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DIVISION ON EARTH AND LIFE STUDIES

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Measuring the Microbial World

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Board on Life Sciences

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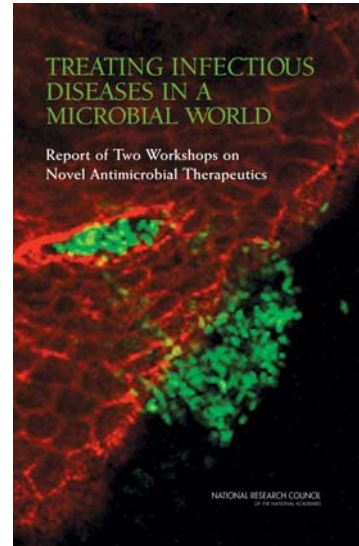
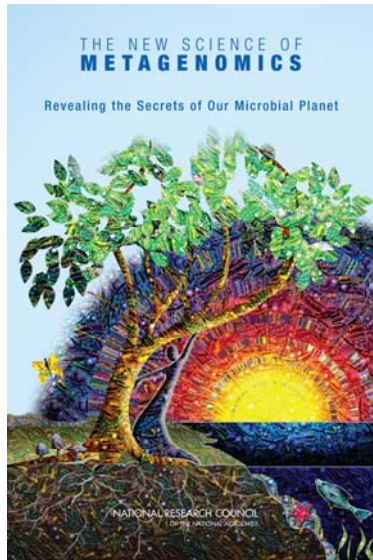
The National Academies

- For advice on issues on science, technology, and public health, the nation's leaders often turn to the National Academies—the private, nonprofit institution specially created by a congressional charter in 1863 for this purpose.
 - National Academy of Sciences
 - National Academy of Engineering
 - Institute of Medicine
 - National Research Council
- The National Academies bring together committees of experts who volunteer their time to address critical national issues and give advice to the federal government and the public. The National Academies are private, nonprofit institutions that issue more than 200 reports each year.

Recent Board on Life Sciences reports

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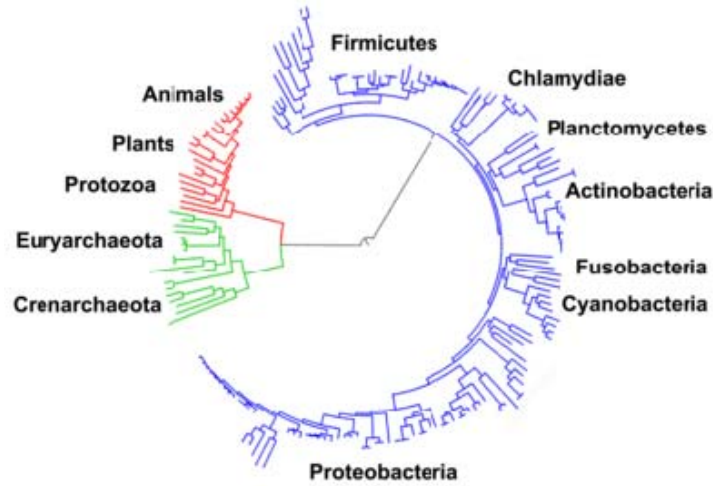
What has the Human Genome Project done for me lately?



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A more complete tree of life

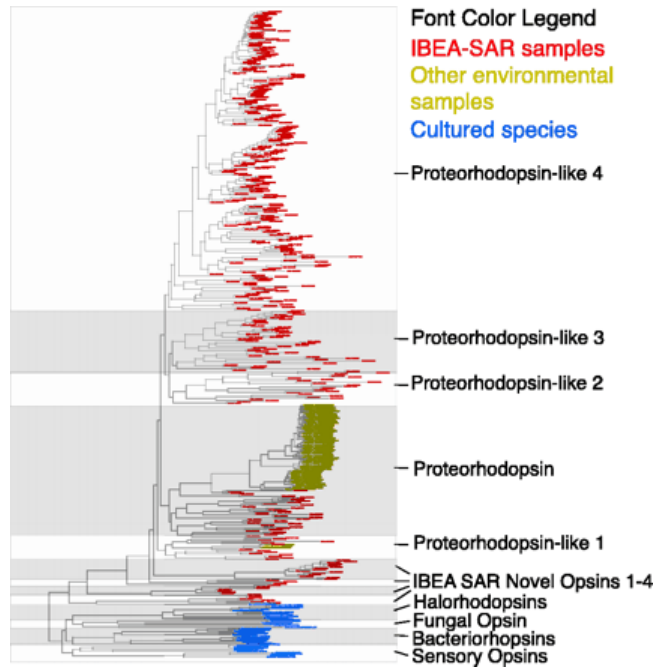


The voyage of the sorcerer II

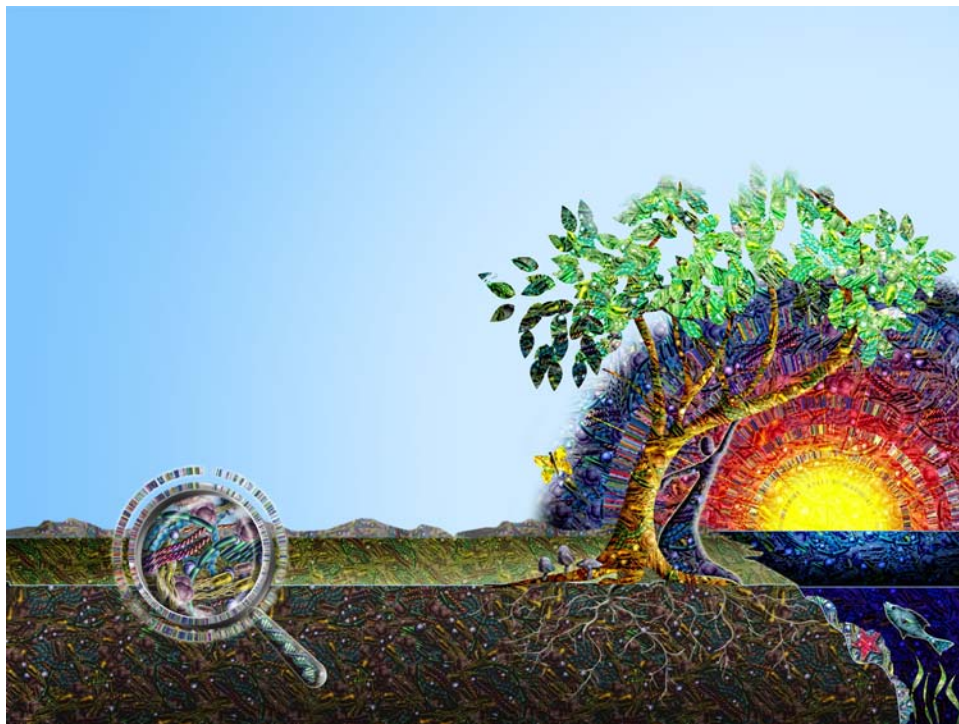


Diversity of proteorhodopsin sequences in the Sargasso Sea

As with many other genes, environmental surveys reveal vast and hitherto unexpected numbers and variations of gene sequences. The Sargasso Sea project revealed not only many new gene sequences but whole new classes of sequences. Only those indicated in blue were previously known from cultured organisms.



So what?



- **The microbial world is vast and largely unexplored**
- **Microbes play a vital, complex and only partially understood role in organisms and ecosystems**
- **Tools and standards to characterize these communities will allow transformed approaches to:**
 - Human health
 - Agricultural productivity
 - Drug discovery and development
 - Novel biomaterials and industrial production processes
 - Climate change mitigation
 - Waste treatment
 - Pollution remediation
 - Environmental monitoring
 -

We are not alone



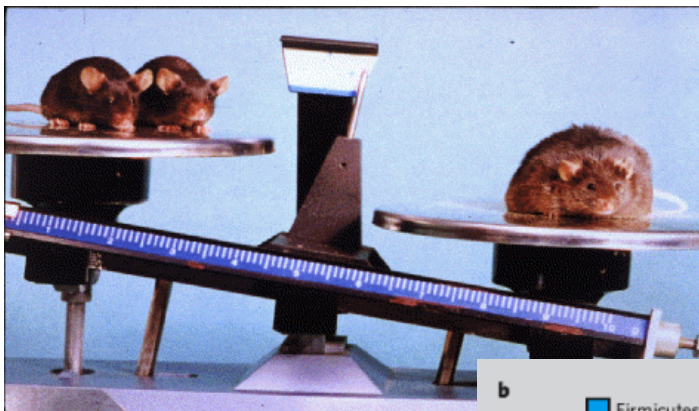
Fun facts about your microbiome!

Your body contains 10 times more microbial cells than human cells!

The average human provides a home for about 2 pounds of microbes!

They help you digest your food, make vitamins for you and protect you from microbial invaders!

Microbes and metabolism



The microbiome and immunity

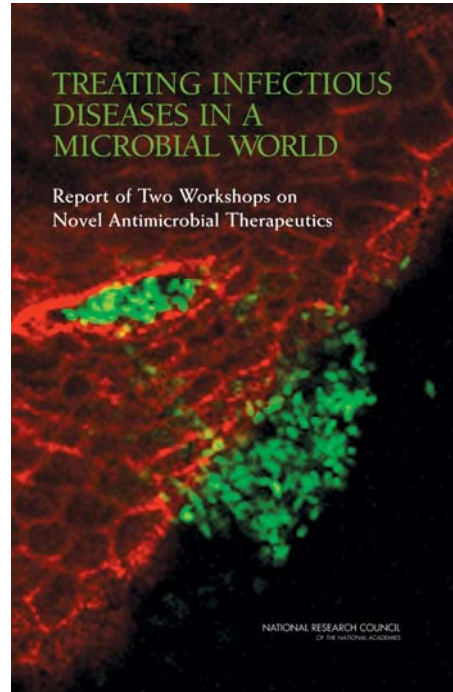


Specifically....

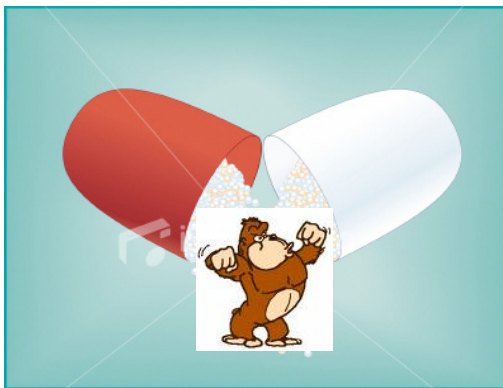
In the area of infectious diseases, tools and standards for microbial ecology will contribute to:

- Detecting and treating infectious diseases
- Predicting the emergence of infectious diseases
- Biosecurity

The role of microbes in treating infectious disease



Workshop goals



Gorillacillin



Immune booster



Old style – bad guys are solitary and easy to tell from the good guys



Huge crowds, most are friendly



Badness is context dependent...



Treating infectious diseases in a microbial world

Antibiotic resistance is ancient, ubiquitous and easily shared
So, gorillacillin will be outwitted. And a non-specifically boosted immune system would have a lot of bad side effects.

So, imitate the immune system

- detect and react to damage
- then turn off again

For example – a potent antibiotic that is activated only in the presence of immune system damage signals

Working with the microbiome

Humans live in harmony with trillions of microbes – if we can understand how they communicate with our immune systems, perhaps it will allow the development of therapeutics that help the immune system react specifically to pathogens

Areas where research is needed:

What is the variability of the human microbiome:

from youth to old age?

in health and sickness?

How is it affected by:

where you live?

what you eat?

antibiotic treatment?

High throughput sequencing is great

But... these are complex, spatially organized communities and sequence only measures one dimension

We will need ways to understand:

- **How is the community structured?**
- **Who is communicating with whom?**
- **Who is sharing genes with whom?**
- **And how is the microbial community interacting with its host?**

And to revolutionize antimicrobial treatment, we need tools

to assess:

- The state of the microbiome
- The state of the immune system
- The communication between the two

Understanding microbial communities

- Proteomics
- Metabolomics
- Single cell analyses
- Imaging technologies
- Functional metagenomics
- Metadata standards
- Dynamic, interactive databases

