

The 1000 Project

A microbial inventory of geothermal ecosystems



New Zealand Geothermal Workshop
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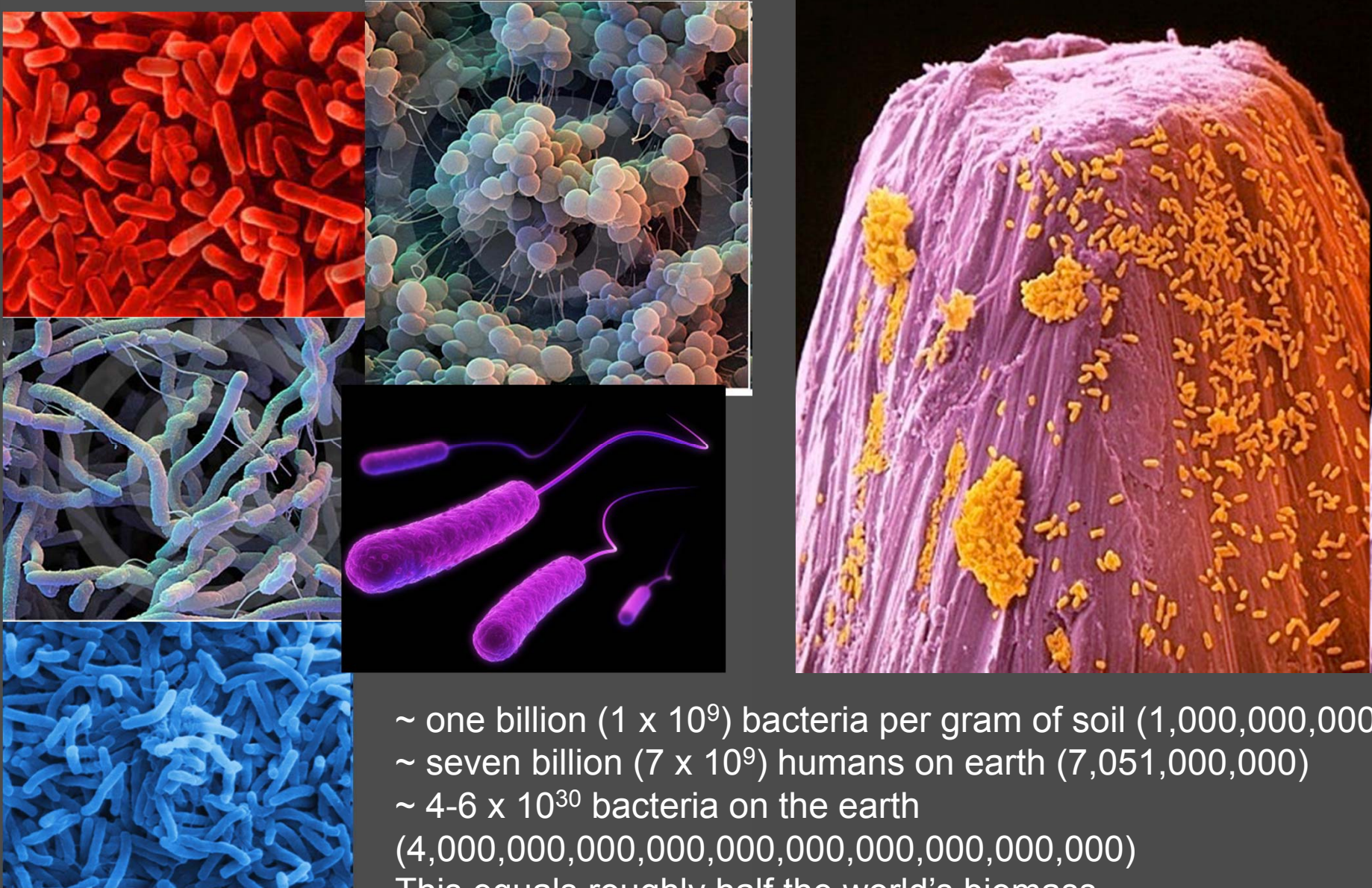


Purpose of presentation



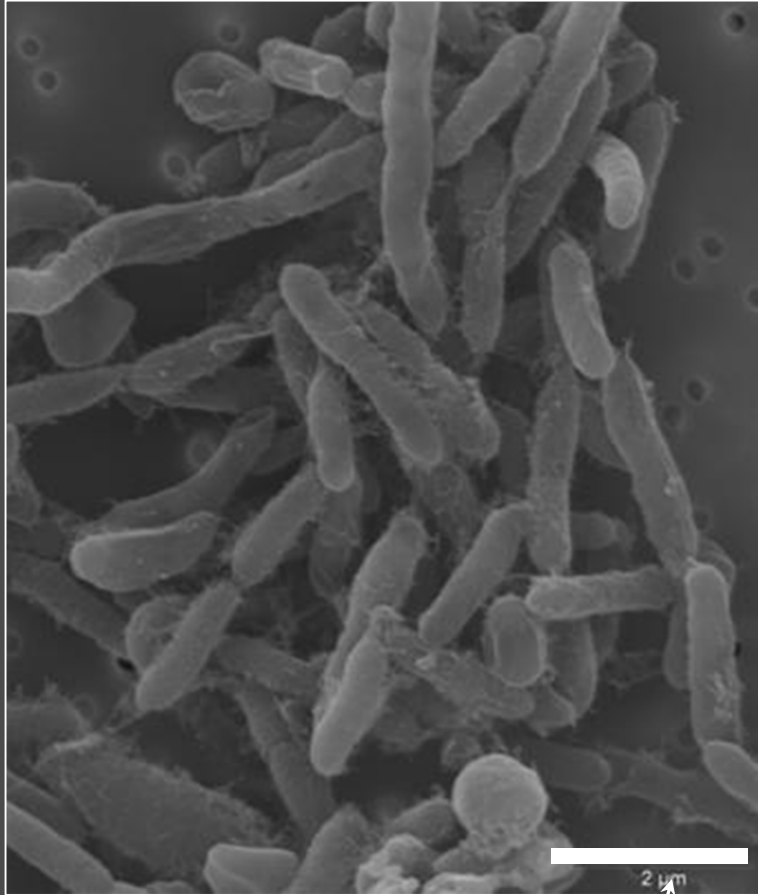
- **Microbiology:**
 - The basics
 - A microbial world
 - Microbiology and geothermal systems
- **Geothermal microbiology**
 - What little we know, and what we know we don't know
- **The 1000 Project**
 - A microbial bioinventory of NZ geothermal ecosystems

Microorganisms: single-celled organisms.
Includes: *Bacteria*, *Archaea* and some eukaryotes



~ one billion (1×10^9) bacteria per gram of soil (1,000,000,000)
~ seven billion (7×10^9) humans on earth (7,051,000,000)
~ $4-6 \times 10^{30}$ bacteria on the earth
(4,000,000,000,000,000,000,000,000,000,000)
This equals roughly half the world's biomass

... into context



2 μm (2/1000th of a millimetre)



...if we took 1 kg of soil: ~50 billion bacteria
and arranged them end-to-end

**More than enough bacteria
to stretch from Hamilton to
and Tauranga (~100km)**

...more fun with numbers



In a standard Human:

cells in the human body: $\sim 1 \times 10^{13}$ (10,000,000,000,000)

bacteria in the human body: $\sim 1 \times 10^{14}$ (100,000,000,000,000)

10x more bacterial cells than human cells!

(No matter whether you are the Prime Minister, the President, the Queen or the King!)



Bacteria=Germs=Bad!.... Really?



- Bacteria are normally associated with disease

But is this fair?

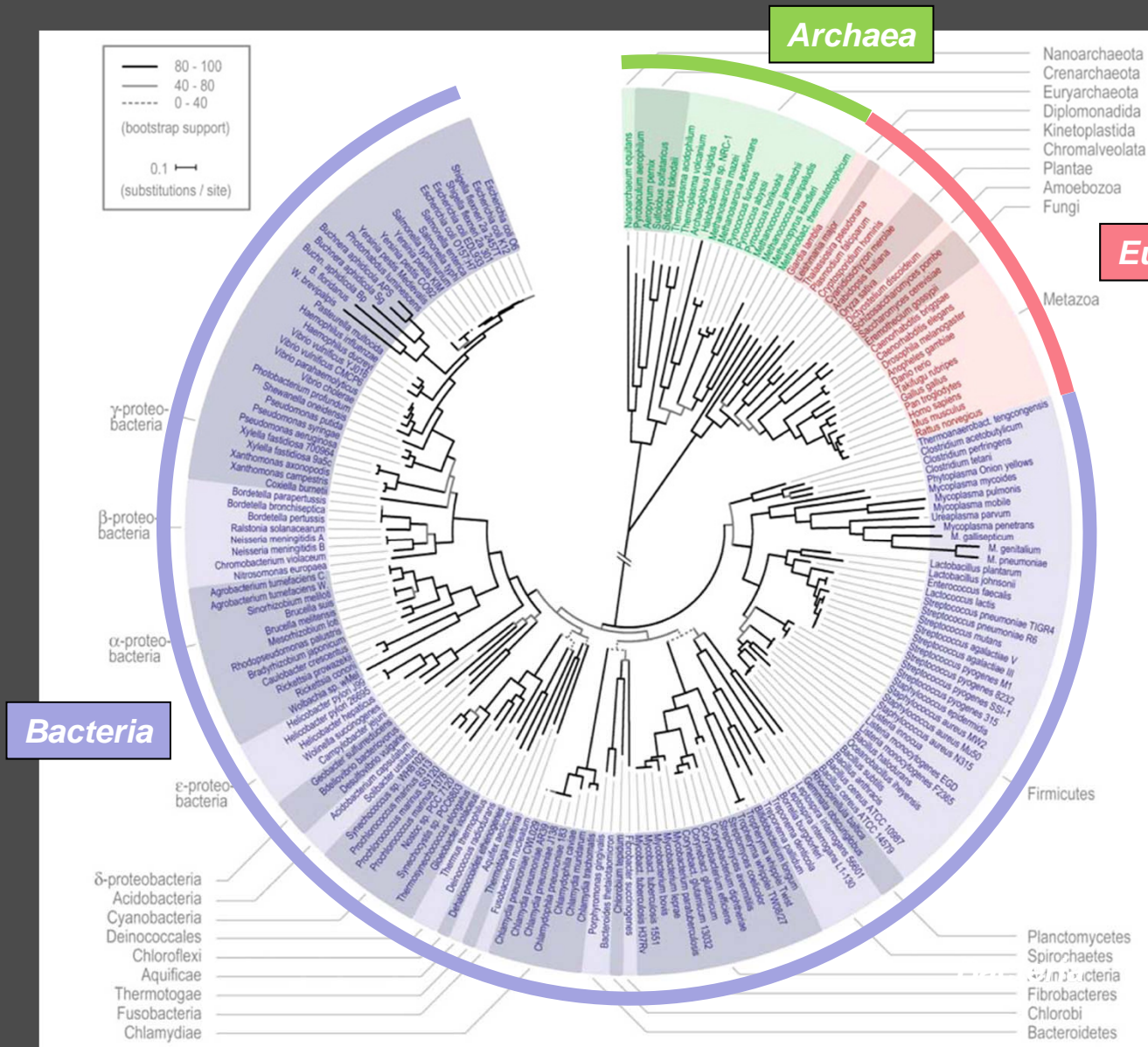
- Microbes are **EVERYWHERE** and involved in practically **EVERYTHING** you can think of.

- Almost every global environment is influenced by microbiology:

- N-fixation in plants
- Cow rumen
- Rocks (endoliths)
- Food
- Sewage
- geothermal
- Human body



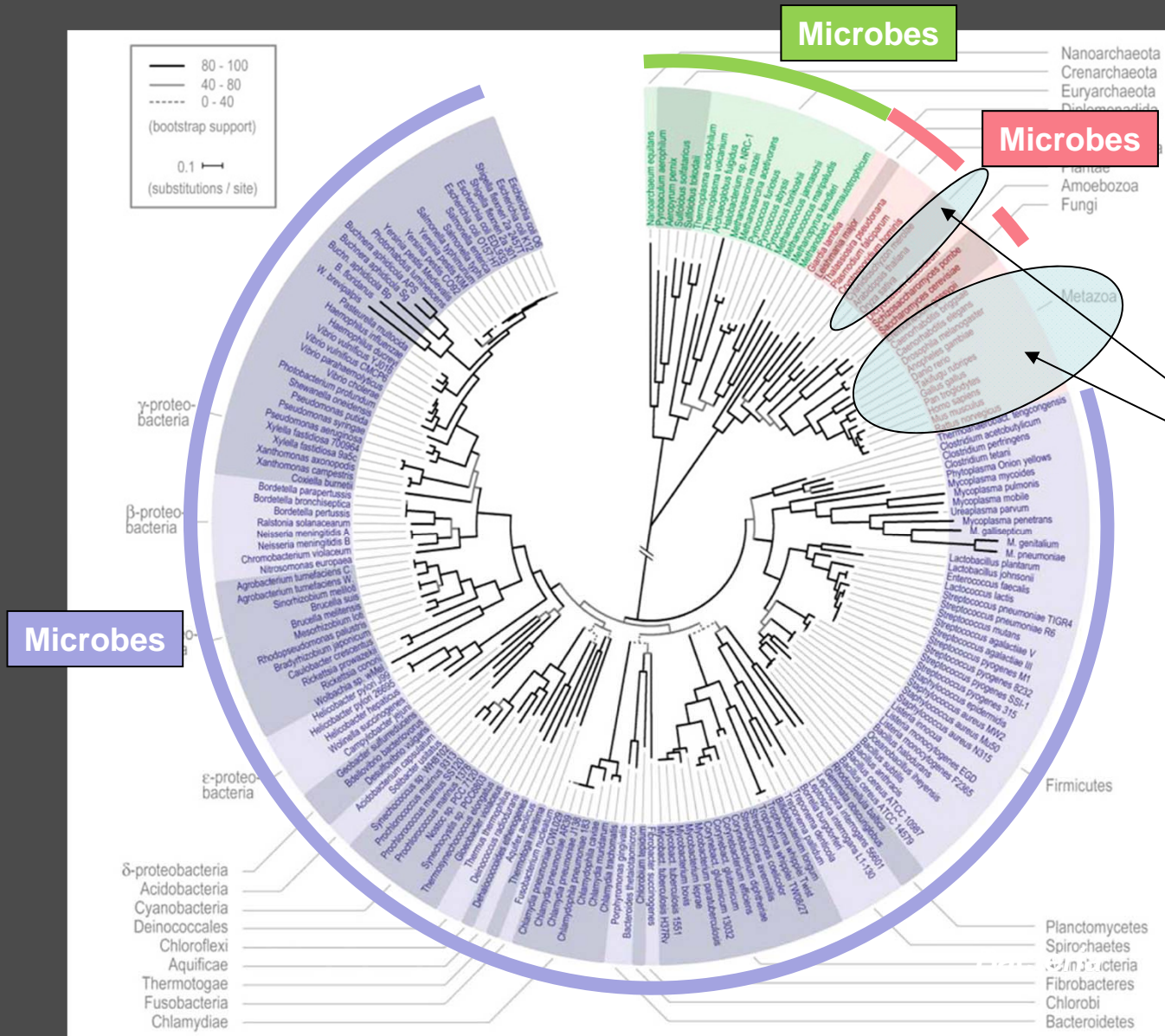
The Tree-of-Life (genetic relatedness)



Based on the SSU rRNA gene sequence

- Universal 'house-keeping' gene
- 16S: *Bacteria* & *Archaea*
- 18S: *Eukaryotes*)

The way a microbiologist views the tree-of-life

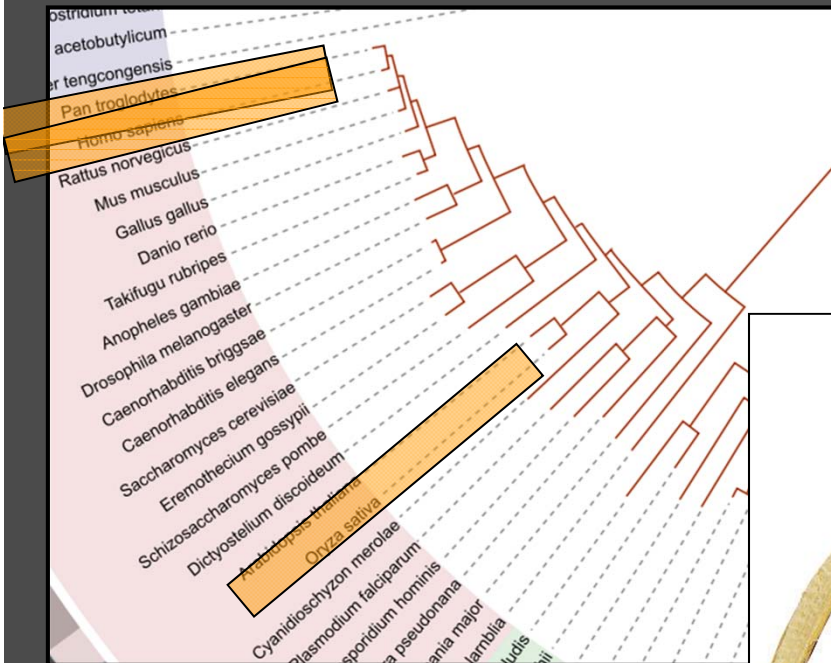
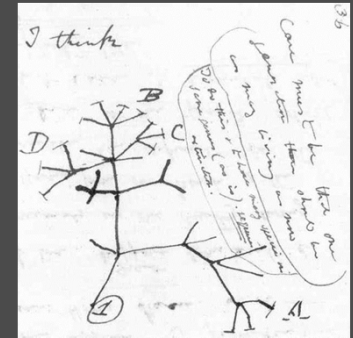


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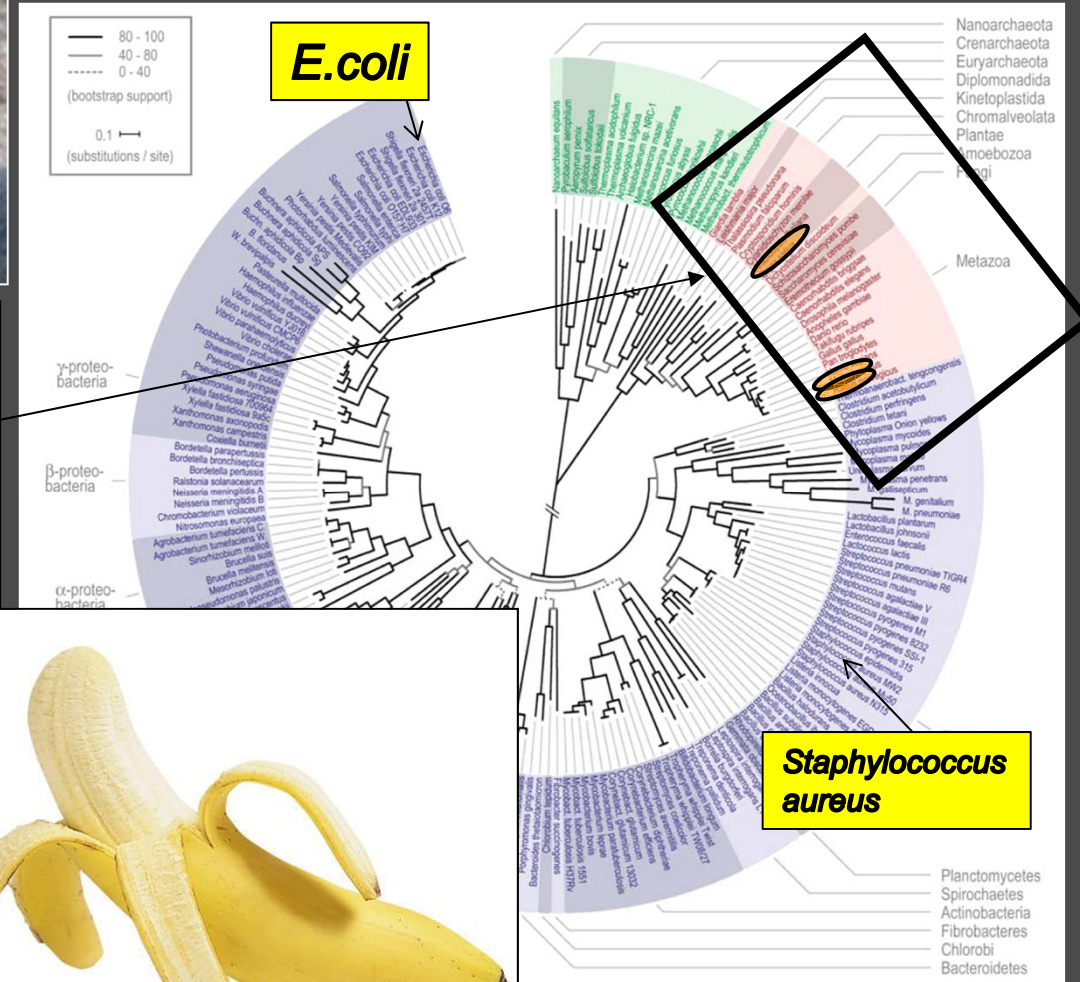
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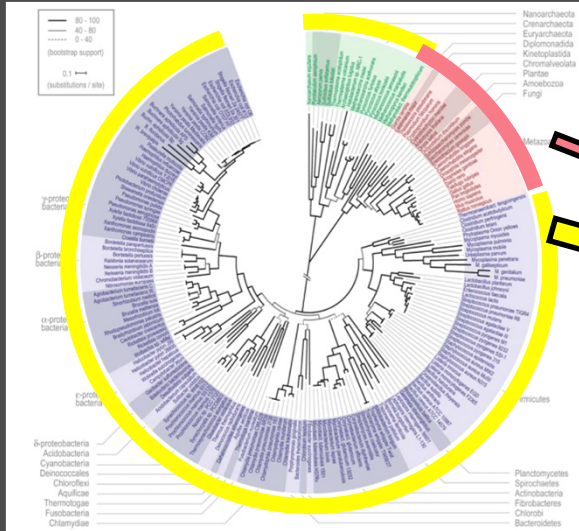
For perspective...

Phylogenetically, Humans, Chimpanzees and bananas are genetically more closely related than *E. coli* and *S. aureus*



Eukaryotes





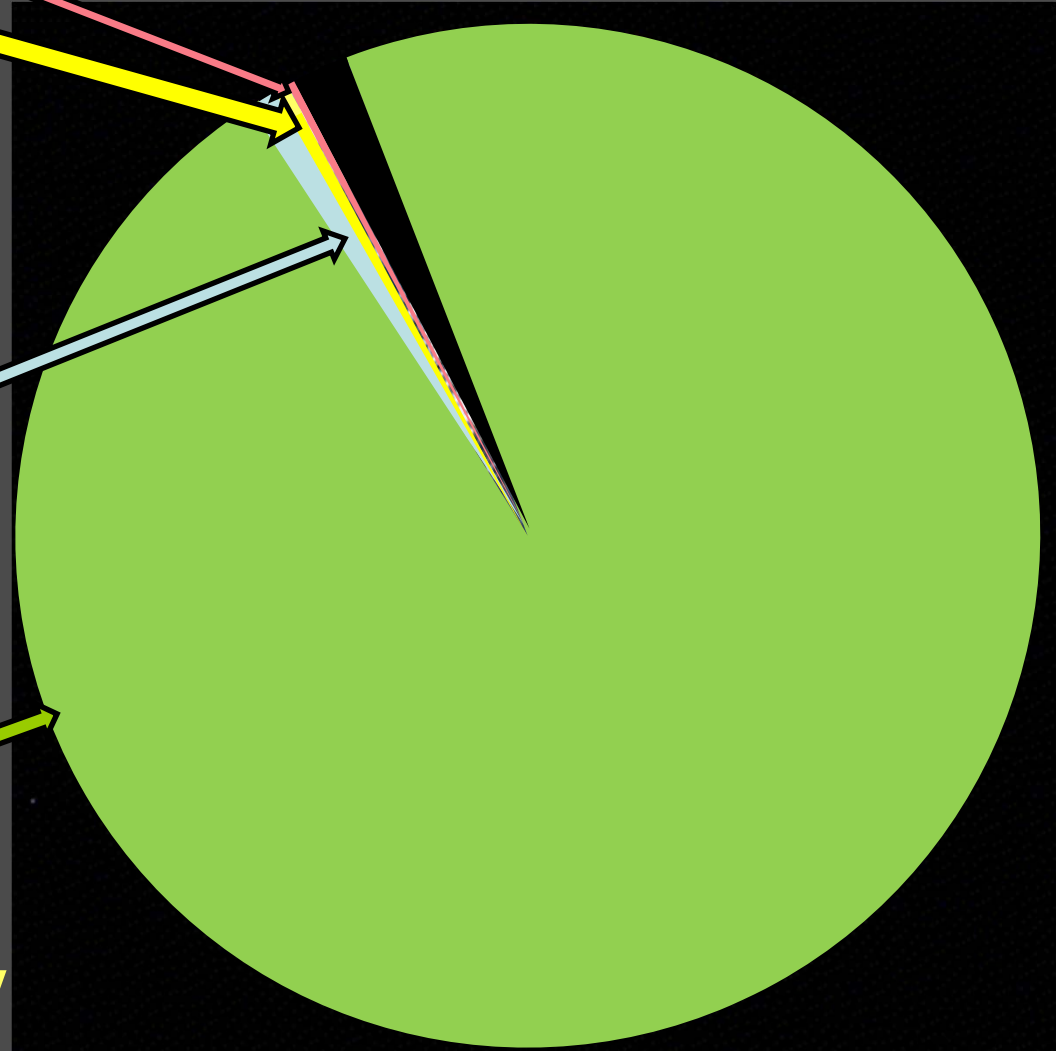
Eukaryotes: all plants, animals, insects, fungi, algae + others (1,200,000 spp.)

Bacteria & Archaea: all cultivated bacterial and archaeal strains (7,710 spp.)

The Uncultivated Majority

Microorganisms we have detected, but haven't been able to cultivate ($>10^6$)

The microbial majority that we haven't detected but know exist ($\sim 10^8 - 10^9$)



Global diversity



Extreme environments are a prime source of new species and genetic diversity

Baas Becking, 1934:

“Everything is everywhere, the environment selects”

Geothermal environments are:

- Chemically and physically unusual
- Rare globally

Rare environments = Rare organisms

... so what's my point?

Microorganisms:

- Are the dominant life form on earth
- Influence/are associated with essentially all ecosystems
- Have a mind-bogglingly large genetic diversity
- Geothermal environments select for novel microorganisms
- Have a huge biotechnology potential

Life?



An example of an extremophile



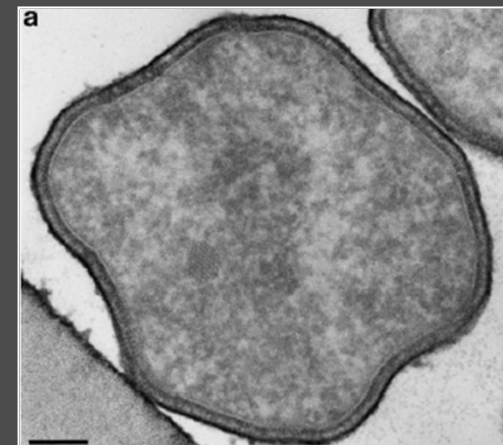
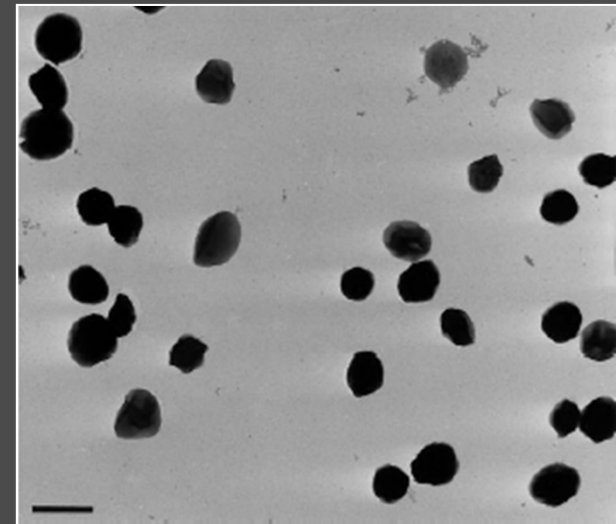
Pyrolobus fumarii

(Fire lobe of the chimney)

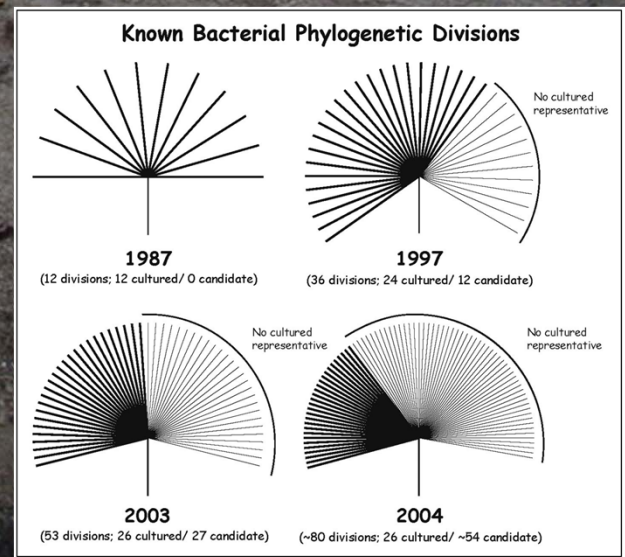
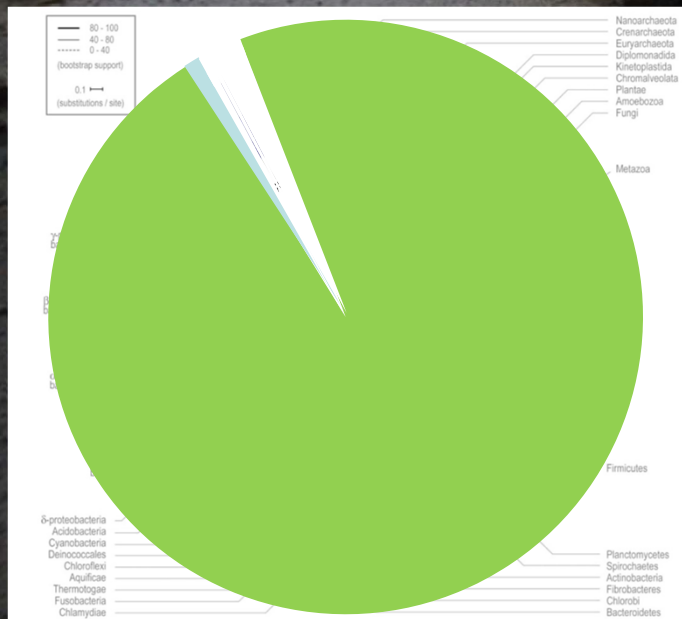
Grows best at 106 °C

Can grow as temps
as high as 113 °C

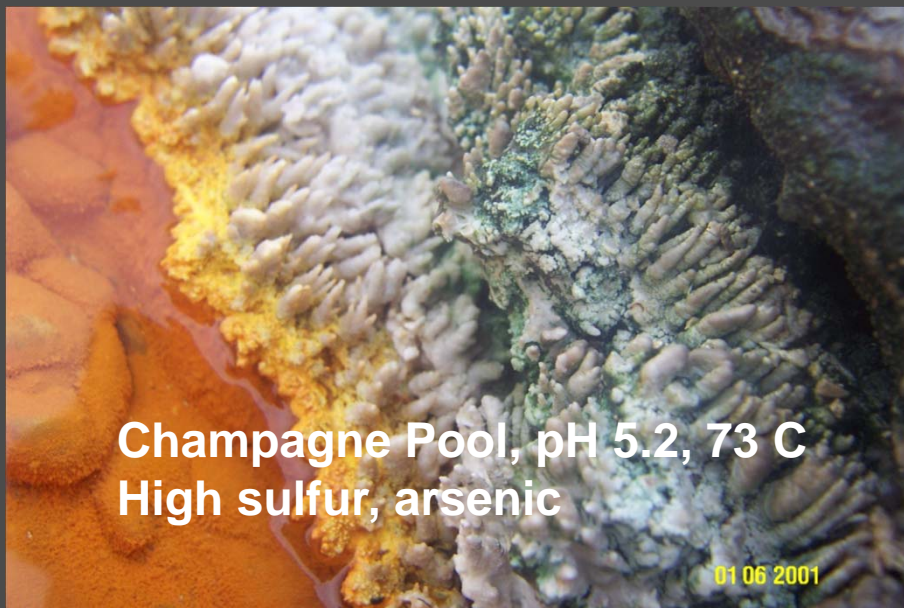
Dies if temperature
goes below 90 °C!



Is the uncultivated majority accessible? & Does NZ harbour the unique microbial communities?

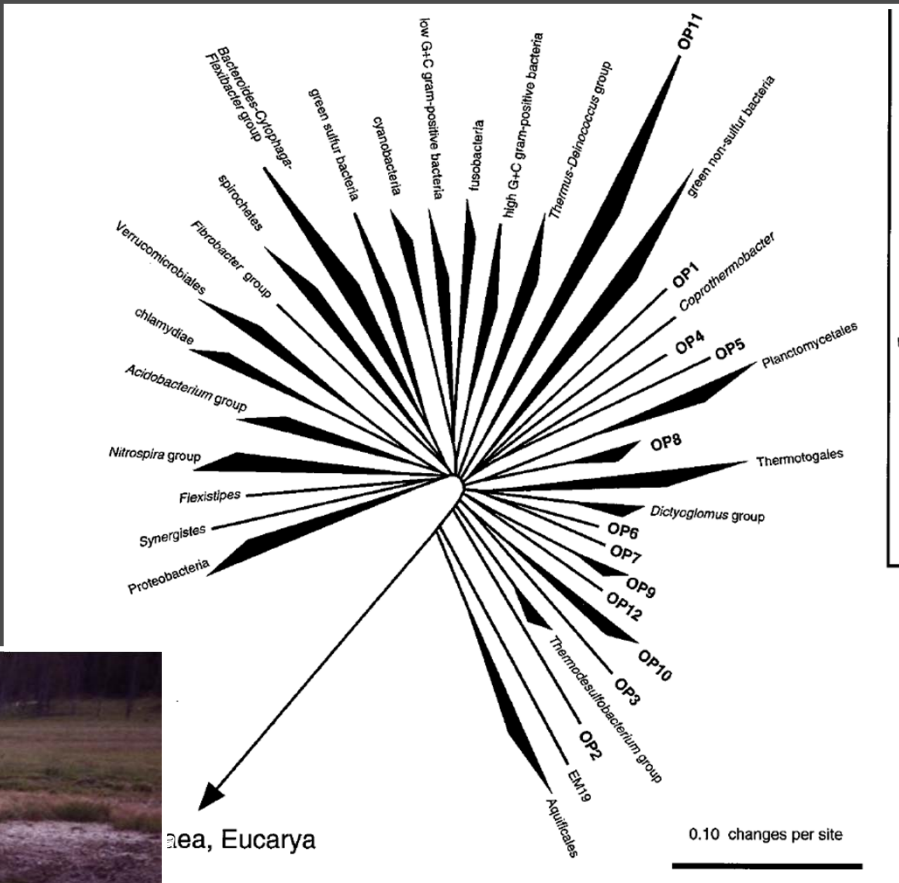


New Zealand – Highly diverse environments



Obsidian Pool, YNP

“the most diverse microbial environment on Earth”
 * 39 bacterial and archaeal phyla*



JOURNAL OF BACTERIOLOGY, Jan. 1998, p. 366-376
 0021-9193/98/\$04.00+0
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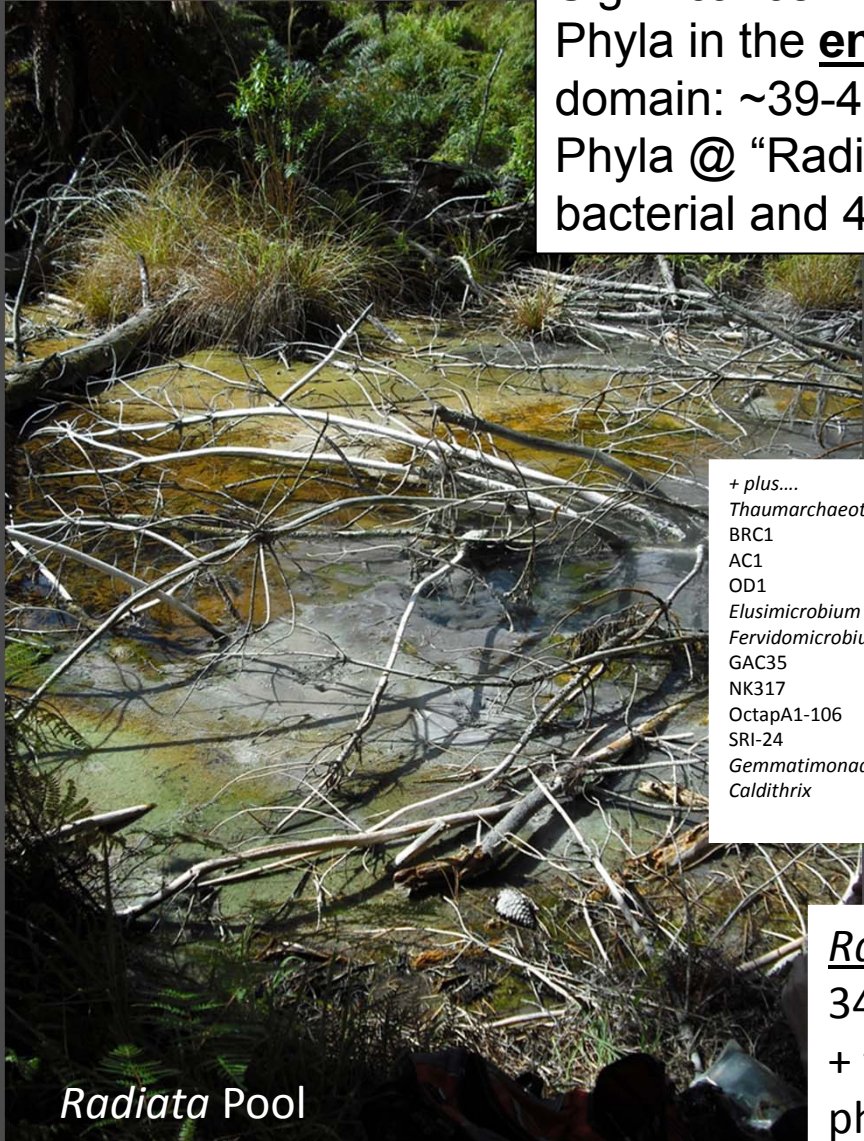
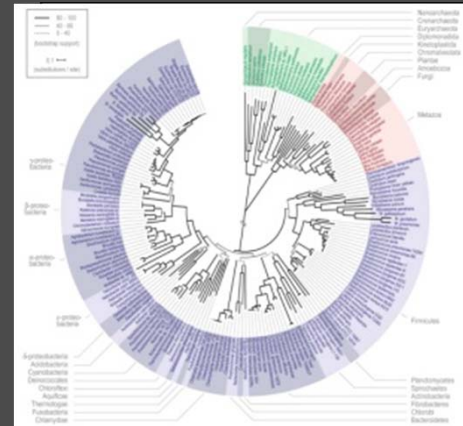
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Novel Division Level Bacterial Diversity in a Yellowstone Hot Spring

PHILIP HUGENHOLTZ, CHRISTIAN PITULLE, KAREN L. HERSHBERGER,† AND NORMAN R. PACE*

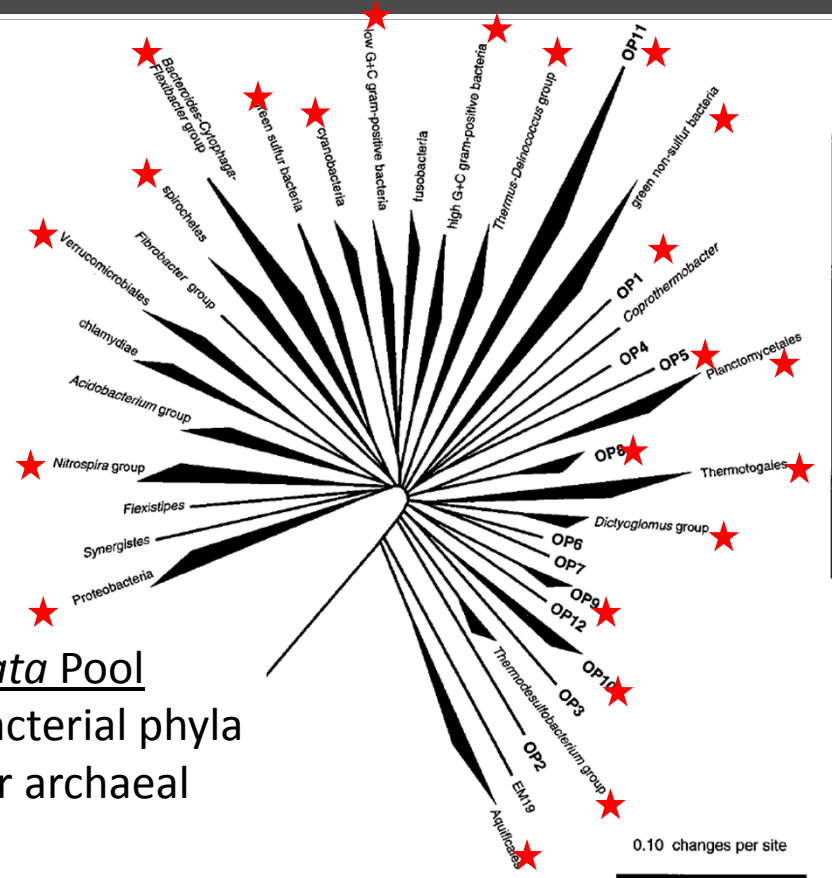
"Radiata Pool, NZ"

Significance:
 Phyla in the **entire** eukaryotic domain: ~39-41
 Phyla @ "Radiata Pool": 34 bacterial and 4 archaeal



- + plus....
- Thaumarchaeota
- BRC1
- AC1
- OD1
- Elusimicrobium
- Fervidomicrobium
- GAC35
- NK317
- OctapA1-106
- SRI-24
- Gemmatimonadates
- Caldithrix

Radiata Pool
 34 Bacterial phyla
 + four archaeal phyla



Radiata Pool

Why we should care about the microbial world?: A New Zealand perspective

- NZ (geothermal) microbial biodiversity essentially unknown
- Untapped resource
- The major future biotechnology and medical advances will take advantage of novel microbial diversity
- Questions:
 - Do NZ geothermal systems harbour the equivalent of a microbial kiwi/kakapo?
 - Does geothermal power production affect microbial diversity?
 - How do we determine what is novel and what is ubiquitous?

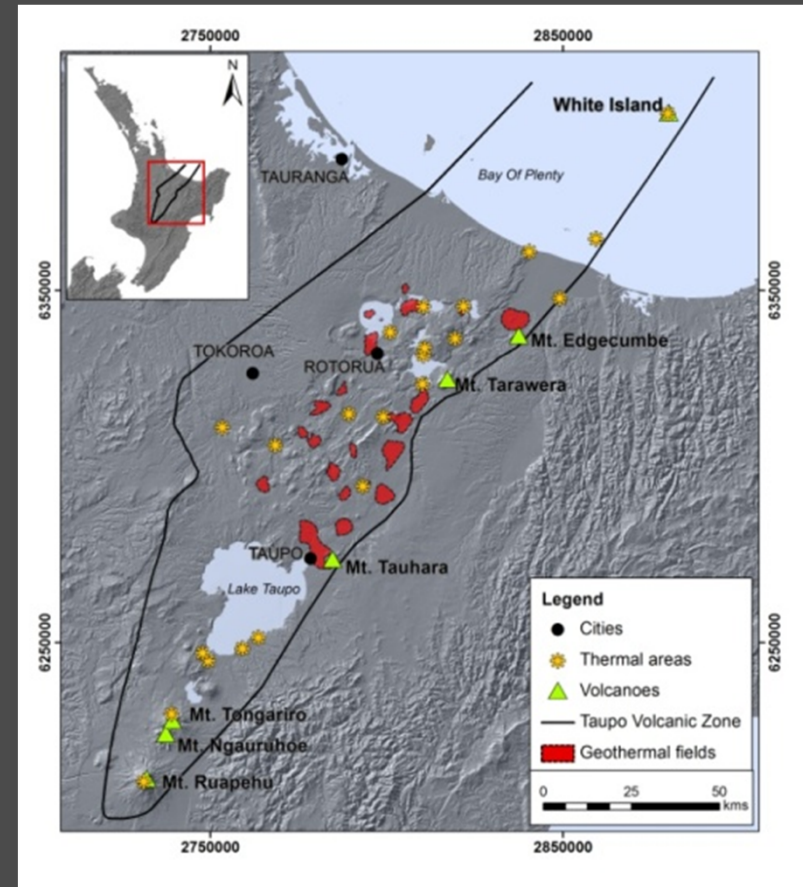


The 1000 Project

- GNS Science + U. Waikato
- \$1M for 2 years from MBIE

Bioinventory of microbial diversity of 1000 TVZ geothermal features

- Physical archive of samples
- Geochemical analysis
- Determine microbial diversity
- Develop “uniqueness” measure as a means to assess value for a range of stakeholders
- Publically accessible GIS database of diversity and geochemistry





Potential Value

- Ecosystem definition and identification (*regional councils, Power companies, Iwi, research community*)
- Bioprospecting, screening, biotechnology (*MBIE, Biotechnology firms, research communities, Iwi*)
- Biosecurity (*EPA, DOC, MPI*)
- Resource management , governance (*MBIE, regional councils, DOC, Iwi*)
- Conservation (*DOC, tourist operations, regional councils, Iwi, research community*)
- Resource utilisation (*power companies, Iwi*)
- Recreation, tourism (*regional councils, tourism operations, Iwi*)
- Cultural, mātauranga Māori

Summary: 1000 Project

If this work interests you or will potentially be of some value to your organisation / research, we'd like to hear from you. We're looking for:

- Interested parties for a steering group
- Access to features in the TVZ
- Priority list of features
- Opinion of what merits “uniqueness”

