CURRICULUM VITAE ABREVIADO (CVA)

Fecha del CVA	12.08.2024

Part A. PERSONAL INFORMATION

First name	Manuel		
Family name	Ferrer		
Gender (*)	MALE	Birth date	15/10/1971
ID number	34856593R		
e-mail	mferrer@icp.csic.es	URL Web	https://www.sysbio.csic.es/
Open Researcher and Contributor ID (ORCID) (*)	0000-0003-4962-4714		

(*) Mandatory

A.1. Current position

Position	Research Professor		
Initial date	16.02.2021		
Institution	CSIC – Instituto de Catálisis y Petroleoquímica [CSIC-ICP; https://icp.csic.es/]		
Department/Center	Applied Biocatalysis		
Country		Teleph. number	+34915854872
Key words	Artificial Intelligence; Bio-Based Products; Biocatalysis; Bioinformatics; Bioprospecting; Biotechnological Innovation; Cancer; Environmental Awareness; HIV; Machine Learning; Microbial Biodiversity; meta-OMICS; Microbiome; Next Generation Sequencing; Nano-engineering; Protein Engineering; Sustainability		

A.2. Previous positions (research activity interuptions, indicate total months)

Period	Position/Institution/Country/Interruption cause
10.06.2009–15.02.2021	Investigador Científico/CSIC-ICP/Spain

A.3. Education

PhD, Licensed, Graduate	University/Country	Year
Bachelor of Chemistry	Granada University	1994
PhD in Chemistry	Autonomous University of Madrid	1999

Part B. CV Summary and Scientific-Technical Background

M. Ferrer graduated in Chemical Sciences by the University of Granada in 1994. In the same year, he began his scientific career at the CSIC-ICP, obtaining his PhD in 1999. In January 2001 he started a postdoctoral stay at the Helmholtz Centre for Infection Research in Germany, after which he returned to the CSIC-ICP. M. Ferrer (H index: 64; 12674 citations) is currently Professor and the head of the Systems Biotechnology group (https://www.sysbio.csic.es/), valued among the best in the Area of Chemistry by CSIC. He has established platforms, delving into the implementation of novel (i.) wet-lab (microbiology, chemistry, enzymology and data processing), (ii.) bioinformatics and (iii.) computational tools, and executing the standardization of bioinformatics, 3D structural modeling, molecular modeling, and machine learning for processing and analyzing next-generation sequencing (NGS) results, the assembly and taxonomic classification of massive sequencing reads, and massive data management, ensuring it is suitable for taxonomic and functional annotations, integration into multi-omics studies, and extends to metabolic (or functional) understanding, biostatistics, visualization, and engineering. This has been applied over three different lines, where bioinformatics is combined with microbiology, chemistry, enzymology and data processing (management and integration): (i.) Environmental research, studying for example extreme environments and the specific microbes and microbial communities inhabiting these ecosystems; (ii.) Enzyme Discovery, Understanding and Design, to isolate and investigate the enzymatic arsenal from highly diverse microbial communities and engineering them to design new catalysts for a most efficient and greener chemical processes and products; (iii.) Biomedical research, advancing in our understanding of microbiota in various contexts, from health to disease; examples include deepening into the impact of diseases and treatments on the metabolically active

fraction of the microbiota and identifying microbiome-associated biomarkers for enhanced anal cancer prevention. Specifically, Prof. Ferrer achieved numerous environmental, biotechnological, and biomedical-related accomplishments and innovations. Significant outputs in environmental research include my contribution to deciphering novel mechanisms by which microbial communities adapt to global warming [Nature Communication 14:1045 (2023)], the origin of key microbial metabolisms [Nat Microbiol 5:1428 (2020)], key strategies to maximize the long-term fitness of microbial hosts by mutualistic and symbiotic associations ([NAS 117:20223-20234 (2020)]. Significant outputs in biotechnology/enzymology research include novel research proposing a new strategy of enzyme supramolecular engineering [ACS Nano 14:17652 (2020)], and addressing the use of computational algorithms to design a new generation of artificial enzymes with multiple active sites, the PluriZymes [Nature Catalysis 3:319 (2020); cover], and to engineer protein nanopores from the strawberry anemone to break down PET microplastics at room temperature [Nature Catalysis (2023) DOI: 10.1038/s41929-023-01048-6]. Significant outputs in biomedical research include my contributions to demonstrating that the effect of different diseases and treatments on our gut microbiota is more visible when examining the metabolically active fraction of the microbiota [e.g., Gut 62:1591 (2013)], identifying microbiome-associated biomarkers for improved anal cancer prevention in susceptible populations [Nature Medicine 29:1738-1749 (2023)].

Key research metrics all scientific career: a) H-index 64; b) 12674 citations; c) 204 SCI contributions (3 cover, Nat Catal (2020), Nat Microbiol (2017), Appl Environ Microbiol (2015)), 13 non-SCI, 41 book chapters, and 1 book (see https://sysbio.csic.es/publications/); d) JCR/2022 average: 8.0; e) 37 articles with JCR/2022, 9.43-82.9; f) 49 projects (5.9 M€, e.g., FP7, H2020, Horizon Europe, EraNet); g) 30 contracts (with national & international companies, e.g.., Reactomix SL, Brudy Technology SL, Igen Biolab Slu, Kimitec, Bayer AG, Patent Co. Doo Misicevo, Norce, CIESM; total, 1.5 M€); h) 15 patents (2 exploited [benefits: 6-€ digits: WO2005/035750 and PCT/EP2010/001770]); i) participation in +125 congresses (55+ invited); j) editorial board member of 7 journals; k) co-organizer of 1 congress and 2 international courses; l) member of 3 scientific societies; m) 4 awards (1 by Diario Medico); n) training of 24 scientists, and 14 researchers in short stays; o) director 6 PhD (two, Extraordinary Price) and 13 Master Thesis. Key research metrics last 5 years: a) H-index 62; b) 11725 citations; c) 47 SCI contributions (1 cover, Nat Catal (2020)), 8 non-SCI, 4 book chapters; d) JCR/2022 average: 8.0; e) 37 articles with JCR/2022, 9.43-82.9; f) 14 projects (2.5 M€, e.g., FP7, H2020, Horizon Europe, EraNet); g) 9 contracts (total, 0.31 M€); h) 5 patents (2 exploited [benefits: 6-€ digits: WO2005/035750 and PCT/EP2010/001770], 2 non-licensed (EP22383112, EP21382486) and 1 in the way to license (EP1641.1745)).

Part C. RELEVANT MERITS

C.1. Publications

Total nº of publications, last 10 years: >153

1. Serrano-Villar S (CA), Tincati C, Raju SC, et al., Ferrer M. (Position: 19/19). 2023. Microbiome-derived cobalamin and succinyl-CoA as biomarkers for improved screening of anal cancer. **Nature Medicine**, 29:1738-1749 (JCR/2022, 82.9).
2. Robles-Martín A, Amigot R, Fernandez-Lopez L, Gonzalez-Alfonso JL, Roda S, Alcolea-Rodriguez V, Heras-Márquez D, Almendral D, Coscolín C, Plou FJ, Portela R, Bañares MA, Martínez-del-Pozo A, García-Linares S (CA), Ferrer M (CA), Guallar (CA). (Position: 15/16). 2023. Sub-micro and nano-sized polyethylene terephthalate deconstruction with engineered protein nanopores. **Nature Catalysis**, 6:1174-1185 (JCR/2022, 37.8).
3. Marasco R, Fusi M, Coscolín C, et al., Ferrer M (CA), Daffonchio D (CA). (Position: 16/17). 2023. Enzyme adaptation to habitat thermal legacy shapes the thermal plasticity of marine microbiomes. **Nature Communications**, 14:1045 (JCR/2022, 16.6).
4. Jiménez D, Martínez-Sanz J, Sainz T, et al., Ferrer M (CA), Serrano-Villar S (CA). (Position: 15/16). 2022. Differences in saliva ACE2 activity among infected and non-infected adult and pediatric population exposed to SARS-CoV-2. **Journal of Infection** 85:86-89 (JCR/2022, 28.2).
5. Serrano-Villar S, et al, Ferrer M (CA). (Position: 18/18). 2021. Blood bacterial profiles associated with human immunodeficiency virus infection and immune recovery. **Journal of Infection Diseases** 223:471-481 (JCR/2022, 16.6).
6. Alonso S, Santiago G, Cea-Rama I, et al., Ferrer M (CA). (21/21). 2020. Genetically engineered proteins with two active sites for enhanced biocatalysis and synergistic chemo- and biocatalysis. **Nature Catalysis** 3: 319-328 (JCR/2022: 37.8). COVER.

7. Ferrer M (CA), Méndez-García C, Rojo D, Barbas C, Moya A. 2017. Antibiotic use and microbiome function. **Biochem Pharmacol.** 134:114-126 (JCR/2022: 5.8).
8. Rojo D, Méndez-García C, Raczkowska BA, Bargiela R, Moya A, Ferrer M (CA), Barbas C. 2017. Exploring the human microbiome from multiple perspectives: factors altering its composition and function. **FEMS Microbiology Reviews** 41:453-478 (JCR/2020: 11.3).
9. Serrano-Villar S, Rojo D, Martínez-Martínez M, et al., Ferrer M (CA). (Position: 16/16). 2016. Gut bacteria metabolism impacts immune recovery in HIV-infected individuals. **EBioMedicine** 8:203-216 (JCR/2022, 11.1).
10. Moya A (CA), Ferrer M (CA). 2016. Functional redundancy-induced stability of gut microbiota subjected to disturbance. **Trends Microbiology** 24:402-413 (JCR/2022, 15.9).

C.2. Congress

1. M. Ferrer. Invited conference "Microbioma: nuevos avances en materia de investigación biomédica" in the "6º ATENEO BIOMÉDICO CÁTEDRA FISABIO – UV"; web: http://fisabio.san.gva.es/web/fisabio/noticia/-/asset_publisher/1vZL/content/6-ateneo-catedra-fisabio; Place: Fisabio-Salud Pública (Valencia, Spain); Date: 26.10.2018.

C.3. Research projects.

1. Reference: Grant Nr INMUNOBIOTA. Title: Productos basados en microbiota para la reducción de infecciones sistémicas multirresistentes asociadas a tratamientos oncológicos. Entity/call: CSIC (ROGRAMA CSIC DE IMPULSO DE LA COLABORACIÓN PÚBLICO-PRIVADA (PROGRAMA **CSIC COCREA**) CONVOCATORIA 2023). Coordinator: Manuel Ferrer Martínez (ICP-CSIC); Project in collaboration as partner of the company Microviable Therapeutics SL. Start: 01.01.2024. End: 31.12.2025. Budget: €50,000. Role: Coordinator. Status: funded and on-going.
2. Reference: Grant Nr CI23-20433. Title: Microbiome-associated biomarkers to improve anal cancer prevention in susceptible populations. Entity/call: **CaixaImpulse Health Innovation call 2023** (https://prensa.fundacionlacaixa.org/wp-content/uploads/2023/10/Press-release-Resolution-Caixaimpulse-Innovation-call-2023.pdf). Coordinator: Dr. Sergio Serrano (Hospital Ramón y Cajal, Madrid). Start: 01.09.2023. End: 31.08.2025. Budget: €135,261. Role: Partner. Status: funded and on-going.
3. Reference: Grant Nr 101000327. Title: Technologies of the future for low-cost enzymes for environment-friendly products (FuturEnzyme). Entity/call: **EU - H2020-FNR-2020**. Coordinator: M. Ferrer [CSIC-ICP]. Start: 01.06.2021. End: 31.05.2025. Budget: 760.727 €. Role: Coordinator. Status: funded and on-going.
4. Reference: Grant Nr 101060625. Title: New system-driven bioremediation of polluted habitats and environment (Nymphe). Entity/call: **EU - Horizon Europe Program for 2021-2027**. Coordinator: Giulio Zanaroli [University of Bologna, Italy]. Start: 01.01.2023. End: 31.12.2026. Budget: 760.727 €. Role: Partner. Status: funded and on-going.
5. Reference: PDC2021-121534-I00. Title: Software de vanguardia para la entrega de enzimas industriales (Delivenz). Entity/call: **Proyectos de I+D+i de «Pruebas de Concepto»,** Programa estatal de i+d+i orientada a los Retos de la Sociedad - Plan Estatal de Investigación Científica y Técnica y de Innovación 2017-2020. Coordinator: M. Ferrer [CSIC-ICP]. Start: 01.12.2021. End: 31.05.2024. Budget: 149.500 €. Role: Coordinator. Status: funded and on-going.
6. Reference: PID2020-112758RB-I00. Title: Metamorfosis de enzimas a plurizimas y catalizadores biohibridos como opcion prometedora en el proceso de creacion de innovacion cientifica y bioeconomica (Metamorph). Entity/call: **PN2020 - Programa Estatal de I+D+i Orientada a los Retos de la Sociedad** - Plan Estatal de Investigación Científica y Técnica y de Innovación 2017-2020. Coordinator: M. Ferrer [CSIC-ICP]. Start: 01.09.2021. End: 31.08.2024. Budget: 169.400,00. Role: Coordinator. Status: funded and on-going.
7. Reference: Grant Nr AC17/00022. Title: Screening for anal cancer based on microbiota in people with HIV (Nymphe). Entity/call: **Instituto de Salud Carlos III and the Spanish Cancer Agency Foundation (AECC) – ERA-NET Program: Aligning national/regional translational cancer research programmes and activities TRANSCAN-2**. Coordinator: Manuel Ferrer Martínez (ICP-CSIC), although the project coordinator for EraNET is Dr. Sergio Serrano (Hospital Ramón y Cajal, Madrid). Start: 31.12.2017. End: 31.11.2021. Budget: €76,230. Role: Manuel Ferrer Martínez (ICP-CSIC), although the project coordinator for EraNET is Dr. Sergio Serrano (Hospital Ramón y Cajal, Madrid). Status: ended.

C.4. Contracts, technological or transfer merits

Contract with companies

1. Title: Prueba de concepto búsqueda de nuevas enzimas degradadoras de polímeros (Reference: Nr 237210). Company: Repsol S.A. Coordinator: M. Ferrer [CSIC-ICP]. Start: 03/05/2022. End: 03/11/2022. Funding received: 44.561,88 €.
2. Title: Enzymes for DON, FB1 and T-2 degradation (ref. CSIC 211979). Company: PATENT CO. DOO MISICEVO (Serbia). Coordinator: M. Ferrer [CSIC-ICP]. Start: 01.08.2020. End: 31.12.2021. Budget: 48.000 €.
3. Title: Engineering the sensory quality of marine ingredientes using marine sensory enzymes (ref. CSIC 191185). Company/Entity: NORCE AS, Bergen (Norway). Coordinator: M. Ferrer [CSIC-ICP]. Start: 01.05.2018. End: 30.04.2023. Budget: 33.551,81 €.
4. Title: Substrate profiling, solvent tolerance and chiral tests for enzymes from Bayer AG (ref. CSIC 020401170045). Company: Bayer AG (Kaiser-Wilhelm-Allee 1, 51373 Leverkusen, Germany). Coordinator: M. Ferrer [CSIC-ICP]. Start: 07.04.2017. End: 29.04.2025. Budget: 83.365,22 €.
5. Title: Proteomic and metabolomics analysis of two functional products from Igen Biolab (ref. CSIC 185273). Company: IGEN BIOLAB SLU (Madrid, Spain) Coordinator: M. Ferrer [CSIC-ICP]. Start: 16.04.2018. End: 13.10.2018. Budget: 11.835,01 €.

Patents

6. Type of industrial protection: SOLICITED PATENT (22383112; EP22383112). Co-authors: S. Serrano-Villar, M. Ferrer. Title: Microbiota-associated markers of high-grade squamous intraepithelial lesions (HSIL). Application date: 17/11/2022. Start date: 16/12/2022. End date: 16/12/2042. Owner: FIBioHRC, ICP-CSIC. Patent status: Priority patent application (in PCT phase) – This patent is the basis of the Project "Microbiome-associated biomarkers for improved anal cancer prevention (CI23-20433)" funded by CaixaImpulse Innovation 2023 (see details above). This project and the patent can serve as a guide for the development of diagnostic products for the market (through a spin-off or another licensing company).
7. Type of industrial protection: SOLICITED PATENT (21382486; EP21382486). Co-authors: S. Serrano-Villar, M. Ferrer. Title: Biomarker and methods to predict susceptibility to SARS-COV-2 and COVID19 severity. Application date: 31/05/2021. Start date: 31/05/2021. End date: 31/05/2041. Owner: FIBioHRC, ICP-CSIC. Patent status: Priority patent application filed
8. Type of industrial protection: SOLICITED PATENT (22383014, EP1641.1745). Co-authors: S. Serrano-Villar, M. Ferrer. Title: Fumonisin enzymatic degradation. Application date: 21/10/2022. Start date: 31/05/2021. End date: 31/05/2041. Owner: ICP, CSIC. Note: The company PATENT CO DOO (Serbia) covers the expenses of the patent that it is going to license.
9. Type of industrial protection: PATENT IN EXPLOITATION (WO2005/035750; EP1673442; US 7,811,784; CA254576. Co-authors: M. Ferrer, T.N. Chernikova, M.M. Yakimov, P.N. Golyshin and K. N. Timmis. Title: Strategy for the construction of transgenic organisms with lower growth temperature and their biotechnology. Application date: 21.04.2005. Owner: ICP-CSIC, HZI. Note: In exploitation by Agilent Technologies (USA), with benefits in the range of 6-digit euro. Although this patent is from 2005, it has been included because it is still in operation and continues to generate profits at this time.

OTHER RELEVANT INFORMATION

Scientific or professional development and training program planned

The student will develop the activities at CSIC (http://www.csic.es/), the Spain's largest public research institution, and third among Europe's largest research organization, and within it, at the Institute of Catalysis (http://www.icp.csic.es/), the newest, best-equipped and fully dedicated Spanish Research Institute in the field of catalysis in energy, environment or fine chemistry areas. Within this Institute, the student will be part of the Systems Biotechnology Group (https://www.sysbio.csic.es/) led by Prof. Manuel Ferrer since 2005, that in the last two CSIC evaluations has been valued among the best in the Area of Chemistry, both in terms of the relevance of scientific and technological contributions, as well as its ability to attract national, european and private financing. The Group has established an extensive network of collaborations, actually accounting approx. 30 research centers and 20 companies, national and international, from about 30 different countries, to which the doctorate will have access. The Group has been, and is part, of large consortia in the framework of projects focused on enzymes and biotechnology such as EraNet (MetaCat, Scratch, ProBone) and European (MAMBA, MAGIC-PAH, ULIXES, KILL-SPILL, INMARE, NYMPHE) projects and currently our Group is the coordinator of the large EU project FuturEnzyme. Also, on microbiome research such as EraNet (Scratch) and National (La Caixa Foundation (CaixaImpulse Health Innovation call 2023; project nr CI23-20433; title: Microbiome-associated biomarkers to improve anal cancer prevention in susceptible populations); CSIC-COCREA, INMUNOBIOTA) projects. The student will have access to all resources and networking activities that may derive from it.

Our Group is also unique in several aspects that favor multidisciplinary, creative, and critical thinking training. First, we cover the entire process from the identification of an enzyme to its industrial application. Second, we conduct research at the interface between analytical, biological, physical, inorganic, and organic chemistry, as well as biology, microbiology, health and medicine (microbiome research), energy, the environment, and materials, among others. Third, the project that the student is going to carry out can be considered innovative based on previous publications in top journals (Nat Med, J Infect, Gut, eBioMedicine, Gut Microbes, etc.), ensuring the technical-scientific impact. Aside from this, the Group offers technical and computational capacities and skills that are rarely found in a single laboratory. Additionally, in the Group, we have established bioinformatics platforms, delving into (i.) the implementation of novel bioinformatics and (ii.) computational tools, and executing the standardization of bioinformatics, 3D structural modeling, molecular modeling, and machine learning for processing and analyzing next-generation sequencing (NGS) results, the assembly and taxonomic classification of massive sequencing reads, and massive data management, ensuring it is suitable for taxonomic and functional annotations, integration into multi-omics studies, and extends to metabolic (or functional) understanding, biostatistics, visualization, and engineering. Through the application of these tools to multiple microbial communities and microorganisms, their genes, proteins, enzymes, and metabolites, the Group has achieved numerous environmental, biotechnological, and biomedical-related accomplishments and innovations. All this guarantees that the PhD student will develop multidisciplinary capabilities.

The training excellence will be guaranteed because the Thesis will be included in the Institutional program of the UAM (Doctoral Program in Molecular Biosciences or similar), that have a demanding follow-up of doctoral students (http://ciencias.biomol.uam.es/phd_monitoring), with a minimum required activities [courses, seminars (>26), training courses (>2), scientific meetings (>1), mini-review (>1)] to achieve a positive evaluation in subsequent tutelages, done every year. This ensures training and compliance with the training plan that will be submitted at the beginning of the thesis. Additionally, the University assigns a Tutor who validates that the activities of both the student and the supervisor are carried out properly and in accordance with the research plan.

Group members

Currently, the group led by Prof. Manuel Ferrer consists of seven members: Prof. Manuel Ferrer Martínez (ORCID: 0000-0003-4962-4714), Dr. Rafael Bargiela (ORCID: 0000-0003-1442-3269), Dr. Laura Fernández-López (ORCID: 0000-0001-8861-3191), Dr. Patricia Molina Espeja (ORCID: 0000-0002-2590-0932), Dr. Fadia V. Cervantes Dominguez (ORCID: 0000-0001-8844-8392), Lcdo. David Almendral López (ORCID: 0000-0002-2117-8911), and PhD student Paula Vidal Ramón (ORCID: 0000-0001-9180-0895). Among them, Dr. Bargiela is an expert in bioinformatics.

Training capacity of the group

The group's training capacity is demonstrated by five theses supervised at UAM in the last five years, two of which received an extraordinary award.

Research line summary

As mentioned in the section "Part B. CV Summary and Scientific-Technical Background", the Systems Biotechnology Group, led by Prof. Manuel Ferrer, has developed cutting-edge platforms that integrate wet-lab techniques (microbiology, chemistry, enzymology, and data processing) with bioinformatics and computational tools. The group has standardized bioinformatics processes, 3D structural modeling, molecular modeling, and machine learning to analyze next-generation sequencing (NGS) data, assemble and classify massive sequencing reads, and manage large datasets for taxonomic and functional annotations. Their work extends to multi-omics studies, metabolic understanding, biostatistics, visualization, and engineering. The group's research spans three key areas: (i) Environmental research, where they investigate extreme environments and the microbial communities within them; (ii) Enzyme discovery and design, focusing on isolating enzymes from diverse microbial communities and engineering new catalysts for sustainable chemical processes; and (iii) Biomedical research, particularly in understanding the impact of diseases and treatments on the metabolically active fraction of the microbiota, as well as identifying biomarkers for improved anal cancer prevention. Significant achievements in environmental research include uncovering mechanisms by which microbial communities adapt to global warming and identifying the origins of key microbial metabolisms. In biotechnology, the group has pioneered strategies in enzyme engineering, such as developing PluriZymes, a new generation of artificial enzymes with multiple active sites, and engineering protein nanopores to degrade PET microplastics. In biomedical research, their contributions have advanced the understanding of how diseases and treatments affect gut microbiota and led to the identification of microbiome-associated biomarkers for enhanced cancer prevention.

The doctoral thesis will focus on the research area of "Biomedical Research" within the group, specifically on the line of fortifying the intrinsic connection between human well-being and microbiomes by pursuing a deeper understanding of the beneficial and metabolically active molecular components and mechanisms driving microbiome development. Specifically, the activities will be carried out within the framework of the Project PID2023-153370OB-I00 “Bioinformatics and AI-Driven Management of Active Microbiomes: A One Health Approach (BAI4MAC)”.

The primary goal is to develop a Digital Platform for Microbiome Management, which includes six key sub-goals. First, the platform will feature algorithms to analyze multi-omic data, enabling the detection of microbiome alterations and identifying their metabolic impacts. Second, it will focus on deciphering and understanding microbiome dynamics. Third, the platform will unlock and implement immunoprotective boosters to enhance the immune system's response. Fourth, it will allow for the customization of microbiomes tailored to specific diseases, particularly in HIV immunopathogenesis and lung cancer, including investigating the microbiome's role in lung cancer immunotherapy. Fifth, the project aims to enhance expertise and training in microbiome and OMICS sciences, ensuring that professionals are well-equipped to utilize these advanced tools. Finally, the platform will facilitate advanced patient care and optimize healthcare resource management, ultimately improving clinical outcomes.

Below is a summary of some of the technological and scientific areas covered by the R&D Project: Artificial Intelligence, advanced data analytics/edge computing, biotech, computational biology, large-scale data and information processing technologies, high-performance computing, data analysis and integration, bioinformatics, fecal microbiota transplantation, HIV, lung cancer, microbiome, microbiota, multi-drug resistant systemic infections, omics, and One Health.