

Backstory

Euro-Biolmaging – Interdisciplinary research infrastructure bringing together communities and imaging facilities to support excellent research

Claudia Pfander,⁴ Johanna Bischof,⁴ Marianna Childress-Poli,^{4,*} Antje Keppler,¹ Alessandra Viale,⁵ Silvio Aime,² and John E. Eriksson³

Euro-Biolmaging ERIC (European Research Infrastructure Consortium) is a European, publicly funded, nonprofit research infrastructure (<https://www.eurobiomaging.eu/>). Our mission is to provide open access to biological and biomedical imaging technologies, training, and image data services to all researchers, regardless of research interest or affiliation, in both academia and industry. To achieve this, we bring together 137 of the most prestigious imaging facilities (status December 2021), employing 500+ imaging specialists, which make their services, technologies, and expertise available to our users. These facilities, grouped together in entities called Nodes, are based across 16 member states in Europe and the European Molecular Biology Laboratory (EMBL) and offer around 50 different imaging technologies, both for biological and biomedical imaging. Each facility has a highly unique profile, not only in imaging technology, but also in surrounding infrastructure and multidisciplinary research environment. All have demonstrated their scientific and technical excellence and commitment to user service in a stringent evaluation by the Scientific Advisory Board of Euro-Biolmaging. In this Backstory, we explain the motivation behind forming an interdisciplinary research infrastructure like Euro-Biolmaging, challenges that we faced along implementation, and explain how such an infrastructure can create opportunities to bring together communities in support of excellent research (Figure 1).

Coordination of such a large, multisited infrastructure requires close collaboration of the international Hub with all the different sites. The Euro-Biolmaging Hub consists of a Statutory Seat in Finland (Turku), a community-specific Bio-Hub for biological imaging at EMBL (Heidelberg), and a community-specific Med-Hub for biomedical imaging in Italy (Torino).

PROXIMITY

What was the motivation to launch the Euro-Bioimaging infrastructure?

When world-class research instruments are placed in centers operating with open access principle and highly skilled staff in place, the efficiency and productivity of instrument use, as well as the quality and reproducibility of the obtained data will all improve significantly. Instead of being mere local service



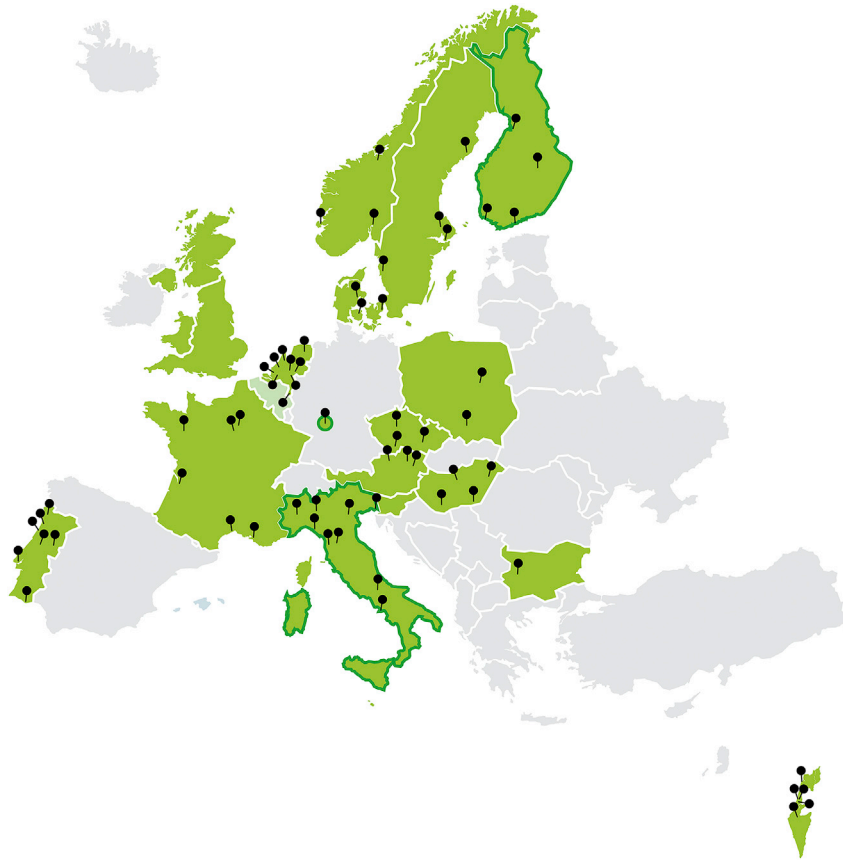


Figure 1. Map of Euro-Biolmaging member states (green), observer states (light green), cities where imaging facilities affiliated with Euro-Biolmaging are located (black pins), and Hub sites (outlined in green).

Credit: Euro-Biolmaging/Solveig Eriksson

providers, imaging core facilities residing in internationally recognized research centers are becoming pioneering and strategically-led powerhouses of science and provide key resources of collaborative and open research operating at the frontiers of science.

Precisely for this reason we wanted to launch a Europe-wide research infrastructure dedicated to imaging. First, we wanted to create a highly-qualified network of expertise, know-how, and cutting-edge technologies, and innovation platforms, by bringing together the most qualified imaging centers in Europe. Second, we wanted to democratize access to the imaging resources – technologies, expertise, advanced training, and image data services - that are available at our Nodes. In that way, every researcher, both from academia and industry, can apply for Euro-Biolmaging services whenever they have a project requiring imaging technologies and expertise, but do not have the equipment or the skills to perform the experiments at their home institute. By providing open access to imaging technologies, training, and data services, Euro-Biolmaging enables European scientists across different disciplines to carry out cutting-edge research, allowing them to address key societal challenges including health and aging, agricultural and marine research, climate action, and environment and to boost all branches of economy related to life sciences, health, diagnostics, pharma, and biotechnology.

With a world-class infrastructure based on open access, we foster excellent science and aim to drive recognition of the importance of imaging in the Life Sciences on an international level.

What are the main challenges facilities have faced so far?

Building capacity, building networks

The preparatory phase of Euro-Biolmaging began in 2009. A major factor for success – and a major challenge at the start – was to build an international imaging community of core facility scientists representing

¹Euro-Biolmaging Bio-Hub Director (EMBL), Heidelberg, Germany

²Euro-Biolmaging Interim Med-Hub Director (University of Torino, CNR), Torino, Italy

³Euro-Biolmaging Director General, Statutory Seat, Turku, Finland

⁴Euro-Biolmaging Bio-Hub (EMBL)

⁵Euro-Biolmaging Med-Hub (University of Torino, CNR), Torino, Italy

*Corresponding: marianna.poli@embl.de

<https://doi.org/10.1016/j.isci.2022.103800>

26 different national imaging communities, who by now know and trust each other and understand the benefits of working collaboratively. Euro-Biolmaging played a vital role in bringing together these imaging scientists and in building coordinated, national imaging communities around Europe, such as the one in Sweden:

“In parallel to the start of the Euro-Biolmaging preparatory phase, the Swedish Bioimaging community was established, and thanks to the funding that we got from the Swedish Research Council in 2010, we implemented a coordinated network for biological and medical imaging. The network had around 150 members representing 11 Swedish universities and virtually all bioimaging facilities (7) that were nationally accessible in 2010,” says **Julia Fernandez-Rodriguez**, Head of the Center for Cellular Imaging Core Facility of the University of Gothenburg, part of the Swedish National Microscopy Infrastructure (NMI), Euro-Biolmaging’s Swedish Node. “In 2014, the Swedish Research Council launched a specific open call for biological imaging infrastructures in Sweden to be included on the national roadmap (strategic areas of research investment). One important aspect that helped us to get Imaging on the national roadmap was the fact that our community was already coordinated nationally (Swedish Bioimaging), with a clear organization for collaboration and user access, and was cooperating internationally with Euro-Biolmaging.”

“Then came the challenge of refining our community even further. Between 2014 and 2015, the Swedish Research Council evaluated all the facilities that applied to form our national microscopy infrastructure. This phase was extremely competitive! We had to show how we were going to run the infrastructure, the operational plan, governance, implement user access, etc. In addition, we had to show that each facility was unique in terms of competence and instrumentation,” says Julia. “Many different imaging facilities from different Swedish Universities applied to this call. Luckily, the evaluation was carried out by an independent international advisory panel with clear research infrastructure criteria. This was crucial to avoid conflicts within our national community. It would have been too challenging to make these hard decisions internally,” reflects Julia. Today, five facilities – distributed in Stockholm, Uppsala, Gothenburg, and Umeå – are part of the National Microscopy Infrastructure.

Recognition by funders

But the challenging and hard work of community building is paying off. “Today, being coordinated nationally and organized internationally as part of Euro-Biolmaging, helps us to gain new funding and more exciting research collaborations. As an example, in 2020, NordForsk launched the Nordic Research Infrastructure Hubs initiative, and granted a consortium of national imaging infrastructures, four of which are also Euro-Biolmaging Nodes, the Bridging Nordic Microscopy Infrastructures (BNMI) grant (220,000 Euros). With this application, we aim to create a strong and well-interlinked network between the different microscopy infrastructures in the Nordic countries: Denmark, Finland, Iceland, Norway, and Sweden. The funding is already contributing to strengthen international competitiveness and facilitating the development of world-leading Nordic microscopy environments, by organizing scientific and technical Symposia, workshops and knowledge-exchange seminars, shadowing programs for facility staff, and short-term scientific mobility grants for researchers and increase the training and innovation activities among the participant Nordic countries. Being connected internationally via Euro-Biolmaging is extremely important when applying for this type of grant,” concludes Julia Rodriguez-Fernandez.

SHARING

How does Euro-Bioimaging contribute to stimulating interdisciplinary research and collaborations across disciplines through its broad but coordinated access and service offer?

Our technology portfolio is extensive, with Euro-Biolmaging Nodes offering around 50 different biological and biomedical imaging technologies (Figure 2).

Bringing together communities and technology

Within our research infrastructure, we bring together biological and biomedical imaging communities who are determined to work together, sometimes on a European-level, sometimes nationally, sometimes even

We wanted to create a highly-qualified network of expertise, know-how, and cutting-edge technologies, and innovation platforms, by bringing together the most qualified imaging centers in Europe.

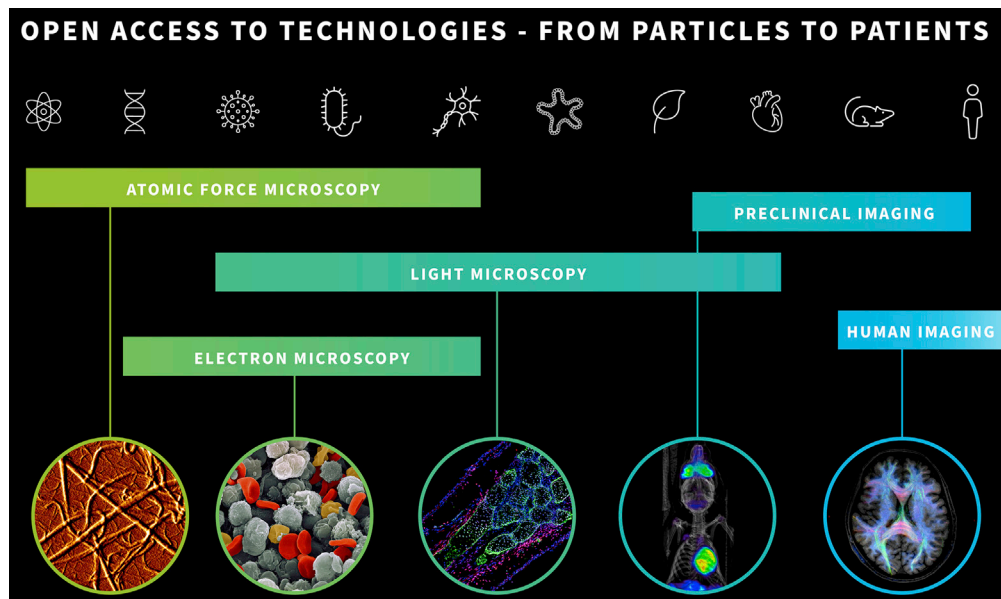


Figure 2. Euro-Biolmaging technology portfolio

From left to right, imaging work done by Pasi Kankaanpää, Viktor Sýkora, Prayag Murawala, and Italian Multi-sited Multimodal Molecular Imaging Node.

Credit: Euro-Biolmaging/Solveig Eriksson

within a Node. Nodes that offer both biological and biomedical imaging technologies are called “Mixed” Nodes - and **Marc van Zandvoort**, Maastricht University, is coordinator of the Advanced Microscopy and Multimodal Imaging (AMMI) Node – Maastricht, one of the first “Mixed” Nodes to join Euro-Biolmaging.

“As a multimodal Node, we connect state-of-the-art (light and electron) microscopy with high-end, innovative molecular and noninvasive imaging technologies, such as MassSpec Imaging and PET,” explains Marc. “This is really interesting from a scientific standpoint because we can really go from bench to bedside and back again. The AMMI Node – Maastricht is organized to work together across various imaging modalities. We run the gamut from noninvasive imaging to invasive validation and from invasive discovery to noninvasive translation. We talk to each other, collaborate, and understand each other’s needs ... This creates an atmosphere of openness and mutual consideration. Of course, multimodal projects can be demanding – it is a challenge to train users from a variety of different backgrounds, and data management and analysis in these projects are particularly complex. We work with various resolutions, scales, and various types of information - and they all have to be linked. Despite the challenge, using multiple modalities provides a true added-value. In fact, applying different techniques to the same samples, tissues, or regions of interest both *in vitro* and intravitaly, provides complementary information and allows a deeper understanding of the processes underlying, for example, the onset, development, and response to treatments of diseases,” says Marc.

We run the gamut from noninvasive imaging to invasive validation and from invasive discovery to noninvasive translation. We talk to each other, collaborate, understand each other’s needs ... This creates an atmosphere of openness and mutual consideration.

Creating the highly skilled experts of tomorrow

“Ironically, the real challenge for us is to find users who want to do these complex, interdisciplinary projects. If the user comes for example from optical microscopy, it is really hard to convince them to leave their comfort zone and use a new technique that they know nothing about,” regrets Marc. “That is why we are so heavily involved in translational and interdisciplinary teaching programs, including a newly accredited

Master in Imaging within the University of Maastricht (with an accent on multimodal techniques) and various PhD and Postdoc courses, like those on “Advanced Optical Microscopy” and “Artificial Intelligence.”

But the biggest success story so far involves a newly-awarded PhD project, within the Maastricht Imaging Valley. “We have one PhD student who will work on a comorbidity model – involving oncology and atherosclerosis. First of all, this PhD project bridges four different Maastricht schools (CARIM, GROW, NUTRIM, and MHeNS), specialized in different disease topics, and is supported by the Faculty of Health, Medicine, and Life sciences. Consequently, the student will have four tutors – one specialized in cardiovascular research, one specialized in neurosciences, one specialized in oncology, and one in optical imaging. Secondly, what makes this project so interesting and challenging is that it involves imaging at all scales - from super resolution microscopy to noninvasive techniques (like MRI, PET) – and even involves human behavior. Two of the Node leaders from the AMMI Node are involved in this project.”

Imaging is a crucial part of research projects in many different disciplines and along the whole research trajectory from basic to translational research. Therefore, Euro-BioImaging can bring together researchers from different backgrounds and at different levels of imaging expertise in a single project.

LANGUAGE

What specific challenges can be faced by interdisciplinary researchers?

Today’s scientists work in a complex world where multidisciplinary/cross-disciplinary studies based on new technologies are often required. Increasing cooperation between institutions and disciplines is expected and necessary. Euro-BioImaging is embedded in the landscape of European research infrastructures (RIs) (<https://lifescience-ri.eu/home.html>) and maintains strong links with other RIs in the life sciences and beyond. Through EU-funded projects, Euro-BioImaging provides open-access biomedical and biological imaging technologies while collaborating with other European Research Infrastructures across disciplines to widen the array of services available at scientists’ fingertips.

Euro-BioImaging user, Roberta Ranieri, provides a compelling example of this interdisciplinarity. Roberta Ranieri was a PhD student at the University of Perugia, Italy, in the lab of Professor Martelli, where she was able to utilize her unique scientific background in cancer biology investigation and drug development methods to study a specific form of acute myeloid leukemia (AML). She was applying her previous laboratory experience, skills, and know-how to screen thousands of drugs and compounds in a search for new effective treatments. This complex, interdisciplinary research was aided by the Horizon 2020-funded CORBEL project that connected Professor Martelli and Roberta with two European Life Science Research Infrastructures, namely EU-OPENSOURCE and Euro-BioImaging.

Her project was one of almost 40 user projects that were selected and granted access, funded by CORBEL, to at least two RIs of their choice. In the CORBEL project, Euro-BioImaging was the most requested research infrastructure, underlining the importance of imaging technologies to cross-disciplinary research in the life sciences.

“The CORBEL experience, within a larger ERC-funded project awarded to Professor Martelli, of the University of Perugia, will hopefully be a step toward novel therapeutic options to treat AML, which are desperately needed. The collaborative spirit of CORBEL and its interdisciplinary approach clearly made our research more significant and will have a positive impact on human health,” explains Roberta Ranieri.

Between 2022 and 2025, Euro-BioImaging will collaborate with the other European life science research infrastructures in the framework of the Horizon Europe-funded emergency project, ISIDORe, to enable access to imaging and other much needed services for researchers urgently working on identifying and understanding COVID-19 variants as well as increasing Europe’s preparedness for tackling infectious diseases (Figure 3).

What type of training activities and resources are offered by Euro-Bioimaging? How does the infrastructure support researchers and students in the wider community?

With the advances in imaging technology, more and more new technologies are available to users, making training in the correct use of the technologies and the connected sample preparation and data analysis



Figure 3. Snapshots of the Euro-Biolmaging community

From top right to top left: Euro-Biolmaging user Roberta Ranieri, with EMBL Staff Scientist, Beate Neumann, during the CORBEL project (photo credit: EMBL/Kinga Ludowiecka), Julia Fernandez-Rodriguez, Center for Cellular Imaging Core Facility, University of Gothenburg (photo credit: Patrik Bergenstav), Marc van Zandvoort, Advanced Microscopy and Multimodal Imaging (AMMI) Node – Maastricht, and Euro-Biolmaging user Marcos Gonzalez Lopez at the CELLIM Facility. Bottom row: 2019 meeting with representatives of the Bio Nodes. 2018 meeting with Med Node representatives. Photo collage by Solveig Eriksson

crucial. The Euro-Biolmaging Nodes offer a wide range of training opportunities that are targeted at users, students, and facility staff. Training courses at our Nodes cover a wide range of topics from basic introductory courses to advanced technologies in both biological and biomedical imaging. These courses, mostly combining theory and hands-on learning, are taught in English, and are open for anyone to apply to. A list of upcoming training courses is available on our website (<https://www.eurobioimaging.eu/content/training>).

During the pandemic, many of the Euro-Biolmaging Nodes developed innovative approaches to allow continued training to take place remotely. Training on the theoretical aspects of microscopy and those for image data analysis could be quite easily transferred to a remote setting, although this presents a challenge for the majority of courses that include strong practical components. Several Nodes now offer training that includes remote control of imaging instruments via remote desktop solutions, allowing the students to gain experience in controlling all parameters of the instrument, whereas the Node staff on site provides support with sample handling. At the same time, Nodes are running virtual courses with multi-camera setups to allow the students to see the details of practical steps, for example of sample preparation, from multiple angles and close up.

Several of the Euro-Biolmaging Nodes participate in MSc degree programmes. In addition, companies on our Euro-Biolmaging Industry Board (<https://www.eurobioimaging-industryboard.com/>) offer internships to MSc students to gain insight into highly qualified job profiles in industry to help them make an informed choice about their future career.

In addition, Euro-Biolmaging projects are a great way for students to gather data and build their skill sets, as in the case of Euro-Biolmaging user and study abroad student Marcos Gonzalez Lopez.

In 2020, **Marcos González López** was a Master's student in "Cell and Gene therapies" from Spain, who became a Euro-Biolmaging user at the CELLIM facility, part of our Advanced Light Microscopy and Medical Imaging Node Brno CZ, while pursuing his Master's degree research. Passionate about stem cells and genetic engineering, Marcos was looking forward to his second year of studies with more hands-on learning, and therefore he started a cooperation with Jan Křivánek's lab in the Department of Embryology

and Histology at Masaryk University in Brno to pursue his Master's thesis. A scholarship from the Czech Ministry of Education, Youth, and Sports (MŠMT) helped to convince Marcos to take advantage of this opportunity to study abroad – despite the COVID-19 situation.

The closeness, proximity of the university with the CELLIM core facility made the study-abroad opportunity even more attractive. Marcos could apply for access to the facility as a Euro-Biolmaging user, and with support from the experts at the Node, learn how to use different imaging techniques, such as confocal microscopy, and gain experience on image data processing and further analysis. "Being able to work in this facility alongside other experts has been an extremely rich experience for me – even against the backdrop of COVID-19," says Marcos Gonzalez Lopez. "The state-of-the-art equipment available at the CELLIM imaging facility is crucial to my work – and the competent and friendly staff have been particularly supportive of his project."

Stories like this are compelling examples of how Euro-Biolmaging provides an avenue for scientists at early career stages to gain access to imaging technologies and expertise that will truly enhance their research – and perhaps define their future career path. Today, Marcos is a PhD student in the Biomedical Sciences Program at Masaryk University, specializing in Cell and Tissue Morphology.

Euro-Biolmaging provides an avenue for scientists at early career stages to gain access to imaging technologies and expertise that will truly enhance their research.

GOVERNANCE

How do you promote interaction between facilities and support mutual learning?

The Euro-Biolmaging Hub team organizes a number of topic-focused Expert Groups which are open to all staff from our Nodes. "Our Expert Groups serve as important platforms to bring together the community around topics of particular interest, such as quality and data management, remote access, and communication," says **Alessandra Viale**, Scientific Project Manager at Euro-Biolmaging Med-Hub. "The work of the expert groups paves the way toward higher quality of offered services by sharing best practices and lays the groundwork for a more homogeneous landscape for users accessing different Nodes."

The expert groups with their regular meetings are also a great way for facility staff all across Europe to get to know each other and build connections that support building of expertise and interdisciplinary collaborations.

"In addition to our topic-focused expert groups, we also have 3 technology expert groups – for medical imaging, light microscopy and electron microscopy," says **Johanna Bischof**, Scientific Project Manager at Euro-Biolmaging Bio-Hub. "The technology expert groups offer a great avenue for the experts at the Euro-Biolmaging Nodes across Europe to come together and exchange about their areas of expertise and keep up to date on the latest technology developments."

In addition, these groups provide a good opportunity to exchange and learn from industry partners, as **Claudia Pfander**, Euro-Biolmaging Industry Board Coordinator, explains, "Imaging companies actively contribute by supporting and providing advanced training on technology to Node staff or by sharing knowledge and best practices in one of the Expert Groups. For example, they participate in our Remote Access group, aiming to support facilities to offer imaging services remotely, which has been crucial during the pandemic, but also offers opportunities for a more democratic and ecological access to imaging in the future. Active engagement with the community helps companies to better identify areas where their customers need more support or even new developments and products to address their research questions."

FUTURE

What are the future projects for Euro-Bioimaging? Are there any other challenges you encountered that aren't discussed here?

As we look to the future, at Euro-Biolmaging we always aim to expand our user base by cooperating closely with universities and research institutions across Europe, industry, European Life Science Research Infrastructures, and the Euro-Biolmaging family. One of the challenges is to sustainably fund user access to our infrastructure and truly democratize imaging, i.e., make the cutting-edge technologies and

know-how available to a user regardless of their background. In response to this challenge, Euro-Biomed participated in several Horizon Europe calls in 2021. ISIDORE, part of the HERA project for pandemic preparedness funded by Horizon Europe, was awarded in July 2021, and with this project, Euro-Biomed will be able to provide funding for scientists undertaking infectious disease research at a Euro-Biomed Node.

In 2020–2021, the first years of operations for Euro-Biomed, despite the global pandemic and lockdowns in Europe we saw some flavor of the breadth and capabilities of the Nodes and saw how imaging technologies have been innovatively used to answer timely research questions, including COVID, cancer, cardiovascular research, neurology, and also marine and plant biology. Still, we are quite convinced that the really significant advances of Euro-Biomed will be seen in the coming years.

In future, we hope our infrastructure will continue to expand to benefit our users, helping them make discoveries that provide better understanding of the basis of our world as well as scientific solutions to its grand challenges.