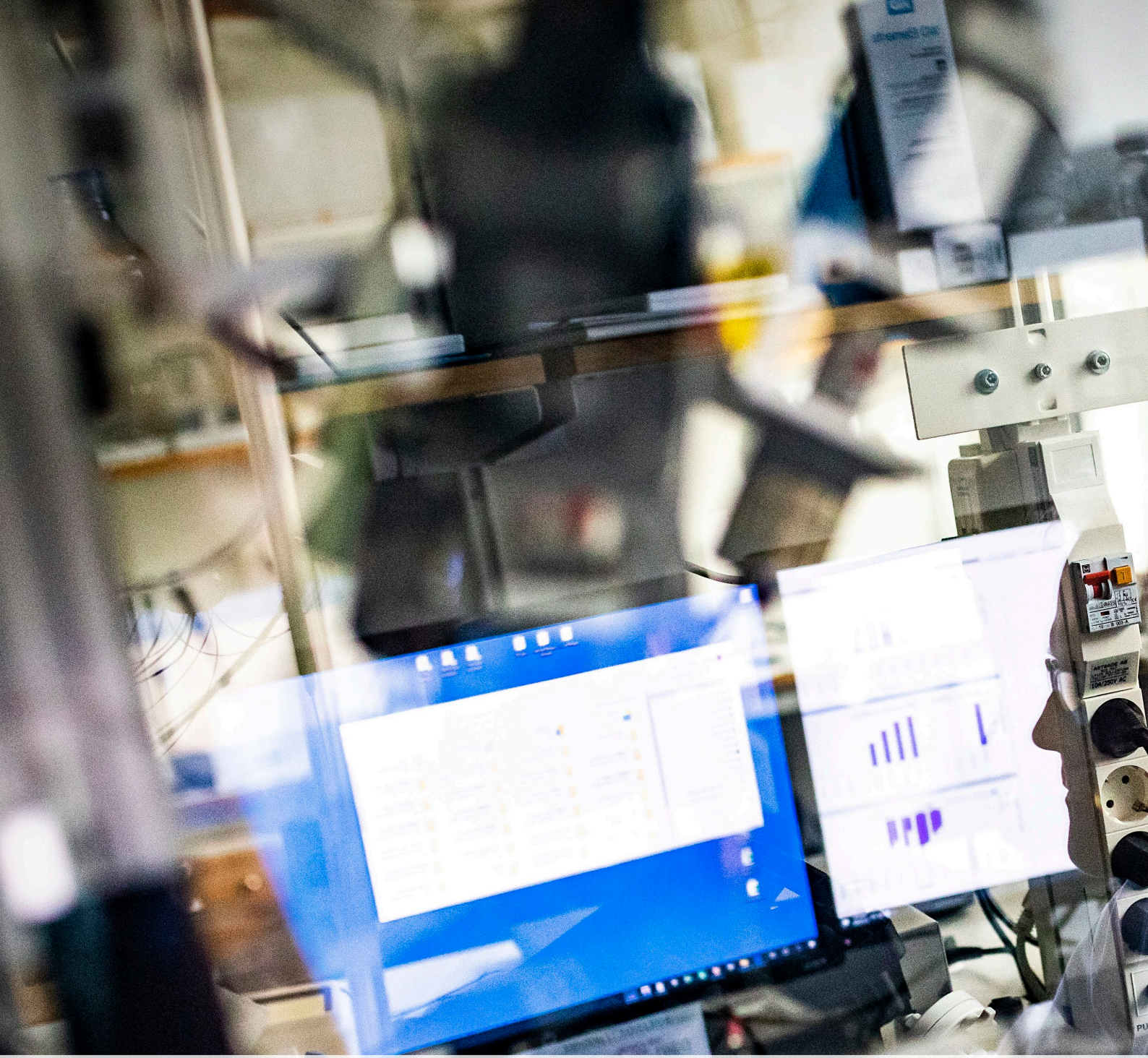
Swedish Metabolomics Centre



The Swedish Metabolomics Centre (SMC)

The Swedish Metabolomics Centre (SMC), located at the Umeå Plant Science Centre (UPSC), is a leading national facility specializing in mass spectrometry–based metabolite analysis.

Originating from pioneering work in plant hormone analysis at SLU in Umeå during the 1990s, SMC was established as a national service and knowledge centre in 2012 through a major grant from the Knut and Alice Wallenberg Foundation (KAW).

Since 2016, it has operated as a national unit within the Science for Life Laboratory (SciLifeLab, Metabolomics and Exposomics Platform). Today, SMC employs around eight full-time staff scientists - most with PhD-level training - supported by postdoctoral researchers focused on method development and innovation.

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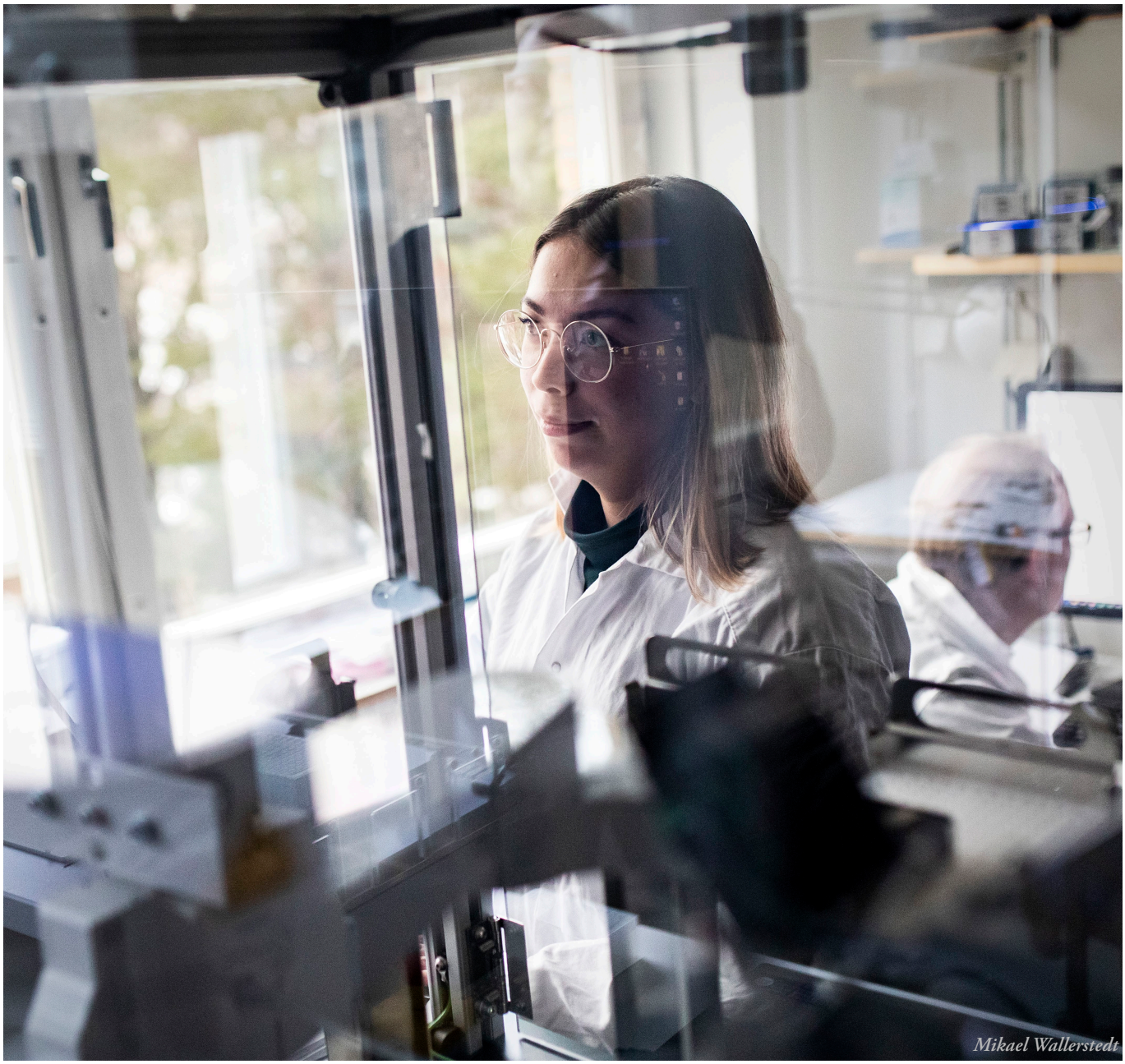
Organization and operations

The Swedish Metabolomics Centre (SMC) is a joint collaboration between the Swedish University of Agricultural Sciences (SLU) and Umeå University (UMU). The host department is the Department of Plant Physiology at Umeå University. SMC functions as a single, integrated unit with shared laboratory facilities and staff employed by both universities. The centre is jointly co-funded by SLU and UmU.

Governance and decision-making at SMC are led by the Head of Unit, Annika Johansson, who holds overall responsibility for operations, strategic direction, and finances. She works in close collaboration with the Platform Scientific Director, Professor Johan Trygg (UMU), and the Heads of Department at Umeå University and SLU. Strategic and scientific development is further supported by an R&D team composed of principal investigators from Umeå University, SLU, and the University of Copenhagen. This group represents a broad range of disciplines—including plant biology, medicine, analytical chemistry, computational methods, and environmental science—and contributes to identifying methodological needs, initiating new developments together with SMC staff, and guiding the integration of novel techniques into the service portfolio.

At the national level, within the SciLifeLab Metabolomics and Exposomics Platform, SMC is also advised by an International Scientific Advisory Group that provides external perspectives on scientific quality, strategic priorities, and alignment with user needs. Within the SciLifeLab Metabolomics platform, Annika Johansson serves as Platform Coordination Officer (20%), and Johan Trygg has served as Platform Director since 2023.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Structure and Available Services

SMC is organized into three operational components: a full-service platform, a collaborative development track for projects requiring extensive method development, and an Open Access laboratory where users can independently access mass spectrometry instruments. The Open Access lab enables Swedish researchers to perform or participate directly in their own analyses, supporting capacity building, hands-on training, and knowledge exchange.

For more than ten years, SMC (Umeå) has operated as a national infrastructure with a strong focus on prospective and functional discovery studies. Over this period, the centre has developed unique expertise in rapidly developing and adapting analytical methods to suit individual projects across a broad spectrum of scientific domains, research questions, sample matrices, and sample types (e.g., plasma, cells, bacteria, plants, tissues). Projects typically involve between 20 and 500 samples and often begin with small- or medium-scale experimental sets that address specific questions in biology, biotechnology, or medicine.

SMC offers a comprehensive service portfolio, including:

- **Untargeted and targeted metabolite and lipid profiling** for small to large sample cohorts.
- **Quantitative metabolite panels**, covering TCA cycle intermediates, free and bound fatty acids, and plant phytohormones.
- **Method development support**, tailored to the specific needs of individual users.
- **Extended metabolite identification and substance confirmation.**
- **Downstream data processing and biological interpretation**, carried out in close collaboration with users.

In full-service projects, SMC receives samples in an agreed format and performs all steps of the workflow, including metabolite extraction, mass spectrometry analysis, data preprocessing, and reporting. Users receive results in a format that can be directly translated into biological insight. For service-based projects, the centre is acknowledged in resulting publications. User fees for full-service projects are calculated according to a transparent full cost model that includes instrument-related costs (rent, service contracts, and gas supply), personnel time, and consumables. With financial support from KAW, SciLifeLab, and university co-funding, instrument and personnel costs are partially subsidised. As analytical packages vary substantially between projects, total costs are calculated on a project-by-project basis. Academic users typically pay approximately 45% of the full cost, while industry users are charged the full cost. Projects requiring extensive method development or deeper scientific involvement are executed as collaborative projects. In these cases, instrument costs are charged to the PI, whereas personnel time is provided free of charge. SMC staff contributing to such projects are included as co-authors on resulting publications.

The **Open Access Lab** allows researchers to rent and use the instrument park; each year approximately 15 PIs and about 25 active Open Access users—mainly from the Umeå area (SLU and UmU)—engage with these facilities. A bookable laboratory bench enables users to perform their own metabolite extractions using SMC's equipment and workflows. Open Access users are expected to acknowledge the centre for instrument access and technical support.

SMC Budget 2025

	Costs (kSEK)
Personnel (UmU + SLU)	8000
Running costs (consumables, service contracts etc.)	4300
Rent	600
Instruments (depreciation)	1600
Sum Cost	14500
	Income (kSEK)
KAW	5000
SciLifeLab	2500
University Co-funding (UmU + SLU)	3000
User fees	4000
Sum Income	14500

Performance 2021–2025

Between 2021 and 2025, the Swedish Metabolomics Centre (SMC) continued to strengthen its position as one of Sweden's most important national infrastructures for metabolomics. Through sustained analytical excellence, method innovation, community engagement, and strong national coordination, SMC consistently supported around one hundred full-service projects annually. Its work spans human, microbial, plant, and environmental research, illustrating the broad applicability of mass spectrometry–based metabolomics across the life sciences. Over these five years, the centre expanded its technological capabilities, deepened its computational capacity, contributed to high-impact scientific publications, and reinforced its role in Open Science and national preparedness initiatives.

Users

Since its inception, SMC has built a broad and diverse user base covering all major universities and research institutes in Sweden (Figure 1). The principal investigators represent a wide range of disciplines, including cell and molecular biology, microbiology, plant physiology, medicine, and ecology.

Over the past four years, the number of international users has increased markedly. Much of this growth is attributable to the plant hormone profiling methods originally developed by the research group of Professor Karin Ljung, and subsequently modified, streamlined, and implemented by SMC. For the past three years, these phytohormone panels have been offered as a fee-for-service to users worldwide and have rapidly gained international recognition.

SLU and Umeå University remain the primary users of the centre. However, this is partly influenced by the inclusion of Open Access users—who are predominantly local PIs—in the total numbers. Importantly, more than half of SLU's users originate from outside Umeå, reflecting SMC's national reach.

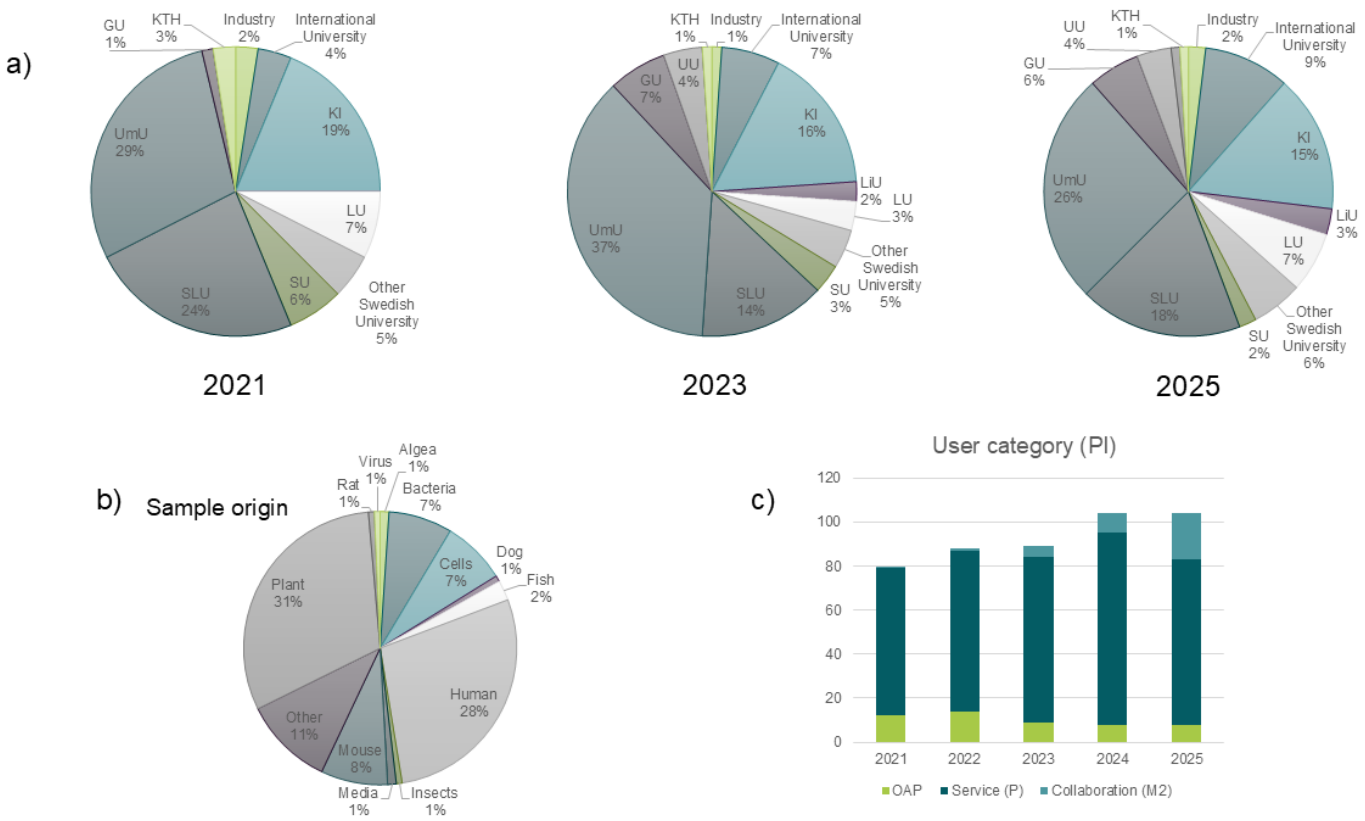


Figure 1. User base: Individual PIs at SMC, 2021–2025.
(a) The user base is geographically well distributed across Sweden, with a steady increase in the number of PIs over the period (2021: 80; 2022: 88; 2023: 92; 2024: 104; 2025: 104). (b) Sample origin distribution, showing the broad range of research areas served by SMC (finalized projects 2021–2024; n = 291). (c) User category distribution (individual PIs). Approximately 10% of users access SMC via Open Access, while the proportion of collaborative projects increased following a strategic shift in 2022.

Technological Development

Between 2021 and 2025, SMC continuously improved its service capacity, analytical workflows, and data-processing pipelines. A major focus in the early part of this period was the expansion of targeted metabolite analysis. SMC developed and launched multiple new targeted LC-MS/MS assays in response to user demand, including panels for glycoalkaloids, mycotoxins, bacterial signaling compounds, and carboxylic acids. Key achievements include the quantification of TCA cycle intermediates in as few as 10,000 cells (Hodek et al., J. Chromatogr. B, 2023; DOI: 10.1016/j.jchromb.2023.123719).

Method development continued in 2024 with the establishment of targeted LC-MS/MS panels for catecholamines and steroid hormones - analytically challenging due to their very low abundance in biological matrices.

Technological innovation was a consistent theme throughout 2021–2025. The Bravo Automated Liquid Handling Platform was fully implemented for plasma and media extractions, including automated derivatization of amino acids and carboxylic acid. Microsampling and miniaturized workflows were validated, enabling the quantification of metabolites in extremely small sample volumes - for example, phytohormones in tomato phloem sap collected using microsamplers.

In 2025, SMC expanded its technological development trajectory by evaluating the BeatBox® automated homogenization system. This platform supports parallel homogenization of 96 tissue samples and represents an important step toward fully automated, high-throughput sample preparation. To support acquisition of this capability, an application was submitted (January 2026) to the Umeå University mid-range equipment call to fund a BeatBox system.

Scientific Highlights

SMC's scientific impact across 2021–2025 was substantial. The center was acknowledged or co-authored in 35, 36, 37, and 31 publications in 2021, 2022, 2023, and 2024, respectively, and continued this strong publication trend in 2025 through contributions to several high-profile studies. These included investigations into:

- sex-specific metabolic responses to polypharmacy in Alzheimer's disease models,
- metabolic resilience to severe NAD^+ depletion in skeletal muscle, and
- development of ultrasensitive analytical methods enabling the creation of nearly SGA-free potato mutants, with major implications for food safety and industrial processing.

Across these years, SMC's scientific contributions spanned plant senescence and stress physiology, metabolic disease mechanisms, microbial interactions, exercise physiology, neuroprotection, and a broad suite of biomedical and environmental metabolomics applications.

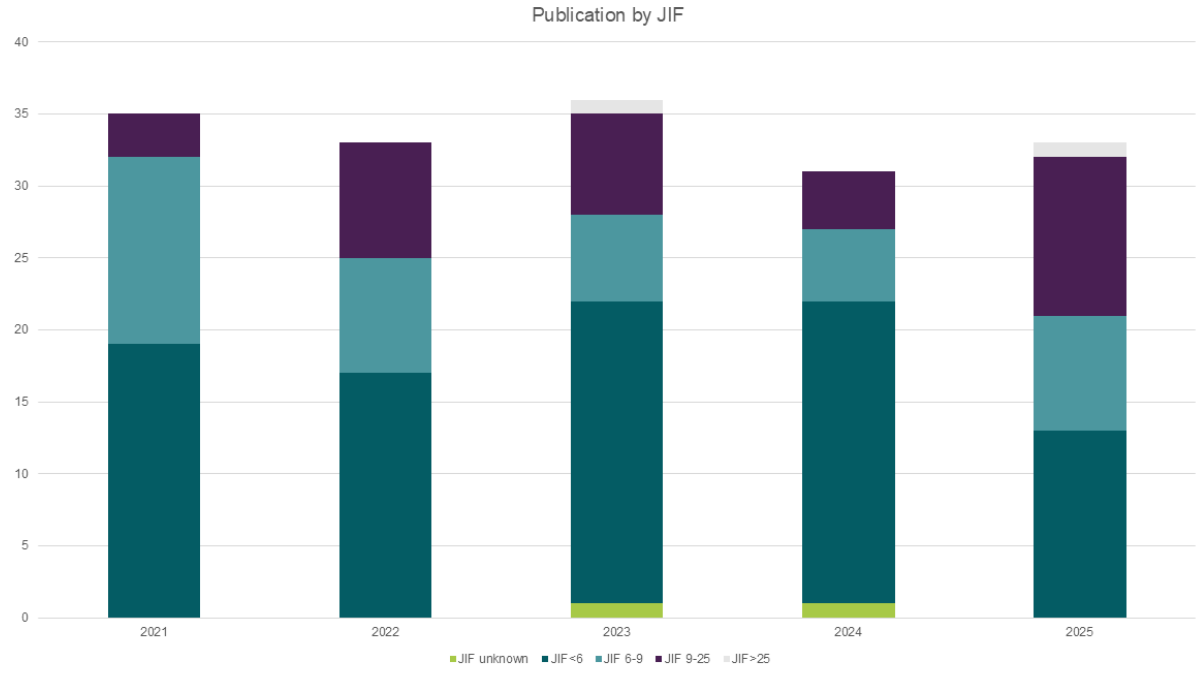


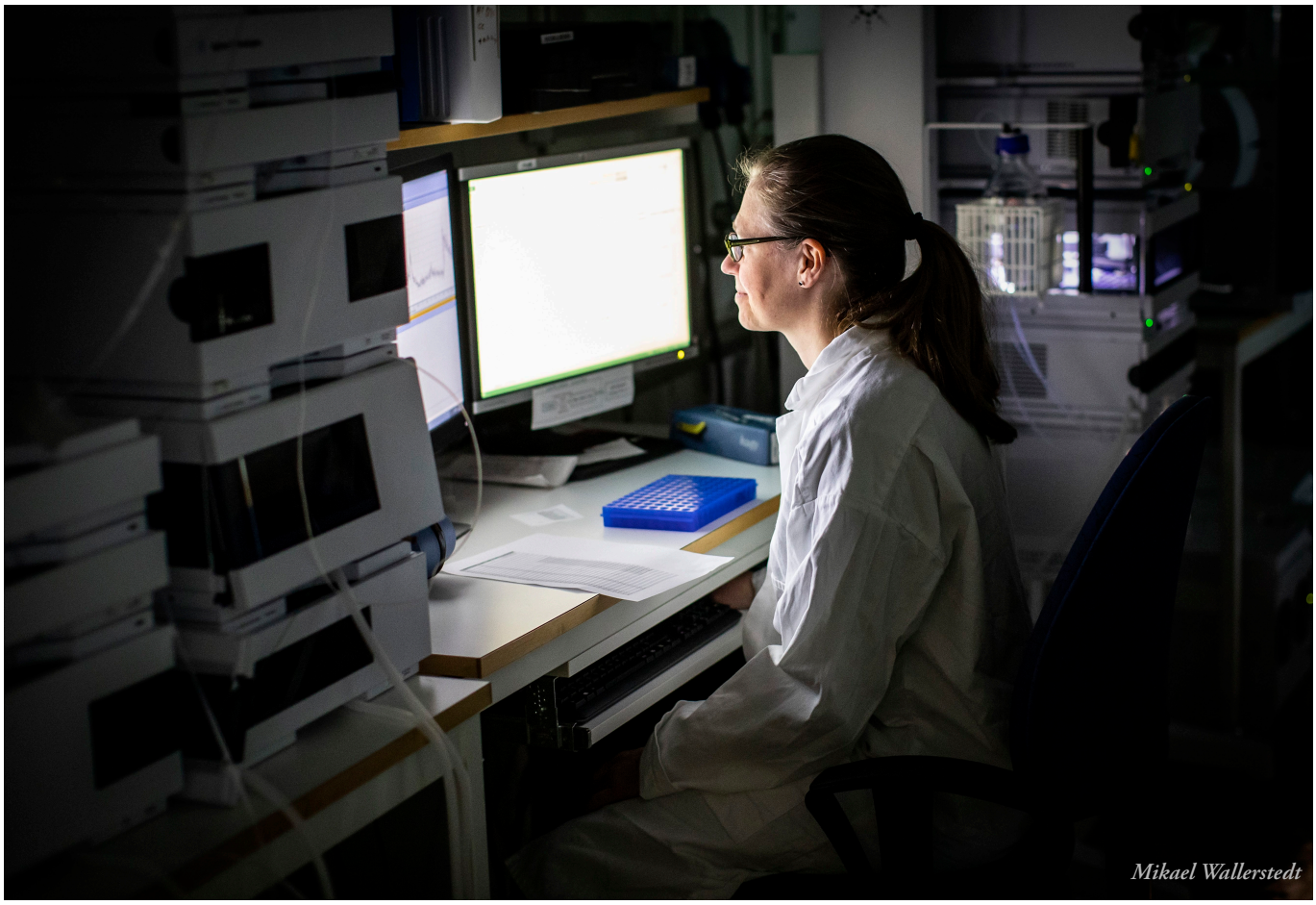
Figure 2: Publications by SMC, 2021-2025, categorized according to the Journal Impact Factor (Clarviate).

SciLifeLab International Evaluation in 2024

In 2024, SciLifeLab conducted a major evaluation of its national infrastructure. The International Evaluation Committee (IEC) delivered a highly positive assessment of the Metabolomics platform and SMC's performance, describing it as a nationally and internationally well-connected, state-of-the-art facility that plays a central role within SciLifeLab's infrastructure.

The evaluators highlighted several key strengths: the scientific quality and innovation of SMC's analytical portfolio; its strong national coordination; its successful integration with other SciLifeLab units such as the Swedish NMR Centre and NBIS; and its leadership in FAIR data management and user training. SMC also demonstrated high scientific visibility, achieving 14.5 publications per FTE between 2021 and 2023—ranking second within the SciLifeLab community—and maintaining a stable user base with approximately 35–40% cost recovery.

The establishment of the SciLifeLab Computational Metabolomics Group in 2024, consolidating all computational expertise working with metabolomics data, was recognized as an important strategic development and a strong foundation for future AI- and machine learning–driven metabolomics interpretation.



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Future developments of the service portfolio

Targeted panels.

A major development focus will be the implementation of methods enabling broad-scale metabolome coverage using targeted analysis panels. These panels will allow confident identification and quantification of hundreds to thousands of metabolites in a single run. Between 2021 and 2025, SMC developed HILIC-LC-MS methods suitable for both untargeted profiling and targeted analysis of several unstable key metabolites, such as ATP/ADP, NAD/NADH, and other phosphate-containing compounds. These targeted panels are continuously being expanded to build a broad quantitative platform for polar metabolites. Future technological development will include extending targeted panels for low-abundance metabolites that require dedicated analytical workflows and, in some cases, pre-purification or concentration steps ahead of MS analysis.

Fluxomics

SMC will continue to advance mass spectrometry–based flux tracer and stable isotope incorporation studies ("fluxomics"), enabling the elucidation of metabolic pathways and reaction kinetics. This work will be carried out in collaboration with researchers at UPSC and the group of Professor Thomas Moritz at the University of Copenhagen. Once a robust mass spectrometry protocol and refined data-handling pipelines are established, the aim is to offer flux tracer analyses as a fee-for-service option or within collaborative project frameworks starting in 2025/2026.

A major achievement within this development area was the successful securing of funding for a new high-resolution GC-MS system through the SciLifeLab Expensive Instrument Call 2025. Procurement will begin shortly, and the instrument is planned for installation during 2026. This system will significantly strengthen SMC's capabilities in fluxomics and metabolite identification, particularly for compounds requiring high mass accuracy and chromatographic resolution.

Metabolite identification

Metabolite identification remains a major challenge in metabolomics, particularly within the Planetary Biology domain. For example, the plant kingdom alone is estimated to contain more than 250,000 specialized secondary metabolites, and many microorganisms also produce strain- or species-specific compounds that remain uncharacterized. To help address this challenge, SMC is collaborating with microbiology teams to investigate selected bacterial strains through their metabolite profiles.

This initiative aims to establish an open-access database of MS/MS spectra and retention times for both known and yet-unidentified metabolites—strengthening future identification efforts across plant, microbial, and environmental metabolomics. A newly recruited postdoctoral researcher, funded by the Novo Nordisk Foundation, is leading much of this work. This position represents the second postdoctoral collaboration between the University of Copenhagen (through Novo Nordisk Foundation support) and SMC, further deepening the partnership and expanding expertise in microbial and comparative metabolomics.

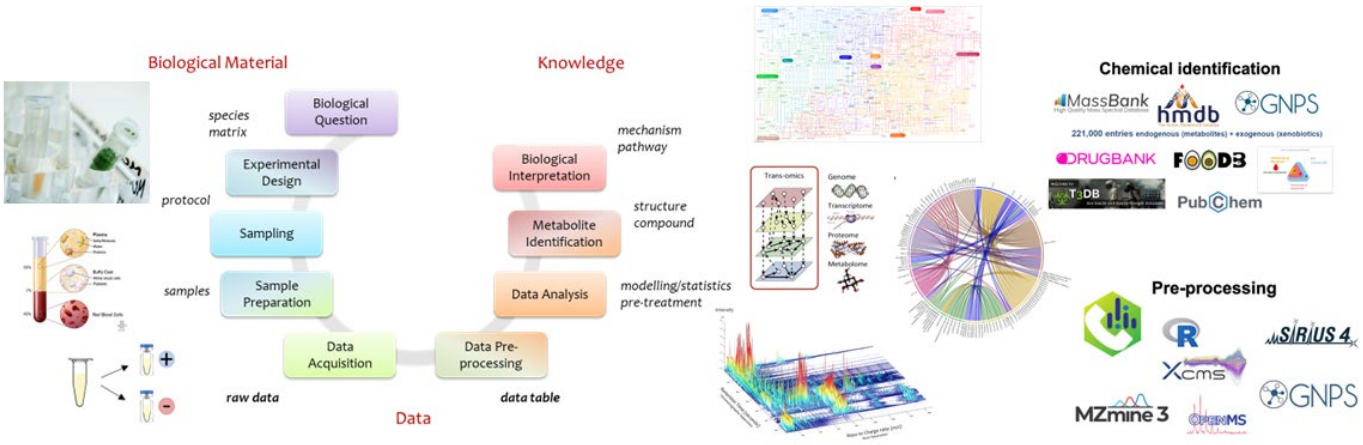

Figure 3: Metabolomics workflow - Overview of a mass spectrometry–based metabolomics workflow, from experimental planning and sample preparation to data acquisition, preprocessing, metabolite identification, and biological interpretation.

Transfer of Knowledge and Outreach

SMC's community engagement has been substantial throughout the period. In 2024, the centre co-organized two major scientific events in Umeå: the "Metabolomics in Life Sciences" conference and the "Metabolomics in Molecular Medicine" symposium. In 2025, SMC further strengthened its leadership in Open Science by co-organizing the "Current Trends in Applied Mass Spectrometry" event in Umeå. This meeting included hands-on training workshops—developed in partnership with EMBL-EBI and the Umeå University Library—focused on FAIR-compliant data submission to the MetaboLights repository.

Building on the strong outcome of the 2024 “Metabolomics in Life Sciences” conference, a second edition was held in late January 2026. The meeting attracted keynote speakers from major European research centres and featured a broad scientific programme covering multiple application areas within metabolomics, reflecting continued community interest and engagement.

In 2022, the Head of Unit, Annika Johansson, initiated a Mass Spectrometry Community in Umeå, bringing together individuals working with mass spectrometry across the region. Participants represent both universities, the university hospital laboratory, the Swedish Defence Research Agency (FOI), and several local companies. The inaugural full-day meeting featured presentations from all participating sites, covering a broad range of mass spectrometry applications—including metabolite and protein analysis, chemical warfare agents, environmental pollutants, and highly specialized clinical assays. A substantial portion of the day focused on small-group workshops designed to build community, increase collaboration, and facilitate knowledge exchange among Umeå-based mass spectrometry practitioners.

Since this first gathering, two major follow-up events have been held, during which the community brought together all major mass spectrometry vendors in Umeå to showcase their latest technologies. These meetings have significantly strengthened the local mass spectrometry ecosystem and fostered new interactions across academic, clinical, governmental, and industrial sectors.

In addition, SMC broadened its societal impact through a deepening collaboration with FOI. Using untargeted metabolomics, SMC supported FOI in identifying metabolic signatures associated with cellular irradiation. This collaboration expanded into a series of three projects and contributes to the development of rapid, non-invasive detection strategies for hazardous exposures, thereby supporting national preparedness efforts.

Swedish Metabolomics Centre

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SciLifeLab

UMEÅ UNIVERSITY

SLU SWEDISH UNIVERSITY OF AGRICULTURAL SCIENCES

Umeå Plant Science Centre

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