

Microbiome and Metagenomics



Overview of this talk

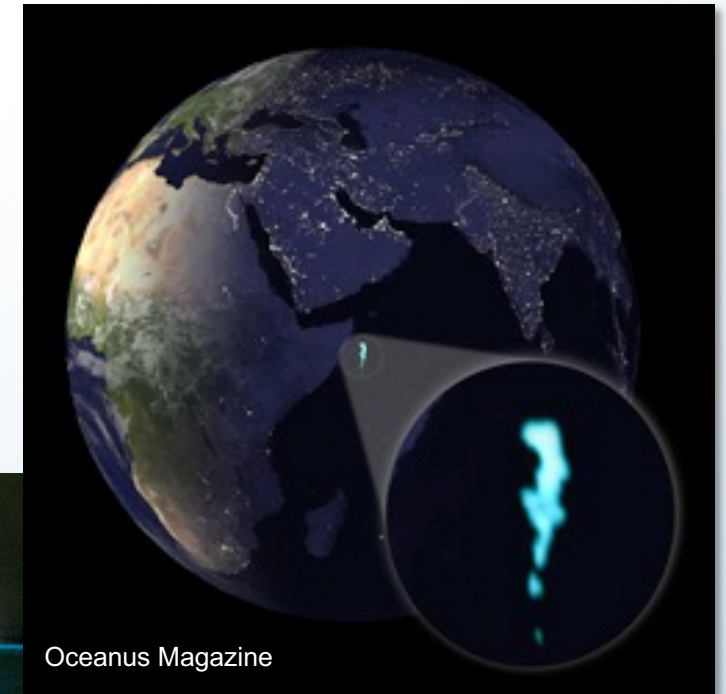
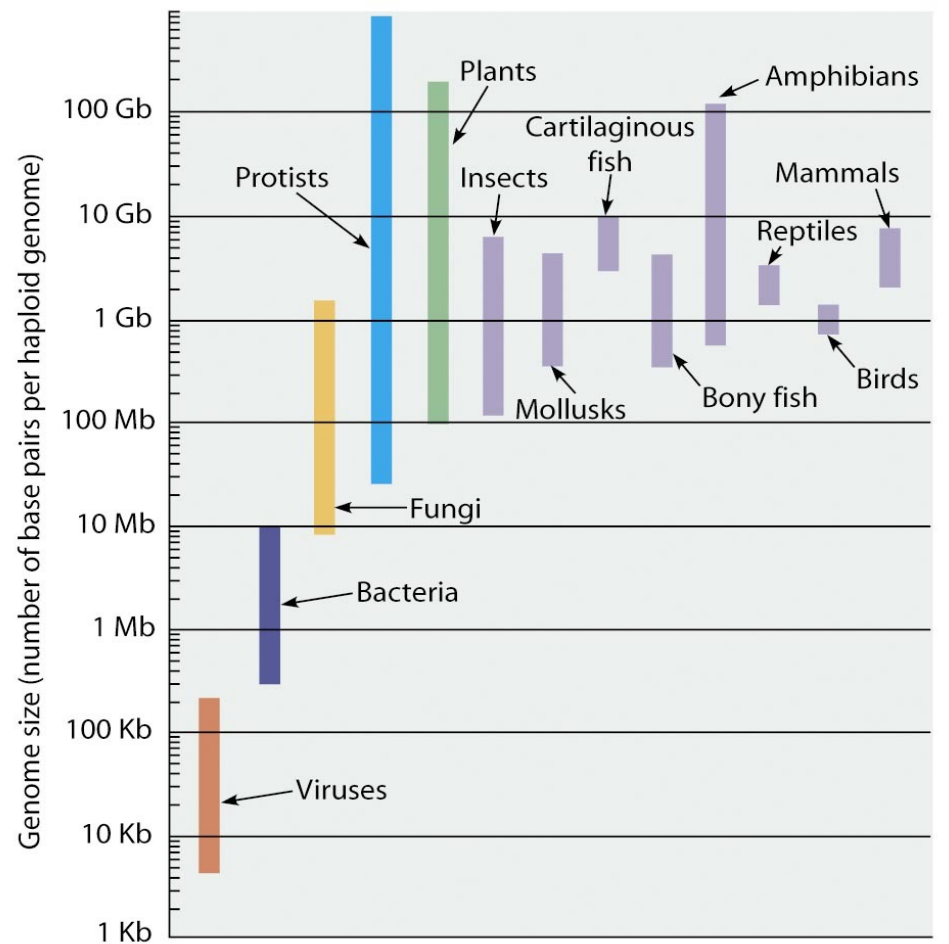
Microorganisms

Microbiomes – humane microbiome

Metagenomics

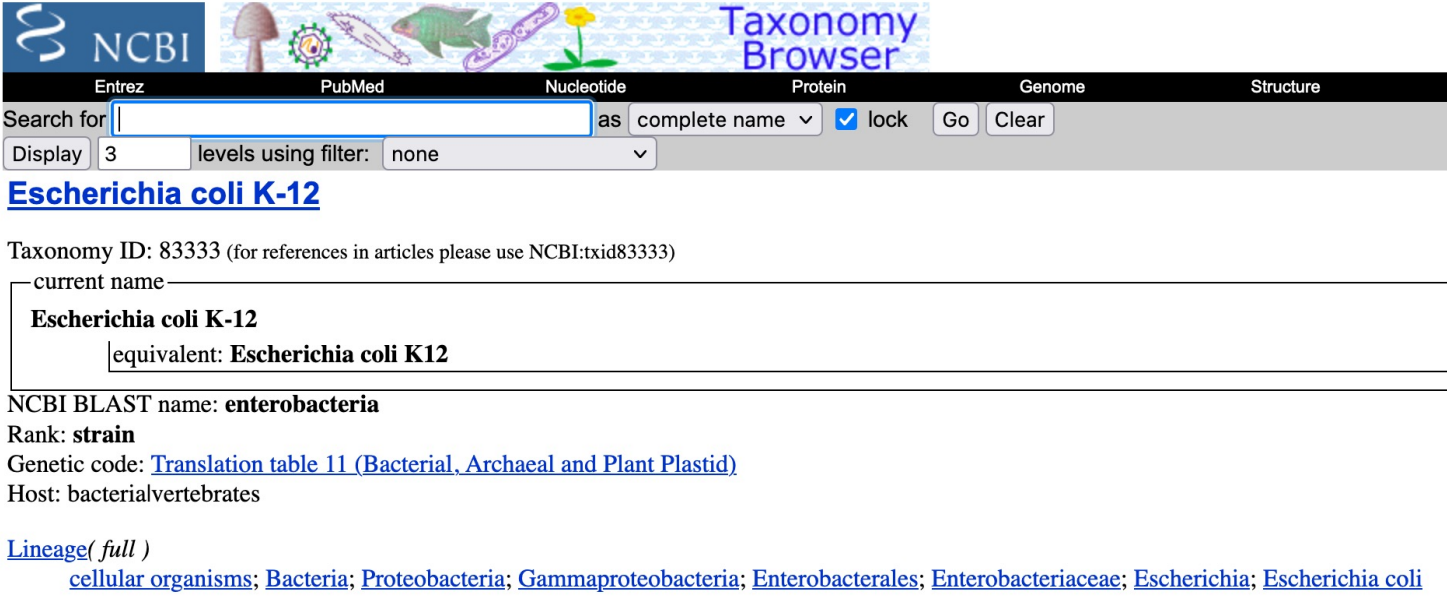
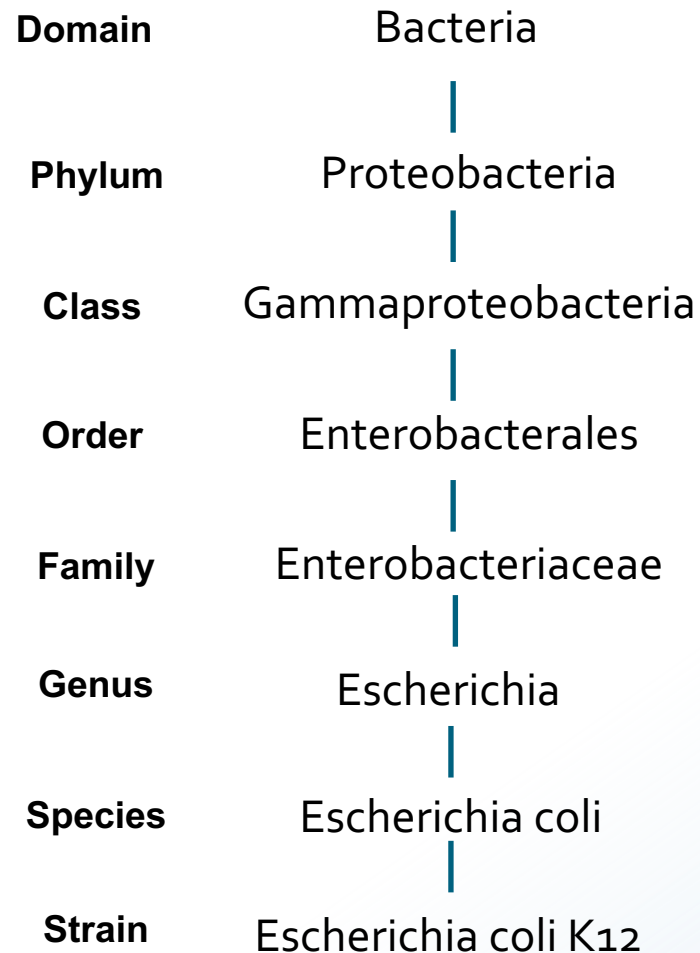
Microbes are single-cell organisms (bacteria, archaea, eukaryotes) and virus

Extreme diversity in appearance and capabilities



Milky Sea effect cause by *Vibrio Harveyi*

Bacteria can be classified into taxonomic levels



The screenshot shows the NCBI Taxonomy Browser interface. The search bar contains "Escherichia coli K-12" and the search results show the following information:

- Search for: as complete name lock Go Clear
- Display: 3 levels using filter: none
- Escherichia coli K-12**
- Taxonomy ID: 83333 (for references in articles please use NCBI:txid83333)
- current name: **Escherichia coli K-12**
- equivalent: **Escherichia coli K12**
- NCBI BLAST name: **enterobacteria**
- Rank: **strain**
- Genetic code: [Translation table 11 \(Bacterial, Archaeal and Plant Plastid\)](#)
- Host: bacterialvertebrates
- [Lineage\(full \)](#)
[cellular organisms](#); [Bacteria](#); [Proteobacteria](#); [Gammaproteobacteria](#); [Enterobacteriales](#); [Enterobacteriaceae](#); [Escherichia](#); [Escherichia coli](#)

Microbial habitats - microbes are found "everywhere"

Microbes are found "everywhere", from the outermost part of the atmosphere to interior of the amniotic sac

Superbakterier truer romstasjonen

Farlige bakterier har kolonisert den internasjonale romstasjonen ISS, men nå slår vitenskapen tilbake.



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Journalist

Publisert i dag kl. 12:36

nrk.no



Pinterest.com

We are utilizing the functional capabilities of microbes

Important in e.g. food industry



We are utilizing the functional capabilities of microbes

Important in e.g. food industry, but could microbes potentially be lethal to us



S/Africa identifies source of deadly listeriosis outbreak

🕒 March 05, 2018 to 05:58 👁 5861

APA-Pretoria (South Africa)

Food from a bologna-making factory in the South African city of Polokwane in northern Limpopo Province is the source of the deadly listeriosis outbreak in the country which has so far killed 180 people and affected 915 others, a senior official said on Sunday.



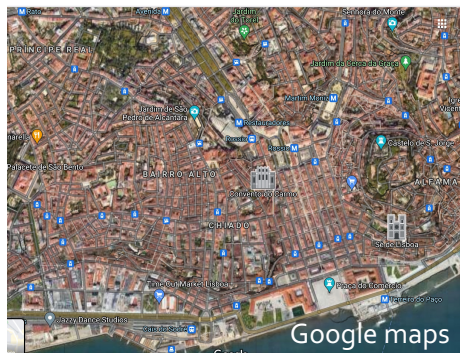
Wikipedia

How many different microbial species are there?

Estimated 10^{12} – 10^{19} microbial species – We have described 10^4



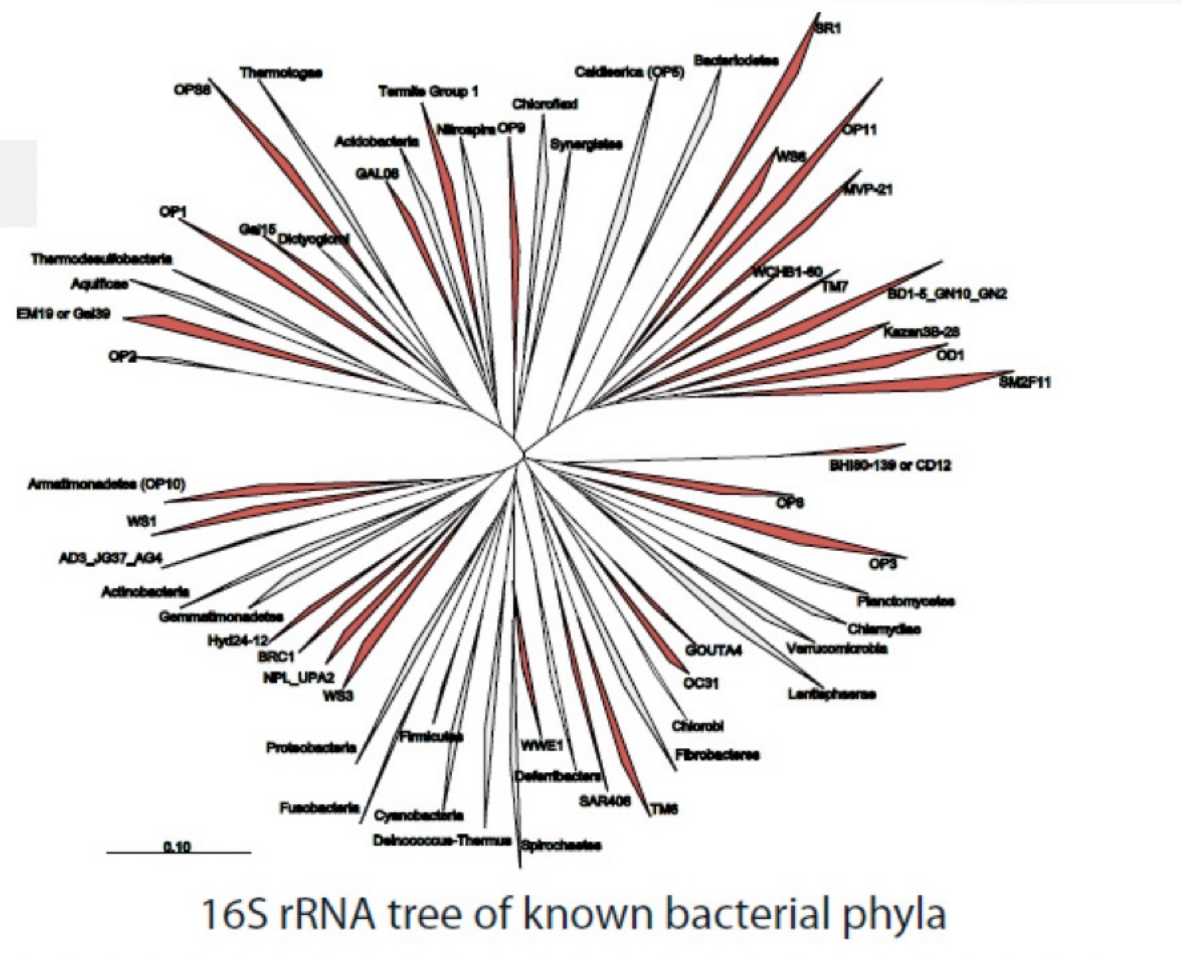
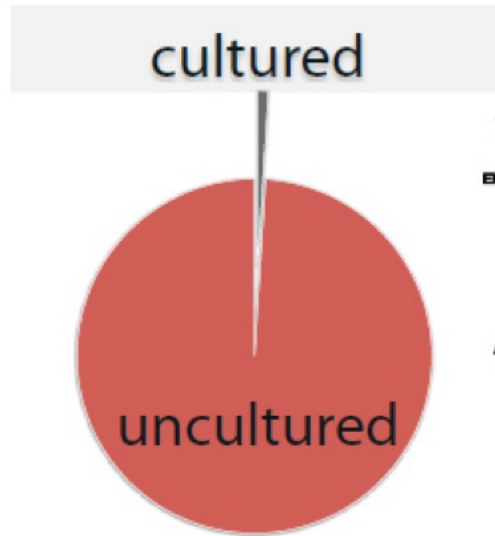
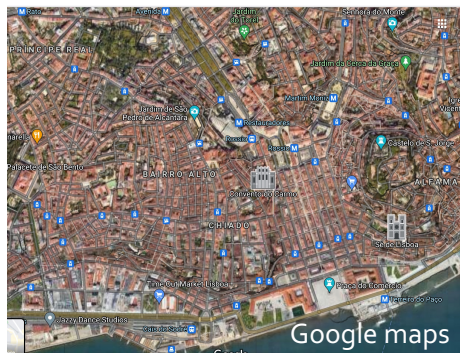
Earth surface = 510 100 000 km²



Lisboa city centre = 5,1 km²

«Microbial dark matter»

Estimated to be > 1000 bacterial phyla – we have described 92...



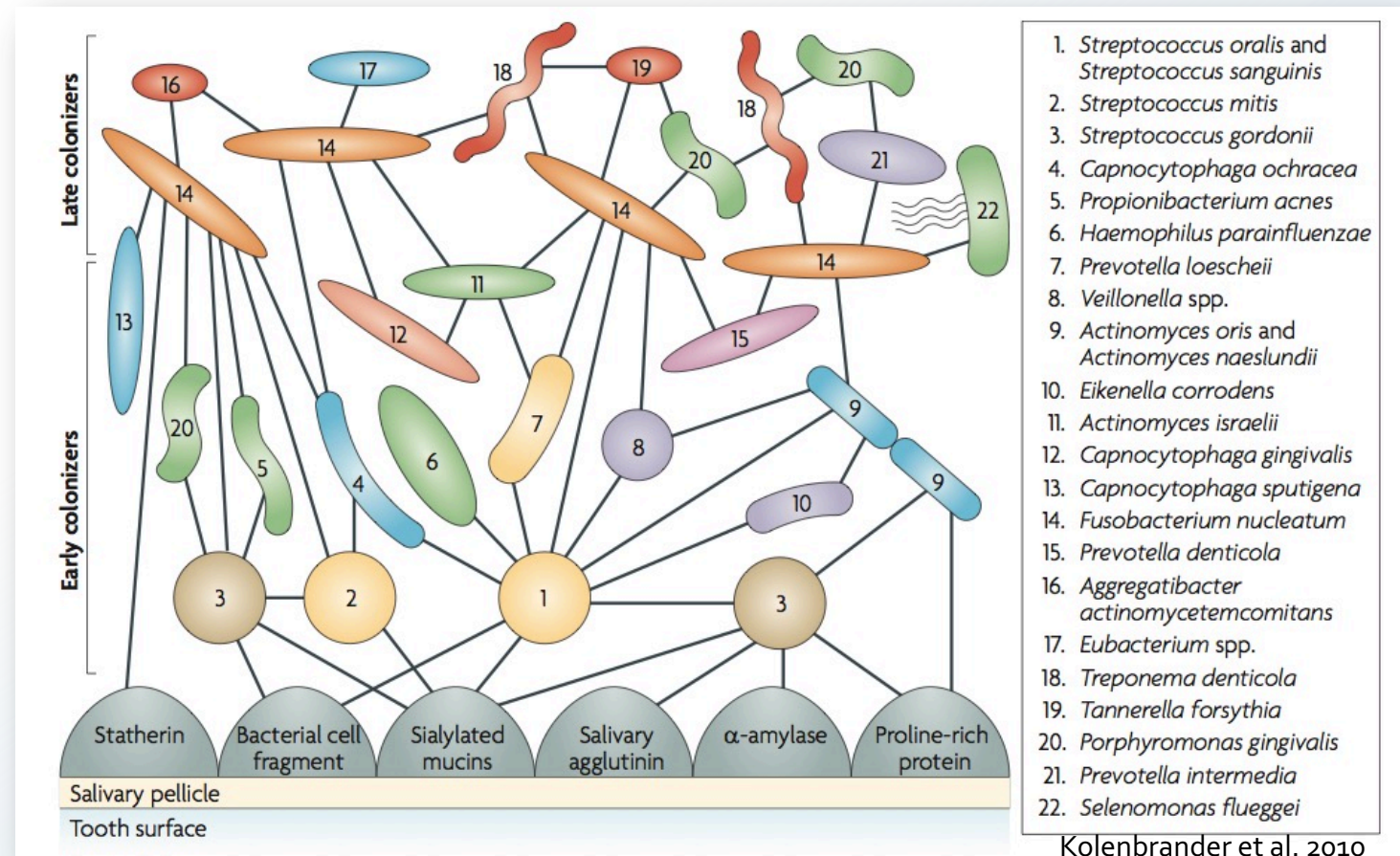
Microbiome is all microbes in a particular environment

The species diversity can be enormous, and often different species collaborate to perform processes

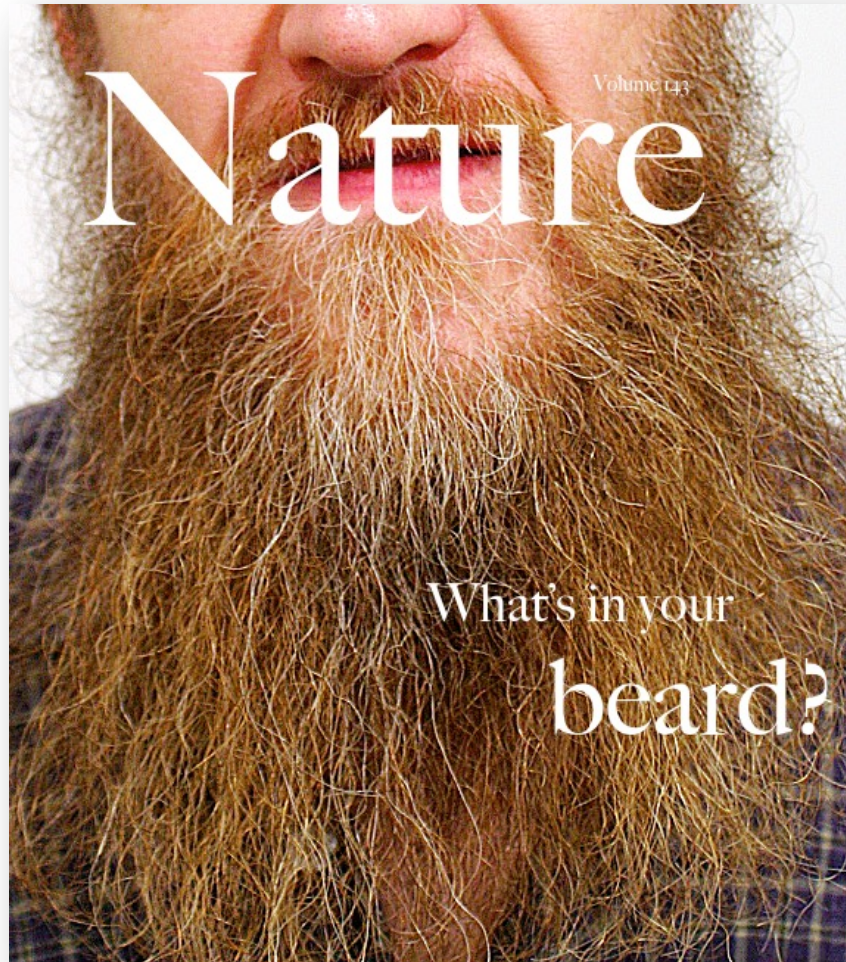


Microbiota is often used for a particular niche

The oral microbiota = microbiome in the oral cavity contain ~1000 bacterial species
 Multiple species collaborate in producing dental plaque

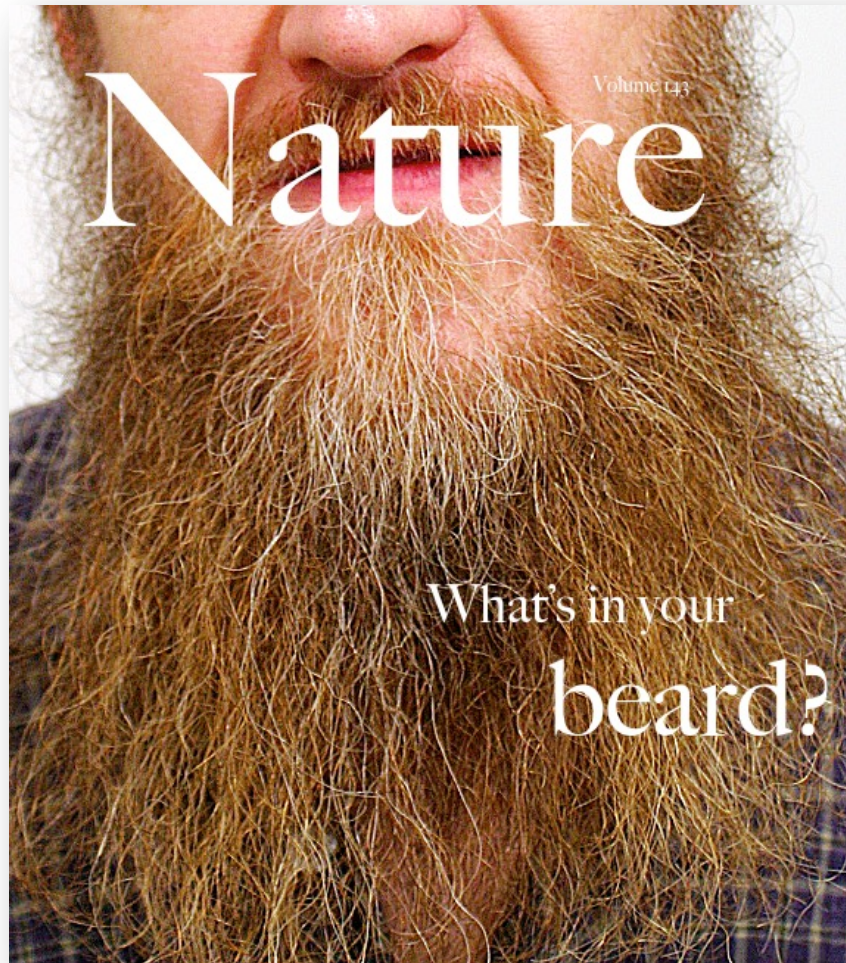


Many types microbiome - Human Beardome



Many types microbiome - Human Beardome

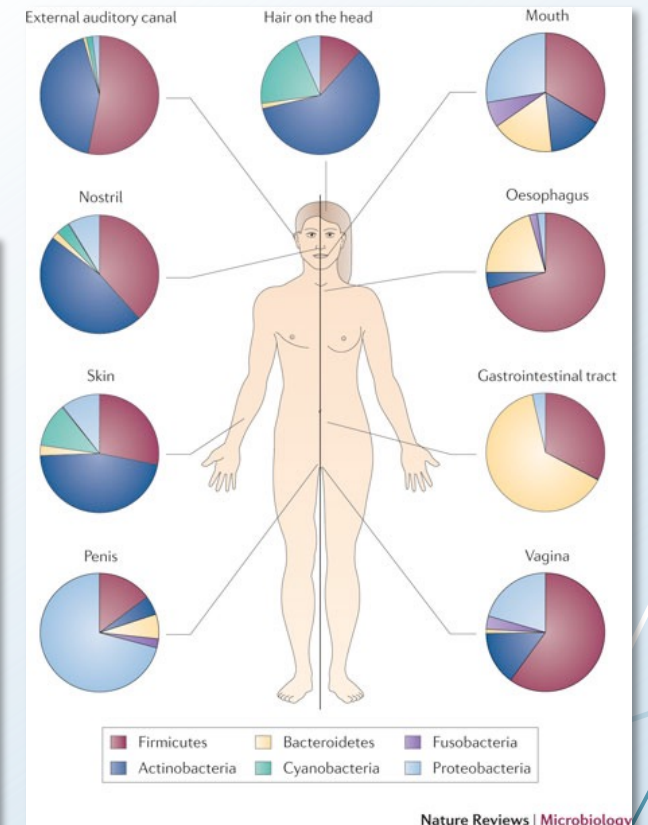
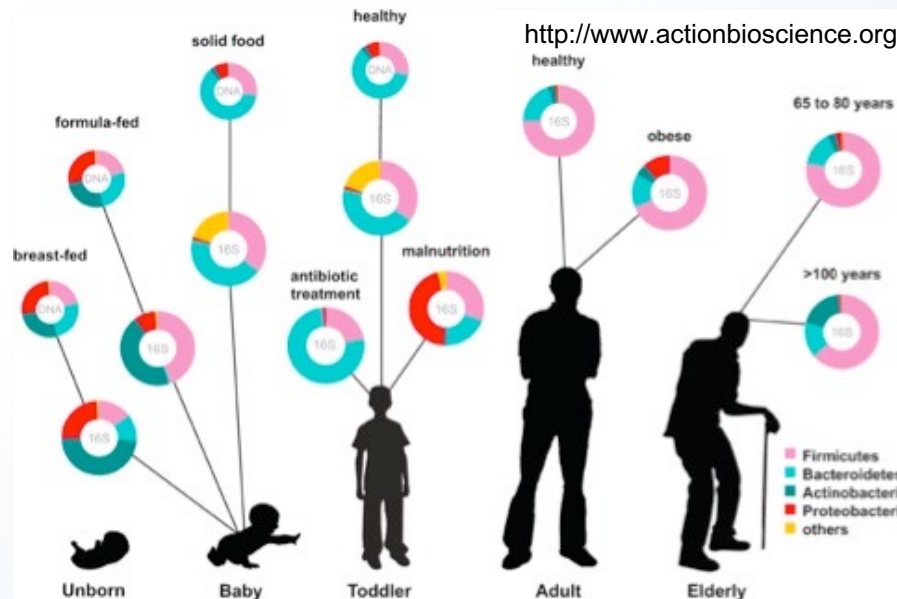
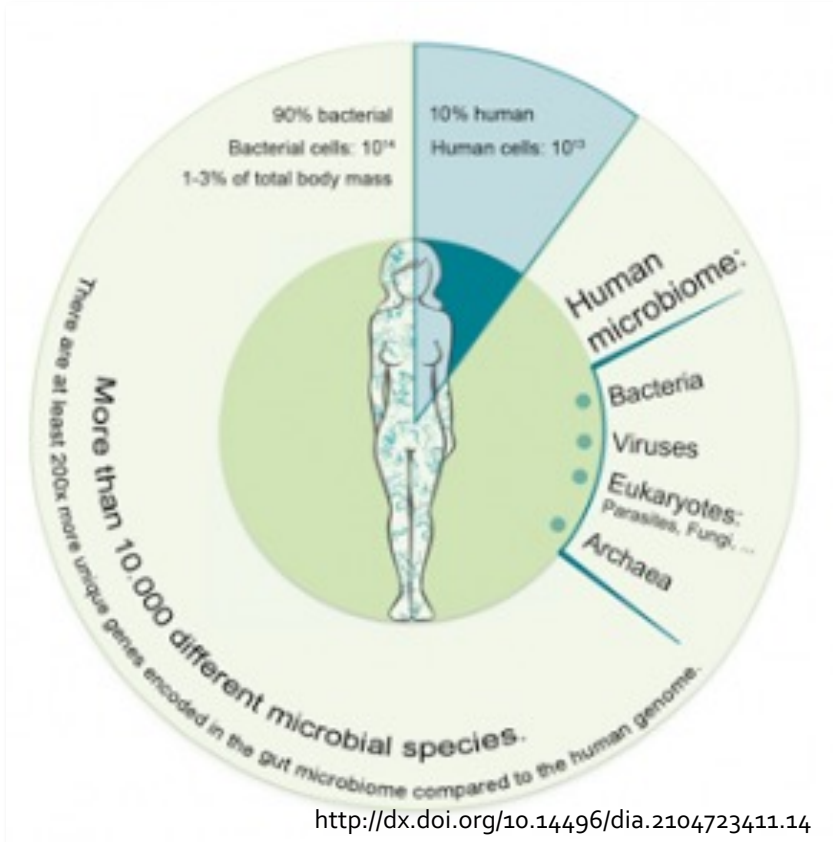
New discoveries open for new usages



The humane microbiome: ~10x more bacterial cells than human cells

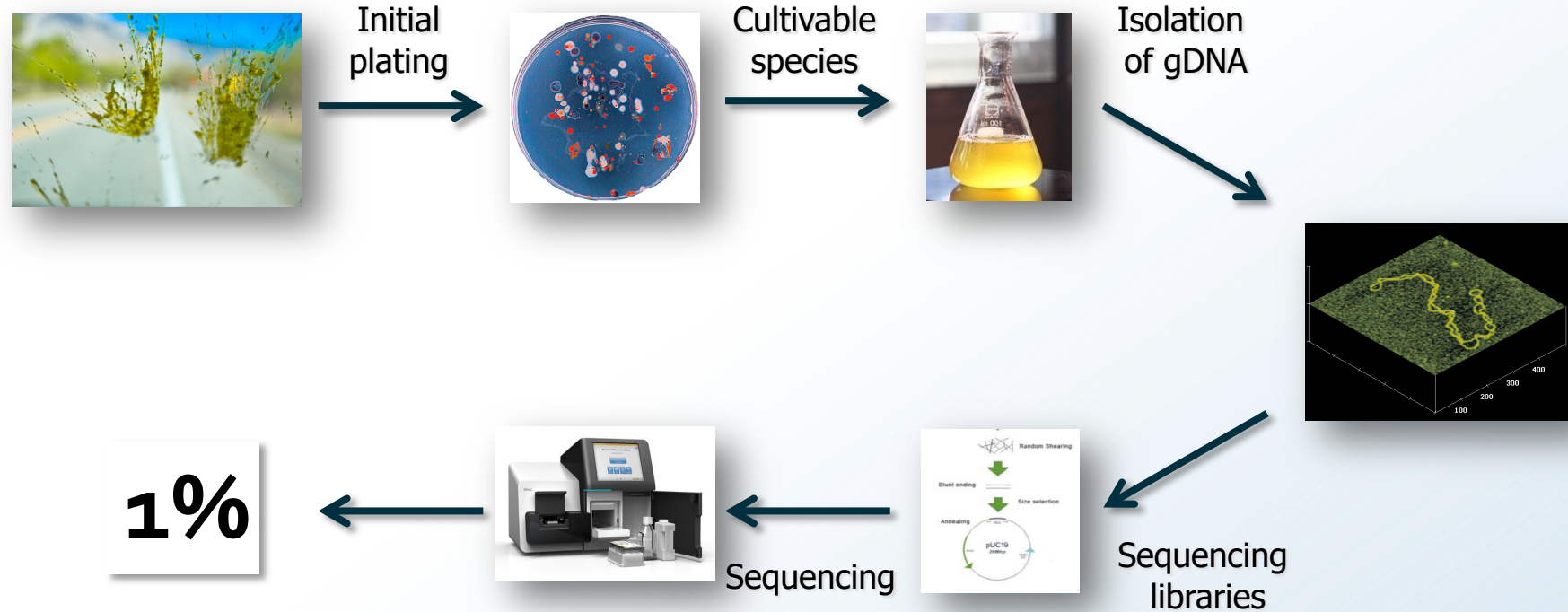
Microbes can break down and produce essential compounds that we can not produce

The human microbiome project – Description of a healthy human microbiome



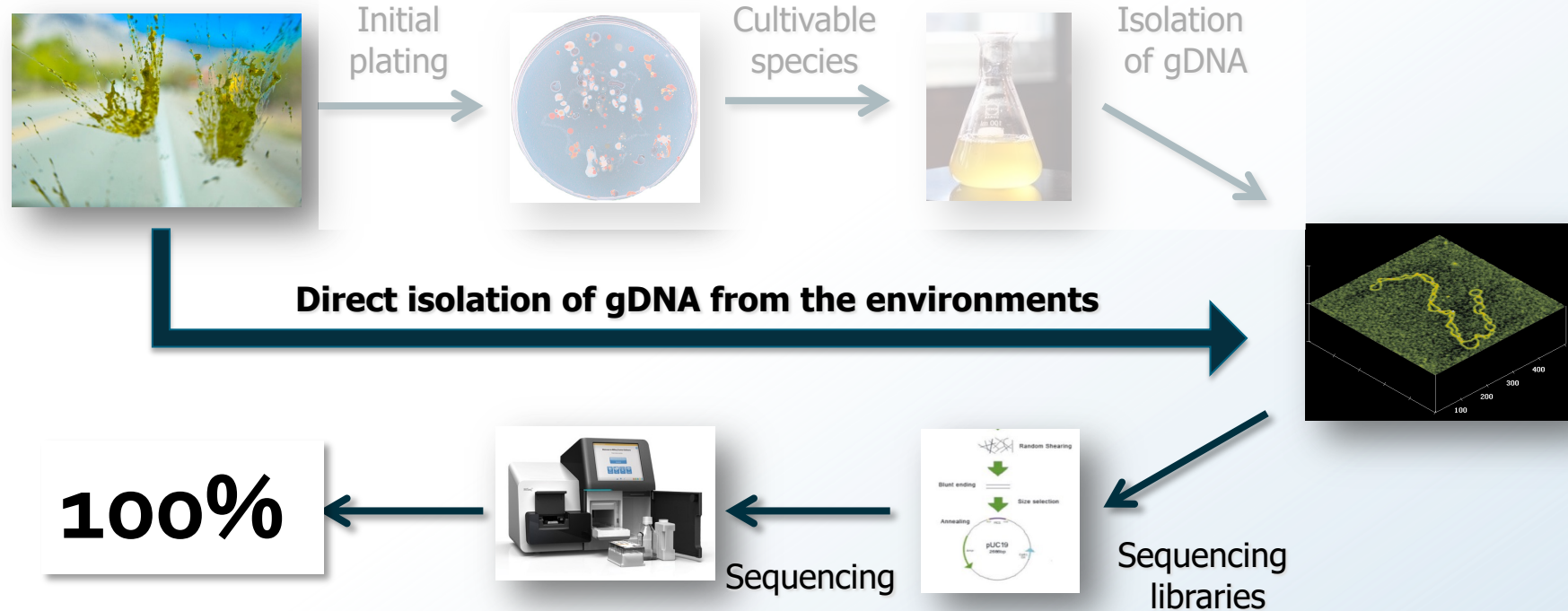
How can we study and understand microbiomes?

Around 1% of the microbes in the gut are directly cultivable

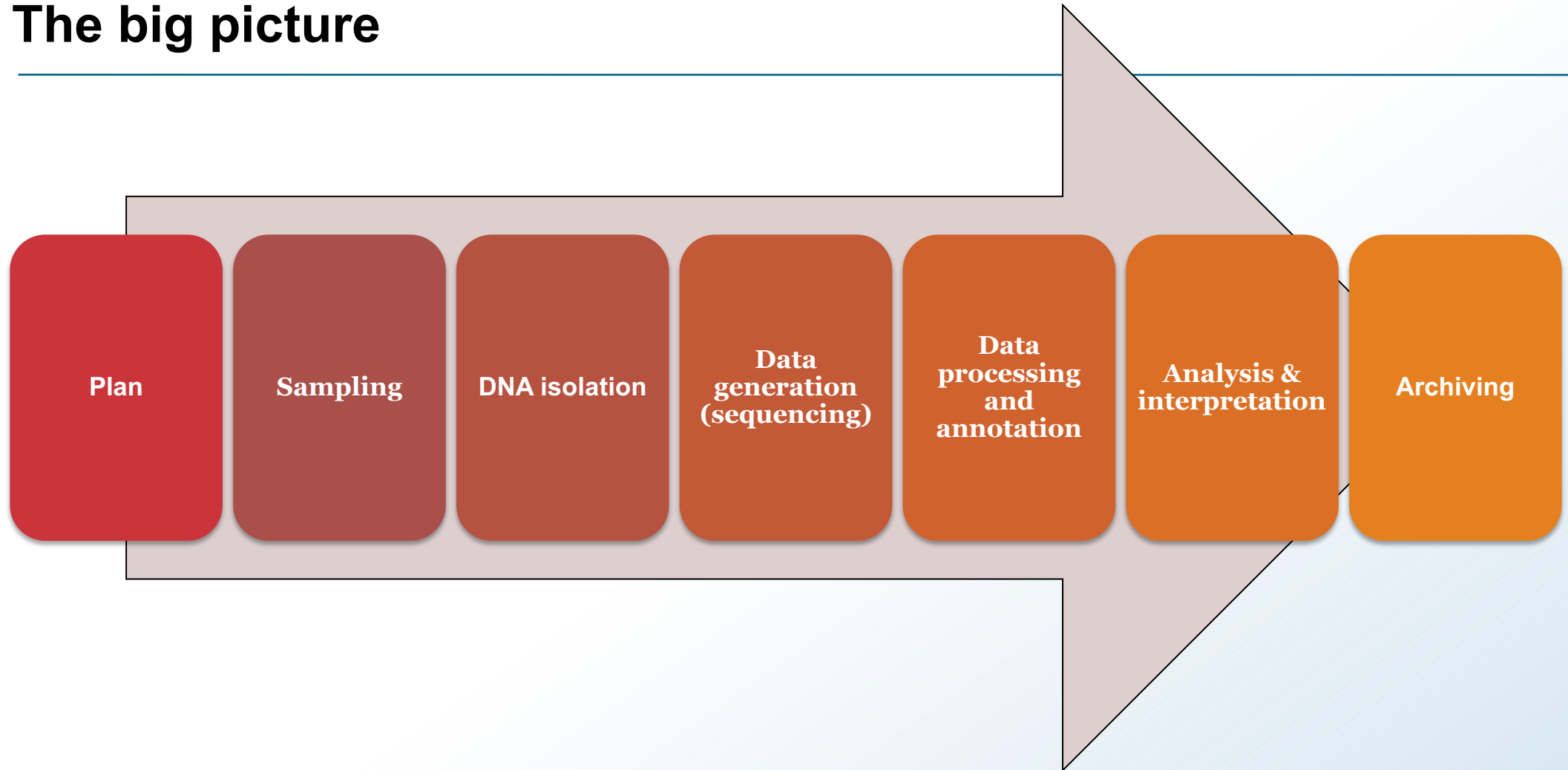


Metagenomics is the study of genetic material recovered directly from environmental samples

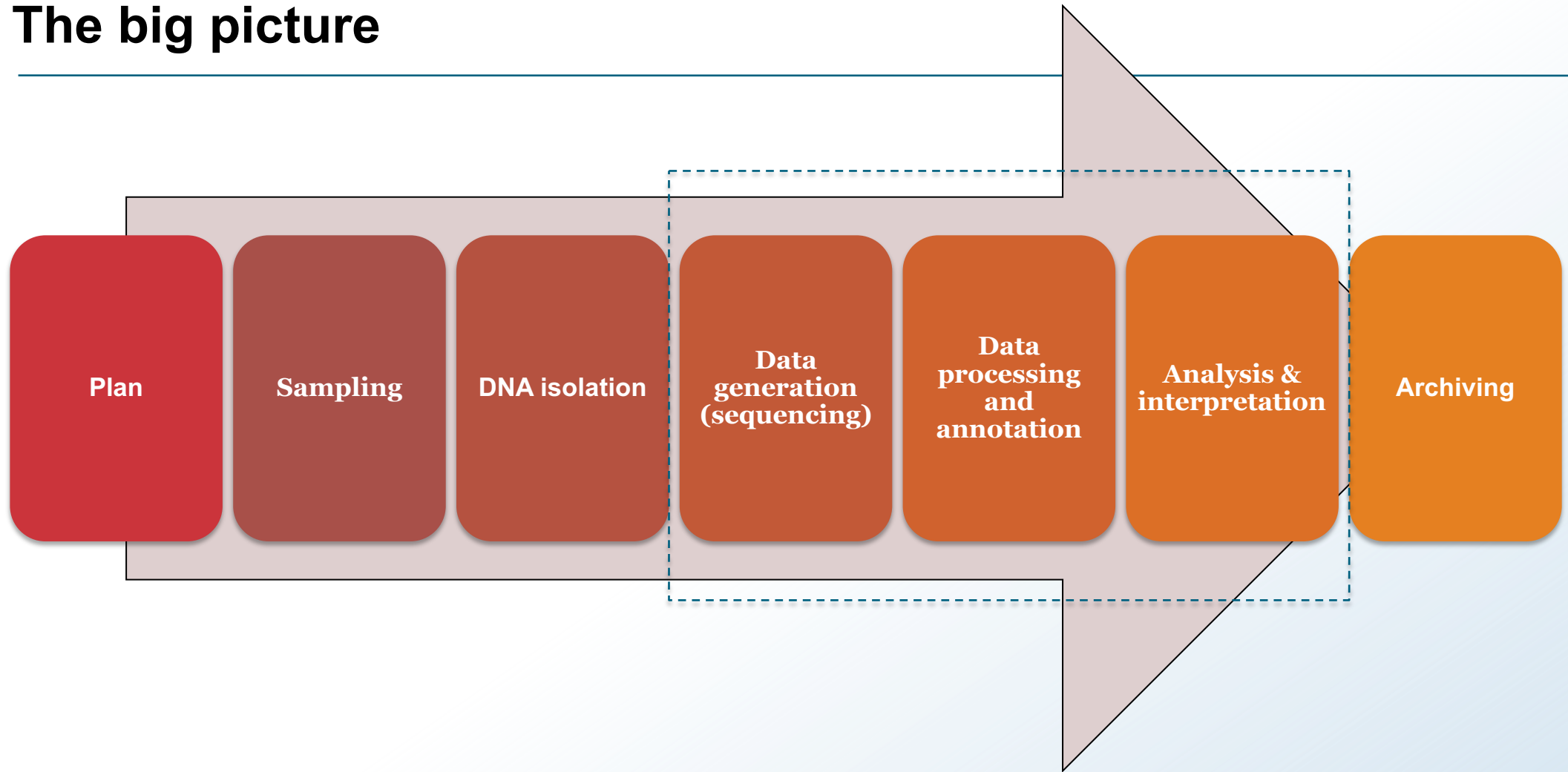
Aim often to explore the relation between the microbes and habitats



The big picture



The big picture



Metagenomic has multiple applications – some examples

Study microbiome-host relationship

Study microbiome differences in healthy and sick individuals

Study microbiome variations after intervention

Discover new species – explore the microbial dark matter

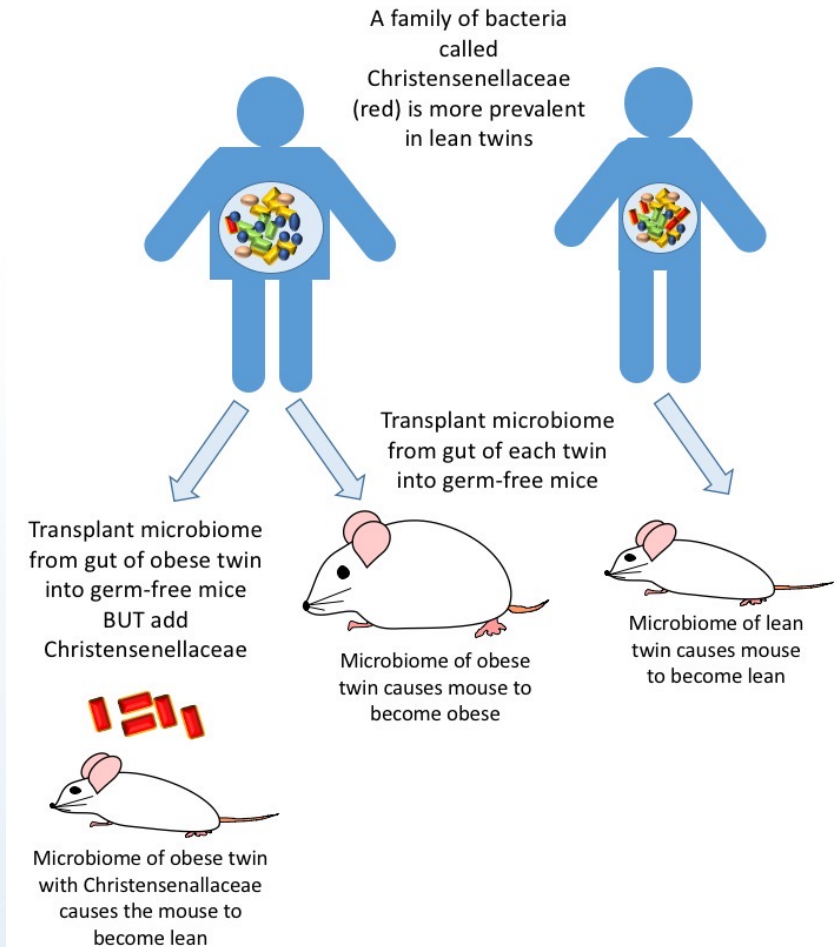
Lean versus obese twins

Obese individuals have lower diversity

Lean individuals have more *Christensenellaceae*

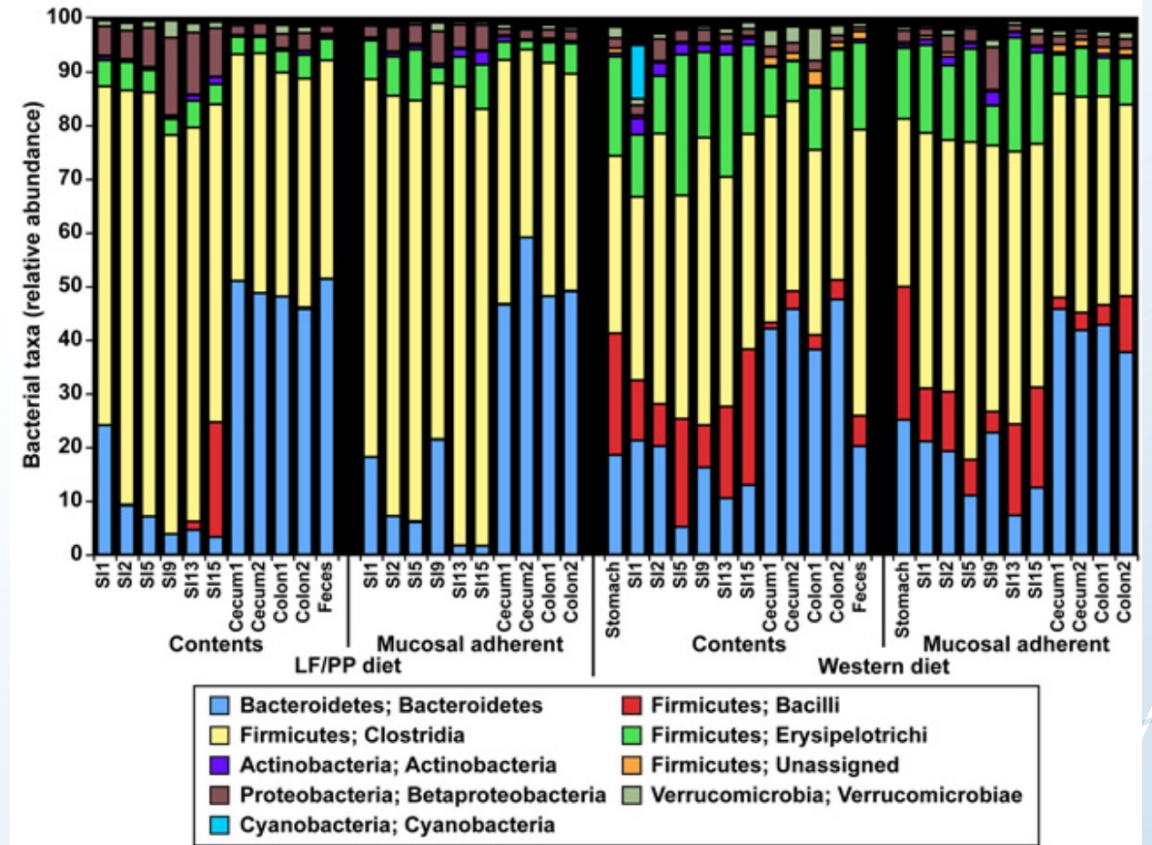
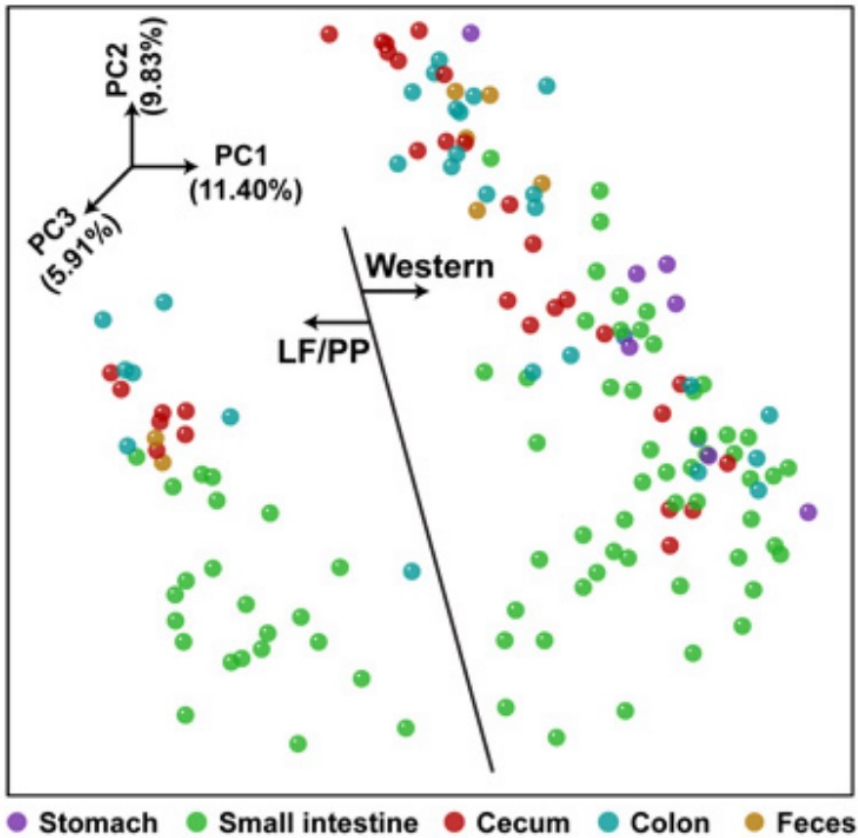
Faecal transplantation to germ-free mice:

- From obese donors = obese mouse
- From lean donors = lean mouse
- From obese donors + *Christensenellaceae* = lean mouse



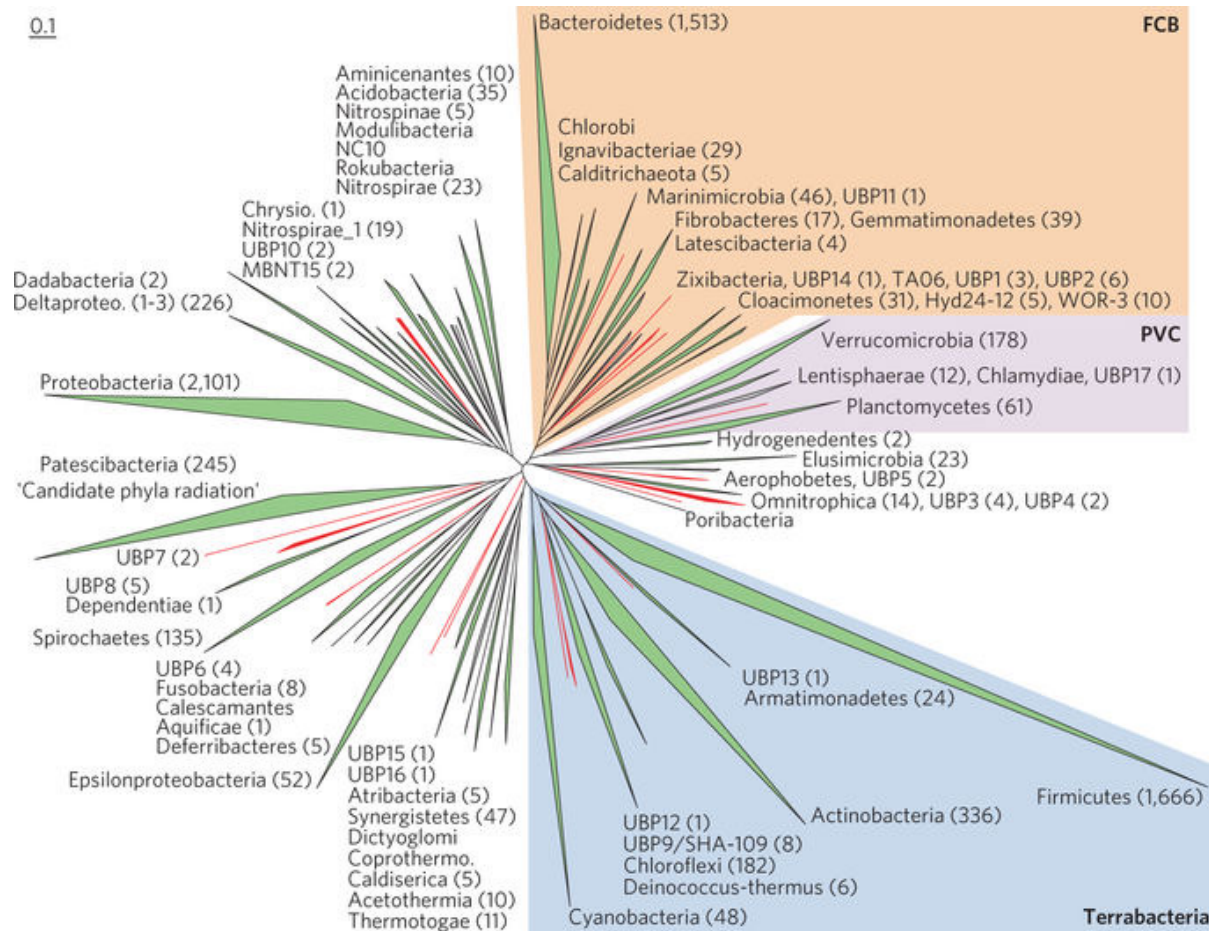
Microbiome variation after change in diet

Changing from Mediterranean to American diet change the composition of the microbiome and is detectable the same day



Explore «the microbial dark matter»

First new genomes of 20 new phylum



nature
microbiology

ARTICLES

DOI: 10.1038/s41564-017-0012-7

OPEN

Corrected: Author correction

Recovery of nearly 8,000 metagenome-assembled genomes substantially expands the tree of life

Donovan H. Parks , Christian Rinke , Maria Chuvochina, Pierre-Alain Chaumeil, Ben J. Woodcroft, Paul N. Evans, Philip Hugenholtz * and Gene W. Tyson*

NewScientist

We contain microbes so deeply
weird they alter the very tree of life

Science fiction reality?

Correlation between microbiome and host behaviour

The New York Times

MATTER

Germs in Your Gut Are Talking to Your Brain. Scientists Want to Know What They're Saying.

Hype or hope...

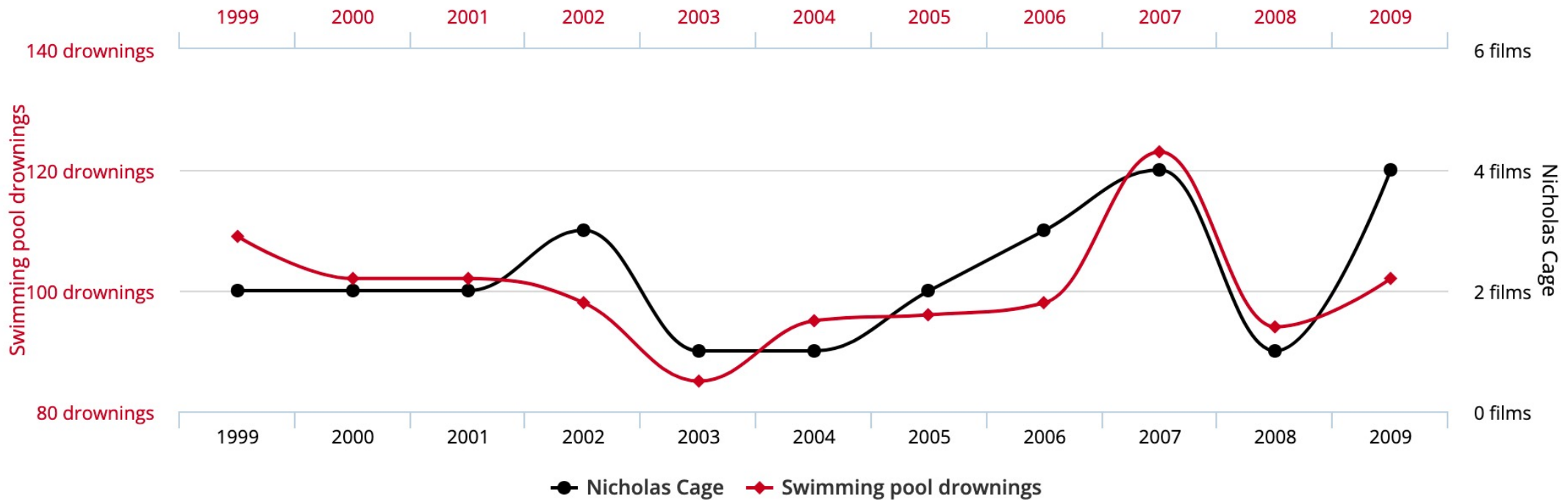
Huge potential both industrial and medical



Correlation does not always explain the cause....

Number of people who drowned by falling into a pool
correlates with
Films Nicolas Cage appeared in

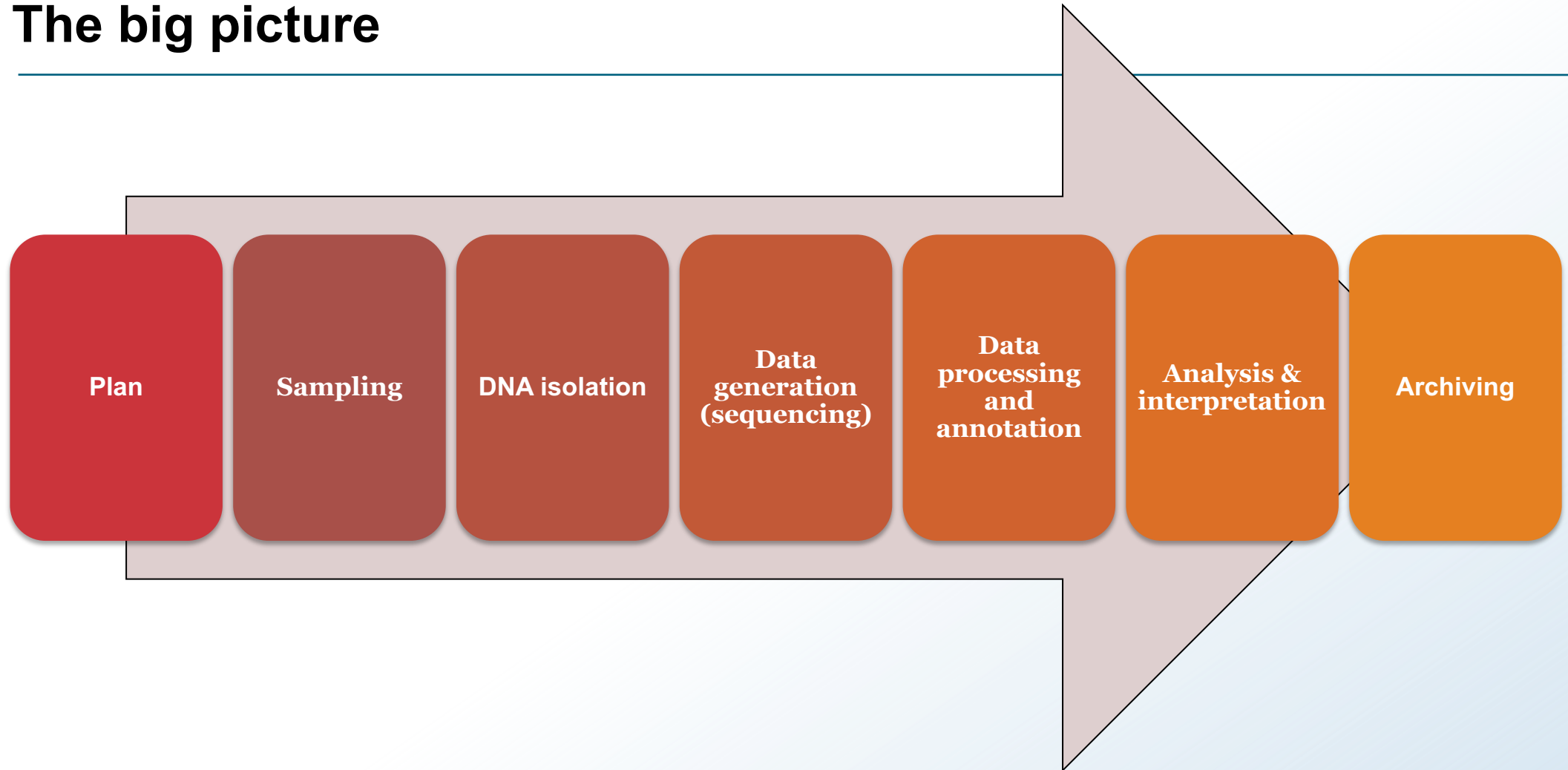
Correlation: 66.6% ($r=0.666004$)



tylervigen.com

Data sources: Centers for Disease Control & Prevention and Internet Movie Database

The big picture



Steps in metagenomics - plan

*Project
plan*



“The plan”

*Aim (goals) of
the project*

*Experimental
design (DoE)*

*Data Management
Plan (DMP)*

Steps in metagenomics - sampling

*What, where, when
and how to sample*



“The plan”



Sampling

*Required
equipment*

Enrichment e.g. filtering

Biological replicates

*How to store
the samples*

*Knowledge to
diversity*

Steps in metagenomics – DNA isolation

*How to lyse cells
and isolate DNA*

*Removal of major
contaminants*

Lysis of microorganisms

- *Gram negative/positive*
- *Fungi*

Virus

- *isolation*

*Quantity and
quality of DNA*



“The plan”



Sampling



**DNA
isolation**

Steps in metagenomics – data generation

Which sequencing technology to use

*Illumina, Ion Torrent
PacBio, Oxford Nanopores*

*Sequencing mode:
Single reads/ Paired end/ Read length*

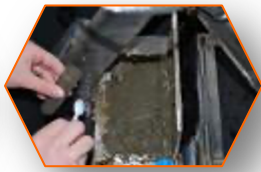
Technical replicates

Sequencing depth

Price



“The plan”



Sampling



**DNA
isolation**

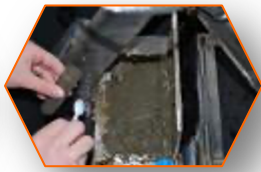


Sequencing

Steps in metagenomics - data processing



“The plan”



Sampling



**DNA
isolation**



Sequencing



**Processing &
annotation**

*Transfer and storage of
raw sequence data*

*Which tools or
pipelines to use*

Reference databases

*High-performance computing
and storage of processed data*

*Availability and
scalability*

Steps in metagenomics - data analysis and interpretation



“The plan”



Sampling



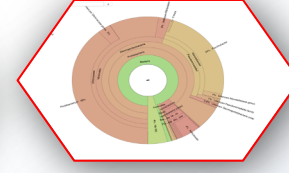
DNA
isolation



Sequencing



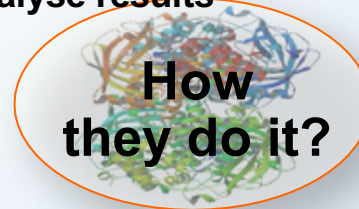
Processing &
annotation



Analyse results

*Tools and data
resources
available*

*Taxonomic and/or
functional analysis*



*Depend heavily on tools
and databases*



Steps in metagenomics - data archiving



“The plan”



Sampling



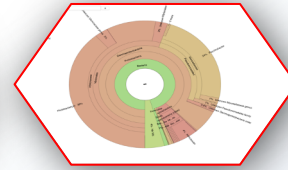
**DNA
isolation**



Sequencing



**Processing &
annotation**



Analyse results

*Publication
of results*



Archiving

*Deposit sequences
into public archives*

*MIMS (Minimum Information
about a Metagenome Sequence)*