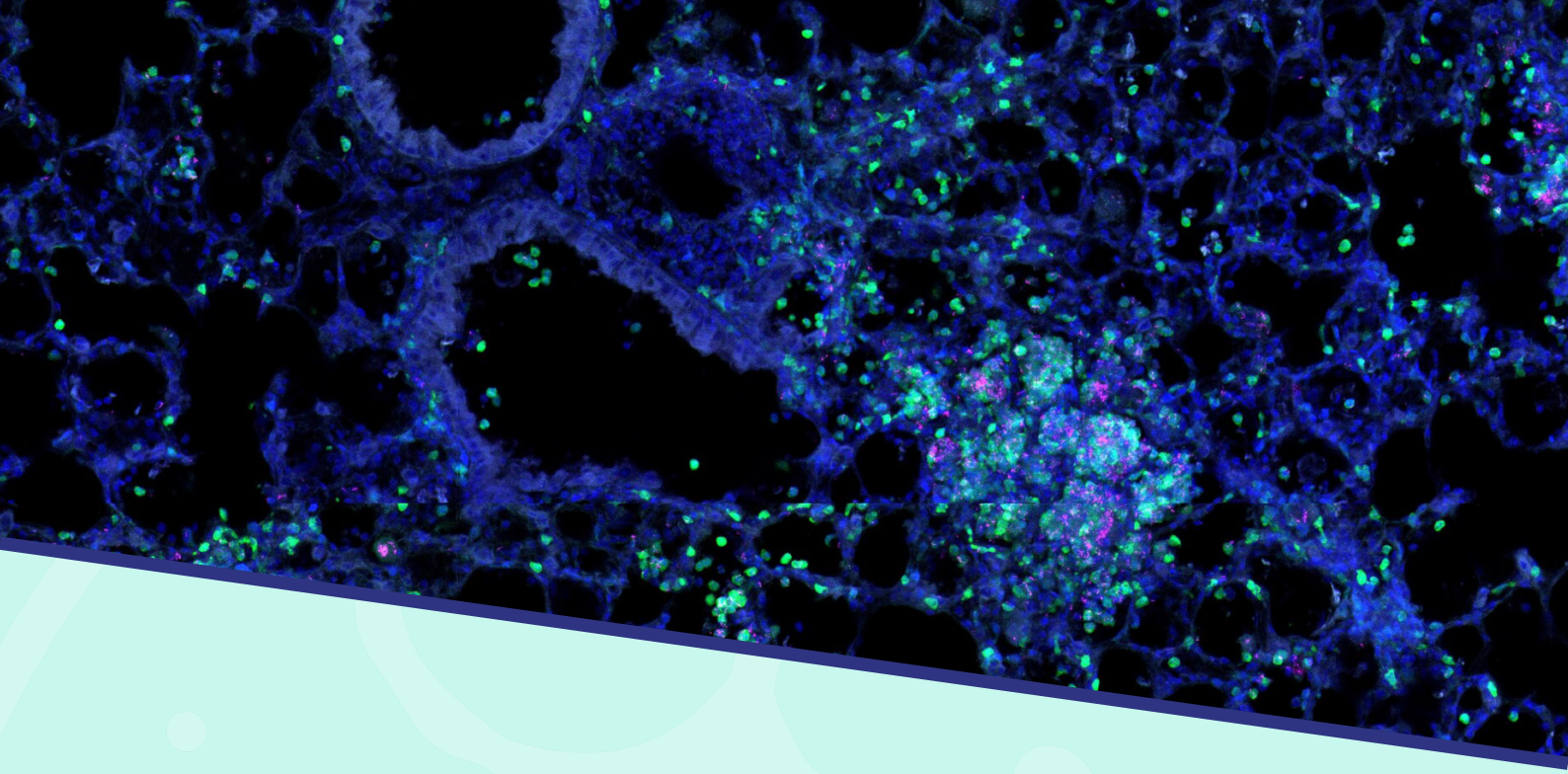
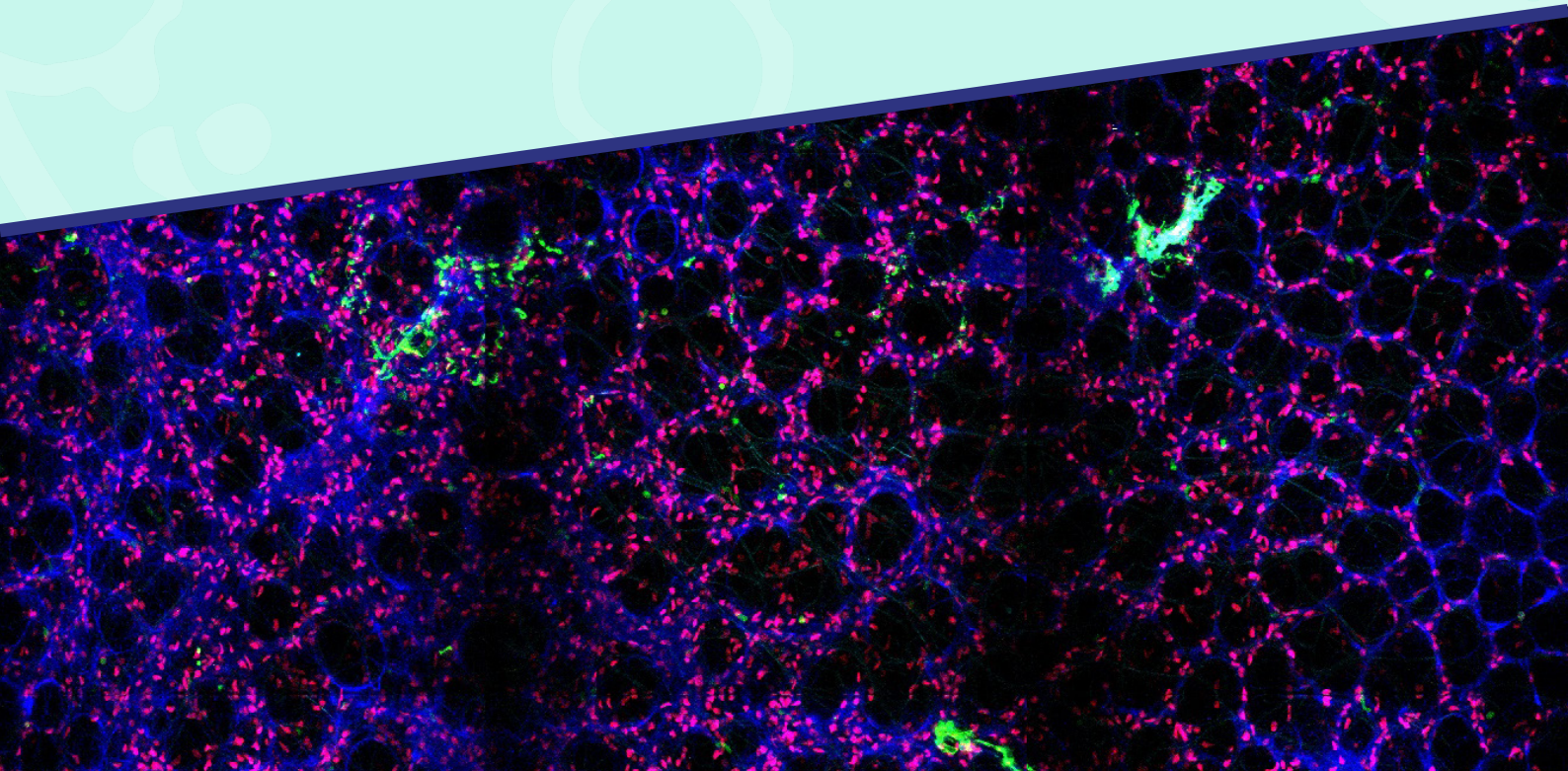


FRANCE-BIOIMAGING ACTIVITY REPORT

2023 - 2024



E·DIT·O

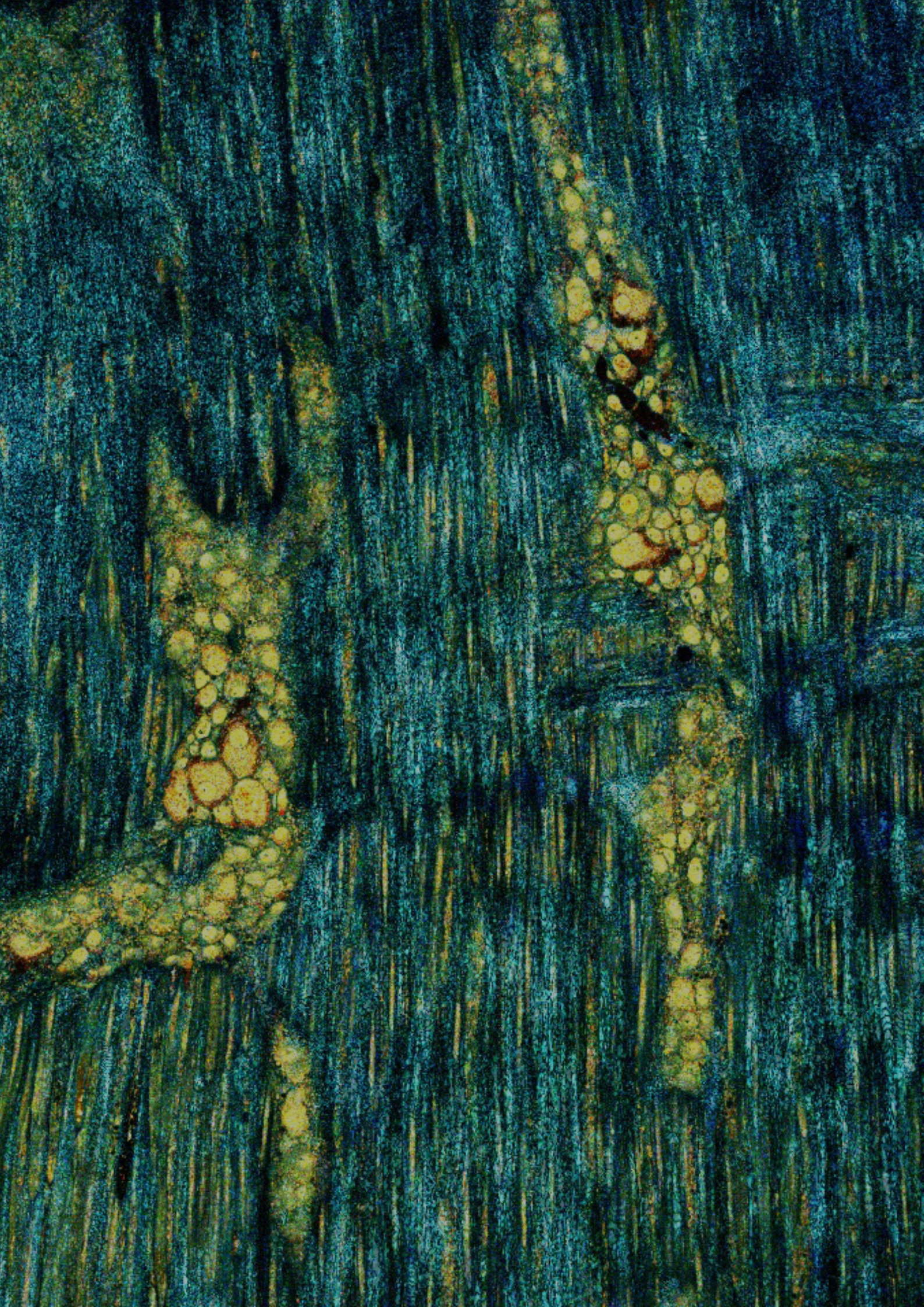
This report covers the **activities of France-BioImaging over the period 2022–2024**, but it represents much more than that. It is the result of the collective investment and commitment of all members since the creation of the infrastructure in 2012. Over the past two years, France-BioImaging has entered a phase of growth, with the **addition of four new nodes**, now covering a large part of the national territory.

This year also marks the birth of **FBI-Core, UAR 2057**, *Unité d'Accompagnement et de Recherche*, created by the CNRS to ensure the **long-term sustainability** of the infrastructure, its administration, and the development of central services and scientific projects. This new structure also guarantees that FBI receives **annual funding from the CNRS** to support these activities. The UAR is expected to be fully operational by the end of the year and, although the current economic context prevents us from reaching the budget initially anticipated, we can be reassured about the **long-term support** from the CNRS and other governing bodies.

Thanks to the efforts of the previous coordination team, whom we warmly thank here, we benefited in 2024 from the **FI2030 BIOGEN grant**, which will allow us to **acquire new equipments.**

In this report, you will also discover that many projects launched over the past years are now reaching maturity: the first **MOOC** is expected to go online before in early 2026, **F-BIAS** is fully operational, the first **FBI Challenges** have been successfully conducted, and **FBI. data** projects are well underway. This biennial report also provides key figures on our platforms and R&D activities.

Finally, this document serves as an **overview of the infrastructure's projects**, its scientists, and its users. As our goal is to reach out to and share with the national and international bioimaging community, we also **highlight a selection of scientific papers** chosen for their societal impact and the transformative role these studies could play in the future.



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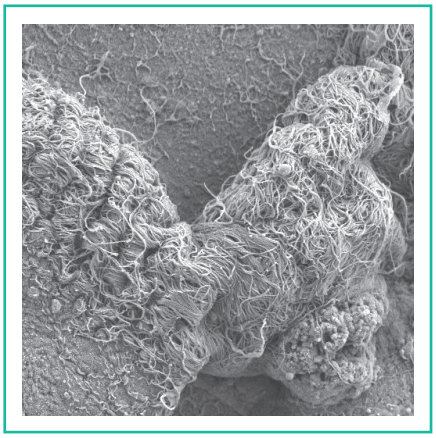

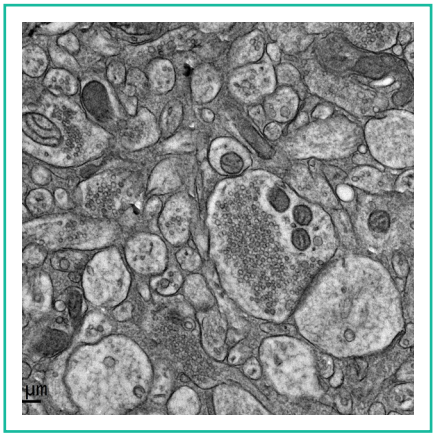

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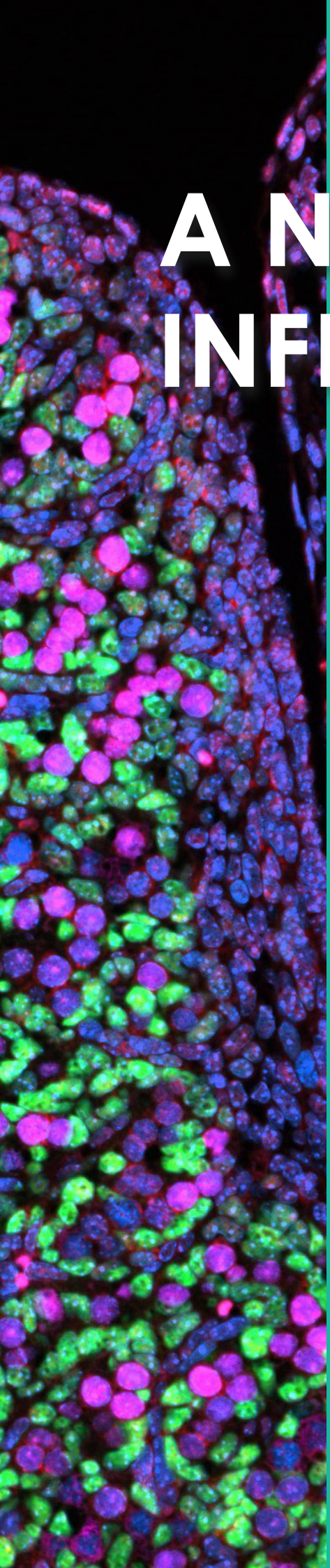


A NATIONAL INFRASTRUCTURE

France-BioImaging (FBI), recognized as a **National Infrastructure in Biology and Health** (INBS) since 2011, was awarded under the national Investissements d'Avenir program (PIA-ANR) in biological imaging, and in 2024 received support from the **ANR France Innovation 2030** initiative for its project **BIOGEN**. The BIOGEN project will both **strengthen the visibility** and **attractivity** of France-BioImaging, and provide our researchers **access** to the most powerful and needed imaging technologies.

FBI is at the crossroads between **biology, biophysics and engineering, mathematics and informatics.** Our unique coordinated infrastructure gathers several large **biological imaging facilities** and **laboratories specializing in R&D for imaging** in ten local and one transversal Nodes. We aim at creating the most efficient **adoption of the latest advances** in all **microscopy-related technologies and methods** by the users of our facilities.

These technologies and methods, reinforced by a strong support in computational analysis, provide **quantitative measures** and **integrative understanding** of a wide range of **cell and tissue activities in biological models**, from the simplest, to small animals in normal and pathological situations.

Missions, vision & goals

As a research infrastructure, France-BioImaging is an organization that provides the scientific community with specialized facilities, resources, and services to **accelerate discoveries** and **promote sustainable research.**

To achieve its objective, **France-BioImaging has 6 main missions.** These missions are the **pillars of France-BioImaging's core values** which reflect the principles and values that are important for the infrastructure, its stakeholders, its users and the life science community.

1. Give access to state of the art and innovative imaging approaches
2. Integrate new developments in physics, chemistry, applied mathematics & computer science
3. Speed up technology transfer
4. Act as a central hub for collaborative projects
5. Organize, support and disseminate activities in the field
6. Participate to national & international educational & training programs

Our philosophy is to **associate leading R&D research teams with service facilities.** Hence, FBI is at the crossroads between molecular and cell biology, biophysics and engineering, mathematics and informatics.

In 2024, our unique infrastructure, structured in ten local Nodes and one transversal Node dedicated to bioimage informatics, gathers together **30 large biological imaging facilities** and **79 R&D teams specialized in imaging.**

The tryptic **"Innovation, Training, Access"** is the backbone of our activities. We **invent** and **disseminate new imaging technologies**, participate in national and international educational and training programs, and make them accessible to national and international users of both the **academic** and **private sectors.**

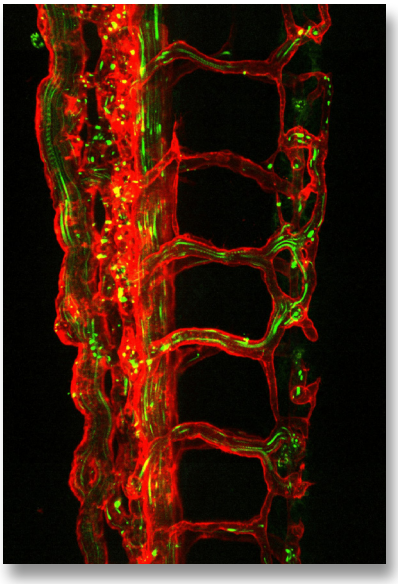
Four new nodes

Over the last two years, France-BioImaging integrated four new nodes in the infrastructure: **Alsace, Normandie, Toulouse** and **Rhone-Alpes.**

These new nodes come to reinforce France-BioImaging's **geographical network**, its **expertise fields** as well as the **diversity of services offered** within the infrastructure.

ALSACE

Molecular & nanoparticular probes / Tomographic diffractive microscopy



The Alsace node brings together **six life sciences imaging facilities** in Strasbourg, Illkirch and Mulhouse and **six highly visible R&D teams** expert in microscopy and image analysis tools.

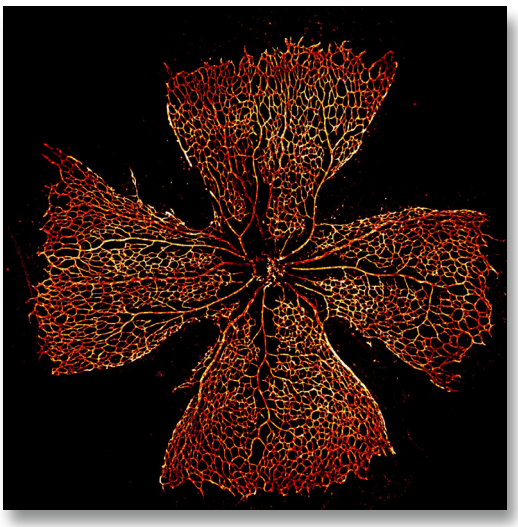
The Alsace node offers a high level of technical and innovative methodological expertises in **multi-scale imaging** at the interface between **biology, chemistry, optics** and **physics**.

The node aims to offer a **fully integrated biological imaging portfolio** from the molecule to the small animal/plant within the FBI infrastructure, based on its **innovative chemical, optical** and **biocomputational developments**, as well as on its already established network of **state-of-the-art imaging instruments** (super-resolution and quantitative fluorescence microscopies, confocal microscopies, F-techniques, small animal imaging systems (SPIM, macroscopes, OCT…)).

NORMANDIE

Multi-scale imaging / Ex vivo and in situ organ imaging

The Normandie node is composed of **one imaging facility** so called **PRIMACEN** (HeRacLeS, US 51-UAR 2026, with user service, research and development activities), and **six highly visible R&D teams** (SFR IRIB, NORVEGE, INC3M, SCALE and BB@C) expert in microscopy techniques, controls and tools.

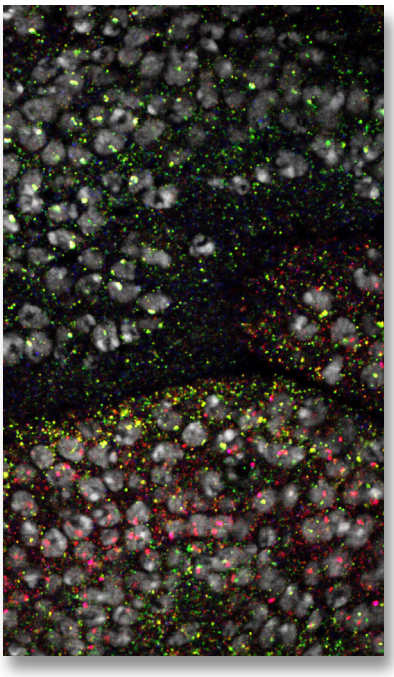


Mainly located in Rouen and distributed to Caen and Le Havre, the Normandie node is offering **high level technical** and **innovative methodological expertise** in multi-scale imaging (TEM, STED, FLIM, TIRF, 2P, LSM…) at the interface between **physiology, biology, chemistry, bioimage analysis**, from the molecule to the small animal/plant.

The Normandie node has expertise in **vascular sciences, microalgal biosciences** and **intercellular communication.** Moreover, we have founded the **International master program in cell imaging** (IMAC) where students are intensively trained on PRIMACEN equipment and have the opportunity to go abroad, including Finland thanks to a tight cooperation.

RHÔNE-ALPES

Spatial transcriptomics/ 3D multiscale imaging



The Rhône-Alpes Node is a **technology-centric node** forged through the partnership between **LyMIC-Lyon** and **ISDV-Grenoble facilities,** with key expertise in approaches to study biomechanical and bio-elastic properties, adaptive optics development, sophisticated large data analysis from 3D mapping gene transcript to thick FIB-SEM data, and dynamic imaging of metabolites.

Gathered into one entity, **LyMIC** consists of three core facilities providing **advanced photonic, atomic force** and **advanced electron microscopies. ISDV** comprises five **photonic microscopy facilities** and **three electron microscopy experts.**

Six R&D teams complete the node and **support the facility**, located at Ecole Normale Supérieure de Lyon (ENS, Lyon) ; Grenoble Institute for Neuroscience (GIN, Grenoble) ; Institute for Advanced Biosciences (IAB, Grenoble) ; Institut Lumière Matière (ILM, Lyon) ; Laboratoire interdisciplinaire de Physique (LiPhy, Grenoble).

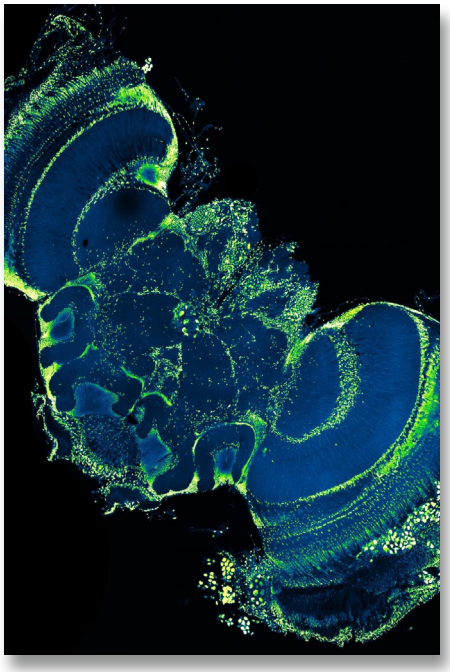
TOULOUSE

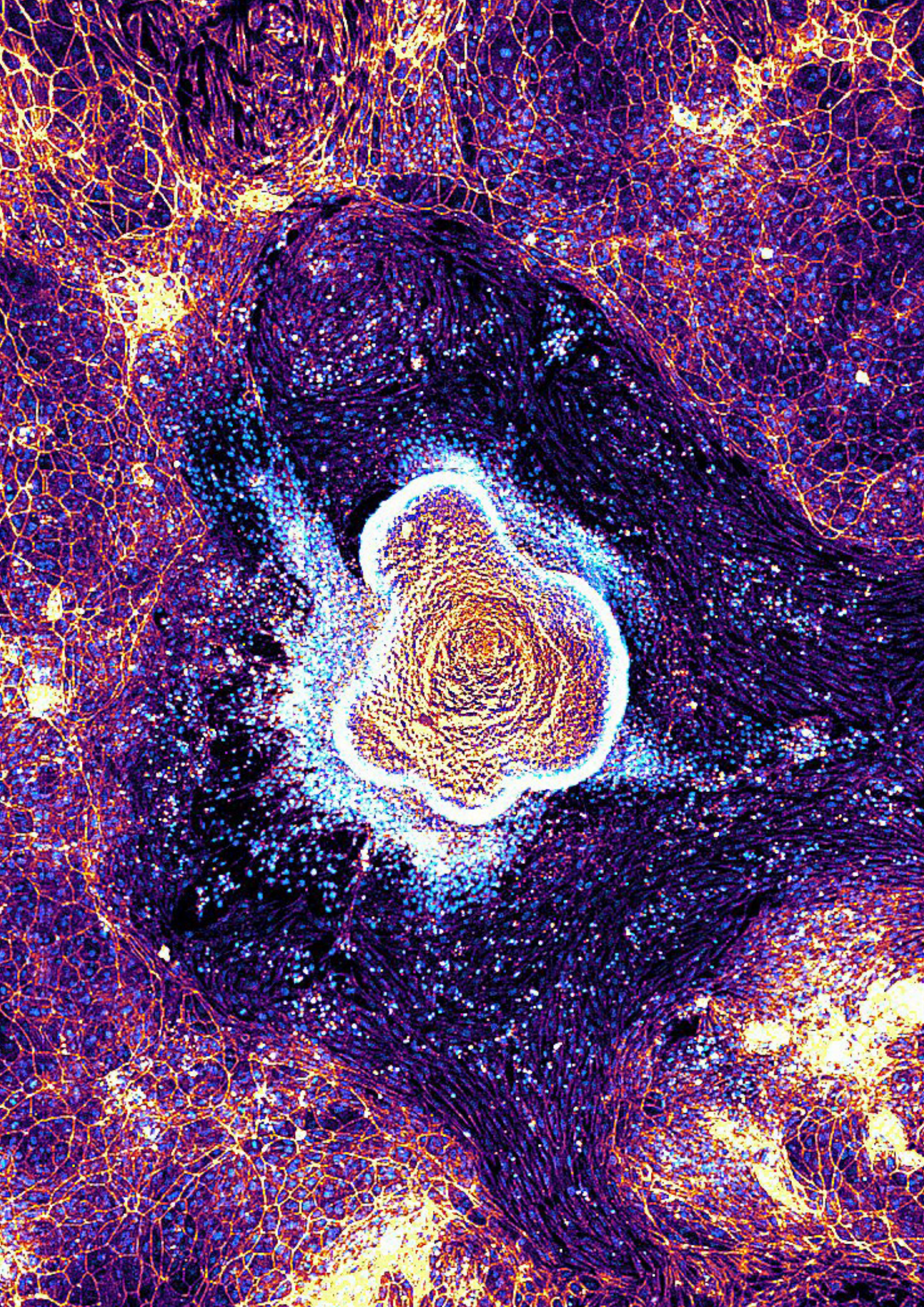
Mechanobiology / Molecules and single cells / Whole organisms

The Toulouse node is composed of a large nationally recognized **multi-site core facility**: **Toulouse Reseau Imagerie.** Distributed on Toulouse greater area, the facility is divided between **medical science, fundamental science, cancer and rejuvenation,** and **agro-bio science**. Moreover, **eight R&D teams** complete the node and supports the facility (from LAAS, CBI, IPBS, IRSD and IMT).

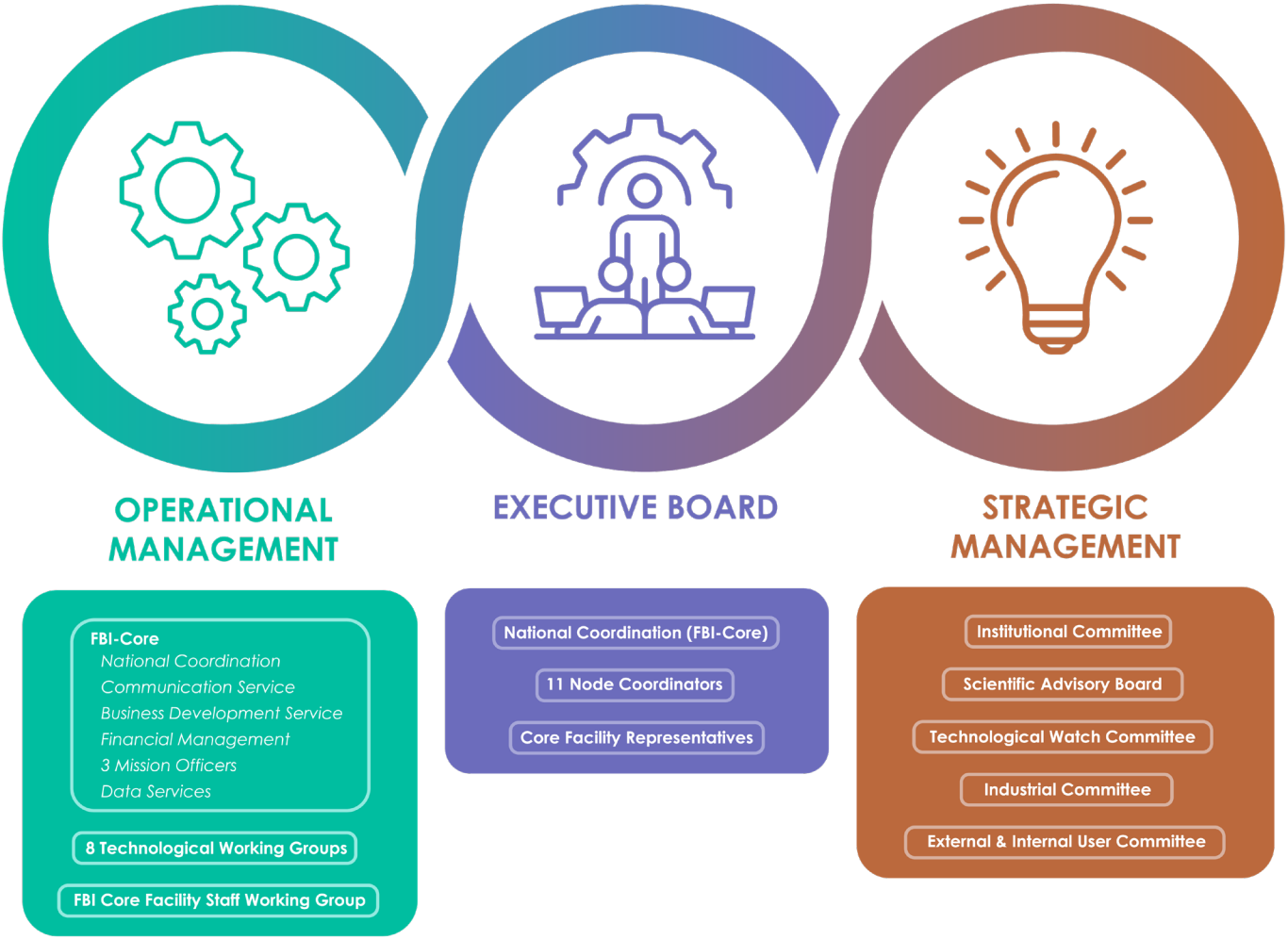
The Toulouse node aims to **maintain the level of scientific excellence** in response to the needs of users and the concerns of host laboratories. **Four scientific axes** are conducted: **mechano-biology, molecules and single cells, whole organisms, image processing** and **quantitative data analysis.**

The mission of the node is also to **develop original devices** to explore biophysical properties in living samples, to work at the interface between machine and sample and to **develop artificial intelligence** applied to bioimaging.





The governance



France-BioImaging infrastructure is composed of **several units working together:**

- **The Executive Board**, which includes the National Coordination, the 11 node coordinators and the Core Facility Representatives;
- **The Strategic Management** is assumed by the Institutional Committee, the Scientific Advisory Board, the Technological Watch Committee, the Industrial Committee and the External & Internal User Committee;
- **The Operational Management**, which is made of FBI-Core, the 8 Technological Working Groups and the FBI Core Facility Staff Working Group.

At the end of 2024, France-BioImaging was adjoined the creation of "Unité d'Appui à la Recherche", **UAR2057 FBI-Core**, which gathers FBI members who are directly involved in infrastructure management. This statute **ensures France-BioImaging sustainability.**

UAR 2057 CNRS, Montpellier University
France-BioImaging-Core

Management Commitee

Director: René-Marc Mège
Deputy Scientific Director: Yves Mély
Deputy Scientific Director: Virgile Viasnoff
General Secretary: Sylvie Djian
Deputy Administrative Director International and Industry: Caroline Thiriet

Support Services

Communication Assistant: Marine Béraud
Business Developer: Samy Al-Bourgol

Mission Officers

Training: Fabrice Cordelières
Integration: Cédric Matthews
Data: Perrine Paul-Gilloteaux

Image Processing & Data Management Services

FBI.Data Manager: Guillaume Gay
Data Engineer: Théo Barnouin
Data Engineer: Raphaël Braud-Mussi
Data Engineer: Marc Mongy
Data Engineer: Jean-François Guillaume
Data Engineer: Guillaume Maucort

Challenges Manager: Emmanuel Faure
Challenges Officer: Dorian Kauffmann

F-BIAS Manager: Jean-Yves Tinevez
F-BIAS Co-manager: Anne-Sophie Macé
Image Analysis Engineer: Arthur Meslin
Image Analysis Engineer Marie Anselmet

Total workforce: 23
Full-Time: 15
Non full-time: 8
FTE: 14.23

CNRS: 2 DR, 1 CR, 9 IR, 5 IE
INSERM: 1 IE
UB: 1 AI
UM: 1 IR
UniStra: 1 PU
Nantes U.: 1 IE
Pasteur Inst.: 1 IR

FBI-Core is made of:

- **The National Coordination** consists of the Scientific Director, two Deputy Scientific Directors, a Deputy Administrative Director International and Industry and a General Secretary;
- **The Support Services** with a Communication Assistant and a Business Developer newly arrived;
- **Three Missions Officers** who manage key structuring missions for the infrastructure;
- **Image Processing & Data Management Services**, including activities around data and image analysis.

Between 2023 and 2024, the Scientific Advisory Board evaluated and endorsed **10 new core facilities and 26 new R&D teams!**

FRANCE BIOIMAGING

KEY FIGURES

7612
users in 2024

248
publications

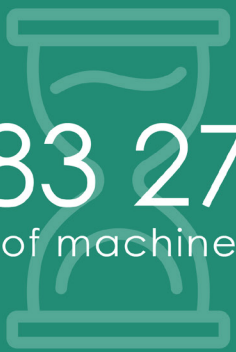
30
imaging platforms

4928
trained users

302
staff members

777
set-ups

312
industry users



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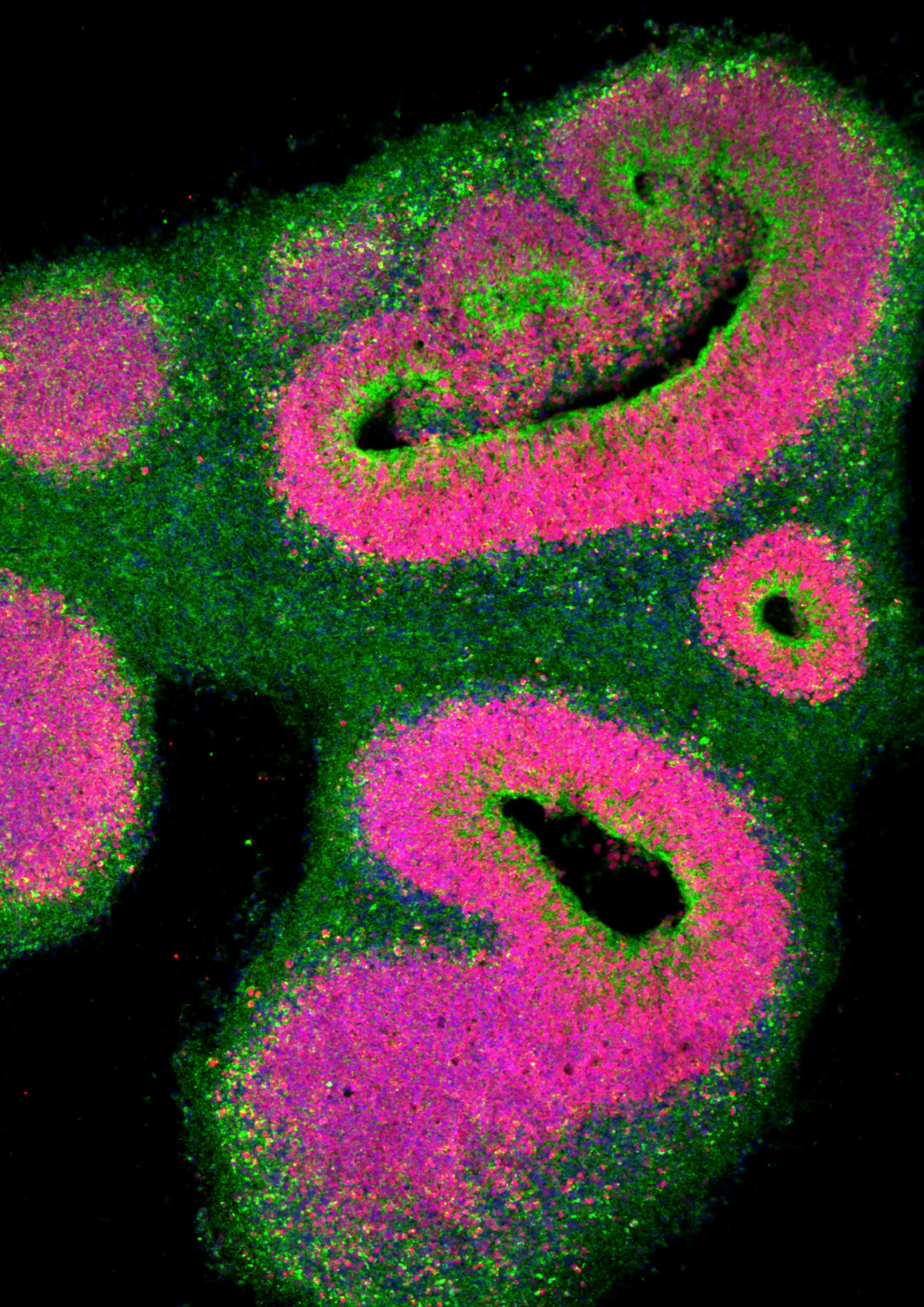
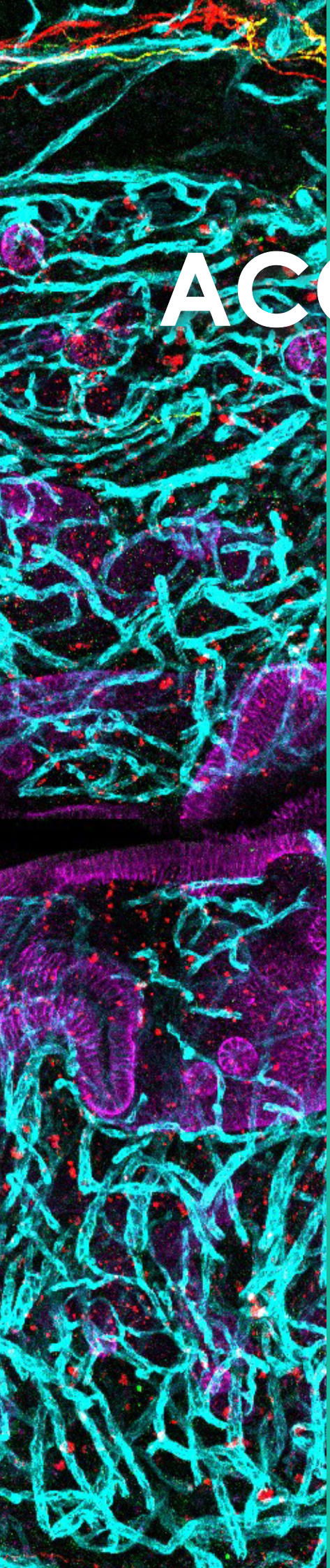




ACCESS

As we provide access to a multitude of biological imaging technologies and services, we strongly encourage every scientist, both from academia and industry, to contact us.

> ALSACE NODE

Molecular & nanoparticular probes • Tomographic diffractive microscopy

Biomolecules in action • Cell biology

> BORDEAUX NODE

Super-resolution • 3D correlative microscopy

Neuroscience • Plant physiology

> BRETAGNE-LOIRE NODE

Microscopy for pre-clinical research

Regenerative medicine • Physiopathology

> ILE-DE-FRANCE SUD NODE

In vivo in toto 3D+t imaging • Non-linear contrasts

Developmental biology • Plant cell biology

> MARSEILLE NODE

Multimodal Imaging • New contrasts

Immunology • Developmental biology

> MONTPELLIER NODE

Functional super-resolution • High-throughput microscopies

Genome organization • Gene expression

> NORMANDIE NODE

Molecular & nanoparticular probes • Tomographic diffractive microscopy

Biomolecules in action • Cell biology

> PARIS-CENTRE NODE

3D CLEM • High content screening • Optogenetics & biosensors

Host-pathogens • Cancer research

> RHONE-ALPES NODE

Spatial transcriptomics • 3D multiscale imaging

Cell metabolism • Biomechanics

> TOULOUSE NODE

Mechanobiology • Molecules and single cells • Whole organisms

Animal visualization • Plant biology

> BIOIMAGE INFORMATICS NODE

Bioimage informatics • Data management

Software platforms • AIIA & data visualization • Very large data management & mining

How to access?

For local users, access is made through local reservation tools.

For external users, as we are the French Node of the European research infrastructure Euro-BioImaging, France-BioImaging invites them to **register through Euro-BioImaging web portal** to access any equipment available on France-BioImaging facilities: *(https://www.eurobioimaging.eu/technologies/)*.

Please contact us if you have questions at *contact@france-bioimaging.org.*

Until the end of 2024 we had the opportunity to facilitate the use of our infrastructure and access to high technology by offering academic external users **a waiver of facility costs.**

Between 2023 and 2024, FBI received, through EuBI 65 requests of access, which makes us a premier user access Node

312 **In 2024, 312 Industrial users utilized France-BioImaging facilities**

In 2024, France-BioImaging launched its first competitive call for access, **"FBI Call for User Access Project 2024",** allowing the external users to benefit from **a grant up to 5000€** for mobility and access to the imaging services at one of our facilities. A total of **12 projects** have been selected for a total of **60000€ in funding.**

France-BioImaging's user success story:

Atitheb Chaiyasitdhi, a research fellow at the University of Leicester, explores **auditory mechanisms in insects**, focusing on specialized sensory structures called chordotonal organs.

With support from **France-BioImaging's User Access Project grant**, he collaborated with the **Imagerie-Gif platform** to apply Focused Ion Beam Electron Microscopy (FIB-EM) to his study. This advanced technique enabled him to **reconstruct the ultrastructure of the locust ear in 3D,** achieving an unprecedented level of detail.

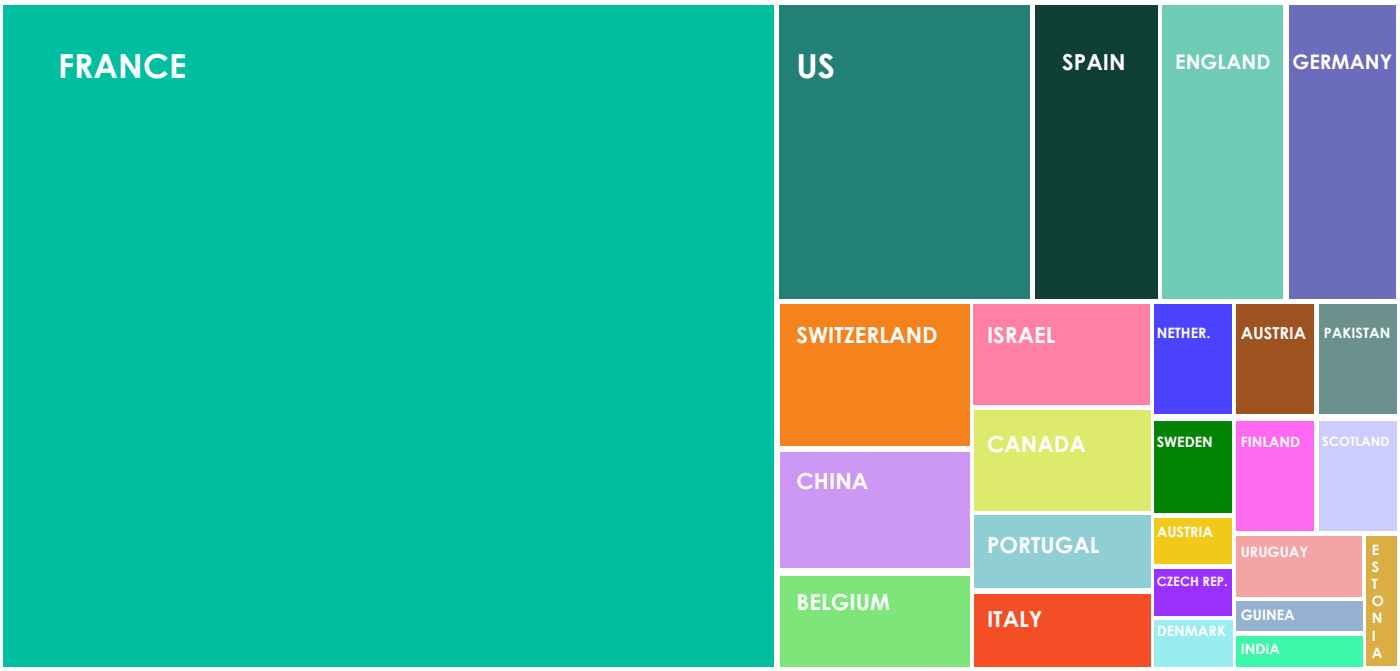
We are also access provider to European projects:

AgroServ project, which supports the **research in agroecology** to contribute towards sustainable and resilient agri-food systems, exploring topics like plant biology, water, soil, and microorganisms.

canSERV project, which provides cancer researchers with the best services in Europe to advance their project in line with the **EU Cancer Mission's goals.**

ISIDORe project, which assembles the largest and most diverse research and service-providing instruments to **study infectious diseases in Europe**, with expertise from structural biology to clinical trials.

304 publications acknowledging France-BioImaging in 2023 & 2024



Distribution of publications aknowledging France-BioImaging by country of co-authors

FOR EXTERNAL USERS:

SUBMIT YOUR PROPOSAL

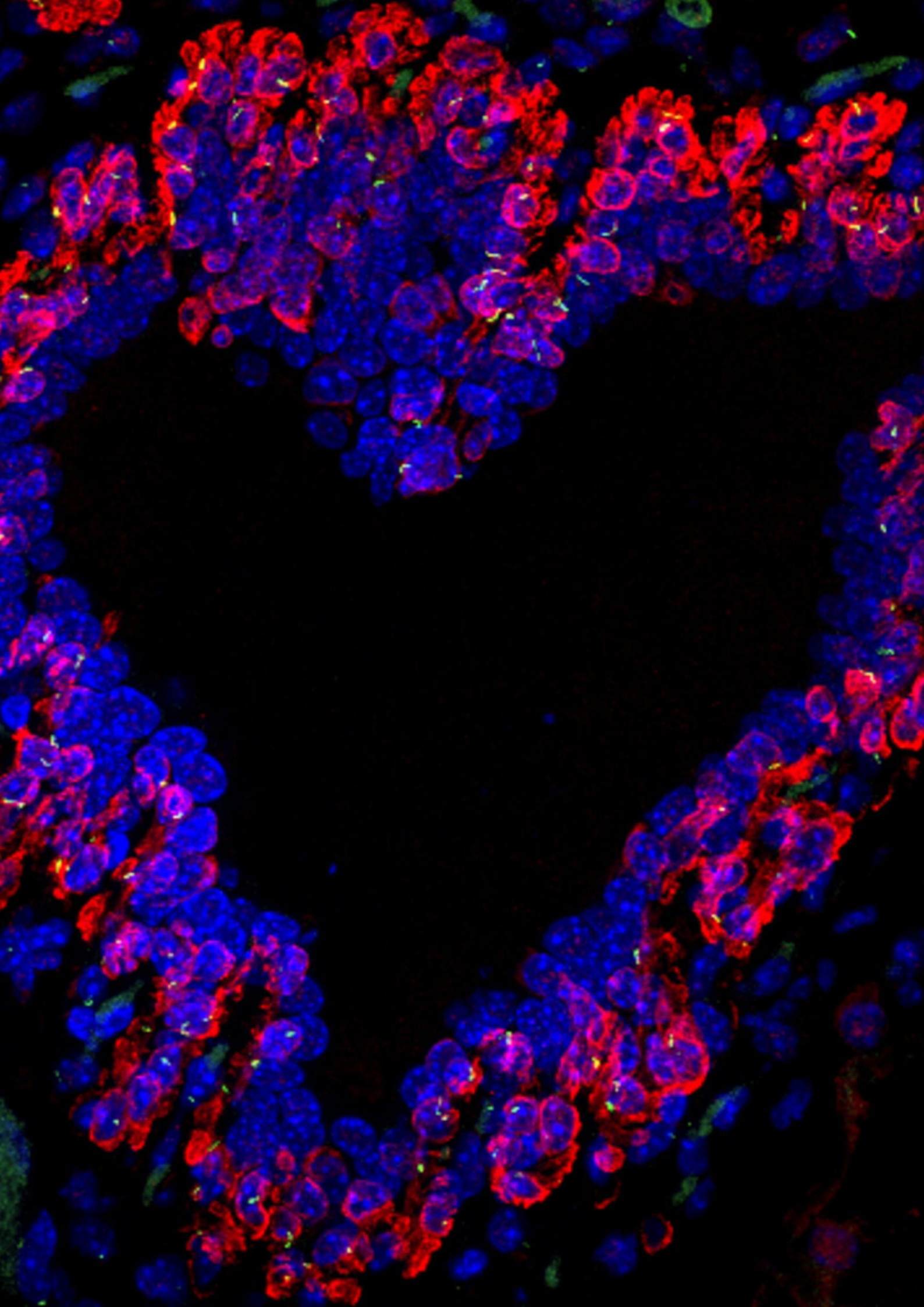
www.eurobioimaging.eu

SCIENTIFIC & TECHNICAL VALIDATION

WELCOME TO OUR FACILITIES!

MANY FUNDING OPPORTUNITIES!

France-BioImaging is an access provider for biological imaging in several Horizon Europe projects.



Relationship with industrial users

In 2024, **Samy Al-Bourgol** joined France-BioImaging as **Business Developer.**

His role is to **assist facilities** and **academic laboratories** that wish to **collaborate with industrials.**

His overall objective is to **create win-win collaborations,** bringing tangible benefits, both scientifically and financially, to the platforms and laboratories integrated into France-BioImaging.

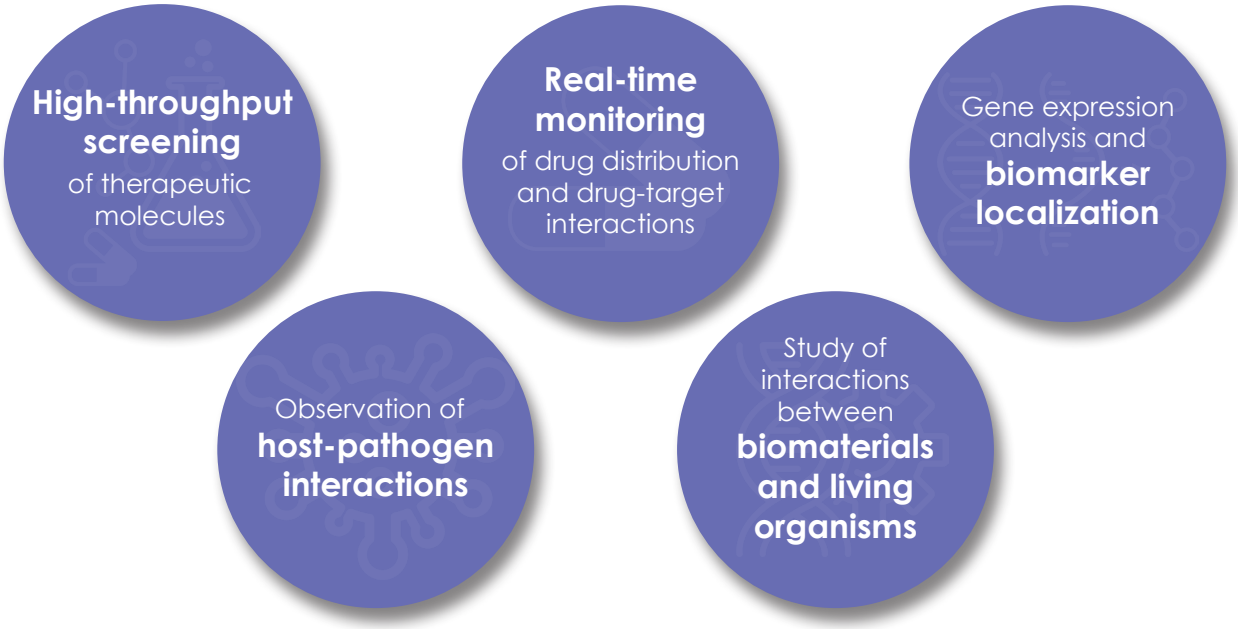
The launch of a collaboration with industrial partners is organised in 4 steps:

- **Initial contact & Need assessment:** The industrial partner gets in touch with our business engineer to explain his project and identify his specific needs. We will assess his requirements to determine how our microscopy expertise can best support his objectives.
- **Selection of technologies and expertises:** We identify the most suitable technologies and expertise among our platforms and laboratories across the country, ensuring the best approach for his project.
- **Administrative process:** We handle the necessary administrative steps, including Non-Disclosure Agreements (NDA), quotes, and funding research, to facilitate the collaboration.
- **Collaboration launch:** Once the framework is set, we officially start the collaboration, providing the industrial partner with high-quality microscopy services tailored to his needs.

In 2024, 36 collaboration contracts were signed with the private sector

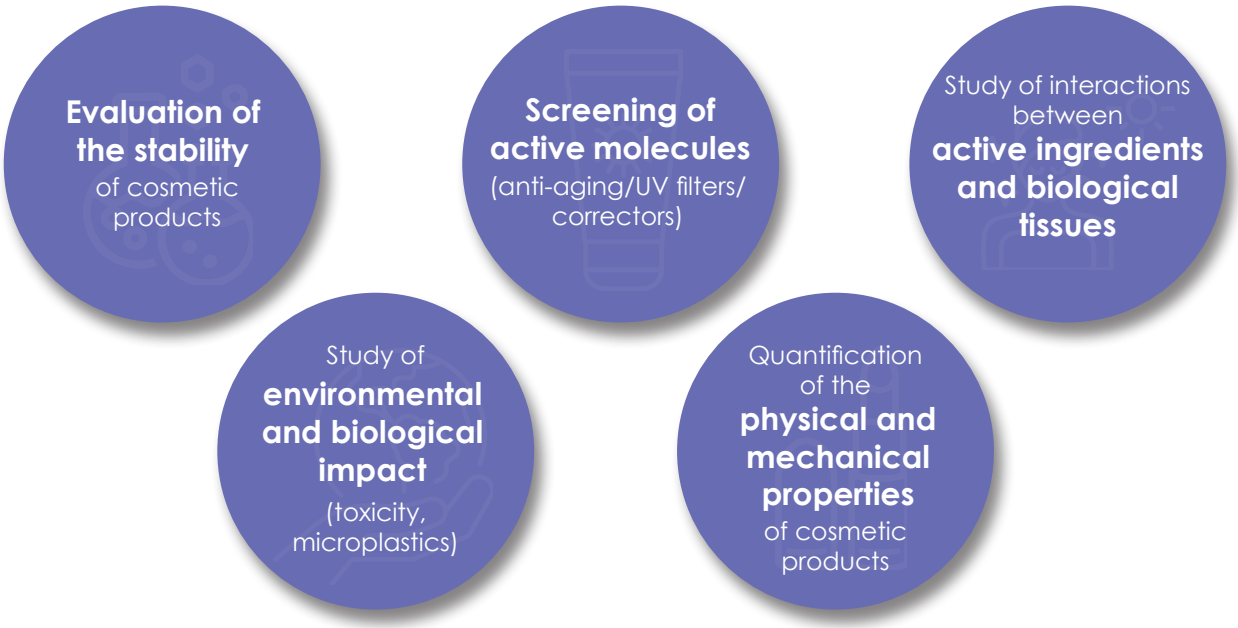
FRANCE-BIOIMAGING FOR THE HEALTH SECTOR

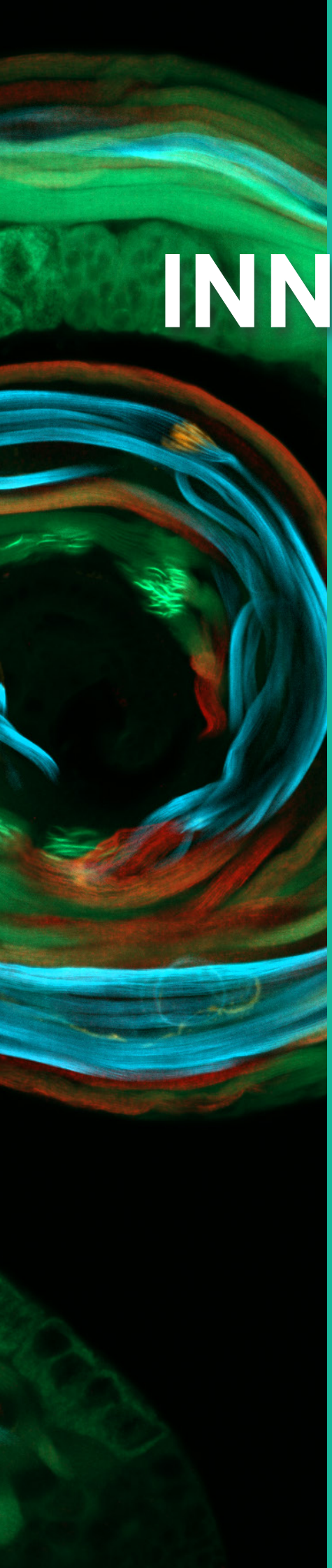
Drawing on our expertise in the healthcare sector, we select the **most appropriate imaging technique** and **study model** to meet the needs of various therapeutic areas:



FRANCE-BIOIMAGING FOR THE COSMETIC SECTOR

In the cosmetics field, we select the **most suitable microscopy technologies** to meet the demands for **hyperpersonalization, effectiveness,** and **naturalness** of products:





INNOVATION

Innovation is one of the **three pillars of France-BioImaging**. We, facility engineers and R&D scientists, have the common goal and interest at **providing state-of-the-art technologies** but also **developing new ones** to have a broader set of approaches available for our users.

In 2024, as part of the PIA FI 2030 framework, the French Ministry of Higher Education and Research allocated 80 M€ for a call dedicated to the National Research Infrastructures in Biology and Health to keep their research and technologies at the highest level of excellence.

France BioImaging was a laureate of the call with its project **Biological Imaging Next-Generation Instruments (BIOGEN)**. With this project, 1.9 M€ are invested to **rejuvenate and upgrade existing technologies** and 7.3 M€ serve to **implement new technologies**, paving the way for the use of **next-generation imaging methods** by our users.

Innovation, pillar of FBI

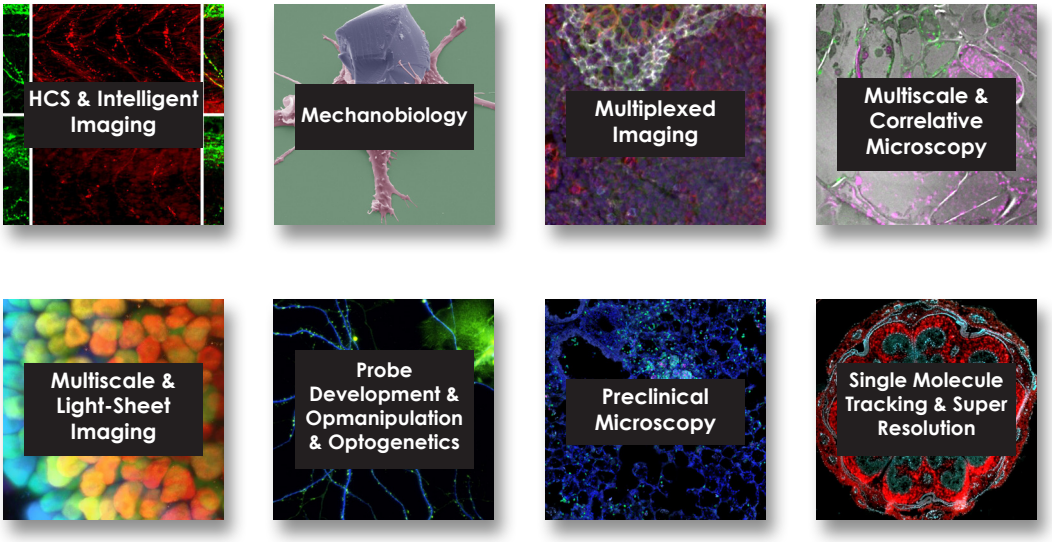
4 FBI structures carry out the technological watch:

- **Industrial committee** (15 private sector companies)
- **Technological Watch committee** (GdR Imabio, RIME, RTMFM)
- **Internal user committee**
- **External user committee**

Moreover, to boost innovation, we created **8 working groups based on networking/ collaborative activities** that provide new insights into **innovative technologies** and **emergent biological fields.**
The objectives are to:

- **Define new avenues**,
- **Solve technical barriers**,
- **Organize training** on emerging technologies and methods.

These working groups evolve in time to be in line with technological developments and future needs.



Boosting technology transfer

Between 2023 and 2024, France-BioImaging renewed its internal call for **"Technology transfer from R&D teams to facilities"** for mature technologies (7 funded projects). Each selected project was awarded with a **80 k€ grant for salary and/or equipment.**

NAMES OF LAUREATES "TECH TRANSFERT FROM R&D TEAMS TO FACILITIES" 2023-2024

- **BiDiMI - Biomarkers Discovery by Multiplex Imaging - Frédéric LOPEZ** *(Toulouse node)*
- **CryoEM-FreshAir - Rémi LE BORGNE** *(Paris-Centre node)*
- **DLSeg - Rémy FLORES-FLORES** *(Toulouse node)*
- **Extending the number of colors usable in spectral confocal microscopy - Mathieu FALLET** *(Marseille node)*
- **FBI-MIN - Emmanuel MARGEAT** *(Montpellier node)*
- **FLIM-UV - Ludovic RICHERT** *(Alsace node)*
- **MAPS - Cyril FAVARD** *(Montpellier node)*
- **MIT - Julien FERNANDES** *(Paris-Centre)*
- **RIM-Ouest - Marc TRAMIER** *(Bretagne-Loire node)*
- **sFBI: silicone Foreign Body Identification - Tatiana PETITHORY** *(Alsace node)*
- **Side C.A.R.S. - Elric ESPOSITO** *(Paris-Centre node)*
- **Smart Microscopy - Steven NEDELLEC** *(Bretagne-Loire node)*
- **Stand-UP - Aurélie LE RU** *(Toulouse node)*
- **TECNUPOSREM - Orestis FAKLARIS** *(Montpellier node)*
- **TempFoCash - Laurent BOURDIEU** *(Paris-Centre node)*
- **Vivo Clim - Chrystel LAFONT** *(Montpellier node)*
- **V-MembO - Claire BOULOGNE** *(Ile-de-France Sud node)*
- **UV_FLIM NA - Yves MELY** *(Alsace node)*
- **3D LIGHTiss - Laurent MALAQUIN** *(Toulouse node)*

46 patents registered since 2011

1 start-up created in 2024: AstraNICE. Developed by the Laboratory of Bioimaging and Pathology (Strasbourg), AstraNICE provides unique fluorescent coatings for surgical instruments.

Innovation and highlights from nodes

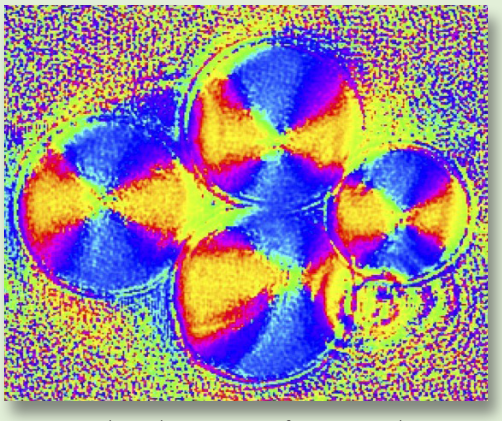
ALSACE

Polarimetric Tomographic Microscopy - 2023

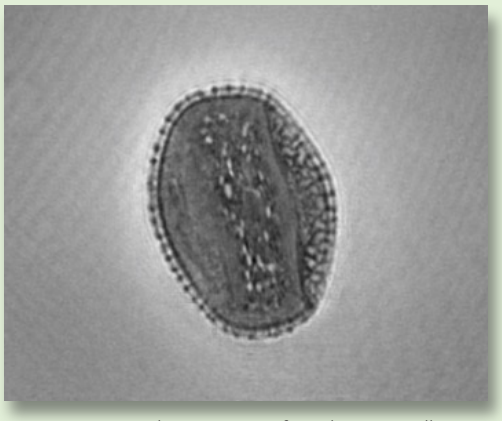
Tomographic Diffractive Microscopy (TDM) is a **computing imaging technique**, calculating the specimen's image from the electromagnetic field it diffracts, so the entirety of the physical information resulting from light-sample interaction. TDM delivers images with a **new contrast** (the distribution of optical indices), and with **2x better resolution** than a conventional microscope. However, while the distribution of optical indices is a new contrast, it is **often only slightly discriminating,** chemically speaking. In particular, polarization effects are often overlooked, especially in commercial implementation of the technique.

We have therefore developed a new system, **controlling the polarization of the incident illuminations**, while detecting the diffracted field using a Polarized Array Sensor (PAS), and Jones formalism for sample images reconstruction *(Optics Express 31, pp. 9034-9051 (2023))*. With this system, we have also demonstrated that a **polarized TDM setup using a PAS for detection** can be turned into a **simplified DIC microscope** when using non-birefringent samples, by adapting data processing and without further hardware modification *(Journal of Microscopy 289, pp. 128-133 (2023))*.

This achievement will allow for **widening the domain of applicability of TDM** towards birefringent samples. A high-sensitivity, high-resolution polarized TDM is essential for studying birefringent materials such as microcrystals, collagen, actin, or tubulin fibers, as well as peculiar structures, capable of inducing partial polarization, such as periodic structures. In a longer term, taking into account polarization effects allows in some cases to improve imaging quality and resolution, as shown by colleagues in Marseille (but in a reflection microscope).



Polarized TDM image of potato starch



Reconstructed TDM image of an olive tree pollen obtained by DIC image

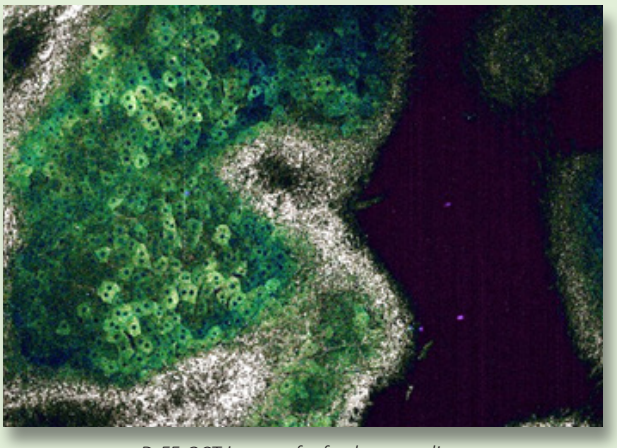
Asemare Mengistie Taddese, Mohamed Lo, Nicolas Verrier, Matthieu Debailleul, and Olivier Haeberlé, ***Jones tomographic diffractive microscopy with a polarized array sensor,*** *Opt. Express 31, 9034-9051 (2023)*

Verrier, N., Taddese, A. M., Abbessi, R., Debailleul, M., & Haeberlé, O. (2023). ***3D differential interference contrast microscopy using polarisation-sensitive tomographic diffraction microscopy****. Journal of Microscopy, 289, 128–133. https://doi.org/10.1111/jmi.13160*

Single-shot Full-Field OCT - 2022/2023

Full-field Optical Coherence Tomography (FF-OCT) provides **high-resolution morphological** and **dynamic imaging** at the cellular scale, making it a interesting tool for biological applications, from studying cellular architecture to capturing motility and dynamic processes label-free.

However, in most of the cases, FFOCT is **limited to ex-vivo imaging** due to motion sensitivity and acquisition constraints, which has limited its impact on live biological investigations.



D-FF-OCT image of a fresh mouse liver

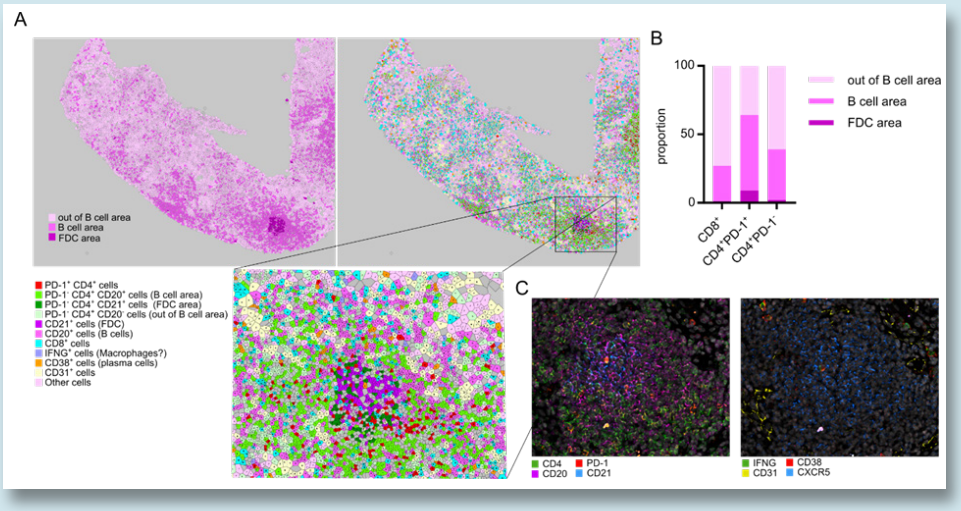
In the IPP team of the ICube laboratory, we developed an **in vivo FF-OCT system** (SO-FF-OCT) that enables high-resolution morphological and dynamic imaging **directly in living systems** while **preserving the unique contrast and resolution of FF-OCT**. Moreover, we have further extended SO-FF-OCT to integrate new functional and mechanical contrast modalities, including elastography, Doppler, and photothermal imaging, under in vivo conditions, providing additional contrasts to observe tissue biomechanics, blood flow, and local thermal properties in a label-free manner. This multimodal in vivo imaging platform has potential applications in small animal models such as *C. elegans*, zebrafish, and mice, as well as in organoid and tissue-engineered models, addressing the need for high-resolution, label-free, and functional imaging.

Emmanuel Martins Seromenho, Agathe Marmin, Sybille Facca, Nadia Bahlouli, Stephane Perrin, Amir Nahas; ***Single-shot off-axis full-field optical coherence tomography****. Appl. Phys. Lett. 12 September 2022; 121 (11): 113702. https://doi.org/10.1063/5.0100944*

Set of multiplex fluorescence techniques - 2023

Immunofluorescence imaging of tissues is a key component of biomedical research, providing complementary information to traditional approaches such as histological staining. Immunofluorescence imaging offers **high spatial resolution over large tissue areas.** New so-called multiplex approaches allow for up to 40 markers to be detected on the same biological sample.

Based on fluorescent immunolabeling techniques using multiple cycles of staining and/or imaging, the **TSA-OPAL and CODEX/Phenocycler methods** are available on the MicroPICell platform. The service relies on different new equipment such as **the LIPSI** , a VENTANA immumostaining automate, or **the Phenocycler machine**, and on the image analysis service.



Spatial multi-phenotyping analysis on a liver biopsy from one AIH patient. (A) Voronoi representation of cellular subsets in an AIH liver biopsy after cell segmentation. FDC area is defined by expression of CD21; B cell area is defined by CD20 expression; and out of B cell area is defined by the absence of CD20 expression. The lower panel shows a zoom on the selection indicated in the upper panel. (B) Representation of the repartition of CD8+, CD4+ PD-1+ and CD4+ PD-1- cells in FDC, B cell and out of B cell area defined in (A). (C) CD4, CD20, PD-1, CD21, IFNγ, CD38, CD31 and CXCR5 marker staining within segmentation.

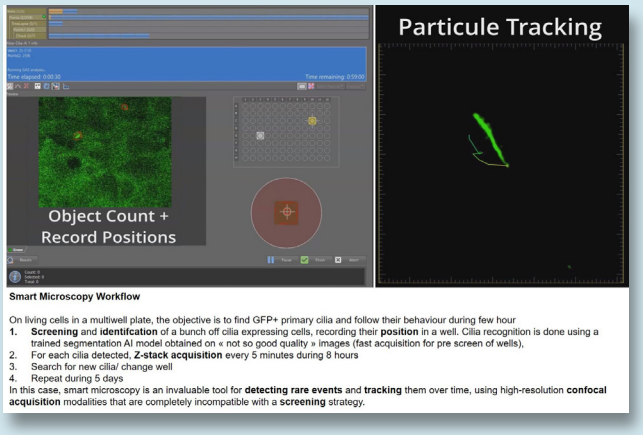
Cardon, A., Guinebretière, T., Dong, C. et al. ***Single cell profiling of circulating autoreactive CD4 T cells from patients with autoimmune liver diseases suggests tissue imprinting.*** *Nat Commun 16, 1161, 2025*

Potier G, Doméné A and Paul-Gilloteaux P. ***A flexible open-source processing workflow for multiplexed fluorescence imaging based on cycles.*** *F1000Research 2022, 11:1121*

Blandin S, Doméné A,, Hulin P, Joussaume A, Nedellec S, Paul-Gilloteaux P. ***Le multiplexing pour une meilleure compréhension de l'environnement tissulaire: presentation de quelques méthodes****, Revue française d'histotechnogie, 2025, vol: 37, n° 1, p: 6593*

LIPSI and smart microscopy - 2023

The LIPSI is a **solution for the screening of fully incubated slides** and/or multiwell plates. It can accommodate up to 20 plates or 60 slides. At this scale, experiments can be conducted free from human bias, and even rare events can be observed with statistical relevance. To deliver the best system, Nikon Instruments Europe has developed, in collaboration with Life Imaging Services (LIS) and Prior, a **fully integrated solution around the Ti2-E.**



- Slide and plate handling is **fully automated** to place them on the stage and retrieve them. 25 slide inserts are included in the package;
- Plates/slides can be placed in the incubator, which is **temperature-controlled** and maintains a **regulated atmosphere** (CO_2) with **humidity control**. Users are free to choose their desired temperature and CO_2 percentage. The system can also be used at room temperature;
- The LIPSI has **two independent components**: the stage in the working area and the incubation unit. Both sections have their own CO_2 controller;
- The robotic module is fully controlled by Nikon's proprietary software, **NIS-Elements**, the same software that manages the entire microscopy range;
- The LIPSI can be used with a **confocal system, a camera, or both.** This makes it very easy to screen tissues with the color camera and then zoom in on a specific area for confocal-quality analysis;
- It is equipped with **two spectral detectors** for spectral multiplexing imaging;
- The LIPSI is fully controllable by **Nikon Jobs software**, which enables complex acquisition and analysis workflows to be written. The system can then **be programmed to acquire image data** in a completely autonomous way (automated acquisition combined with real-time image analysis) as described by the **concept of smart microscopy.**

The idea behind RIM is to **use the "speckles" of the full-field illumination laser** to create a structured illumination pattern at the diffraction limit 1. By varying the pattern from image to image using an adaptive optic element (in our case, an SLM), we can **acquire a stack of images** with one camera, corresponding to **cumulative homogeneous illumination**. By solving the inverse problem, we are able to **reconstruct a super-resolved image** at the focal plane with an unprecedented optical cross-section.

Compared with conventional SIM, RIM is able to **work deep in the sample**, as speckle is insensitive to scattering. The main application is the acquisition of super-resolved images in depth with a very small amount of light and at high speed. This is a very **good compromise between z-cutting** and **super-resolution,** with full-field illumination particularly suited to thick living samples.

In prep. ***Implementation and optimization of a Random Illumination Microscope: towards robustness for microscopy core facility.***
Nina Soler, Gilles Le Marchand, Stéphanie Dutertre, Xavier Pinson, Munish, Grégoire Michaux, Loïc Schmitt, Hélène Bouvrais, Claire Caron, Nicolas Jolivet, Giulia Bertolin, Simon Labouesse, Thomas Mangeat and Marc Tramier

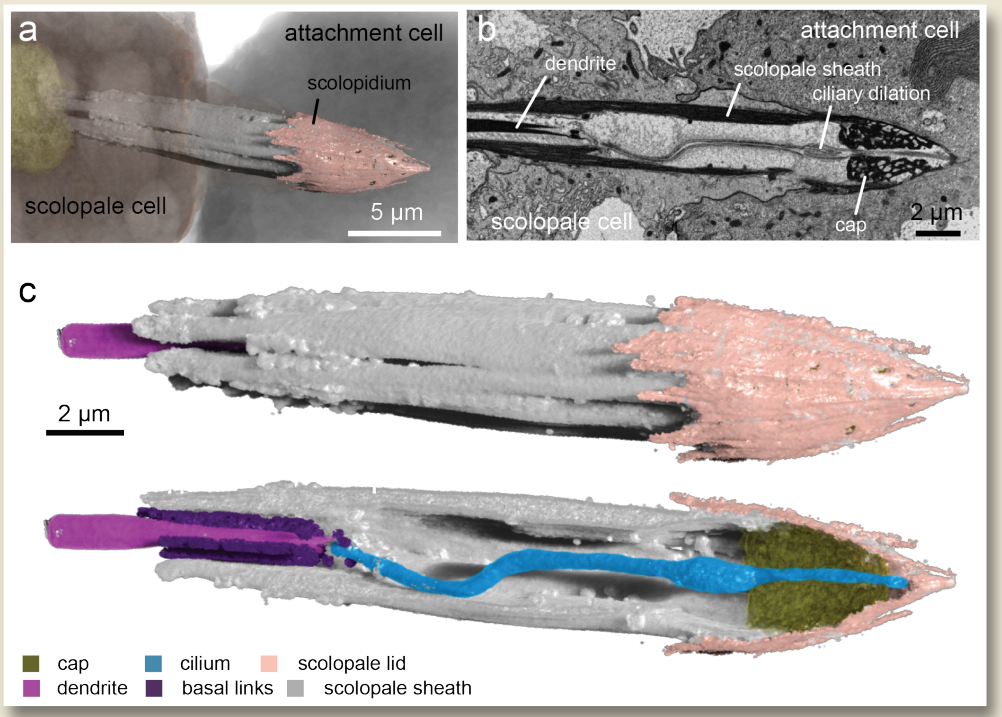
FIB-SEM for “dual-beam” imaging - 2023

Imaging is an essential approach in cell biology, which covers a range of scales from the molecule to the whole organism. Recently, **developments in 3D imaging** have made it possible to better understand **the cell in its environment** and in its responses to surrounding factors.

In 2023, the Imagerie-Gif platform acquired a **FIB-SEM for “dual-beam” imaging**, using a focused ion beam (FIB) to progressively slice the sample (FIB-SEM), currently offering the **highest resolution along the Z axis**, with a slice thickness that can be reduced down to 2 nm.

FIB-SEM is an extremely useful technology in cell biology, with a **wide range of applications** (study of viral and bacterial proliferation in eukaryotic cells, membrane remodeling under stress, study of intercellular connections, etc.).

For example, a recent study with young researcher Atitheb Chaiyasitdhi was funded by FBI. The project is focusing on the **chordotonal organ** in the locust ear and **uses FIB-SEM** to reconstruct the organ’s 3D structure. This approach provided insights into the mechanics of insect auditory transduction and brought us closer to solving the two questions: How does the chlodotonal organ convert such a broad range of mechanical forces into electrical signals? And do these organs share a common underlying mechanism?



Three-dimensional (3D) ultrastructure of a scolopidium. (a) 3D reconstruction at the interface between a scolopale cell and an attachment cell using Focused Ion Beam-Scanning Electron Microscopy (FIB-SEM). (b) Longitudinal FIB-SEM slice reveals the dendrite and its ciliated distal end enclosed within the scolopidium sheath; the cilium dilates near its insertion into the porous cap before it terminates in an electron-dense region at the border of the attachment cell. (c) 3D model of a complete scolopidium.

A. Chaiyasitdhi, M. Nowotny, M. Van der Heijden, B. Warren. ***Stretching of the insect mechanoreceptor evokes mechano-electrical transduction in auditory chordotonal neurons.*** *bioRxiv 2025.06.27.662008; doi: https://doi.org/10.1101/2025.06.27.662008*

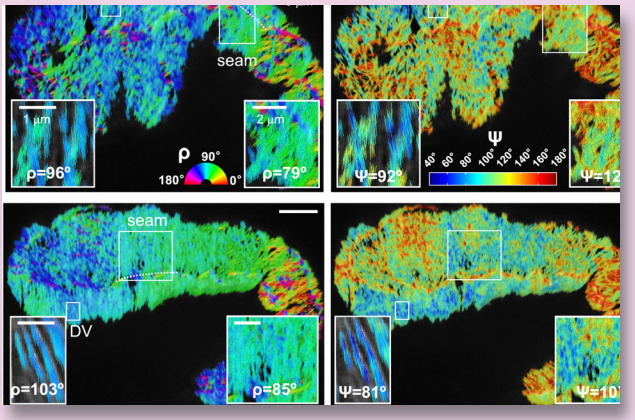
MARSEILLE

Polarimetry for live imaging of actin organization - 2023/2024

A major technological breakthrough in biomolecular imaging was achieved with the **development of genetically encoded reporters** that reveal actin filament organization in living cells and tissues using polarimetric imaging.

This innovation combines genetic engineering with polarization-resolved microscopy to **visualize the dynamic and structural organization** of actin in vivo with high precision. The project, led by teams from IBDM and the Fresnel Institute (Marseille Node), Paris-based labs, and international collaborators, culminated in a publication in Cell *(Martins et al., 2025; doi: 10.1016/j.cell.2025.03.003)*.

These new tools offer unprecedented **insight into cytoskeletal architecture** and are poised to transform studies of cell mechanics, development, and morphogenesis. The technology is now being **deployed across several France-BioImaging platforms.**



Polarimetry measurements of actin filament organization in live elongating C. elegans embryos expressing selected reporters

Martins CS, Iv F, Suman SK, Panagiotou TC, Sidor C, Ruso-López M, Plancke CN, Omi S, Pagès R, Gomes M, Llewellyn A, Bandi SR, Ramond L, Arbizzani F, Rimoli CV, Schnorrer F, Robin F, Wilde A, LeGoff L, Pedelacq JD, Jégou A, Cabantous S, Rincon SA, Chandre C, Brasselet S, Mavrakis M. ***Genetically encoded reporters of actin filament organization in living cells and tissues.*** *Cell. 2025 May 1;188(9):2540-2559.e27. doi: 10.1016/j.cell.2025.03.003. Epub 2025 Apr 2. PMID: 40179884.*

CXEM workflow - 2023/2024

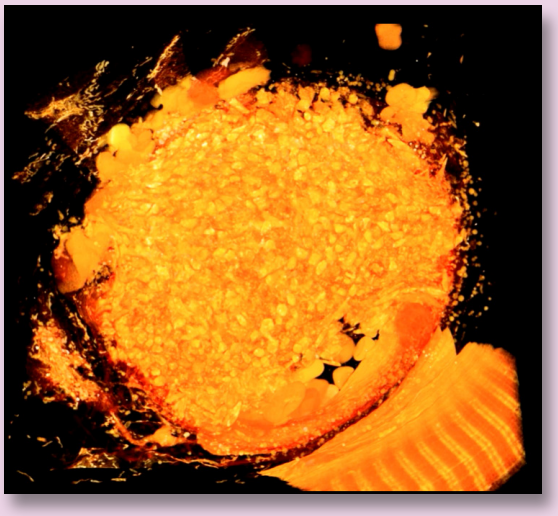
During the past 4 years the IBDM Electron Microscopy Facility implemented a **workflow for Correlative X-ray and Electron Microscopy (CXEM).**

The main advantage of Computed X-ray Tomography (or Micro-CT) for an electron microscopist is its ability to "see through" a sample and to reveal its overall organization in 3D **without any labelling.** The second advantage of Micro-CT is the fact that it is **non-destructive.** Thirdly, the contrast we usually give to samples for electron microscopy is compatible and even beneficial for X-ray imaging. Altogether, this means that we can **use X-ray tomography to map the microscale morphology** of a sample in order to target a specific region of interest without having to go through the time-consuming and destructive collection of semi-thin sections.

We routinely use the micro-CT tool, not only to target a given organ or a given group of cells, but also to pre-orient the sample in order to cut it under a specific orientation. It is a timesaving tool within the frame of a 2D electron microscopy project, but it really is key within the frame of a 3D electron microscopy project given that Serial BlockFace and Focused Ion Beam techniques are destructive. We now plan to **integrate light microscopy** within the frame of a pre-embedding CLEXM workflow to add molecular information to the established CXEM workflow.

Finally, thanks to the France Innovation 2030 investment program, we are about to equip our facility with its own micro-CT device in order to run the CXEM workflow at a higher throughput.

As an application example of the CXEM workflow, you can have a look at the following paper where we used micro-CT to map platelet aggregates within arteries in order to explore them by Serial BlockFace SEM, another example of "Find a needle in a haystack".
Have a look at movie S1, it is a wonder that we could not have obtained without CXEM:



Extract from S1 movie:
Representative movie of the core of the thrombus after a laser injury in SBF. After determination of platelets thrombi localization in the arterial microcirculation by micro-CT. The thrombus core was studied with an SEM microscope equipped with a VolumeScope SBF module. Acquisitions were performed out at a thickness of 100 nm and a pixel size of 10 nm on 40mm of length. This representative movie is a 3D modelling illustrating the presence of resting platelets, activated platelets and red blood cells in the thrombus core induced after a laser-injury.

DNAse-dependent, NET-independent pathway of thrombus formation in vivo. *Estelle Carminita, Lydie Crescence, Nicolas Brouilly, Alexandre Altié, Laurence Panicot-Dubois, Christophe Dubois. Proc Natl Acad Sci U S A. 2021 Jul 13;118(28)*

MONTPELLIER

Biodetection by Calibrated Micro/Nanostructured Surfaces - 2023

Our study presents a **new strategy for enhancing fluorescence-based biodetection** through spatially addressable micro- and nanostructured surfaces. By designing lenticular dome-like geometries, we **optimized the fluorescence interference contrast (FLIC) effect**, enabling robust signal amplification across multiple fluorophore wavelengths. The approach was validated with several fluorescent dyes and confirmed at high resolution using STED microscopy. Its diagnostic potential was demonstrated through sensitive detection of the SARS-CoV-2 receptor-binding domain (RBD) with antibody recognition, achieving limits of detection comparable or superior to conventional assays.

These findings pave the way for **multiplexed, highly sensitive diagnostic applications** using calibrated micro/nanostructured platforms.

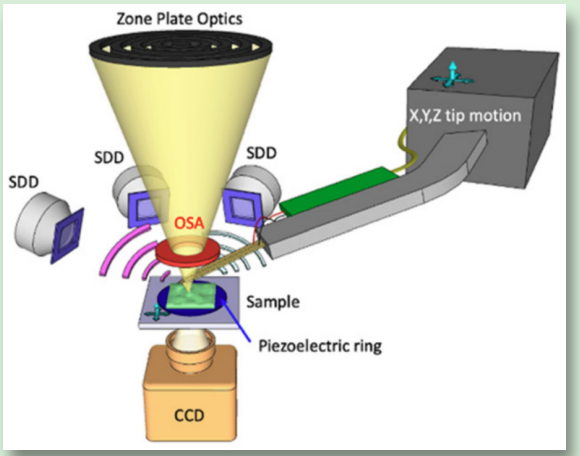
Dobroiu S, van Delft FCMJM, Sudalaiyadum Perumal A, Dash S, Aveyard J, van Zijl J, Snijder J, van den Heuvel E, van Berkum J, Blanchard MP, Favard C, Nicolau DV. ***Spatially Addressable Multiplex Biodetection by Calibrated Micro/Nanostructured Surfaces.*** *ACS Sens. 2023 May 26;8(5):1882-1890. doi: 10.1021/acssensors.2c01939. Epub 2023 Apr 26. PMID: 37099014.*

MONTPELLIER

In situ AFM system for a soft X-ray spectromicroscopy synchrotron beamline - 2023

Our study presents the **development of a novel in situ atomic force microscopy (AFM) system** integrated into a soft X-ray spectromicroscopy synchrotron beamline. The custom instrument operates under high vacuum and enables **correlative acquisition of AFM and X-ray fluorescence (XRF) maps**, while preserving scanning transmission X-ray microscopy (STXM) capabilities. Preliminary tests demonstrate the feasibility of combining AFM topography with XRF elemental mapping, **providing complementary nanoscale information** on sample structure and composition.

This proof-of-concept paves the way for advanced multimodal imaging approaches at synchrotron facilities.



Sketch of the developed system as deployed at the TwinMic beamline. The monochromatised X-ray beam is incident perpendicularly on the sample plane and is focused through a zone plate diffractive optics while the order sorting aperture (OSA) selects the first diffraction order. The sample is scanned in the X and Y directions on the TwinMic sample stage and the transmitted X-rays are collected using a CCD camera through an X-ray–visible light converting system (not shown here for simplicity). Lowenergy X-ray fluorescence (LEXRF) is collected by up to 8 silicon drift detectors (SDDs) in a backscattered configuration. The AFM tip is controlled by an X, Y, Z motor stage.

Hafner A, Costa L, Kourousias G, Bonanni V, Žižić M, Stolfa A, Bazi B, Vincze L, Gianoncelli A. ***An innovative in situ AFM system for a soft X-ray spectromicroscopy synchrotron beamline.*** *Analyst. 2024 Feb 7;149(3):700-706. doi: 10.1039/d3an01358h. Epub 2023 Nov 23. PMID: 38130190.*

NORMANDIE

Light sheet microscope (α³ Facility Edition, Phase View) - 2023

The α³ Facility Edition combines patented technologies to produce a uniform, optimally resolved light sheet image across the entire field.

Double intelligent illuminators perform a real-time focus sweep, ensuring homogeneity for artifact-free imaging. It offers the **highest resolution,** allowing macro-scale imaging followed by finer imaging without manual interaction. Imaging is narrow, with **excellent channel colocation** and high-resolution homogeneity.

Fully automated, it includes sample loading and handling, automatic illumination and detection objective changes, and a **LINDA interface** with a 3D viewer for configuring and editing acquisition volumes, providing a **real-time 3D preview** of samples before scanning.

Autofluorescence signal from Copepod Eurytemora affinis. Copepods were sampled at the Villequier station (49°30'51.5"N 0°40'36.9"E, Normandy, France) in the oligo-mesohaline zone of the Seine estuary. After methanol fixation, copepods with eggs were stabilized in agarose 1% low melting for observation. Image was acquired from light sheet microscope (a³ Facility Edition, Phase View) by using x10 illumination objectives and x10 observation objective, and 405 nm laser excitation (viridis LUT). 3D representation with Napari software (v 0.6.2).

NORMANDIE

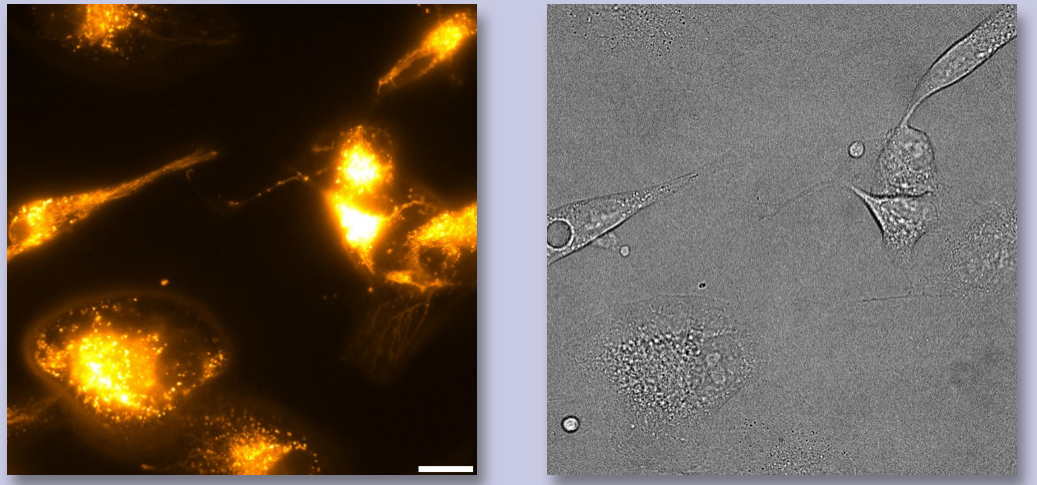
Fast multi-color wield-field/TIRF microscope (IX83, CellVivoTIRF, Evident) - 2023

The Fast multi-color wield-field/TIRF microscope (IX83, CellVivoTIRF, Evident) is particularly adapted for living cell observation by **reducing phototoxicity** (Fast) with **image improvement** (CellSens 2D deconvolution).

The 8-color sources of LED illumination and the 4 colors excitation laser for TIRF imaging, combined with the strategy of using multi-band filters, as well as the high-quality detectors, offer photonic microscopes with **ever-increasing performance** in terms of spatial, temporal, and spectral resolution.

This system with **multi-parametric settings** allows acquisition of 3 or 4 color images in less than 500 ms, in multi-positions configuration, in time-lapse mode (thermostated chamber with 5% CO2) with correction of focus drift. It is equipped with X4 to X20 objectives, of very **high quality for fluorescence** light and **phase contrast**, a x63 oil immersion objective to achieve high lateral resolution and a x100 objective specially designed for TIRF imaging.

The **Deblur tool of CellSens software** (Evident) able to **include image processing almost simultaneously** with acquisition is a major innovation that simplifies the image analysis process.



New lipophilic probe (UMR CNRS 6064, Rouen) after 1hr incubation in H28 cell lines. Observation after 555-nm illumination LED (on left) and phase contrast transmitted light (on right) with x20 objective through IX83, CellVivoTIRF microscope (Evident). Image from time lapse observation (frame rate 100 ms) to measure vesicles trafficking. Scale bar: 15 µm

NORMANDIE

France-Finland training on “performance measurement of advanced-light imaging devices also described as Metrology” - 2024

In November 2024, we’re kicking off the **collaborative training sessions** between respective IMAC (Rouen) and BIMA (Turku) **master programs.** Master’s students from Turku could therefore benefit from **on-line and on-site courses,** tutorials and practical works. This training aims to equip students with **essential skills and knowledge** in metrology for light microscopy approaches.

The key objectives for participants were to:

- **Perform measurements** and metrology analyses on light microscopy systems,
- **Utilize metrology tools**, flowcharts, protocols, and measurement analyses effectively for future professional applications,
- **Understand the pros and cons** of employing metrology or quality assessment in their work,
- **Enhance technical knowledge** related to light imaging,
- **Develop diagnostic reasoning** based on acquired metrology data.

Students from University of Turku/åbo Akademi University preparing fluorescent beads during practical sessions

UNIVERSITY OF TURKU

Åbo Akademi University

3D Super-resolution radial fluctuation - 2020-2023

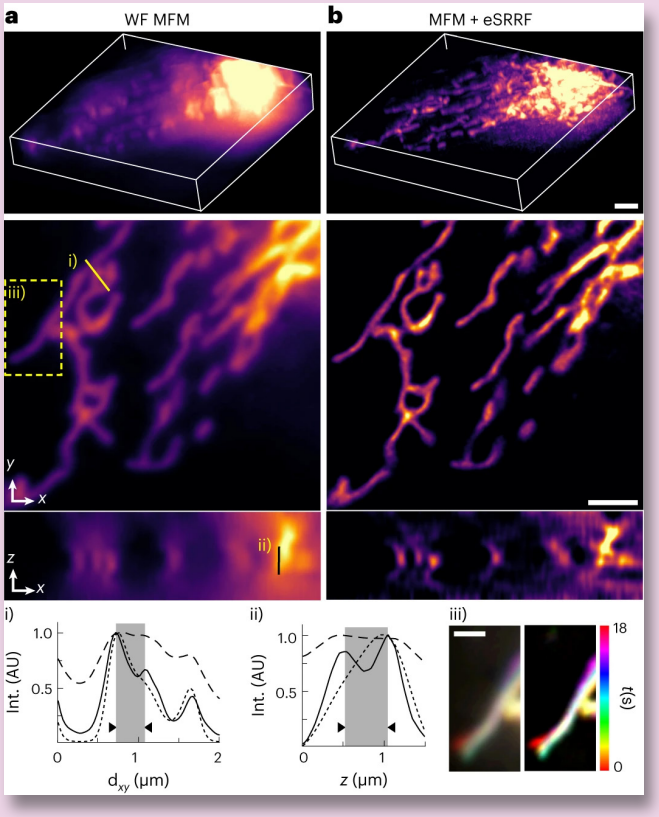
This international collaboration brought together physicists, microscopists and cell-biologists worldwide to combine algorithm development with cutting-edge imaging.

It aimed to develop and validate eSRRF, an **enhanced version of fluctuation-based super-resolution microscopy**, and extended it to 3D by integration with **Multifocus Microscopy (MFM)**, enabling fast volumetric super-resolution of live cells at ≈1 volume per second.

By extending eSRRF to three dimensions and applying it to the multiplane acquisition capability of MFM, the method enables **volumetric super-resolution imaging** at ~1 volume per second with enhanced resolution in both lateral and axial dimensions.

This combination takes advantage of MFM's ability to **capture multiple focal planes simultaneously** without mechanical scanning and leverages the **temporal coherence of fluorescence fluctuations** across planes to **reconstruct high-fidelity 3D images.**

The result is a robust, accessible platform for observing nanoscale dynamics in living cells under gentle illumination conditions, **expanding the applicability of super-resolution microscopy** to more complex and sensitive biological systems.



a, Live-cell volumetric imaging in MFM WF configuration of U2OS cells expressing TOM20-Halo, loaded with JF549.

b, 3D eSRRF processing of the dataset creates a super-resolved volumetric view of 20×20×3.6μm3 at a rate of ~1Hz (MFM+eSRRF). The 3D rendering (top); single cropped z-slice (FRC resolution in xy, interpolated, 231±10nm; eSRRF, 74±12nm) (middle); single cropped y-slice (FRC resolution in xz eSRRF, 173±19nm) (bottom).

(i) and (ii) mark the positions of the respective line profiles in the xy and z-plane in the MFM (dashed line), deconvolved MFM (dotted line; Extended Data Fig. 10) and MFM+eSRRF (solid line) images (a,b). The distance of the structures resolved by eSRRF processing (marked gray) is 360nm in the lateral directions (x,y) and 500nm in the axial direction (z).

(iii) marks the displayed area of the temporal color-coded projection of a single z-slice over the whole MFM (left) and MFM+eSRRF (right) acquisition. Scale bars, 2μm (a,b) and 1μm (iii). FRC shown as mean±s.d.

Laine, R. F., Heil, H. S., Coelho, S., Nixon-Abell, J., Jimenez, A., Wiesner, T., ... Hajj B. , Leterrier C. & Henriques, R. . ***High-fidelity 3D live-cell nanoscopy through data-driven enhanced super-resolution radial fluctuation.*** *Nature Methods, (2023) 1-8.*

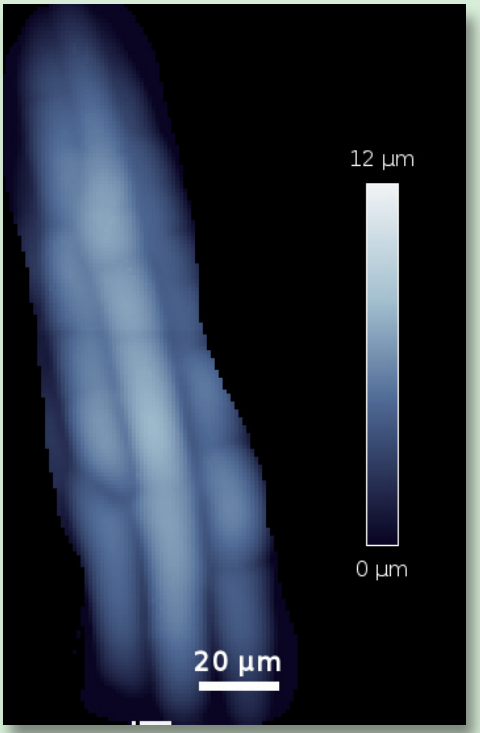
RHONE-ALPES

JPK Nanowizard IV XP Hybrid stage AFM (Bruker) coupled to an inverted epifluorescence microscope (Zeiss) - 2024

The main specificity of the new AFM is **its coupling to a Hybrid Stage**, *i.e.* a sample stage that is motorized (in X and Y) and also contains 3 additional piezo actuators (X, Y and Z) the move the sample by 100x100x100 μm^3.

The 100 µm Z piezo is particularly useful for large samples and/or large scans. Also, the Smart Mapping modality allows **the acquisitions of maps on ranges overcoming the piezo ranges**: whn a limit is reached, the system automatically replaces the sample (or the AFM head for the Z direction) with the stepper motors and then continues the scans and stitches the maps together. This is particularly useful for large samples and was almost impossible to obtain on the other setups at the PLATIM/ LYMIC.

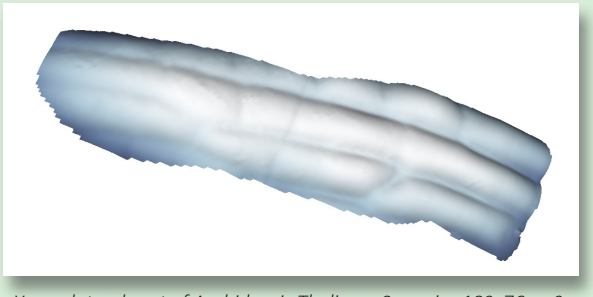
The system is equipped with a **double optical coupling**: an inverted microscope and a bright field top-view system. The AFM allows the collection of images from either of the optical systems, their calibration and then the selection of one (or several) acquisition areas directly on the optical image.



Young lateral root of Arabidopsis Thaliana

In the case of a multiple selection, the instrument can **automatically scan all the areas,** which represents a considerable time gain for the user and increases the throughput of the measurement.

This AFM has also been equipped with a **Petri Dish Heater system**, which allows to heat the sample and maintain a constant temperature (above room temperature) during the measurements. This module is particularly useful when working in single living cells.

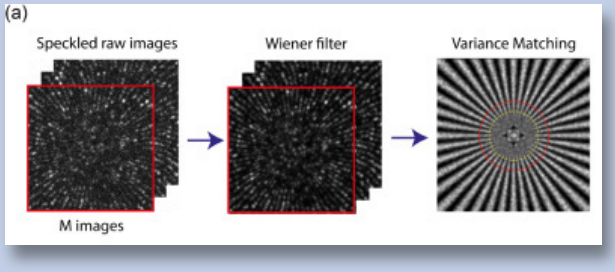

Young lateral root of Arabidopsis Thaliana. Scan size 183x76µm2.

RIM and EDF-RIM: From TIRF imaging to organoids - 2023/2024

Random Illumination Microscopy (RIM) uses second-order speckle statistics to **generate super-resolved images.** Reconstruction is based on the variance of speckled images using an iterative variance-matching algorithm (algoRIM), which **requires only the speckle auto-covariance**, a well-characterized quantity. Despite involving non-linear processing, RIM reconstructions remain linearly related to fluorescence density, achieving lateral resolution comparable to Structured Illumination Microscopy (SIM) and optical sectioning akin to ideal confocal microscopy. The use of random speckle illumination greatly **simplifies both experimental setup and computational reconstruction.** RIM has proven robust for imaging both live and fixed biological samples, in challenging conditions such as TIRF and deep tissue imaging. It has also recently been extended to non-linear imaging. Initially developed in Toulouse and transferred to Rennes, RIM has been **implemented in TIRF-specific setups** and **adapted for imaging organoids** up to 600 µm deep, thanks to ANR and CPER support.

To accelerate imaging of large biological samples, we developed an **Extended Depth of Field (EDF)** version of RIM. EDF-RIM combines speckle-based illumination and variance processing to produce **high-resolution projective images of thick samples**, without requiring knowledge of illumination patterns. Compared to conventional 2D-RIM scans across volumes, EDF-RIM achieves a **10× increase in speed** and a **10× reduction in light dose**, while maintaining similar resolution. Since axial information is lost in EDF projections, we propose a method to retrieve sample topography for cell-sheet-like structures. This work was developed in close collaboration with the Marseille and Bretagne-Loire nodes.

Building on these advances, we develop **Pseudo-RIM (pRIM)**, which combines structured illumination with RIM's statistical reconstruction to improve robustness and speed. It is implemented at the Toulouse node and **enables multicolour super-resolved imaging at 25 Hz**. Its resilience to pattern distortions offers a key advantage over SIM. This innovation lays the foundation for the RIMEO start-up, which aims to make RIM technology widely accessible to biologists.



TIRF-RIM principle. (a) Multiple images of the sample are recorded under different random speckled illuminations. Each raw speckled image is prefiltered using a Wiener filter to reduce the noise. The super-resolved reconstruction is obtained from the variance of the prefiltered images using AlgoRIM (Methods). The red circle indicates the resolution limit of standard fluorescence microscopy; the yellow circle illustrates the resolution gain brought by RIM.

K. Affannoukoué, S. Labouesse, G. Maire, L. Gallais, J.Savatier, M. Allain, Md Rasedujjaman, L. Legoff, J. Idier, R. Poincloux, F. Pelletier, C. Leterrier, T. Mangeat, and A. Sentenac. ***Super-resolved total internal reflection fluorescence microscopy using random illuminations.*** *Optica 10, 1009-1017 (2023)*

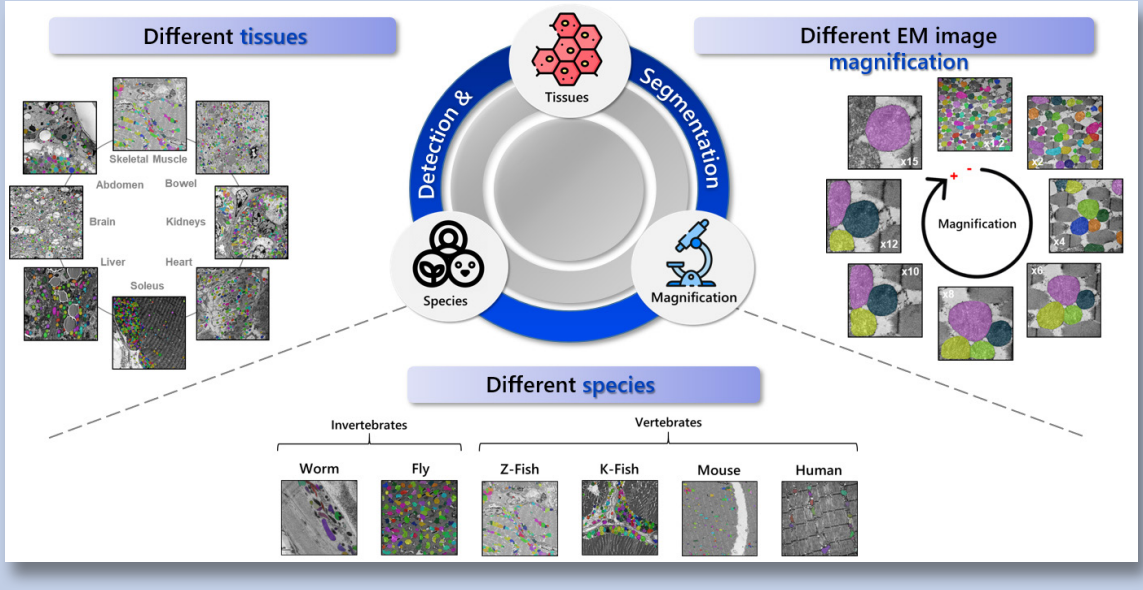
TOULOUSE

EMito-Metrix: A user-friendly application to study mitochondria morphology & ultrastructure from 2D TEM images - 2024

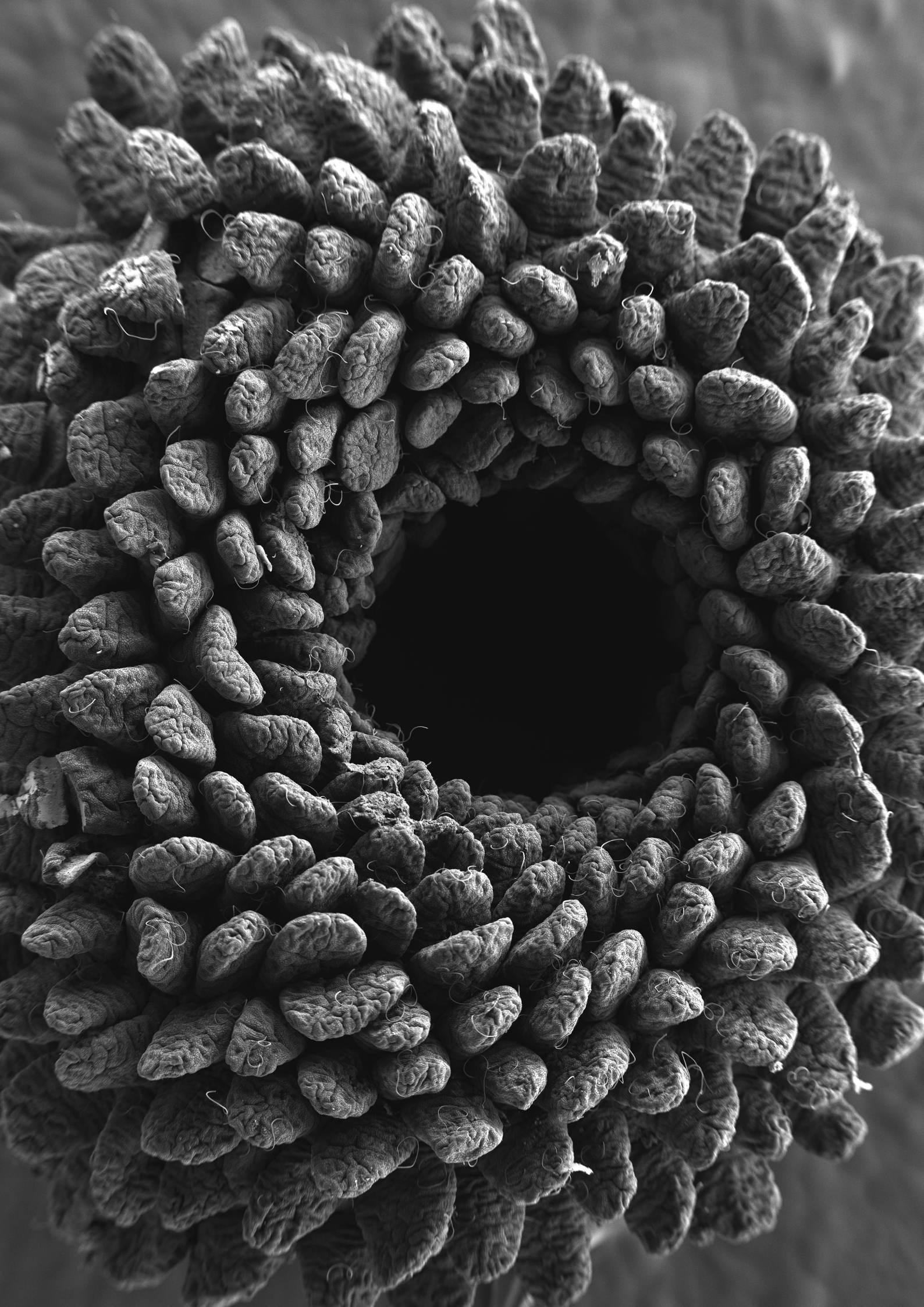
In collaboration with biology researchers from the RESTORE institute, the imaging platform has developed a turn key pipeline, **EmitoMetrix**, which enables biologists to **automatically evaluate mitochondria morphology** across species.

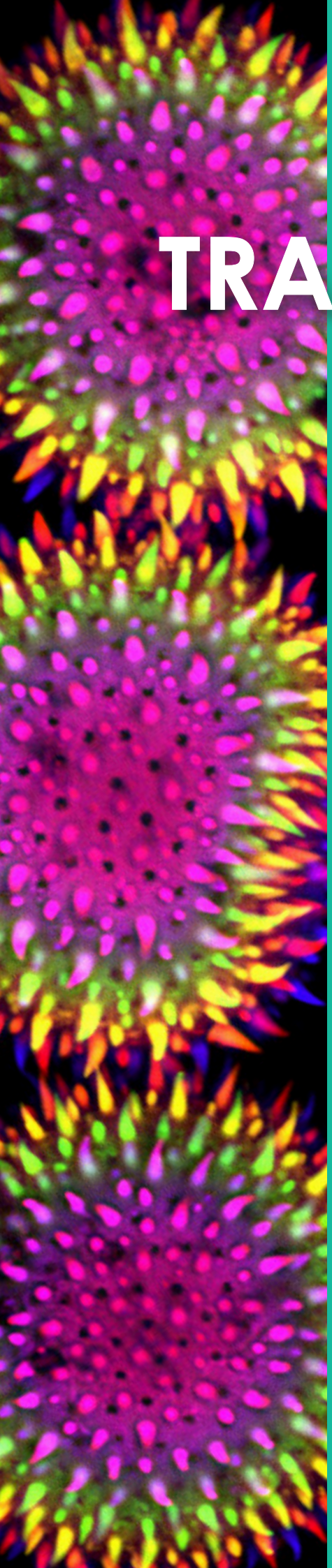
The use of this application has been validated on images from different tissues (muscle, abdomen, liver, kidney, heart, intestine, head), different species (killifish, zebrafish, *C. elegans*, *Drosophila*, mice and humans) and different ages.

It is an indispensable tool for **predicting the extent to** which a genetic mutation, nutritional challenge or drug treatment **would generate detectable changes** in mitochondrial morphology.



Inserm Transfert. (2025). **EMito-Metrix License** *– research purposes restricted. Zenodo. https://doi.org/10.5281/zenodo.17064295*





TRAINING

Beyond its active role as participant and support for training activities in imaging, FBI is also convinced of the importance to build a more integrated training offer to ensure sufficient biological imaging capability in France at all levels and sustainable career pathways.

The future of biological imaging is reliant not just on technologies but more importantly on a well-trained and highly skilled community of developers, users and core facility staff. As such, high-quality training should be well supported by all stakeholders.

Training mission

The France BioImaging (FBI) training mission is dedicated to **developing** and **disseminating high-quality educational resources** in biological imaging, with a core focus on **transferring theoretical** and **practical knowledge** to both facility end-users and infrastructure staff.
This comprehensive training aims to:

- Serve as a prerequisite for equipment access,
- Enhance user skills,
- Support continuous professional development and technology transfer for personnel.

The mission is structurally organized into three specialized sub-groups, namely **Electron Microscopy** (ME, in collaboration with RIME), **Light Microscopy** (MP, in collaboration with RT-MFM), and **AI Image Analysis Methods** (MAIIA, in collaboration with RT-MFM).

A central strategic objective is to **rationalize content creation** by increasing its granularity, thereby enabling seamless adaptation across face-to-face, remote, and e-learning modalities. This is achieved through **the construction** of a **«knowledge book»** meticulously structured around a Field, Topic, and Notion hierarchy.

The Notion, representing the most granular unit, is defined as a **training sequence** lasting approximately 5-15 minutes and explainable within 1-3 slides. This granular framework ensures content homogenization, reusability, and facilitates cross-validation with external training programs, which is crucial for the FBI training system. Presently, the knowledge books comprise approximately **60 fields**, encompassing **250 topics**, and organizing over **400 transferable notions.**

The period from late 2022 to late 2024 saw s**ignificant progress in content production**, **MOOC development**, and the establishment of key collaborations, albeit alongside persistent challenges, particularly concerning funding stability.

LATE 2022 INITIATIVES

A crucial step in content production involved the organization of a first in-person workshop in September 2022 in Bordeaux, **focusing on training participants** in simple **video production techniques, including scripting, storyboarding,** and **post-production**. This workshop brought together 18 participants and aimed to enable autonomous video content creation at each facility.

Initial MOOC development was underway across the three sub-groups: the **EM** sub-group had selected **ultramicrotomy** as its MOOC focus, while the **MP** sub-group was exploring various topics including **transmission, wide-field, or confocal microscopy**. The **MAIIA** sub-group was considering a MOOC on **machine learning approaches** in collaboration with the RT-MFM working group.

PROGRESS AND CHALLENGES IN 2023

The year 2023 was marked by a strong push towards **MOOC prototyping** and **content creation**, building on the established methodological framework. A second in-person workshop was held in March 2023 in Bordeaux, specifically dedicated to the concrete **production of video material for the MOOCs**, encompassing planning, scripting, and actual video shooting.

ACHIEVEMENTS AND OUTLOOK IN 2024

The first quarter of 2024 saw continued efforts to **finalize the MOOC content** and prepare for broader dissemination. A third workshop was held in March 2024 in Bordeaux, primarily focused on the production of material and aiming to finalize videos.

Discussions with FunMOOC regarding contractualization and MOOC hosting continued, with the contract becoming ready. Contractualization is now achieved and the online posting should be achieved before the end of 2025.

Collaborations expanded, with FBI-Training's methodology presented at the **European eRImote project,** highlighting its unique and innovative approach to remote training solutions. International interest also surged from Global BioImaging for FBI-Training's structured approach to educational materials, leading to invitations for **presentations at international events** (EuBI All Hands Meeting - April 2024; ABIC Annual Meeting - October, 2024; GBI Exchange of Experience - October 2024; Workshop Aneris - December 2024) and **discussions with Africa BioImaging** (December 2024) for specialized training tailored to French-speaking communities, including «train the trainer» initiatives.

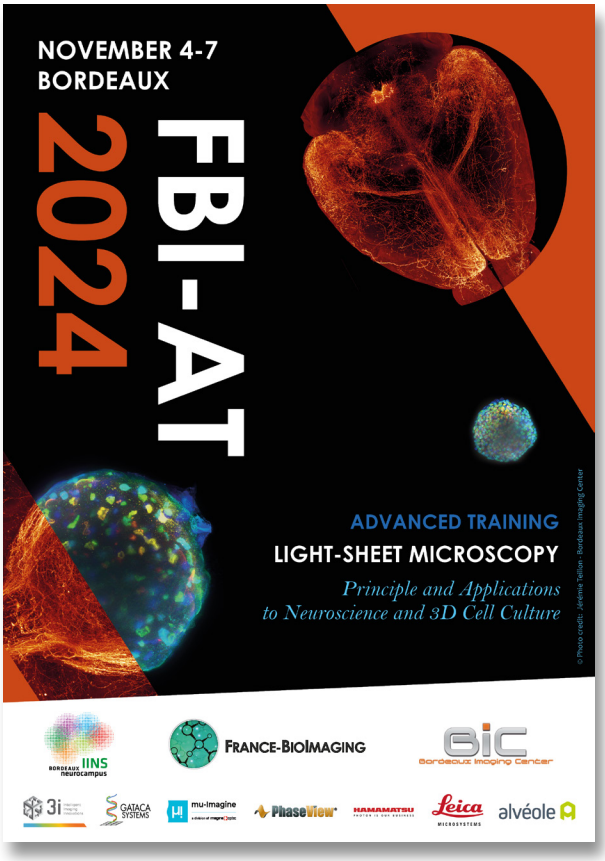
France-BioImaging Advanced Training 2024

The main objective of France-BioImaging Advanced Training is to offer **intensive training to the most advanced microscopy techniques**, to microscopy users. Trainees benefit from France-BioImaging members' experience and expertise hosting the training as well as internationally known speakers.

FBI-AT 2024 edition, organized by Bordeaux Imaging Center (Bordeaux node), was dedicated to *"Light-Sheet Microscopy: Principle and Applications to Neuroscience and 3D Cell Culture"*.

The participants had the opportunity to follow plenary sessions led by experts in neurosciences and Light-Sheet microscopy. Then, they could apply the notions seen that morning with hands-on workshops around four tracks:

- Large sample imaging – Clearing & Expansion
- 3D cellular models Culture & Imaging
- Neuronal network imaging
- Image Analysis



FBI-AT is a great training event for researchers already trained in basic microscopy willing to **become familiar with advanced techniques** to answer their specific biological questions, or to be exposed to new developments that will allow them to tackle new questions in their project.

20
Participants (13 national & 7 international)

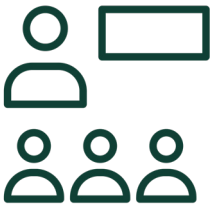
27
Speakers and instructors

11
Practical workshops

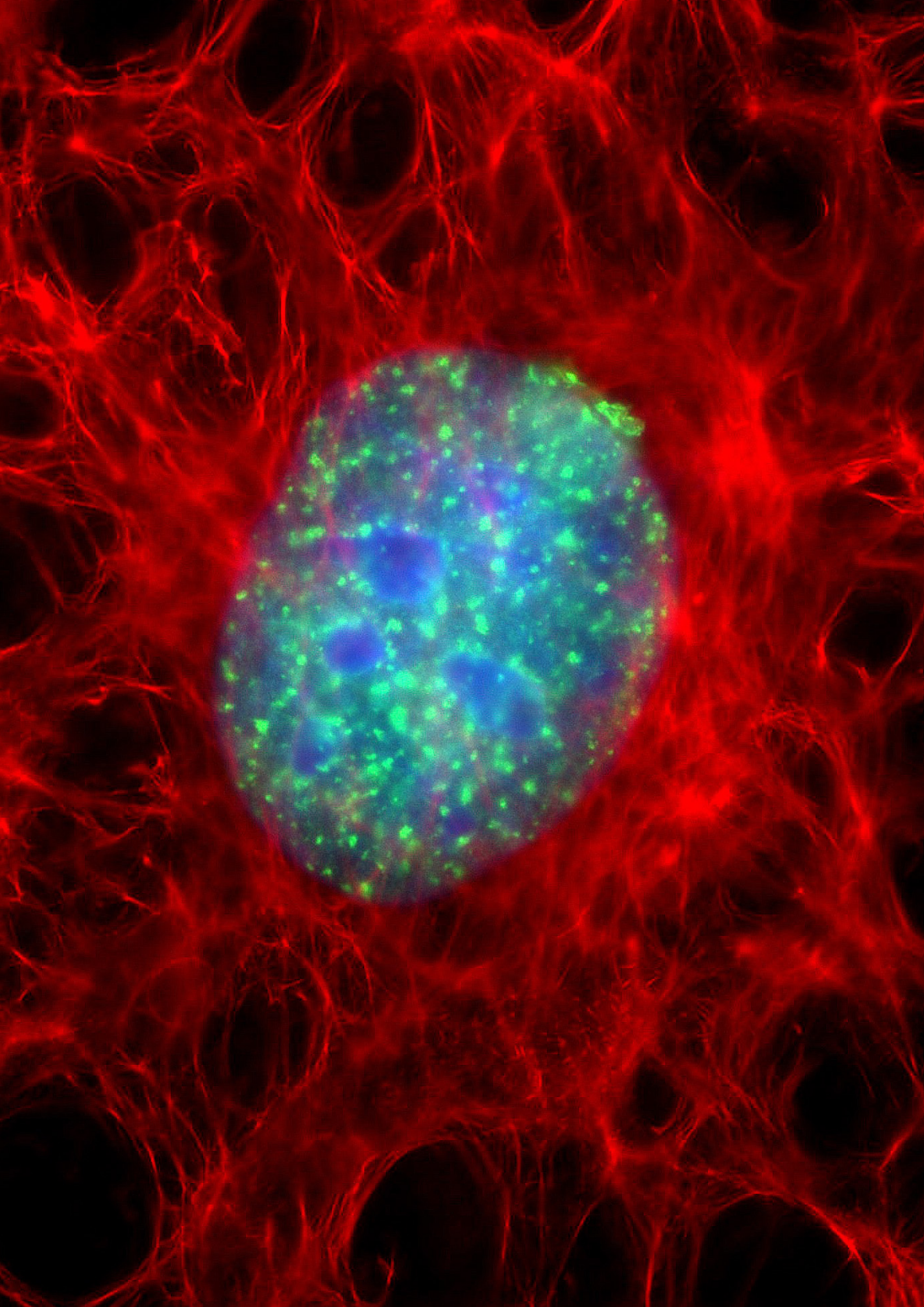
Key figures training in 2024

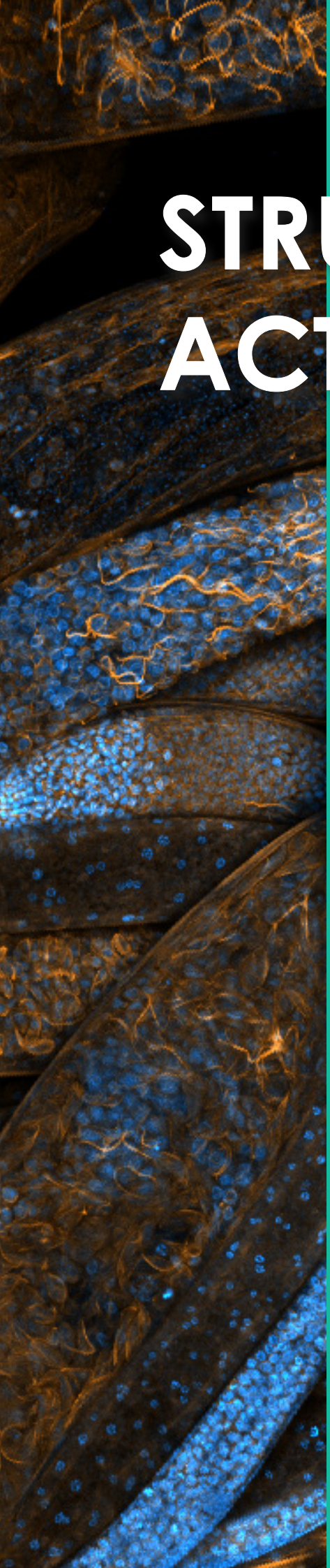
4703 users trained in our facilities

87 institutional training courses 110 initial training courses



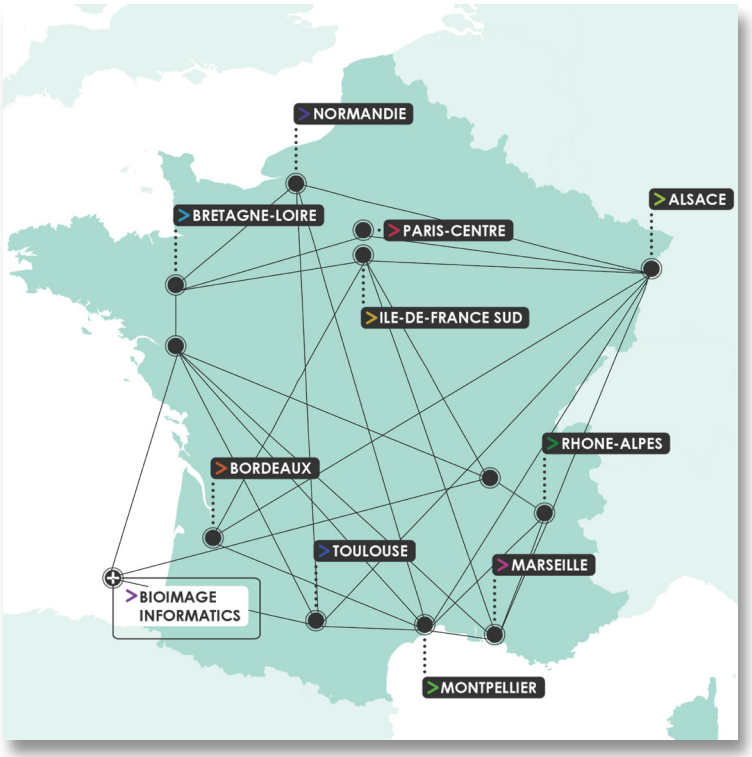
8 participations or co-organizations of doctoral programs





STRUCTURING ACTIVITIES

Core facilities integration



Historically, imaging core facilities, structured by RIO, then IBiSA initiatives, preceded the creation of the national infrastructure. As a result, for many years, they developed operational methods in silo. The framework of the national infrastructure was an opportunity to to **rethink the overall scheme of this organization**, both operationally scale and in terms of instrument pooling and sharing to give the infrastructure a **functional cohesion.**

A **working group** comprising all the **node pilot engineers** has continuously integrated the incoming engineers from new nodes (there are now 12 engineers in the working group). Its first aim was to **evaluate** and **disseminate the management tools** to move the platforms towards an infrastructure-based entity. What has been achieved since 2023.

Over the last two years, we worked with **collective intelligence**. This new way of working was implemented during a year's work with the support of a coach. We have **redefined the roadmap** for our work **up to 2026** as following:

- WG energy-efficient platforms
- WG new tools for a better integration
- WG management of deployed tools
- WG development of tools

Each work group brings together 3- 4 engineers with a leader who ensures that the objectives set out in the roadmap are met:

- The WG energy-efficient platforms aims to **estimate the CO2 cost** of a typical handling experimentation, to s**et up indicators specific to our activity**, and to **create a web site** for exchanging, lending or donating instruments;
- The WG new tools for a better integration aims to **propose new tools** for increasing collaborative work and to **train to use them**. OpenIRis and Resana softwares were initially selected;
- The WG management of deployed tools aims to **manage processes already in place** and **develop them** further as annual surveys, charter evolution, mapping instruments and skills, OpenIRis deployment training;
- The WG development of tools aims to **develop new tools that do not exist elsewhere**, such as the current development of a **platform-wide instrument metrology dashboard.**

To sum up, 2024 was a year in which **we rethought the way we organized our work**, as the collective grew. We collectively s**et the objectives for the coming years**, underlining our responsibility as engineers to take **environmental impact** into account in our activities.

FBI.data: towards a national shared service for bioimaging data management and computing

The primary mission of the FBI.data team is to develop a data management system that follows datasets **from production to publication in public repositories**, ensuring that essential metadata are captured from the very beginning of each project. This service is also built on the idea of **shared storage and computing infrastructures** at regional mesocenters, with minimal deployment and maintenance efforts required at the local platform level.

The program is structured into f**our main axes**, which also define the service offer. Collaborations with other national infrastructures, notably the French Institute of Bioinformatics (IFB), are central across all axes.

AXIS 1 – COMMUNITY SUPPORT AND ENGAGEMENT

This axis focuses on supporting platforms, users, R&D teams, and institutions. In line with the national **Open Science policy,** it aims to provide services and expertise on bioimaging data management.

The main activities on this period were to provide:

- **Guidelines and tools** through a unified Data Management Plan (DMP) for France BioImaging,
- **Support** for users and R&D teams in creating project-specific DMPs,
- **Network of local data and computing coordinators** to identify bottlenecks and support funding requests (e.g., for local buffer servers or network upgrades).

AXIS 2 – DATA STORAGE (DEPLOYMENT ON MESOCENTERS, INTEROPERABILITY)

FBI.data is developing a **novel storage and data management system** combining multiple technologies to support open science. Procedures for secure data transfer from acquisition systems to regional mesocenters are being piloted by the system.

The first tools, currently in testing at pilot sites, provide basic storage functions and limited computing capabilities. During the 2023-2024 period, the first release of the systeme and enrolment of beta-users was delivered, together with an extensive documentation.

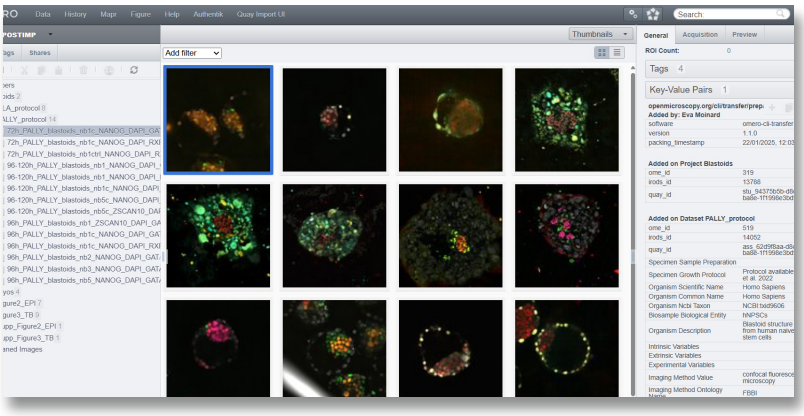


Illustration: one of the data access proposed by the system, this one based on Omero https://nte.omero-fbi.fr/webclient/?show=dataset-519

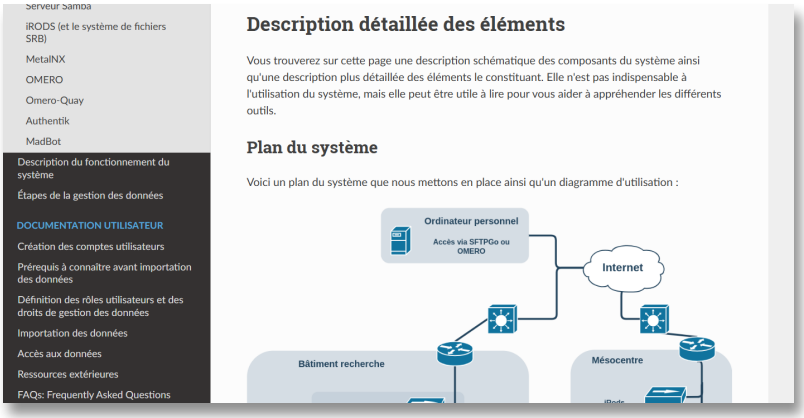


Illustration : Documentation from https://docs.omero-fbi.fr/

AXIS 3 – COMPUTING (INTEGRATION OF TOOLS, AI, AND ACCESS TO CLUSTERS)

Bioimaging data must be analyzed to extract quantitative insights. However, datasets are large and workflows (especially AI-based) are often difficult for non-specialist biologists to use. FBI.data aims to address this by **hosting data directly at mesocenters**, avoiding unnecessary transfers, and enabling local analysis.

Activities in 2023-2024 include the definition of the **specifications of IR-FBI analysis containers** together with F-BIAS.

AXIS 4 – IMAGE ANALYSIS CHALLENGES

To demonstrate the benefits of data sharing, FBI.data organizes **international microscopy image analysis competitions.** These challenges involve:

- Sharing curated datasets,
- Defining well-bounded scientific questions,
- Establishing evaluation metrics,
- Comparing methods, primarily AI-based, to identify the most effective solutions.

During the reporting period, the first FBI challenge «**Light My Cells: Bright Field to Fluorescence Imaging Challenge**» (*Grand Challenge*) was organised (ran in 2024) and the 2025 was prepared «**Fuse My Cells: From Single View to Fused Multiview Lightsheet Im**» (*Grand Challenge*).

These competitions encourage platforms and R&D teams to annotate and share data, while generating added value by framing community-relevant problems. Successful methods aimed then to be integrated into user-friendly software platforms to be disseminated across the infrastructure.

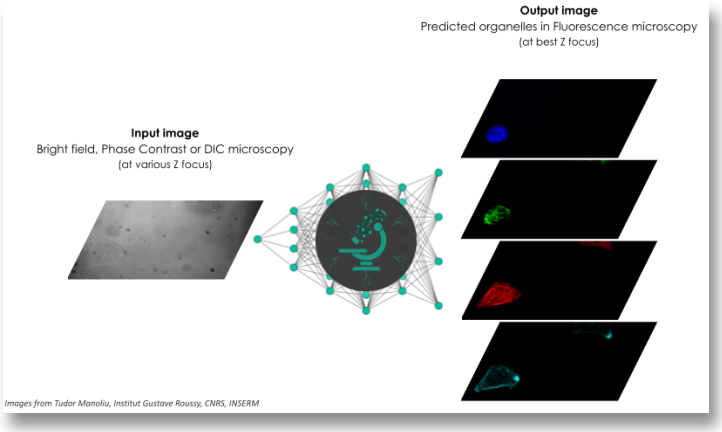


Illustration : Light my cells first FBI Challenge in 2024

At the end of Light My Cells, **217 participants** from all around the world and **3 winners**: Trang Lee, Yu Zhou, and Marek Wodziński.

Top 1 winner, **Trang Lee** from Stanford University (USA), was invited to **participate in our Annual Meeting in Strasbourg** to present her solution in front of the entire France-BioImaging community.

Through its four axes, FBI.data is building a **national shared infrastructure** for bioimaging data management and computing. By providing uniform tools, interoperable storage solutions, access to scalable computing resources, and community-driven AI challenges, it ensures that French bioimaging datasets can be **well-managed, accessible, and scientifically impactful** (AI-ready) within the framework of open science.

F-BIAS: France-BioImaging Analysts

F-BIAS is a professional network that **federates the bioimage analysis across France**, working in France-Bioimaging (FBI) core facilities with the mission of **supporting the research project** of FBI users. It was created in 2021, with the aim of offering to analysts a critical mass of colleagues with whom to **share technical and technological expertise** and **know-how**, in the scope of image analysis as a service. Indeed, most analysts are recruited within microscopy facilities where they are often the only specialist.

The **F-BIAS network operates mainly virtually**, providing several means of instant and formal communication to its members. We organize monthly meetings during which technical questions around image analysis are addressed.

The meetings include activities such as sharing preview versions of tools and pipelines developed by members and collecting feedback or discussing an article or a new bioimage analysis tool but can also enable one analyst to receive feedback by peers on a user project.
A private instant communication channel has been deployed, which allows for quickly interrogating the network.

In April 2024, we also organized our **first in-person meeting,** in Bordeaux. Analysts presented the tools they master (as technical tutorials) and shared this knowledge with their peers (with hands-on practice). We also organized round tables on core facility works and organizational aspects. The input of F-BIAS is highly valued by its members, analysts, and their managers. This helped grow the network from **10 to 22 members in 2024** (Figure 1).

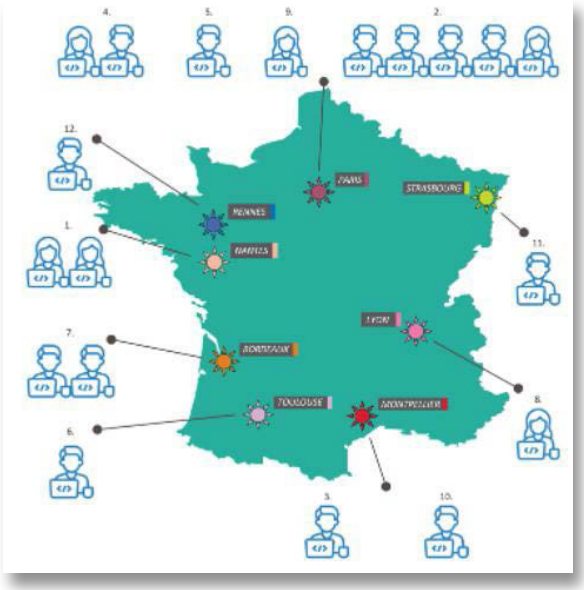


Figure 1: Geographical repartition of F-BIAS members and their host structure in 2024

In 2022, we leveraged the effective F-BIAS team to **deliver image analysis assistance to FBI users**. We began by **offering consultations** on biological image analysis to French researchers in the form of **online sessions open to all**, organized remotely every two months and communicated via the FBI newsletter and website.

For each open desk, around four online sessions of one hour are planned, with users booking one of the sessions in advance. Two to five experts are present for each online session with the FBI user and they can:

- Offer advice on which tool to use,
- How to use it with online demonstration on the user data,
- Implement a preliminary version of an analysis pipeline,
- Create small macros for analysis or task automation.

Most of the time, the different analysts suggest their own preferred approaches and tools, giving other analysts the opportunity to discover new methods and ideas and users to have different approaches to solve their questions.
Today, about **40 open-desk sessions have been organized**. The feedback from users has been very positive at the onset. Indeed, F-BIAS reaches out to researchers that normally do not have access to the expertise of an analyst. The collaboration with F-BIAS brings significant scientific added value to their project.

Consultations are well suited when the user request can be addressed with existing tools or well-established pipelines. This is not always the case and ambitious projects prompt for customized tools. This is more difficult to implement, as it requires a significant time effort from the analysts, who are already supporting the users of their local core facility. F-BIAS received **the direct support of FBI** and at the end of 2023, through the allocation of two data analysts fixed-term positions to the project, one at the Curie Institute and the other at the Pasteur Institute.

This enabled F-BIAS to **deploy collaborative projects services.** This term refers to the creation and delivery of a custom image analysis pipeline by the analyst to the user, with both parties closely working together. The project corresponds to an articulated request from the user but involves an original contribution and some scientific responsibility from the analyst. Most of these projects are carried out remotely, often with mentoring: a junior analyst leads the project while being mentored by a more senior analyst. The topics covered are indeed very diverse and extend from cell imaging in light microscopy, to electron microscopy image analysis and small animal imaging. Their diversity reflects the **richness of quantitative imaging-based research projects** within the perimeter of FBI.

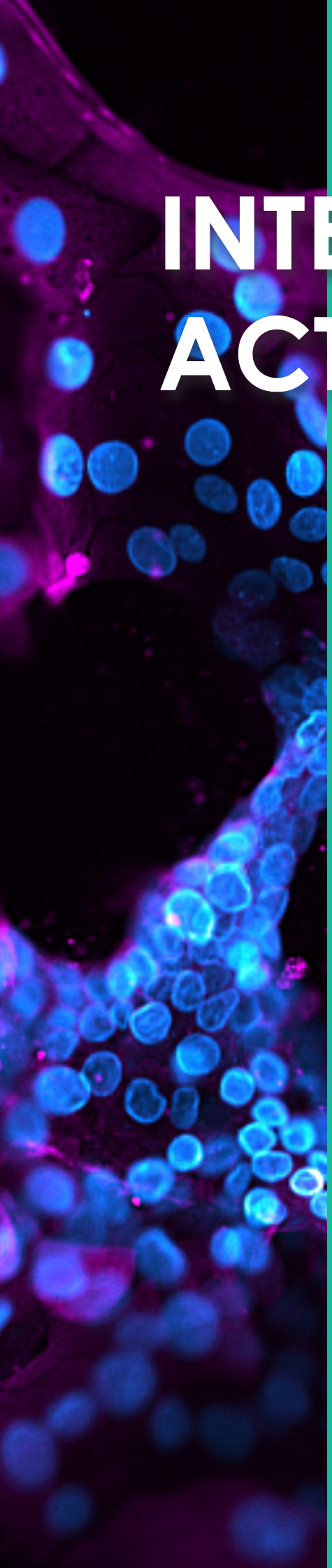
Collaborative project requests are discussed with users during one of the open-desk sessions, or directly during a dedicated meeting. The request is then discussed internally with F-BIAS members to assess its feasibility and elect the analyst that will be dedicated to the project. The analyst selection is based on availability and expertise. If accepted, the request is made and logged in the Euro-Bioimaging Access Portal. The time spent by the analyst on a project is billed to the user, using a fee schedule agreed upon by the F-BIAS members, and subsidized in kind by FBI. Today, **F-BIAS is running 12 collaborative projects**.

The table below gives statistics on the projects that finished in 2024:

Collaborative projects (2024)	F-BIAS
N. projects / year / analyst	8.0 ± 0.0 (N=2)
Project effort	48.8 ± 27.9 hours (N=5)
Project duration	7.3 ± 4.0 months (N=3)

In 2025, we published an article that describes our experience in creating and animated a nationwide core facility offering services in bioimage analysis:

Ambroset M, Anselmet M, Benedetti C, Meslin A, Maillot A, Rouvière C, Maucort G, Marine B, Albert M, Letort G, Trullo A, Bäcker V, Mutterer J, Cordelières F, Pécot T, Phan M-S, Rigaud S, Feyeux M, Paul-Gilloteaux P, Macé A-S, Tinevez J-Y. ***F-BIAS: Towards a distributed national core facility for bioimage analysis.*** *PLOS Computational Biology 2025;21:e1013058. https://doi.org/10.1371/journal.pcbi.1013058.*



INTERNATIONAL ACTIVITIES

France-BioImaging is not only a national infrastructure serving researchers across France: it is also deeply **embedded in the global scientific landscape.** By developing strong international collaborations, FBI ensures that the latest imaging technologies, expertise, and best practices circulate beyond borders and that French research stays connected to worldwide innovation.

These international ties span European networks like **Euro-BioImaging ERIC**, global alliances such as **Global-BioImaging**, targeted partnerships like the **IRN China** project, and dedicated initiatives supporting researchers in **low- and middle-income countries.**

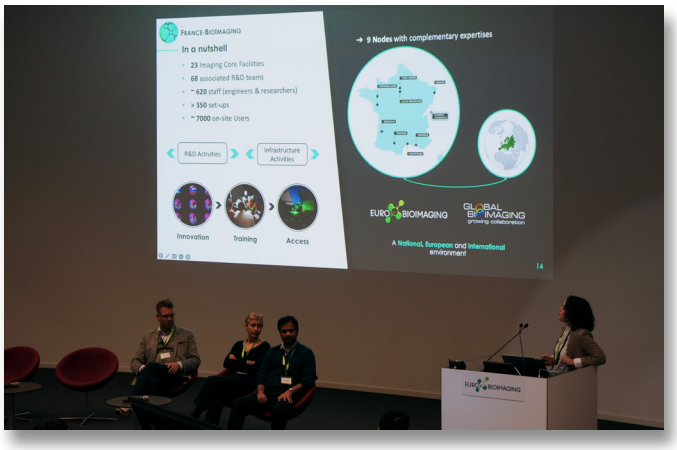
Together, they reflect FBI's mission to **make advanced imaging openly accessible,** to foster scientific excellence, and to contribute to **solving global challenges** in health, agriculture and the environment.

Euro-BioImaging

Euro-BioImaging ERIC (European Research Infrastructure Consortium) is the European research infrastructure dedicated to **providing open access** to a comprehensive portfolio of cutting-edge imaging technologies, services and expertise across life sciences and biomedical research. As an ESFRI landmark, EuBI ensures that scientists from all disciplines and countries can **a**ccess advanced imaging resources through a single entry point: the **Euro-BioImaging web portal.**

France-BioImaging is the official **French node of EuBI,** meaning it hosts and coordinates national imaging platforms that contribute services to this European network.

Through this participation, **international researchers benefit from the expertise**, instruments, and training opportunities offered by French platforms, while **French users gain visibility and integration** into large-scale European projects and collaborations.



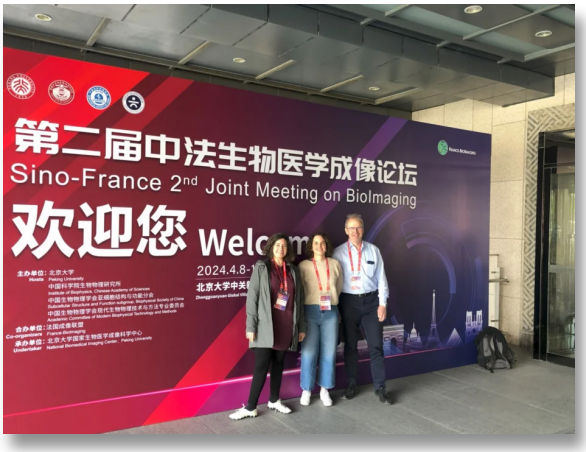
Global-BioImaging

Global-BioImaging is an international network created in 2015 to connect imaging infrastructures, technical experts and policy makers from all continents. Its mission is to **promote worldwide collaboration** in biological and biomedical imaging, share best practices, and support the development of harmonised standards and sustainable infrastructure models.

FBI's involvement in GBI includes participating in staff exchange programs, organising and attending international workshops, and co-developing training resources. This global engagement helps **FBI's teams stay at the forefront of technological developments**, while contributing to making imaging technologies more accessible to research communities worldwide, including emerging and low- and middle-income countries.

CNRS IRN «BioImage» with China

As part of its international strategy, France-BioImaging has initiated an ambitious collaboration with China, anchored in the creation of an **International Research Network (IRN China)**, a five-year program officially submitted and validated by the **CNRS** called **BioImage**.



The launch of this cooperation began in **April 2024,** when FBI co-organised the **2nd Sino-French Joint Meeting on BioImaging** in Beijing, hosted by Peking University, as part of the celebrations marking 60 years of diplomatic relations between France and China.

This three-day event brought together 12 French speakers, mostly FBI-affiliated, and 17 Chinese colleagues to share the latest innovations in multimodal and cross-scale imaging, data analysis, and platform strategies. It also included strategic meetings with NBIC (National Biomedical Imaging Center), the CNRS bureau in Beijing, and the French Embassy, laying the foundation for long-term collaboration.

Building on this successful first step, FBI coordinated the submission of the **IRN China** project to the CNRS in 2024. The network focuses on **advanced optical imaging,** including the design of fluorescent probes, super-resolution microscopy, deep tissue imaging and AI-driven image analysis.
The IRN China brings together major institutions:

- **In France:** IBENS (ENS Paris), IINS (Bordeaux), ISMO (Université Paris-Saclay) and INP (Toulouse)
- **In China:** National Biomedical Imaging Center (Peking University), Institute of Biophysics (Chinese Academy of Sciences), and Westlake University (Hangzhou)

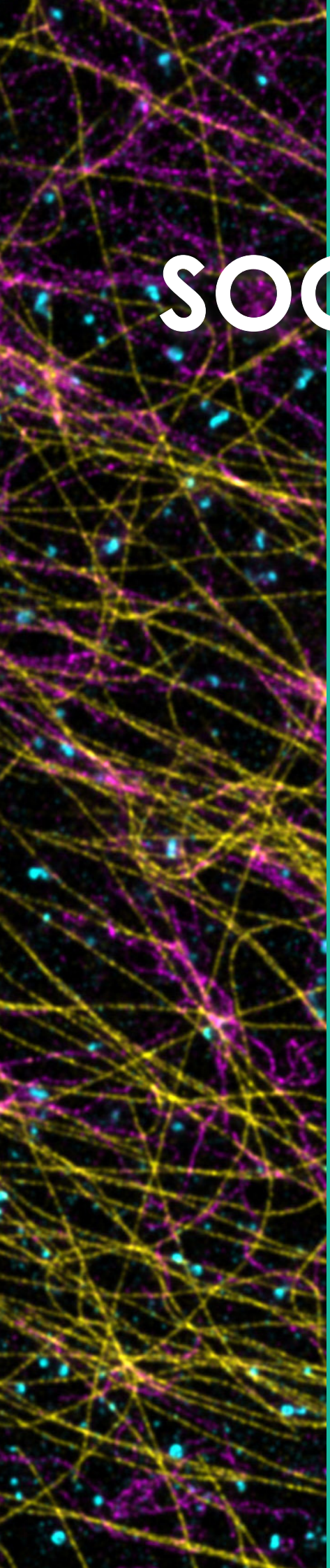
Through workshops, researcher mobility and coordinated R&D, the IRN aims to accelerate technological transfer to imaging platforms, strengthen scientific ties, and tackle key challenges in biological imaging on both sides.

FBI Africa-France Initiative

In line with its commitment to openness and inclusion, France-BioImaging launched the **FBI Africa-France initiative:** a dedicated program supporting scientific collaboration and capacity building between imaging communities in France and African countries.

Through specific calls for projects, the initiative funds mobility, training, and research projects carried out by students, early-career researchers and faculty from African universities and institutions. Since 2023, it has supported over **ten collaborative projects**, addressing questions from infectious diseases to plant biology and climate resilience.

By facilitating access to state-of-the-art imaging technologies, promoting knowledge exchange and nurturing new scientific networks, FBI Africa-France contributes to **strengthening research capacity** and **addressing shared scientific and societal challenges** on both continents.



SOCIAL IMPACT

Highlights on how the imaging technologies and image analysis tools available on FBI nodes have been used to **answer timely research questions**, including cancerology, immunology, microbiology research, and also plant biology.

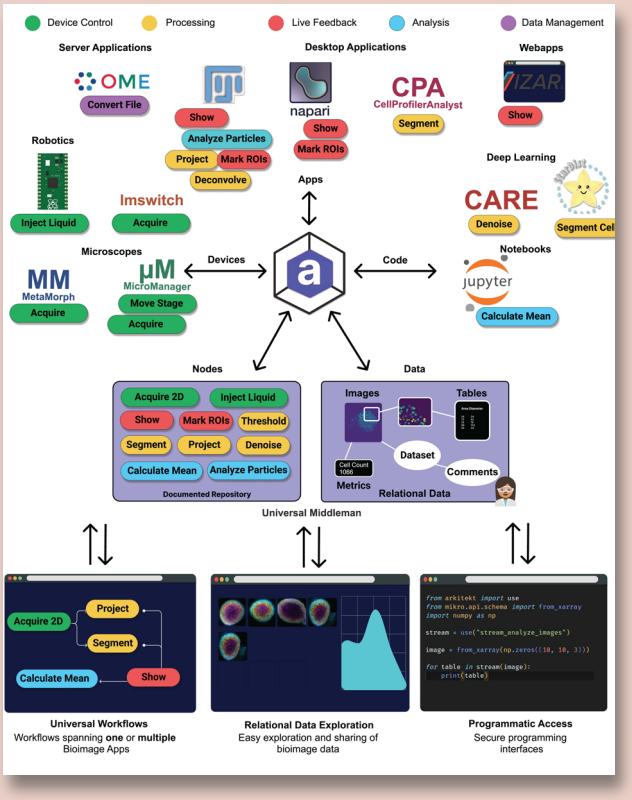
SOFTWARE BORDEAUX

ARKITEKT: STREAMING ANALYSIS AND REAL TIME WORKFLOWS FOR MICROSCOPY

Quantitative microscopy workflows have evolved dramatically over the last years, progressively becoming more complex with the emergence of deep learning. Long-standing challenges like 3D segmentation of complex microscopy data can finally be addressed, and new imaging modalities are breaking records in both resolution and acquisition speed, generating gigabytes if not terabytes of data per day. With this shift in bioimage workflows comes an **increasing need for efficient orchestration and data management,** necessitating multi-tool interoperability and the ability to span dedicated computing resources.

We developed **Arkitekt**, an **open-source middleman** between users and bioimage apps that **enables complex quantitative microscopy workflows in real time.** It allows orchestrating popular bioimage software locally or remotely in a reliable and efficient manner. It includes **visualization and analysis modules**, but also **mechanisms to execute source code** and **pilot acquisition software**, making 'smart microscopy' a reality.

The core design of Arkitekt platform, serving as a middleman for real-time microscopy experiments and streaming analysis workflows: Arkitekt **allows the interaction with various tools** in different categories: devices, bioimage apps and custom code.
These tools connect to Arkitekt platform and **advertise their functionality as nodes.** Nodes are abstract descriptions of the tool functionalities, including which bioimage data they can work with (for example, taking an image as an input and a ROI as an output).



Arkitekt stands as **the data hub for connected apps** and makes their functionality accessible and inspectable for every app in the laboratory through remote calls. Arkitekt takes care of the communications and orchestration of all apps from data acquisition to postprocessing analysis, organizing and maintaining the data and metadata in a relational data graph.

Arkitekt also provides an **abstraction layer for users and applications** alike to interface with the connected apps and data, both visually and programmatically. Workflows of connected functionality can be created through drag and drop. All of the data can be visualized directly in the web interface, while exploring associated metadata, or sent to one of the apps directly. Programmatic access is facilitated by easy-to-learn client libraries that require no advanced configuration and facilitate the easy inclusion and dispersion of new custom functionality as plugins.

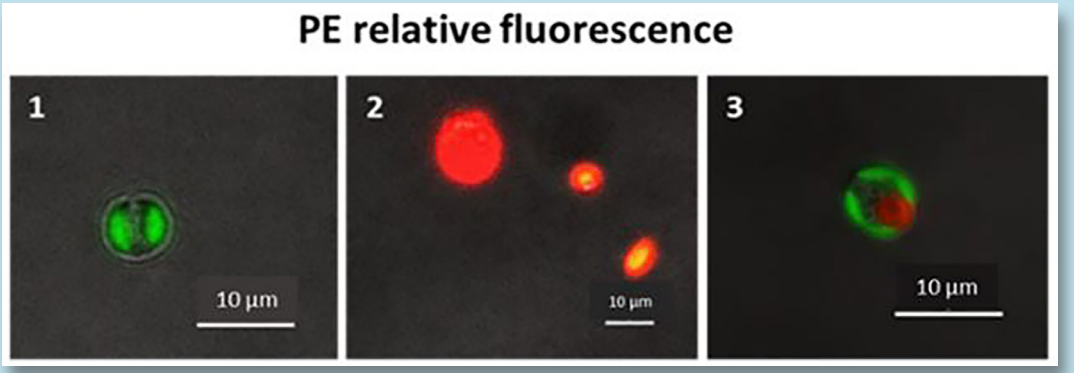
Arkitekt: streaming analysis and real-time workflows for microscopy, *Roos J, Bancelin S, Delaire T, Wilhelmi A, Levet F, Engelhardt M, Viasnoff V, Galland R, Nägerl UV, Sibarita JB, Nature Methods (2024) https://doi.org/10.1038/s41592-024-02404-5*

ALGAE IMAGED WITH CONFOCAL AFTER CYTOMETRY CELL SORTING

The haptophyte *Prymnesium parvum* is widely distributed and capable of **forming blooms** in both coastal and brackish inland water bodies. This unicellular microalgae can **produce toxins**, called prymnesins, and other secondary metabolites to kill or inhibit the growth of other organisms, a process called **allelopathy**. This leads to **Harmful Algal Blooms** (HABs), which result in **severe ecological and economic impacts** in many areas around the world . The most recent example is from the Oder River in Poland, in 2022, where a bloom of *P. parvum* caused the death of 250 tons of fish. In this context, it is crucial to deepen our knowledge regarding the underlying factors that lead to the formation of these HABs.

P. parvum is a mixotrophic microalga, *i.e.* it is able to combine **phototrophy and heterotrophy** (phago and/or osmotrophy) **to acquire energy and nutrients** for its growth . This nutrient strategy found in many toxic microalgae, allows them to grow under adverse conditions, which could explain their ecological success. Phagotrophy among planktonic microalgae has long been considered an important adaptation to life in oligotrophic aquatic habitats. More recently, it has been recognised that mixotrophy is also important in eutrophic estuaries and coastal marine bays, especially among harmful bloom-forming microalgae. In these water bodies, mixotrophic microalgae feed directly on nutrient inputs and indirectly on algal prey.

This study demonstrated that **feeding on living prey can significantly increase the growth rate** of *P. parvum* and that *P. parvum* is **able to utilize recently formed algal debris to grow.** The present study also highlights the **link between phagotrophy, allelopathy and growth** in *P. parvum*. These data may be used to improve existing models on trophic modes and more widely on mixotrophy in oceans.



Epifluorescence micrographs of monocultures of (A) P. parvum and (B) T. amphioxeia and (C) mixed culture of (1) Prymnesium parvum with (2) Teleaulax amphioxeia and in between (3) P. parvum containing one T. amphioxeia cell. Cells were observed under Nikon A1RS confocal microscope after cell sorting with a FACS ARIA III flow cytometer.

C. Boucher, T. Lacour, A. Julie, D. Réveillon, H. Per Juel, F. Mairet, **Mixotrophic lifestyle of the ichthyotoxic haptophyte, Prymnesium parvum, offered different sources of phosphorus,** *Harmful Algae, Volume 127, 2023, 102483, ISSN 1568-9883, https://doi.org/10.1016/j.hal.2023.102483.*

TUMOR-ASSOCIATED MACROPHAGES CONFER RESISTANCE TO CHEMOTHERAPY (TRIFLURIDINE/ TIPIRACIL) IN DIGESTIVE CANCERS BY OVEREXPRESSING THYMIDINE PHOSPHORYLASE

Pyrimidine analogs are part of the **first-line chemotherapy regimen** for gastrointestinal cancers. **Trifluridine combined with tipiracil,** a specific thymidine phosphorylase inhibitor, in TAS-102 has recently emerged as a **potential alternative** in the face of primary or secondary chemoresistance to 5-fluorouracil. Despite its promise, we report that **macrophage-specific overexpression** of thymidine phosphorylase results in **macrophage-induced chemoresistance** to TAS-102 that is **insensitive to tipiracil inhibition.**

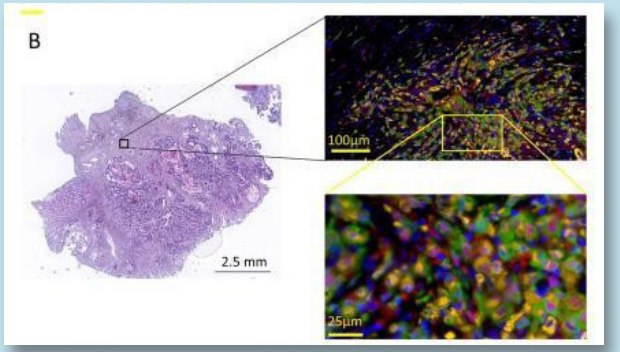


Fig. 6. Macrophages are a major source of TP expression in human colorectal tumors. (B) Immunofluorescence analysis of TP, CD68, CD163 expression in human colon tumor tissues. Nuclei were stained with DAPI.

Furthermore, we illustrate the **human-specific nature of this mechanism**, as mouse macrophages do not express substantial levels of thymidine phosphorylase, which constrains the applicability of mouse models. To study the importance of macrophages in chemoresistance to trifluridine, we developed a humanized mouse model with tumor-implanted human macrophages and **demonstrated their important role in treatment resistance** to pyrimidine analogs. Additionally, our findings revealed that **macrophages represent a significant source of thymidine phosphorylase expression**, comprising over **40 % of the expressing cells**, in human colorectal cancer, thereby contributing to chemoresistance.

M. Malier, M.H. Laverriere, M. Henry, M. Yakoubi, P. Bellaud, C. Arellano, A.Sébillot, F. Thomas, V. Josserand, E.Girard, G. S. Roth, A. Millet, ***Tumor-associated macrophages confer resistance to chemotherapy (Trifluridine/Tipiracil) in digestive cancers by overexpressing thymidine phosphorylase****, Cancer Letters, Volume 606, 2024, 217307, ISSN 0304-3835, https://doi.org/10.1016/j.canlet.2024.217307.*

DIFFERENTIAL EARLY RESPONSE OF MONOCYTE/ MACROPHAGE SUBSETS TO INTRA-OPERATIVE CORTICOSTEROID ADMINISTRATION IN LUNG TRANSPLANTATION

The «Vaccin Immunopathology Immunomodulation» team at the INRAE-UVSQ Molecular Virology and Immunology joint research unit (Jouy-en-Josas) is studying the **immune mechanisms involved in lung transplantation**, both in humans and in pig models. In collaboration with the cytometry facility of Imagerie-Gif, they **analyzed the responses of sub-populations** of pulmonary monocytes/ macrophages (classical and non-classical monocytes, alveolar macrophages) **during the encounter between donor and recipient**, using cell sorting and RT-qPCR. Together they have shown that **conventional peri-surgical treatment** with corticoids in the recipient **induces a partial anti-inflammatory profile**, which varies according to the type of monocytes/macrophages (*PLoS One, 2023; Front Immunol, 2023*). **Pre-treatment of the donor extends the anti-inflammatory effect** of corticoids to alveolar macrophages and inhibits their ability to recruit T lymphocytes, leading to a **graft immunological state favorable** to tolerance (article in preparation).

Through projects in preparation (funding applications in progress from ANR, VLM, ABM, HorizonEurope), the team is seeking to **develop strategies to reinforce the anti-inflammatory response** in the peri-surgical setting by targeting macrophage sub-populations more specifically using nanomedicine approaches. This work will provide important data for improving clinical outcomes in lung transplantation.

Mickael Bourge from the Imagerie-Gif cytometry platform is co-author of the article (Front Immunol, 2023) and of the article in preparation.

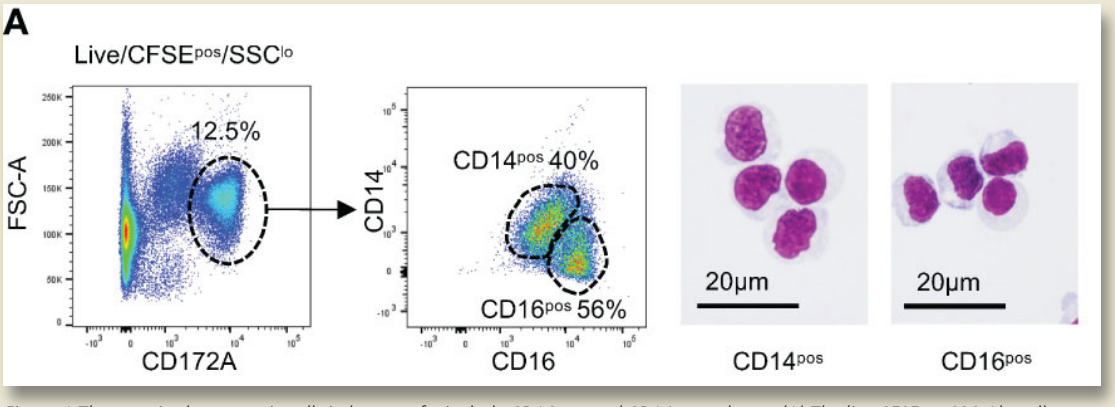


Figure 1 The recruited monocytic cells in lung grafts include CD16pos and CD14pos subsets. (A) The live CFSEposSSC-Alo cells were selected as we reported in (19). The CD172Ahi cells were gated and were further split into CD14pos and CD16pos cells. The two subsets were sorted by flow cytometry and stained with May-Grunwald Giemsa. The represented gating strategy is shown on a pig cross-circulation experiment at 10 h, depicted as a cross symbol in other figures.

Glorion M, Pascale F, Huriet M, Estephan J, Gouin C, Urien C, Bourge M, Egidy G, Richard C, Gelin V, De Wolf J, Le Guen M, Magnan A, Roux A, Devillier P, Schwartz-Cornil I, Sage E. ***Differential early response of monocyte/macrophage subsets to intra-operative corticosteroid administration in lung transplantation.*** *Front Immunol. 2023 Oct 24;14:1281546. doi: 10.3389/fimmu.2023.1281546. PMID: 37942330; PMCID: PMC10628533.*

DEVELOPMENTAL BIOLOGY

ILE-DE-FRANCE SUD

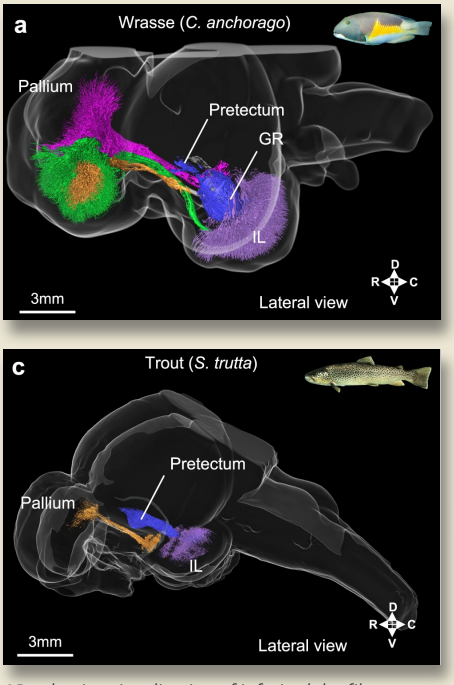
EXPLORING IN 3D THE FISH BRAIN USING TISSUE CLEARING, LIGHTSHEET IMAGING AND VOLUME SEGMENTING

The “Development & Evolution of the Forebrain” team at the Paris-Saclay Institute of Neuroscience is deciphering the **molecular and cellular mechanisms** underlying the **diversification of the forebrain anatomy** and functions in the course of vertebrate evolution.

In collaboration with the ISC MIMA2 they prepared and imaged fish brains from different species to **identify brain organization** that could underlie tool-using abilities in cortex-deprived brains. Using lipophilic tracers to visualize fiber tracts in cleared brains imaged with a Lightsheet7 (Zeiss) the team identified a **significant enlargement of a fiber tract** connecting the forebrain to the inferior lobe. This mesencephalic structure is absent in amniotes. This work provides evidence suggesting that higher-order cognitive functions, such as the use of tool, may have emerged in non-telencephalic structures.

Matthieu Simion from the ISC MIMA2 is a co-author of the article.

Estienne, P., Simion, M., Hagio, H. et al. ***Different ways of evolving tool-using brains in teleosts and amniotes.*** *Commun Biol 7, 88 (2024). https://doi.org/10.1038/s42003-023-05663-8*



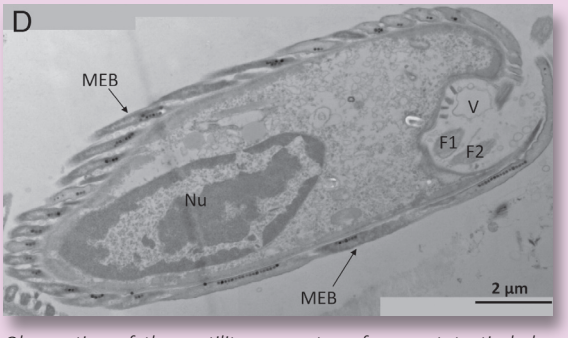
3D selective visualization of inferior lobe fiber tracts comparing the wrasse (C. anchorago; a), the cichlid (N. brichardi; b), the trout (S. trutta; c), the Astyanax surface fish (A. mexicanus; d), and the zebrafish (D. rerio; e). Lateral views are shown in (a–e), while a dorsal view of one side of the wrasse brain is shown in (f). Homologous tracts are shown in the same color across species. Besides wrasses and cichlids, no fibers connecting the pallium to the inferior lobe were detected in the other species of teleosts examined, irrespective of brain size. The main connections of the inferior lobe in these species are with the pretectum (blue), whereas they are with the pallium in wrasses and cichlids (ventral tract in green, dorsal tract in magenta). Local inferior lobe networks are shown in purple, and preglomerular complex projections to the pallium are shown in orange. Brain regions: GR:corpus glomerulosum pars rotunda, IL inferior lobe. R:rostral, C:caudal; D: dorsal; V: ventral; L: lateral ; M: medial.

MICROBIOLOGY
MARSEILLE

COLLECTIVE MAGNETOTAXIS OF MICROBIAL HOLOBIONTS IS OPTIMIZED BY THE THREE-DIMENSIONAL ORGANIZATION AND MAGNETIC PROPERTIES OF ECTOSYMBIONTS

The PICSL platform at IMM contributed to the project led by Christopher Lefevre's team (CEA Cadarache) through its **expertise in transmission electron microscopy** (TEM), as part of an interdisciplinary study published in PNAS.

The goal was to better understand a **unique symbiosis** between a eukaryotic protist and magnetotactic bacteria. TEM enabled high-resolution imaging of the internal structures of the cells and the detailed interactions between the symbiotic partners. These analyses revealed the **spatial organization and distribution of bacteria within the protist**, providing important insights into how this biological relationship functions.



Observation of the motility apparatus of magnetotactic holobionts MHBs) isolated from Carry-le-Rouet, France. (D) Stitched TEM images of longitudinal ultrathin sections of a MHB showing the vestibulum on the front of the protistan cells and the two flagella.

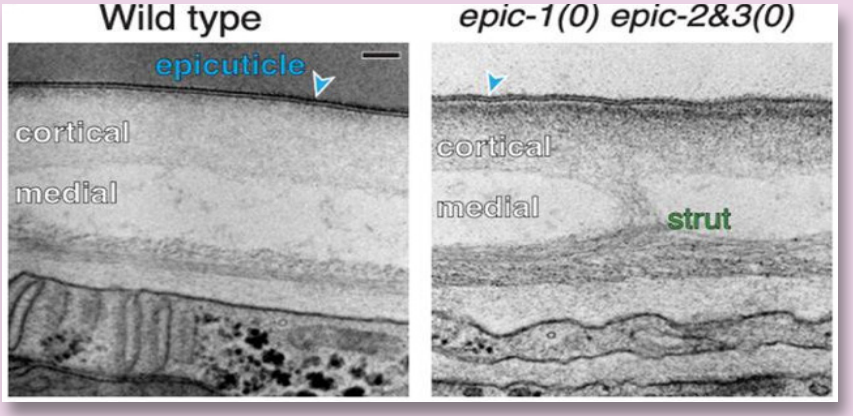
This work highlights the power of advanced imaging technologies in **exploring complex microbial ecosystems.** It also demonstrates the **strategic value of France-BioImaging platforms** in supporting cutting-edge research. The project is a compelling example of the **intersection between microbiology, cell biology, and materials science.**

D.M. Chevrier, A. Juhin, N. Menguy, R. Bolzoni, P.E.D. Soto-Rodriguez, M. Kojadinovic-Sirinelli, G.A. Paterson, R. Belkhou, W. Williams, F. Skouri-Panet, A. Kosta, H. Le Guenno, E. Pereiro, D. Faivre, K. Benzerara, C.L. Monteil, & C.T. Lefevre, ***Collective magnetotaxis of microbial holobionts is optimized by the three-dimensional organization and magnetic properties of ectosymbionts****, Proc. Natl. Acad. Sci. U.S.A. 120 (10) e2216975120, https://doi.org/10.1073/pnas.2216975120 (2023).*

C. ELEGANS EPICUTICLINS DEFINE SPECIFIC COMPARTMENTS IN THE APICAL EXTRACELLULAR MATRIX AND FUNCTION IN WOUND REPAIR

In early 2024, the Electron Microscopy Facility at IBDM supported a project led by Andrew Chisholm's lab (UC San Diego) focused on **the role of epicuticlins in *C. elegans*.** These poorly understood proteins are related to the **epicuticle in larger nematodes and insects.** To uncover their function and localization, the facility employed **advanced sample preparation techniques**, including High-Pressure Freezing and Freeze Substitution. This approach preserved tissue ultrastructure with exceptional quality, enabling the **visualization of subtle phenotypic differences** between wild-type and mutant worms by TEM. The work revealed **how epicuticlins define distinct compartments** in the apical extracellular matrix and contribute to wound repair. Just seven months after initial contact, the results were published in Development.

The project was funded through **France-BioImaging's user access program**, with the infrastructure acknowledged in the publication. This highlights the **impact of expert EM support** in accelerating international research collaborations.



(F) TEM images of epicuticle in wild-type and epic-1(0) epic-2&3(0) adults. Images are representative of two wild type and four EPIC triple mutants (day 1 adults). The epicuticle (blue arrowheads) in epic-1(0) epic-2&3(0) animals was 6-14 nm thick, compared with 8.5-15 nm in wild type; the cortical layer beneath the epicuticle was consistently more darkly stained in EPIC mutants versus wild type.

M. Pooranachithra, E. M. Jyo, N. Brouilly, N. Pujol, A. M. Ernst, A. D. Chisholm; ***C. elegans epicuticlins define specific compartments in the apical extracellular matrix and function in wound repair.*** *Development 1 November 2024; 151 (21): dev204330. doi: https://doi.org/10.1242/dev.204330*

PLANT BIOLOGY
MONTPELLIER

HASE SEPARATION AND MOLECULAR ORDERING OF THE PRION-LIKE DOMAIN OF THE ARABIDOPSIS THERMOSENSORY PROTEIN EARLY FLOWERING 3

This study investigates the **temperature-sensitive phase separation** of the *Arabidopsis* thermosensory protein **EARLY FLOWERING 3** (ELF3), driven by its prion-like domain (PrLD). Using structural, biophysical, and microscopy approaches, the authors show that **ELF3 PrLD forms higher-order oligomers in the dilute phase**, which are essential for phase separation. Temperature and pH changes trigger the transition to condensed liquid droplets that progressively mature into ordered hydrogels. Small-angle X-ray scattering, atomic force microscopy, and electron microscopy revealed that these condensates display **molecular stacking and structural ordering.**

The work provides **detailed insight into the structural states of ELF3**, establishing a framework for understanding how plant prion-like domains act as thermosensors through dynamic phase transitions.

S. Hutin, J.R. Kumita, V.I. Strotmann,A. Dolata, W.L. Ling, N. Louafi, A. Popov,P . Milhiet, M. Blackledge, M.H. Nanao, P.A. Wigge, Y. Stahl, L. Costa, M.D. Tully, & C. Zubieta, ***Phase separation and m olecular ordering of the prion-like domain of the Arabidopsis thermosensory protein EARLY FLOWERING 3,*** *Proc. Natl. Acad. Sci. U.S.A. 120 (28) e2304714120, https://doi.org/10.1073/pnas.2304714120 (2023).*

CELL BIOLOGY
MONTPELLIER

A NUCLEAR PROTEIN QUALITY CONTROL SYSTEM FOR ELIMINATION OF NUCLEOLUS-RELATED INCLUSIONS

This study identifies a **nuclear protein quality control system** that eliminates aberrant protein inclusions linked to the nucleolus. Combining genetics, cell biology, and advanced imaging, the authors demonstrate **how specific nuclear mechanisms detect and remove these aggregates** to preserve cellular homeostasis.

Microscopy experiments were performed at Montpellier Ressources Imagerie (MRI), a France-BioImaging node, highlighting the **role of high-end imaging** in uncovering nuclear protein surveillance pathways. These findings provide new insight into **how cells maintain nuclear integrity under stress conditions.**

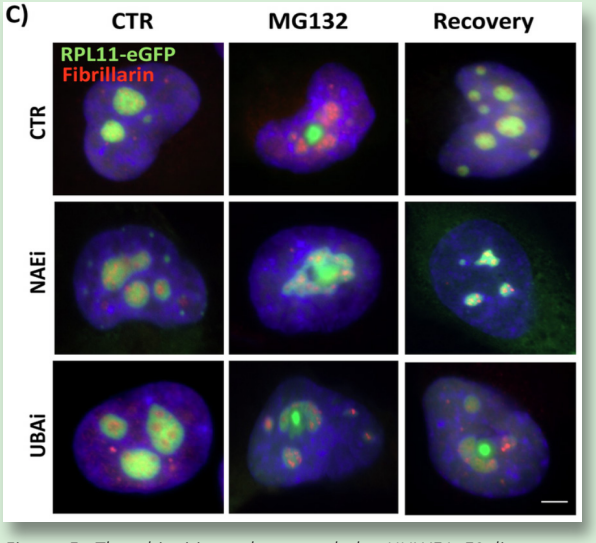


Figure 5. The ubiquitin pathway and the HUWE1 E3 ligase are dispensable for the formation but essential for the elimination of nucleolus-related inclusions. (C) Immunofluorescence merge image of H1299 RPL11-eGFP cells treated with UBAi or NAEi during stress (MG132, 5μM, 15h) or during the recovery period.

Brunello L, Polanowska J, Le Tareau L, Maghames C, Georget V, Guette C, Chaoui K, Balor S, O'Donohue MF, Bousquet MP, Gleizes PE, Xirodimas DP. ***A nuclear protein quality control system for elimination of nucleolus-related inclusions.*** *EMBO J. 2025 Feb;44(3):801-823. doi: 10.1038/s44318-024-00333-9. Epub 2024 Dec 17. PMID: 39690241; PMCID: PMC11791210.*

LIPID METABOLISM IN DIATOMS UNDER NITROGEN STARVATION AND RESUPPLY

Microalgae are photosynthetic microorganisms contributing to around **50% of global primary production** as the main aquatic ecosystems producers. Under the same word, microalgae include a high diversity of genetically and physiologically distant phenotypic group. **One major phylum is the *Stramenopiles***, a vast group that is believed to have arisen through secondary endosymbiosis, *i.e.* after a red alga was engulfed and conserved as a plastid by an heterotroph cell. This peculiar evolutionary origin resulted in a **specific intracellular organization** and a set of **original metabolic pathways** in these organisms, including diatoms. From the metabolic point of view, diatoms possess a **mixture of animal- and plant-like metabolisms** such as the urea cycle and the fatty acid synthesis in the plastid. *Phaeodactylum tricornutum* is a model species frequently used to study lipid metabolism in diatoms.

When exposed to a nutrient limitation or starvation, diatoms are known to **accumulate neutral lipids in cytoplasmic lipid droplets** (LDs). Those lipids are produced partly *de novo* and partly from the recycle of plastid membrane lipids. Under a nitrogen resupply, the **accumulated lipids are catabolized,** a phenomenon about which only a few data are available. Various strains of *P. tricornutum* includind Pt1 and Pt4 have been isolated around the world that may differ in lipid accumulation patterns.

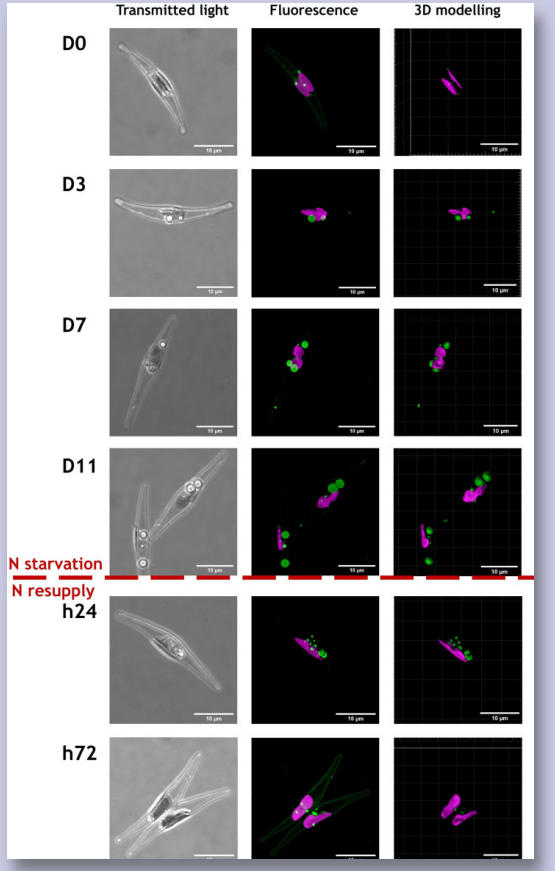


Figure 3 Representative images of cells from Pt4 ecotype during a nitrogen (N) starvation of 11 days followed by a N resupply of 3 days. Chlorophyll autofluorescence (650-700 nm) and Bodipy 505-515 fluorescence (505-550 nm) are displayed in magenta and green, respectively. Cells were selected from an overall number of 26, 24, 27, 26, 28 and 29 cells at respective timepoints from D0 to h72. The scale bar measures 10 µm.

In this work, a combination of cell imaging methods were used to **follow and compare cells** from ecotypes Pt1 and Pt4 experiencing a N starvation and resupply conditions. Nitrogen starvation produced a standby mode where an accumulation of LDs occurs at the expense of the plastid. In this context, **the two ecotypes adopted distinct strategies** regarding the repartition of accumulated lipids between LDs. Additionally, the **extant of lipid accumulation was possibly linked to cell volume** as larger cells contain a larger plastid to be disassembled as a source for neutral lipid production. Finally, when resupplied with nitrogen, **fast recovery was achieved in both ecotypes** through a similar fragmentation process that could be linked to lipophagy.

Altogether, our results **deepen the understanding of LDs dynamics** and open research avenues for a better knowledge of lipid degradation in diatoms.

Murison V, Hérault J, Côme M, Guinio S, Lebon A, Chamot C, Bénard M, Galas L, Schoefs B, Marchand J, Bardor M, Ulmann L. ***Comparison of two Phaeodactylum tricornutum ecotypes under nitrogen starvation and resupply reveals distinct lipid accumulation strategies but a common degradation process.*** *Front Plant Sci. 2023 Sep 22;14:1257500. doi: 10.3389/fpls.2023.1257500. PMID: 37810403; PMCID: PMC10556672.*

VACCINATION STRATEGY THROUGH THE UPPER RESPIRATORY TRACT AND NANOPARTICLES

Intranasal vaccination is an interesting **alternative strategy to intramuscular administration** because it better mimics infection at the mucosal surfaces through which most of the pathogens enter the body. However, **the lack of effective mucosal adjuvant**, **mucosal enhancer**, or **mucosal immune booster** may limit the efficacy of vaccine through upper respiratory tract. In this regard, **nanocarriers**, which are able to associate with, protect, and deliver antigens through the mucosal barrier, are promising. Since cationic maltodextrin-based nanoparticles (NP+) have been successfully used through intranasal instillation, they are now considered as mucosal enhancer of antigenic protein delivery. NP+ loaded with phosphatidylglycerol (NPPG) are **efficient for intranasal vaccination** but n**on-specific to trigger immune cells.**

Here we focused on **phosphatidylserine (PS) receptors**, specifically **expressed by immune cells** including macrophages, to **improve nanoparticle targeting** through an efferocytosis-like mechanism. Consequently, the lipids associated with NPPG have been substituted by PS to generate NP+ with dipalmitoyl-phosphatidylserine (NPPS). Both NPPS and NPPG exhibited similar physical characteristics and intracellular distribution in THP-1 macrophages. **NPPS cell entry was faster and higher** (two times more) than NPPG. Surprisingly, competition of PS receptors with phospho-L-serine did not alter NPPS cell entry and annexin V did not preferentially interact with NPPS. Although the protein association is similar, **NPPS delivered more proteins** than NPPG in cells. On the contrary, the proportion of mobile nanoparticles (50%), the movement speed of nanoparticles (3 µm/5 min), and protein degradation kinetics in THP-1 were not affected by lipid substitution.

Together, the results indicate that NPPS enter cells and deliver protein better than NPPG, suggesting that **modification of the lipids of NP+** may be a useful strategy to e**nhance nanoparticle efficacy for mucosal vaccination.**

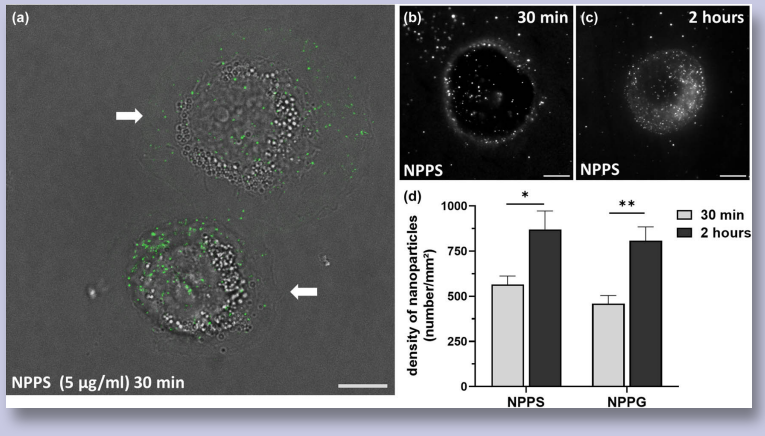


*Figure 3 Internalised nanoparticle imaging in living macrophage-like THP-1 cells. (a) Macrophage-like THP-1 cells were exposed to 5µg/mL of NPPS for 30min and imaged by confocal microscopy (Green, FITC-labelled nanoparticles, maximum projection; Grey, bright field, white arrows indicated lamellipodia edges). Scale bar: 10µm. (b and c) Macrophage-like THP-1 cells were exposed to 5µg/mL of NPPS for 30min (b) or 2h (c) and imaged in a single focal plan at the mid-cell body level by TIRF microscopy. Scale bar: 10µm. (d) Density of nanoparticles within a single focus plane of macrophage-like THP-1 cells through TIRF microscopy are represented as histograms expressing the mean value (±SEM) of a minimum of 7 cells. *p < 0.05; **p < 0.01.*

Brinkhuizen C, Shapman D, Lebon A, Bénard M, Tardivel M, Dubuquoy L, Galas L, Carpentier R. ***Dipalmitoyl-phosphatidylserine-filled cationic maltodextrin nanoparticles exhibit enhanced efficacy for cell entry and intracellular protein delivery in phagocytic THP-1 cells.*** *Biomol Concepts. 2023 Jun 28;14(1). doi: 10.1515/bmc-2022-0029. PMID: 37377352.*

PLANT CELL WALL PATTERNING

Plant cells are surrounded by a **polysaccharide cell wall** that withstands internal cellular pressure but adapts and restructures as the cell expands. In growing pollen tubes, the **proteins RALF4 and LRX8** are required to **monitor integrity of the cell wall.** *Moussu et al.* demonstrated that these proteins **form a complex** with pectic polysaccharides, the gel-like component of the cell wall (see the Perspective by Mohnen). In addition to the roles of RALF4 and LRX8 in signaling to the intracellular environment, the protein-polysaccharide complex performs a **structural role in patterning the cell wall.**

This work contributes to our understanding of **how signaling proteins can react to changes** in the physical state of the extracellular structure.

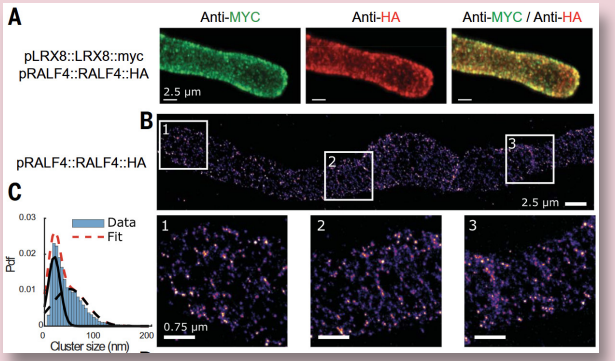


Fig. 2. LRX8, RALF4, and pectin associate in vivo and forma reticulated pattern. (A) Representative immunolabeled pollentube images of a transgenic line expressing LRX8-myc andRALF4-HA under their native promoter in the Col-0 accession. (B) Representative pollen tube dSTORM image of immunolabeled pRALF4::RALF4::HA in Col-0. Bottom: Magnification of thecorresponding squared regions marked in the pollen tube shankshown above. (C) Histogram of RALF4-HA probability densityfunction (Pdf) versus cluster size (blue). Fit of the Gaussianmixture model shows two cluster populations with a mean sizeof 18 nm (monomer 35%) and 47 nm (dimers 65%). A totalof 1137 clusters were analyzed from seven pollen tubes fromfour plants.

Moussu S, Lee HK, Haas KT, Broyart C, Rathgeb U, De Bellis D, Levasseur T, Schoenaers S, Fernandez GS, Grossniklaus U, Bonnin E, Hosy E, Vissenberg K, Geldner N, Cathala B, Höfte H, Santiago J. ***Plant cell wall patterning and expansion mediated by protein-peptide-polysaccharide interaction.*** *Science. 2023 Nov 10;382(6671):719-725. doi: 10.1126/science.adi4720. Epub 2023 Nov 9. PMID: 37943924.*

NR5A2 IS DISPENSABLE FOR ZYGOTIC GENOME ACTIVATION BUT ESSENTIAL FOR MORULA DEVELOPMENT

After fertilization, mammalian embryos rapidly **activate gene expression** to specify the cell types that support implantation and form all of the tissues in the body. **The factors preparing the cells** in a mouse embryo to take on different lineages are not well understood. *Festuccia et al.* showed that the **orphan nuclear receptor NR5A2** performs successive roles in this process. First, NR5A2 participates in **activating the embryonic genome.** Then, in the eight-cell morula stage, NR5A2 performs its main role, **coordinating the expression of factors** responsible for specifying distinct lineages and genes ensuring housekeeping functions. This role is essential, and **in the absence of NR5A2, development derails.**

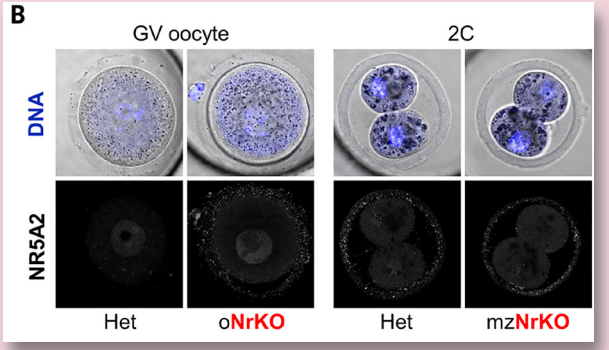


Fig. 1. Preimplantation development does not require maternal NR5A2 and ESRRB. (B) (Top) Immunofluorescence analysis for NR5A2 in controls and oNrKO germinal vesicle (GV) oocytes, maternal and zygotic Nr5a2 KO (mzNrKO) embryos at the 2C stage

Festuccia N, Vandormael-Pournin S, Chervova A, Geiselmann A, Langa-Vives F, Coux RX, Gonzalez I, Collet GG, Cohen-Tannoudji M, Navarro P. ***Nr5a2 is dispensable for zygotic genome activation but essential for morula development.*** *Science. 2024 Oct 4;386(6717):eadg7325. doi: 10.1126/science.adg7325. Epub 2024 Oct 4. PMID: 39361745.*

PLANT BIOLOGY TOULOUSE

EXPLAIN THE REPRESSION OF MICROBE-TRIGGERED IMMUNITY (MTI) OBSERVED DURING VVLYK6 OVEREXPRESSION BY A POSSIBLE INTERACTION BETWEEN VVLYK6 AND THE FUNCTIONAL CO-RECEPTOR VVLYK1-1.

Botrytis cinerea, a major **pathogenic fungus affecting grapevines** (*Vitis vinifera*), significantly impacts wine yield and quality. **Identifying the genes involved in vine-pathogen interaction** is therefore crucial for **developing more resistant varieties**, which represents a strategic challenge for viticulture.

During a fungal attack, **plants detect pathogens via receptors called PRRs** (Pattern Recognition Receptors), located on the plasma membrane. These PRRs recognize conserved molecular patterns (MAMPs), triggering immune responses. Among them, **LysM-type receptors** play a key role in recognizing fungal elements such as **chitin**. A new LysM receptor, named **VvLYK6**, has been identified in grapevines as being **strongly induced during infection** by *B. cinerea*. To understand its function, overexpression experiments were conducted in *A. thaliana* and grapevine cells. Contrary to expectations, **overexpression of VvLYK6** led to a **reduction in immune responses**: decreased MAPK activation, defense gene expression, callose deposition, and increased susceptibility to fungal pathogens.

These results indicate that VvLYK6 acts as a **negative regulator** of chitin-induced defenses, suggesting that it may be a **susceptibility gene** rather than a resistance gene.

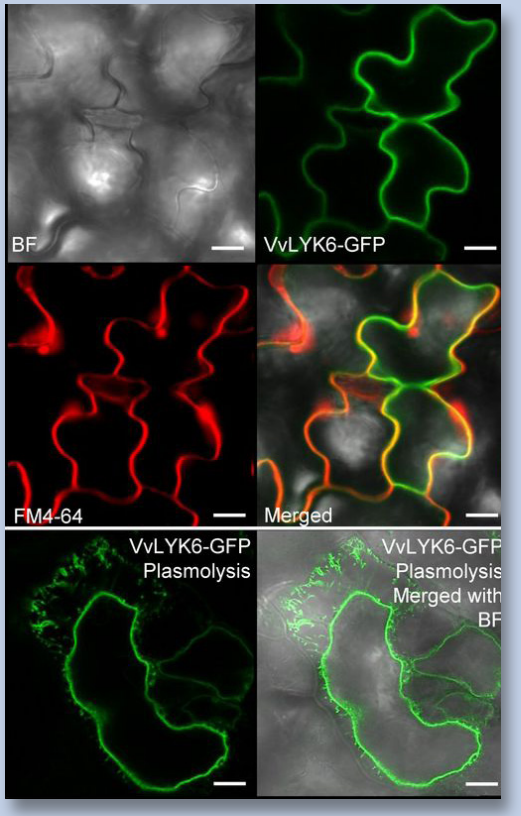


Figure 2C Subcellular localization of VvLYK6 in A. thaliana leaves. GFP-tagged VvLYK6 in leaf segments of A. thaliana co-localizes with the plasma membrane marker probe (FM4-64). Plasmolysis of plant cells expressing VvLYK6 tagged with GFP reveals that the GFP signal does not localize to the cell wall. Scale bars represent 20 µm. Similar localization was observed in three independent lines. BF = Brightfield.

This discovery has a significant impact: **instead of strengthening immunity, VvLYK6 weakens it.** This calls into question its role in the vine's natural defense strategy and opens up new perspectives for breeding programs.

Preprint: J. Villette, T. Marzari, D. Landry, T. Roudaire, A. Klinguer, N. Leborgne-Castel, C. Vicedo, V.Gasciolli, C. Pouzet, B. Lefebvre, M.C. Héloir, B. Poinssot, **The Vitis vinifera receptor VvLYK6 negatively regulates chitin-triggered immune responses and promotes fungal infections***, bioRxiv 2025.06.06.658283, doi.org/10.1101/2025.06.06.658283*

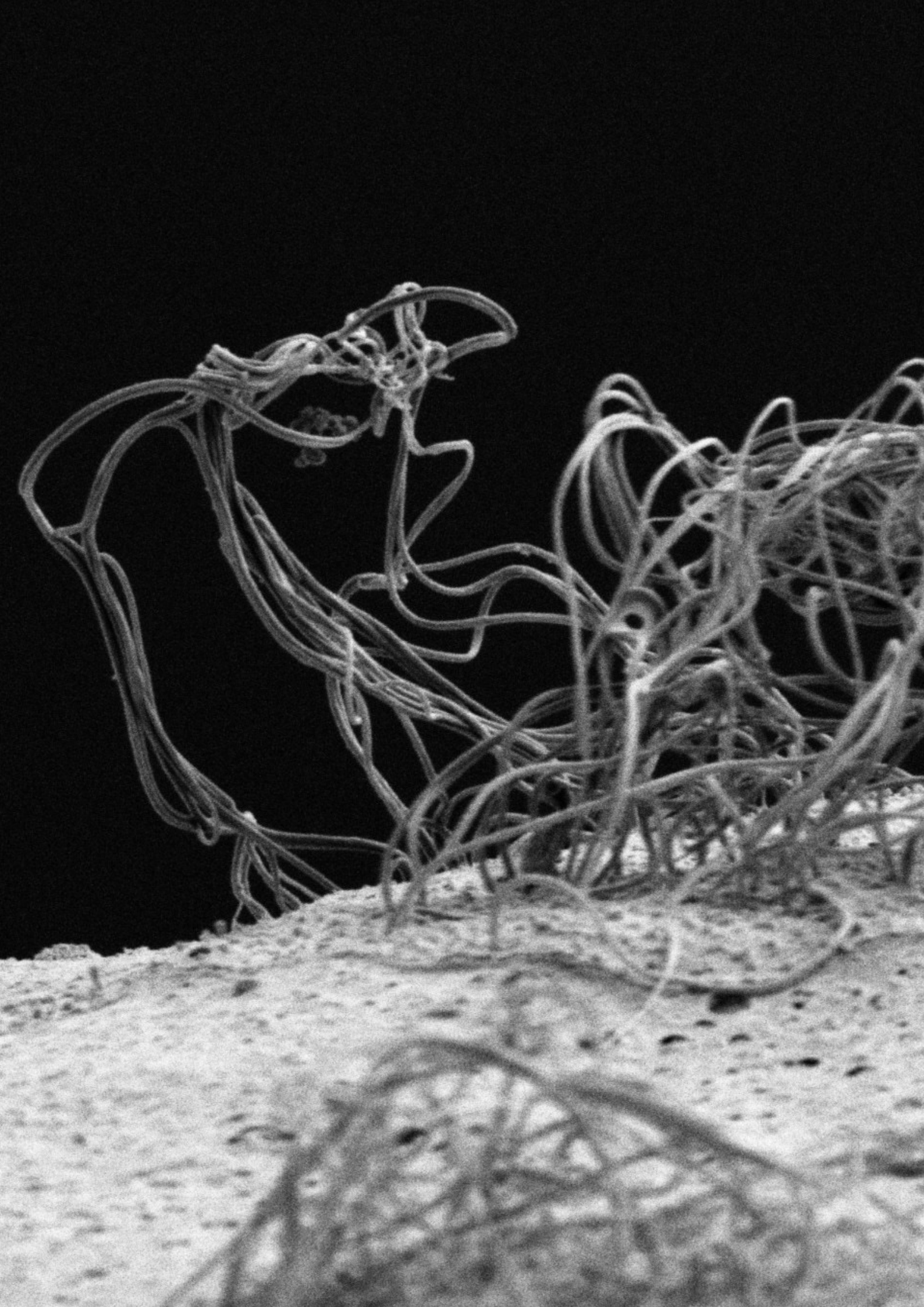
HOST-PATHOGEN INTERACTIONS
IPDM

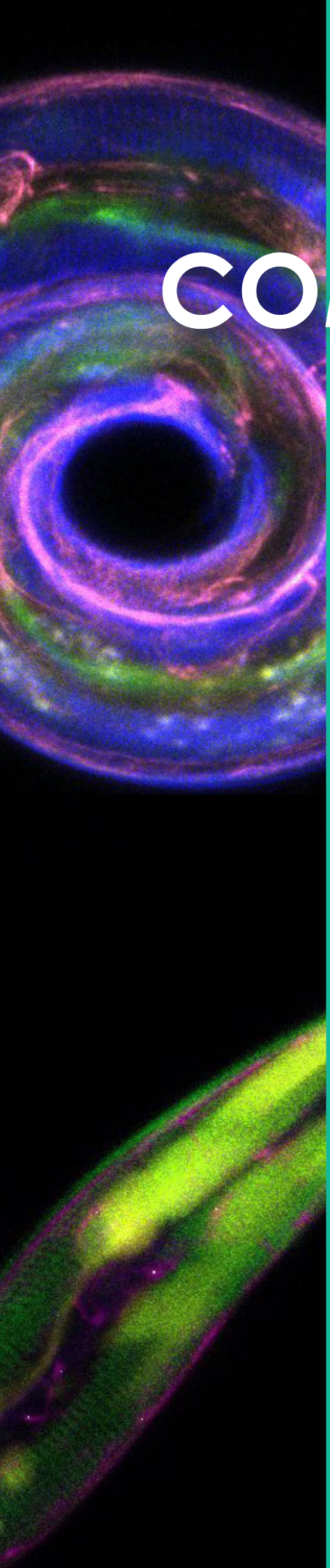
FEASIBILITY STUDY ON MULTI ANIMAL TRACKING TOOLS ON NON-TAGGED INDIVIDUALS

In vivo animal models remain indispensable for studying host-pathogen interactions in aquaculture, as they capture the complexity of biological processes beyond what can be achieved with cell culture, organoids or zebrafish larvae. Rainbow trout is a key species for **investigating viral and bacterial infections and monitoring animal welfare** is a central concern in these studies. Behavioural variables such as swimming speed, inter-individual distances or spatial distribution can serve as early and measurable indicators of stress or disease, provided they are detected with sufficient sensitivity and precision.

This feasibility study, **supported by the Animal Health department of INRAE**, focused on evaluating the potential of recent academic image analysis tools to **address the challenge of long-term multi-animal tracking.** Dedicated experimental setups were designed to record rainbow trout behaviour under standard and infected conditions. Candidate tracking methods were systematically benchmarked against ground truth data, using metrics from the Single Particle Tracking challenge. This systematic evaluation provided a **robust comparison of approaches** and allowed **the identification of the most effective solutions** for detecting behavioural changes at the individual level within a group.

The preliminary results demonstrate that **advanced tracking tools can improve the accuracy and reliability** of behavioural monitoring in aquaculture, enabling earlier identification of stress or pathological signs. These findings formed the basis of **a collaborative grant proposal with the IPDM node,** aimed at developing dedicated **multi-animal tracking solutions for infectiology studies.** By combining high-quality behavioural data with innovative analysis pipelines, this project seeks to strengthen research capacities in animal health and contribute to improved monitoring and welfare of aquaculture species.





COMMUNICATION

According to the actions led last years, France-BioImaging has pursued its communication strategy to:

- **Develop its visibility** along the scientific community,
- **Bring together the platform** and R&D team's staff members of the infrastructure.

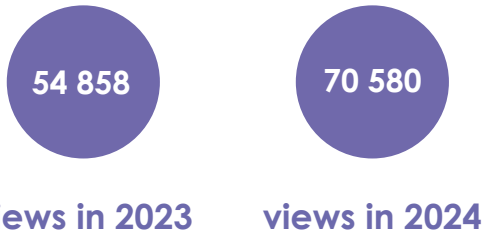
France-BioImaging's objectives are now to **maintain its position and strengthen links** it has created with its communities.

FBI website

Those last two years mark a turning point in communication on France-BioImaging's website with the views **increasing by 45% between 2022 and 2023**. This trend lasts in 2024 with a number of user **acquisition still growing.**

Multiple types of content are posted on the website and are in tune with infrastructure's communication strategy:

- **Share of news and activities** of the infrastructure and nodes (core facilities and R&D teams) to bring together our members;
- **Highlight of our members research work** by posting popularized articles of scientific publications to demonstrate their expertise and the impact of bioimaging on scientific community;
- **Share job offers, open calls, etc...** to boost the visibility and the attractivity of France-BioImaging.

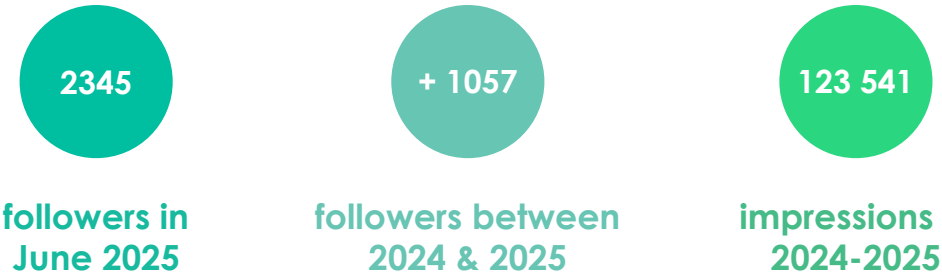


Social networks

LINKEDIN

After two years of regular publications, France-BioImaging has **built a strong community on LinkedIn**, which became the **main social network** of the infrastructure. LinkedIn is a strong tool for France-BioImaging to **develop its visibility** among different scientific communities, **establish its expert role** in bioimaging or even **target industrial audiences.** After experiencing a dynamic loss in 2024 mid-year, France-BioImaging rebounded with the new communication assistant who enabled the account to regain dynamism.

Types of posts turn around main topics: events, valorization, opportunities, news.



X (TWITTER)

France-BioImaging X account (formerly Twitter) knew a **strong decrease of all the performance indicators** following the buyback by Elon Musk and USA elections in November 2024. These events led to **scientific communities migration to other social networks.** Therefore, X became a **secondary social platform f**or France-BioImaging. However, we keep posting regularly to maintain an activity because we **still have a huge community on X.**

X is more used to **post "live" content**, for instance in live from trade shows or during our events.

followers in June 2025

followers between 2024 & 2025

impressions in 2024-2025

BLUESKY

France-BioImaging launched its account on Bluesky in December 2024, following the **departure of many scientists of X to this platform.** Our objective is to **reach these scientific communities** by continuing the strategy we had on X. After a rapid start, the **growth of the France-BioImaging account is stabilising.**

followers in June 2025

Annual Meetings

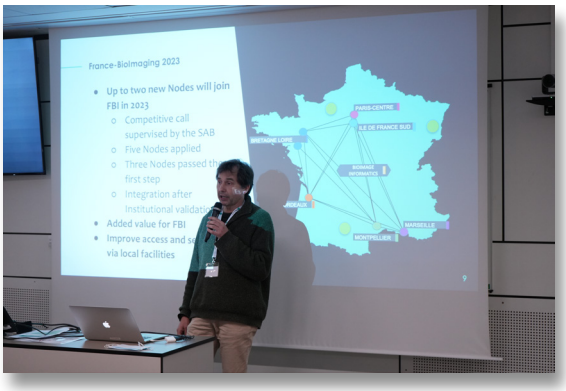
In 2023 and 2024, Annual Meetings took place in two nodes recently integrated in France-BioImaging:

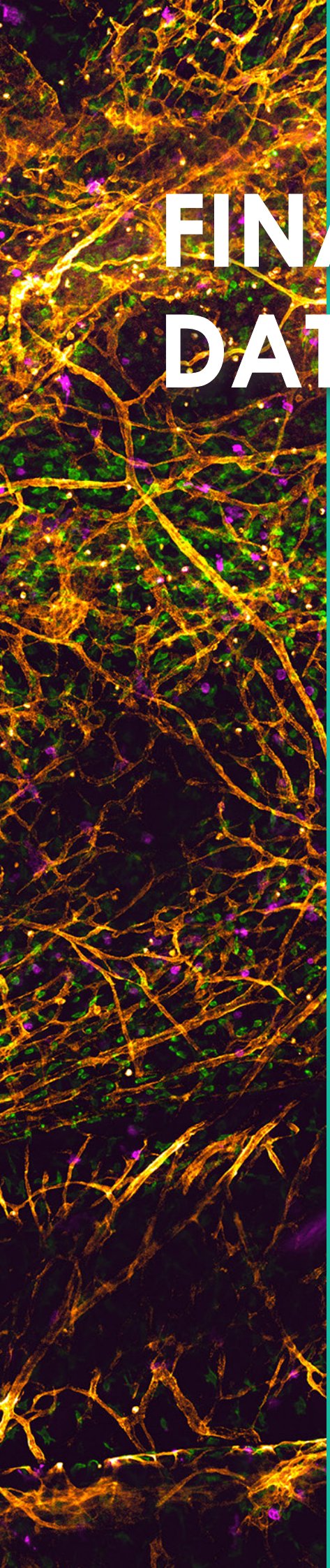
- **Toulouse** in 2023,
- **Alsace (Strasbourg)** in 2024.

FBI Annual Meeting 2023 was focused on **"Multiscale mechanobiology of cells and cell systems"**, a topic specially selected for being one of Toulouse node's expertise.

FBI Annual Meeting 2024's topic was on **"Live Functional Imaging: From Chemical Synthesis of Probes to Instrumentation"**, one of the research areas of Alsacian node.

These two last editions allowed new nodes to **show off their expertises and research work** to the France-BioImaging community. Moreover, they are a great opportunity for our members to **discuss our infrastructure's future** and more widely the **bioimaging development in France.**

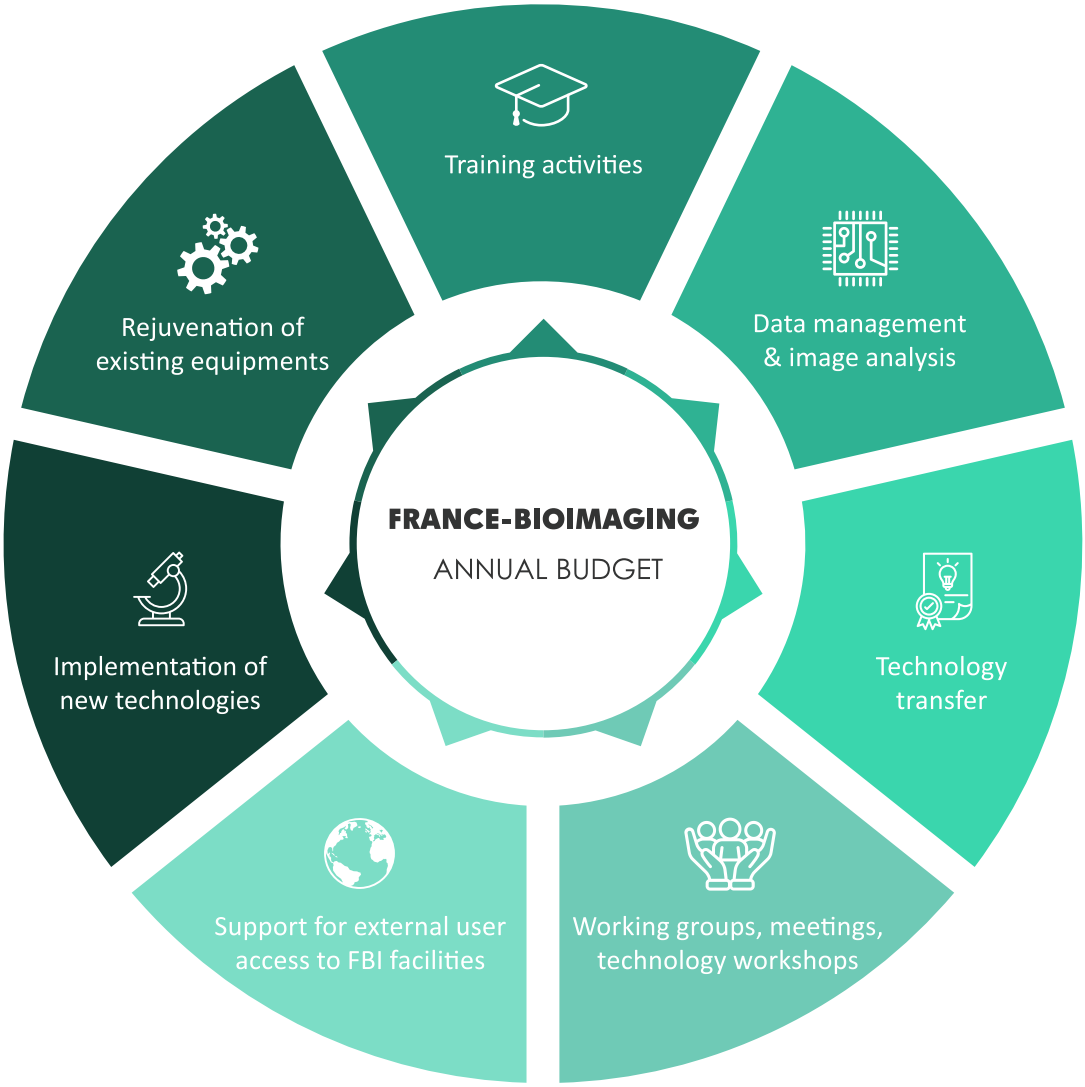




FINANCIAL DATA

FBI is funded by the **Programme d'Investissements d'Avenir** (PIA) since 2012 (grant Agence Nationale de la Recherche, number ANR-10-INBS-04, 26M€). Successfully evaluated in 2019 by the ANR, the **additional funding** (3,2M€) allows the **development of new projects** for the 2020-2024 period. In 2024, France-BioImaging was the **laureate of new funding (9,2M€)** for the 2025-2030 period.

The main funding actions planned are:



Partner institutions

CNRS
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Aix-Marseille Université
Institut Pasteur
Inria
Institut d'Optique Graduate School
Université de Bordeaux
Généthon
Université de Montpellier
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Université Claude Bernard Lyon 1
Université de Rouen
Université de Caen Normandie
Université Le Havre Normandie

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