

# ELIXIR Food and Nutrition Community

Jildau Bouwman | FNS-Cloud meeting Brussels



# ELIXIR: the offer



## Guidelines

Guidelines and best practices to help you manage life science data, run training courses, develop software and more.



## Web portals

Find the right software, training courses, standards and more in our interlinked portals to life science resources.



## All resources

Find compute services, databases, and the full list of resources ELIXIR coordinates.



## Partnerships with Industry and SMEs

Join events and projects that bring the private and public sectors together.



## Opportunities to work together

Join a scientific group in ELIXIR or partner with us to apply for EC funding.



## For ELIXIR members

If you work at an institute that is part of ELIXIR, then remember to take advantage of the benefits ELIXIR offers.

# ELIXIR: services



## Scientific domain

Chemical biology

Enzymes,  
interactions and  
pathways

Evolution and  
phylogeny

Genes and genomes

Literature

Molecular and  
cellular structures

Proteins and  
proteomes

## Type of service

Compute

Data resources

Interoperability  
and standards

Software tools

Training

## Key service collections

Core Data  
Resources

ELIXIR Deposition  
Databases

Recommended  
Interoperability  
Resources

**COVID-19 resources:** ELIXIR provides a range of services that you can use for studying the SARS-CoV-2 coronavirus and the COVID-19 disease.





# ELIXIR: communities



## 3D-BioInfo

Helps to understand the 3D structure of macromolecules like proteins and DNA.



## Food and Nutrition

Aims to help us understand the effect of food choices on human health.



## Intrinsically Disordered Proteins

Develops standards, tools and resources to help identify and characterise IDPs.



## Metabolomics

Provides the resources, analysis tools and infrastructure to help metabolite identification.



## Plant Sciences

Develops an infrastructure to facilitate genotype-phenotype analysis for crop and tree species.



## Single-Cell Omics

Identifies and addresses challenges in single-cell and spatial omics.



## Toxicology

Supports the integration of standards, tools and resources to aid toxicology research projects.



## Biodiversity

Aims to help us understand biodiversity, and how it responds to changing environmental pressures.



## Galaxy

Fosters a Galaxy community in Europe, together with Galaxy resources and training.



## Marine Metagenomics

Develops a sustainable metagenomics infrastructure to nurture research and innovation in the marine domain.



## Microbial Biotechnology

Helps the development of tailor-made microbes and biological systems.



## Proteomics

Develops and maintains sustainable proteomics tools and data resources.



## Systems Biology

Aims to make systems biology modelling a central pillar of research in biology.

## Human Data Communities



## Federated Human Data

Develops long-term strategies for managing and accessing sensitive human data.



## Human Copy Number Variation

Aims to make it easier to detect, annotate and interpret human Copy Number Variations (hCNVs).



## Rare Diseases

Supports the development of new therapies for rare diseases.



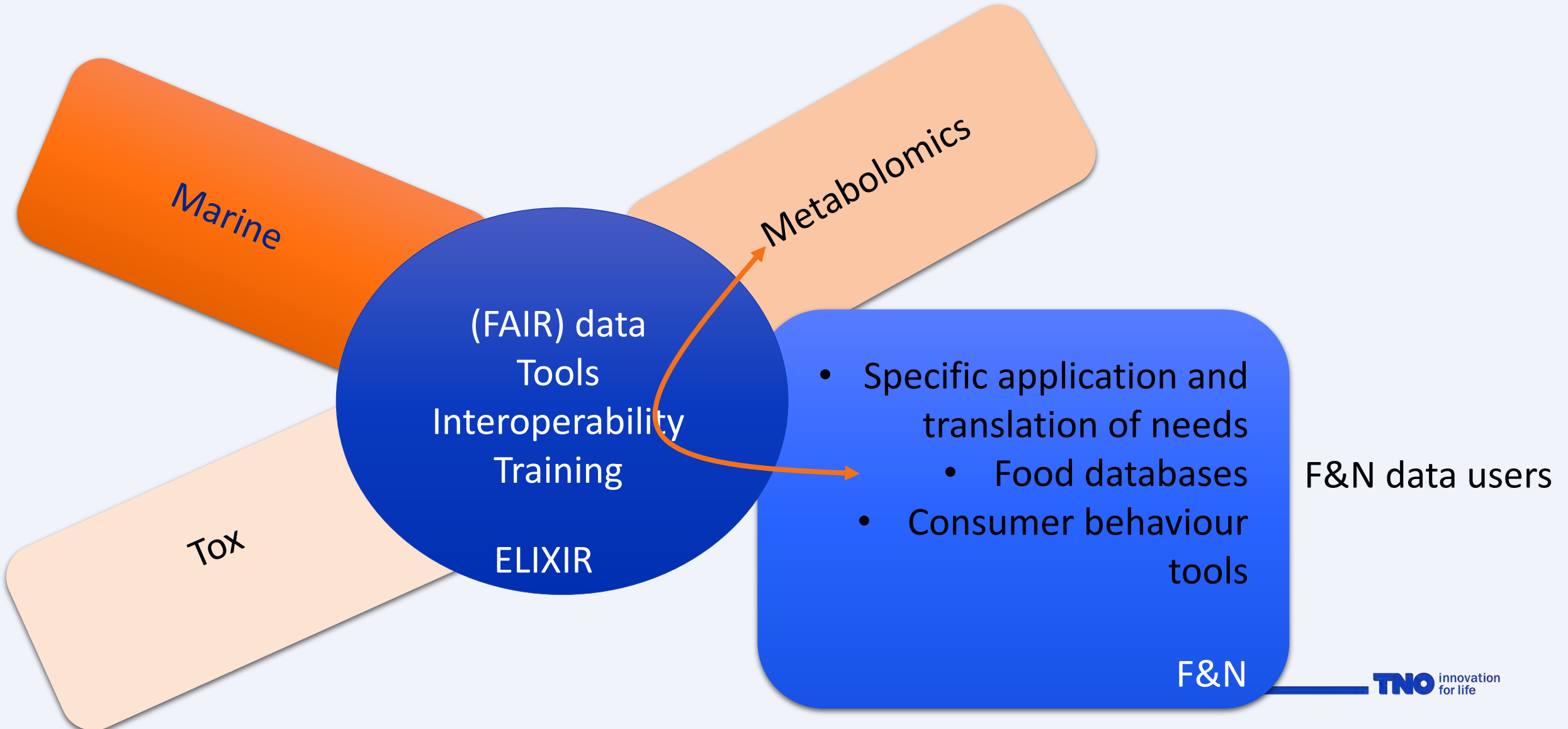
# Why a food and nutrition community?

ELIXIR focusses on Biomedical data on health (unhealthy subjects)

- Healthy citizens
- Social science
- Psychology
- Food composition
- Food preparation
- Effect food on health



# F&N community and the connection to ELIXIR





# Bioinformatics needs (1)

## Standardization/Interoperability

- Terminology: ontology development (not all relevant ontologies for F&N are in place and managed)
- Standardization of questionnaires (Questionnaires are hardly aligned)
- Tools for standardization (Tools for standardization are not always available to F&N scientists)
- Training on FAIR data principles (not all F&N scientists know how they are share FAIR data and where to find help)
- Technical interoperability solutions

## Data availability

- Data formatting standards for
- Connectivity of structured data
- Rich meta-data capture (not)
- Ethical compliance and approval of informed consent and data
- Queries and tools to find data



The screenshot shows a web browser window with the F1000Research website. The article title is "The future of food and nutrition in ELIXIR [version 1; peer review: 1 approved with reservations]". The authors listed are Bachir Balech, Lorraine Brennan, Enrique Carrillo de Santa Pau, Duccio Cavalieri, Susan Coort, Domenica D'Elia, Lars Ove Dragsted, Tome Eftimov, Chris T. Evelo, Polonca Ferk, Paul Finglas, Agnese Gori, John Hancock, Matúš Kalaš, Barbara Koroušić Seljak, Carl Lachat, Brane Leskošek, Edoardo Pasoli, Graziano Pesole, Karl Presser, Anna Sandionigi, Monica Santamaria, Duygu Dede Şener, Maria Traka, Guy Vergères, Karin L. Zimmermann, Jildau, and Bouwman. The article has 1049 views and 84 downloads. The peer review status is "1 approved with reservations". The article is dated 25 Aug 22.

Home » Browse » The future of food and nutrition in ELIXIR

OPINION ARTICLE

**The future of food and nutrition in ELIXIR [version 1; peer review: 1 approved with reservations]**

Bachir Balech<sup>1</sup>, Lorraine Brennan<sup>2</sup>, Enrique Carrillo de Santa Pau<sup>3</sup>, Duccio Cavalieri<sup>4</sup>, Susan Coort<sup>5</sup>, Domenica D'Elia<sup>6</sup>, Lars Ove Dragsted<sup>7</sup>, Tome Eftimov<sup>8</sup>, Chris T. Evelo<sup>5</sup>, Polonca Ferk<sup>9</sup>, Paul Finglas<sup>10</sup>, Agnese Gori<sup>4</sup>, John Hancock<sup>11</sup>, Matúš Kalaš<sup>12</sup>, Barbara Koroušić Seljak<sup>8</sup>, Carl Lachat<sup>13</sup>, Brane Leskošek<sup>9</sup>, Edoardo Pasoli<sup>14</sup>, Graziano Pesole<sup>1,15</sup>, Karl Presser<sup>16</sup>, Anna Sandionigi<sup>17,18</sup>, Monica Santamaria<sup>19</sup>, Duygu Dede Şener<sup>5</sup>, Maria Traka<sup>10</sup>, Guy Vergères<sup>19</sup>, Karin L. Zimmermann<sup>20</sup>, Jildau, Bouwman<sup>21</sup>

Check for updates

ALL METRICS

1049 VIEWS

84 DOWNLOADS

Get PDF

Open Peer Review

Reviewer Status ?

Reviewer Reports

Invited Reviewers

1

Version 1

25 Aug 22

read

# Bioinformatics needs (2)

## Data reuse

- Complex data integration (including omics and personalization) with specific focus on metabolomics and microbiome
- Hardware for analysis
- Software and pipelines for analysis
- Interaction with consumers (onboarding and transparency)
- Training on data reuse





# Bioinformatics needs (3)



## Advocacy and training

- Researchers and governmental organizations publish research documents to spread knowledge but hardly publish data (raw or modified). Convincing arguments and incentives must be created to consider publication of documents of equal importance as publication of data.
- Training/Capacity Building on FAIR data and standards (not all F&N scientists know the FAIR principles and are aware of the standard's importance to align their data management plans with FAIR principles and where to find support)

## Tool and service availability and interoperability

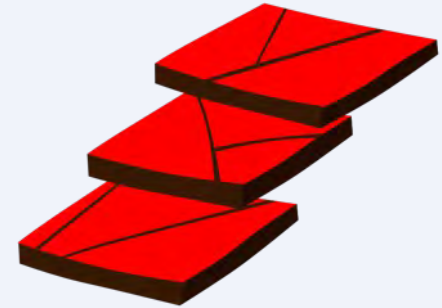
- Make also tools and services available with which data can be analyzed, visualized and manipulated
- Need for alignment of existing and new analysis software with ELIXIR existing ELIXIR efforts (e.g. microbiomics/GALAXY and similar dataflows)
- Public and private repositories must be integrated in such a way that it allows users to easily transfer data into existing tools for their data processing. This would lead to a landscape of repositories and tools where an arbitrary number of systems can be connected or chained to perform data analysis.

## Networking actions

- Interaction with consumers (onboarding and transparency) and other stakeholders such as F&N researchers, policy makers, educators, industry, hospital and patients
- Alignment with European Open Science Cloud (EOSC) strategy for sustainable long term data reuse and other initiatives

# Alignment with ELIXIR Platforms

- Data Platform → DASH-IN: align with ELIXIR resources
- Tools Platform → tools provided and used by the F&N community will be registered in the bio.tools registry
- Interoperability Platform → F&N data must be interoperable in order to align with other data sources. Extension of the current metadata standards toward food and consumer science is needed
- Compute Platform → Computing power necessary for the analyses. The community should have a helpdesk that knows the access points for compute platforms
- Training Platform → Courses from the F&N community (e.g. FNS-Cloud, NuGO) can be registered in TeSS



# Alignment with ELIXIR communities

- The Federated Human Data community for long-term strategies for managing and accessing sensitive human data and connecting consumer and patient data
- The Rare Diseases community for privacy issues on the individual data and describing phenotypes.
- The Marine Metagenomics (Microbiome) community for the solutions in the area of microbiome/metagenome analysis.
- The Biodiversity focus group for the accessibility to taxonomic and molecular data (including other metadata) related to the species described so far (biodiversity catalogues).
- Plant Science community for the link between plant science in general and plants as food compounds.
- The metabolomics community for readouts of intake and health
- The toxicology (not yet an approved community) on describing phenotypes
- The newly developing Microbiome community and the Microbial Biotechnology community for two different microbiome approaches
- The Machine learning focus group for complex data integration (including omics and personalization) with specific focus on metabolomics and microbiome, and software and pipelines for analysis.
- (other Communities are Proteomics, Galaxy, 3D-Bioinformatics and Intrinsically Disordered Proteins)



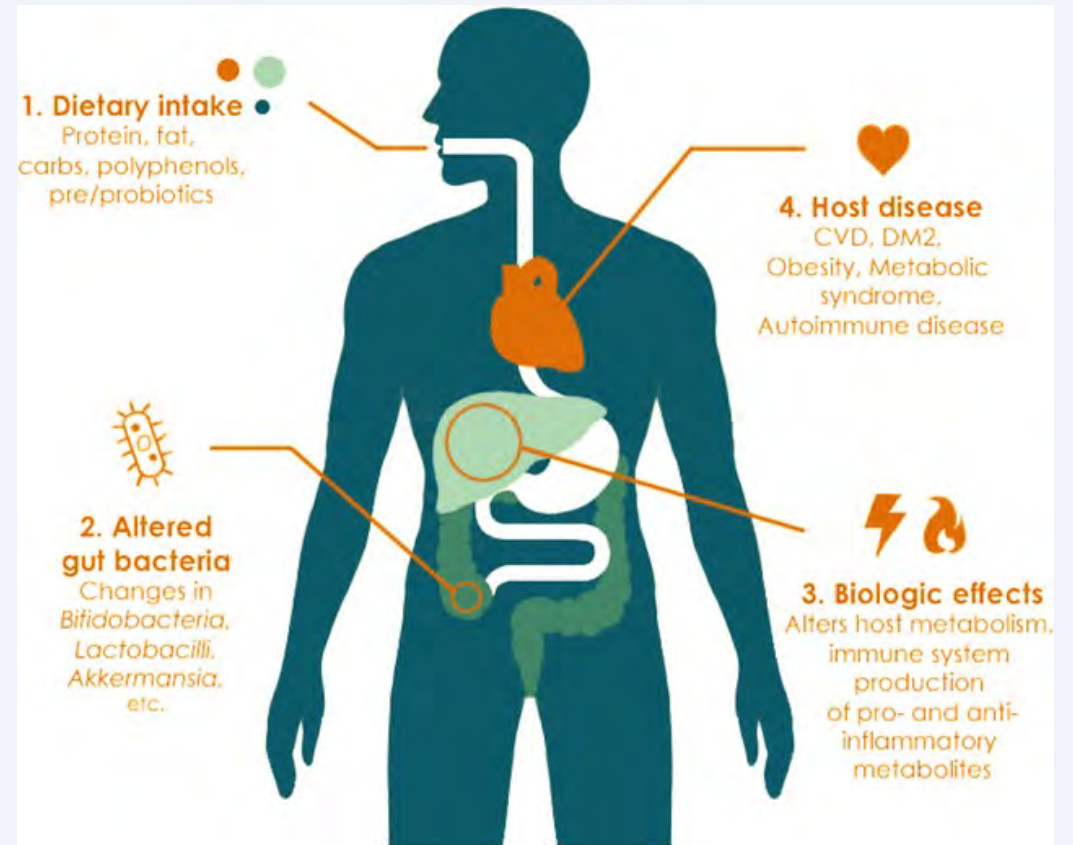
# Key F&N community challenges

- Measure a health effect → Define **individual health status**
- Every **individual** has different **dietary needs** → Develop individual advice (e.g. what advice is needed for an individual at risk for a non-communicable disease)
- Quantify what individuals have eaten (standard is questionnaires but these are very unreliable) → **Complex dietary and food intake biomarkers**



# Implementation study: Food, microbiome & health

- FNS-Cloud (DIME study, ontology, FAIRspace)
- JPI INTIMIC Knowledge platform



# FAIR meta-data availability through PhenotypeDB

Phenotype Database

https://dashin.eu/interventionstudies/

Hello jidau.bouwman!

Profile

Home Create Import Browse/Edit Analyze Export Modules Admin

microb|

## Introduction

The Phenotype Database is an application that can store any biological study. It contains templates which makes it possible to customize.

In order to allow flexibility to capture all information you require within a study, and to make it possible to compare studies or study data, the system uses customizable templates and ontologies. It is especially designed to store complex study designs including. [Read more...](#)

[Share your study](#)

## Usage Statistics

151 Studies

Not accessible: 0 studies Read only: 0 studies

Readable & writable: 151 studies

Users, studies and te

Click and drag in the plot are

Total

2014 2015

NuGO

nd NBIC. All rights reserved. For more information go to <http://abnp.org>.

Mica | INTIMIC

https://mica-test.mdc-berlin.net/network/intimic

110%

Mica Home Repository Search Research Data Access

Administration Tobias P

## Individual Studies

Show 25 entries

Search:

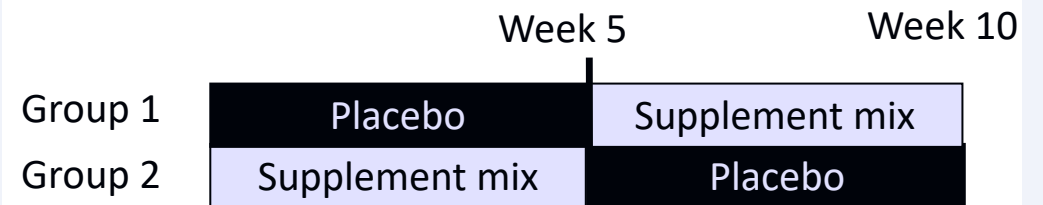
Acronym	Name	Study design	Participants	Countries
Diet4MicroGut_PRIN2011	Diet4MicroGut_PRIN2011	Cohort	153	Italy
DIMISA	DIMISA	Cross-sectional	184	Spain
DONALD	DOrtmund Nutritional and Anthropometric Longitudinally Designed	Cohort	128	Germany
DORIAN	DORIAN, InterOmics, GUTMOM, MISVILUPPO	Cross-sectional	90	Italy
EarlyMicroHealth	EarlyMicroHealth	Cohort	151	Spain
EDILS	EDILS	Cohort	280	France



# Nutritional issues

- Large background on treatment (many measurements needed)
- Broad effect (many different processes)
- Seasonal effect (cross-over design essential)

→ Data integration essential



# Structured meta-data

The screenshot shows a web browser window with the URL <https://dashin.eu/interventionstudies/study/design/35827>. The page is titled "Study [Foodmix]" and displays the study design. A navigation bar at the top includes links for Home, Create, Import, Browse/Edit, Analyze, Export, Modules, and Admin, along with a search bar. The user is logged in as "jildau.bouwman" and has buttons for Profile and Logout. The study design is presented in a table with two groups, Group 4 and Group 3, each showing a sequence of treatments: Screening, Placebo, and AIDM.

Phenotype database

Hello jildau.bouwman ! [Profile](#) [Logout](#)

Home Create Import Browse/Edit Analyze Export Modules Admin Search term

Study [Foodmix] [study](#) / [subjects](#) / **[design](#)** / [samples](#) / [assays](#)








This page shows your study design

The study design consists of treatment types and sample types, grouped together in sample & treatment groups. Double click on a subjectgroup or sample & treatment group to see details.

Group 4	Screening	Placebo	AIDM
Group 3	Screening	AIDM	Placebo

### Diet intervention (switch)

Currently, this template contains the following fields. Drag fields to reorder. Drag fields to the list of available fields to remove the field from the template.

name (Short text)		
↑	Event name (STRING) (Short text)	
↑	Intervention/Challenge (Dropdown selection of terms)	
↑	Event-type (Dropdown selection of terms)	
↑	Route (Dropdown selection of terms)	
↑	Description (Long text)	
↑	Diet description (File)	
↑	Diet carbohydrate-level (Energy%, Decimal number)	
↑	Diet fat-level (Energy%, Decimal number)	
↑	Diet protein-level (Energy%, Decimal number)	
↑	Migration (Short text)	

### Available fields

These fields are available for adding to the template. Drag a field to the template to add it.

2nd Event-type (Dropdown selection of terms)  
Compound (DB selection of terms)  
Compound dose (Dropdown selection of terms)  
Compound dose (Dropdown selection of terms)  
Compound frequency (Dropdown selection of terms)  
Compound full (Dropdown selection of terms)  
Vehicle (Dropdown selection of terms)

#### Create new field

Name:

Type:

Unit:

Comment:

Required:

#### Text

Short text (max 255 chars)

Long text (unlimited number of chars)

Dropdown selection of terms

Extendable selection of terms

#### Numerical

Decimal number (1.31)

Natural number (100)

#### Other

Term from ontology (A term that comes from one or more selected ontologies)

File

True/false (true/false)

Template

Omics module

#### Date

Date (2010-01-01)

Relative time (3 days)

Short text (max 255 chars) ▼

Unit:

Comment:

Required: ☐

Save Cancel



# JPI HDHL INTIMIC knowledge platform

INTIMIC has created a network of transnational and multidisciplinary collaboration to further develop and increase the impact of microbiome research in human health. It assembles 52 partners all over Europe (including Israel) and thus allows addressing the microbiome research community in a broad and comprehensive way. The consortium was generated by national and European funding organizations to reflect the local and international excellence in the best way.



## Partner countries (alphabetical order):

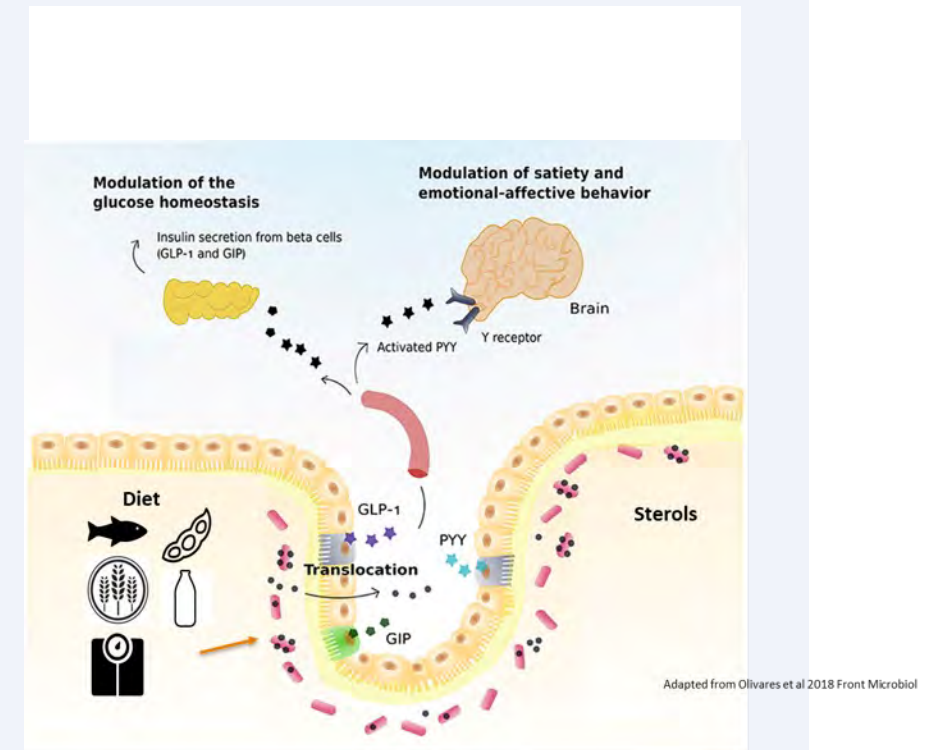
- Austria (5 partners)
- Belgium (1 partner)
- France (5 partners)
- Germany (12 partners)
- Israel (3 partners)
- Italy (13 partners)
- The Netherlands (5 partners)
- Spain (3 partners)
- Sweden (4 partners)

[Learn more about our partners](#)

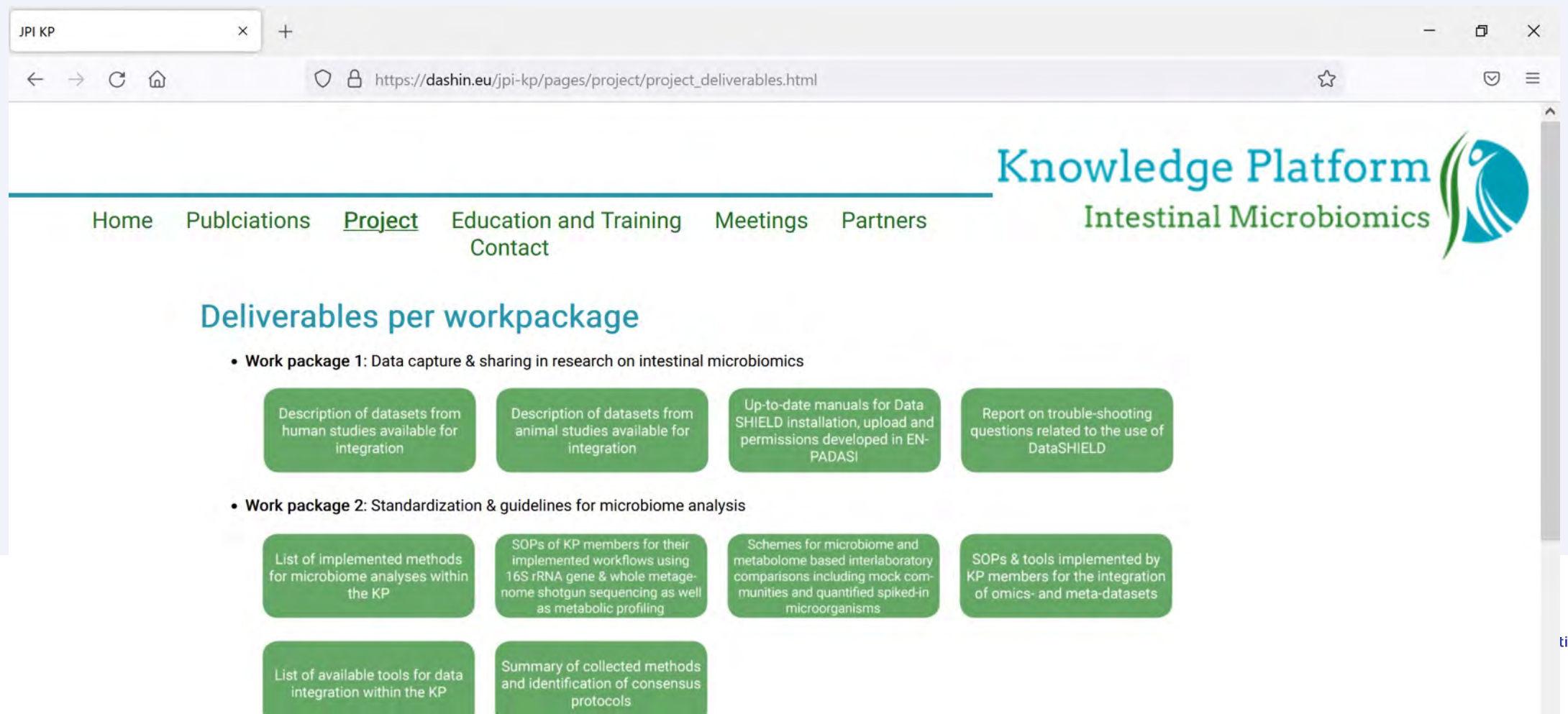


# AIM of INTIMIC KP

- Foster transnational and multidisciplinary collaboration and networking in order to accelerate, further develop and **increase the impact** of intestinal microbiome research related to human health



# Deliverables of the KP (<https://dashin.eu/jpi-kp>)



The screenshot shows a web browser window with the address bar displaying [https://dashin.eu/jpi-kp/pages/project/project\\_deliverables.html](https://dashin.eu/jpi-kp/pages/project/project_deliverables.html). The website header includes the "Knowledge Platform Intestinal Microbiomics" logo and a navigation menu with links: Home, Publications, Project, Education and Training, Meetings, and Partners. Below the navigation menu, the page title "Deliverables per workpackage" is displayed. The content is organized into two main sections: "Work package 1: Data capture & sharing in research on intestinal microbiomics" and "Work package 2: Standardization & guidelines for microbiome analysis". Each section contains a grid of green boxes, each representing a specific deliverable.

**Knowledge Platform**  
Intestinal Microbiomics

Home Publications Project Education and Training Meetings Partners  
Contact

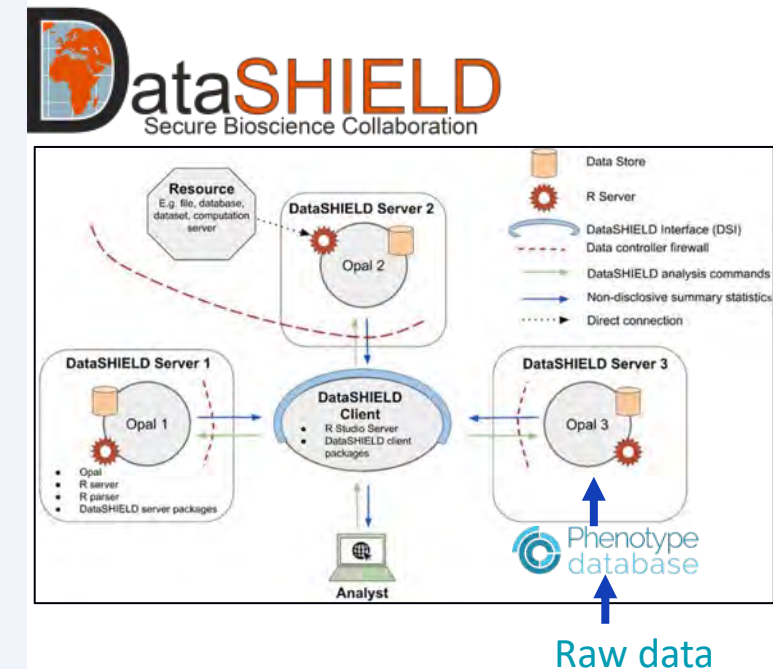
## Deliverables per workpackage

- **Work package 1: Data capture & sharing in research on intestinal microbiomics**
  - Description of datasets from human studies available for integration
  - Description of datasets from animal studies available for integration
  - Up-to-date manuals for Data SHIELD installation, upload and permissions developed in EN-PADASI
  - Report on trouble-shooting questions related to the use of DataSHIELD
- **Work package 2: Standardization & guidelines for microbiome analysis**
  - List of implemented methods for microbiome analyses within the KP
  - SOPs of KP members for their implemented workflows using 16S rRNA gene & whole metagenome shotgun sequencing as well as metabolic profiling
  - Schemes for microbiome and metabolome based interlaboratory comparisons including mock communities and quantified spiked-in microorganisms
  - SOPs & tools implemented by KP members for the integration of omics- and meta-datasets
  - List of available tools for data integration within the KP
  - Summary of collected methods and identification of consensus protocols



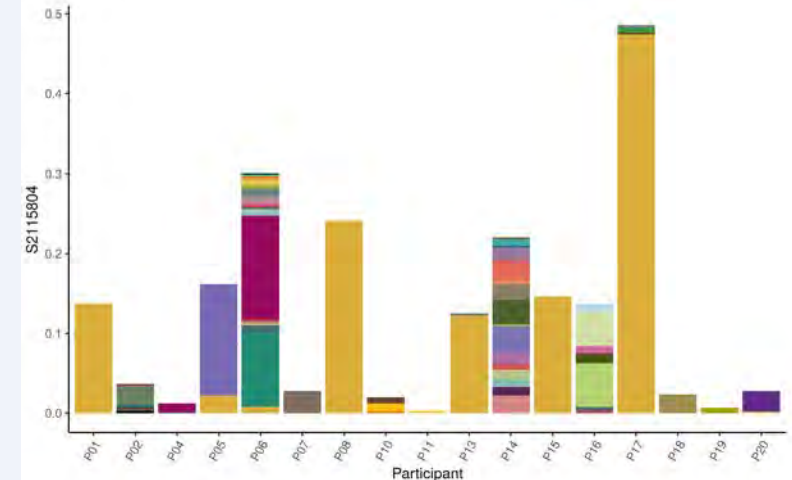
# Results: Data (<https://dashin.eu>)

- Expansions of the Phenotype database standards with (microbiome) standards
  - Observational study data
  - Intervention study data
  - Microbiome data
  - Other omics data (food, processing, fermentation, Food-Biomarker, physical activity, metagenomics, metabolomics)
- Many datasets available in a standardized way (also for studies focusing on prebiotic)
- Cleaned set from literature of infant studies download (on the KP website)
- Data of some open data sources is made FAIR



# Results: ANALYSIS

- Better insight in the background of the variation in the measures → needed for better and more standardization
  - Region for 16S PCR (please note that some species may not be detectable)
  - Databases/ bioinformatics pipeline
  - Sample preparation
- Shotgun metagenomics is the future, but standardization is even more challenging
- Population (biological) variance is often overwhelmed by the combined technical variance
- The core human microbiome is difficult to strictly define
- Functional microbiome is shared with other host species



Results of a ringtrial

## Results: Tools & other output

- SOP databank in place
- Definition of and list of functional foods
- Described connection food microbiome and gut microbiome
- Web-interface (easyPubmed) for literature review (will be on the KP website)
- Inventory of for models and model organisms (intimicdb.com registration needed) → including specimens, isolates
- Training material collected on the website

# Impact

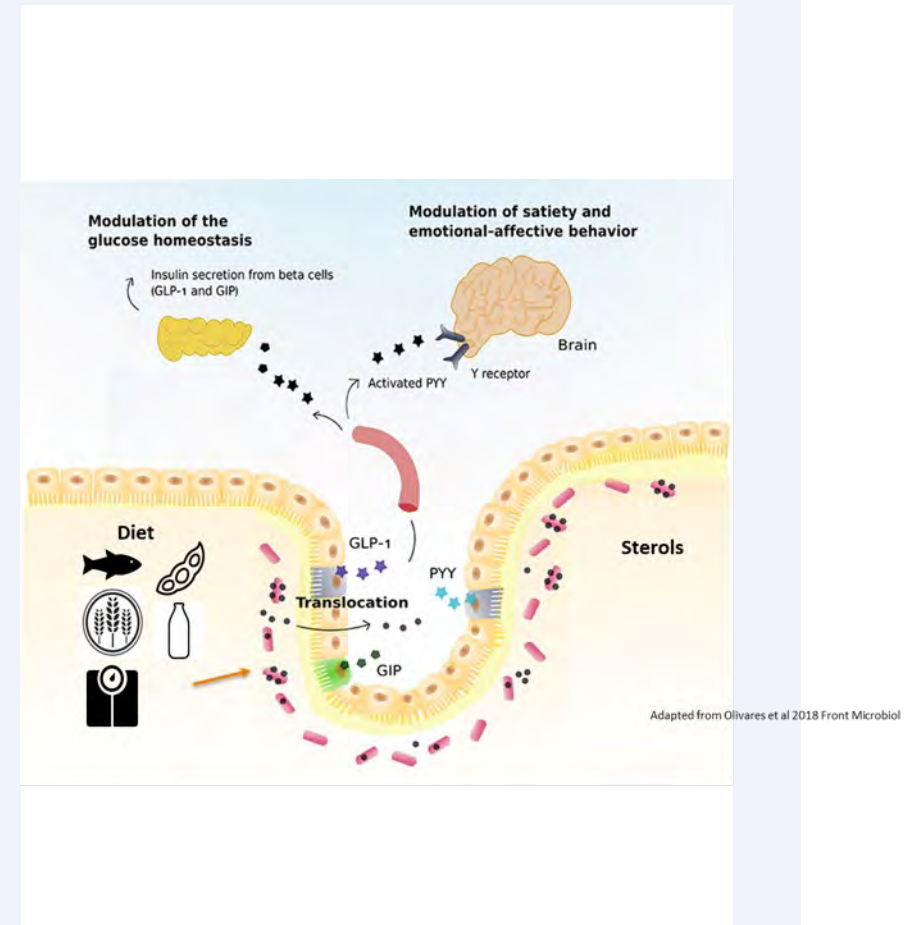
- False positives and negatives should be removed in the analysis for more societal impact
- The microbiome is heavily affected by the diet, including the food microbiome
- Definition of functional food
- Dysbiosis can be diagnosed
- The microbiome is clinically relevant to many diseases and from a diagnosis and intervention point of view
- The core human microbiome will help here, but the road is long



# ELIXIR implementation study

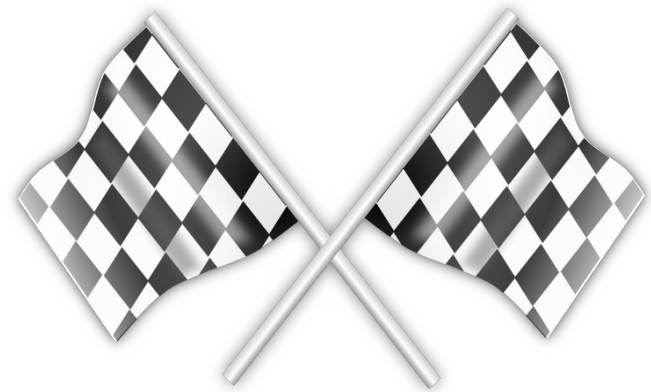
This implementation study describes the integration of microbiome, metabolomics and dietary data of nutrition studies, as a first example how the F&N Community can benefit from ELIXIR and vice versa

- WP1 - Collection of relevant datasets & training → Workshop
- WP2 - Development and implementation of microbiome standards → Workshop
- WP3 - Development and implementation of metabolomics standards → Workshop
- WP4 - Integration of study (meta)data, microbiome and metabolome → Hackathon (starting tomorrow with DIME study)



# Expected outcomes

- A better interaction between ELIXIR and the F&N Community
- Unify the RICHFIELDS, ENPADASI and FNS-Cloud requirements and ontologies
- Link standards and ontologies with other standardized ones (provided through ELIXIR).
- Standardization in consumer and human nutrition science (to be able to analyze food behavior)
- Show the modulating effect of food on the human gut microbiome and health





Thank you!



[Jildau.bouwman@tno.nl](mailto:Jildau.bouwman@tno.nl)



# Insights in microbiome analysis

**We want this**



**Population variance**  
(information on actual biological variation)



**We get this**

**Variation in microbiome data**  
(observed variation in combined datasets)



**Preparation bias**  
(DNA extraction, storage, primers, ...)



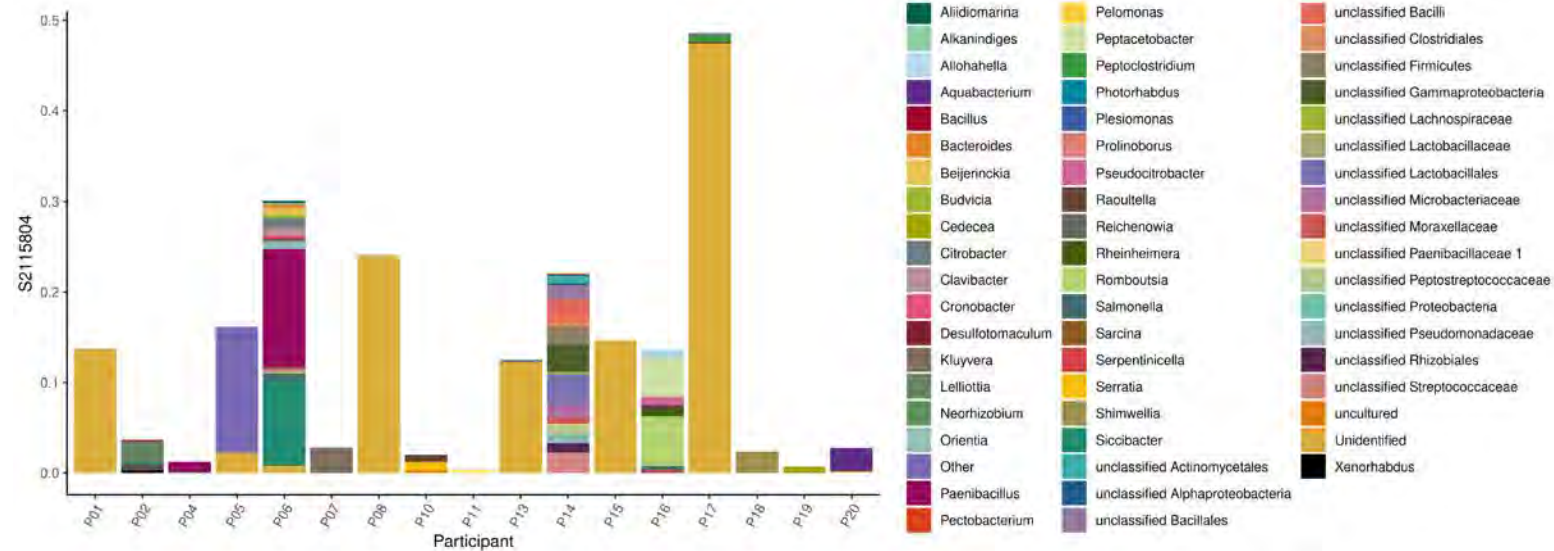
**Sequencing bias**  
(platform, read length, ...)



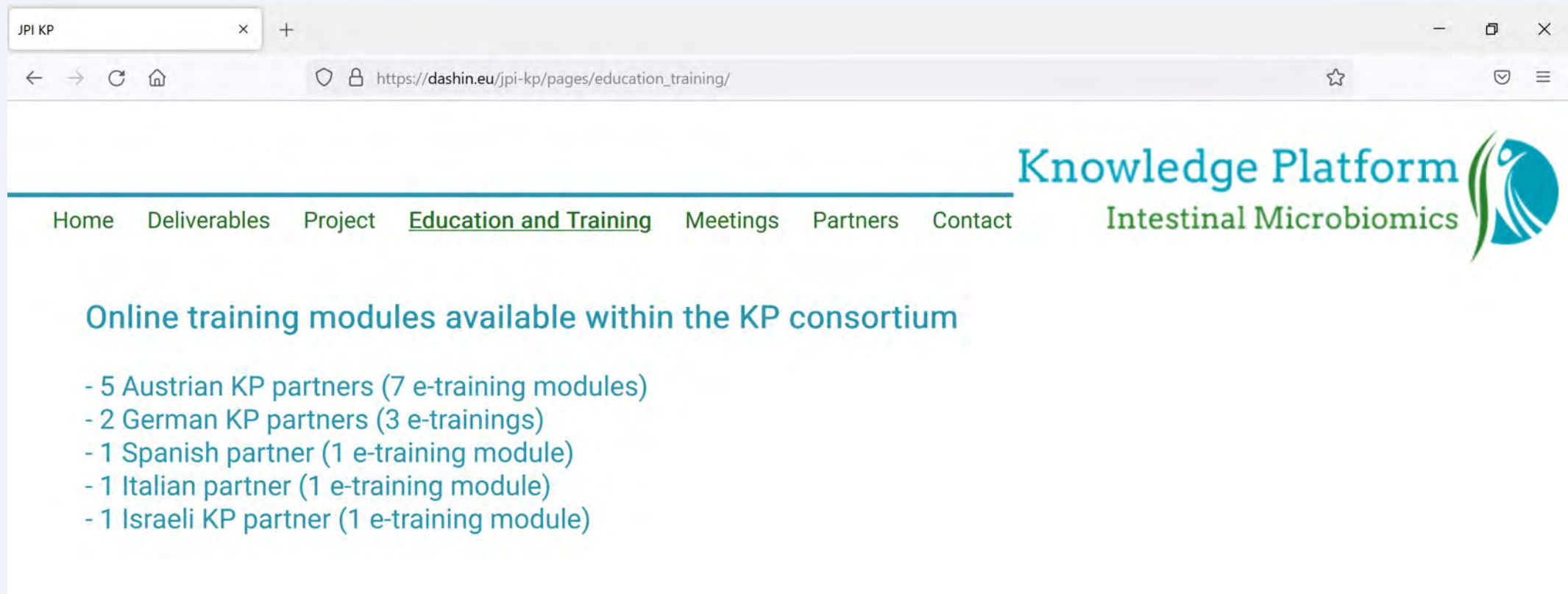
**Bioinformatics bias**  
(pipeline, parameters, database, ...)



# Many differences in ringtrial



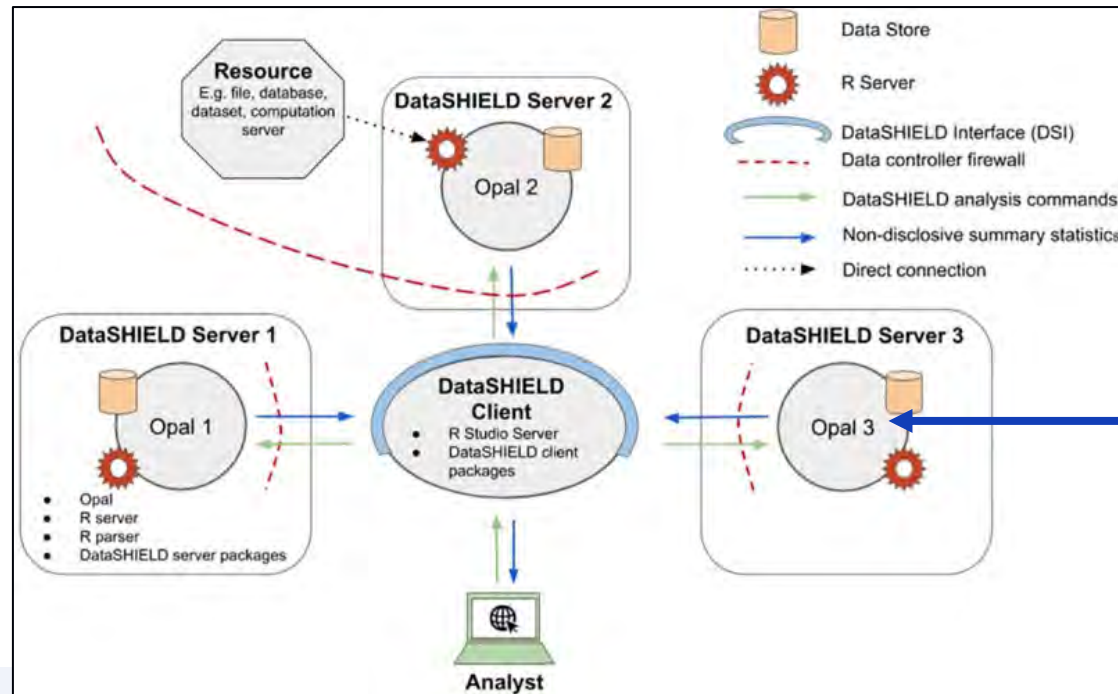
# Training developed in the KP



The screenshot shows a web browser window with the address bar displaying [https://dashin.eu/jpi-kp/pages/education\\_training/](https://dashin.eu/jpi-kp/pages/education_training/). The page title is "JPI KP". The website header includes a navigation menu with links: Home, Deliverables, Project, Education and Training, Meetings, Partners, and Contact. The logo for "Knowledge Platform Intestinal Microbiomics" is displayed on the right, featuring a stylized blue and green circular icon. The main content area is titled "Online training modules available within the KP consortium" and lists the following:

- 5 Austrian KP partners (7 e-training modules)
- 2 German KP partners (3 e-trainings)
- 1 Spanish partner (1 e-training module)
- 1 Italian partner (1 e-training module)
- 1 Israeli KP partner (1 e-training module)

# FAIR data availability through DASH-IN



Interventions studies  
with Raw data

Schematic diagram of a multi-site DataSHIELD infrastructure

# SOP databank in place (collected via survey)

31 Workflows analyzed

KP-HM

## Sample Types

**High Biomass:** Stool (13), Skin (5), Saliva (3), Lower Respiratory (3), Nasal (1)

**Low Biomass:** Tissue (3), Blood (1), Vaginal swab (1)

**Other:** In vitro gut simulation fermenter (1), Indoor Environment (1)

## Sample Stabilization

Commercial Kit (15), RNALater (11), NA (3), EDTA (1), Glycerol (1)

## Sequencing

Illumina MiSeq (17), NovaSeq (2), NextSeq (2), HiSeq (1), IonTorrent GeneStudio S5 (1)

## Controls

Negative Sample (29), Mock Community (11), Spike-in Control Cells (1) DNA Spike (2), NA (2).

## Region

16S rRNA: V3-4 (9), V1-2 (1), V1-3 (3), V4-5 (3), V4 (5), all regions (6).

Fungal ITS (6), Shotgun (7)

## 16S Ref. Databases

SILVA (8),

Greengenes (6),

Unite IST (2),

RDP (1),

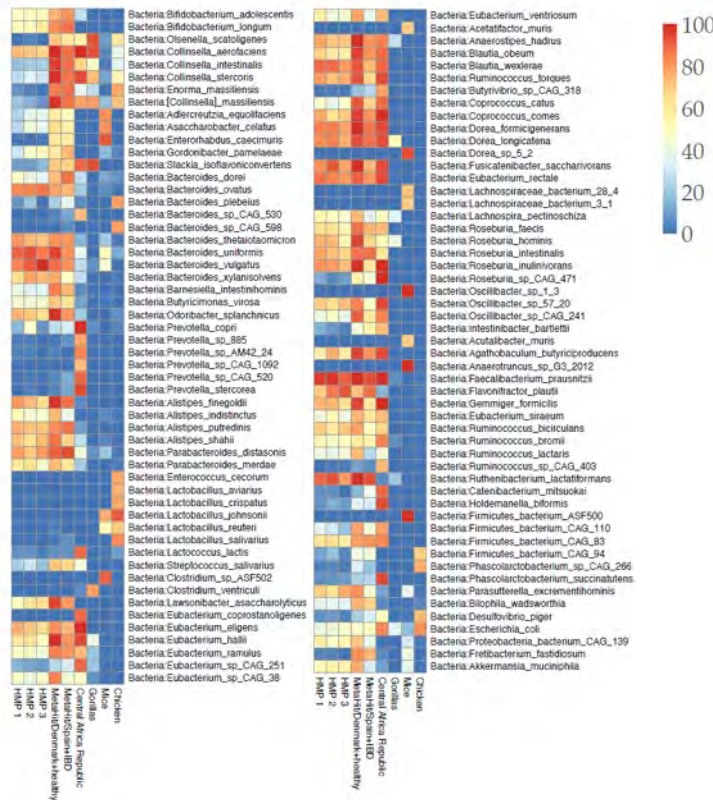
Commercial (1).

## Clustering

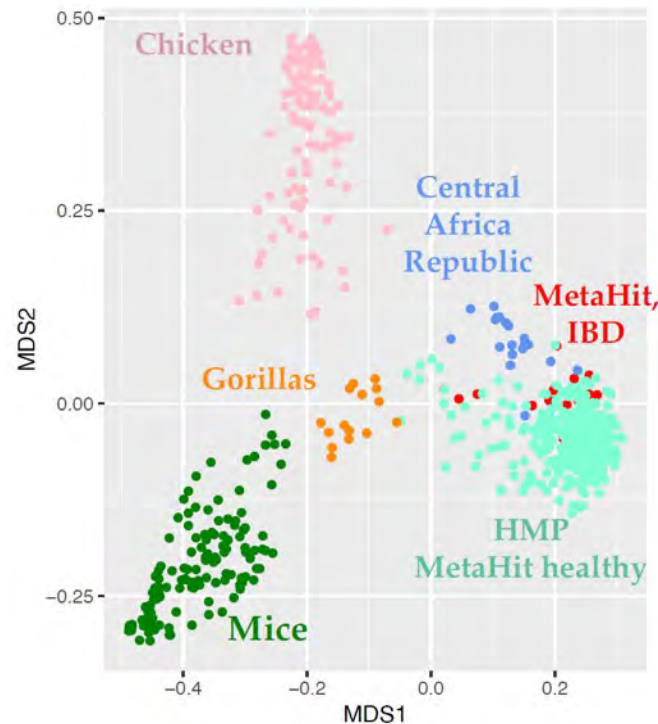
dada2 Amplicon Sequence Variants (23), 97 % OTU (6), Self-developed (2)



# A human core microbiome is hard to define



## Taxonomy: find a set of consistent taxa across populations



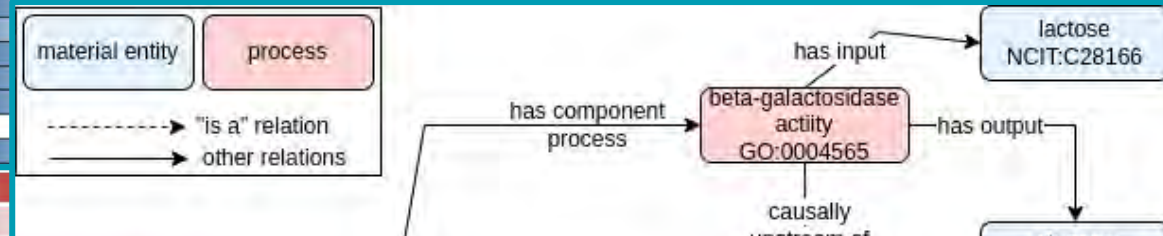
- We analyzed data from 9 cohorts
- Human samples clustered separately from animal samples

Unweighted UniFrac-based MDS analysis of 370 human and 277 animal samples

No species appeared in 90% or more of the samples of all human cohorts

# Tools developed in INTIMIC KP

Participant	Abundance.Const.Spike	Presence.Const.Spike	Assessed.Spike.Species	Contaminant.Taxa (S4)	Total.Points	Percent	Passed (>7)
Max	12	12	33	20	77	100,0	ye
P01	11	8	31				
P02	4	12	29				
P03	11	12	31				
P04	9	12	31				
P05	6	12	27				
P06	11	12	26				
P07	9	12	32				



Extension of the Ontology for nutritional studies (ONS: ENPADASI) with fermented foods and functional foods

Manuscript: From association to causative studies on gut microbiota composition and impact on metabolism and immunity

## FOBI: Food-Biomarker Ontology

FOBI: an ontology to represent food intake data and associate it with metabolomic data

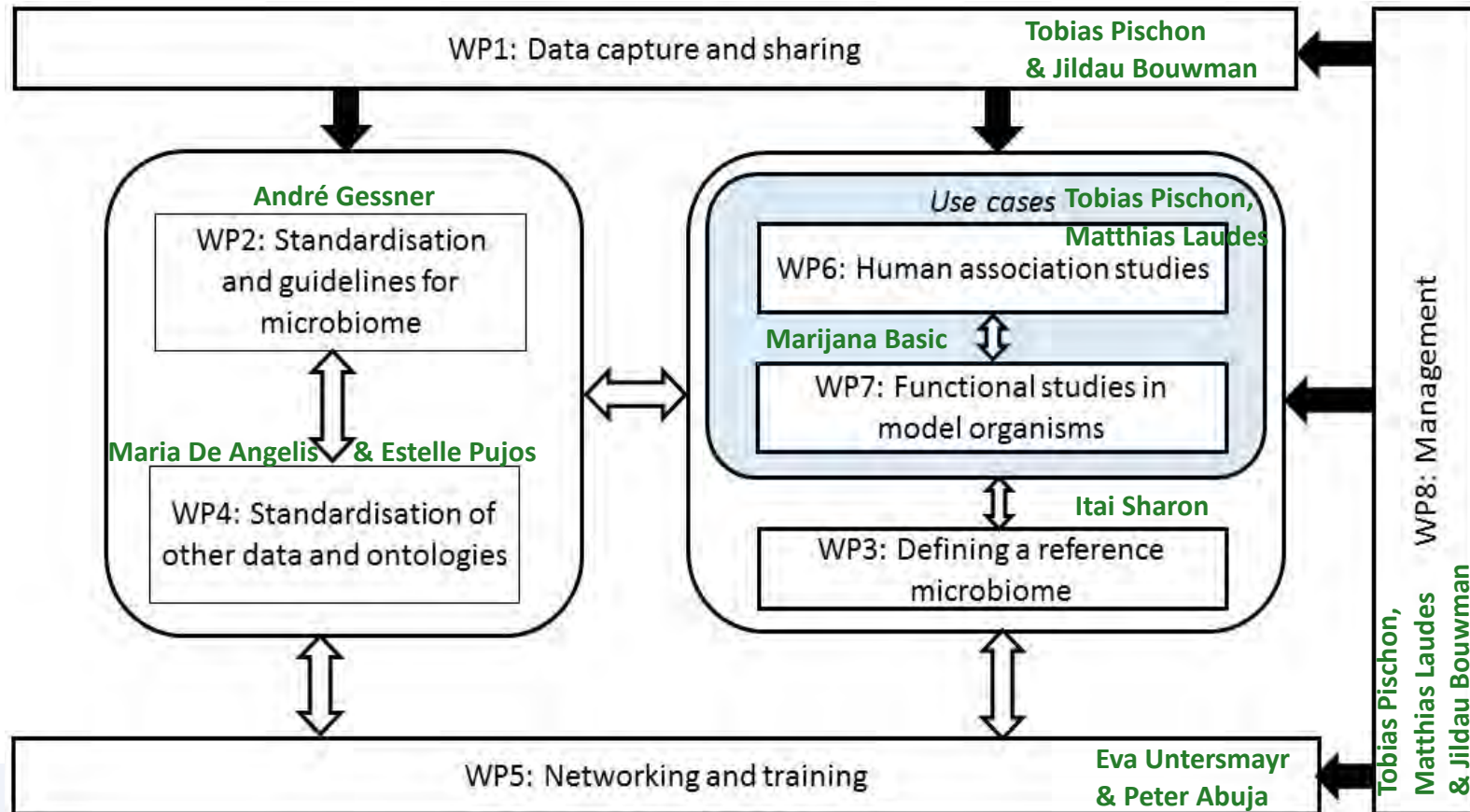
Pol Castellano-Escuder, Raúl González-Domínguez, David S Wishart, Cristina Andrés-Lacueva, Alex Sánchez-Pla

Database, Volume 2020, 2020, baaa033, <https://doi.org/10.1093/databa/baaa033>

Published: 17 June 2020 Article history

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# Structure INTIMIC-PH





# Scientific Impact

- Presentations and publications (most open access):
  - 20 publications in the special issue of nutrients 'Connection between microbiome, lifestyle and diet'
  - 18 direct publications of the knowledge platform
  - Studies available via DASH-IN for future work
  - <https://dashin.eu/jpi-kp/pages/home/>

