

## Deliverable 2.1

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<b>Abstract:</b> This initial deliverable reports the mapping of all ESFRIs and e-infrastructures that are relevant to PhenoMeNal including academic and industrial users.	
<b>History of changes</b>	
<ul style="list-style-type: none"> <li>• Focus of M6 report is now on the mapping of biomedical ESFRIs and e-infrastructures that are relevant to PhenoMeNal users</li> </ul>	



- Detailed report on the joint WP2/4 ESFRI workshop has been included as Appendix
- Section on the interaction with other e-infrastructures in H2020 has been included
- The section on user interaction has been removed, this will be included in the M12 report
- Section on the management of WP2 tasks and the contribution of each of the partners to the M6 report has been included
- Section on mapping of national infrastructures has been revised, in particular for Spain



## Table of Contents

1. Executive Summary .....	4
2. Contribution towards the project objectives .....	4
3. Detailed Report on Deliverable .....	4
3.1. Overview of the (Biomedical) European Structural Framework Infrastructures (ESFRIs) .....	4
3.2. Mapping of the relevant international and national e-Infrastructures.....	9
4. Work Plan and management of WP2 tasks.....	13
5. Conclusion.....	14
6. Appendix .....	15
6.1. Consensus document regarding metabolomics services for BMS RIs .....	15
6.2. A mapping of relevant national (e-)Infrastructures per country.....	22



## 1. Executive Summary

The PhenoMeNal project aims to develop and deploy an integrated, secure, permanent, on-demand, service driven, privacy-complaint and sustainable e-infrastructure for data processing and analysis pipelines for molecular phenotyping data. Long-term sustainability, beyond the initial 3-year funding period, is a major challenge and one of the main project objectives for the PhenoMeNal consortium. Sustainability measures include building strong relationships to all stakeholders, to industry and to all parties developing components of the PhenoMeNal e-infrastructure and virtual research environment (VRE).

In this first report we present a mapping of the (biomedical) European Strategy Forum for Research Infrastructures (ESFRIs) and other international and national (e-) infrastructures.

## 2. Contribution towards the project objectives

2.1. Mapping of e-infrastructures, users, and investments for supporting policy developments in the field of metabolomics, biomarkers and biobanks.

## 3. Detailed Report on Deliverable

### 3.1. Overview of the (Biomedical) European Structural Framework Infrastructures (ESFRIs)

ESFRIs, and e-infrastructure initiatives in general, have a long and more sustainable horizon. Building strong relationships with these ESFRIs, international and national (e-) infrastructures and organisations like the European Bioinformatics Institute (EMBL-EBI) and the European Genome-Phenome Archive (<https://ega-archive.org>, EGA), to ensure that they support and if possible continue to sustain the development of PhenoMeNal, is therefore a key part of the PhenoMeNal sustainability model. To this end, efforts were taken to engage and interact with the relevant infrastructures.



## Workshops

**ESFRI workshop**, Florence (February 5<sup>th</sup>, 2016): to discuss the use of metabolomics in the context of the different biomedical ESFRIs. This workshop was organised as part of the joint activities of WP2 and WP4 (Interfacing with Biomedical European Infrastructures) by PhenoMeNal partner Consorzio Interuniversitario Risonanze Magnetiche di Metallo Proteine (CIRMMP) for ESFRIs collectively participating in the **CORBEL** (Coordinated Research Infrastructures Building Enduring Life-science Services, <http://www.corbel-project.eu/home.html>) project. CORBEL aims to establish a collaborative framework of shared services between the ESFRI Biological and Medical Research Infrastructures through the provision of a unified interface, aligned services and coordinated user access to a range of advanced technology platforms. During the meeting, the role of metabolomics for these infrastructures was discussed. A summary document that recapitulates the main points of the discussion was prepared after the workshop, and reviewed by the participants. The final document is available as Appendix 6.1.

- **Ethical Legal and Social Implications (ELSI) workshops**, London (November 20th 2015 and January 27th 2016): These workshops were hosted by Imperial College of Science and Technology (ICL, WP7 lead). Representatives from EGA, BioMedbridges (<http://www.biomedbridges.eu>) and CORBEL were invited to explore the possible synergies and commitments towards the development of PhenoMeNal.

Metabolomics is one of the latest -omics sciences with a growing interest for its application in prognosis, diagnosis, patient stratification and personalized medicine. It is expected that metabolomics has the potential to become a complementary, or even as the tool of choice, in a standard clinical setting, providing accurate and less expensive (on large scale) technologies for diagnosis, prognosis, and prediction of diseases. For these reasons, biomedical research infrastructures are strongly interested in the development of this technology, and in the European initiatives devoted to its technical advancement. Metabolomics is multidisciplinary in nature and can therefore become a “bridge” between the different communities (clinicians, biologists, chemists) served by the research infrastructures. In a recent joint statement ([http://www.biomedbridges.eu/sites/biomedbridges.eu/files/documents/other/biomedbridges\\_and\\_cosmos\\_joint\\_statement.pdf](http://www.biomedbridges.eu/sites/biomedbridges.eu/files/documents/other/biomedbridges_and_cosmos_joint_statement.pdf)), the BioMedBridges and COSMOS ([www.cosmos-fp7.eu/](http://www.cosmos-fp7.eu/)) projects have highlighted the emerging role of metabolomics in biomedical research and stress the need for further efforts in developing common standards and procedures to harmonize both experimental procedures and the data and



metadata produced in metabolomics. Metabolomics, and consequently PhenoMeNal, could be particularly relevant for the following research infrastructures:

S.no	Infrastructure Acronym	ESFRI Infrastructure description
1	AnaEE	Infrastructure for Analysis and Experimentation on Ecosystems ( <a href="http://www.anaee.com/">http://www.anaee.com/</a> )
2	BBMRI	Bio-banking and Biomolecular Resources Research Infrastructure ( <a href="http://bbmri-eric.eu/">http://bbmri-eric.eu/</a> )
3	EATRIS	European Advanced Translational Research Infrastructure in Medicine ( <a href="http://www.eatris.eu/">http://www.eatris.eu/</a> )
4	ECRIN	European Clinical Research Infrastructure Network ( <a href="http://www.ecrin.org/index.php">http://www.ecrin.org/index.php</a> )
5	ELIXIR	European Life-science infrastructure for biological information ( <a href="https://www.elixir-europe.org/">https://www.elixir-europe.org/</a> )
6	EMBRC	European Marine Biological Resource Centre ( <a href="http://www.embrc.eu/">http://www.embrc.eu/</a> )
7	Erinha	European Research Infrastructure on Highly Pathogenic Agents ( <a href="http://www.erinha.eu/">http://www.erinha.eu/</a> )
8	EU-OPENSREEN	European Infrastructure of Open Screening Platforms for chemical biology ( <a href="http://www.eu-openscreen.eu/">http://www.eu-openscreen.eu/</a> )
9	EuroBioImaging	Research infrastructure for imaging technologies in biological and biomedical sciences ( <a href="http://www.eurobioimaging.eu/">http://www.eurobioimaging.eu/</a> )
10	Infrafrontier	European infrastructure for phenotyping and archiving of model mammalian genomes ( <a href="https://www.infrafrontier.eu">https://www.infrafrontier.eu</a> )
11	INSTRUCT	Integrated Structural Biology Infrastructure ( <a href="https://www.structuralbiology.eu/">https://www.structuralbiology.eu/</a> )
12	ISBE	Infrastructure for Systems Biology Europe



		<a href="http://project.isbe.eu">http://project.isbe.eu</a>
13	MIRRI	Microbial Resource Research Infrastructure <a href="http://www.mirri.org/home.html">http://www.mirri.org/home.html</a>

**Table 1:** List of ESFRIs with relevance for metabolomics

**BBMRI** require metabolomics as an efficient tool to monitor pre-analytical sample variations: metabolites are proved to be the most sensitive biomarkers of degradation phenomena among the various biomolecules. Emphasis should be given to the fact that successful molecular analysis not only depends on the quality of the clinical data but also on the availability of the information on sample history: collection and handling times and temperatures should be carefully annotated and become part of the associated dataset. Inclusion of metabolomic profiles in the biobank databases would be a useful addition to assess sample quality and history. An Expert Center for Metabolomics (EXCEMET, [www.excemet.org](http://www.excemet.org)) has been formally established as a reference infrastructure for biobanks and has been described as a model of a BBMRI-ERIC Expert Center. Many of the PhenoMeNal consortium partners are also part of EXCEMET. BBMRI is a partner in the Phenomenal consortium: this guarantees that specific actions are directed towards the needs of biobanks, including the creations of biobanks-targeted platform for samples related metadata handling and exploitation.

**Euro-BioImaging** is a pan-European infrastructure whose mission is to build a distributed imaging infrastructure across Europe that provides open access to innovative biological and medical imaging technologies for European researchers and it could play a crucial role in the interoperability of imaging and metabolomics. An integration of systemic biofluids metabolomics with in vivo imaging data (e.g. tumor biopsies), could improve the translation of basic science to the clinical practice. For this reason there is a need of a computational platform and tools that could handle these different sources of biological data and analyze them to produce statistically relevant conclusions.

**EU-OPENSREEN** would benefit from consistent, streamlined metabolomics data analysis pipelines to be applied e.g. in the evaluation of drug toxicity. Metabolomics can be used to facilitate lead compound discovery, to improve biomarker identification (for monitoring disease status and drug efficacy), to monitor drug metabolism and toxicity, to facilitate clinical trial testing and to improve post-approval drug monitoring. At the two extreme points of the development pipeline, metabolomics could complement both



preclinical studies, monitoring the systemic effects of the drug candidates on treated mouse models, and phase 4 postmarketing surveillance, helping to clarify the molecular mechanisms of adverse effects onset.

**INSTRUCT** requires metabolomics to help bridge the molecular level and the entire cell level, as it develops towards integrated structural cellular biology. CIRMMMP is partner in Phenomenal and is also a partner in INSTRUCT, assuring the coordination of future actions between the two initiatives.

**ELIXIR** is an infrastructure which goal is to coordinate Europe's laboratories and data centres to help the collection and storage of big datasets produced by life science experiments. ELIXIR aims to ensure that biological data is integrated into a coordinated system in which all parts of the scientific community can access existing research easily. EMBL-EBI is the coordinator of both ELIXIR and Phenomenal.

**ISBE** recognizes that metabolomics is a key technology for systems biology: metabolites are system variables that can be used to model the dynamics of biological systems. Systems biology is defined as the computational and mathematical modeling of complex biological systems and so requires a large scale computational facility designed to tackle the grand challenge of integrating different sources of large scale omics data. Metabolomics data are already being used within ISBE activities.

The **EMBRC** infrastructure promotes the use of state-of-the-art metabolomics techniques in the study of emerging-model and non-model marine organisms in order to develop a more comprehensive understanding of the novel biology of these organisms and impacts of environmental change on this diversity.

Personalized medicine is a peculiar theme for **EATRIS** and **ECRIN**. Metabolomics is the basis for a future new paradigm in personalized medicine and in prevention, allowing switching from the classical reactive medicine to a true predictive and preventive medicine. To do so, the power of information technology, databases and computational platforms (PhenoMeNal) is needed.

**INFRAFRONTIER** and **MIRRI** are interested in the development of an integrated platform where mouse and microbial data can be analysed jointly with human data.



### 3.2. Mapping of the relevant international and national e-Infrastructures

In figure 1 a schematic representation is given of the PhenoMeNal cooperative ecosystem, the different initiatives are described in the section below.

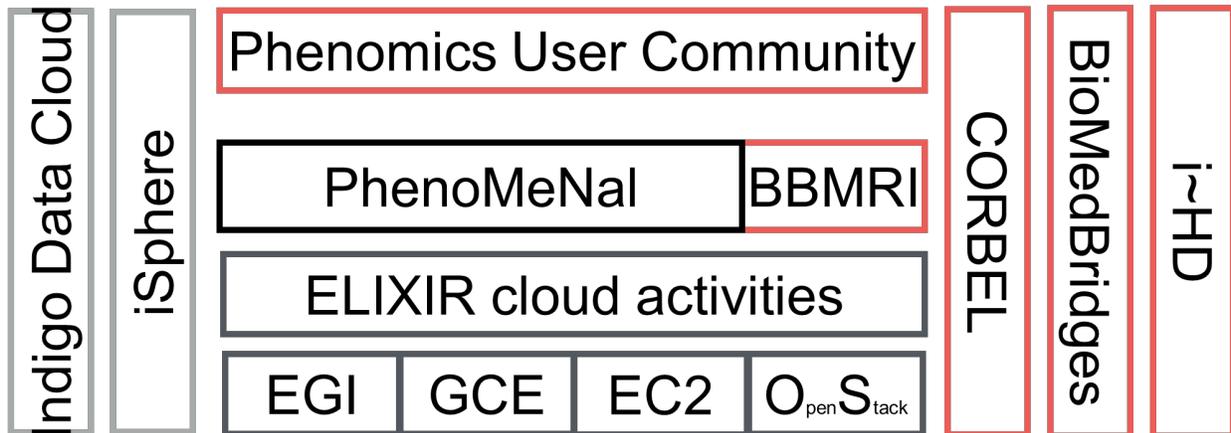


Figure 1. Schematic representation of the PhenoMeNal cooperative ecosystem

The Phenomics user community comprises all users of the PhenoMeNal infrastructure, both with universities, university medical centers, clinics and companies, and which is closely linked to the **ELIXIR cloud activities** and **BBMRI** ESFRI-initiatives (see paragraph above).

PhenoMeNal operates in an ecosystem, comprising amongst others of the following initiatives:

- **IndigoDataCloud** (INtegrating Distributed data Infrastructures for Global ExpLOitation, <https://www.indigo-datacloud.eu>), aims at developing a data and computing platform targeting scientific communities, deployable on multiple hardware and provisioned over hybrid (private or public) e-infrastructures. By filling existing gaps in PaaS (Platform as a Service) and SaaS (Software as a Service) levels, INDIGO-DataCloud helps developers, resources providers, e-infrastructures and scientific communities to overcome current challenges in the Cloud computing, storage and network areas.
- **iSPHERE**, also known as the VRE4EIC initiative (Virtual Research Environment to Empower Multidisciplinary Research Communities and Accelerate Innovation and Collaboration, <http://www.vre4eic.eu>) develops a reference architecture and prototypes to be used for future VREs including building blocks that can be used to



improve existing VREs. The project addresses the key data and software challenges in supporting multidisciplinary data driven sciences.

- **Corbel** and **Biomedbridges** have been described in the paragraph above
- **i~HD**, The European Institute for Innovation through Health Data, is to become the European organization of reference for guiding and catalyzing the best, most efficient and trustworthy uses of health data and interoperability, for optimizing health and knowledge discovery, <http://www.i-hd.eu>

The lowest horizontal bar of the figure 2.1 represents different options to run the PhenoMeNal infrastructure on, as to ensure maximal flexibility on the application:

- **European Grid Infrastructure** (EGI) Federated Cloud (<http://www.egi.eu/infrastructure/cloud/>) - The EGI Federated Cloud is a seamless grid of academic private clouds and virtualized resources, built around open standards and focusing on the requirements of the scientific community.
- **Google Compute Engine** (GCE), part of Google Cloud Platform, <https://cloud.google.com/compute/>
- **Amazon Elastic Compute Cloud**, part of Amazon Web Services (AWS). <https://aws.amazon.com/ec2/>
- The **OpenStack** project is a global collaboration of developers and cloud computing technologists producing the open standard cloud computing platform for both public and private clouds, <https://www.openstack.org/>

Other international e-infrastructures initiatives:

- The **European Open Science Cloud for Research** ([http://www.egi.eu/news-and-media/newsfeed/news\\_2015\\_034.html](http://www.egi.eu/news-and-media/newsfeed/news_2015_034.html)) - The Open Science Cloud, part of the European Commission's Digital Single Market Strategy, empowers research data sharing, data stewardship and data reuse in Europe.
- **EGA** - European Genome-Phenome Archive is available at the European Bioinformatics Institute (EBI) and the Centre for Genomic Regulation (CRG). EGA provides a service for the permanent archiving and distribution of personally identifiable genetic and phenotypic data resulting from biomedical research projects.
- **eTRIKS** - European Translational Information and knowledge management services. eTRIKS is the result of a collaboration between 17 different partners. Each combining their strengths in the development of a platform and services for data staging, exploration and use in translational research.



In the framework of H2020 we the EC is organizing very valuable interactions with other e-infrastructure initiatives, which are attended by the coordinator of PhenoMeNal, as is listed in the figure below.

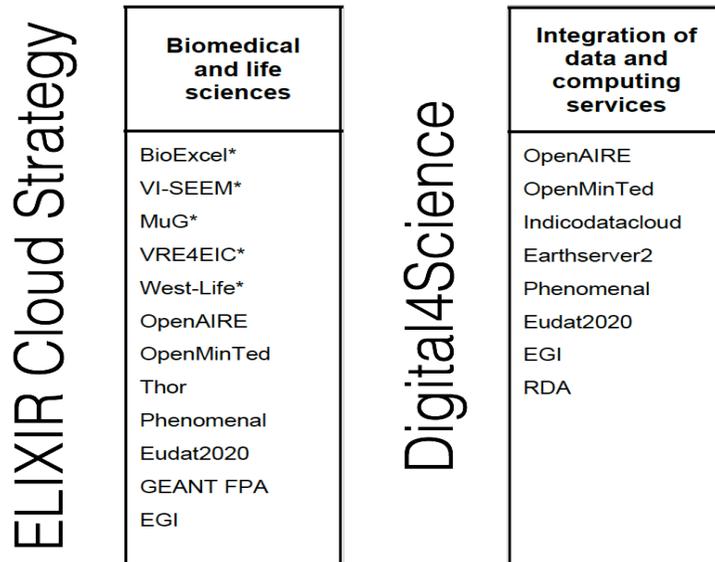


Figure 2. Interaction with other e-infrastructures in the framework of H2020.

### ELIXIR Cloud strategy

- BioExcel (<http://bioexcel.eu>) - is a newly launched Centre of Excellence for provision of support to academic and industrial researchers in the use of high-performance computing (HPC) and high-throughput computing (HTC) in biomolecular research.
- VI-SEEM (<https://vi-seem.eu>) - is a three-year project that aims at creating a unique Virtual Research Environment (VRE) in Southeast Europe and the Eastern Mediterranean (SEEM), in order to facilitate regional interdisciplinary collaboration, with special focus on the scientific communities of Life Sciences, Climatology and Digital Cultural Heritage.
- MuG (Multiscale Complex Genomics, <http://www.multiscalegenomics.eu>)- The project responds to the latest computational challenges of 3D/4D genomics by bringing this community closer to the HPC and Big Data world and providing a suitable set of tools and infrastructure.
- VRE4EIC has been already been described above.
- West-Life (<http://about.west-life.eu>) - is a H2020 Virtual Research Environment project that provides the application level services specific to uses cases in structural



biology, covering all experimental techniques (e.g. Xray, cryo-EM, NMR, SAXS), enabling structural biologists to get the benefit of the generic services developed by EUDAT and the EGI.

- THOR (Technical and Human Infrastructure for open Research, <http://project-thor.eu>) - establishes a seamless integration between articles, data, and researchers across the research lifecycle.
- EUDAT (<http://www.eudat.eu>) - is the collaborative Pan-European Infrastructure providing research data services, training and consultancy for researchers, research communities and research infrastructures and data centers.
- GEANT ([http://www.geant.org/Projects/GEANT\\_Project\\_GN4-1](http://www.geant.org/Projects/GEANT_Project_GN4-1)) - is the leading collaboration on e-infrastructure and services for research and education.
- EGI has been already been described above.

## Digital4Science

- OpenAIRE2020 (<https://www.openaire.eu>) - Assists in monitoring H2020 research outputs and is a key infrastructure for reporting H2020's scientific publications.
- OpenMinTed (Open Mining Infrastructure for Text and Data, <http://openminted.eu>) - aspires to enable the creation of an infrastructure that fosters and facilitates the use of text mining technologies in the scientific publications world, builds on existing text mining tools and platforms, and renders them discoverable and interoperable through appropriate registries and a standards-based interoperability layer, respectively.
- PRACE (Partnership for advanced computing in Europe, <http://www.prace-ri.eu>) - Its mission is to enable high impact scientific discovery and engineering research and development across all disciplines to enhance European competitiveness for the benefit of society.
- RDA (Research Data Alliance Europe, <https://europe.rd-alliance.org>) - builds the social and technical bridges that enable open sharing of data. The RDA vision is researchers and innovators openly sharing data across technologies, disciplines, and countries to address the grand challenges of society.



## **Interactions with global infrastructures**

Below we give an overview of the relevant e-Infrastructure initiatives that have been identified in Europe. However, we are aware as a consortium that also in the US, Canada and Asia there are significant initiatives in this area. Our consortium partners have extensive global contacts and interactions, for instance with e-Infrastructure arising from the NIH Common Funds (<https://commonfund.nih.gov/>, USA), Massbank (<http://www.massbank.jp/?lang=en>, Japan), Human Metabolome Database (<http://www.hmdb.ca/>, HMDB Canada) and from Beijing Genomics Institute (<http://bgi-international.com/>, BGI China).

### **3.3. Mapping of national (e-) infrastructures**

In Appendix 6.2 a detailed overview is given of the national (e-)infrastructures. The overview indicates that there are many (e-)infrastructures in the different countries. Individual partners of PhenoMeNal have strong ties with the national e-Infrastructures. The design choice of PhenoMeNal to establish a virtual research community ensures that PhenoMeNal can be easily integrated into these e-Infrastructures and that no duplications occur. This report is a living document and will be updated in M22.

## **4. Work Plan and management of WP2 tasks**

The work package is led by Leiden University. There is a close link and interaction with WP4 (interfacing with other biomedical ESFRIs, led by CIRRMMP) and WP3 (outreach and dissemination, led by University of Birmingham) and WP1 (management, led by EBI). To this end we organized a bimonthly interactions between these work packages. For the mapping of the e-infrastructure input was provided by EBI (interaction with other e-infrastructures in H2020), CIRMMMP (on ESFRIs, Italian country report), University of Oxford (UK country report), University of Uppsala (Swedish country report), University of Barcelona (Spanish country report), Leibniz-Institut für Pflanzenbiochemie (German country report), INRA (French country report), ISB (Swiss country report).



*Utilization of resources:*

<b>Partner</b>	EMBL- EBI	CIRMMP	UL	UOXF	SIB	UU
<b>PM</b>	0.25	0.75	2	0.5	0.5	0.5

## 5. Conclusion

PhenoMeNal operates in a complex cooperative ecosystem, of e-infrastructure initiatives and (biomedical) ESFRIs. This mapping has provided the consortium with a clear overview of all the interactions that exist. The strongest interactions are with BBMRI, ELIXIR and CORBEL (for ELSI issues). Representatives have attended many of the meetings of PhenoMeNal from these organisations.

We have good interactions with other e-infrastructures being developed in H2020, due to the regular meetings organised by the EC, as well as in direct 1:1 interactions. Our consortium partners have extensive global contacts and interactions, for instance with e-Infrastructure arising from the NIH Common Funds (USA), Massbank (Japan), Human Metabolome Database (Canada) and the Beijing Genomics Institute (China).



## 6. Appendix

### 6.1. Consensus document regarding metabolomics services for BMS RIs

(drafted on the occasion of the meeting of CORBEL Use Case 2, Florence 4-5 February 2016)

#### Background

On February 5<sup>th</sup>, 2016 the Consorzio Interuniversitario Risonanze magnetiche di Metallo Proteine (CIRMMP), which is a partner of both PhenoMeNal and (through the Instruct infrastructure) CORBEL projects, organized in Florence a meeting with representatives of some of the Research Infrastructures involved in CORBEL.

The PhenoMeNal project (<http://phenomenal-h2020.eu/>) will develop and deploy an integrated, secure, permanent, on-demand service-driven, privacy-compliant and sustainable e-infrastructure for the processing, analysis and information-mining of the massive amount of medical molecular phenotyping and genotyping data that will be generated by metabolomics applications now entering research and the clinic. In particular, PhenoMeNal aims to develop a set of interacting compute, data and gateway virtual machine images and the middleware to integrate them into a coherent e-Infrastructure with data access control.

The EC-funded project CORBEL (<http://www.corbel-project.eu/>) is an initiative of eleven Biological and Medical Research Infrastructures (BMS RIs: ELIXIR, BBMRI, EATRIS, ECRIN, EU-OPENSREEN, Euro-BioImaging, INFRAFRONTIER, Instruct, ISBE and MIRRI), which together will create a platform for harmonised user access to biological and medical technologies, biological samples and data services required by cutting-edge biomedical research. The overarching goal of CORBEL is to boost the efficiency, productivity and impact of European biomedical research through the provision of a unified interface, aligned services and coordinated user access to a range of advanced technology platforms. By harmonising user access, unifying data



management, creating common ethical and legal services, and offering joint innovation support, CORBEL will raise a new model for biological and medical research in Europe.

The following persons representing RIs were present at the workshop:

- Bahne Stechmann [stechmann@fmp-berlin.de](mailto:stechmann@fmp-berlin.de) EU-OPENSSCREEN
- Marie Vidal [Marie.Vidal@mdc-berlin.de](mailto:Marie.Vidal@mdc-berlin.de) ISBE
- Norman Morrison [norman.morrison@manchester.ac.uk](mailto:norman.morrison@manchester.ac.uk) ISBE
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- Fraucke Leitner [frauke.leitner@embl.de](mailto:frauke.leitner@embl.de) EuroBioImaging
- Sofie Vanmaele [sofie.vanmaele@obs-vlfr.fr](mailto:sofie.vanmaele@obs-vlfr.fr) EMBRC
- Michael Raess [michael.raess@infrafrontier.eu](mailto:michael.raess@infrafrontier.eu) Infrafrontier
- Antonio Rosato [rosato@cerm.unifi.it](mailto:rosato@cerm.unifi.it) INSTRUCT

During the meeting, the role of metabolomics for these infrastructures was analyzed, and the following position paper resumes the main points emerged from the discussion.

### **The role of Metabolomics in BMS RIs**

Metabolomics is one of the latest -omics sciences, devoted to the characterization of the ensemble of metabolites produced by an organism. Metabolomics data can be acquired on any tissue or body fluid under a range of different biological/clinical settings. The main technological platforms for metabolomics data acquisition are high-end Mass Spectrometry (MS) and Nuclear Magnetic Resonance (NMR) instruments. The analysis of metabolomics data requires extensive computational capabilities, and the application of advanced statistical approaches. Metabolomics is playing (and will play even to a further extent) a crucial role in the biomedical community. It is also expected that in the future metabolomics will be routinely used in clinical setting for diagnosis, prognosis, patient stratification and personalized medicine [1].

Following this trend, BMS RIs are fully supportive of European initiatives devoted to the technical advancement of metabolomics, and have already expressed interest in adopting this technology. Clearly, the degree of interest is different for different RIs, depending especially on how close their activities are to clinical applications. Notably, because metabolomics is multidisciplinary in nature, it constitutes a technology that



could directly connect the different communities (clinicians, biologists, chemists) served by the BMS RIs involved in CORBEL.

A significant development that is relevant to EU-OPENSREEN (European Infrastructure of Open Screening Platforms for Chemical Biology, <http://www.eu-openscreen.de/>) is the expanding role of metabolomics research in toxicology. EU-OPENSREEN integrates high-throughput screening platforms, chemical libraries, chemical resources for hit discovery and optimisation, bio- and cheminformatics support, and a database containing screening results, assay protocols, and chemical information. In this context, metabolomic profiles of urine and serum of patients that have been treated with drugs in clinical trials may contribute to the prediction of efficacy and/or toxicity of the treatment, and provide hints about the underlying biochemical mechanisms [2]. The approach can also be used to predict individual ability to metabolize a given drug and individual susceptibility to the side effects of that drug. Because of its conceptual and technical overlap with many aspects of pharmaceutical research, metabolomics is finding applications that span almost the full length of the drug discovery and development pipeline. Metabolomics can be used to facilitate lead compound discovery, to improve biomarker identification (for monitoring disease status and drug efficacy), to monitor drug metabolism and toxicity, to facilitate clinical trial testing and to improve post-approval drug monitoring [3]. Metabolomics could complement both preclinical studies, monitoring the systemic effects of the drug candidates on treated mouse models, and phase 4 post-marketing surveillance, helping to clarify the molecular mechanisms of the onset of adverse effects. Metabolomics potentially offers drug researchers and drug regulators an effective, inexpensive route to addressing many of the riskier or more expensive issues associated with the discovery, development and monitoring of drugs.

For these reasons, EU-OPENSREEN will direct users towards PhenoMeNal's services including metabolomic analyses on a case-by-case basis. This will enhance the added value provided to users by the infrastructure.



**ISBE** (Infrastructure for Systems Biology in Europe, <http://project.isbe.eu/>) aims to allow researchers to gain easy access to the best systems biology expertise, resources and services including state-of-the-art facilities, data, models, tools and training. Systems biology is defined as the computational and mathematical modelling of complex biological systems and so requires a large scale computational facility designed to tackle the grand challenge of integrating different sources of large scale omics data. ISBE recognizes that metabolomics is a key technology for systems biology [4]: metabolites are system variables that can be used to model the dynamics of biological systems. Because metabolomics aims at obtaining an integrated and comprehensive view about the dynamics within a living system by using data from different levels (different systemic biofluids, different cell types, different tissues), it is the –omic science that most closely follows the paradigm of systems biology. Integrated meta-analysis and meta-modelling of metabolomic data could reveal specific cellular and molecular perturbations (pathways) underlying the development of diseases, possibly useful for diagnosis. In particular, metabolomic datasets aggregated in a dynamic, relational database, will allow for the identification of clinical and molecular profiles of different pathologies that can lead to potential biomarkers for time\cost effective diagnosis and possible druggable targets. From a systems biology approach in the analysis of metabolomic data, new hypotheses for possible causes underlying the onset of diseases and common shared mechanisms between related pathologies could emerge [5].

Therefore, the generation of metabolomic data for modelling and data integration purposes should be easily harmonized with ISBE standard development and can contribute to the application of metabolomics to e.g. personalized medicine, in conjunction with EATRIS and ECRIN.

**Euro-BioImaging** (EuBI, <http://www.eurobioimaging.eu/>) will provide open user access to a complete range of state-of-the-art imaging technologies in biological, molecular and medical imaging for life scientists in Europe and beyond. EuBI will offer image data support and training for infrastructure users and providers and continuously evaluate



and include new imaging technologies to ensure cutting-edge services in a sustainable manner. Of interest to EuBI is the possibility to obtain metabolomic profiles not only of biological fluids, but also of solid-state samples, such as tumor biopsies [6]. Metabolomics on biopsies, in general, allows for a more detailed fingerprinting of the tumor metabolism, while the systemic biofluids allow for the study of the tumor–host interactions. An integration of this information with in vivo imaging data, especially NMR-based metabolomics with NMR-based imaging, could improve the translation of basic science to the clinical practice. Metabolomics data provides more details on biochemistry whilst imaging data provides more spatial localization details. A combination of imaging and metabolomics approach would be an ideal tool to develop biomarkers for e.g. identify malignancy [7]. Moreover, metabolic biomarkers discovered in vitro by NMR on tissue specimens can be translated into more precise in vivo magnetic resonance spectroscopy protocols, which represents another strength of an integrated approach. Since metabolic derangement is associated with cellular injury and death, NMR-based metabolomics of tissues may be a very sensitive and useful tool for the quantification of diseases.

**INFRAFRONTIER** (<https://www.infrafrontier.eu/>) is the European Research Infrastructure for phenotyping and archiving model mammalian genomes. The INFRAFRONTIER Research Infrastructure contributes to improving the understanding of gene function in human health and disease using the mouse model. The core services of INFRAFRONTIER comprise the systemic phenotyping of mouse mutants in the participating mouse clinics, and the archiving and distribution of mouse mutant lines by the European Mouse Mutant Archive (EMMA).

Animal models are an essential tool for researchers hoping to learn more about disease. In many cases, data cannot be collected from living patients as this sometimes calls for organ dissection or other highly invasive procedures. For this reason, there is increasing interest in trying to explore a bridge connecting the mechanism basis of human disease with experimental animal models by comparing the metabolites differences in human and animal samples [8]. Some initial work in this area was already



undertaken within the BioMedBridges initiative. The comparison of morphological image data on cellular phenotypes of individual genes, with morphological image data of the diseased tissues in mouse models and human patients could create a powerful predictor of optimized biomarkers as well as drug targets in e.g. cancer. Linking these imaging data with molecular data including the cancer genome sequence and cancer expression data, will allow in silico validation of the predictions and prioritization of biomarkers for validation in clinical research.

### **Conclusions**

In summary the representatives of RIs convened in Florence recognize that metabolomics perfectly fits with the spirit of systems biology and systems medicine, providing a global overview of biochemistry in complex organisms. Metabolomics investigates the final products of the cascade of interactions that involve genes, proteins, and finally metabolites, both at the systemic level and in individual cell types. Furthermore, in the near future, metabolomics will have a crucial role next to the other – omic sciences, because of its ability to detect in real time the adaptive multiparametric response of the organisms to patho-physiological stimuli or genetic modifications. The earliest available signs of any disease onset are compensatory alterations of the individual's metabolome before clinical symptoms appear. Specific and reliable detection of those early signs should allow for effective prevention even with mild counter-measures like lifestyle changes or low dose treatments. There are many points of possible interactions between the different RIs and the metabolomic community.

For these reasons the RIs representatives acknowledge that metabolomic services could be a useful complement to the services offered by the different RIs to their respective users base. In particular, the development of tools and methods for acquiring, integrating and analysing big datasets of metabolic phenotypes that PhenoMeNal will be pursuing appears crucial to ensure the throughput and the qualitative standards sought by BMS RIs. Thus, the success of PhenoMeNal represents



a crucial step toward the integration of metabolomics research and applications in the broader network of the activities of European BMS RIs.

In addition, it is also clear that high-throughput NMR and MS for metabolomics activities are technically challenging and costly, which can be integrated in the pipeline of the services offered by BMS RIs only if a pan-European infrastructure devoted to the production of metabolomics data becomes available. There is a general consensus that the lack of a reference European Infrastructure for metabolomics hampers a fast and organized development of the field.

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## 6.2. A mapping of relevant national (e-)Infrastructures per country

### 6.2.1. United Kingdom

Infrastructure Name	Short description	Type	Reference (e.g. Web or elsewhere)
ARCHER	UK national supercomputing service	e-infrastructure	<a href="http://www.archer.ac.uk">www.archer.ac.uk</a>
UK BioBank	Long-term biobanking study on genetic predisposition and environmental exposure	Research facility with e-infrastructure and storage	<a href="http://www.ukbiobank.ac.uk">www.ukbiobank.ac.uk</a>
NIHR Biomedical Research Centres/Units (BRC/BRU)	Conduct and support translational research to transform scientific breakthroughs into treatments for patients	Research facilities (including on informatics)	<a href="http://www.nihr.ac.uk/about/biomedical-research-centres.htm">www.nihr.ac.uk/about/biomedical-research-centres.htm</a>
NIHR Health Informatics Collaborative	Set up to deliver high quality data in five key therapeutic areas: acute coronary syndromes, ovarian cancer, hepatitis, renal transplantation and intensive care.	Research facility on informatics	<a href="http://www.nihr.ac.uk/about/hic.htm">www.nihr.ac.uk/about/hic.htm</a>
MRC/NIHR National Phenome Centre	NMR/MS phenotyping research centre (PhenoMeNal partner via ICL)	Research facility	<a href="http://www.nihr.ac.uk/about/mrc-nihr-phenome-centre.htm">www.nihr.ac.uk/about/mrc-nihr-phenome-centre.htm</a>
NIHR Healthcare Technology	HTCs develop concepts, demonstrate proof of	Technology transfer	<a href="http://www.nihr.ac.uk/about/health">www.nihr.ac.uk/about/health</a>



Cooperatives	principle and devise research protocols for new medical devices, healthcare technologies or technology dependent interventions for underserved patient groups	enabler	<a href="http://care-technology-co-operatives.htm">care-technology-co-operatives.htm</a>
NIHR Biosample Centre	High throughput and high quality biosample processing, storage and retrieval services to support NIHR-supported research	Research facility	<a href="http://www.nihr.ac.uk/about/national-biosample-centre.htm">www.nihr.ac.uk/about/national-biosample-centre.htm</a>
NIHR BioResource	A panel of 1000s of volunteers who are willing to be approached to participate in research studies including to develop new treatments for a range of diseases, and to investigate the links between genes, the environment, health and disease	Research facility	<a href="http://www.nihr.ac.uk/about/bioresource.htm">www.nihr.ac.uk/about/bioresource.htm</a>
Alan Turing Institute	UK national institute for data science	Research facility	<a href="http://www.turing.ac.uk">www.turing.ac.uk</a>
Genomics England	Delivering the 100,000 Genomes Project - creating a new genomic medicine service for the UK National Health Service by sequencing 100,000 genomes from	e-infrastructure	<a href="http://www.genomicsengland.co.uk">www.genomicsengland.co.uk</a>



	around 70,000 people		
Dementias Platform UK	Multi-million GBP public-private partnership, developed and led by the UK Medical Research Council, to accelerate progress in, and open up, dementias research	e-infrastructure	<a href="http://www.dementiasplatform.uk">www.dementiasplatform.uk</a>
Collaborative Open Plant Omics platform	Storing, annotating and sharing valuable information as well as promoting clear guidance, training, for UK plant sciences research	e-infrastructure	<a href="http://gtr.rcuk.ac.uk/project/2AB18676-46EC-41E6-A197-21E6F153FF50">http://gtr.rcuk.ac.uk/project/2AB18676-46EC-41E6-A197-21E6F153FF50</a>
The Digital Catapult	Helping UK businesses unlock new value from sharing proprietary data in faster, better and more trusted ways	Technology transfer enabler	<a href="http://www.digitalcatapultcentre.org.uk">www.digitalcatapultcentre.org.uk</a>
EPSRC IoT Research Hub	New interdisciplinary research hub to drive forward UK research in the Internet of Things, including for applications in healthcare	Research facility	<a href="http://www.epsrc.ac.uk/newsevents/news/iotresearchhub/">www.epsrc.ac.uk/newsevents/news/iotresearchhub/</a>
ELIXIR UK Node	Co-leading the ELIXIR EXCELERATE platform for integration and interoperability of data and services	e-infrastructure	<a href="http://www.elixir-uk.org">www.elixir-uk.org</a>
Internet of Things	Aimed at improving the	Technology	<a href="https://www.go">https://www.go</a>



Cities Demonstrator (Manchester)	services for its residents, demonstrating applications of IoT services in four key areas: transport; energy and environment; culture and community and <i>healthcare</i>	transfer demonstrator	<a href="http://www.gov.uk/government/news/manchester-wins-10m-prize-to-become-world-leader-in-smart-city-technology">v.uk/government/news/manchester-wins-10m-prize-to-become-world-leader-in-smart-city-technology</a>
UK Data Archive	Acquires, curates and provides access to the UK's largest collection of social and economic data	e-infrastructure	<a href="http://www.data-archive.ac.uk">http://www.data-archive.ac.uk</a>

### 6.2.2. The Netherlands

Infrastructure Name	Short description	Type	Reference (e.g. Web or elsewhere)
SURF	A collaborative ICT organisation for Dutch higher education and research. SURF offers students, lecturers and scientists in the Netherlands access to the best possible internet and ICT facilities.	e-Infrastructure	<a href="https://www.surf.nl/en">https://www.surf.nl/en</a>
3 TU Data Centre	Offers the knowledge, experience and the tools to archive research data in a standardized, secure and well-documented manner.	Storage	<a href="http://datacentrum.3tu.nl/en/home/">http://datacentrum.3tu.nl/en/home/</a>
DANS	Promotes sustained access	Storage	<a href="http://dans.knaw.nl">http://dans.knaw.nl</a>



	to digital research data files and encourages researchers to archive and reuse data.		<a href="#">.nl/en</a>
BBMRI-NL	Uniting all national biomedical research infrastructures into one streamlined, efficient body of research infrastructure.	e-Infrastructure	<a href="http://www.bbMRI.nl/">http://www.bbMRI.nl/</a>
Proteins@Work	Provides access to state-of-the-art proteomics technology, equipment and expertise to researchers in the life sciences from academia and industry.	Research facility	<a href="http://www.netherlandsproteomicscentre.nl/paw">http://www.netherlandsproteomicscentre.nl/paw</a>
Netherlands Metabolomics Centre	Is a public-private research foundation. As part of the NMC the Data Support Platform has been set up to support storage of experimental metabolomics data, and their processing. This bioinformatics support platform provides a means for communication between the partners of the NMC for the exchange of data, software, and tools.	Research facility	<a href="http://www.metabolomicscentre.nl/about-services">http://www.metabolomicscentre.nl/about-services</a>
CTMM	A public-private partnership for translational research.	Research partner	<a href="http://www.ctmm.nl/en">www.ctmm.nl/en</a>
NL-OPENSREEN	Making ultra throughput screening of unique small molecule	Research facility	<a href="http://www.congresroute2020.nl/NL-">http://www.congresroute2020.nl/NL-</a>



	libraries available to the Dutch life science community.		<a href="#">OPENSREEN 6.pdf</a>
Biomedical Metabolomics Facility Leiden	Development of innovative analytical strategies for metabolomics-driven systems biology in personalized health strategies	Research facility	<a href="http://www.oari.science.leidenuniv.nl/#/group/METABOLOMICS">http://www.oari.science.leidenuniv.nl/#/group/METABOLOMICS</a>



### 6.2.3. Sweden

Infrastructure Name	Short description	Type	Reference (e.g. Web or elsewhere)
BILS/NBIS	Is the Swedish ELIXIR node and a national support infrastructure for bioinformatics.	e-Infrastructure	<a href="http://www.bils.se">http://www.bils.se</a>
SNIC	Swedish National Infrastructure for Computing	e-Infrastructure	<a href="http://www.snic.se">http://www.snic.se</a>
SciLifelab	Science for Life Laboratory, SciLifeLab, is a national center for molecular biosciences with focus on health and environmental research. SciLifeLab is a national resource and a collaboration between four universities: Karolinska Institutet, KTH Royal Institute of Technology, Stockholm University and Uppsala University.	Research facility	<a href="http://www.scilifelab.se">http://www.scilifelab.se</a>
BBMRI-SE	Uniting all national biomedical research infrastructures into one streamlined, efficient body of research infrastructure.	e-Infrastructure	<a href="http://www.bbMRI.se/">http://www.bbMRI.se/</a>
CARAMBA	Clinical Analysis & Research Applying Mass	Research facility	<a href="http://www.medicinsci.uu.se/caramba">http://www.medicinsci.uu.se/caramba</a>



	spectrometry & Bioinformatics at Akademiska University Hospital		<a href="#">mba/</a>
Swedish Metabolomics Centre	The Swedish Metabolomics Centre (SMC; SLU/UmU) is a state-of-the-art facility which has specialized in the use of mass spectrometry based methods for the analysis of metabolites in different biological systems.	Research facility	<a href="http://www.swedishmetabolomicscentre.se/">http://www.swedishmetabolomicscentre.se/</a>
NCMSI	National Center for Mass Spectrometry Imaging	Research facility	<a href="http://farmbio.uu.se/Plattform/NCMSI/">http://farmbio.uu.se/Plattform/NCMSI/</a>
eSSENCE	Is a strategic collaborative research programme in e-science between three Swedish universities with a strong tradition of excellent e-science research: Uppsala University, Lund University and Umeå University.	e-infrastructure	<a href="http://essenceofscience.se/">http://essenceofscience.se/</a>
SERC	The Swedish e-Science Research Centre (SeRC) is formed by the four universities Kungliga Tekniska högskolan (KTH), Stockholms universitet (SU), Karolinska institutet (KI) and Linköpings	e-infrastructure	<a href="http://www.e-science.se/">http://www.e-science.se/</a>



	universitet (LiU) around the two largest high performance computing centers in Sweden.		
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#### 6.2.4. Spain

<b>Infrastructure Name</b>	<b>Short description</b>	<b>Type</b>	<b>Reference (e.g. Web or elsewhere)</b>
Integrated Infrastructure for Omics Technologies (IOT)	This distributed ICTS is composed of the Genomics Platform of the Centro Nacional de Análisis Genómico (CNAG) and the Metabolomics platform of the Centre for Omic Sciences (COS). This facility has the whole range of required technologies to quantify all the elements that make up biological systems, including DNA, RNA, epigenomic marks, proteins, metabolites, and structural elements such as membranes.	e-Infrastructure	<a href="http://www.idi.mineco.gob.es/portal/site/MICINN/menuitem.8ce192e94ba842bea3bc811001432ea0/?vgnnextoid=b2cd185702d0b410VgnVCM100001d04140aRCRD&amp;lang_chosen=en">http://www.idi.mineco.gob.es/portal/site/MICINN/menuitem.8ce192e94ba842bea3bc811001432ea0/?vgnnextoid=b2cd185702d0b410VgnVCM100001d04140aRCRD&amp;lang_chosen=en</a>
BSC-CNS	Barcelona Supercomputing Center – Centro Nacional de Supercomputación is the Spanish National Supercomputing Facility. It offers the research community access to world-	e-Infrastructure	<a href="https://www.bsc.es/">https://www.bsc.es/</a>



	<p>class High-Performance Computing infrastructure. BSC is also home to four research departments which focus on the application of supercomputing in science and technology.</p>		
<p>RES (Spanish Supercomputing Network)</p>	<p>Is a distributed virtual infrastructure of supercomputers located in different sites, each of which contributes to the total processing power available to users of different R&amp;D groups in Spain or based in another country but developed by with participation of Spanish researchers.</p>	<p>e-Infrastructure</p>	<p><a href="http://www.bsc.es/marenostrum-support-services/res">http://www.bsc.es/marenostrum-support-services/res</a></p>
<p>PRB2 (Biomolecular and Bioinformatics Resources Platform)</p>	<p>Is a technology platform created by the Spanish Government that entangles different complementary disciplines that allow the efficient management of complex investigations in biomedicine. Its structure consists of three technology platforms - ProteoRed (proteomics), CeGen (genomics), INB (bioinformatics) - and two biobanks: BNADN (DNA bank) and BNLC (cell lines</p>	<p>Technology platform</p>	<p><a href="http://www.prb2.org/es/home">http://www.prb2.org/es/home</a></p>



	bank).		
RedIRIS	Is the Spanish academic and research network that provides advanced communication services to the scientific community and national universities.	e-Infrastructure	<a href="http://www.rediris.es/index.php/en">http://www.rediris.es/index.php/en</a>
SIDIAP	Is a system of information for the development of research in primary healthcare. Its database has clinical information from more than 5.8 million people from Catalonia.	Storage	<a href="http://www.sidiap.org/index.php/en">http://www.sidiap.org/index.php/en</a>
National Biobanks register	Has access to all the biobanks (banks of biological samples of human origin) existing in Spain.		<a href="https://biobancos.isciii.es/ListadoBiobancos.aspx">https://biobancos.isciii.es/ListadoBiobancos.aspx</a>
CSUC	Consorti de Serveis Universitaris de Catalunya offers e-Infrastructure to Catalan universities, with servers oriented to be used and shared by all the consortium.	e-Infrastructure	<a href="http://www.csuc.cat/en">http://www.csuc.cat/en</a>



### 6.2.5. Germany

Infrastructure Name	Short description	Type	Reference (e.g. Web or elsewhere)
German Network for Bioinformatics Infrastructure	de.NBI is a national infrastructure supported by the Federal Ministry of Education and Research providing comprehensive, high-quality bioinformatics services to users in life sciences research and biomedicine. In particular, metabolomics expertise is provided by the de.NBI partners CIBI and NBI-SysBio.	infrastructure	<a href="http://www.denbi.de">http://www.denbi.de</a>
CMP	Comprehensive Metabolomics Platform at the Helmholtz Zentrum München offers non-targeted deep metabotyping based on multiparallel ultra-high resolution analytical tools (UPLC/MS, ICR-FT/MS or NMR). Up to 10.000 mass features are detected in a single analysis with approximately 2.500 annotated metabolites. The comprehensive description of the metabolic status allows		<a href="https://www.helmholtz-muenchen.de/research-unit-analytical-biogeochimistry/index.html">https://www.helmholtz-muenchen.de/research-unit-analytical-biogeochimistry/index.html</a>



	hypothesis free multivariate data analysis to retrieve meaningful marker candidates.		
Plant Metabolism and Metabolomics Laboratories	at the Cluster of Excellence on Plant Science (CEPLAS) offer a wide range of services for the identification and quantification of metabolites. The aim of the laboratories is to apply routine methods and establish new methods for the extraction and subsequent analysis of primary and secondary metabolites, mainly via liquid and gas chromatographic separation methods that are hyphenated with mass spectrometry detection.		<a href="http://ceplas.eu/en/research/plant-metabolism-lab">http://ceplas.eu/en/research/plant-metabolism-lab</a>



### 6.2.6. France

**French Institute of Bioinformatics (IFB).** The French Institute of Bioinformatics (referred to as IFB hereafter) is a national service infrastructure in bioinformatics that was created following the call for proposals, “National Infrastructures in Biology and Health”, of the “Investments for the Future” initiative. This project gathers together the bioinformatics platforms of the main French research organizations, [CNRS](#), [INRA](#), [INRIA](#), [CEA](#) and [INSERM](#), as well as [CIRAD](#), the [Pasteur](#) and [Curie](#) Institutes, and the French universities. There are currently 30 [platforms](#) grouped into six regional centers that span the whole of France. IFB's principal mission is to provide basic [services](#) and resources in bioinformatics for scientists and engineers working in the life sciences. IFB is the French node of the European research infrastructure, [ELIXIR](#).

There are 761,408 users registered on the six regional centers, hardware infrastructure is built upon 32,192 cores with a storage size of 16,510.20 To. The infrastructure hosts 5,797 tools.

**MetaboHUB (<https://www.metabohub.fr/index.php?lang=en>).** MetaboHUB is the French National Facility in Metabolomics & Fluxomics created in 2013 in the framework of the Program “Investissements d’Avenir” (Investment for the Future) launched by the French Ministry of Research and Higher Education and the National Agency for Science (ANR). MetaboHUB aims at providing state-of-the-art tools, services and support in metabolomics and fluxomics to academic research teams and industrial partners in the fields of nutrition, health, agriculture and biotechnology. MetaboHUB being an infrastructure on four different sites (cities), the solution proposed by PhenoMeNal facilitates sharing of data and software between partners. MetaboHUB also handles large scale metabolomics clinical analysis and benefits from PhenoMeNal developments and guidelines.

### 6.2.7. Italy

**Consortium GARR:** <http://www.garr.it/b/eng>. GARR is the Italian Research & Education Network (NREN). It designs and operates the national high-speed telecommunication network for University and Scientific Research. Its shareholders are four major Research and Academic organizations in Italy, namely CNR, ENEA, INFN and Fondazione CRUI. The latter represents the Conference of Italian University Rectors. Its main purpose is to ensure top-level connectivity to all bodies in higher education and research in Italy.



**CINECA:** <http://www.cineca.it/en>: Cineca is a non profit Consortium, made up of 70 Italian universities, 4 Italian Research Institutions and the Italian Ministry of Education. It is the largest Italian computing centre, and one of the most important worldwide. CINECA is active in the technological transfer sector through high performance scientific computing, the management and development of networks and web based services, and the development of complex information systems for treating large amounts of data. CINECA is a member of the European research infrastructure PRACE. Its interaction with CIRMMP focuses on the provision of high-performance computing services, on demand.

**INFN** (National Institute for Nuclear Physics) <http://home.infn.it/en/>: INFN is the Italian research agency dedicated to the study of the fundamental constituents of matter. INFN has been developing since its creation in-house open ICT innovative solutions for its own advanced needs of distributed computing and software applications. It has a remarkable excellence expertise on Grid and Cloud technologies, having fostered and participated, with leadership roles, to many of the large Projects financed by EC, that promoted the realization of the European Grid Infrastructure – EGI. INFN was the coordinator of the Italian Grid Infrastructure (IGI). INFN has consolidated collaborations with the main international Research Centres developing ICT solutions for the scientific world and is a primary partner of many projects funded by the EC through the FP7 and H2020 programs. CIRMMP and INFN have a long story of collaboration, particularly in the use of grid computing for structural biology applications. Since 2015, the teams have worked jointly with EGI to establish protocols for the use of GPGPUs in grid and validated them using test cases provided by CIRMMP.

**INFN-CNAF:** <https://www.cnaf.infn.it/en/>: CNAF is a center of INFN that has the specific mandate to do research in data processing and computing technology, and as such it provides ICT services to INFN and other projects in which INFN is involved. It is the main data center of INFN, and coordinates the H2020 INDIGO-DataCloud project, of which CIRMMP is a partner.

**Istituto Superiore di Sanità (ISS)** <http://www.iss.it/>: ISS is to perform research activities that are of relevance to the National Health system, ranging from technological advances in medicine to clinical trials, also in the context of national and international collaborations. It can perform analyses on drugs,



vaccines, medical devices, integrators, etc. It supervises laboratories for medicine in sports as well as institutes for zootechnics control. It maintains numerous databases related to the healthcare system in Italy, on data such as orphan drugs, chemical toxicity, carcinogens, mortality indexes. It develops software tools for the analysis of such data. ISS is also the Italian node of ECRIN and constitutes the national hub ItaCRIN (<http://www.iss.it/itacrin/index.php?lang=1&anno=2016&tipo=2>).

**Istituti di Ricovero e Cura a Carattere Scientifico (IRCCS):** IRCCSs are hospitals with top level research activities, mainly of clinical and translational type, in biomedicine or in healthcare management. IRCCS are appointed by the Italian Ministry of Health for research in a specific area of biomedicine, or in multiple, related areas.

**Telethon foundation** <http://www.telethon.it/en/> : Telethon is a non-profit foundation that develops in-house, through three directly managed institutes, and external research in the field of rare diseases with a particular focus on the development of treatments.

**BBMRI-IT** (<http://www.bbmri.it/home>): is a research infrastructure involving biobanks and biological resource centers located throughout Italy. The Italian node BBMRI-IT includes 18 universities, 23 IRCCS, 40 hospitals, many associations of patients and about 80 bioresources among biobanks, collections and biological resource centers.

**IATRIS** (<http://www.iatris.it/siam/cont.php?id=148&lang=2>): IATRIS is the Italian Advanced Translational Research Infrastructure. It is a network of institutions of excellence in the national landscape, capable of providing specific support in the field of translational medicine. The creation of IATRIS has been fostered by ISS, in order to coordinate the participation in the (European Advanced Translational Research Infrastructure in Medicine) preparatory phase of the [EATRIS](#) project, through the construction of the Italian node.

#### 6.2.8. Switzerland

**Vital-IT** (<http://www.vital-it.ch/>) is a bioinformatics competence center designed to support and collaborate with life scientists in Switzerland and beyond. For this purpose, it maintains one of the most powerful life science computational



facilities in Europe. The multi-disciplinary team provides expertise, training and maintains a high-performance computing (HPC) and storage infrastructure. Vital-IT stems from the vision of different partners with highly complementary competences: the Swiss Institute of Bioinformatics (SIB), the Universities of Lausanne, Geneva and Basel, the Ludwig Institute for Cancer Research, the Swiss Federal Institute of Technology in Lausanne (EPFL), Hewlett Packard Company and Intel Corporation. These institutions and companies provide an unrivalled alliance of expertise in the processing and analysis of biological information, fundamental science and leading edge technology for the development of a high profile, innovative and robust computational biology platform. Vital-IT's core activity is the provision of infrastructure to support research groups in biology and medicine, and the maintenance and development of hardware and software solutions in life science that allows the results of the research to be turned into products with added value. Additionally, the group serves as an interface between academic research and its users and customers in the commercial world.

**Swiss Biobanking Platform (SBP)** (<http://www.swissbiobanking.ch/>) vision is to help Switzerland consolidate its position at the forefront of biomedical research by facilitating access and optimal usage of its existing and future biobanked specimens. The present SBP concept is in its construction phase under the supervision of the Swiss National Science Foundation (SNSF), the Swiss Academy of Medical Sciences (SAMS) and the SBP Project Group. It pertains to the Biobanking and BioMolecular resources Research Infrastructure (BBMRI), one of the largest health Research Infrastructure in Europe today aimed at establishing, operating, and developing a pan-European distributed research infrastructure of biobanks and biomolecular resources. SBP will setup a professional organisation in close collaboration with the 5 University Hospitals in Switzerland. The SBP also creates a central web based catalogue of existing and de novo biobanks with data and samples' access policies, integrate non-human biobanks, coordinate and harmonize biobanking activities, support in terms of legal, ethical and societal issues (ELSI), implement a proof of concept study for the credibility of the platform, and develop a business model to ensure sustainable funding of the SBP.