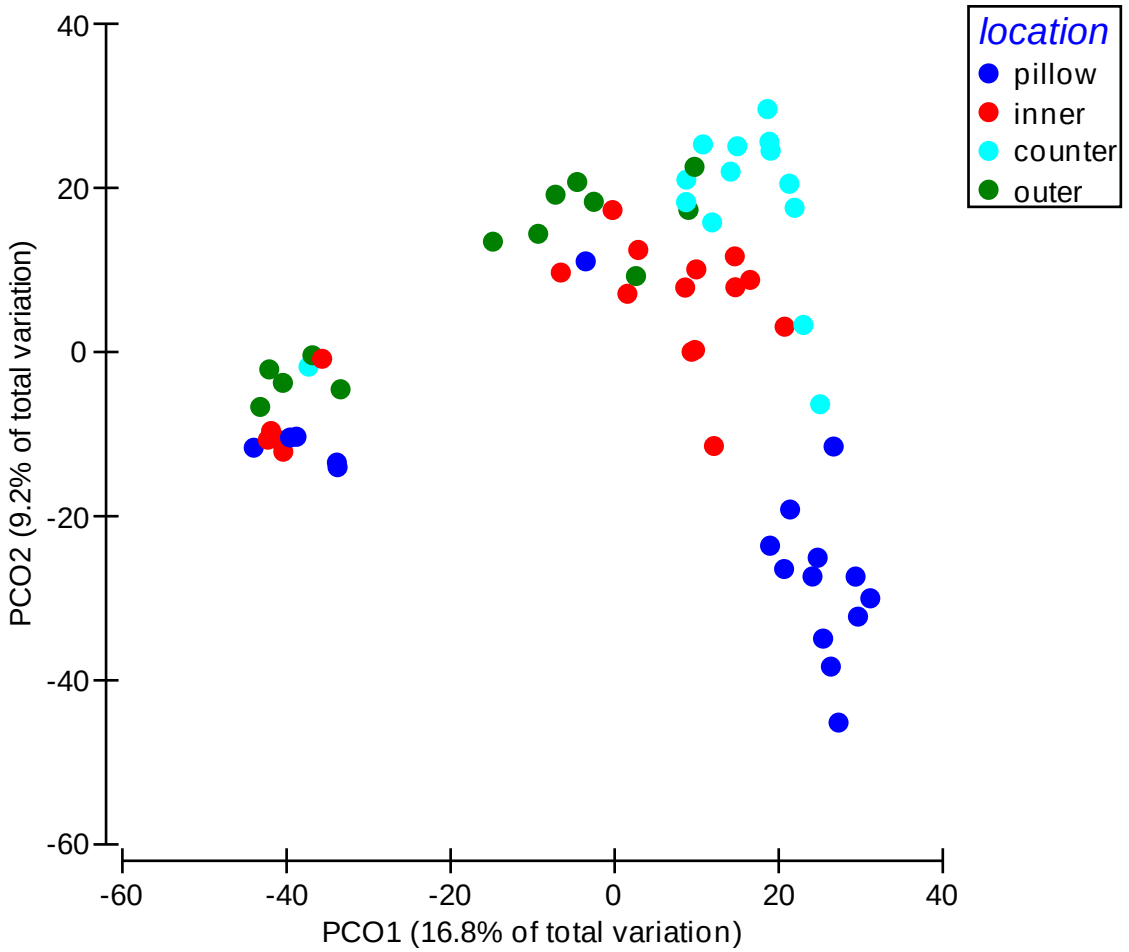
The Himba of Namibia

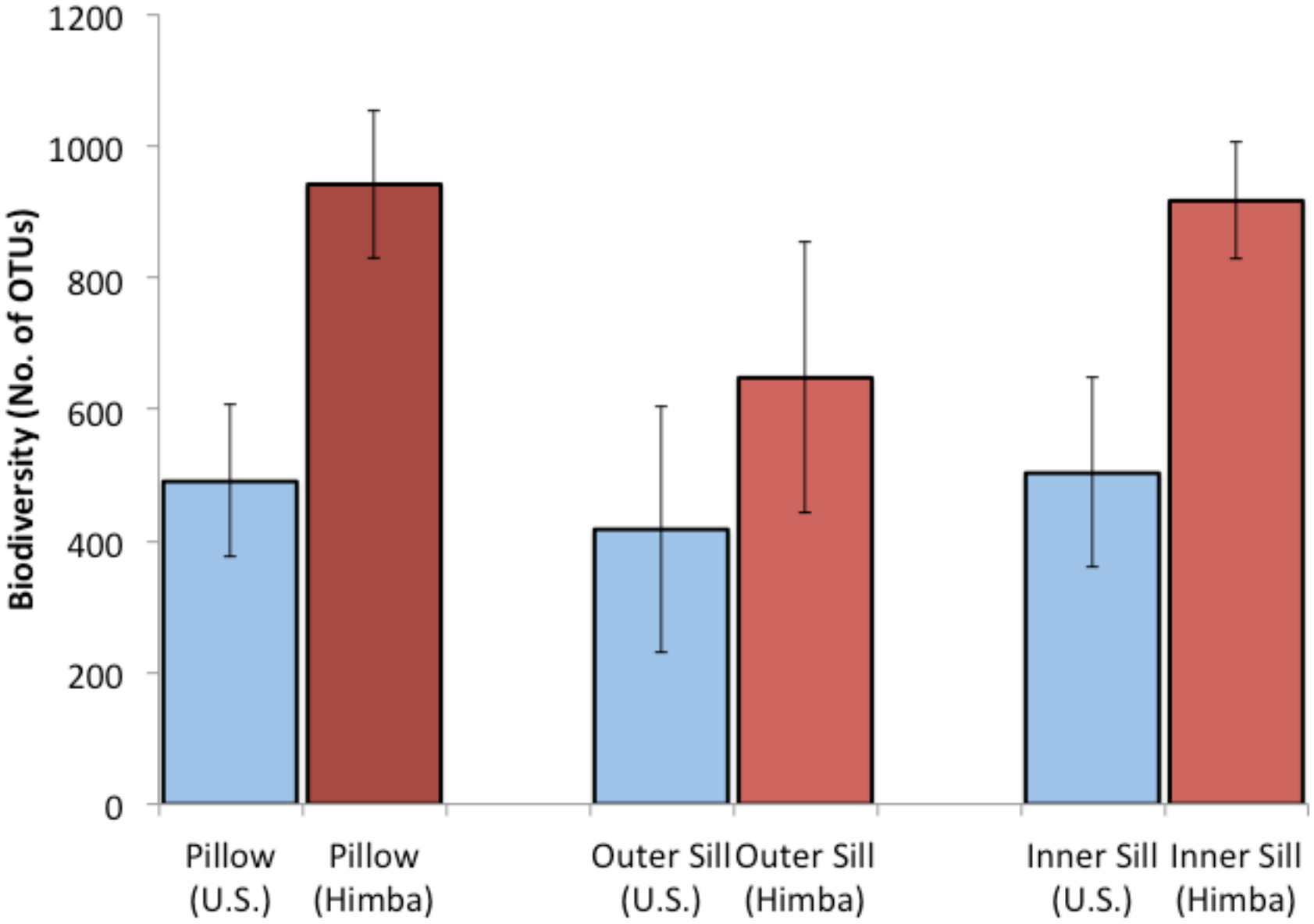


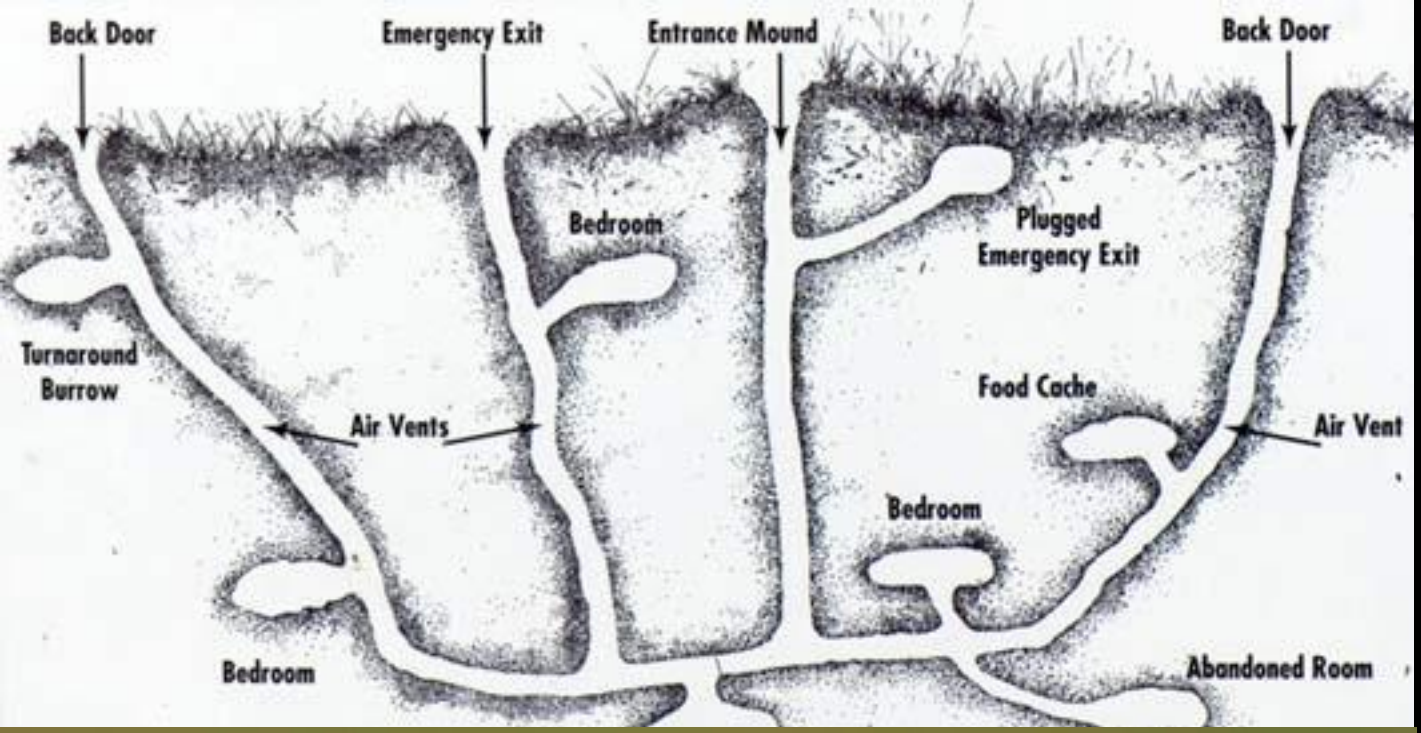
Modern Himba vs Modern U.S. (which is like Finland)



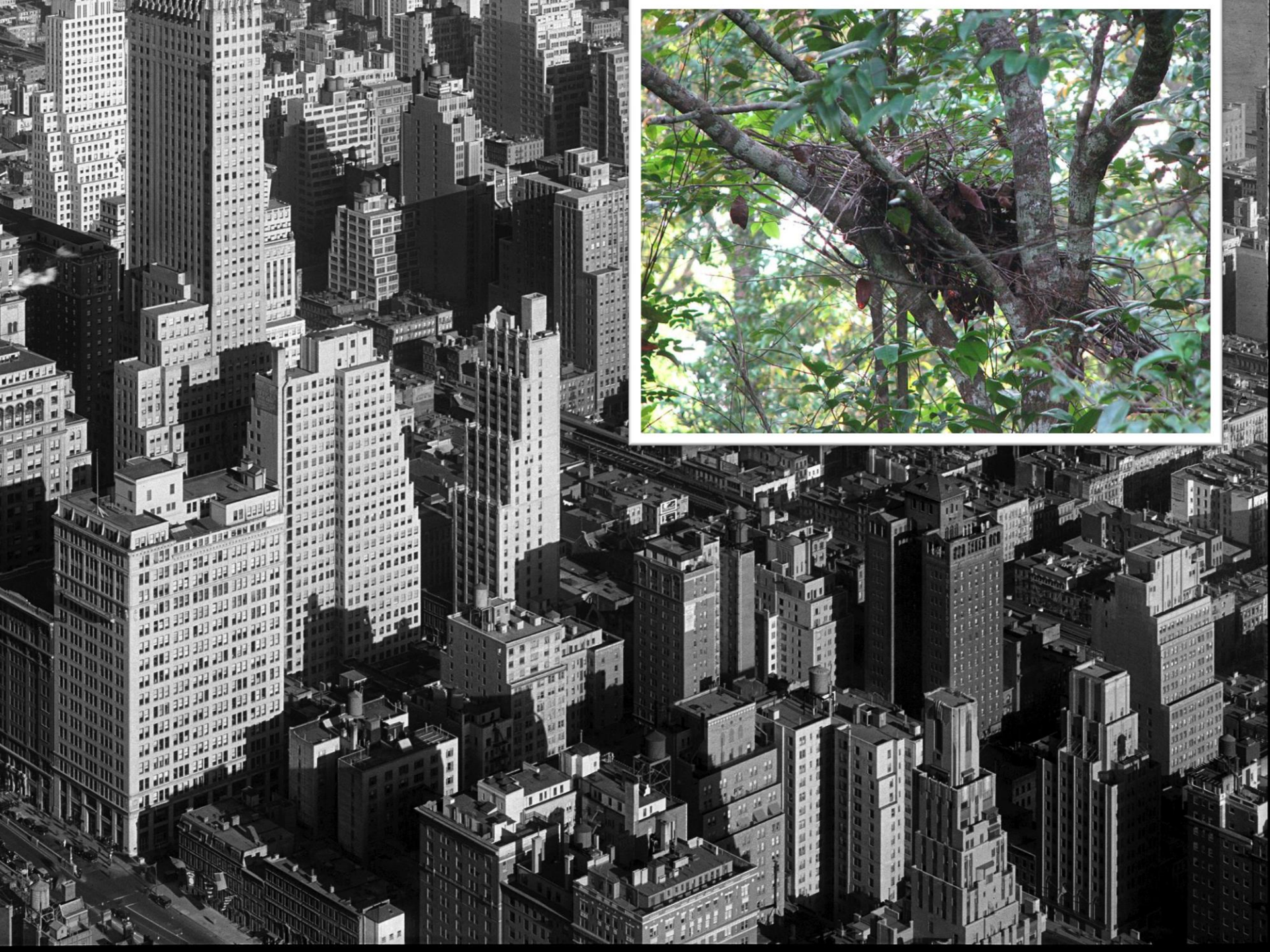
Modern Himba vs Modern U.S.




Biodiversity (No. of OTUs)
1200
1000
800
600
400
200
0
Pillow (U.S.)
Pillow (Himba)
Outer Sill (U.S.)
Outer Sill (Himba)
Inner Sill (U.S.)
Inner Sill (Himba)



How does this compare to the homes of our relatives?



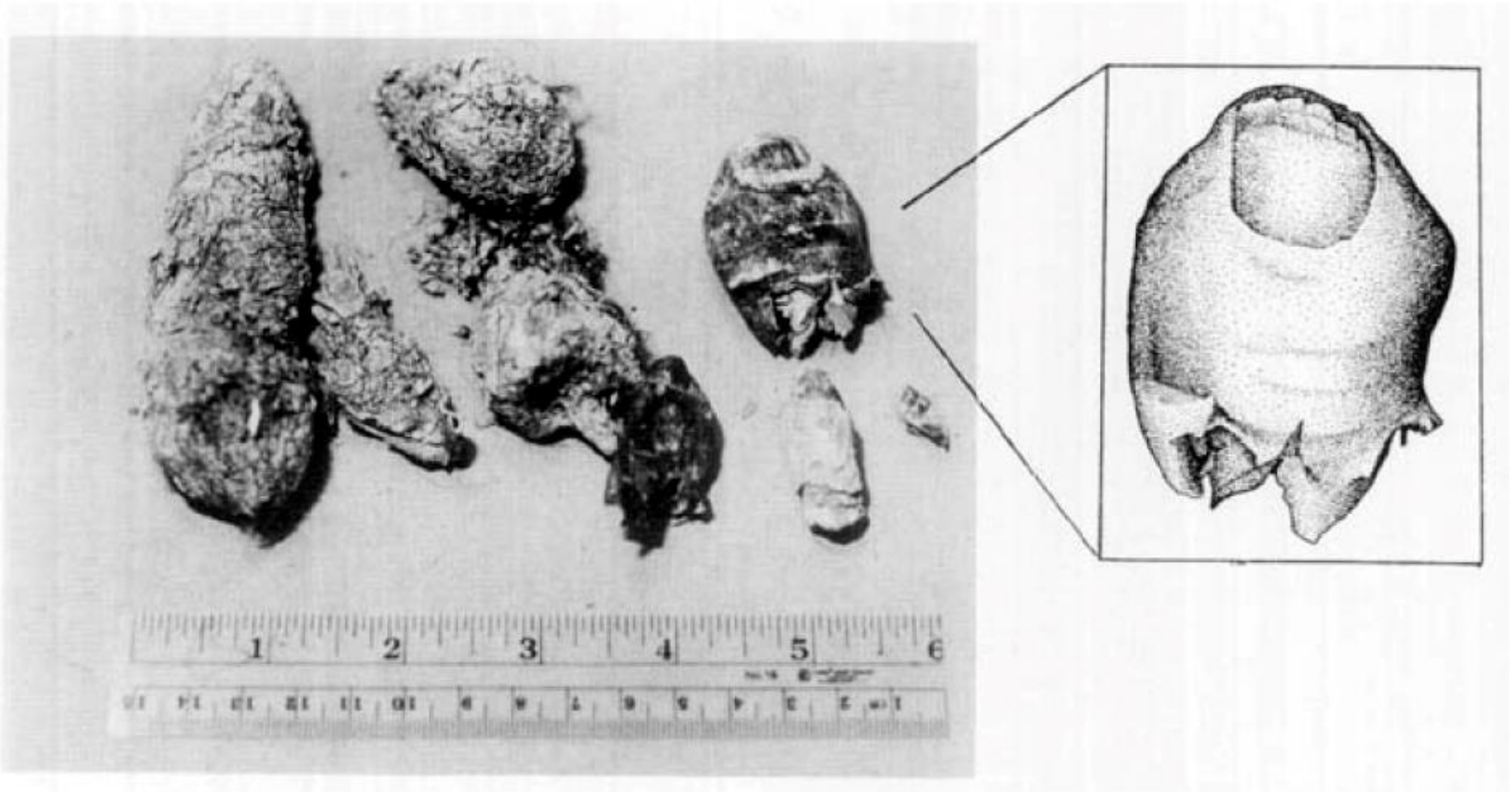
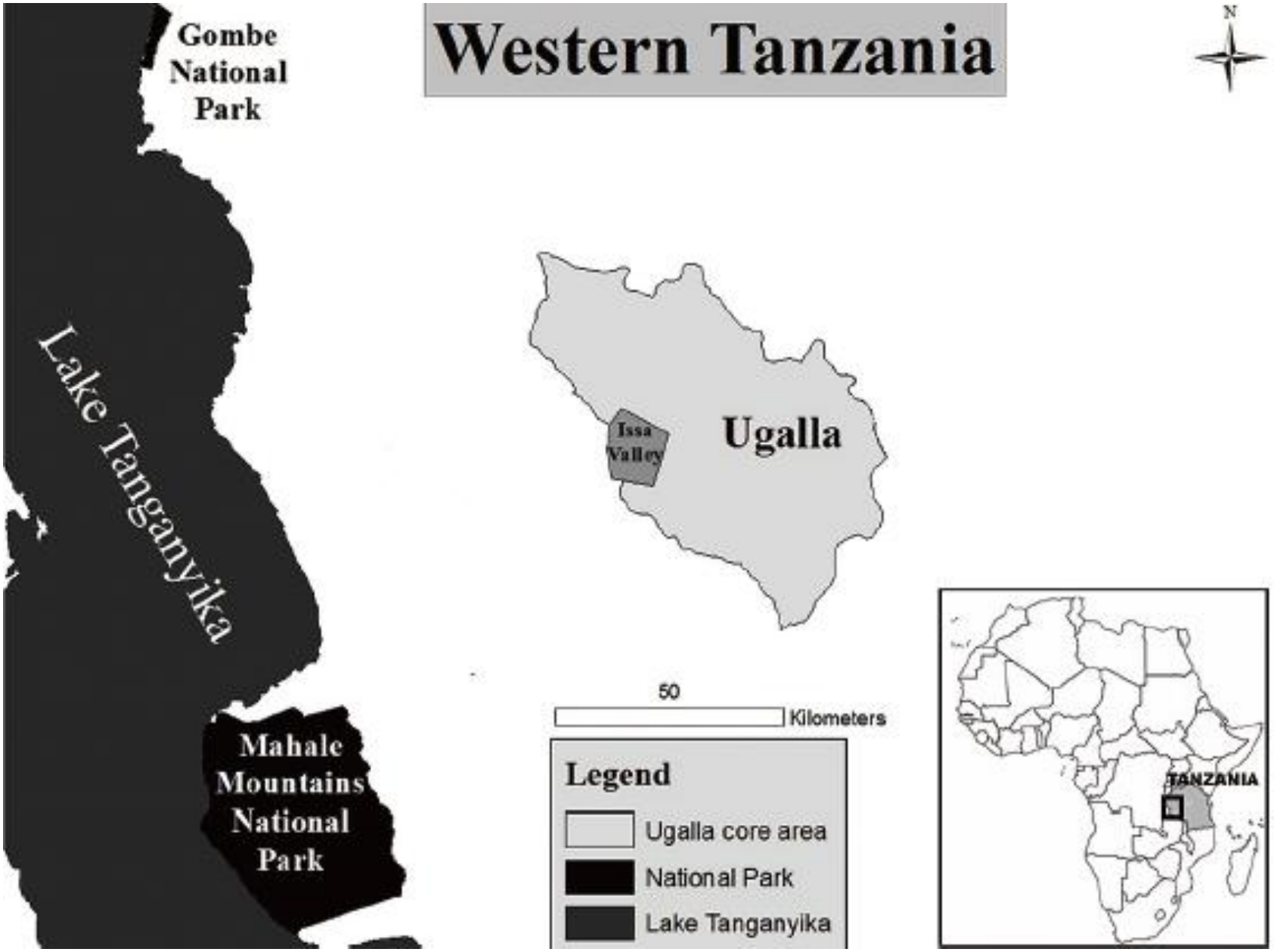


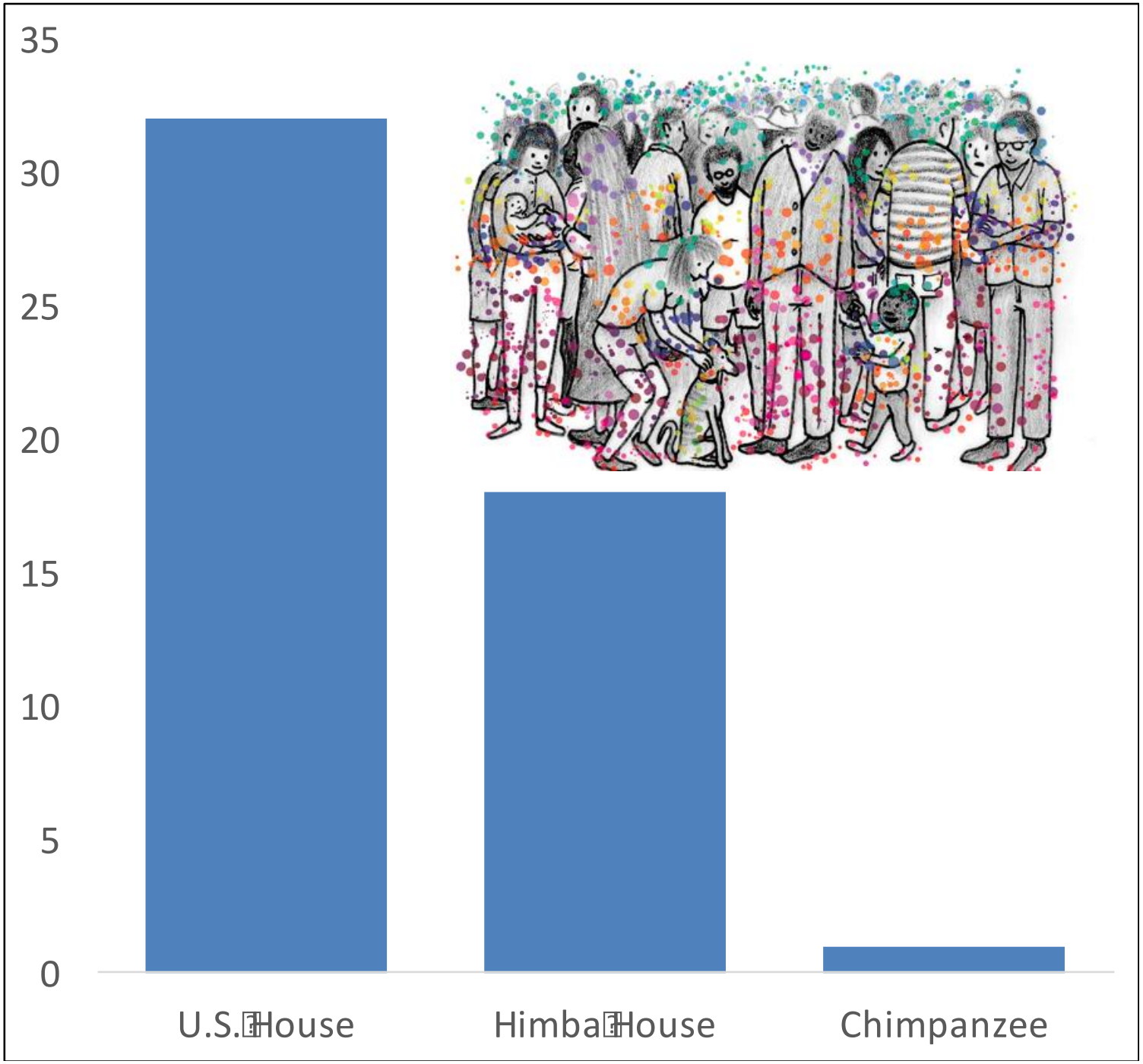
Figure 1. Photograph of leopard scat with enlarged sketch of pedal digit I.

Fay et al. (2005)

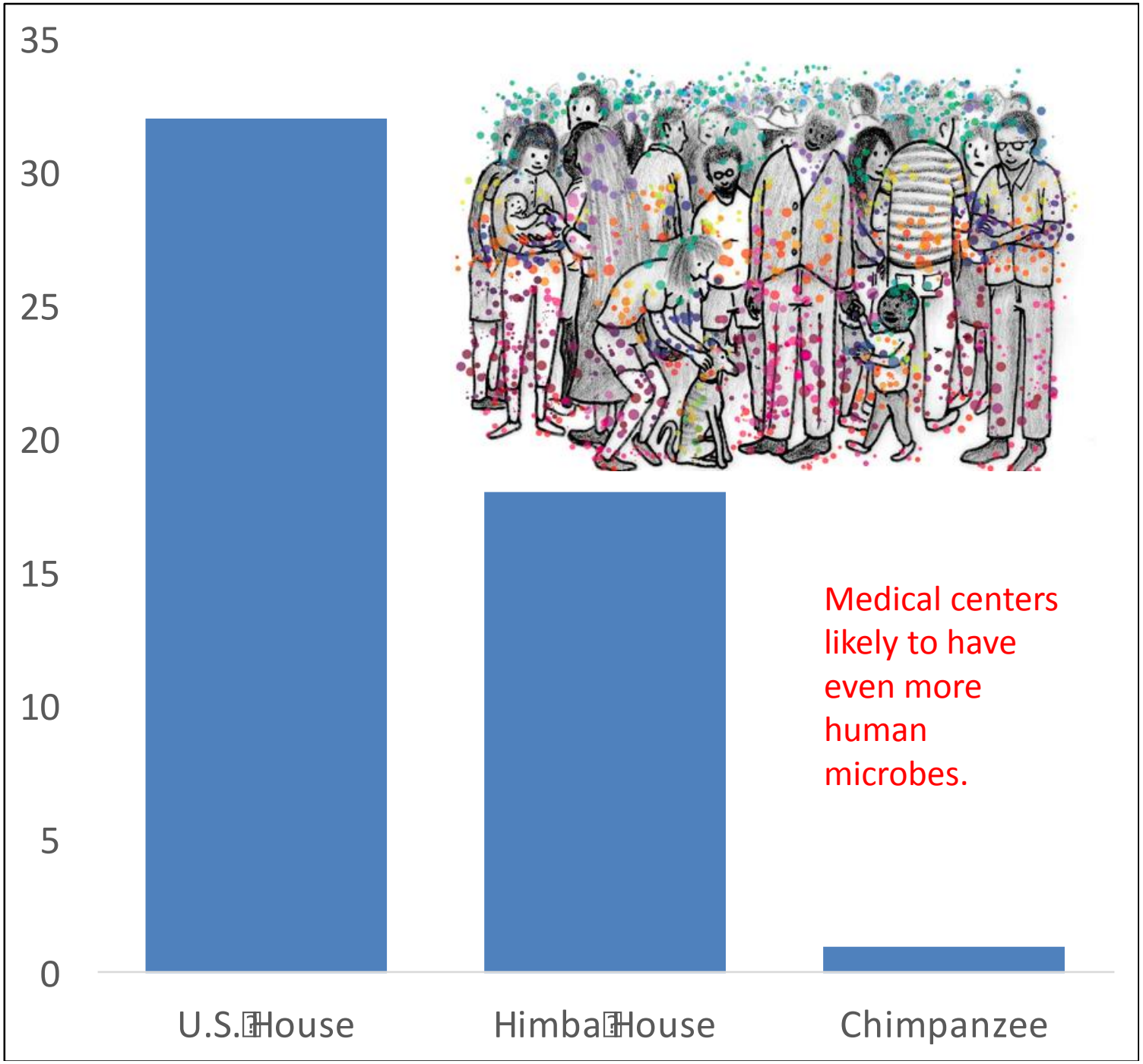
Western Tanzania

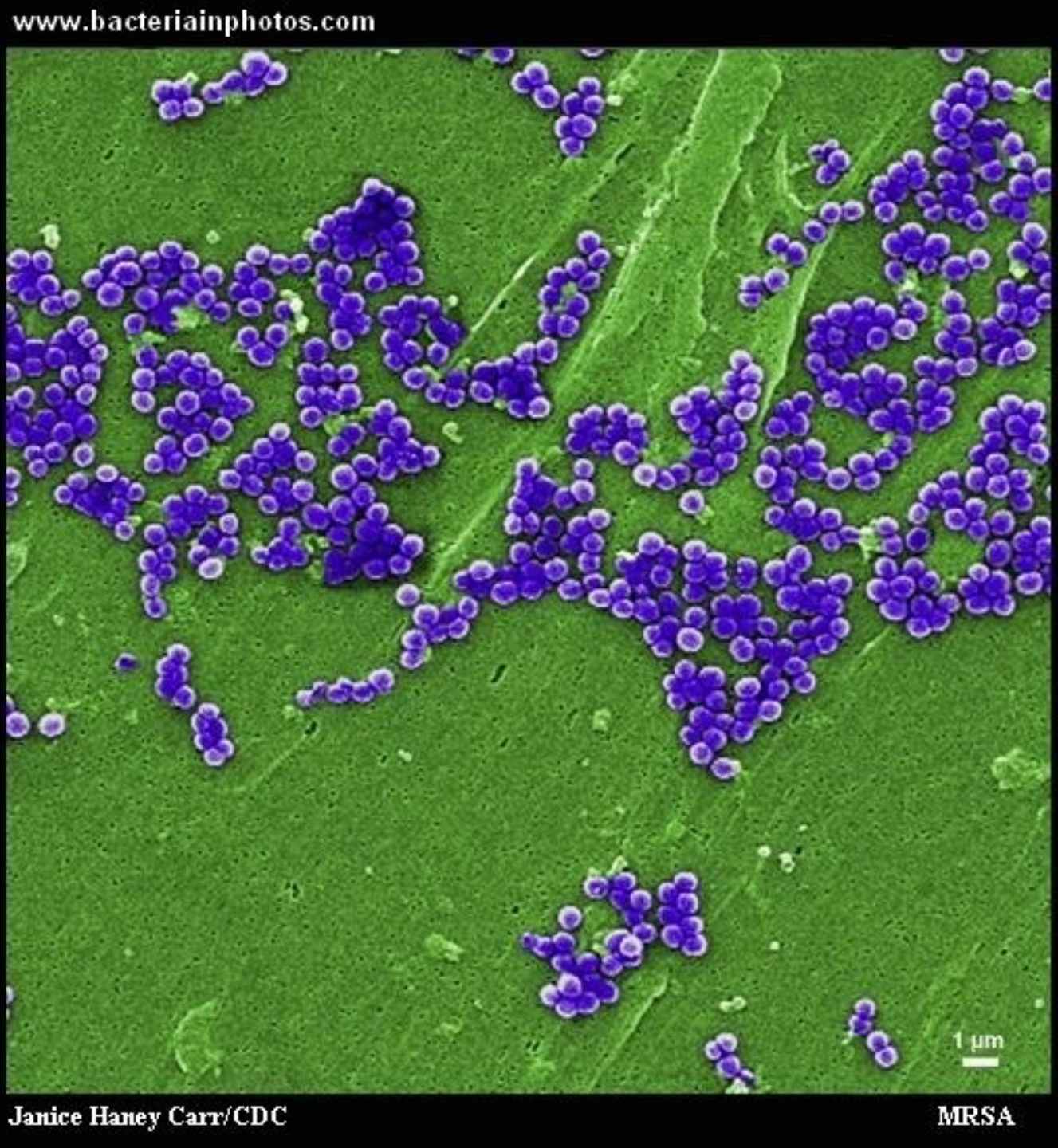


Proportion from bodies



Proportion from bodies





Every day you breathe in thousands of species. In addition, you fail to be exposed to most of the species your ancestors breathed in and slept on. Some of each group can kill you. Most are benign. Some you depend upon for life and we really can't distinguish these three groups yet.

>200,000 species

(which is to say, we have mostly revealed our ignorance)

The Bad

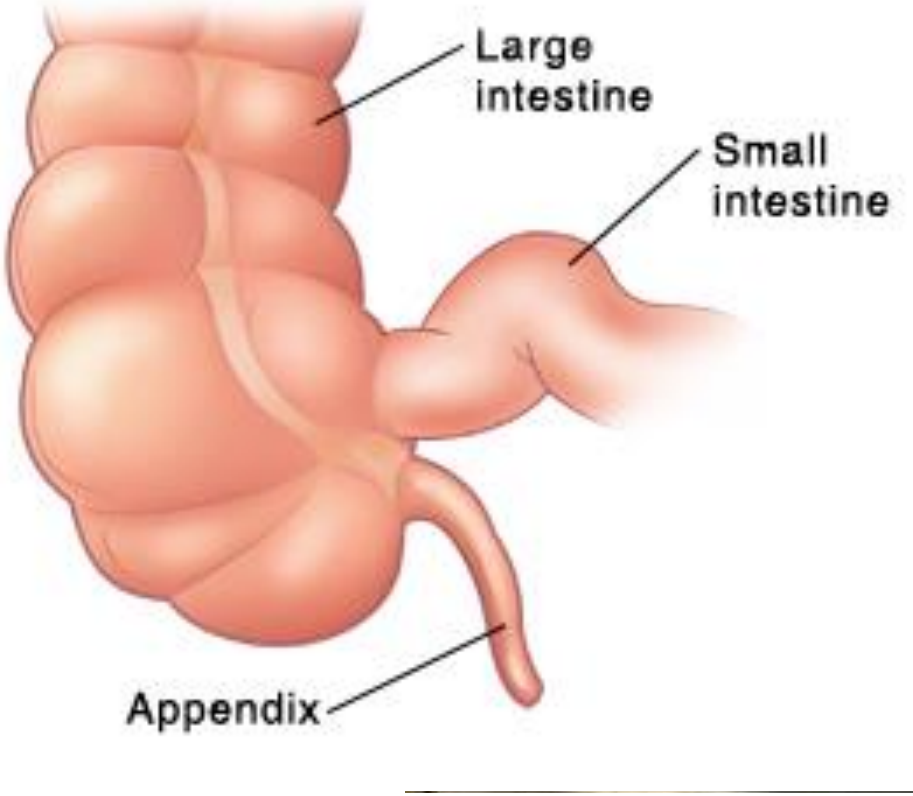
- To get rid of bad
  - Vaccinate
  - Wash Hands
- To avoid favoring bad
  - Don’t overuse antibiotics
  - Don’t use antimicrobials
  - Don’t use antimicrobials!

Take Home

- We imagine our houses to be sterile
- They are full of hundreds of thousands of species
- Most of those species are not well studied (or studied at all)
- Overuse of antibiotics, use of antimicrobials favors BAD species
- Favoring beneficial species will take MUCH more science

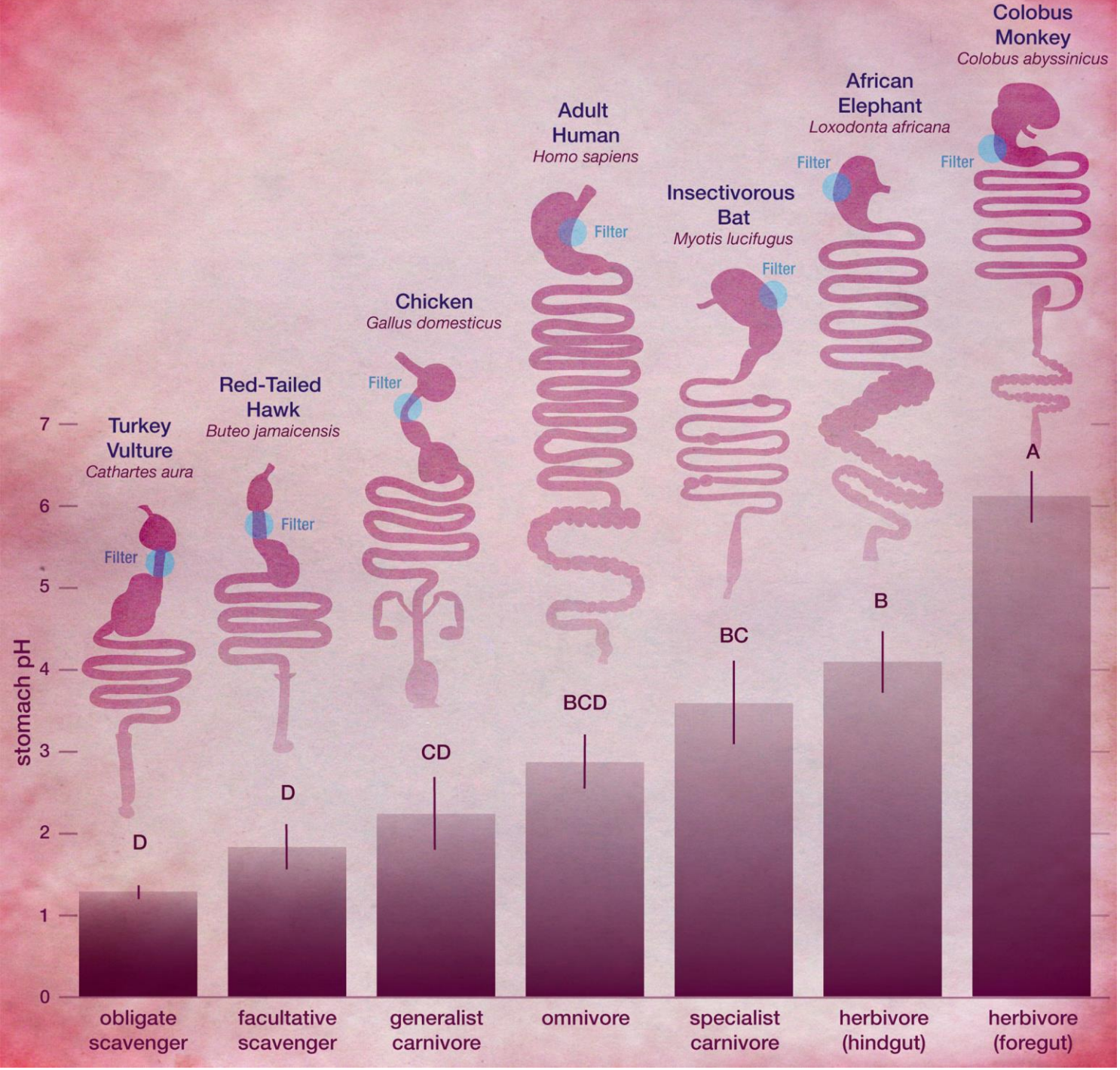
Should we redesign the indoors?

Appendix (as garden)



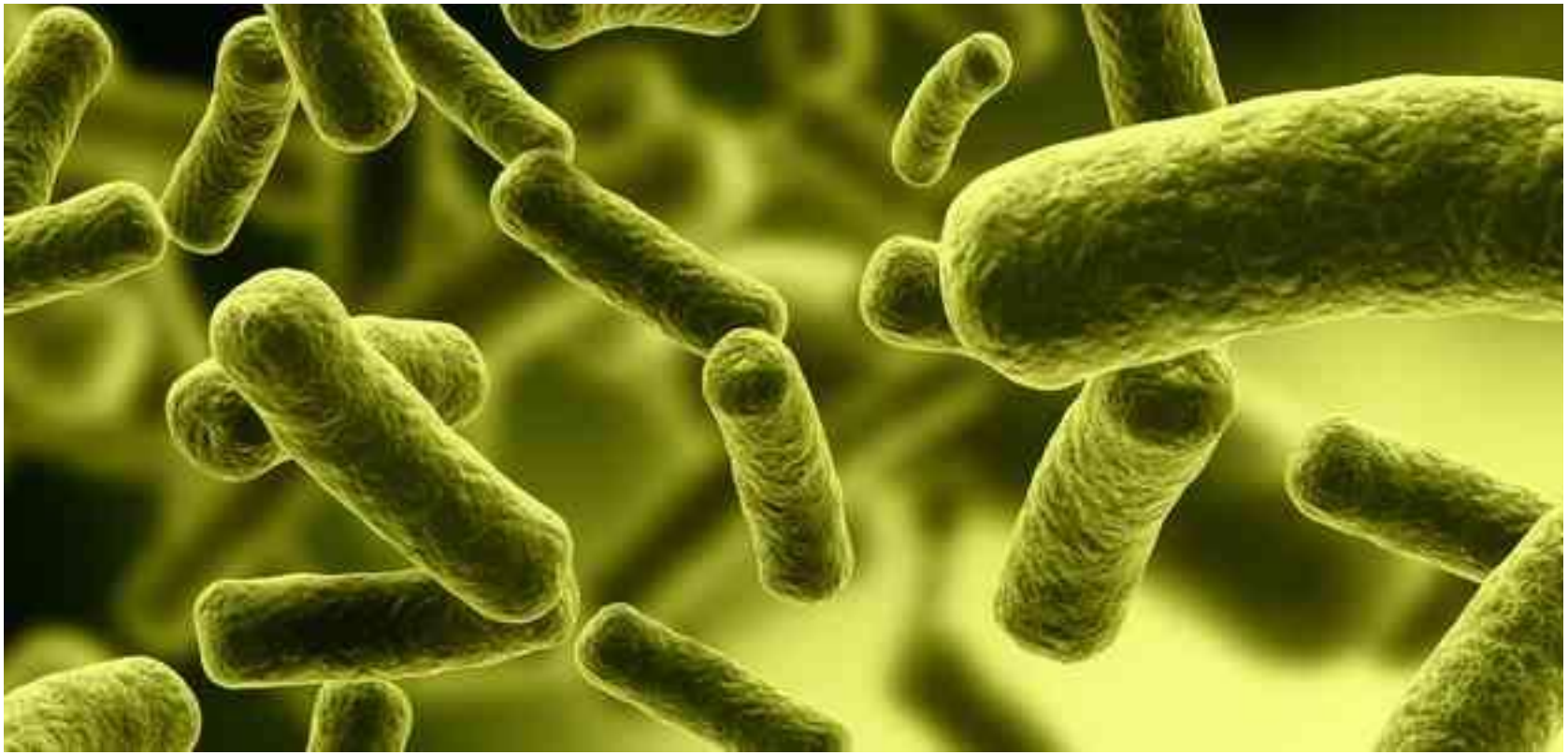
Similar stories for microbes in armpits, vaginas, guts, and stomachs.

Stomach as filter



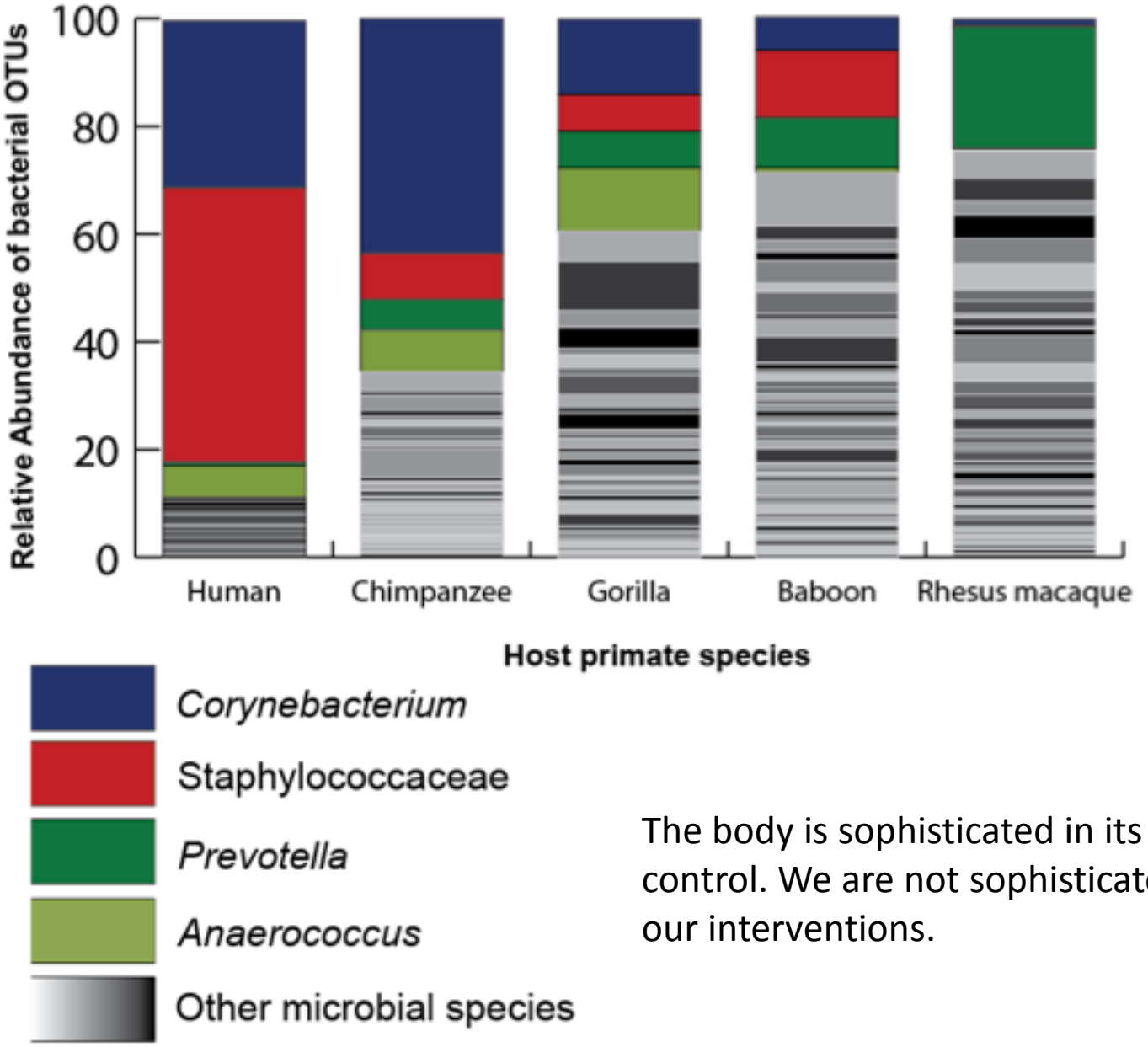
Also, see gastric bypass, proton pumps and age.

Large Intestine as Selective Benefactor

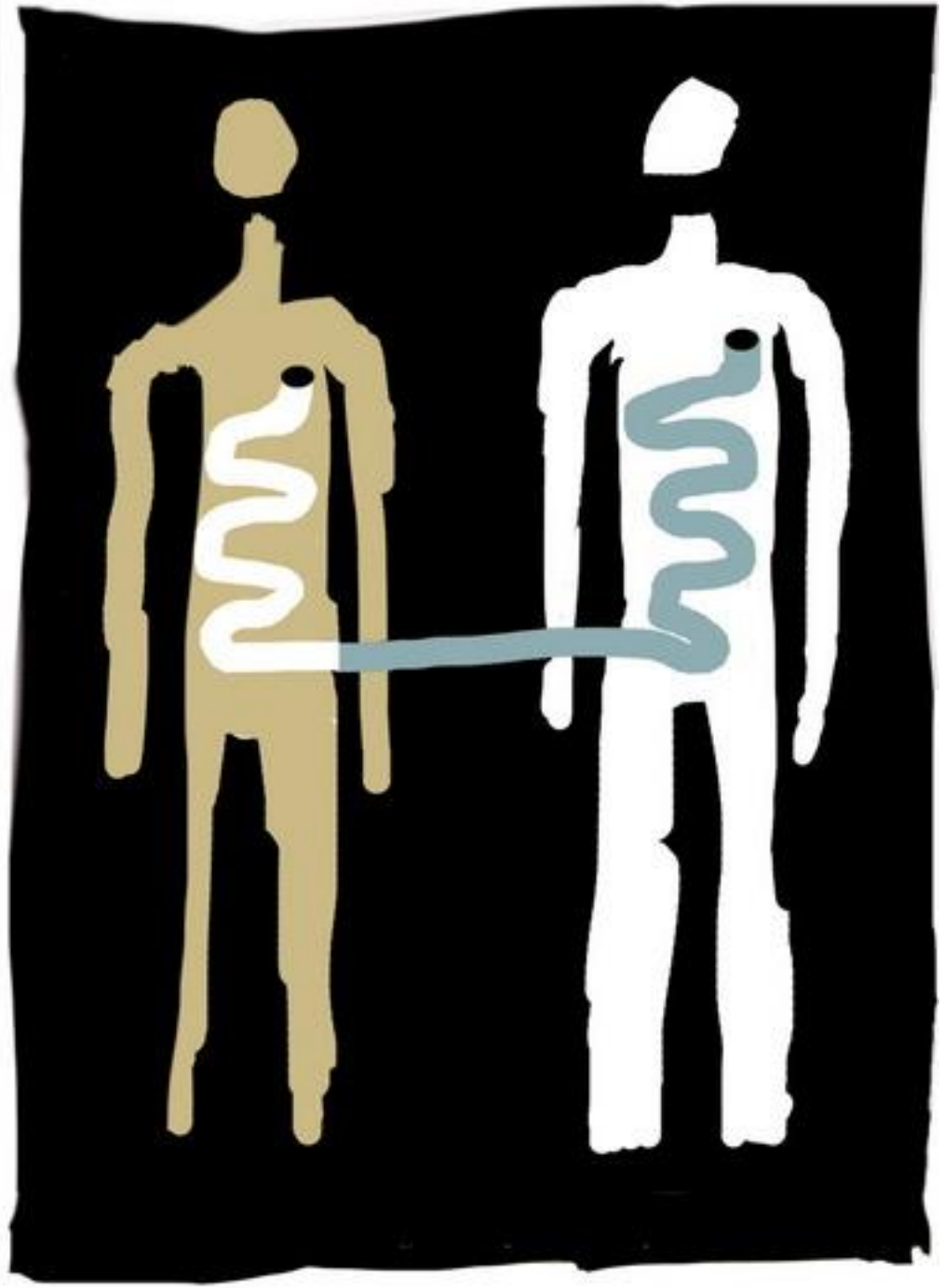


Bacteroidetes bacteria, which host nitrogen (in mucin) feeds in order to help break down complex carbohydrates. Work by Aspen Reese.

Armpit Organ as Food and Home



The body is sophisticated in its microbial control. We are not sophisticated (yet) in our interventions.



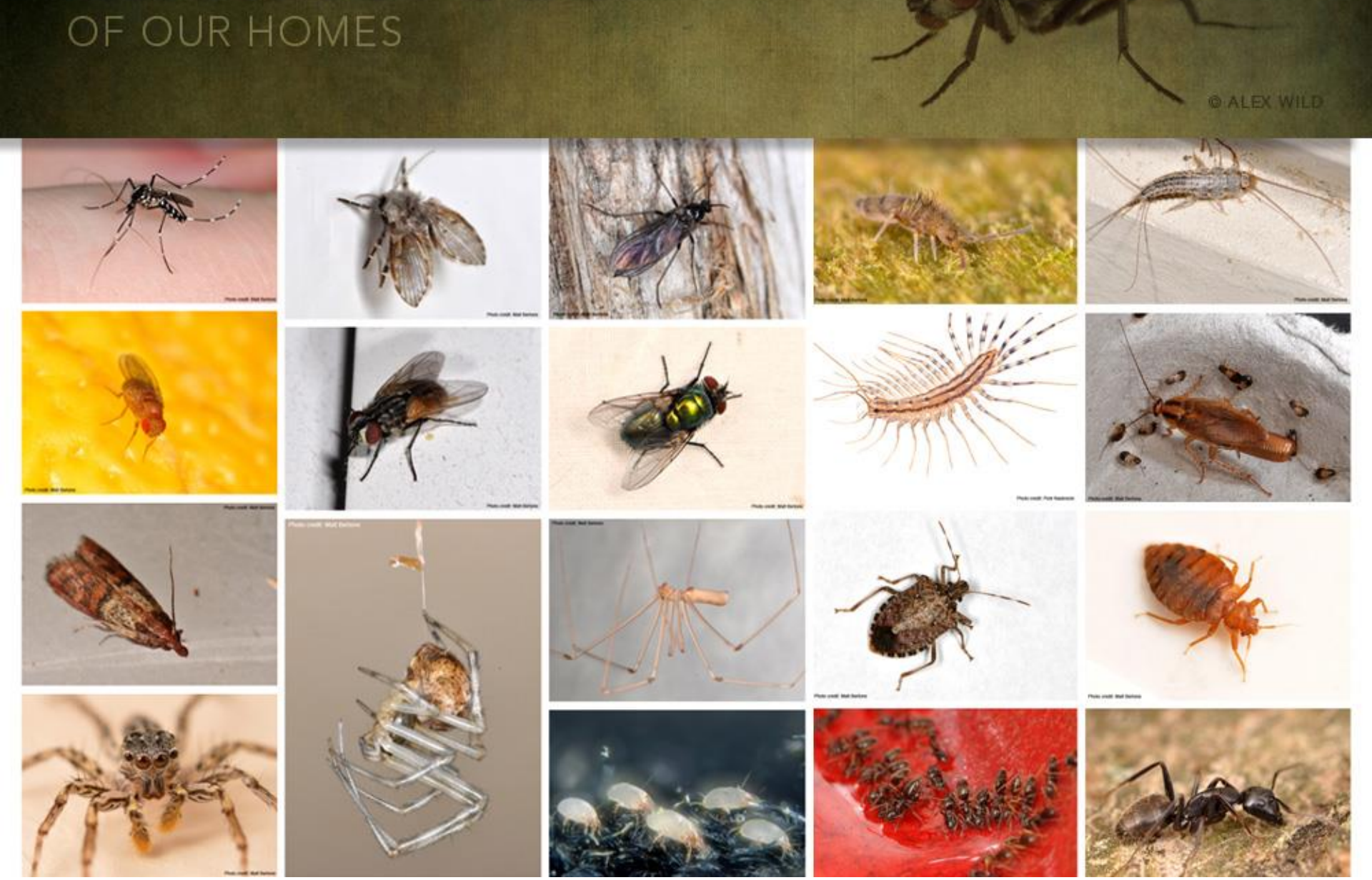
The parable of the fecal sandwich

The parable of the dirt sandwich

The parable of the open window

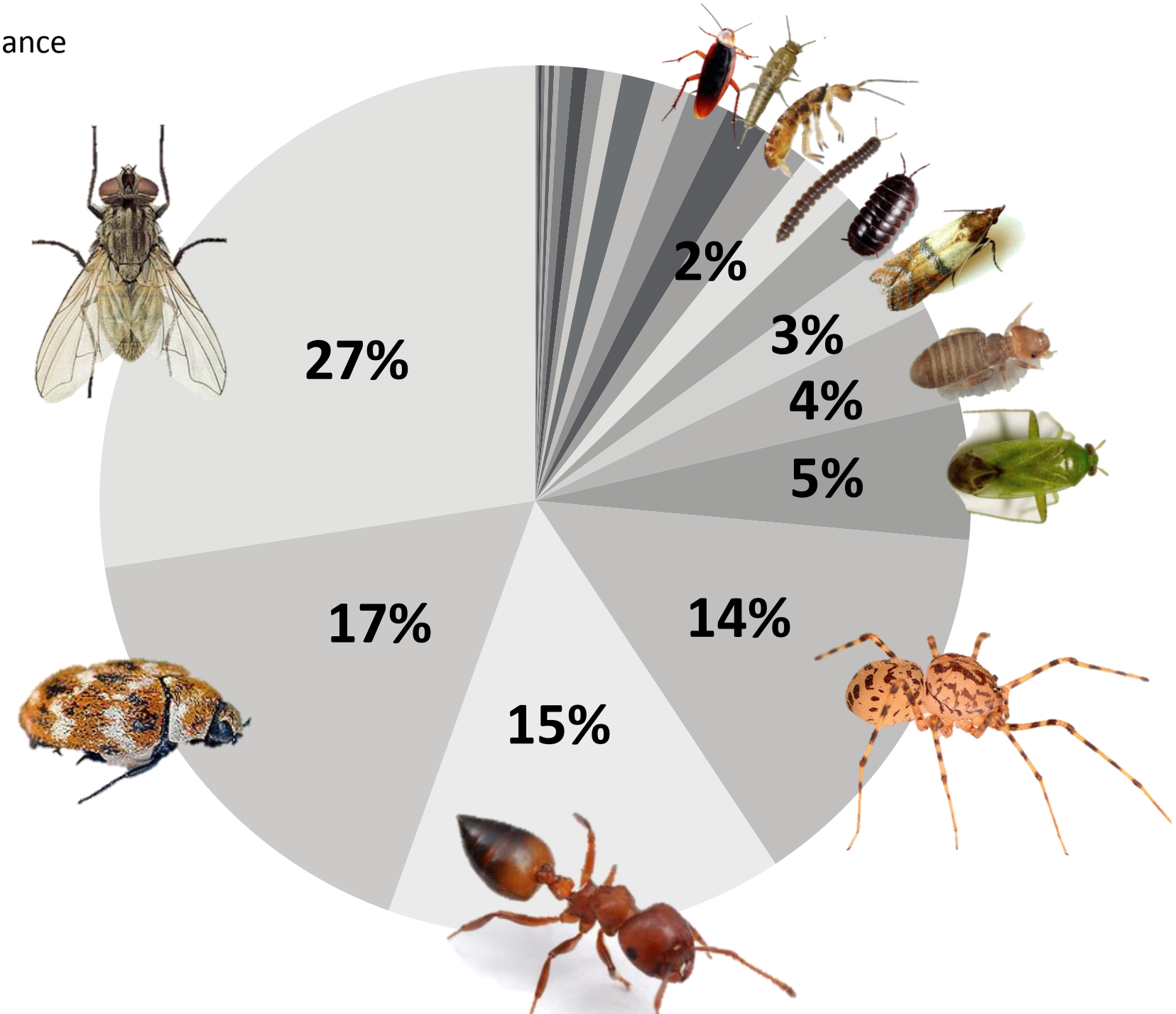
1 in 10 Americans spends at least a night in the hospital each year

A twist on which species benefit us?

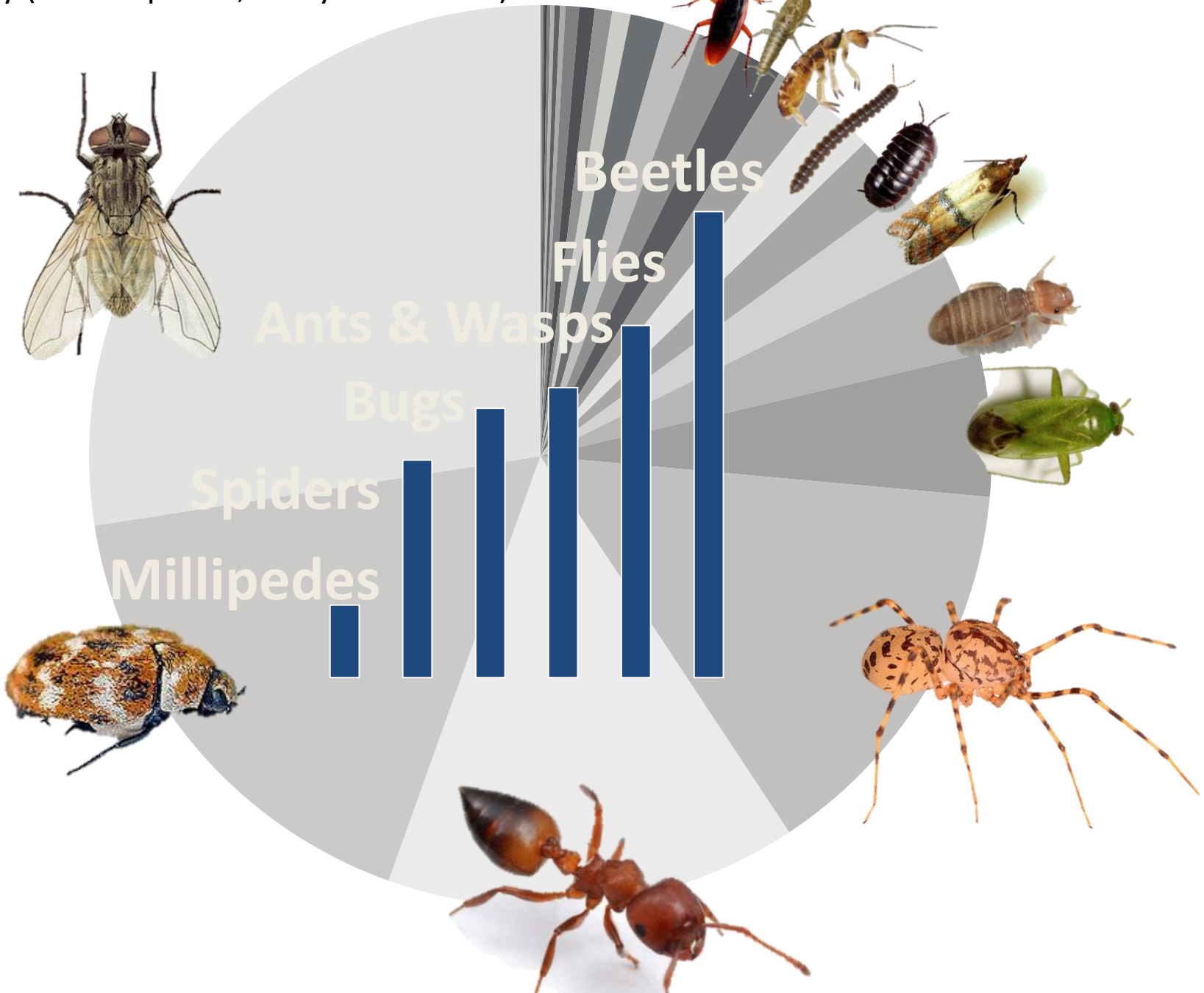


More than 2000 species

Abundance

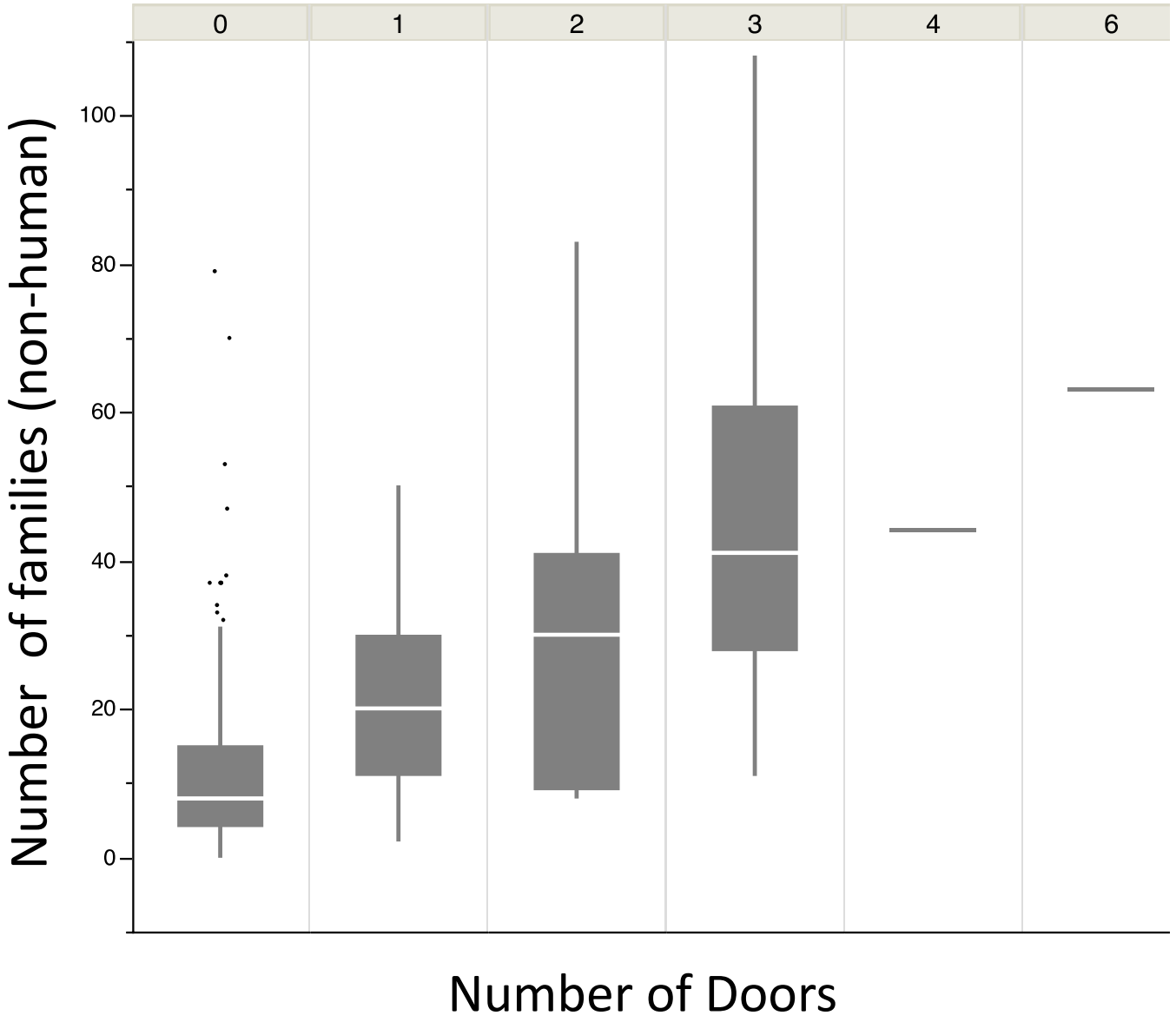


Diversity (>2000 species, many not named)

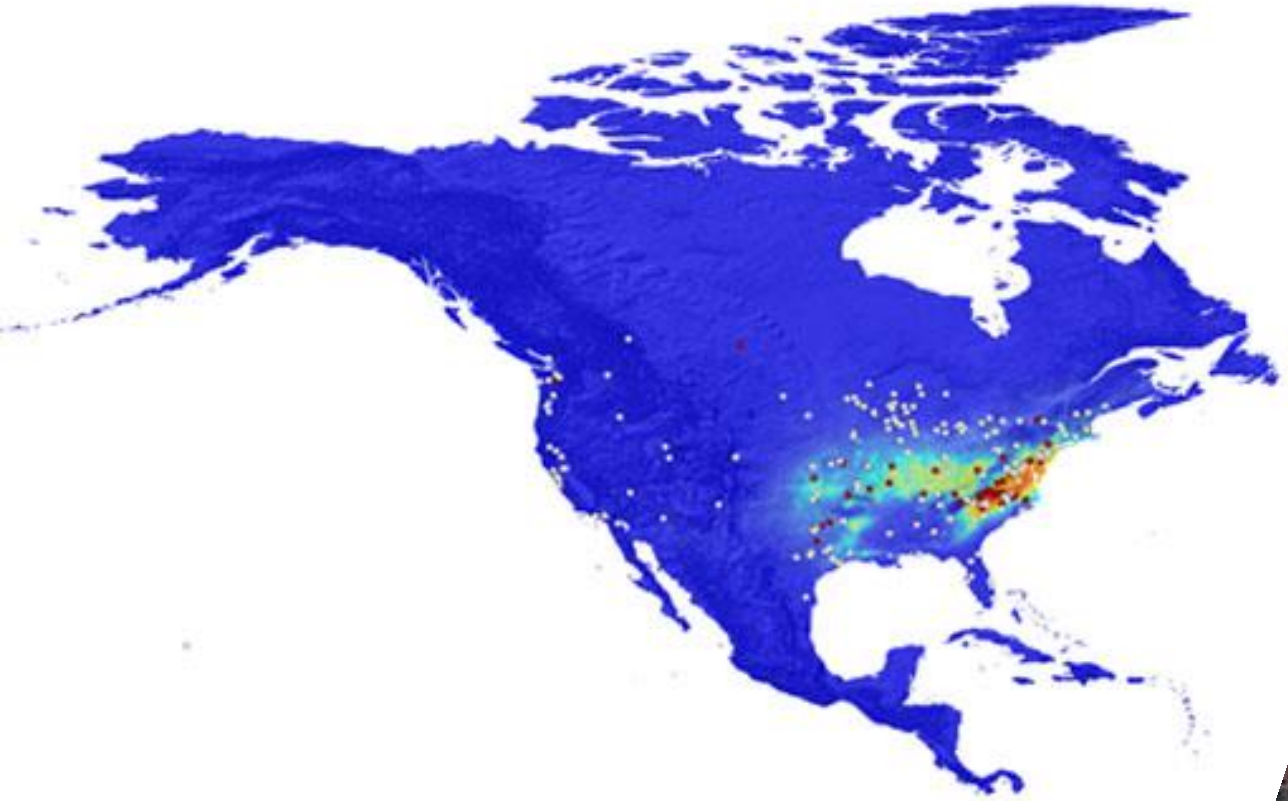


Matt Bertone

More Doors = more traffic in and out and it *also* means **more kinds** of insects



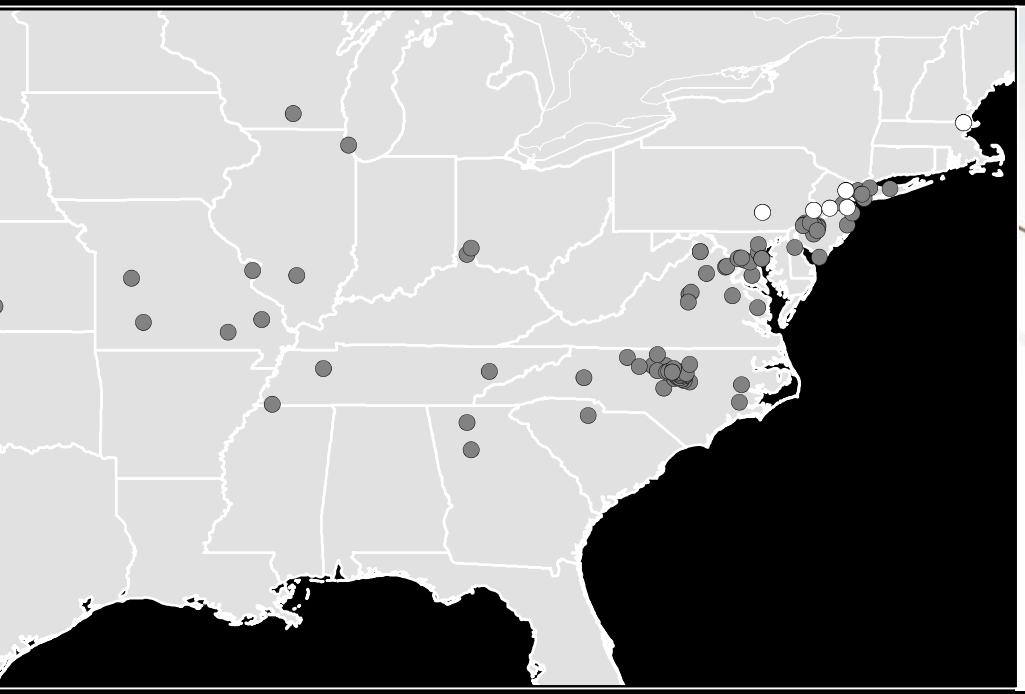
One by one…



Work with MJ Epps

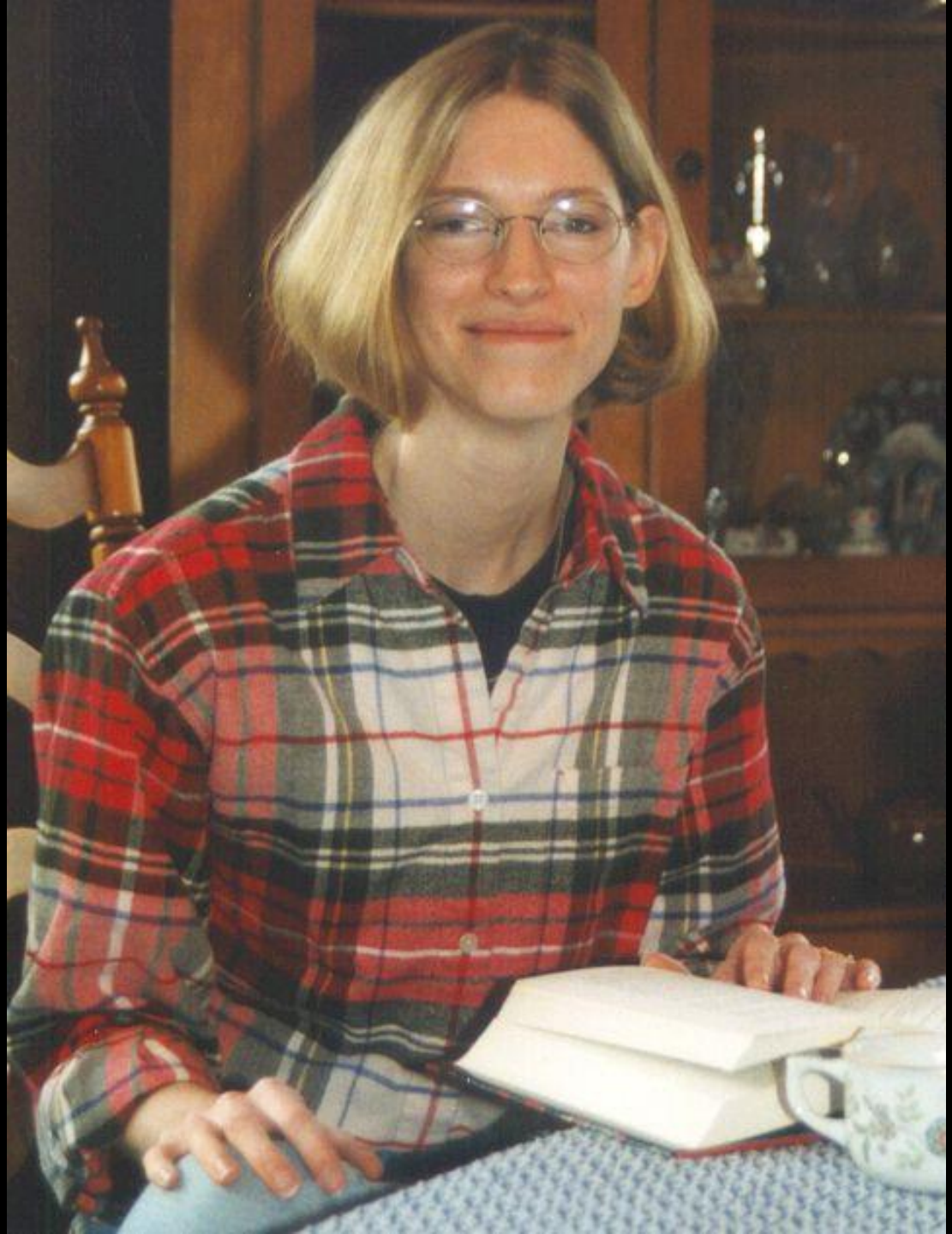

©Piotr Naskrecki 2012

Another species?



Diestrammena japanica

What Good is It?



	Total 78%
Lignin	37,5
Saccharine acids (hemicelluloces)	22,6
Aliphatic acids (lignin, carbohydrates)	14,4
Fat and resinous acids (extractives)	0,5
Polysaccharides (celluloce and hemicelluloces)	3,0

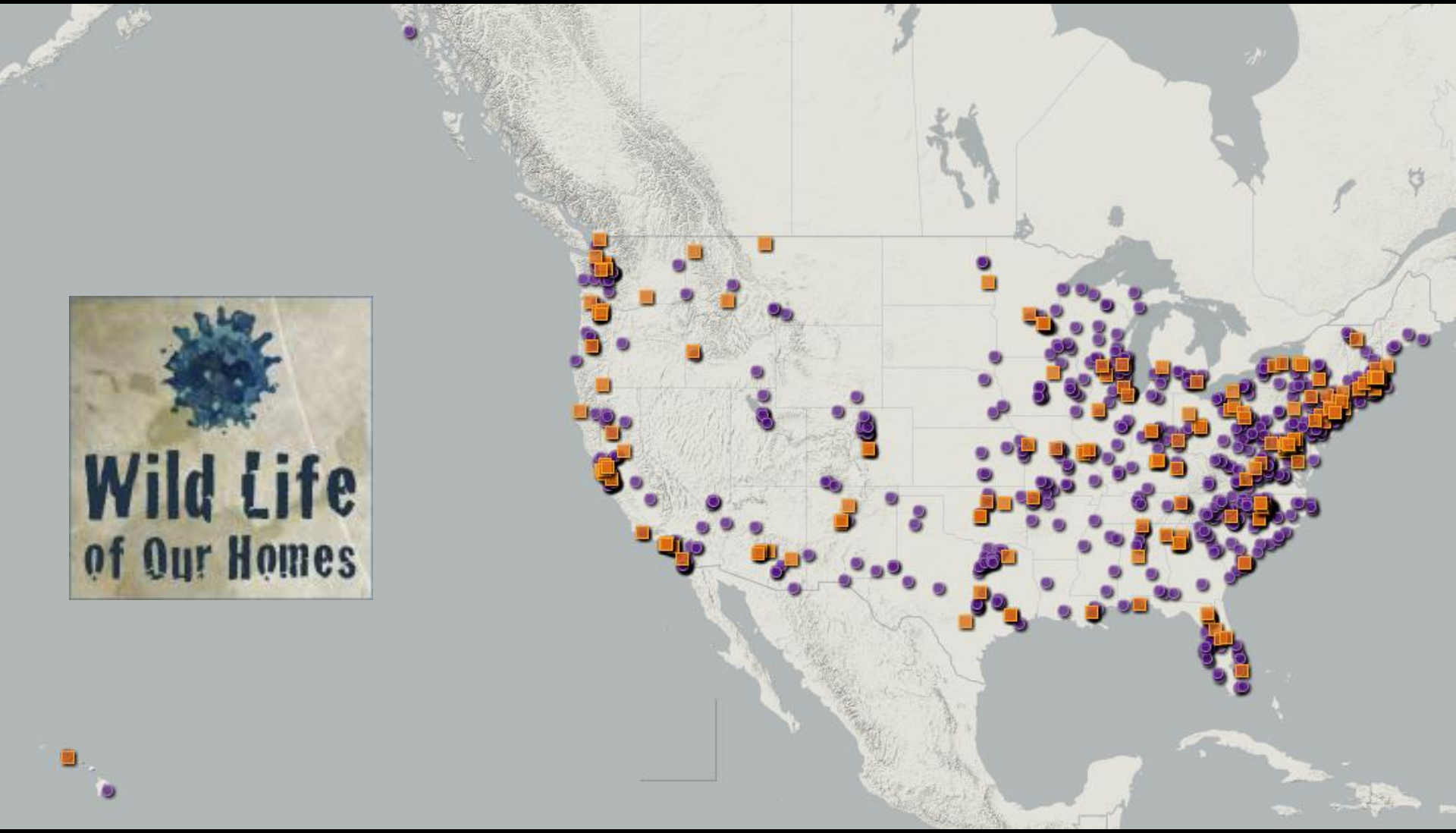
Low odds

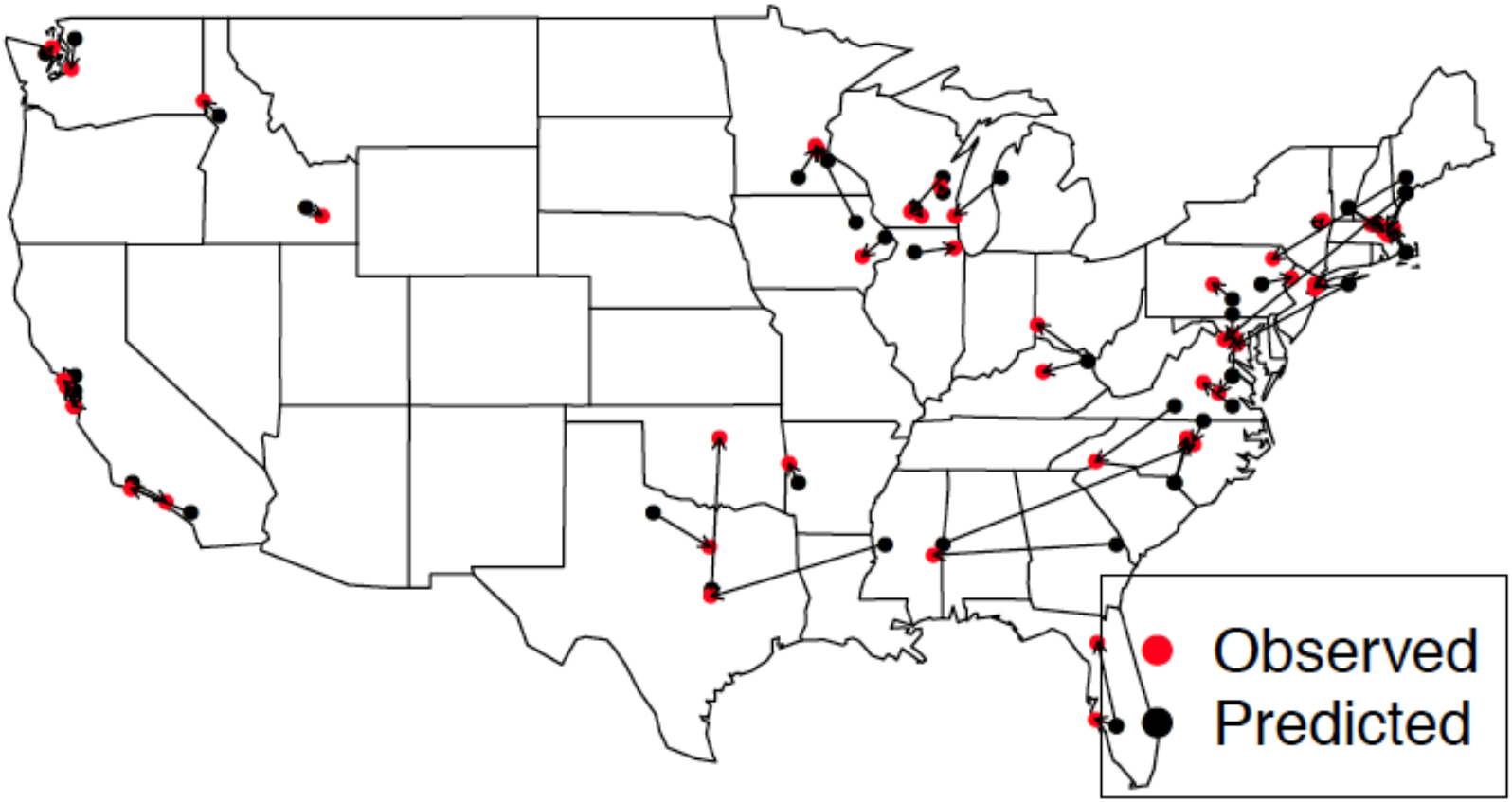
- 4 bacteria species on Earth break down lignin (none super well).

Low odds

- 4 bacteria species on Earth break down lignin (none super well).
- We **found an additional 8 species** that break down lignin, IN AN ACID BATH!


CAVIAR PETROSSIAN PARIS


Wild Life
of Our Homes


Observed
Predicted

Improvised Explosive Devices


Immunosupressants
17,000,000,000,000

Probiotics

New Textiles and Design

Note: We looking for more textile & design partners)

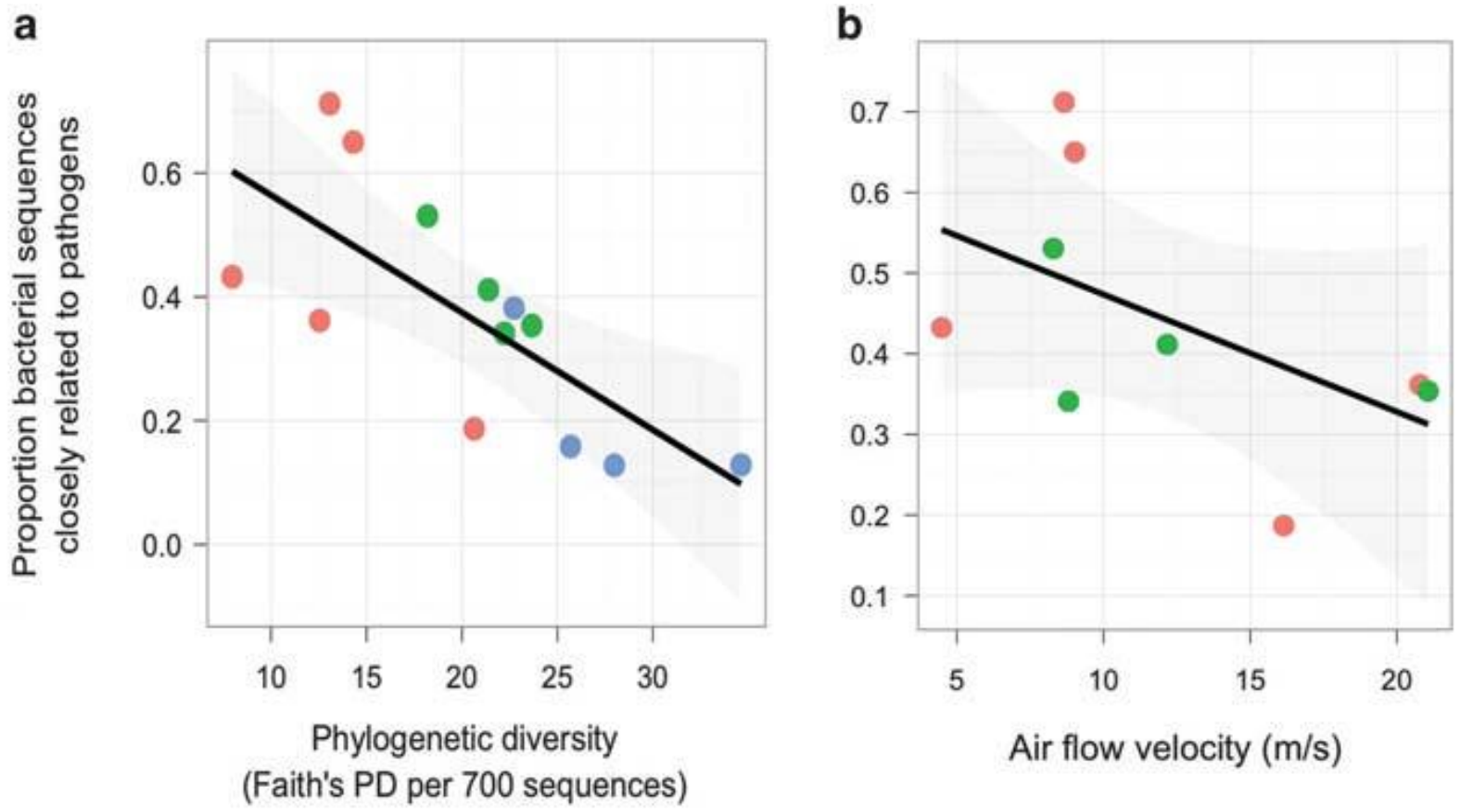
And we have a bunch more examples

Here we confront the astonishing potential value of the species we haven't yet studied. Species we can sometimes find and study in homes (around the world) but that we need to conserve wherever they might be.

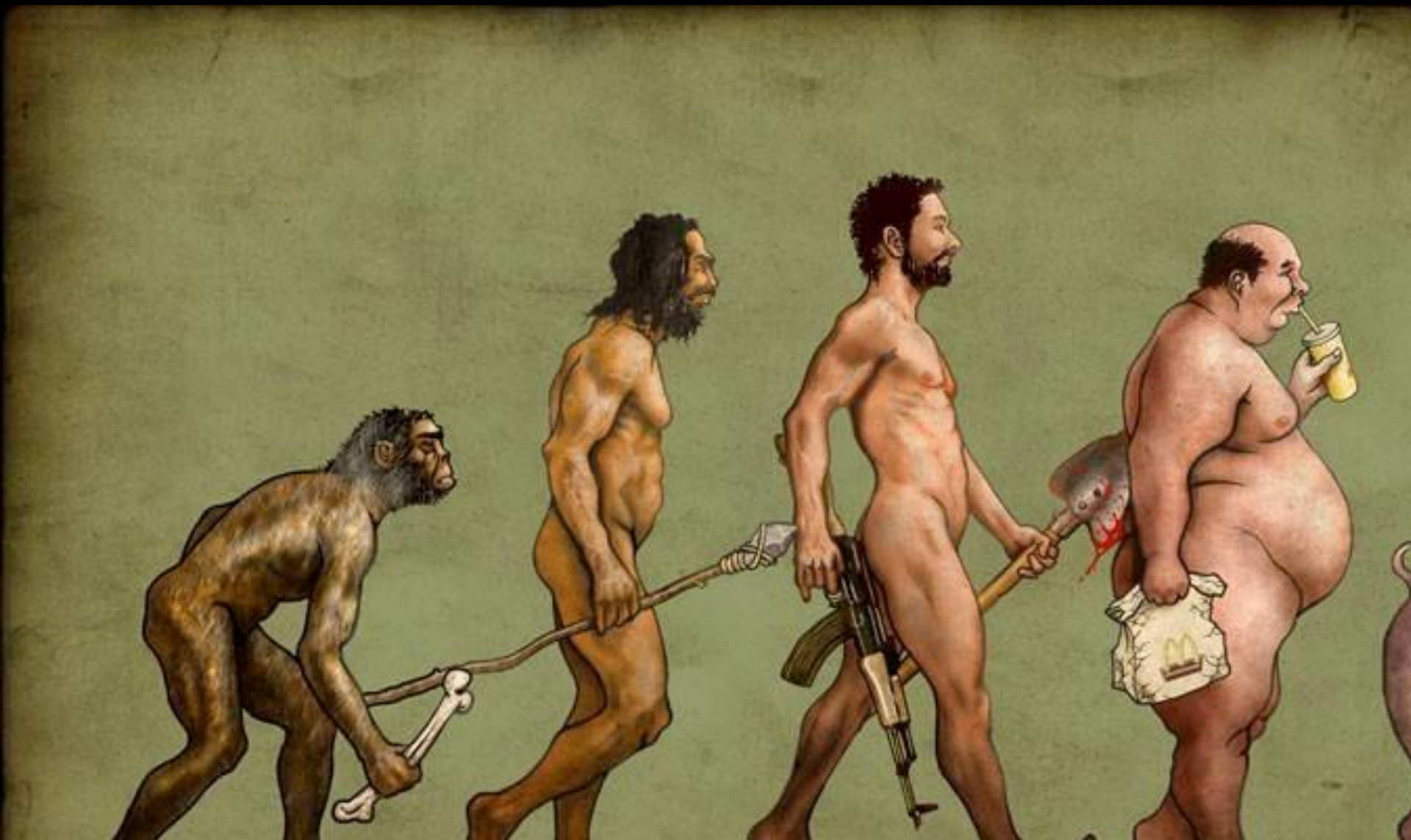
But can’t you name at least one household microbe that we know is good?


CO-WHAT?
KICKED!
YEAST

Food (the end)


a
Proportion bacterial sequences closely related to pathogens
0.0
0.2
0.4
0.6
10
15
20
25
30
Phylogenetic diversity
(Faith's PD per 700 sequences)
b
0.1
0.2
0.3
0.4
0.5
0.6
0.7
5
10
15
20
Air flow velocity (m/s)

Our Shifting Associations

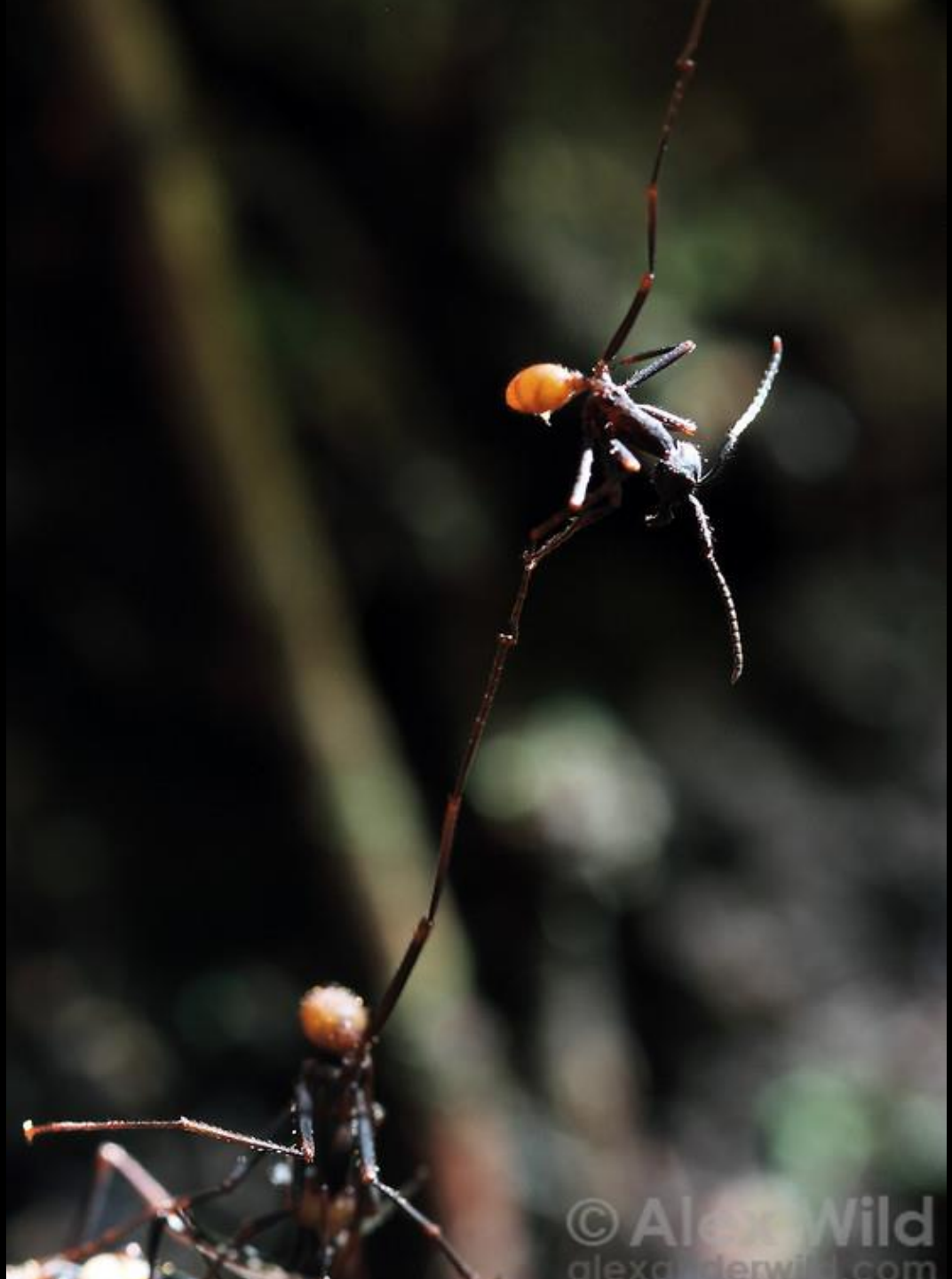



T. K.


© Alex Wild

Neivamyrmex opacithorax, photo by Alex Wild


© Alex Wild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alexanderwild.com

Societal Immortality

Neivamyrmex harrisi male, photo by Alex Wild

But Immortality has Costs

Neivamyrmex harrisi male, photo by Alex Wild


©Alex Wild

Vatesus rove beetle, skimming off society's margins, the urban coyote of ant civilizations

REVIEW ARTICLE (C.W. RETTENMEYER MEMORIAL PAPER)

The largest animal association centered on one spe
ant *Eciton burchellii* and its more than 300 asso

C. W. Rettenmeyer · M. E. Rettenmeyer ·
J. Joseph · S. M. Berghoff

Received: 5 May 2010 / Revised: 28 July 2010 / Accepted: 21
ine: 6 November 2010

Abstract As possibly two of the last tru
Rettenmeyer and his wife Marian dedic
study of army ants and their associa
55 years, the Rettenmeyers wer
mainly to the Central Americ
dreds of self-collected sam
of other scientists, who
It comes as no surp
n-
ıtude
nusiasm.
became the

ords Myrmecophiles · Ant guests · Symbiosis ·
hropods · Tropical ecology · Biodiversity

Introduction

Army ants are functionally defined by sharing a suite of life-history characteristics: they are carnivorous and raid for

To Say Nothing of Gut Microbes, Parasites, etc... This is just animals!

He was alive!

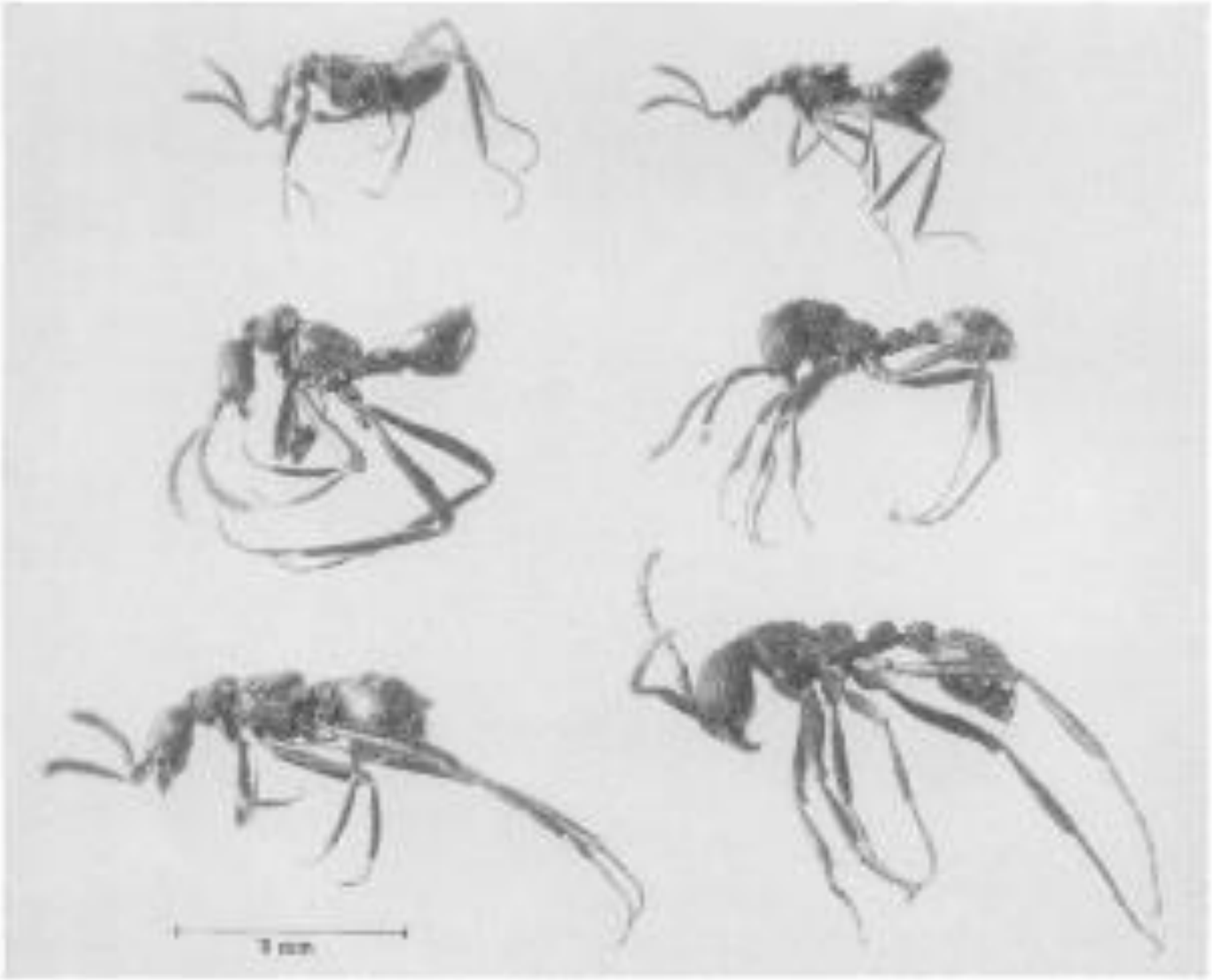
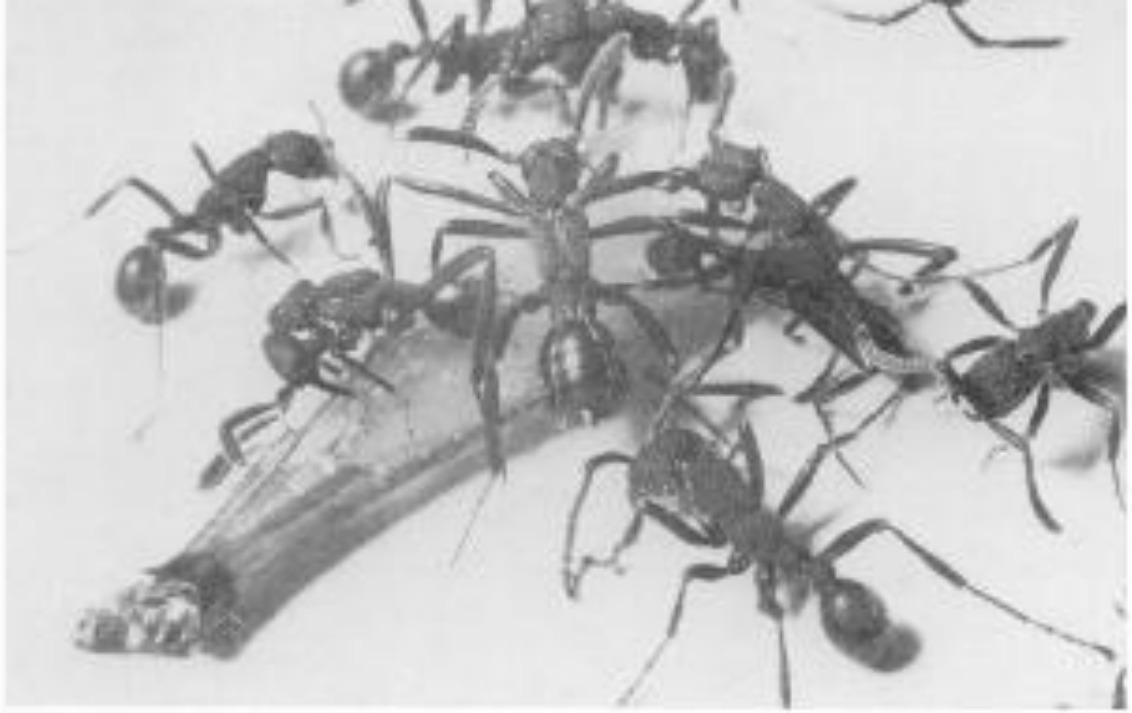
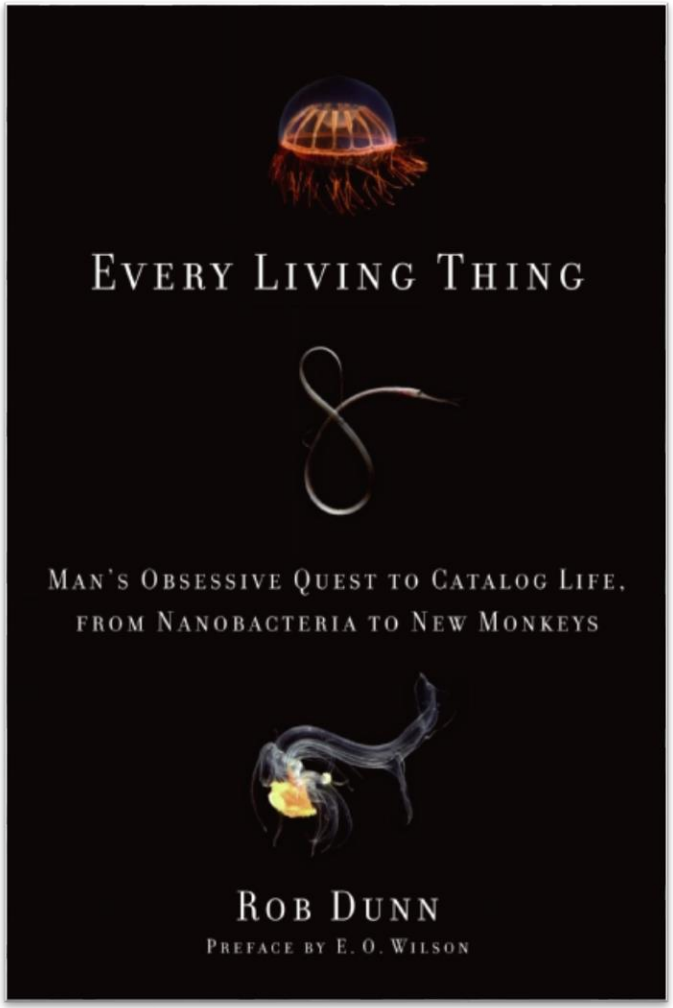


FIG. 9. Three species of Staphylinidae with two workers from their host colony, *Neivamyrmex sumichrasti*. The reddish black color and the punctation on the head and thorax of these beetles closely resemble those of its host. Upper left: *Ecitotima miriventris* Seevers, showing long process of third and fourth segments of abdomen (first and second "gaster" segments) extending anteriorly to front coxae. Upper right: *Ecitosius gracilis* Seevers. Lower left: Male and female *Ecitosius robustus* Seevers.

Ant Yeti

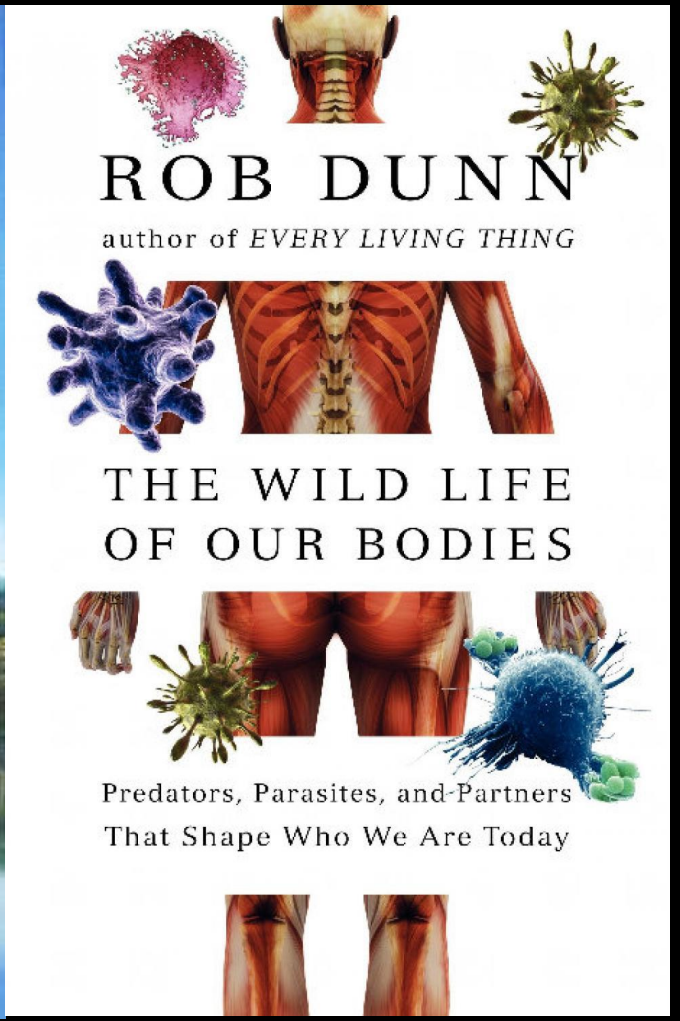


rrdunn@ncsu.edu



Available in Kindle, Paperback and Hardcover on Amazon

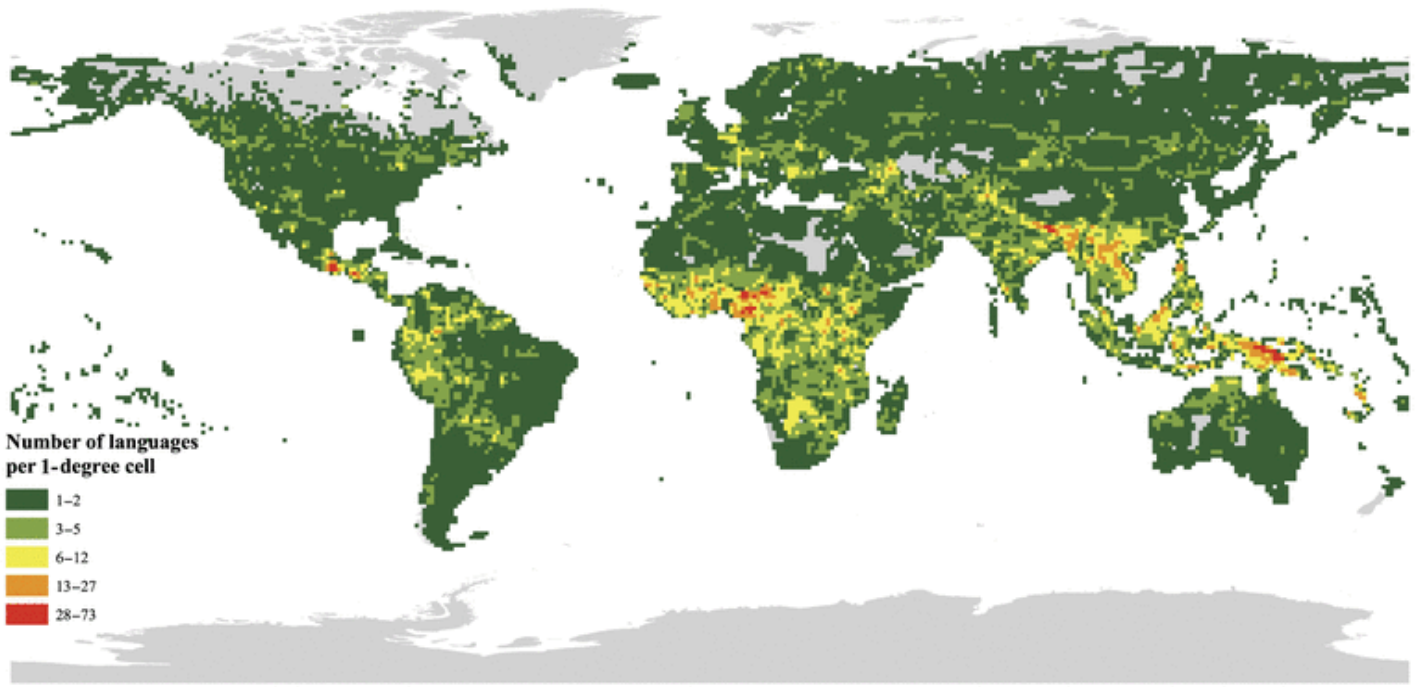
Alexis Rockman



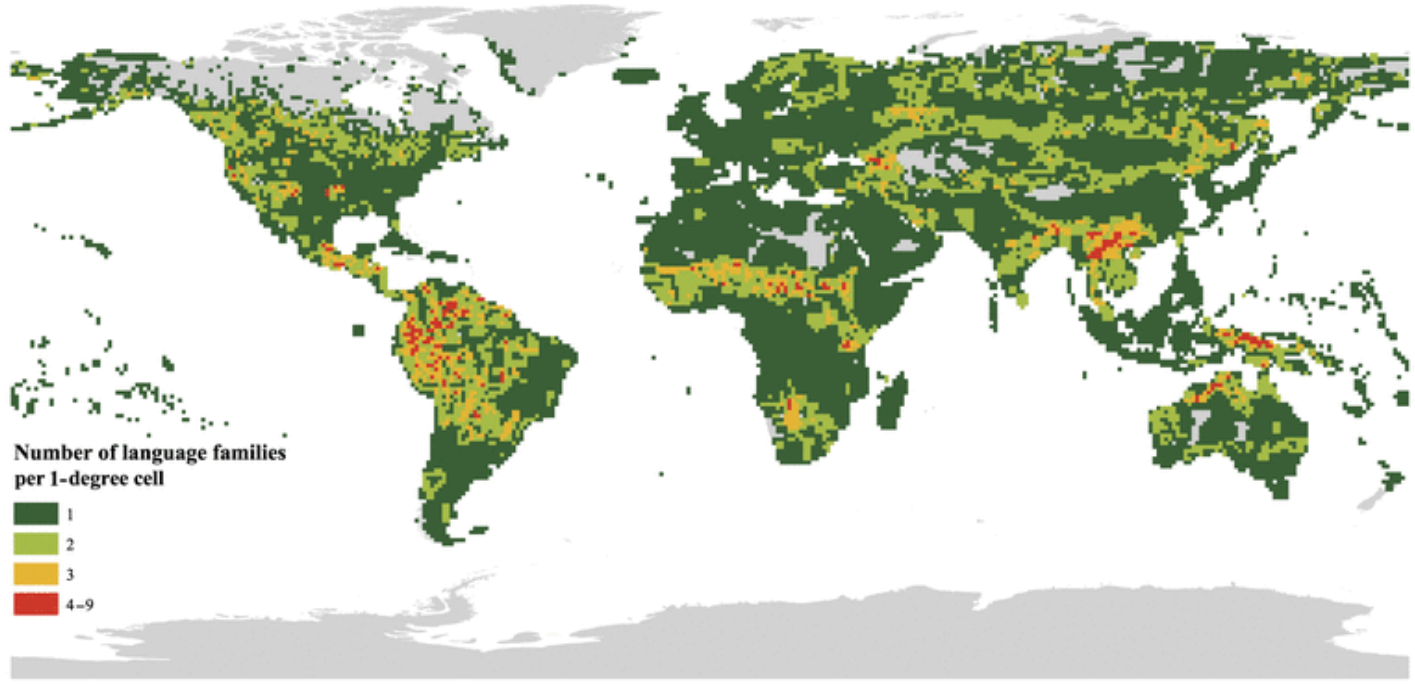
Available in Kindle, Paperback and Hardcover on Amazon

Ron Mueck

a



b

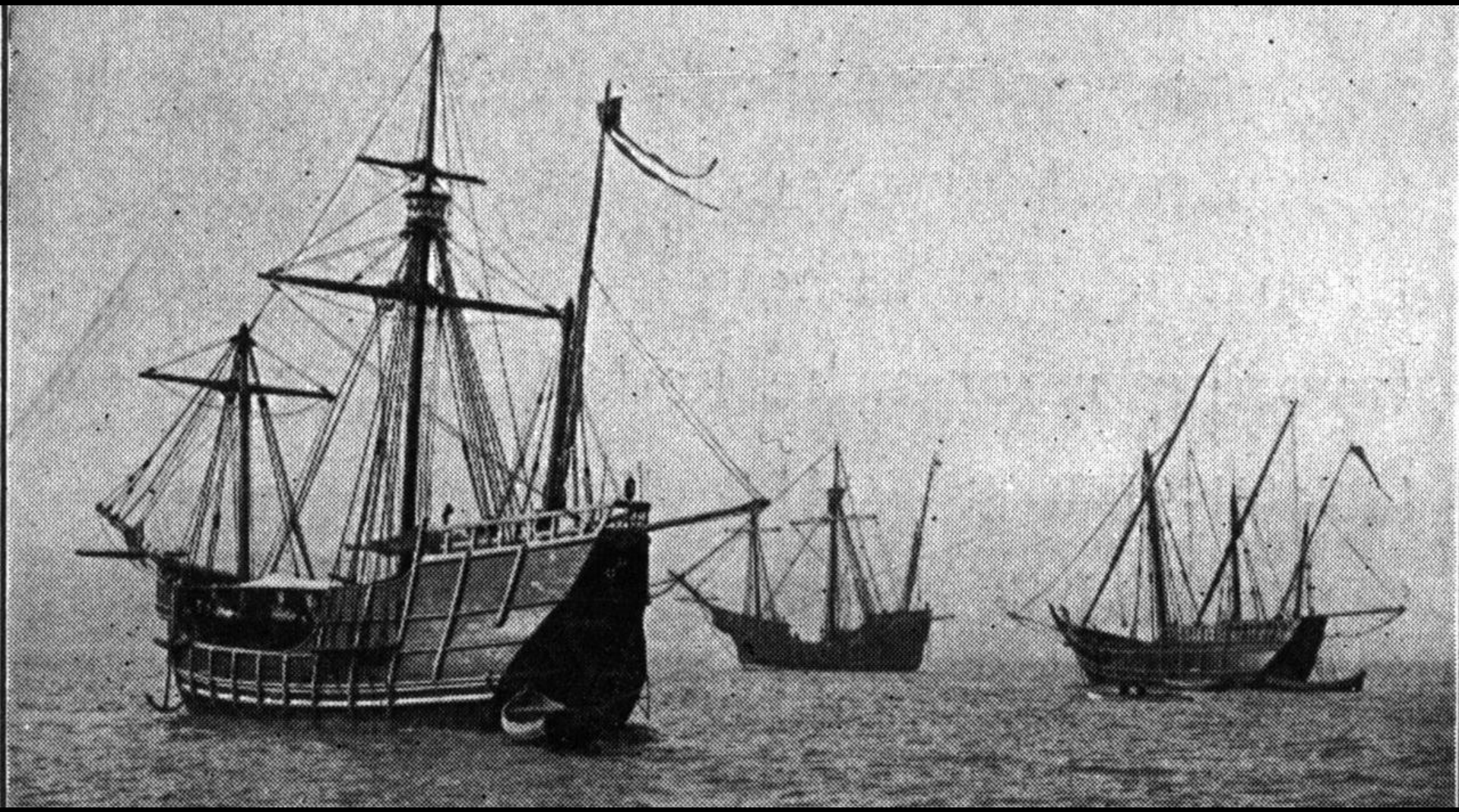


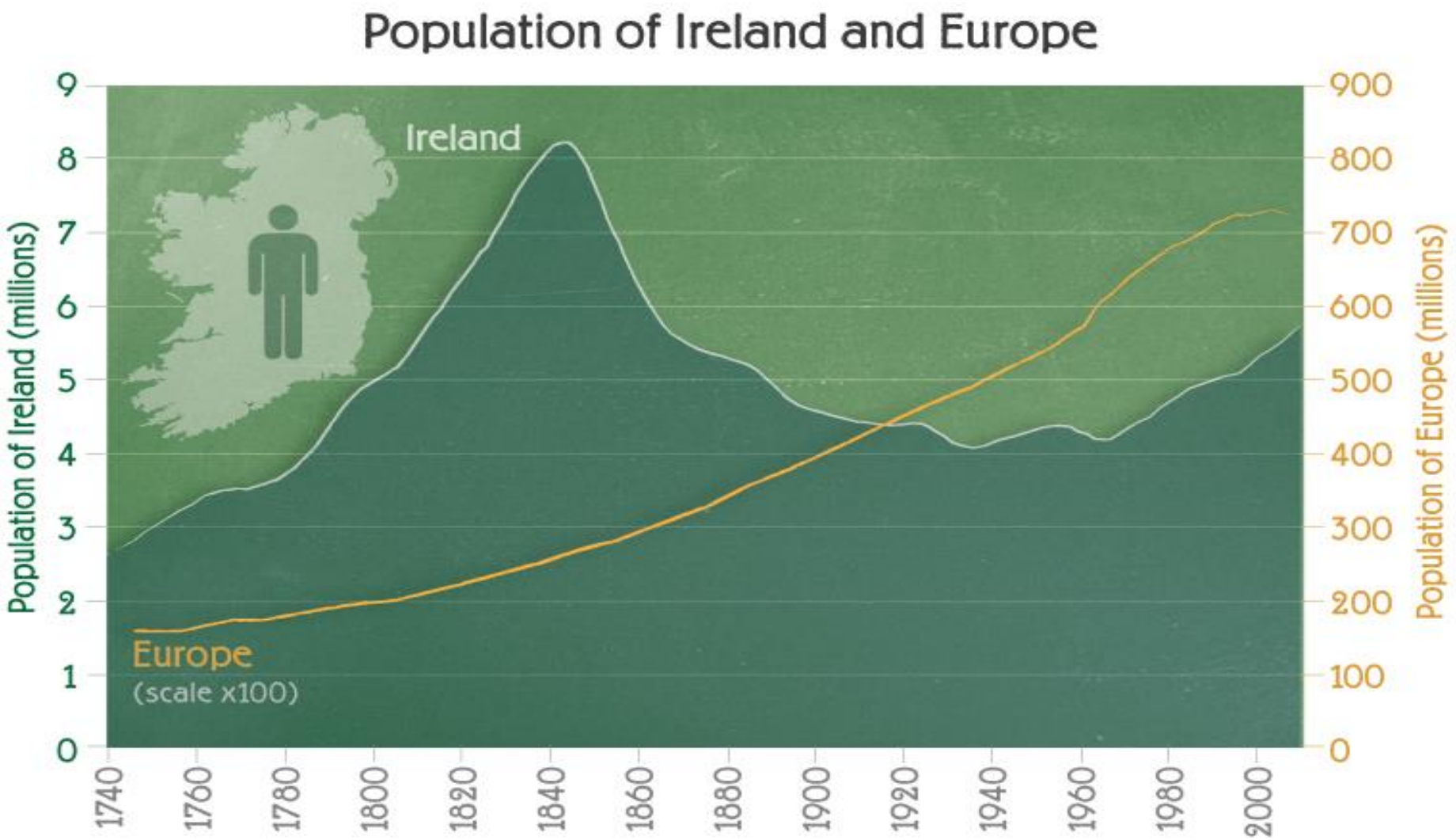
Roughly 30,000 plant species consumed

Centers of Diversity

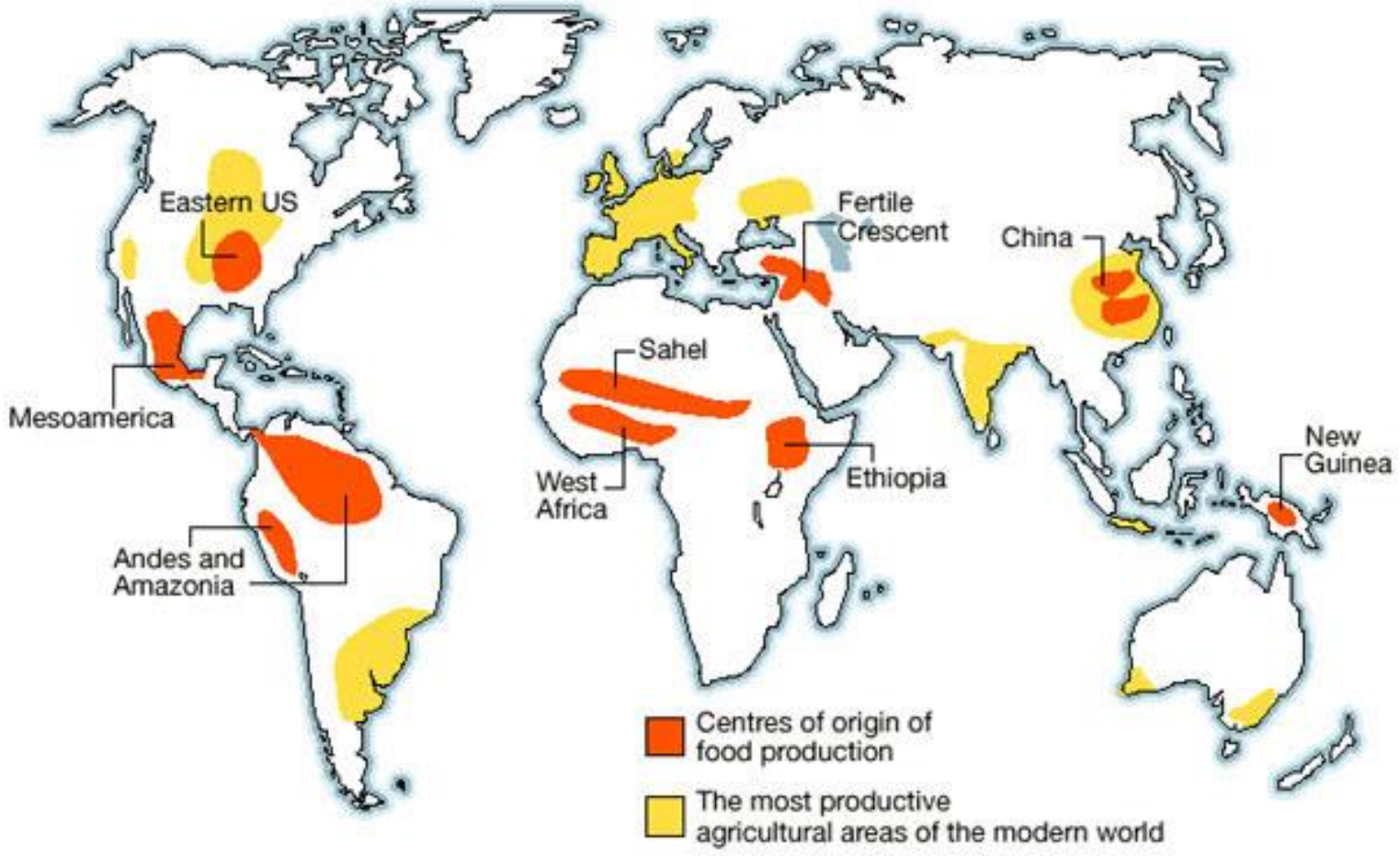
Regional simplification, global diversification (700 species, 1,000,000 varieties)

Global Simplification Begins (and was inevitable)

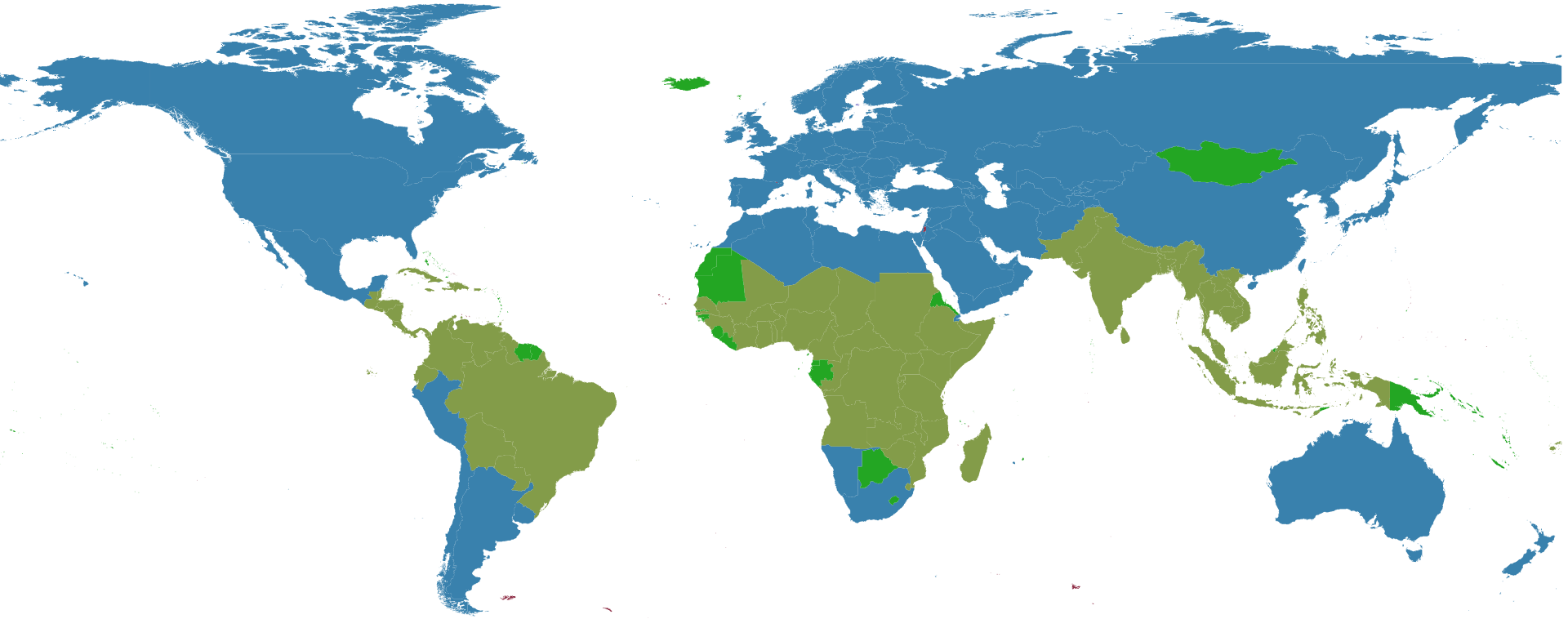


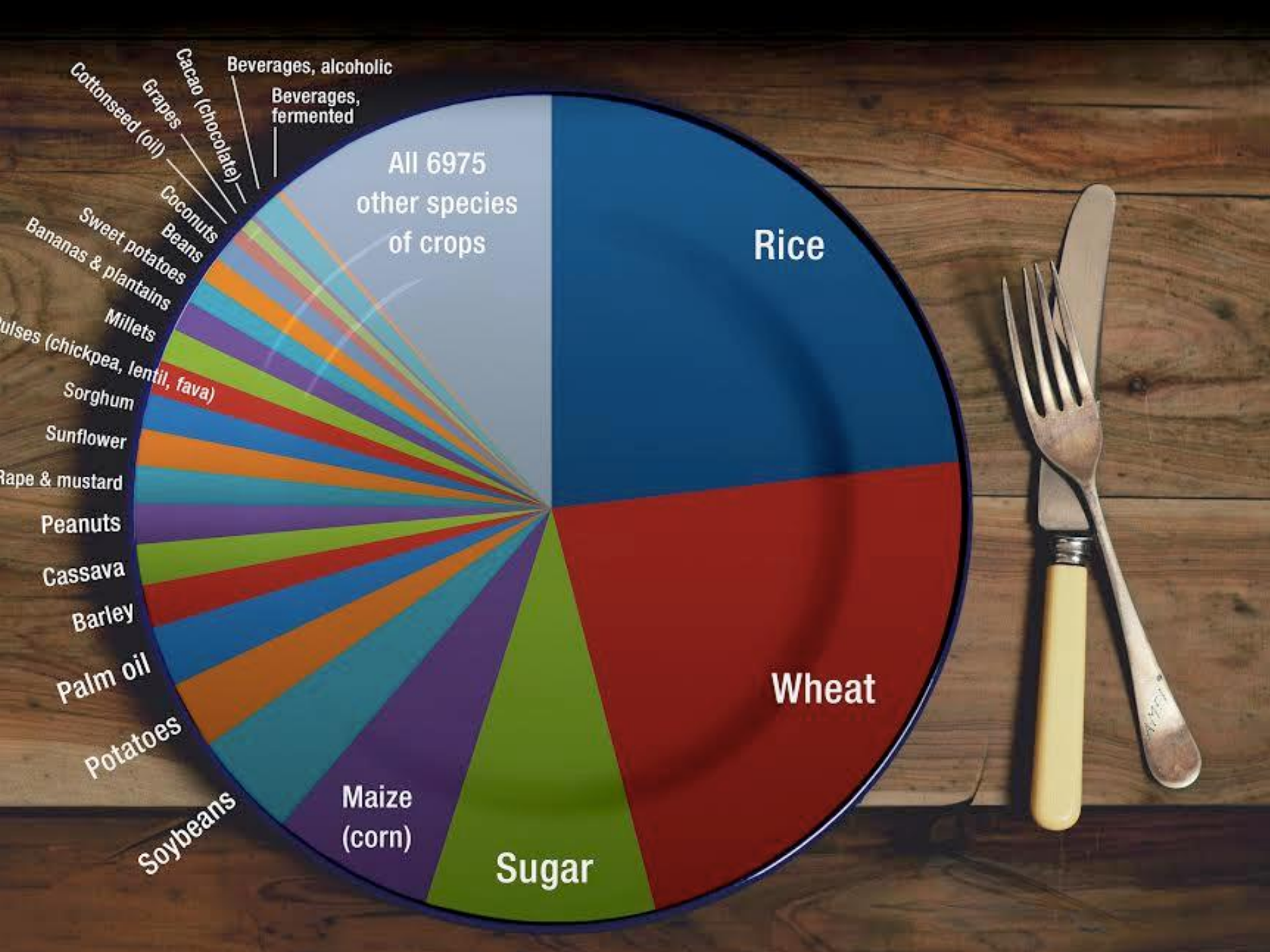

Population of Ireland and Europe
Ireland
Europe
(scale x100)
Population of Ireland (millions)
Population of Europe (millions)
0
1
2
3
4
5
6
7
8
9
0
100
200
300
400
500
600
700
800
900
1740
1760
1780
1800
1820
1840
1860
1880
1900
1920
1940
1960
1980
2000

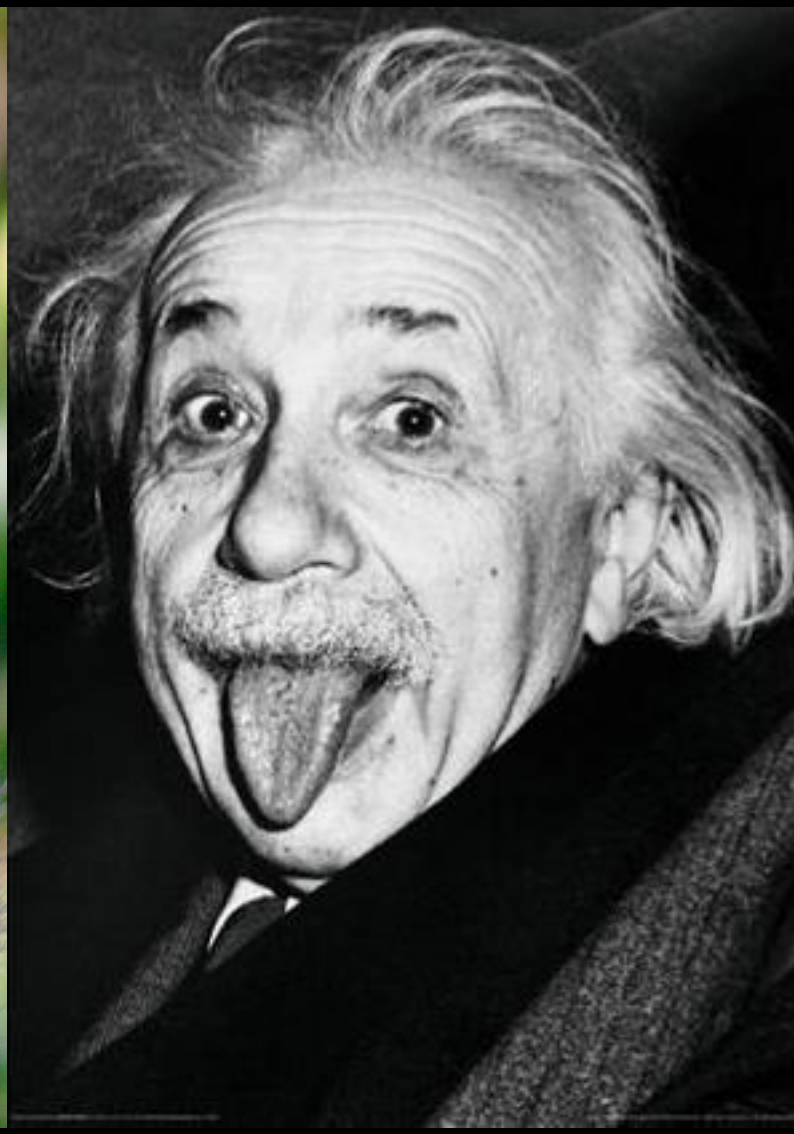
Most food is produced in yellow regions, by few varieties, despite the consequences

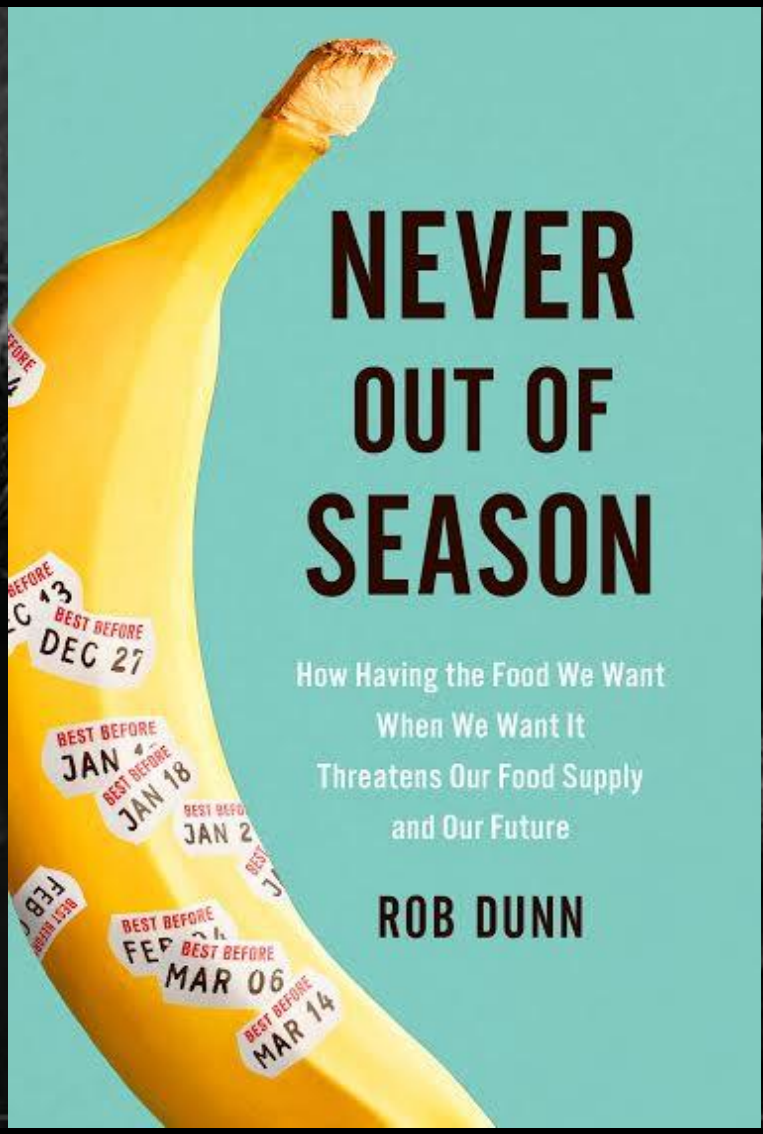


Crop biogeographic regions (2010)



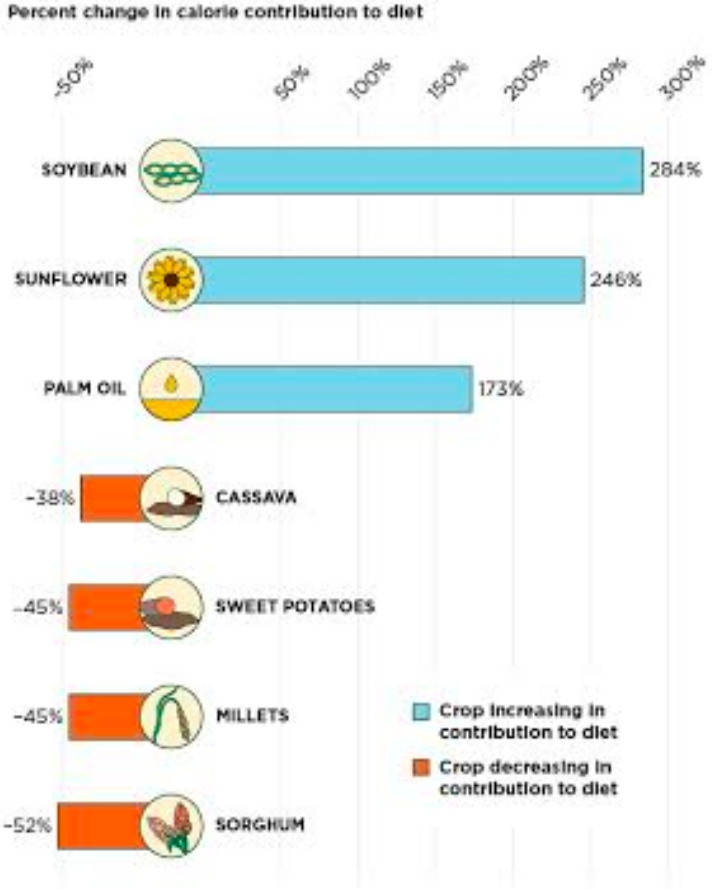

Beverages, alcoholic
Beverages, fermented
Cacao (chocolate)
Grapes
Cottonseed (oil)
Coconuts
Beans
Sweet potatoes
Bananas & plantains
Millets
ulses (chickpea, lentil, fava)
Sorghum
Sunflower
Rape & mustard
Peanuts
Cassava
Barley
Palm oil
Potatoes
Soybeans
Maize (corn)
Sugar
Wheat
Rice
All 6975 other species of crops



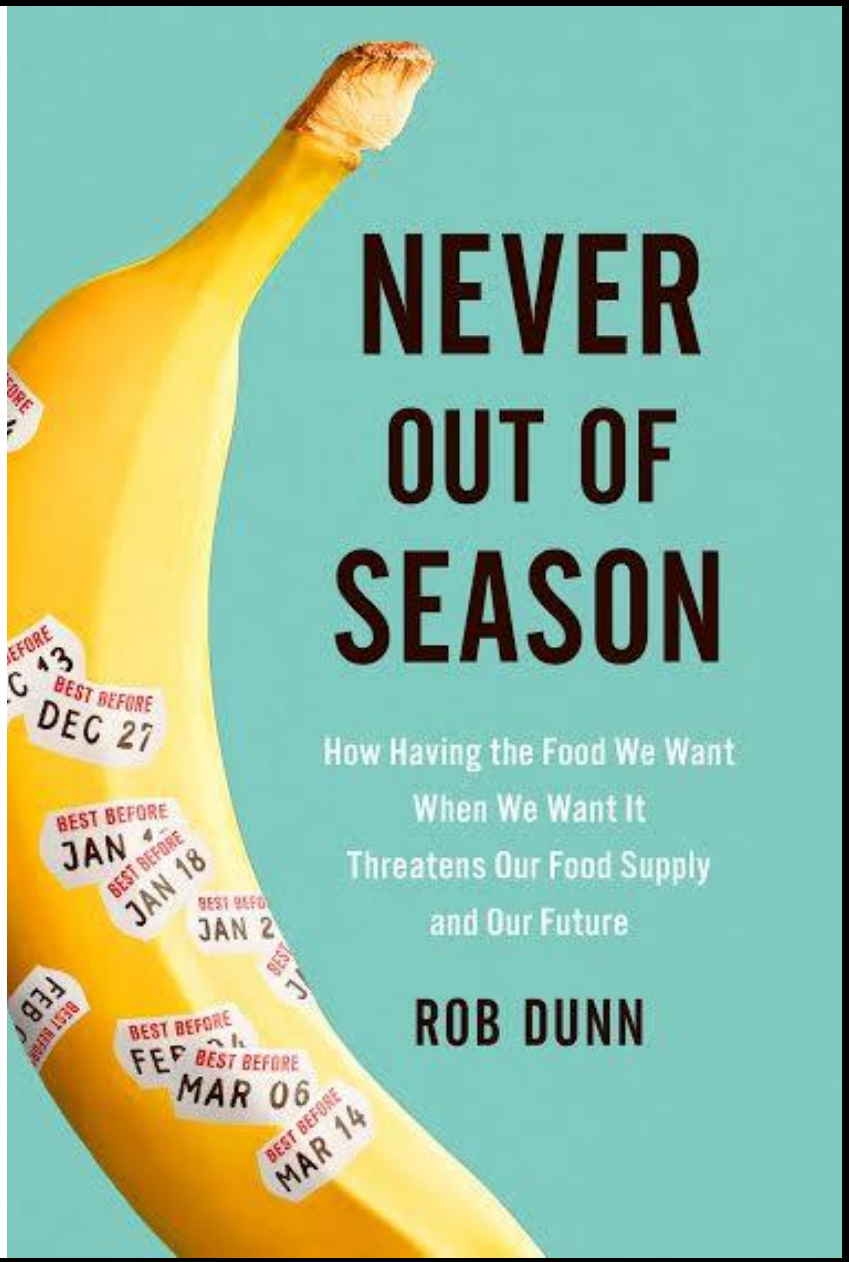

NEVER
OUT OF
SEASON
How Having the Food We Want
When We Want It
Threatens Our Food Supply
and Our Future
ROB DUNN
BEST BEFORE
DEC 27
BEST BEFORE
JAN 18
BEST BEFORE
MAR 06
BEST BEFORE
MAR 14

Over the last 50 years, the global diet has shifted dramatically, including greater amounts of major oil crops and lesser quantities of regionally important staples.

Average change in the calories from crops in national diets worldwide, 1961–2009

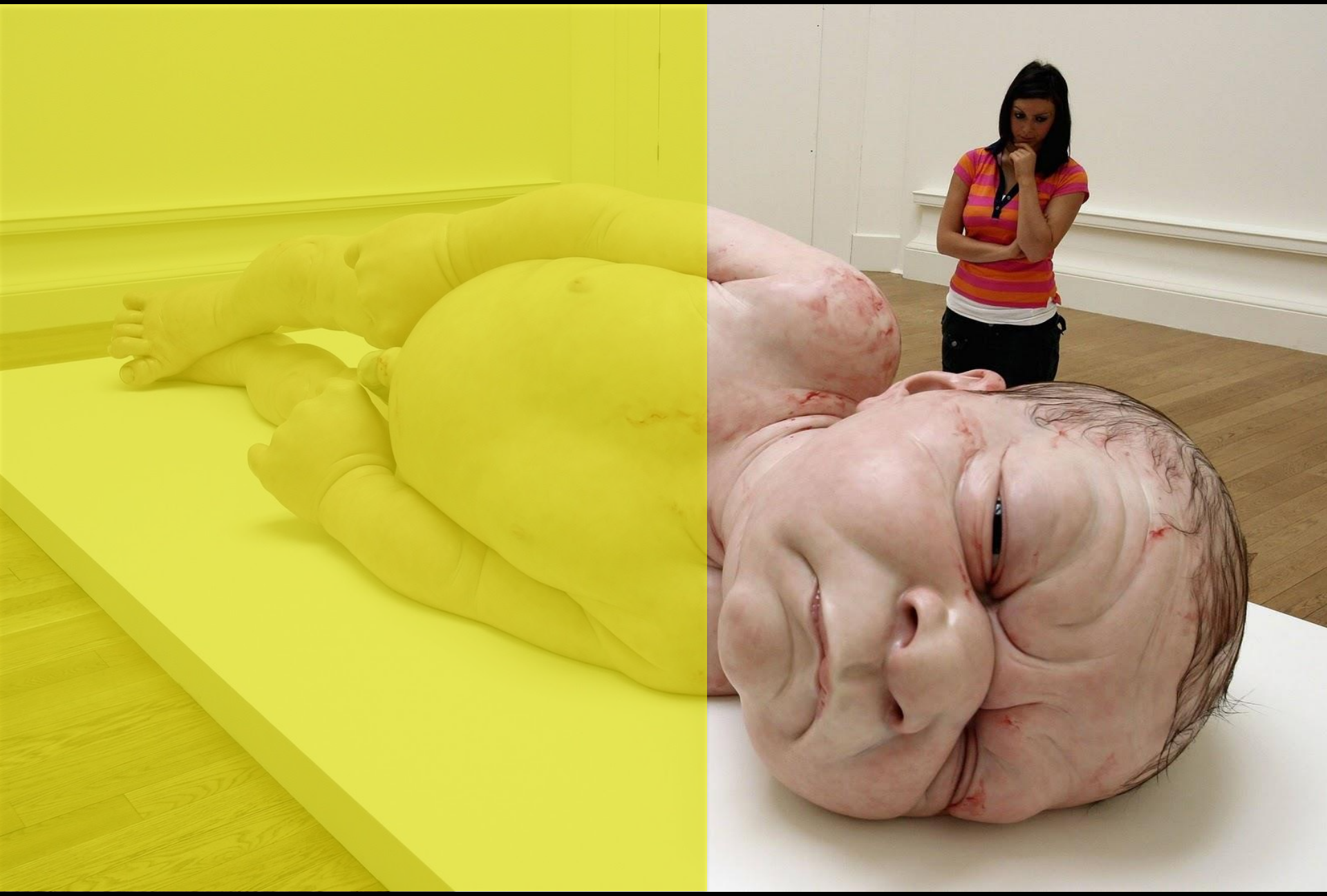


Source: Khoury et al. 2014. Proc. Natl. Acad. Sci. USA.

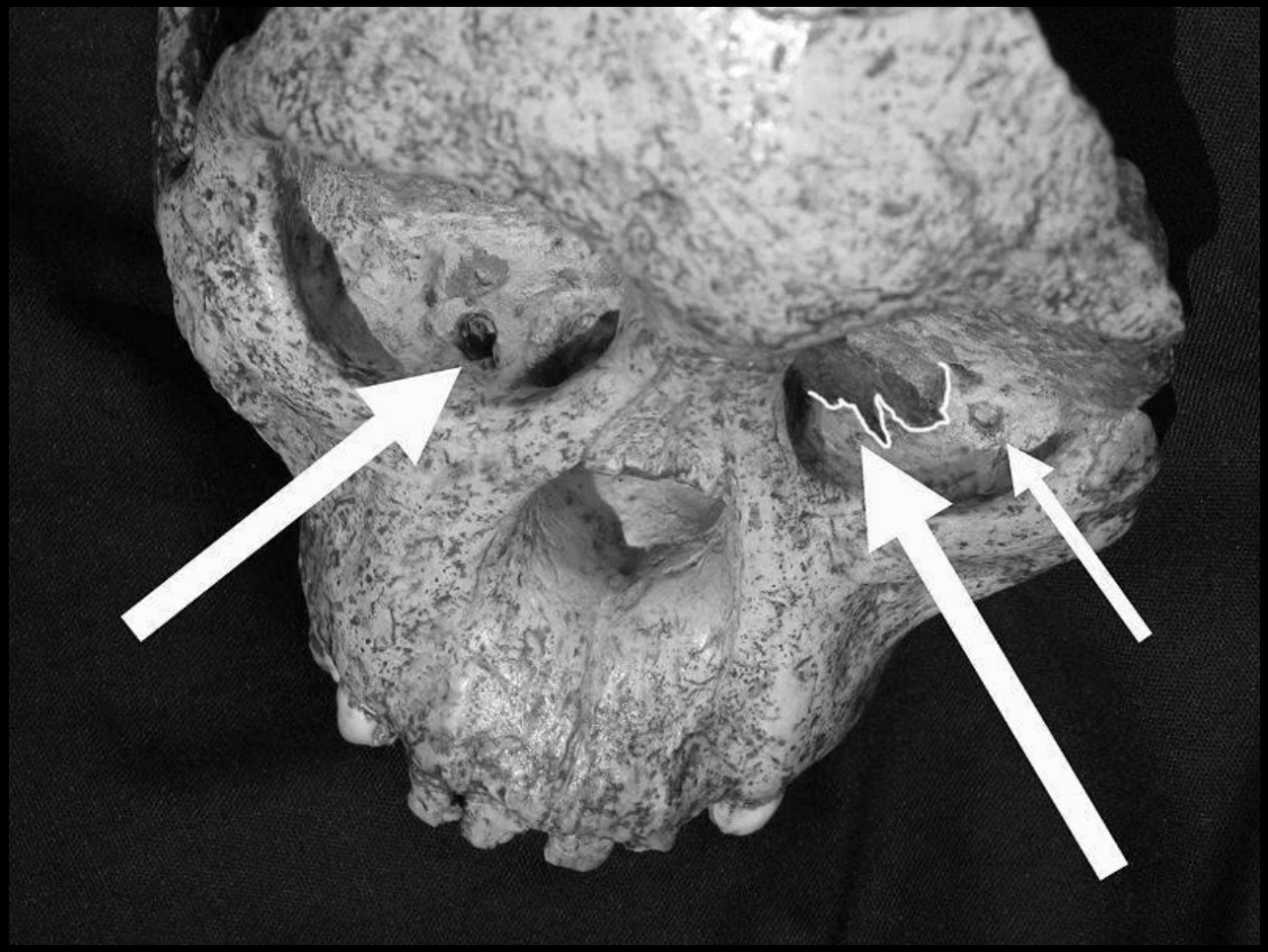


For food species…

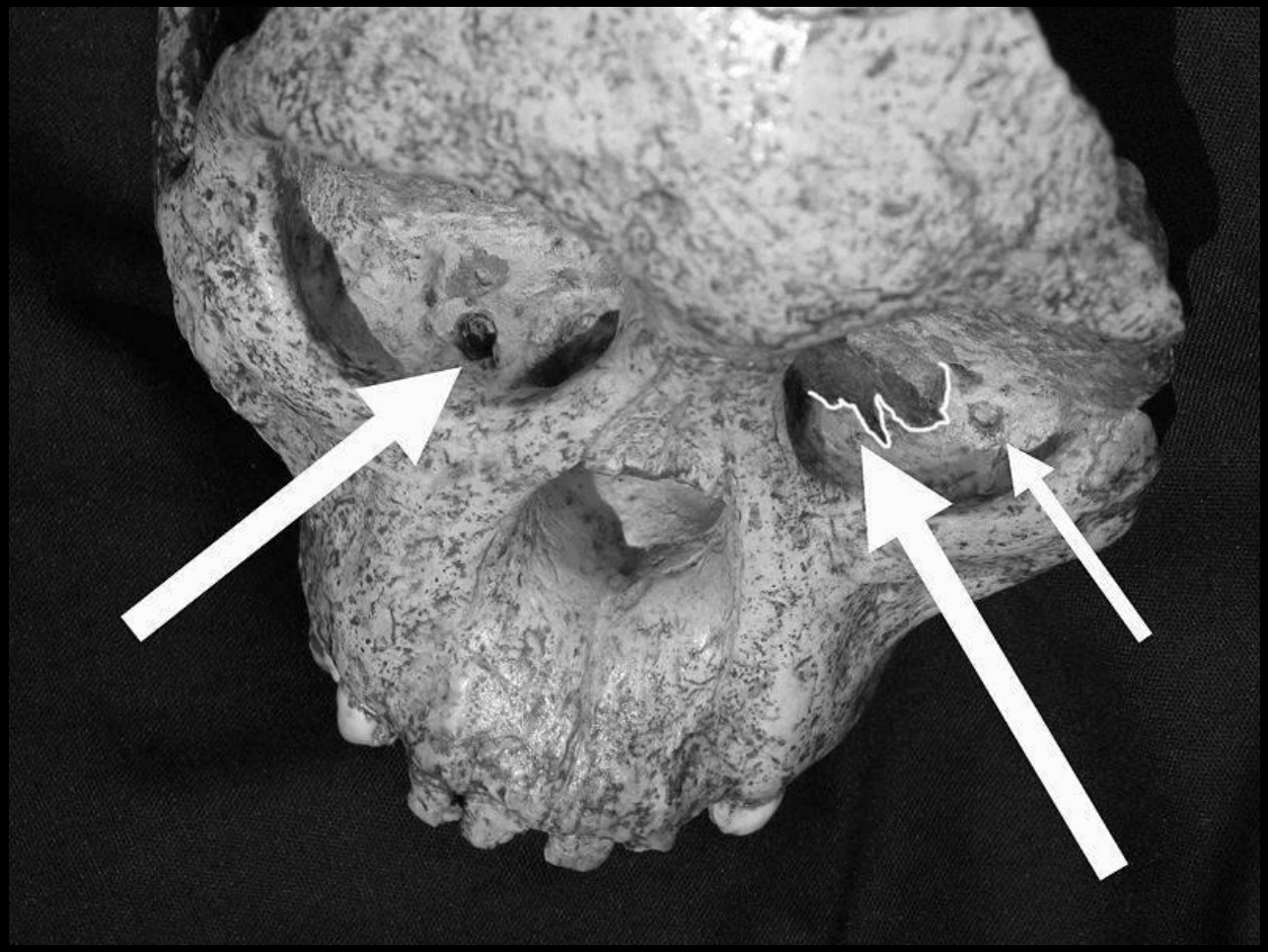
we have created, are creating, a world in which while individuals may consume many plant species, that the vast majority of calories come from very few species that we farm in order to produce sugar, fat, and protein (rather than the foods themselves).

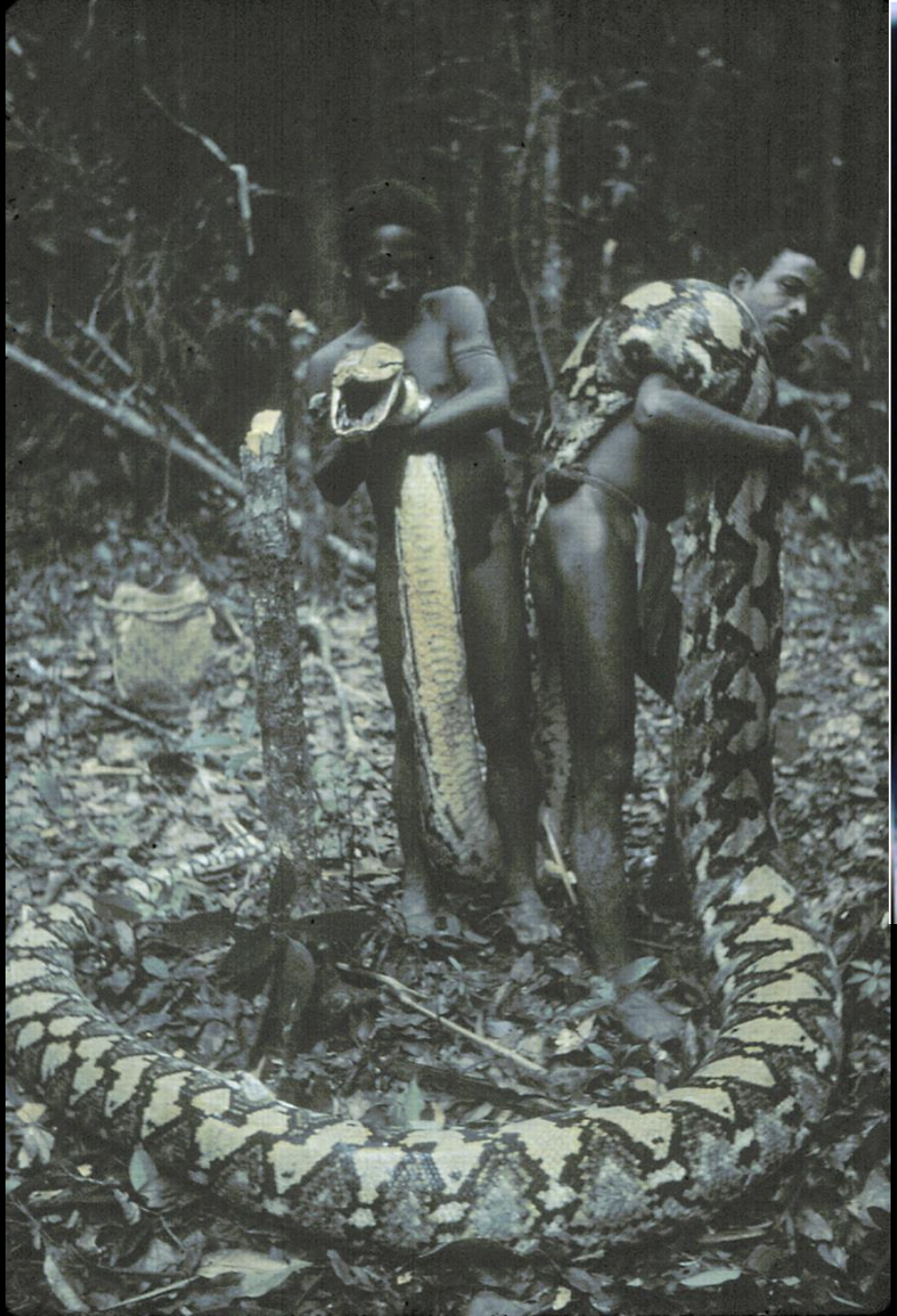


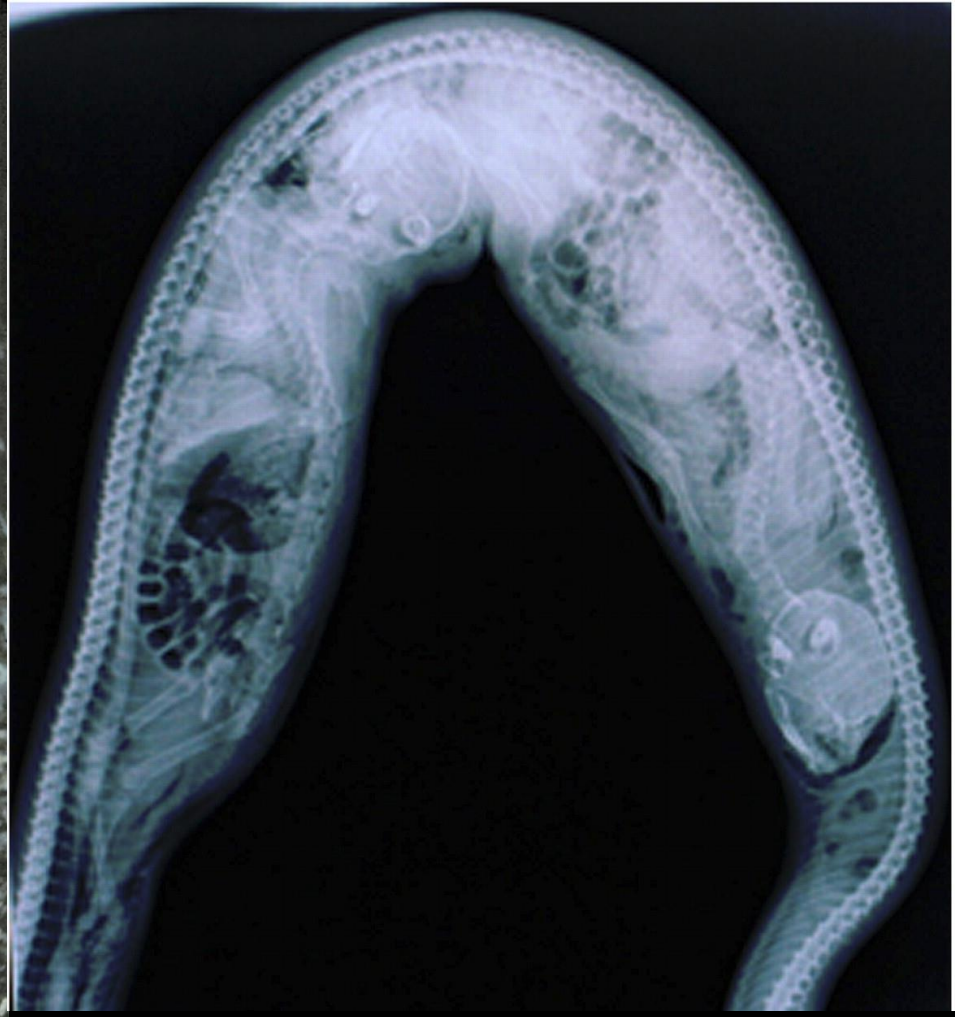
Predators



First in Flight





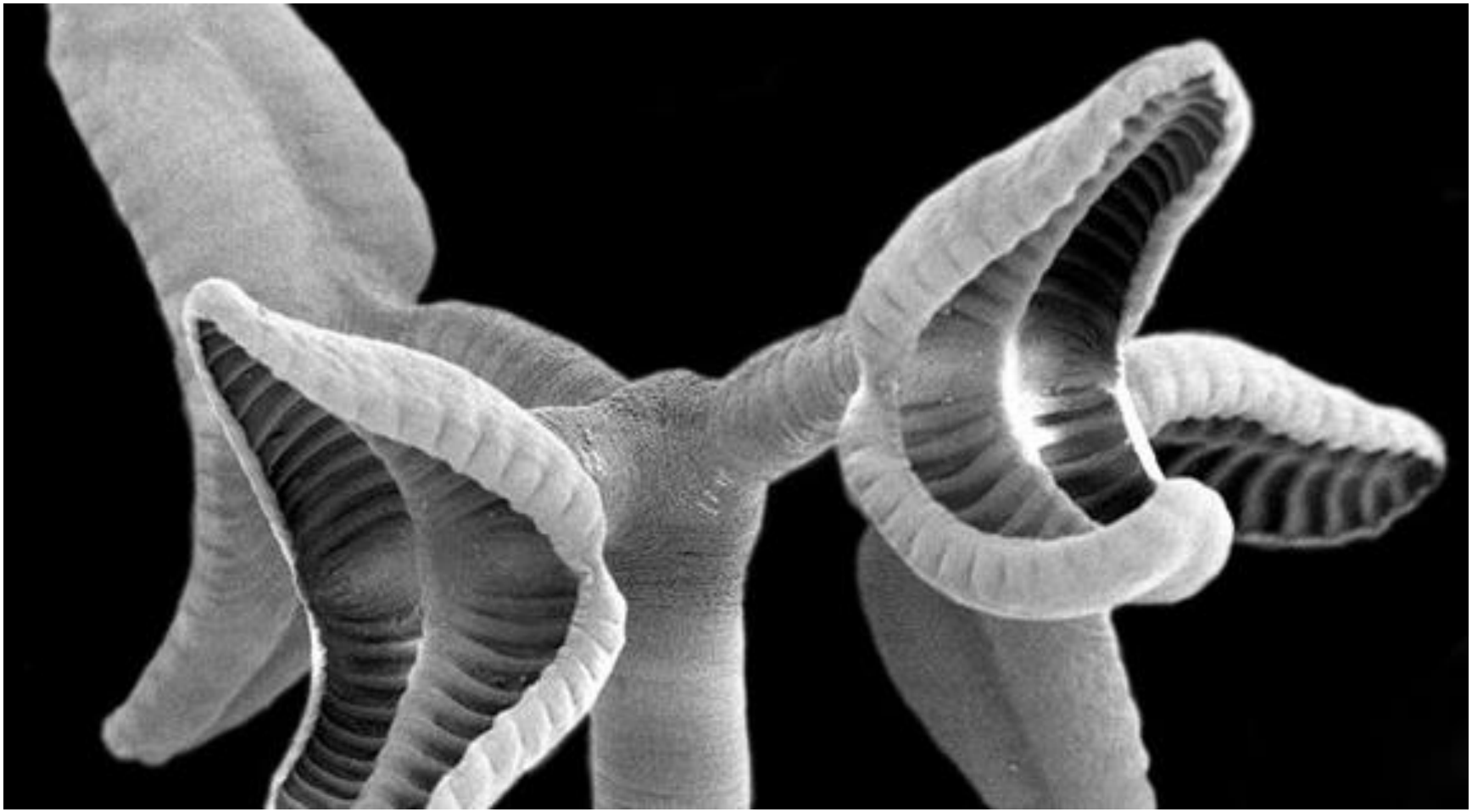


Headland, Thomas N., and Harry W. Greene. "Hunter–gatherers and other primates as prey, predators, and competitors of snakes." Proceedings of the National Academy of Sciences 108.52 (2011): E1470-E1474.

For predators…

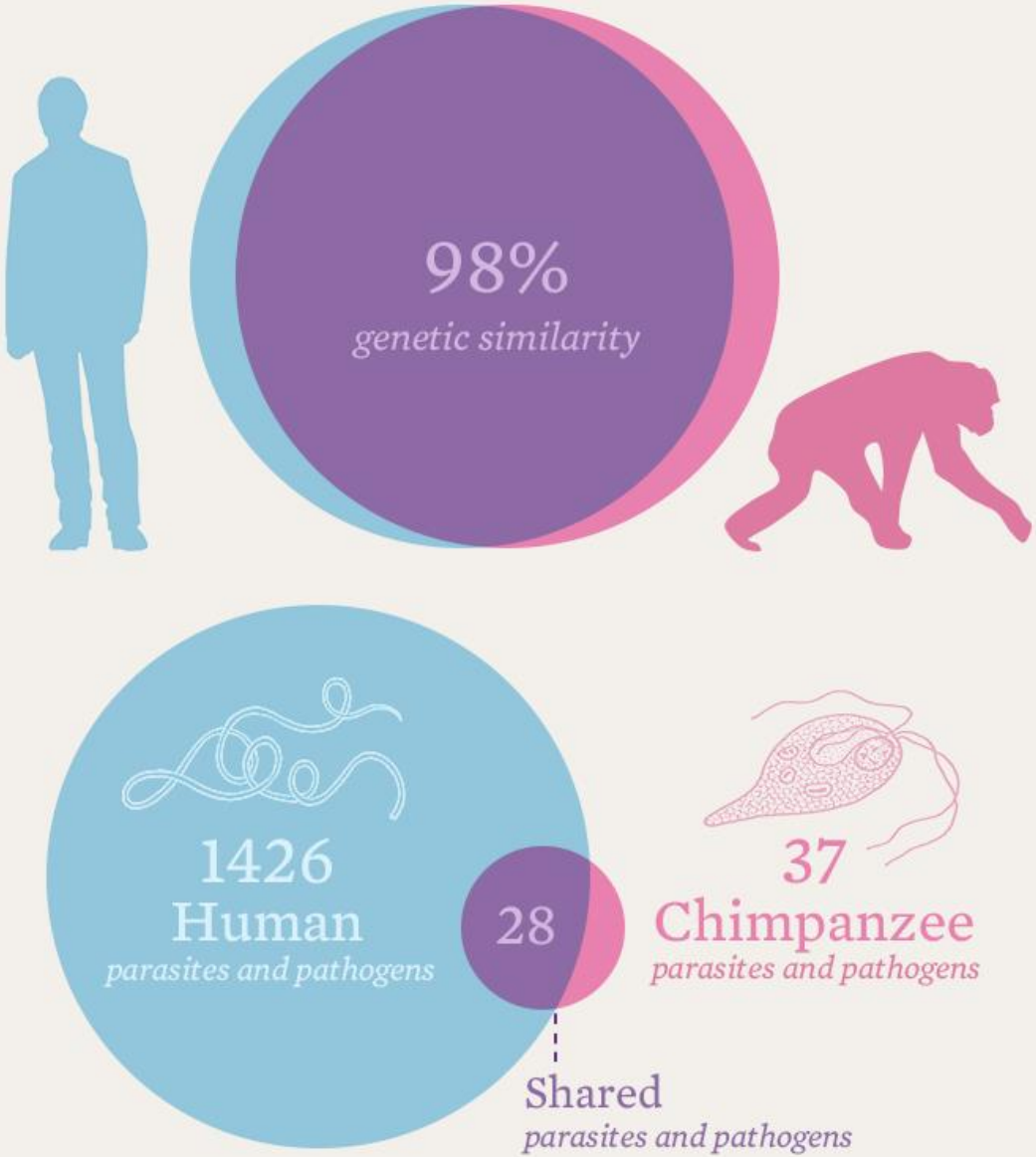
we have largely escaped, having killed off most of the most dangerous large species, a wonderful circus of monsters. But the influence of predators lurks in our language, in our fears, and in our anxieties.

Parasites and Pathogens

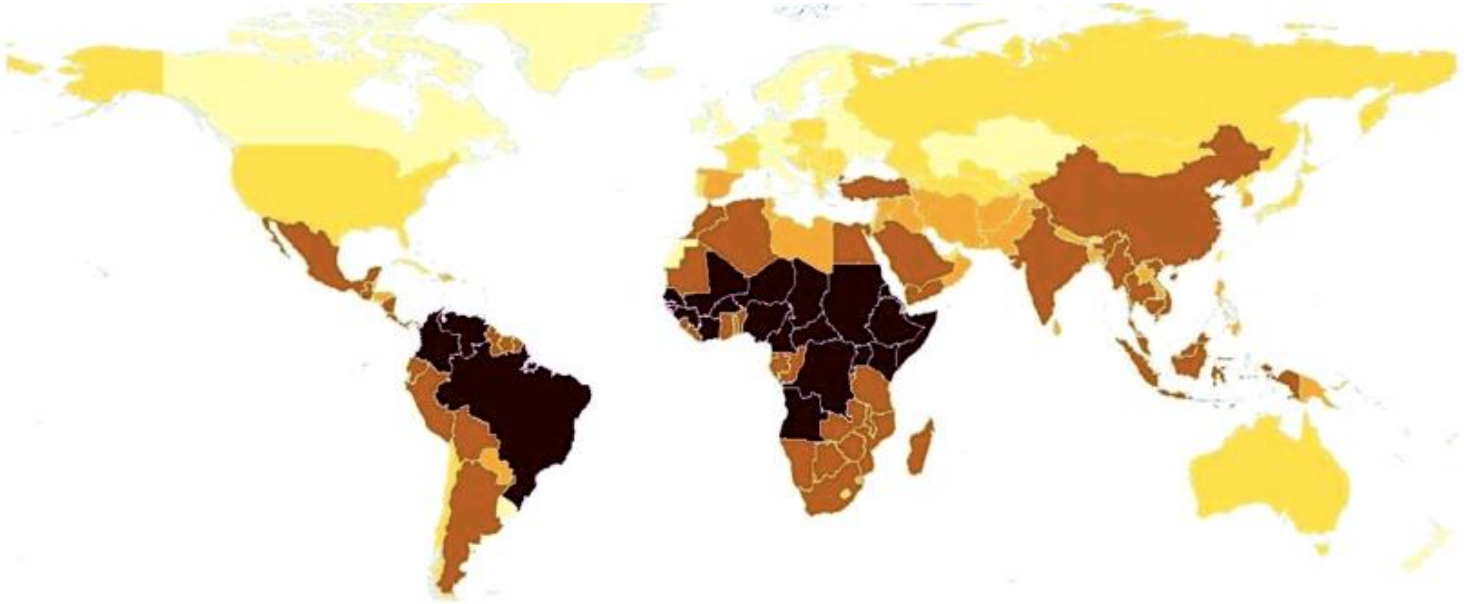


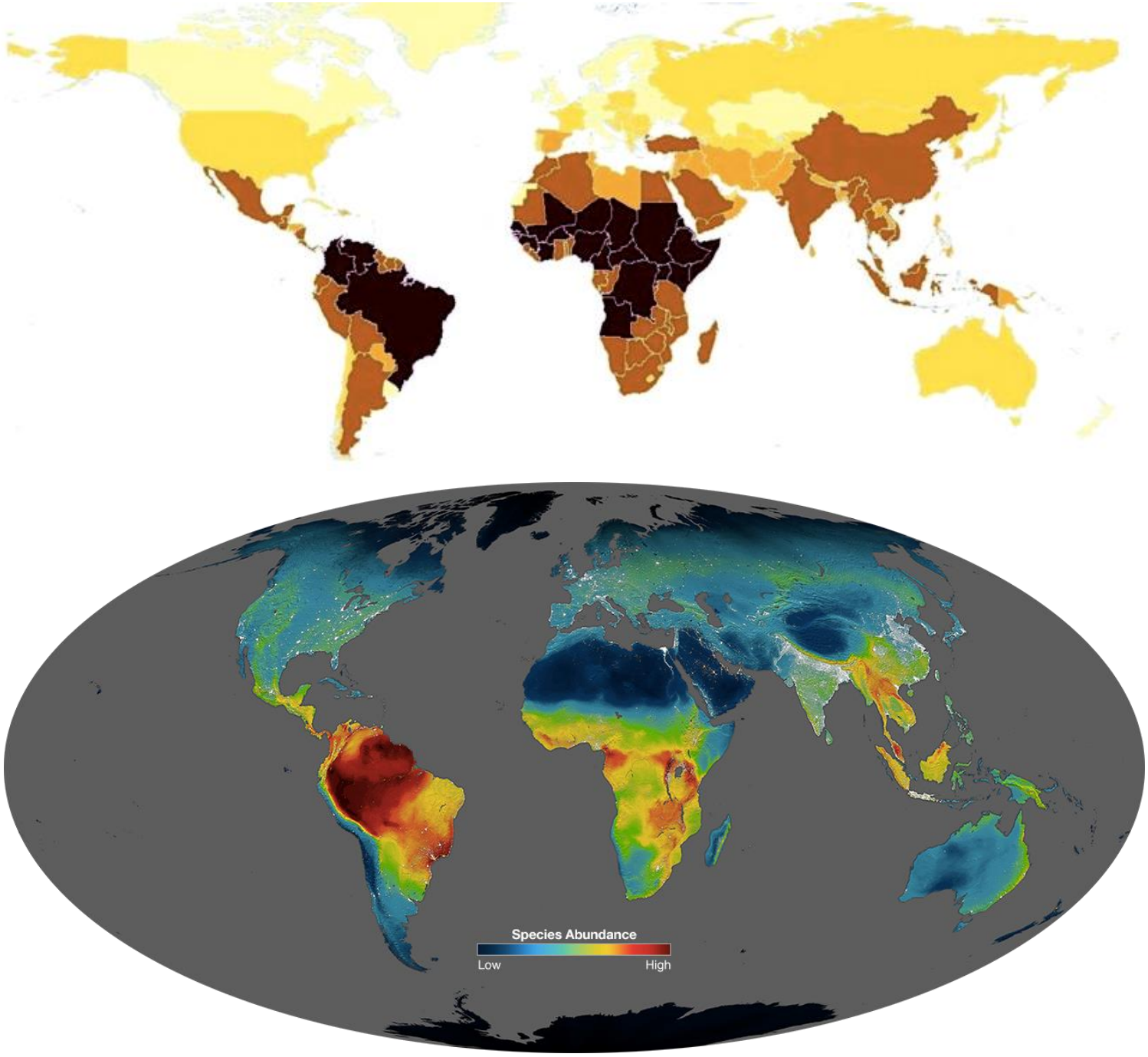
Parasites and Pathogens

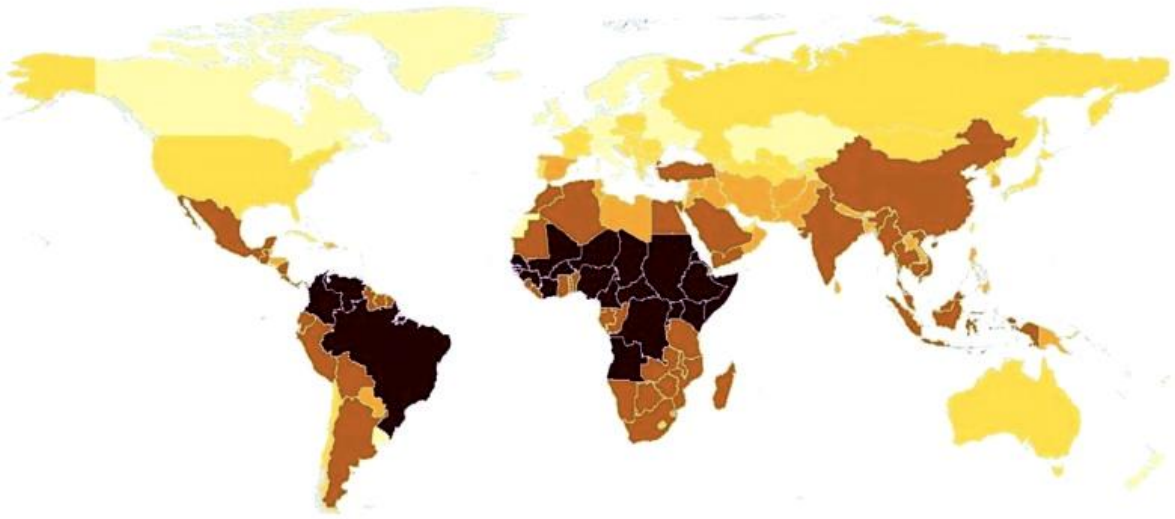
- In chimps about 50 species
- In modern humans about 2000 species (no official tally)
- Differences due to group size (initially), then domesticates, then spread to regions with new parasites and pathogens.

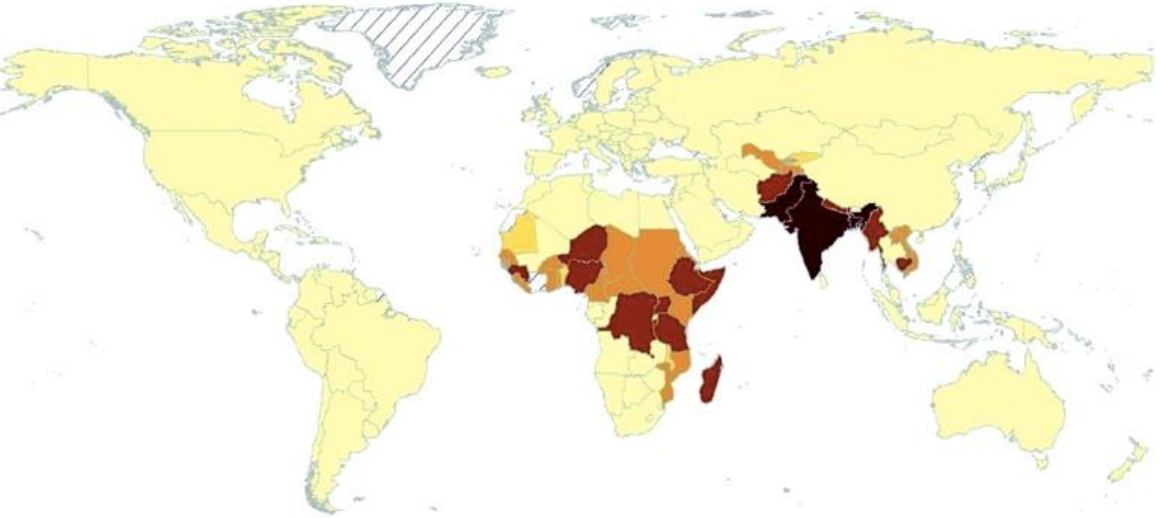


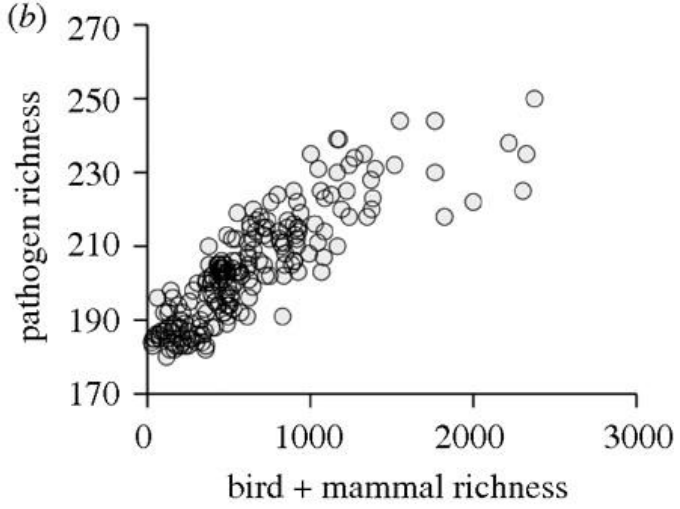
We're not as similar as you think

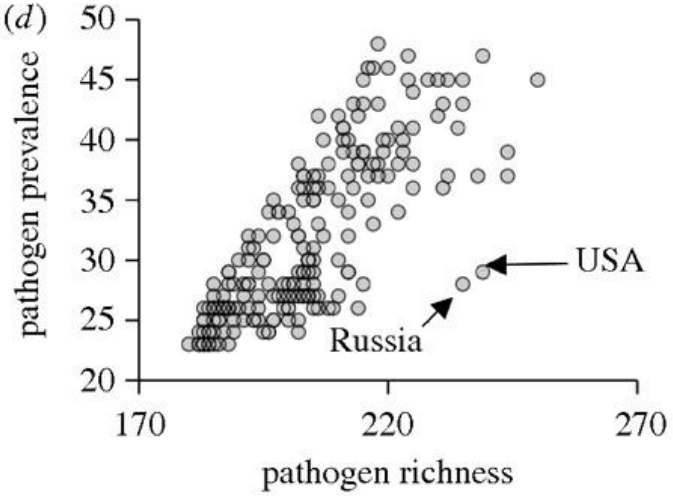


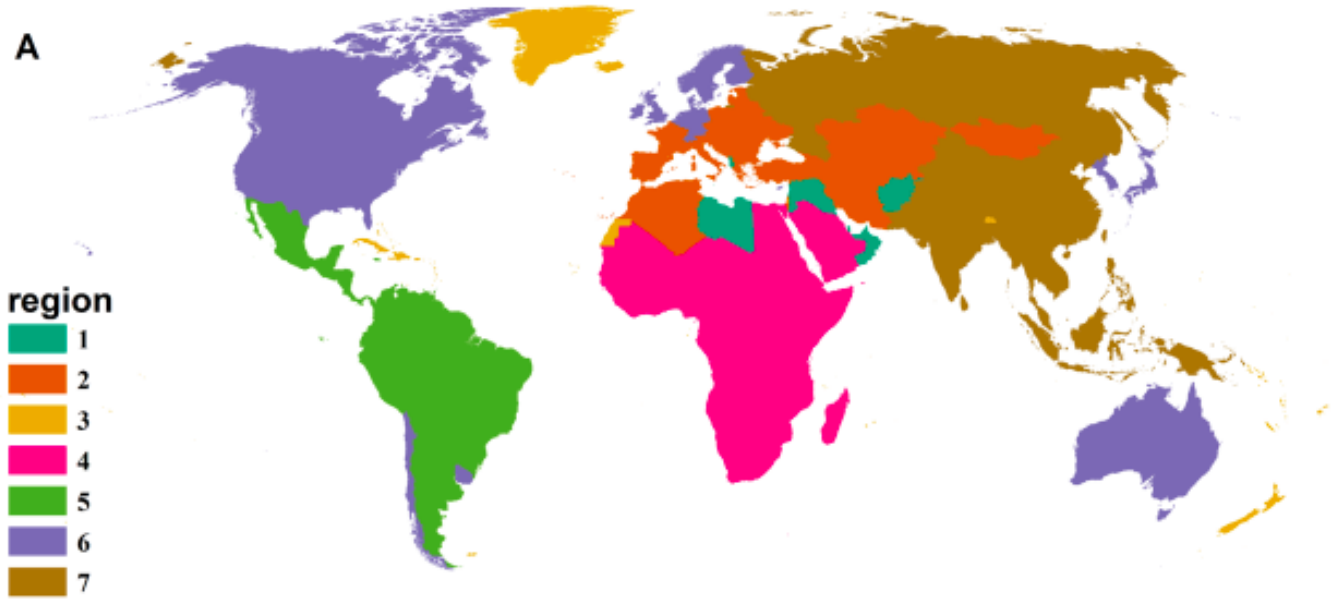

Species Abundance
Low
High



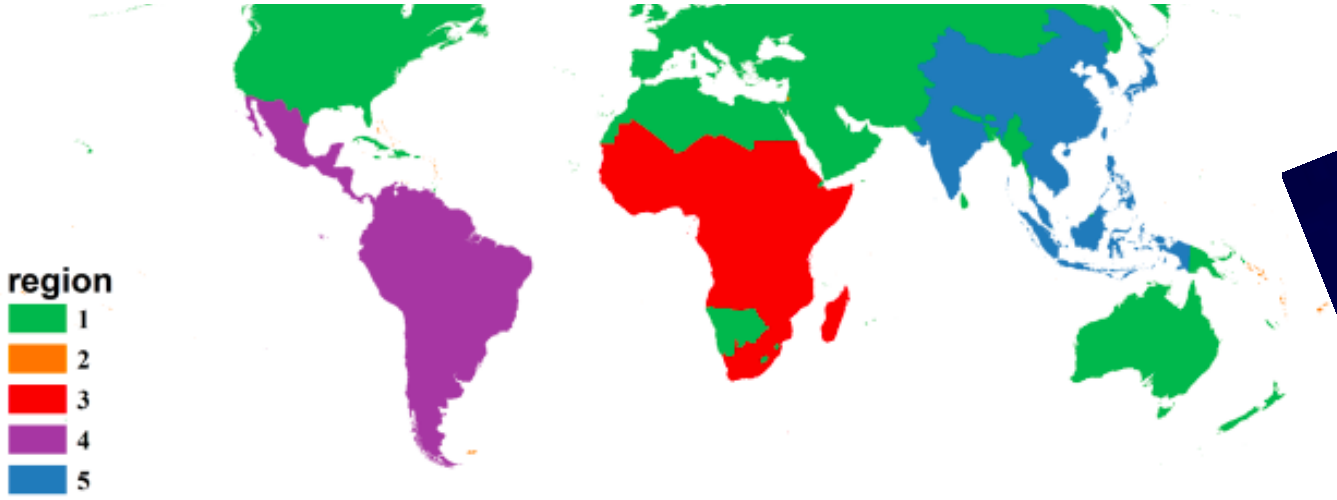


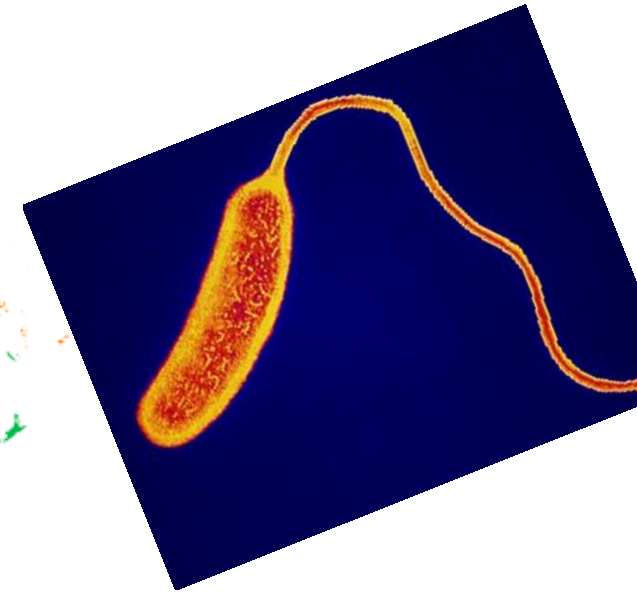

(b)
pathogen richness
270
250
230
210
190
170
0
1000
2000
3000
bird + mammal richness

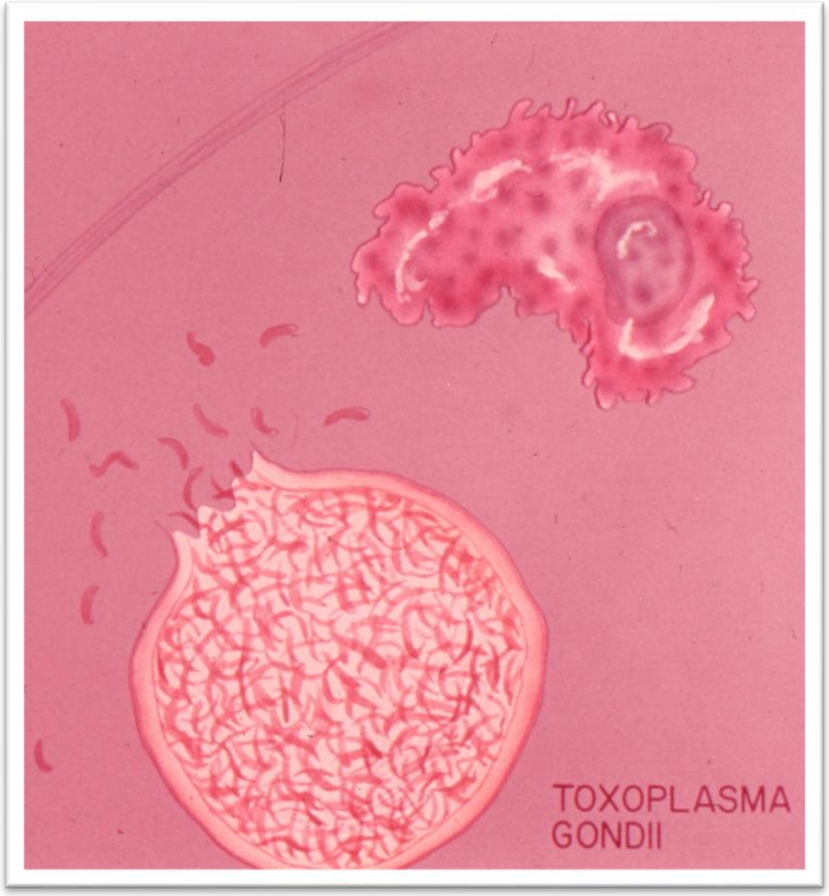

(d)
pathogen prevalence
50
45
40
35
30
25
20
USA
Russia
170
220
270
pathogen richness

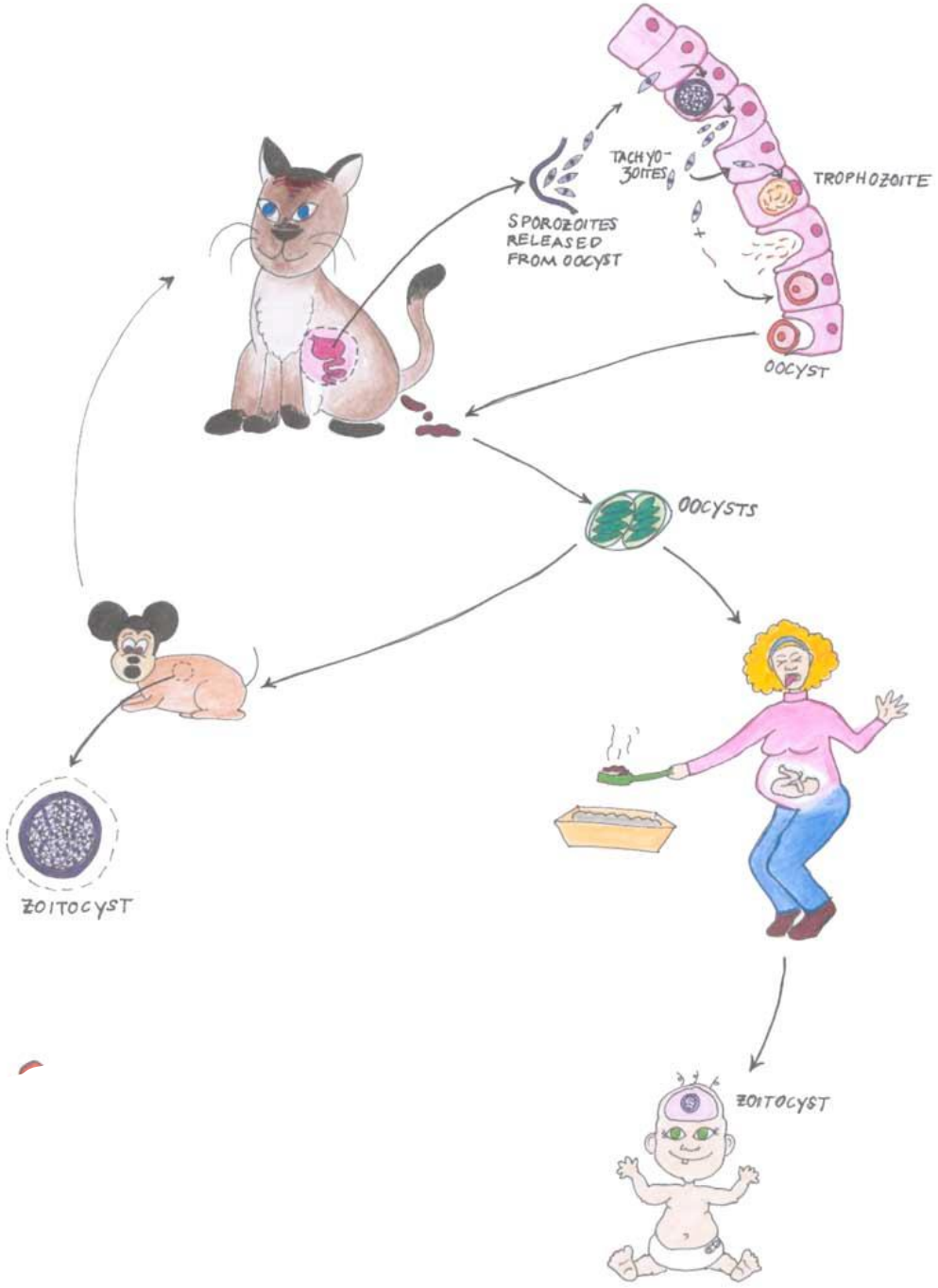


The Most Geography in the World?





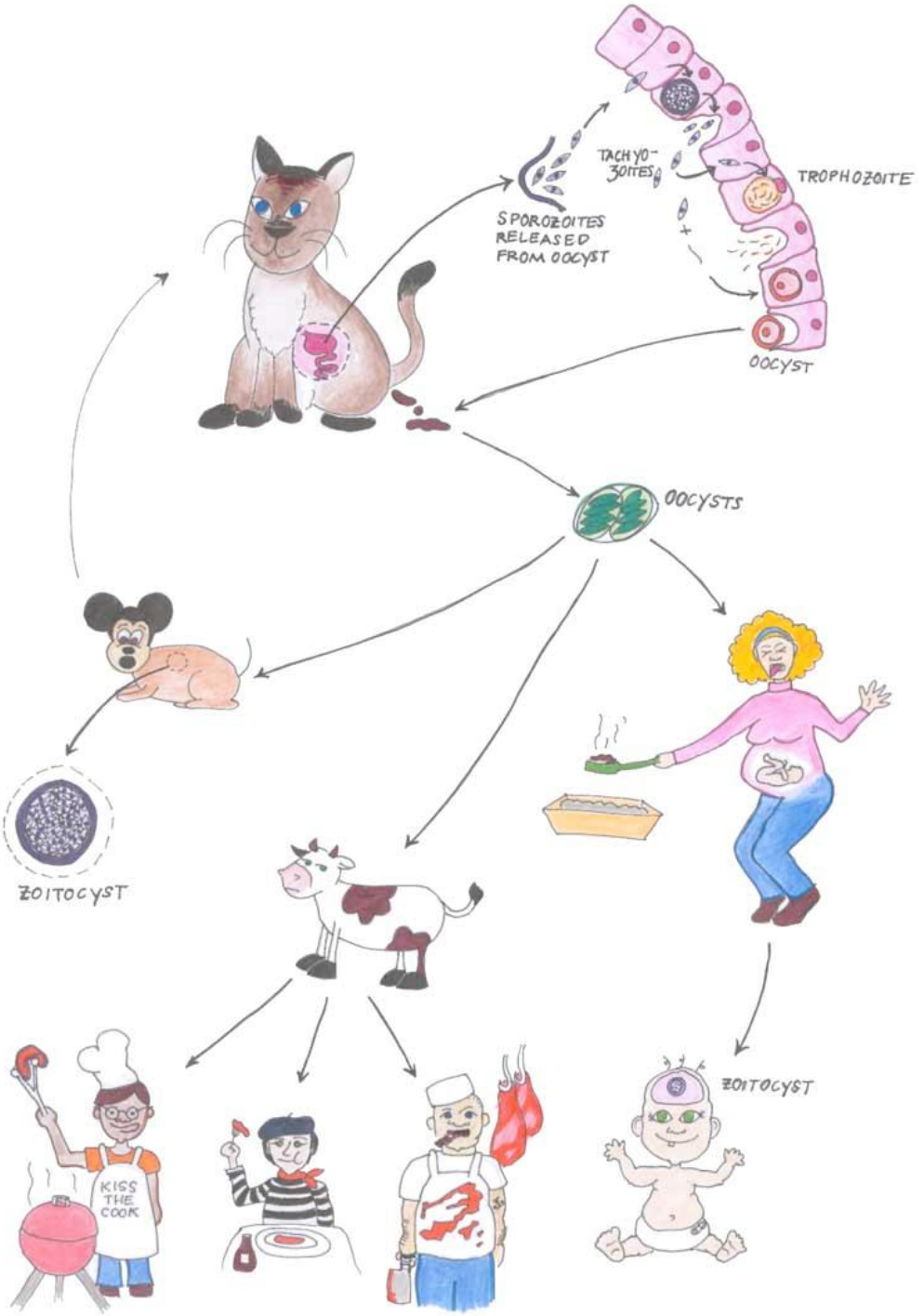

TOXOPLASMA
GONDII

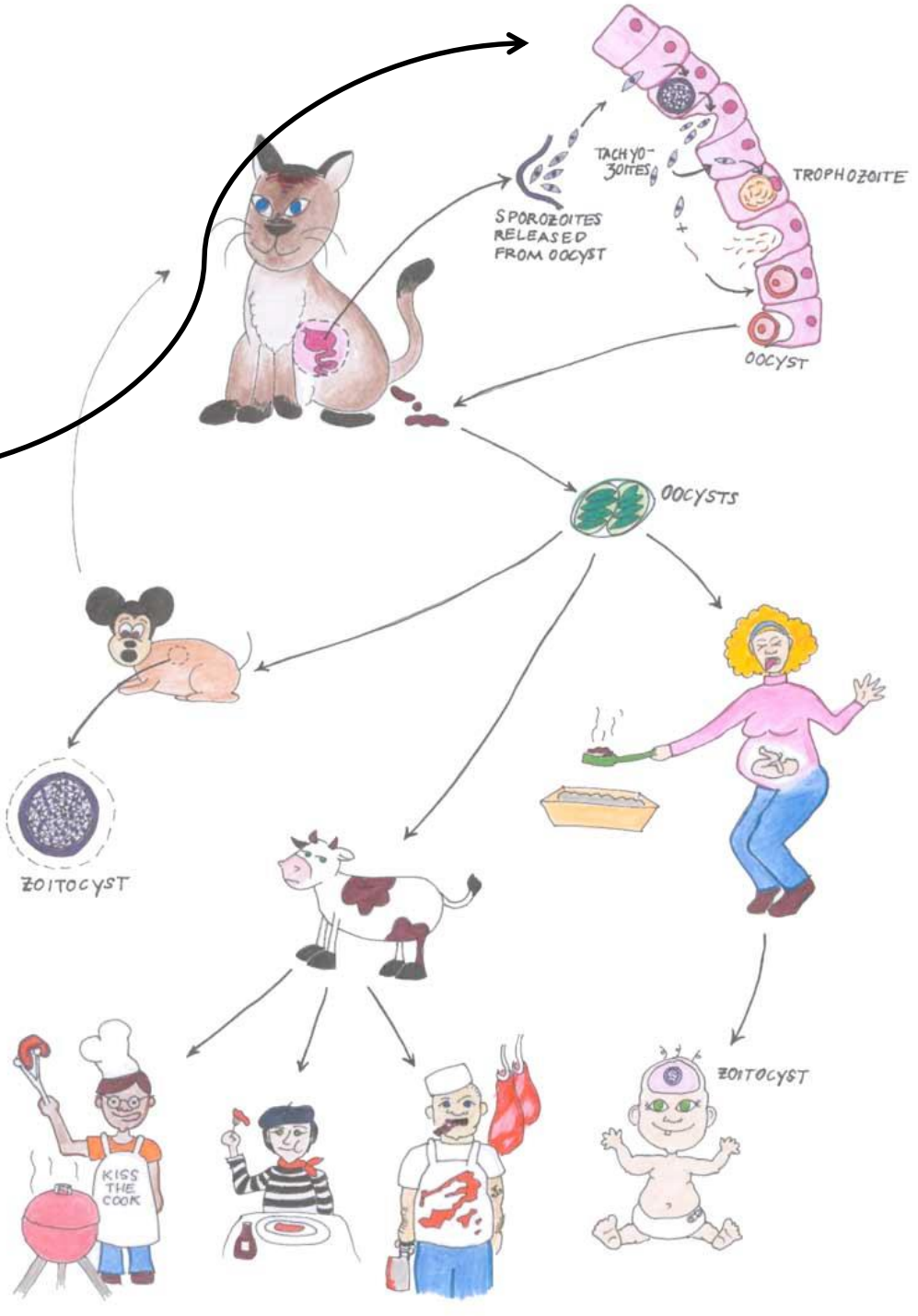

TACHYO-
ZOITES
TROPHOZOITE
SPOROZOITES
RELEASED
FROM OOCYST
OOCYST
OOCYSTS
ZOITOCYST
ZOITOCYST

The Effects of Presence: *Toxoplasma gondii* makes rats and mice….

- Less scared
- Less vigilant of predators
- Attracted to the smell of cat pee
- More likely to get eaten by a cat

(and hence fulfill the "wishes" of the parasite)


TACHYO-
ZOITES
TROPHOZOITE
SPOROZOITES
RELEASED
FROM OOCYST
OOCYST
OOCYSTS
ZOITOCYST
KISS
THE
COOK
ZOITOCYST

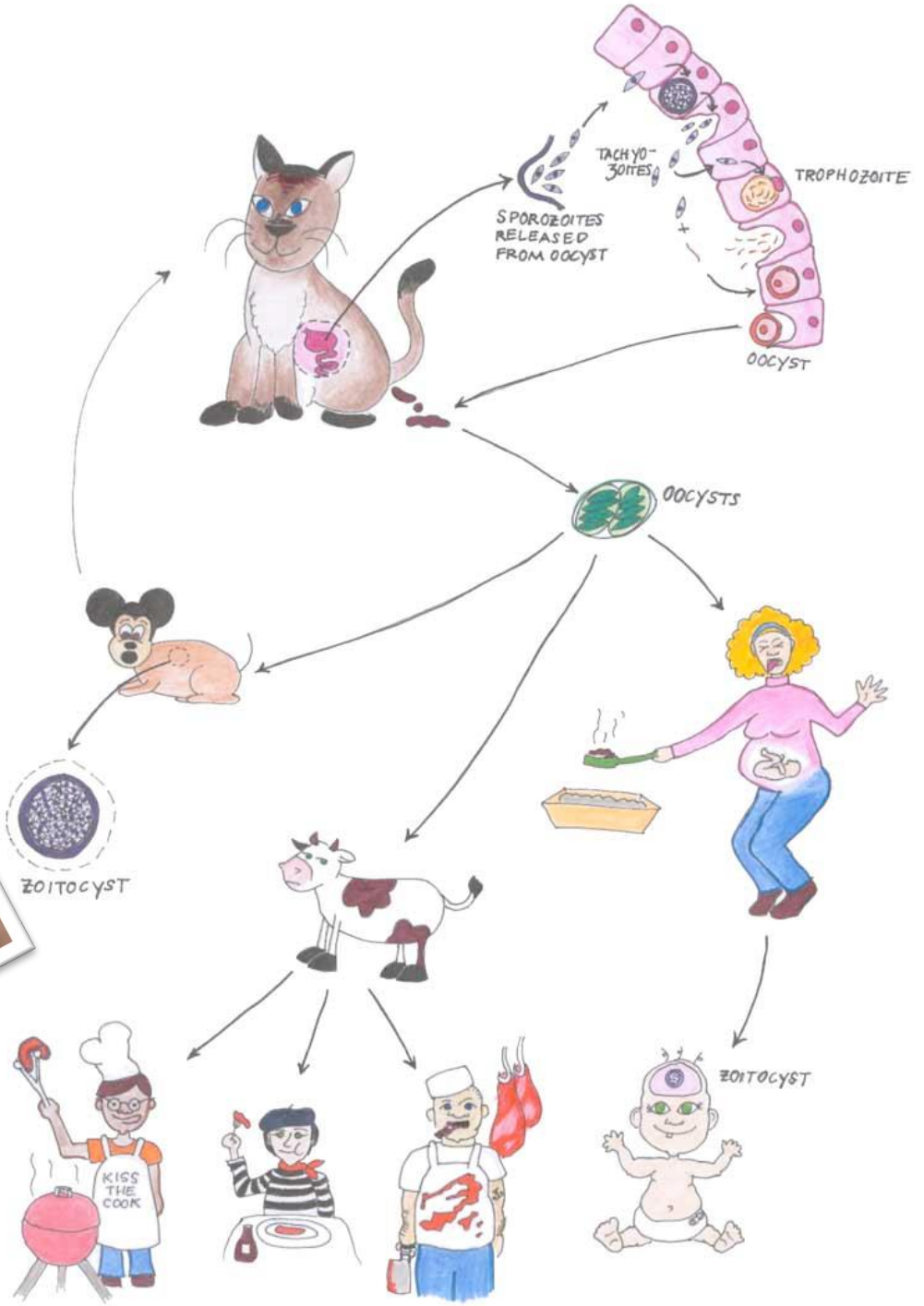

TACHYO-
ZOITES
TROPHOZOITE
SPOROZOITES
RELEASED
FROM OOCYST
OOCYST
OOCYSTS
ZOITOCYST
KISS
THE
COOK
ZOITOCYST

But what happens to behavior when *Toxoplasma gondii* ends up in humans?

- "**increased activity, decreased reaction times and altered personality profiles** (Flegr and Hrdý 1994, Webster 2001, Flegr et al. 2002, 2003, Flegr 2007)
- **2.65 times more likely to be in car accidents than the general population** (Flegr et al. 2002, Yereli et al. 2006, Kocazeybek et al. 2009).
- **More likely to suffer schizophrenia**
  - "a stronger association between schizophrenia and detection of *T. gondii antibodies (combined odds ratio* 2.73) than for any human gene (Purcell et al. 2009)."

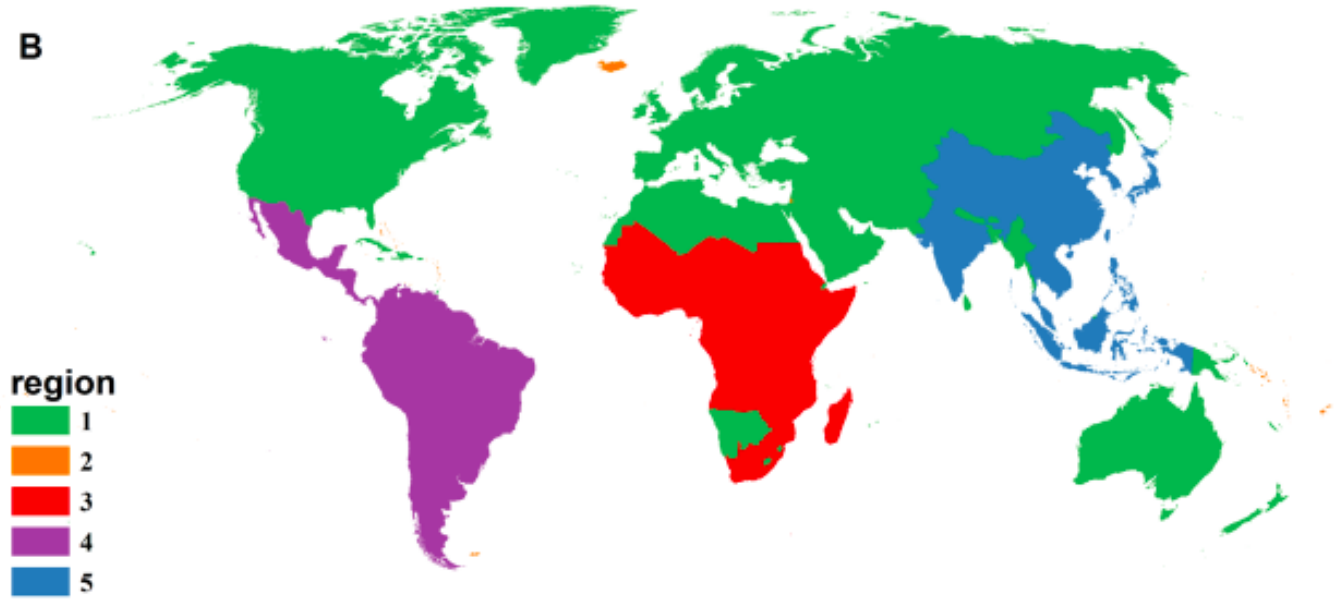
From a 2010 review by Joanne Webster at Imperial College in London

The French


TACHYO-
ZOITES
TROPHOZOITE
SPOROZOITES
RELEASED
FROM OOCYST
OOCYST
OOCYSTS
ZOITOCYST
KISS
THE
COOK
ZOITOCYST

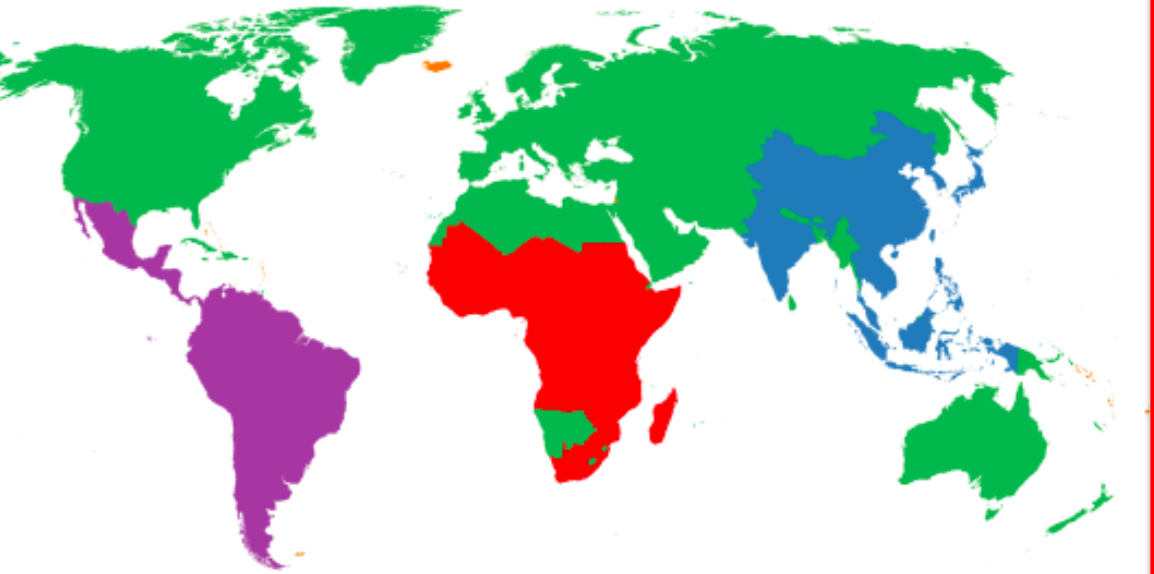
The Effects of Absence

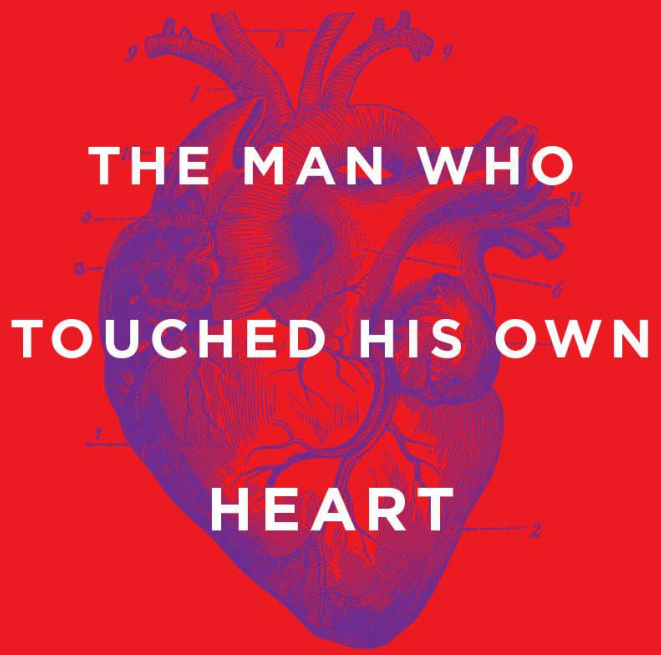
In developed countries we are different from any population of any species ever to live, not because of intelligence, or cleverness or brutality, but instead because we are missing our worms, for the first time in more than 100 million years.



The Effects of Absence

And what is more striking, is that just before we lost many of these parasites and pathogen, we were not typical. We were more afflicted than are most species.





Available in Kindle, Audio Book Paperback and Hardcover on Amazon

Micro-mutualists and commensals

Forehead Mites

Meet Your Mites

Arthropods

of Our Homes

Wild Life

of Our Homes

Cat Tracker

Education

Students Discover

Camel Crickets

Home Census

Urban BUZZ

Your Bacteria

Belly Button Biodiversity

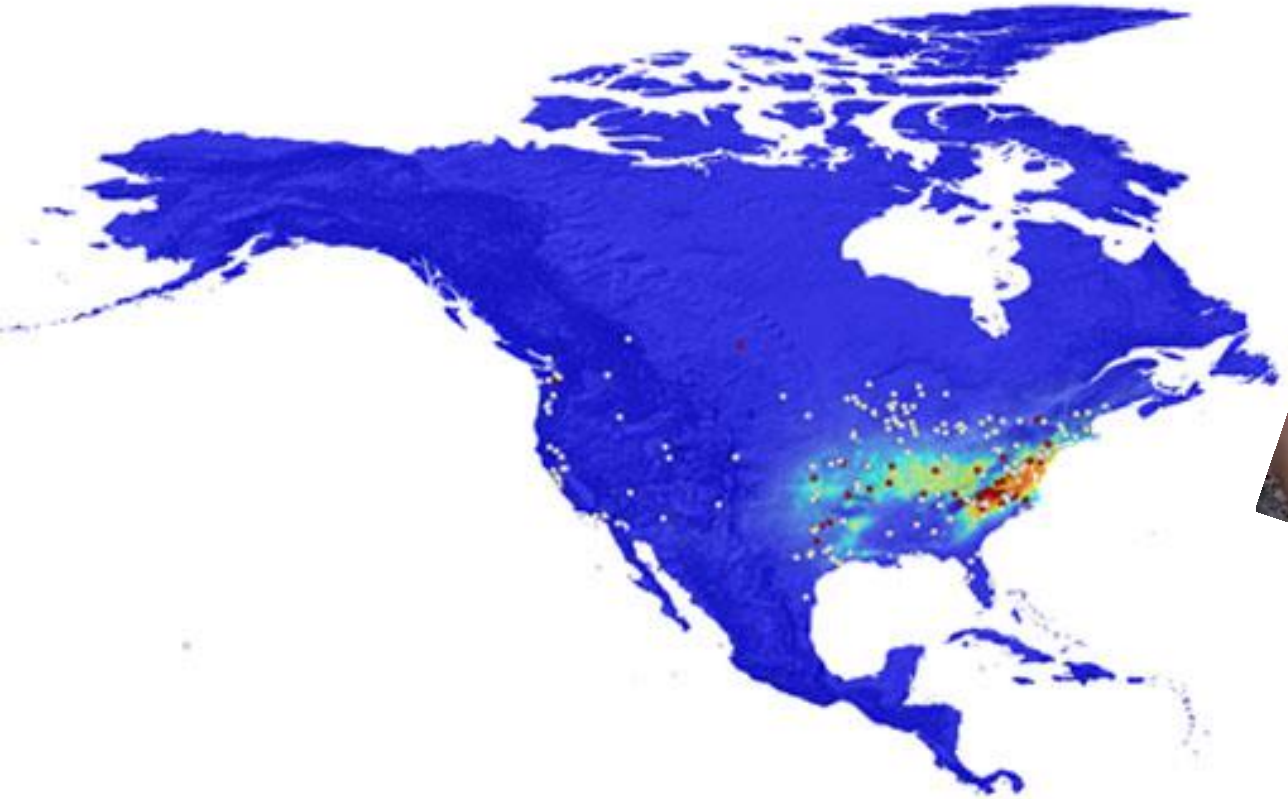
School of Ants

An (in)sight

100,000 years

1,000,000 years

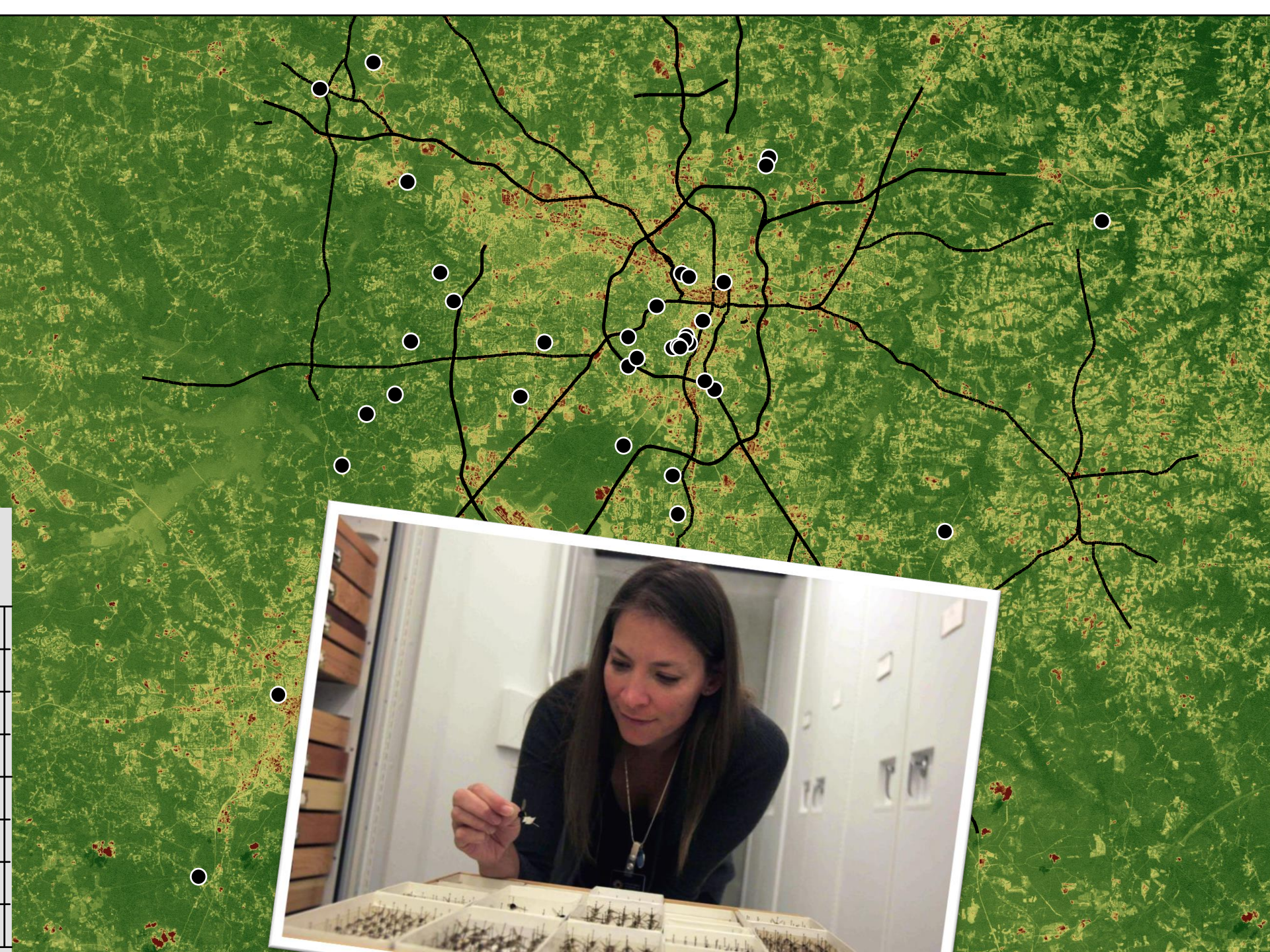
Eva, “Very few species will be found in modern houses”




©PIOTR NASKRECKI

Another species?

Diestrammena japanica




EXIT

ARTHROPODS
OF OUR HOMES









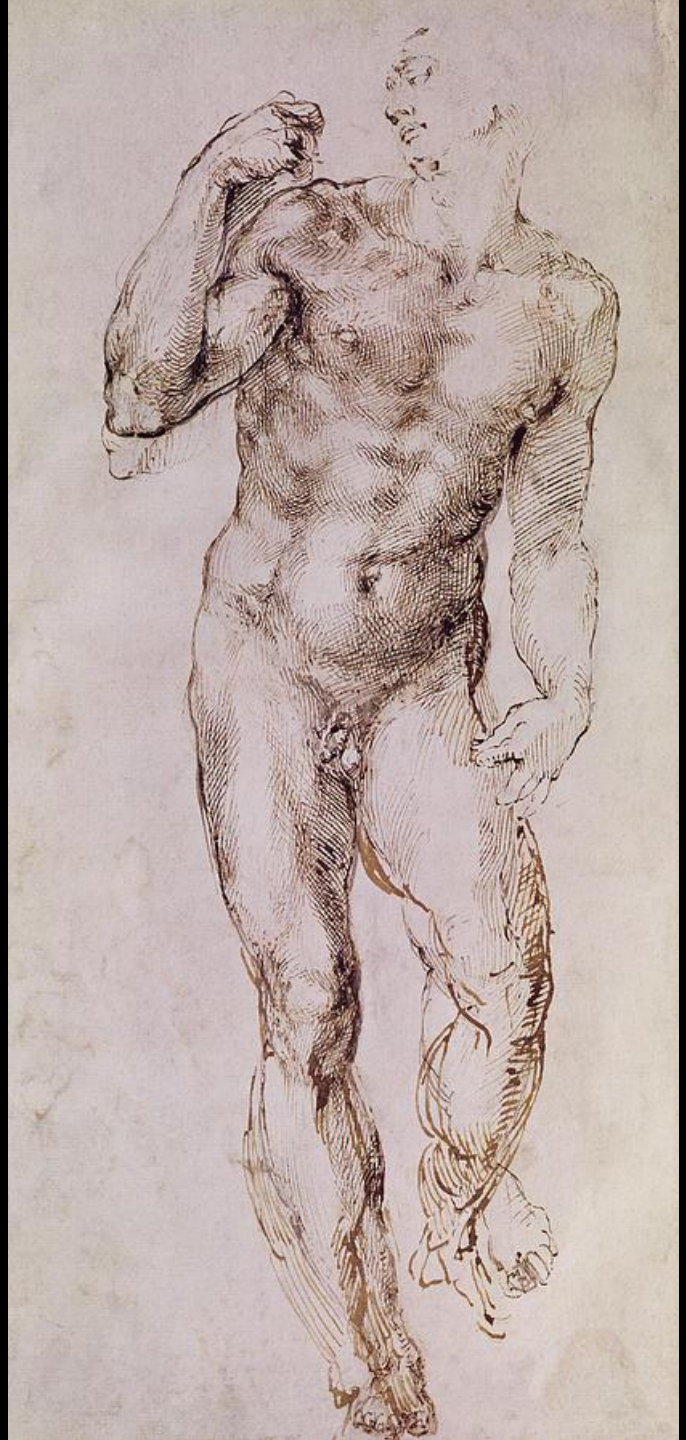






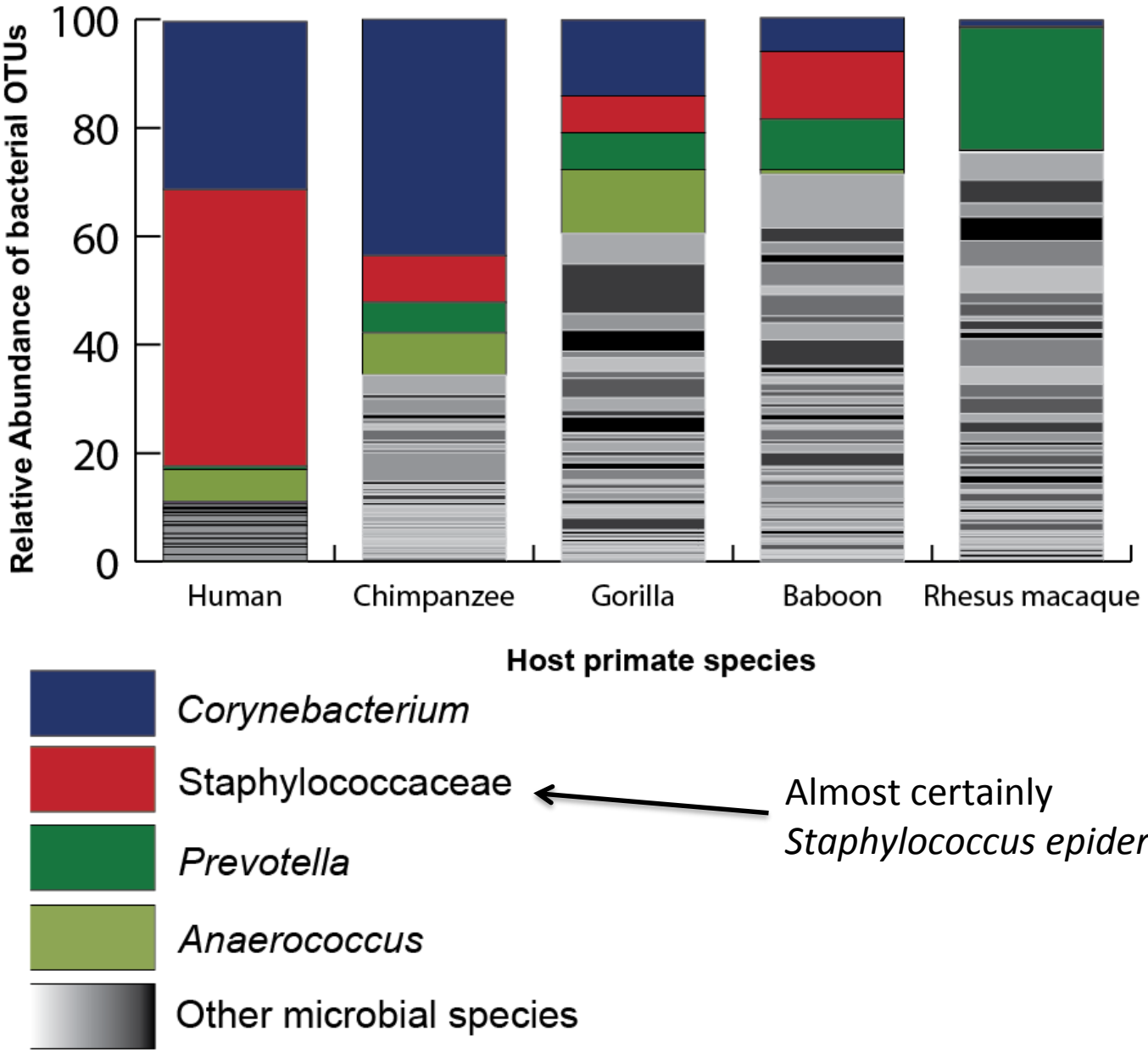


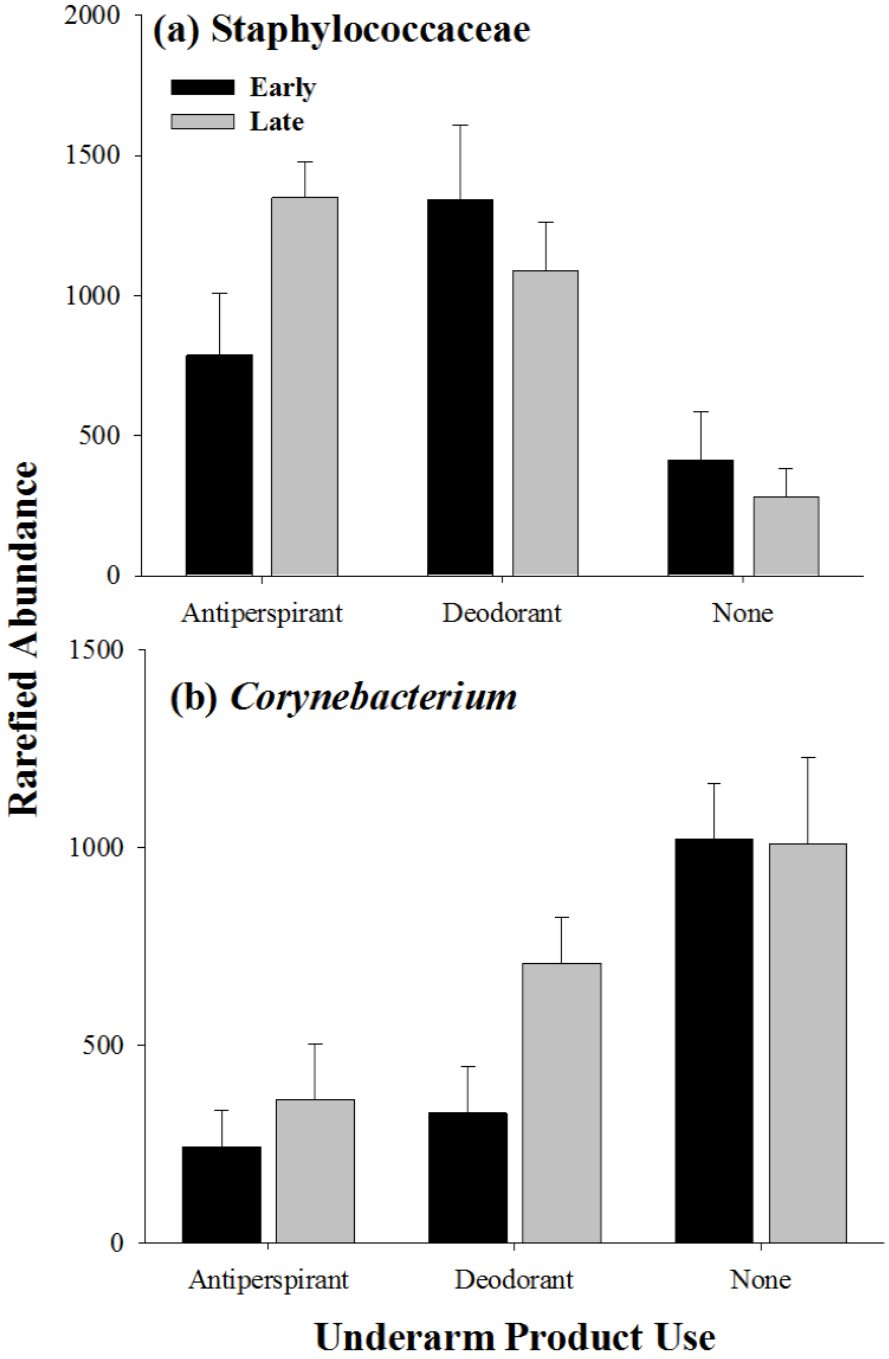




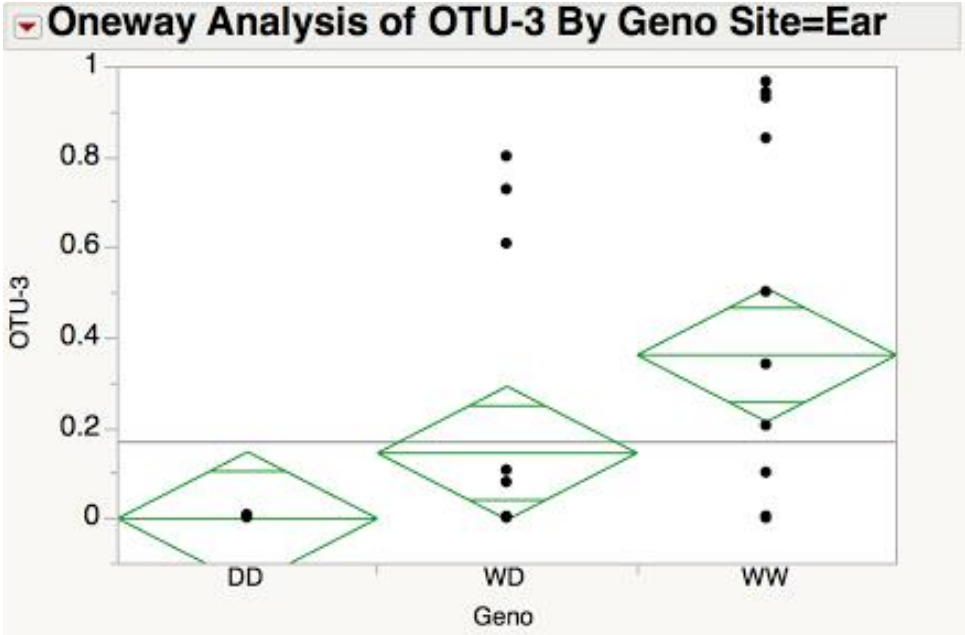
Skin

Who cares? (sex, death, and repulsion)


Relative Abundance of bacterial OTUs
100
80
60
40
20
0
Human
Chimpanzee
Gorilla
Baboon
Rhesus macaque
Host primate species
Corynebacterium
Staphylococcaceae
Prevotella
Anaerococcus
Other microbial species
Almost certainly
Staphylococcus epidermidis


(a) Staphylococcaceae
Early
Late
2000
1500
1000
500
0
Antiperspirant
Deodorant
None
(b) Corynebacterium
1500
1000
500
0
Antiperspirant
Deodorant
None
Rarefied Abundance
Underarm Product Use

Results so new that they are ugly



Oneway Anova

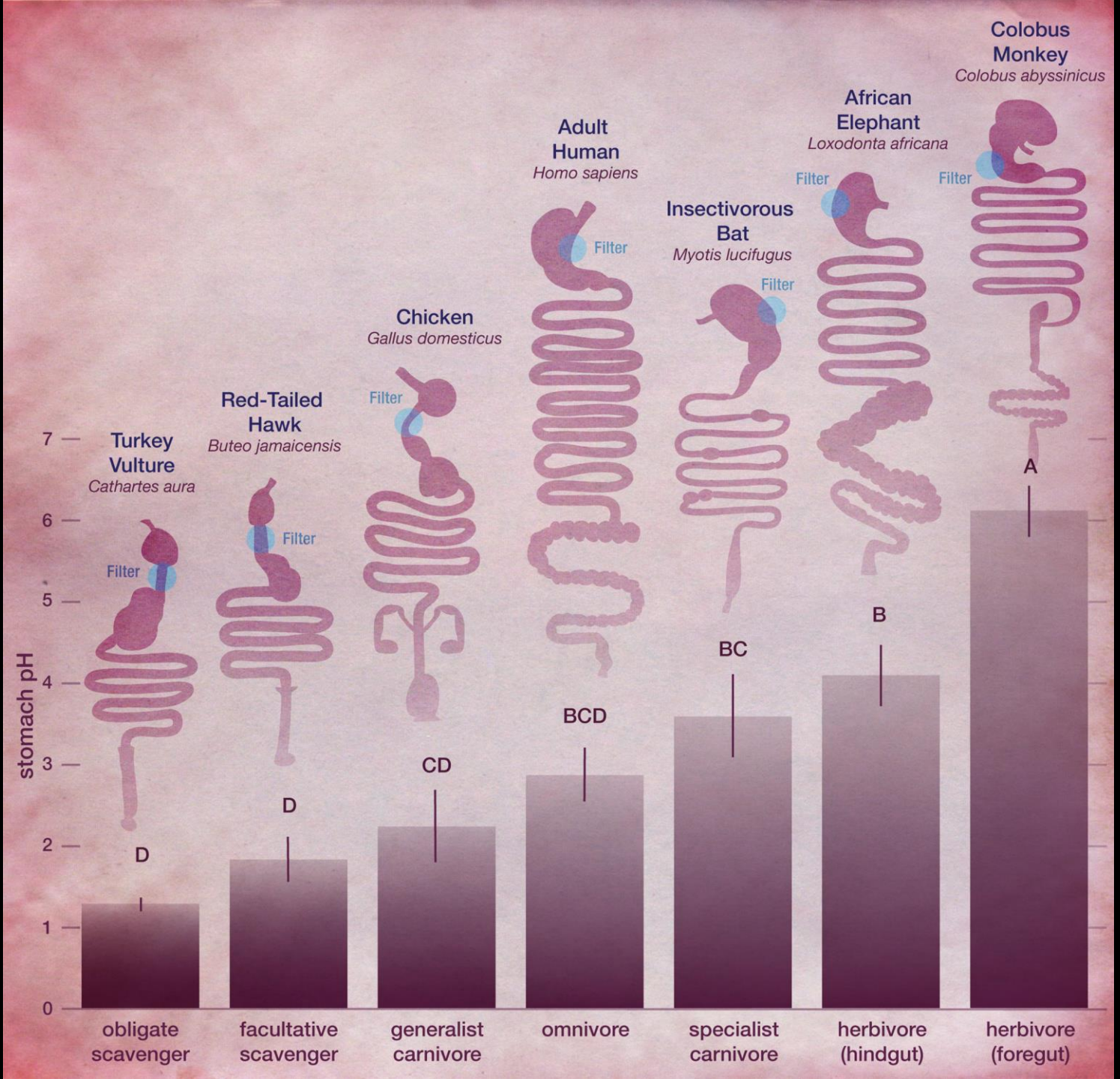
Summary of Fit

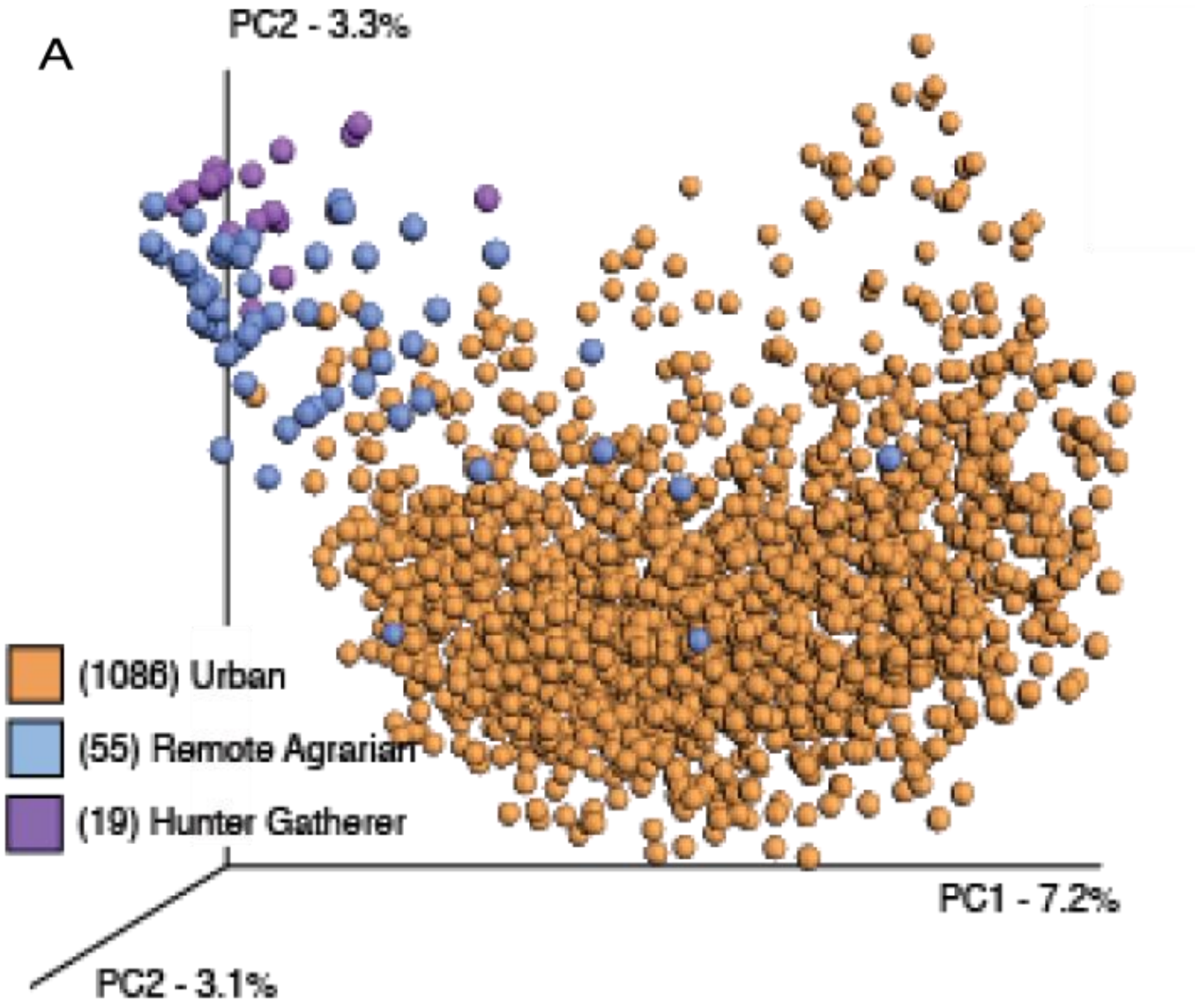
Rsquare	0.215343
Adj Rsquare	0.18047
Root Mean Square Error	0.293123
Mean of Response	0.169664
Observations (or Sum Wgts)	48

Analysis of Variance

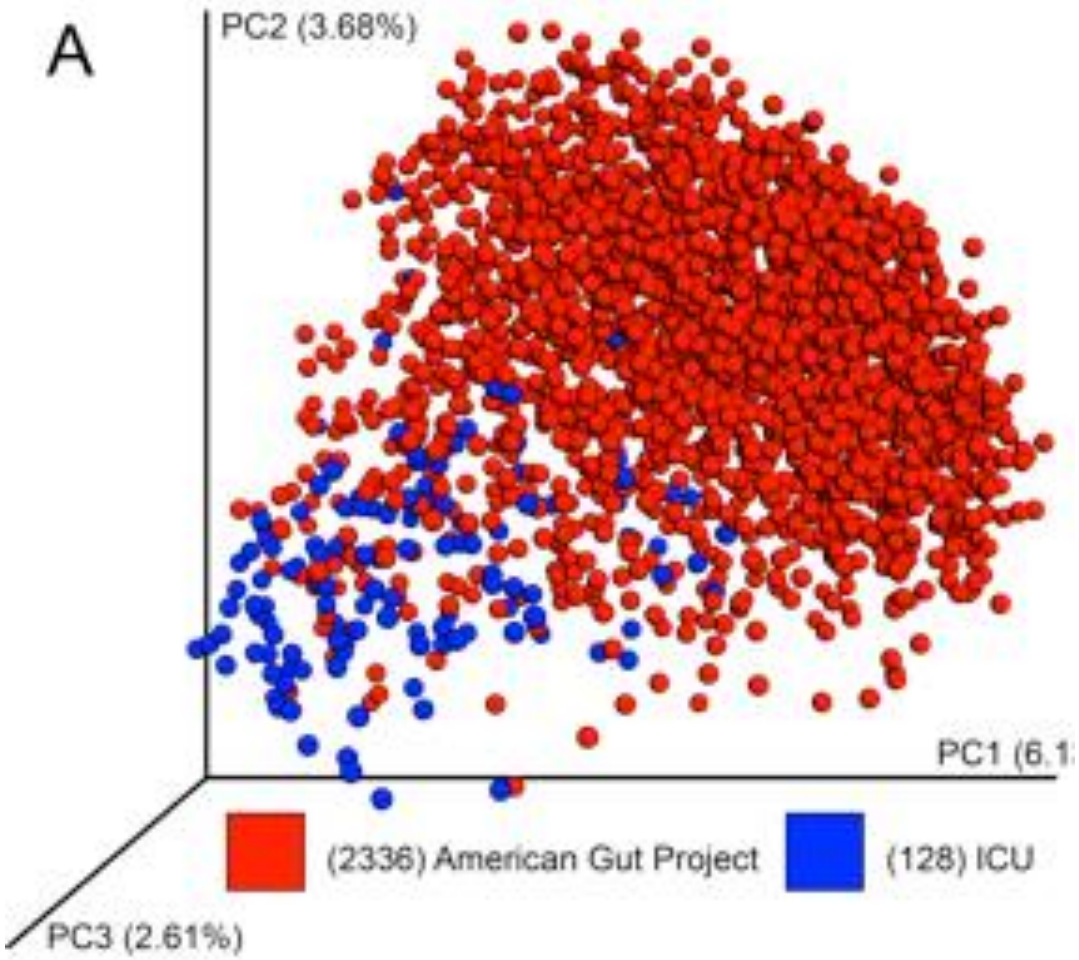
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Geno	2	1.0611184	0.530559	6.1750	0.0043*

Guts


Turkey Vulture
Cathartes aura
Filter
Red-Tailed Hawk
Buteo jamaicensis
Filter
Chicken
Gallus domesticus
Filter
Adult Human
Homo sapiens
Filter
Insectivorous Bat
Myotis lucifugus
Filter
African Elephant
Loxodonta africana
Filter
Colobus Monkey
Colobus abyssinicus
Filter
stomach pH
0
1
2
3
4
5
6
7
D
D
CD
BCD
BC
B
A
obligate scavenger
facultative scavenger
generalist carnivore
omnivore
specialist carnivore
herbivore (hindgut)
herbivore (foregut)


A
PC2 - 3.3%
(1086) Urban
(55) Remote Agrarian
(19) Hunter Gatherer
PC1 - 7.2%
PC2 - 3.1%

So far, for bacteria, lifestyle and genomes not geography



These lifestyle effects matter greatly to autoimmune disorders, to response to pathogens, and even for food.

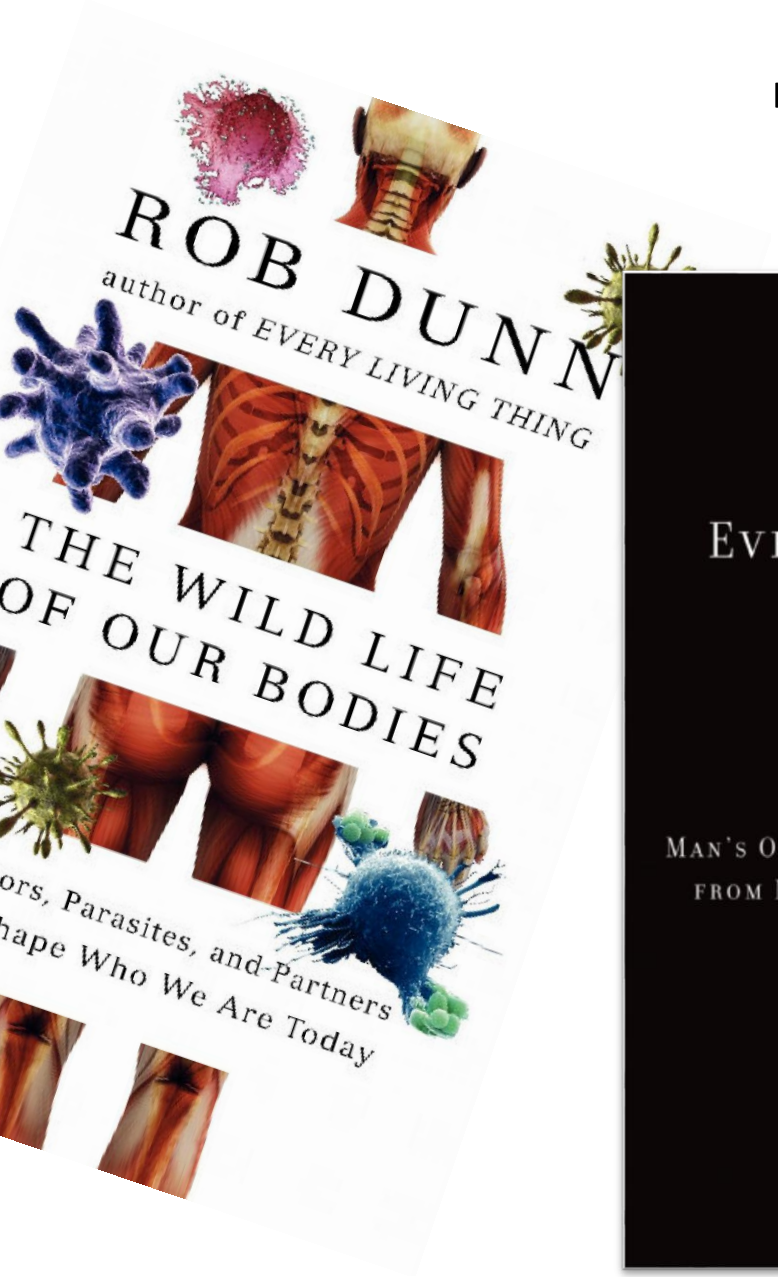
Take home?

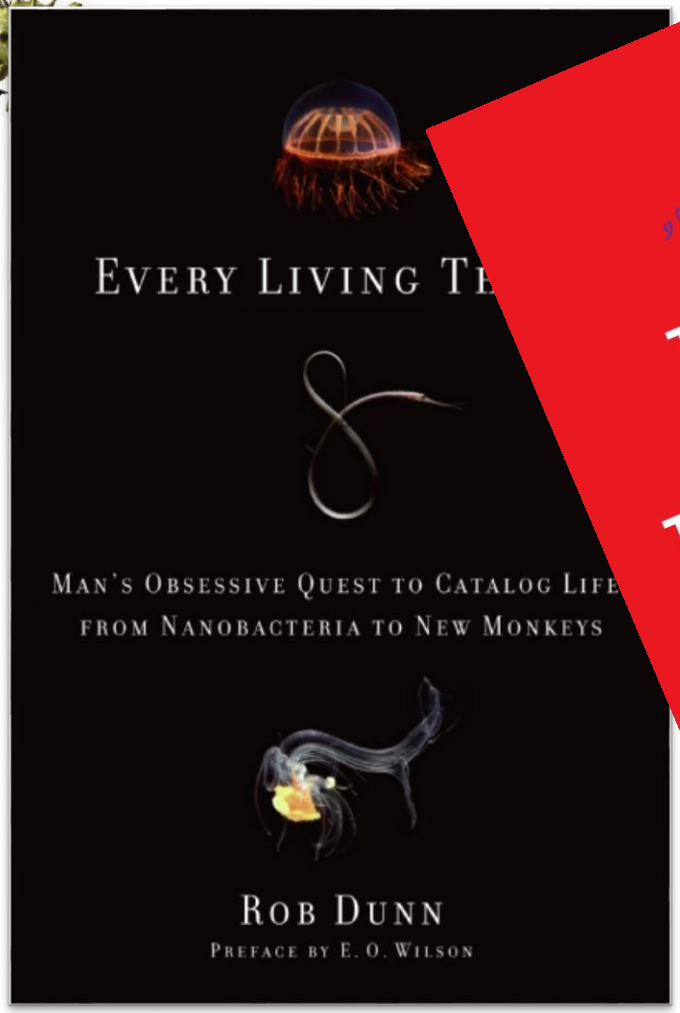
We have seen massive changed in the species associated with individual humans and humanity in general. These changes are geographically structured as a result both of history (be it ancient or modern) and climate. This matters because climate is changing. We assume (implicitly) the status quo in term of our interactions and the status quo is changing. These changes, most of them unstudied and hard to predict, we have the single largest impact on the future of humanity.

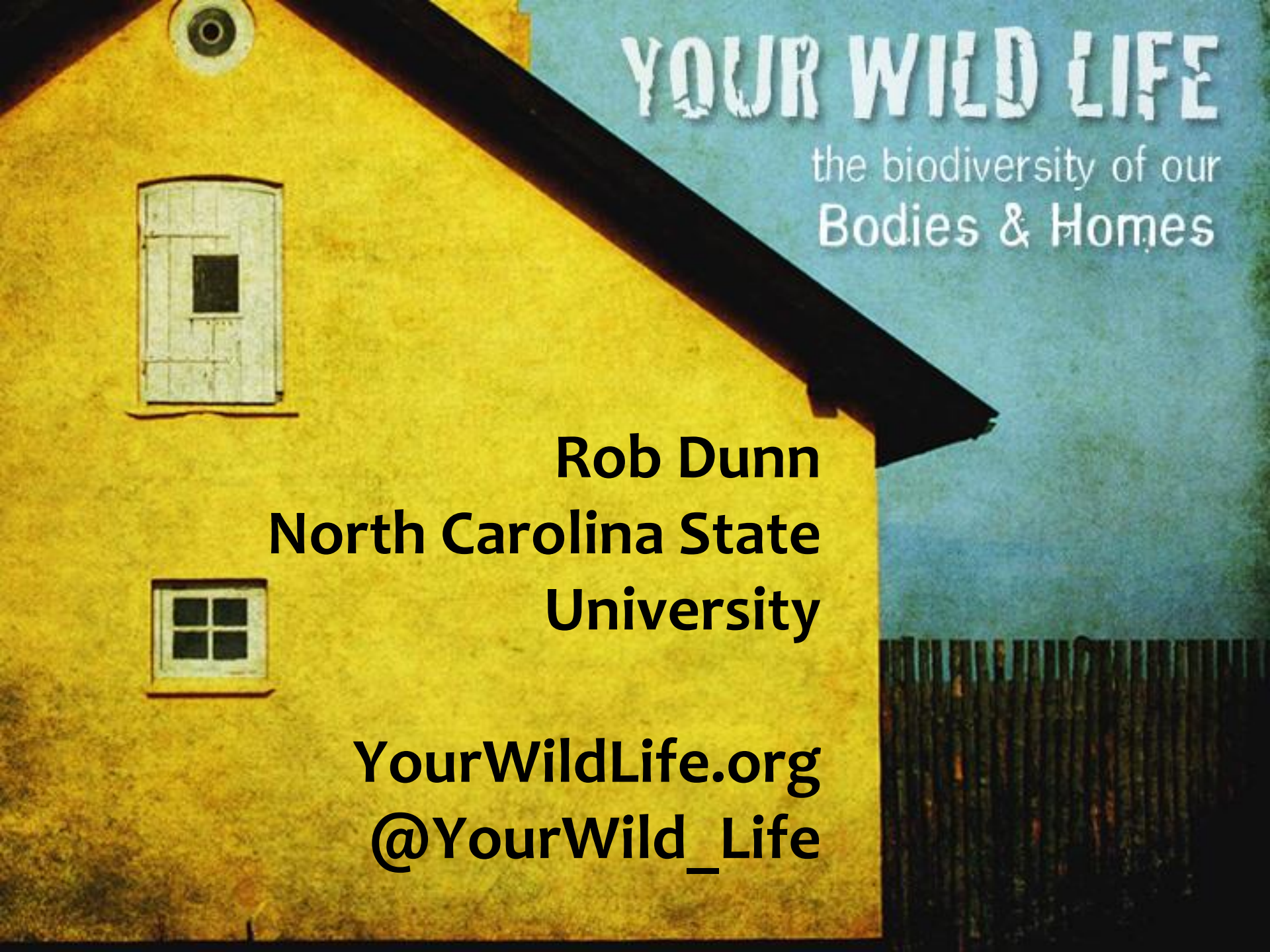
The Metaphorical Fecal Transplant

In this picture, we imagine we are the ant

rrdunn@ncsu.edu







Rob Dunn
North Carolina State University

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