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A Strategic Research and Innovation Agenda to drive the EU Agri-Food Biotech Alliance

EIT Food – Europe's leading food innovation initiative, working to make the food system more sustainable, healthy and trusted

Knowledge & Innovation Community on Food, part of the European Institute of Innovation and Technology (EIT)

www.eitfood.eu

A Strategic Research Agenda to drive the EU Agri-Food Biotech Alliance

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0. Foreword

Since its inception, EIT Food has been driven by the urgency to support a fair and needed transition to more sustainable and healthier food systems and has documented, through its Protein Diversification Think Tank, how protein diversification is one of the most impactful levers to achieve it.

This urgent action was confirmed this end of 2025 through The UN Global Environment Outlook, Seventh Edition: A Future We Choose, the product of 287 multi-disciplinary scientists from 82 countries, is the most comprehensive scientific assessment of the global environment ever carried out. Stating how food system transformation is central to the future of our living, the report promotes the following key recommendations :

> *Transforming the food system requires actions from policymakers, regulators, the food industry, the financial sector, farmers, researchers, communities and individuals, including:*
>
> - shifting to healthy and sustainable diets, including greater consumption of plant-based foods;
> - adopting more sustainable and resilient food production practices;
> - reducing food losses and waste and enhancing circularity across food systems;
> - accelerating the development and uptake of novel alternative proteins, such as cultivated meat;
> - and reforming food markets and trade, e.g., diversifying agribusiness supply chains and incentivizing environmentally responsible practices.

Our initiative to accelerate the deployment of agrifood biotechnologies solutions in Europe is a clear answer to each of these priorities, and this paper is, among other goals, meant to document it, building on the contribution of more than hundred experts of the matter. Beyond that, the final purpose of this Strategic Research Agenda (SRIA) is to decipher and prefigure the initiatives and pathways we could collectively activate as of 2026 and with the support of all the stakeholders that want to make our global and European food system better.

If you want to contribute to this unprecedented initiative, please reach out to:

lorena.savani@eitfood.eu and **mariana.fazenda@eitfood.eu**

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1. Context and Rationale

1.1 Europe at a Crossroads

The global food system is under unprecedented pressure. Climate change, biodiversity loss, and resource scarcity are converging with rising demand for proteins and functional ingredients. By 2050, the world will need to feed nearly 10 billion people while reducing the environmental footprint of agriculture. At the same time, health systems face rising costs from diet-related diseases, highlighting the urgent need for healthier, more sustainable nutrition.

Against this backdrop, advanced biotechnologies represent a historic opportunity. They enable Europe to reimagine food production – from precision fermentation and molecular farming to cellular agriculture and microbial bioconversion. These innovations can deliver high-quality proteins and ingredients with a fraction of the land, water, and emissions required by conventional systems.

Yet Europe is also at risk of falling behind. Competitor regions are scaling rapidly:

- The United States has already deployed billions in public and private capital for cellular agriculture and precision fermentation, with over 100 start-ups backed by venture investment.
- Asia, particularly Singapore, China, and Israel, is establishing biomanufacturing hubs and regulatory pathways that accelerate market entry.
- Europe, by contrast, remains fragmented: world-class science but scattered pilot plants, underfunded scale-up, and a regulatory system often perceived as slow and complex.

The question is clear: will Europe remain a consumer of other regions' biotech innovations, or will it become a global leader in developing and scaling its own solutions?

1.2 Why AgriFood Biotech, Why Now?

AgriFood biotech is not a distant promise – it is already reshaping global markets. Precision fermentation is projected to reach a multi-billion-euro market by the early 2030s. Molecular farming has demonstrated the ability to produce complex proteins at scale, while microbial and cell-based proteins are rapidly gaining traction as alternatives to conventional animal products.

For companies making long-term investment decisions, the US may remain a scientific powerhouse, but its policy environment suddenly looks less stable. Europe has an opening, but only if it moves with coherence and speed. Recognizing this, policymakers have elevated fermentation, both precision and biomass fermentation, to a new strategic

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status. For the first time, these technologies are explicitly tied to Europe's competitiveness and sovereignty. Fermentation is increasingly understood as a platform for producing high-value food ingredients, dairy analogs, functional proteins, oils, fats, and enzymes without the land and emissions footprint of conventional agriculture. It offers a pathway for diversifying Europe's protein supply and strengthening food-system resilience at a time when climate extremes, trade disruptions, and geopolitical tensions are tightening margins across primary production.

Europe is uniquely positioned for leadership. Its scientific base in fermentation is world-class. Its industrial fermentation expertise, from pharmaceuticals to enzymes, is deep and long-established. Its universities and research institutions generate a steady pipeline of biotechnological breakthroughs. And despite frequent portrayals as adversaries of innovation, Europe's farmers are central to any viable bioeconomic future.

Food represents far more than a consumer sector. It is the interface where climate resilience, trade security, public health, rural livelihoods, and cultural identity converge. The updated strategy acknowledges food's dimensions but stops short of giving it the same industrial status as biochemicals or pharmaceuticals. That decision carries real risks. While Europe awaits consensus, Singapore, China, Australia, and even the UK are establishing themselves as hubs for food biotechnology. By the time the EU fully aligns, the commercial center of gravity may have shifted elsewhere.

For Europe, the stakes go beyond economics:

- Sustainability: Biotech can drastically reduce emissions, water use, and land pressure.
- Resilience: Diversifying protein sources strengthens EU food security against global shocks.
- Competitiveness: A vibrant biotech sector can generate hundreds of thousands of skilled jobs and anchor Europe as a global hub for innovation.
- Health: New ingredients can improve nutrition, support healthy ageing, and reduce the burden of non-communicable diseases; advances in understanding of bio-based mechanisms and natural processes will accelerate healthy food innovations
- Consumers protection: Food biotech strengthens Europe's role as *guardian of food safety*. Advanced technologies can prevent, monitor, and control hazards along the food chain – from microbial contamination to allergen risks – ensuring that safe, traceable, and high-quality products reach consumers. By embedding robust safety standards and transparency, Europe can build trust and safeguard citizens while accelerating innovation.
- Food loss and food waste reduction: biotech will help create efficient preservatives and will provide scalable solutions to recycle or upcycle food loss and waste into valuable ingredients or compounds
- Food safety: advances in biotech will help improve detection, control and fight against pathogens and diseases.

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At the same time, Europe must respond to the strategic priority set by the European Commission's Life Sciences Strategy (2024), which recognizes food and feed biotechnology as essential to resilience, sustainability, and competitiveness. The upcoming Biotech Act will further shape the environment for innovation, providing a window of opportunity to align food biotech with EU policy priorities.

1.3 Barriers holding Europe back

Despite its potential, Europe's food biotech sector faces significant barriers:

- Regulatory hurdles: The Novel Foods approval pathway remains slow and costly, discouraging investment and delaying scale-up.
- Fragmented infrastructure: Few shared pilot or demonstration facilities exist, leaving start-ups unable to bridge the "valley of death."
- Limited access to finance: European investors remain cautious, leading to funding gaps at critical stages.
- Talent shortages: Skills in bioprocess engineering, fermentation, and regulatory science, but also in food systems science and entrepreneurial thinking, are in high demand but short in supply.
- Public perception challenges: Citizens and consumers need trusted, science-based communication to build acceptance and participation
- Lack of CO_2 pricing in the food sector: Without a clear carbon price signal, companies have little incentive to reduce emissions, making sustainable alternatives less competitive.

These barriers explain why much of the current innovation is being scaled outside Europe, even when scientific breakthroughs originate here.

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1.4 The Case for coordinated Action

To unlock the promise of food biotech, Europe requires a coordinated, systemic response:

- Focus on advancing biotech science, scientific collaboration and partnership, even beyond the EU.
- Align policy and regulation to provide predictable, science-based pathways (connected with EuropaBio).
- Mobilise public-private funding to de-risk early investments and crowd in private capital.
- Support investment in shared infrastructures and facilities – when and where needed - that allow SMEs and start-ups to scale.
- Build a skilled workforce through dedicated education and training.
- Engage citizens and consumers with transparent communication to build trust.

The **EU Agri-Food Biotech Alliance** is being created to serve exactly this purpose: reducing fragmentation, connecting ecosystems, and aligning Europe's efforts. By developing a shared Strategic Research and Innovation Agenda (SRIA), the Alliance ensures that food biotech becomes a driver of Europe's competitiveness, sovereignty, and sustainability.

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2. Vision, Mission and Strategic Objectives

2.1 Why a Vision for Food Biotech matters

Europe is entering a decisive decade. Global competitors are investing billions into advanced biotechnologies for food, feed, and health. The United States, supported by large-scale private investment, has already positioned itself as a frontrunner in precision fermentation and cellular agriculture, while Asian countries are building dozens of demonstration plants to accelerate scale-up. Unless Europe takes bold action, it risks becoming dependent on external supply chains for future protein sources and high-value ingredients – a strategic vulnerability for both food sovereignty and competitiveness.

Against this backdrop, the European Union has the opportunity to define a clear and ambitious vision: to harness biotechnology not only as a driver of competitiveness and jobs, but also as a transformative enabler of sustainability, resilience, and health. The EU Agri-Food Biotech Alliance offers the platform to make this vision a reality, by coordinating investment, policy, and innovation agendas across the continent.

2.2 The Vision for 2050

By 2050, Europe will build a resilient and sustainable agri-food system powered by biotechnology—delivering healthy, affordable and nutrient-dense agri, feed and food ingredients; restoring biodiversity; reducing environmental impact; and ensuring Europe's strategic autonomy and competitiveness.

This transformation will enable a climate-positive agri-food system, localised and resilient value chains, cost-competitive biotech-enabled ingredients and proteins, and position Europe as a global leader in safe, sustainable biotechnology

Key targets for 2050 include:

- A climate-positive protein system, cutting over 500 Mt CO_2 eq annually.
- 70% substitution of chemicals in agriculture inputs.
- Feed & Food sovereignty: Europe is no longer dependent on imports for critical ingredients, through the creation of local value chains
- Cost parity for protein sources through precision fermentation, plant molecular farming, and tissue culture, expanding Europe's food portfolio beyond today's paradigms.
- Global leadership: Europe setting the standard for sustainable and safe biotech solutions.

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2.3 The Mission for 2050

Accelerate Europe's transition to a resilient, sustainable and competitive and agri-food system by harnessing safe and trusted biotechnology to produce healthier, affordable and climate-positive agri, feed and food components—strengthening biodiversity, reducing environmental impact and securing Europe's strategic autonomy.

The EU Agrifood Biotech Alliance will unite, empower, and accelerate Europe's agri-food biotech community by:

- **Building a leading, coordinated consortium** that brings together all forward-thinking stakeholders across research, industry, investors, policy, and civil society.
- **Reducing fragmentation by integrating existing initiatives, infrastructures, and resources** into a cohesive, agile, and impactful European alliance.
- **Steering the development and scalable growth of a competitive, resilient, and sustainable agri-food biotech sector** aligned with EU strategic priorities including the Green Deal, Farm to Fork, and Strategic Autonomy.
- **Recommending supportive, future-fit policy frameworks, funding mechanisms, and regulatory pathways** to enable Europe's leadership in food biotechnology.
- **De-risking and accelerating breakthrough innovations and affordable, market-ready solutions** through efficient collaboration programs, mobilized co-investment, and a strong public-private partnership model (Joint Undertaking).
- **Fostering up- and reskilling and talent development, entrepreneurship, and next-generation biotech leadership** to future-proof Europe's innovation capacity.
- **Integrating food environments, social sciences, and consumer acceptance research and activities** to ensure public engagement and consumer dialogue are part of the innovation pathway and that biotech-driven solutions are sustainable, inclusive, culturally relevant, and trusted by European citizens.

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2.4 Strategic Objectives by 2035

To reach these targets, the SRIA sets out four overarching strategic objectives:

1. **Sustainability**
   - Cut agricultural emissions and resource use through biotech-enabled inputs and feed.
   - Reduce and upcycle residues, sides-streams, food loss and food waste.
   - Scale natural biofertilisers and biopesticides to replace synthetic inputs.

2. **Food Security**
   - Achieve EU protein independence by investing in microbial, plant-based, and cell-cultured solutions.
   - Reduce dependency on imported feed and agriculture inputs.
   - Secure resilient European supply chains for critical ingredients and feedstocks.

3. **Competitiveness and Growth**
   - Build a globally competitive biotech industry with strong SMEs, corporates, and investors.
   - Support and consolidate capacity building, network integration and structural convergence across all EU countries, incl RIS countries.
   - Position Europe as a global innovation hub for biotech scale-up and regulation.

4. **Health and Nutrition and Consumers protection**
   - Ensure all EU citizens have access to safe, affordable, and appealing alternative proteins.
   - Improve animal health and welfare through biotech.
   - Advance innovation in gut health, ageing, and personalised nutrition through biotech, innovative food as a medicine solutions.

2.5 Milestone 2035 – building the Foundations

The journey to 2050 requires an interim milestone in 2035, where large-scale deployment will be visible and measurable. By then:

- 15+ flagship demonstration plants will be operating across Europe, producing microbial proteins and lipids, molecular farming ingredients, and bio converted feed at scale.
- A public-private co-investment portfolio of at least €2 billion will have been mobilised, combining EU, national, corporate, and philanthropic funding.
- More than 200,000 skilled jobs will have been created in biotech-related sectors.

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- 100,000 professionals will have been trained through the Biotech Academy and aligned skills programmes, ensuring Europe has the workforce to sustain growth.
- 1+ B€ of public investment will be mobilised to support agri-food biotech R&I and flagship demonstrations.
- A living network of interconnected innovation ecosystems will have been created, offering pan-European coverage for biotech innovators needing access to cutting edge research and innovation support.
- Dozens' novel food protein companies have received regulatory approval to sell their products in the EU. Following its introduction on the market in 2030, the first cultivated foie gras reaches price parity across Europe.
- A better collaboration of food industries, startups and research institutions within Europe has helped consolidate multiple competitive advantages for EU players that have become leaders in their category at a global scale.

2.6 Why this vision is achievable

The vision is ambitious and achievable because Europe already has strong foundations: world-class universities and RTOs, innovative SMEs, global agrifood corporates, and a regulatory tradition that places citizen trust at its core. What has been missing until now is alignment and scale. The EU Agri-Food Biotech Alliance fills this gap by bringing together stakeholders, aligning investments, and creating a shared Strategic Research and Innovation Agenda (SRIA).

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3. The EU Agri-Food Biotech Alliance – The Enabler

3.1 Why an Alliance?

Europe is rich in world-class universities, research and technology organisations (RTOs), innovative start-ups, and multinational food and biotech companies. Yet this strength is undermined by fragmentation. Initiatives often remain isolated, with limited cross-sector collaboration or alignment with policy priorities. As a result, investment is scattered, infrastructure is duplicated or under-utilised, and the EU lacks a unified voice on food biotech at the global stage.

The EU Agri-Food Biotech Alliance was established to overcome this fragmentation and create a neutral, trusted platform where stakeholders can collaborate. Anchored in EIT Food's convening role, the Alliance serves as the connective tissue of Europe's food biotech ecosystem. It ensures that resources are pooled, strategies are aligned, and Europe speaks with one voice on the future of biotech for food and feed.

EIT Food already constitutes the most comprehensive knowledge and expertise network in the agri-food-related biotech sector, enabled by its unique partnership structure. The participation of Europe's leading universities and research institutes in this domain ensures a critical mass of excellence, allowing the Alliance to consolidate expertise, accelerate innovation, and act as a unifying force for Europe's leadership in sustainable agri-food biotechnology.

3.2 The Role of the Alliance

The Alliance is designed as a long-term coordination mechanism, capable of guiding Europe's transition from isolated efforts to systemic transformation. Its roles are fourfold:

1. **Orchestrator of Ecosystems**
    - Connecting academia, industry, investors, policymakers, and civil society (quadruple helix).
    - Building trust between stakeholders with diverse incentives.
    - Ensuring regional inclusion, so Central & Eastern Europe, the Nordics, and Southern Europe are equally represented.
2. **Catalyst for Investment**
    - Mobilising and aligning public and private capital.
    - Reducing risk for corporates and SMEs by de-risking pre-competitive areas.
    - Preparing the ground for a €2B public–private portfolio.

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3. **Neutral Broker with Policymakers**
    - Acting as a trusted interface with the European Commission and Member States.
    - Supporting policy alignment, particularly with the Biotech Act, EU Protein Strategy, and the Life Sciences Strategy.
    - Translating innovation into evidence for regulators and policymakers.

4. **Incubator for Systemic Initiatives**
    - Hosting and steering the development of the Strategic Research and Innovation Agenda (SRIA).
    - Preparing the governance, partnerships, and co-investment logic that can evolve into a Joint Undertaking (JU) under FP10.
    - Working on many levers of change simultaneously and in an orchestrated way (skills, investments, regulations, public awareness, technology, etc.).

3.3 Achievements so far

The Alliance builds on concrete foundations laid in the past two years:

- **Protein Diversification Think Tank (PDTT):** Generated actionable intelligence, policy briefs, and foresight on protein system transformation.
- **Biofutures Programme (2023–24):** Early collaboration model that demonstrated the appetite for systemic coordination.
- **McKinsey Advanced Biotech for Sustainability Report:** Harnessing the economic and environmental benefits of advanced biotechnology
- **Horizon-funded Consortia:** FEASTS, EPIC-Shift, Sustain-a-Bite
- **JU proposal (in preparation with Food4All):** Positioning food and feed biotech within the European debate on future Joint Undertakings.
- **Biotech Portfolio (in preparation):** Will co-finance pre-competitive projects with corporates.
- **Biotech Academy (in preparation):** To train, up- and reskill the workforce needed for biotech scale-up.
- **Pre-competitive Projects (in preparation):** Structured collaborations with global mission-driven organizations and philanthropic actors to jointly de-risk early-stage innovation and accelerate systemic impact.

These initiatives have demonstrated that when EIT Food and its partners convene the ecosystem, impact follows. The Alliance is now scaling this approach to the full biotech spectrum.

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3.4 The Alliance as the embryo of a possible future JU

The long-term ambition is clear: Europe needs Joint Undertaking for Food Biotech. But a JU cannot emerge overnight – it requires evidence, critical mass, and political momentum.

The Alliance is therefore positioned as the embryo of the JU:

- **Stage 1 (2024–2026):** Coordinating the SRIA, aligning stakeholders, and building the investment case.
- **Stage 2 (2026–2028):** Transitioning into a formal PPP entity with clear governance and co-funding.
- **Stage 3 (2028 onwards):** Establishing a full JU under FP10, with the Alliance's SRIA as its backbone.

By embedding the Alliance in this trajectory, stakeholders can see their engagement not as an isolated effort but as the first step in a long-term European flagship programme.

3.5 The value of Membership

For partners, membership in the Alliance delivers both strategic and tangible value:

- **Strategic positioning:** A seat at the table shaping Europe's biotech agenda.
- **Early influence:** The chance to shape the SRIA and future JU priorities.
- **Collaboration opportunities:** Access to joint projects, peer learning, funding mechanisms, and shared infrastructure.
- **Reputation and visibility:** Alignment with a high-profile, EU-recognised initiative.

4. Strategic Research & Innovation Agenda (SRIA)

4.1 What is a SRIA and why it matters

A Strategic Research and Innovation Agenda (SRIA) is the backbone of every major European public–private partnership. It sets out the long-term vision, priorities, and roadmap for investment, guiding both public and private stakeholders towards shared objectives. For the European Commission, it provides the evidence base for approving a Joint Undertaking (JU); for corporates and innovators, it provides clarity on where to invest; and for Member States, it provides alignment with national and regional strategies.

In the case of food biotechnology, the SRIA is especially critical. Without a shared strategic agenda, efforts risk remaining fragmented – with multiple actors pursuing different directions, duplicating efforts, and missing opportunities for scale. The SRIA ensures that the ecosystem speaks with one voice, making Europe a credible global competitor in the race to scale advanced biotechnologies for food.

4.2 Objectives of the SRIA

The SRIA for the EU Agri-Food Biotech Alliance is designed to:

1. Articulate a shared European vision for advanced biotech for food (with Food4All ambition) up to 2050, with measurable milestones for 2035.
2. Define research and innovation priorities across the biotech spectrum – from precision fermentation and cellular agriculture to molecular farming, microbial bioconversion, and algae.
3. Provide a roadmap for investment and infrastructure, including flagship demonstration plants, skills development, and regulatory innovation.
4. Guide the mobilisation of a €2B public–private co-investment portfolio, ensuring efficient use of EU, national, private, and philanthropic capital.
5. Lay the groundwork for a future Joint Undertaking (JU), providing the content and legitimacy required for European Commission approval.

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4.3 A Two-Stage Development Process

To ensure credibility and inclusivity, the SRIA will be developed in two distinct stages:

Stage 1: Draft / High-Level SRIA (by end 2025)

- A "living document" that captures the collective vision and initial priorities of the Alliance.
- Provides enough structure for corporates and organisations to take the document inside their boards and management teams.
- Basis for securing Letters of Intent (LoIs) from strategic partners, demonstrating critical mass and commitment to the European Commission.

Stage 2: Detailed SRIA (by end 2026)

- A comprehensive and fully detailed agenda, structured around priority areas, funding logic, governance, and policy alignment.
- Provides the full technical and strategic foundation required for the launch of a Joint Undertaking under FP10.
- Aligns with EU flagship strategies such as the Biotech Act, the EU Protein Strategy, and the New European Innovation Agenda.

The SRIA is co-created with the ecosystem. Each partner in the Alliance has a role to play:

- **Corporates**: Identify market needs, investment priorities, and demonstration opportunities.
- **Research and Technology Organisations (RTOs):** Map scientific advances, TRL progress, and research gaps.
- **Start-ups and SMEs:** Provide bottom-up innovation and highlight barriers to scale.
- **Investors:** Guide financing models and co-funding pathways.
- Farmers and **farming organisations**
- **Member States and regions**: Ensure alignment with Smart Specialisation Strategies and regional innovation valleys.
- **Civil society and NGOs**: Empower citizens with transparent, contextualised information and enable their active participation in shaping biotechnological innovation. Their engagement ensures that innovation reflects societal values, builds trust, and strengthens democratic legitimacy.

Through workshops, surveys, and bilateral consultations, the Alliance will consolidate these inputs into a coherent, evidence-based SRIA that reflects the diversity of the European ecosystem.

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4.5 The Role of the Alliance in the SRIA Process

The EU Agri-Food Biotech Alliance is the neutral broker and coordinator of the SRIA process. Its responsibilities include:

- Designing and running stakeholder engagement formats (workshops, consultations, foresight exercises).
- Ensuring territorial balance across regions, so no Member State is left behind.
- Building synergies with other EU initiatives (e.g. Circular Bio-based Europe JU, BIOCONNECT, Horizon Europe partnerships).
- Consolidating inputs into a single, authoritative agenda that reduces fragmentation.
- Providing a direct channel to DGs (SANTE, RTD, AGRI, GROW, CLIMA) to ensure policy alignment.

By centralising this process, the Alliance ensures that the SRIA is not just another strategy paper, but a political and operational instrument capable of unlocking investment and driving impact.

4.6 The SRIA as the bridge to a Joint Undertaking (JU)

The SRIA is the bridge towards the creation of a Joint Undertaking for Food Biotech.

- In 2025, the draft SRIA will secure partner buy-in and demonstrate critical mass.
- In 2026, the detailed SRIA will provide the Commission with the technical and strategic evidence needed to propose a JU under FP10.
- From 2027 onwards, the SRIA will evolve into the JU's operational programming document, shaping annual work programmes, funding calls, and governance.

Thus, the SRIA provides both short-term value (clarity, coordination, investment roadmap) and long-term impact (the foundation of a European flagship programme).

4.7 Deliverables of the SRIA Process

The SRIA process will deliver:

- **A draft SRIA (2025)** – high-level, strategic, and mobilisation-focused.
- **A detailed SRIA (2026)** – comprehensive, structured, aligned with FP10/MFF 2028–2035.
- **Letters of Intent (LoIs)** from strategic partners, committing to active engagement and co-investment.
- A **governance proposal** for the future an eventual Joint Undertaking of Public Private Partnership.
- A set of **investment roadmaps** for 15+ flagship demonstration plants.

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5. Main Technologies and Market Applications

5.1 Overview of Technology Domains & Key Enablers

Six core platform domains are prioritised for agrifood applications: These platforms are **technologically different**, but **market complementary.**

	Technology platforms
Solid State Biomass Fermentation	Cultivating microorganisms on moist, solid, non-soluble organic material with little to no free water. to produce protein-rich food and/or feed
Liquid Biomass Fermentation	Using fungi, yeast or bacteria to produce protein-rich food and/or feed biomass at scale
Precision Fermentation	Engineering microorganisms to produce specific high-value proteins or compounds, enzymes, lipids, colorants, food additives, vitamins…
Gas Fermentation	Biological conversion of gaseous carbon sources including CO2 into ingredients, nutrients, proteins, microbial biomass
Plant Molecular Farming	Using plants as biofactories to produce proteins and bioactive compounds.
Plant Cell & Tissue Cultivation	Culturing plant cells to produce fat, proteins, specialty ingredients, nutrients
Animal Cell & Tissue Cultivation	Culturing animal or plant cells to produce fat, animal proteins, specialty ingredients, nutrients
Enzymatic Bioconversion	Converting agri-food waste, by-products or side-streams into high-value proteins or ingredients (lipids, bioactives…) using enzymes
Algae & Aquatic Biotech	Cultivating algae and aquatic organisms for agriculture, biosolutions, proteins, lipids, and bioactives.

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These key platforms require complementary technology enablers:

Technology Enablers	
Genetics & Genomics	Driven creative process for adapting or developing new plant or animal traits, varieties, cell lines
Culture Collection, Microbial resources	Screen, establish develop reliable and efficient cell lines, robust, stable microbial strains/platforms, with high food safety; development of cell banking technologies for the target plant species, including regeneration of plants from cell cultures
Microbiome Engineering	Microbiome engineering and design of synthetic microbial consortium seeks to improve the function of an ecosystem by manipulating the composition of microbes and to distribute microbial functions across specialized partners to minimize metabolic burden and increase yield stability.
Feedstock Pretreatment, Circular Feedstock System	The essential preliminary step that modifies raw biomass to make it more amenable to subsequent conversion technologies. This initial phase is critical in optimizing the efficiency and effectiveness of downstream processes. It also requires integrated biorefinery process design and circular system design.
Culture Media	Develop low-cost food-grade media or non-animal cell culture media components, as well as the development of specific growth factors production technology, with high food safety standards.
Bioreactors, Process Control, Safety	Innovative vessels, materials or devices for the safe, controlled and affordable growth of living cells or microorganisms, at a scale that meets supply demands, with lower sustainable impact; tools and methods for continuous processes thereby strongly reducing CAPEX and OPEX requirements. Advanced monitoring and innovative solutions for detailed process control, data generation, safety, and traceability. Innovative solution for disinfection. Low-cost, modular, and mobile bioprocessing technologies are adapted to primary production and fragmented value chains.
Downstream Processing	Recovery, separation, purification, concentration and formulation of biosynthetic products to isolate the target product from natural sources such as animal or plant tissue or fermentation broth, while also removing any contaminants.
Food Technology, Science, Formulation	Knowledge and solutions that support food formulation, improvement in taste, texture and nutrition, preservation, clean label, and new food forms. Valorization of side streams.
Omics	Metagenomics, multi-omics, and bioinformatics for analysis, selection/ characterization, design optimization of genes, microbes, microbiomes, and optimizing fermentation processes & bioconversion.
AI	AI-Ready Data, Generative AI and LLMs, specialized models, delivering clean, unified data to power reliable results and boosting efficiency across research teams.

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Systemic Enablers

Skills & Workforce	Fill the training gaps for scientist, engineers, production workforce, data scientists, regulatory experts
Regulation	Facilitate EU novel food approval, regulatory sandboxes
Sustainability, LCA, TEA standards	Explicit metrics on GHG, land, water, biodiversity impact, harmonised taxonomy, standards and frameworks; foster open-source sharing of comparable information
Consumer Acceptance & Market Pull	Consolidate social sciences and understanding of consumer habits and expectations; fully integrate the need for favorable food environments; engage with retailers and foodservice actors; explore schemes for advanced market agreement or public procurement.
Collaboration with Primary production	Integration of farmers; foresight projection and governance on future feedstock need and allocation; deployment of circular feedstock schemes
Infrastructures	Foresight projection of pilots & infrastructure needs; coordinated initiatives to facilitate access to shared facilities
Entrepreneurship	Develop a full set of initiatives and mechanisms to support startups from early stage to scale-up and through the valleys of death
Public engagement, consumer dialogue	Engage consumers in the design of new products; develop social sciences activities and pedagogic content with consumer associations
Financing & Risk-Sharing	need for enhanced funding in research; blended finance schemes and PPPs to support scale up
Ecosystem building, collaboration, tech transfer	Driving ecosystemic collaboration and synergies; bridging the gap between academic innovation and industrial application; fostering and facilitating startup – corporate collaborations
Policy support mechanisms	Incentives and facilitating schemes to accelerate market development, incl. public procurement, tax incentives, ...
International cooperation	Contribute to international coordination on key policy enablers, frameworks, standards, ...

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5.2 Overview of Market Applications

Intro

Advanced biotechnology enables multiple interconnected transitions across the agri-food system. The transformation potential becomes tangible only when technology platforms are deployed into specific value chains where they create a measurable impact on resilience, sustainability, nutrition, and competitiveness.

When talking about agrifood biotechnology, we consider applications into three R&I pathways:

- Agri-BioSolutions: seeds, animal genes, bio-solutions, soil microbiome, biostimulants, bioremediation
- Feed Applications: protein and lipid ingredients, feed additives, methane reduction
- Food Applications: dairy, meat, fish & seafood, egg replacement, bakery applications, lipids, functional foods, nutraceuticals

5.2.1 Agri-Biosolutions

Biotechnology will strongly impact all primary production activities

Agri-Value Chain	Technology Platforms	Example Outputs*	System Benefits
Seeds & Animal genes	Genetics, Microbiome Engineering	CRISPR crops, precision breeding	Improved resistance and sustainability
Biofertilisers & biostimulants	Microbial solutions, Microbiome Engineering	Rhizobia, nutrient-efficiency microbes	Less synthetic fertiliser, improved yields
Biocontrol & pest management	BF, microbial bioconversion	Bt proteins, microbial protection agents	Reduced chemical pesticide dependency
Soil health & resilience	Microbiome engineering + sensing	Root microbiome activators, improved soil structure	Higher carbon, water retention
Molecular farming inputs	MF	Plant-produced actives and proteins	EU sources for strategic ingredients

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5.2.2 Feed Applications

Biotechnology will deploy across feed and additives to improve animal nutrition, health and environmental performance: bulk protein enrichment, high value lipid enrichment, enzymes, additives to improve feed quality

Feed Value Chain	Technology Platforms	Example Outputs	Strategic Outcomes
Feed proteins (poultry, swine, aquaculture)	BF, Algae, Bioconversion	Microbial protein, single-cell protein	Lower import dependency on soy & fishmeal
Methane reduction additives	PF, Algae	Precision actives, red seaweed extracts	20–30% reduced ruminant emissions
Functional additives & processing aids	PF, enzymes, lipids	Amino acids, digestive enzymes	Improved feed conversion ratios

5.2.3 Food Applications

Biotechnology will gradually provide a large portfolio of food solutions:

- Protein rich ingredients or pure proteins: fermentation-derived, plant-enhanced, insect protein, cultivated meat or cell-based
- Lipid (fat/oil) rich ingredients or pure lipids: omega-3/6/9 fatty acids, microbial oils, algal-derived DHA and EPA, sustainable palm oil substitutes.
- Vitamins & amino acids: microbial production for food and feed fortification.
- Processing aids, enzymes & biocatalysts: for processing, nutritional enhancement, flavour, or fragrance.
- Bioactive/functional ingredients: probiotics, post-biotics, prebiotic oligosaccharides, bioactive peptides, bioactive molecules.
- Carbohydrates: alternative sugars, sweeteners, alternative approach to conventional fungicides.
- Preservative/technological/sensory additives: fermentation-derived preservatives, antioxidants, vitamins, flavour enhancers, colourants, pigments, stabilisers, texture agents.

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Food Value Chain	Core Challenges	Technology Platforms	Example Biotech Outputs*	Key SRIA Priorities
Dairy	Methane footprint, cost at scale, functional parity	PF, BF, MF, Algae, CTC	Casein, whey, dairy lipids, enzymes	Hybrid dairy, circular feedstocks, DSP cost reduction
Meat	Texture, flavour, affordability	BF, PF (heme), MF (fat), Algae, CTC	Mycoprotein, structured fats, fibers	Hybrid meat systems for foodservice first
Egg	Foaming, emulsification	PF, BF, Algae	Ovalbumin, lysozyme, algal pigments	PF proteins for bakery & specialised nutrition
Fish & Seafood	Resource pressure on fishmeal/oils	Algae, BF, PF, CTC	DHA/EPA oils, collagen proteins, fibers	Algal omega-3 for feed and food markets
Lipids & Oils	Palm oil & fish oil sustainability	PF, PMF, Algae	Tailored lipids, structured fats	Strategic autonomy in functional oils
Functional Foods & Beverages	Import dependence on enzymes & actives	PF, BF, Algae, CTC, PMF	Vitamins, pigments, probiotics, fibers, antioxidants	EU production of processing aids
Additives	Reduce loss and waste; improve health, address UPF issues	PF, BF, PMF	Preservatives, sweeteners, bio-based food additives	

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5.3 Mapping Technology and Market Interactions

The six core technology platforms apply differently to applications markets:

Technology Platform	Food	Feed	Agri-BioS.	Main Advantages
Biomass Fermentation	✅	✅	✅	Scalable bulk protein + soil solutions
Precision Fermentation	✅	▪	▪	High-value proteins, enzymes, lipids, bioactive molecules
Gas Fermentation	✅	▪	▪	High-value ingredients, reduced pressure on natural feedstock
Plant Molecular Farming	✅	▪	✅	Cost efficiency for specialised actives
Plant Cell/Tissue	✅	▪	▪	Complement for crops under threat
Enzymatic Bioconversion	▪	✅	✅	Circularity & waste valorisation
Algae/Aquatic Biotech	✅	✅	✅	Omega-3s + carbon & nutrient uptake

Legend: ✅ Direct application • ▪ Partial / spillover × Not applicable

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6. Main Technological Challenges to be addressed

Biotechnology for food and feed has reached a stage where laboratory breakthroughs are no longer a priority: Europe must now address and overcome the systemic bottlenecks of scale-up, industrial deployment, and market adoption.

To succeed, this transition must also integrate resource efficiency and life-cycle sustainability — ensuring that advances in biotechnology contribute to the optimal use of energy, water, and land, and to the circular valorisation of feedstocks. These elements are essential to reduce the sector's carbon footprint and align with the ambitions of the EU Green Deal and Farm-to-Fork Strategy.

This chapter details key technological priorities of each of the 6 key technology platforms and highlights the cross-cutting barriers faced across technology platforms.

6.1 Solid State Biomass Fermentation (BF)

Solid state biomass fermentation is a promising platform for producing low-cost, scalable, and sustainable proteins and lipids while reducing reliance on imports and conventional feed crops. It leverages side-streams and low-cost feedstocks, aligning with circular bioeconomy objectives. It builds on decades of experience of some pioneer startups and offers the capability to develop a diverse range of promising food and ingredient solutions, without the need of a complex downstream process, at lower cost.

Key Challenges & Priorities

- Side stream quality
- Feedstock supply strategy, security, circular integration
- Strain selection and optimisation
- Fermentation engineering, yield improvement
- Food additives obtained by BF using residual materials (co-products) from agri-food processing
- More focus on advanced analytical tools
- Regulation is unclear on the use of side streams for food grade production andshould be addressed

TRL & Timeline

- TRL 3–6 (2025–2026): Pilot optimisation
- TRL 6–8 (2025–2035): Demonstration and FOAK deployments

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Investment needs

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity/ Project Level
Microbial strain selection	Screen and establish efficient microbial strains suitable for degrading and using biomass as feedstock (includes genome sequencing with suitability evaluations)	Medium	30	R&D - Demonstration
Solid-state fermentation feedstock optimization	Develop plant-based raw material and side stream pretreatments, stabilization, decontamination strategy development	Medium	70*	R&D - Demonstration
Bioprocess scale-up	Develop bioprocess scale-up systems and downstream processing	Medium	150*	R&D - Demonstration
Ingredient characterization & functionalization	Analytics: including composition, safety (e.g. toxicity, allergenicity assays) and bioavailability studies; Functionality improvement	Medium	70	R&D - Demonstration
Techno-economics & Environment	Performing LCAs/TEAs	Medium	30	Support
Society	sLCA, consumer engagement and acceptance, ethics, policies and regulation	Medium	20	Support
Economics	Generate regional and global consumer and market analyses	Medium	10	Support
			380	

Figures with stars (*) indicate potential requirements for large-scale infrastructure (e.g. pilot plants) which is not included in costs here

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Targeted investment is required to scale solid-state biomass fermentation (BF) from pilots to commercial deployment:

Infrastructure & Scale-Up

- Mid-scale pilots and FOAK demonstration plants (€15–40M per site).
- Modular, decentralized units integrated into regional circular bioeconomy clusters.

Strain & Process Optimization

- Improved strains and process intensification (€5–10M per programme).
- Tools for managing feedstock variability and ensuring consistent quality.

Analytics, Safety & Regulatory Readiness

- Advanced monitoring and quality assurance systems.
- Regulatory assessments and clear EU guidance for using side-streams in food-grade BF.

Feedstock & Supply Chain Development

- Secure feedstock contracts, preprocessing capacity, and regional biomass mapping.

Market Activation

- Application labs, formulation work, and partnerships with food manufacturers.

Estimated Investment (2025–2035)

- €150–300M to reach TRL 8 and establish competitive European BF capacity.

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6.2 Liquid Biomass Fermentation (BF)

Liquid biomass fermentation is a promising platform for producing low-cost, scalable, and sustainable proteins and lipids while reducing reliance on imports and conventional feed crops. It leverages side-streams and low-cost feedstocks (e.g. molasses), aligning with circular bioeconomy objectives. This market tends to use only molasses as a feedstock and not a diverse set of side-streams allowing better use of these for food applications: for sustainability and strategic autonomy reasons this must change to the use of side-streams as the main feedstock

Key Challenges & Priorities

- Side stream quality
- Feedstock supply strategy, security, circular integration
- Feedstock diversification (agricultural residues, forestry by-products, gases (such as biogenetic, industrial emissions, CO_2), fishery byproducts, marine and fishery byproducts (abundant in Europe and rich in proteins and lipids, and their valorization aligns with circular bioeconomy and zero waste objectives), and algae grown on waste nutrient sources.
- Improved raw material pre-treatment to integrate co-products
- Strain selection and optimisation
- Fermentation engineering, yield improvement, energy and water saving; continuous processing
- Food additives obtained by BF using residual materials (co-products) from agri-food processing
- More focus on advanced analytical tools
- Downstream processing challenges (flavour, texture, removal of nucleic acids or cell walls)
- Regulatory, safety, and labelling considerations
- Regulation is unclear on the use of side streams for food grade production andshould be addressed.

TRL & Timeline

- TRL 3–5 (2025–2028): Pilot optimisation
- TRL 6–8 (2028–2035): Demonstration and FOAK deployments

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Investment needs

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity/ Project Level
Microbial strain selection	Screen, establish and develop efficient microbial strains suitable for food and feed ingredient production (includes genome sequencing with suitability evaluations)	High	100	Demonstration - Flagship
Media components	Develop low-cost media, including side stream and waste -based feedstocks and their pretreatment, stabilisation, potent inhibitor removal needs	Very high	200*	Demonstration - Flagship
Bioreactors & process design	Develop efficient bioprocesses including scale-up, automation and on-line monitoring and downstream processing	Very high	300*	Demonstration - Flagship
Ingredient characterization and functionalization	Analytics: including composition, safety (e.g. toxicity, allergenicity assays) and bioavailability studies; Functionality improvement.	Very high	200	Demonstration
Techno-economics & Environment	Standardisation of global LCA evaluation, performing LCAs/TEAs	Medium	70	Support
Society	LCA, consumer engagement and acceptance, ethics, policies and regulation	Medium	50	Support
Economics	Generate regional and global consumer and market analyses	Medium	10	Support
			930	

Figures with stars (*) indicate potential requirements for large-scale infrastructure (e.g. pilot plants) which is not included in costs here

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Scaling liquid biomass fermentation to a diversified, circular, and food-grade platform requires targeted investments in:

Infrastructure & Scale-Up

- FOAK demonstration plants and upgraded fermenters capable of handling diverse side-streams (€20–50M per site).
- Energy- and water-efficient continuous processing systems.

Feedstock Diversification

- Pre-treatment technologies for agricultural residues, forestry by-products, algae, and fishery co-products.
- Regional feedstock mapping and long-term supply agreements.

Strain & Process Optimisation

- Strain engineering for growth on unconventional feedstocks (€5–10M per programme).
- Improved yields, flavour/texture optimisation, and nucleic acid reduction.

Downstream Processing & Quality Assurance

- Investment in extraction, purification, and flavour-mitigation technologies.
- Advanced analytics for safety, consistency, and nutritional profiling.

Regulatory & Safety Readiness

- Novel food dossiers and clear guidance for food-grade use of side-streams.

Estimated Investment (2025–2035)

- €200–350M to reach TRL 8 and establish competitive European liquid BF capacity.

6.3 Precision Fermentation (PF)

Precision fermentation is the most advanced technology platform, already in use for specialty enzymes, fats, vitamins and functional ingredients, and also some food ingredients. However, significant progress is needed to make PF competitive at scale for bulk proteins and functional ingredients.

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Key Challenges & Priorities

- Strain engineering: Advanced tools like CRISPR, adaptive laboratory evolution, and synthetic biology are essential for optimizing host organisms (e.g., Bacillus, Pichia, E. coli, Saccharomyces) for yield, robustness, and minimal by-product formation.
- Cells – Procurement & Preparation: Expand the diversity of microbial chassis; optimise post-translational modifications, increase the solubility of recombinant proteins produced.
- Feedstock diversification, incl. gases
- Fermentation optimisation and validation at different TRL levels (for fed-batch and continuous), online monitoring and control tools.
- Pre-competitive collaboration for microbial strain sharing.
- Design synthetic consortia to minimise metabolic burden and optimise division of labour in biomanufacturing.
- Need more robust microorganisms that cope with impurities and feedstock variability.
- Culture Medium: Develop low-cost, efficient, and stable formulations tailored to cell lines. Chemically defined media tailored to specific strains and products can reduce variability, improve reproducibility, and minimize protease-related degradation, especially in enzyme production. Marine byproducts (e.g., hydrolysates from fish processing) can serve as sustainable, nutrient-rich media components for precision fermentation, reducing reliance on conventional agricultural inputs.
- Fermentation optimisation and validation at different TRL levels (for fed-batch and continuous), online monitoring and control tools. Process control and monitoring: Real-time analytics (e.g., Raman spectroscopy, online biomass sensors) and digital twins can enhance process stability and reduce batch failure rates.
- Consistency and quality: maintaining reproducibility on an industrial scale. The availability of microbial strains: designing microorganisms capable of efficiently producing complex molecules.
- Safety & Analytics: Develop novel analytical methods and adapt pharma-grade systems for food-grade requirements.
- Enviromental impact assessments (e.g., LCA) and long-term adoption impacts.
- Consumer acceptance and labeling: Clear communication strategies and transparent labeling are needed to build trust in PF-derived ingredients, especially in food applications.
- Investment needs: focus more on the use of existing pilot facilities than investing in new redundant CAPEX.
- Clear pathway for regulatory approval

TRL & Timeline

- TRL 3–5 (2025–2028): Pilot optimisation.
- TRL 6–8 (2028–2035): Demonstration and FOAK deployments.

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Investment needs

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity/ Project Level
Strain development	Establish reliable and efficient, roboust, stable microbial strains/ platforms	Very High	60	demonstration - flagship
Media sourcing, feedstock and composition	Develop complying, safe, sustainable, low cost media - search for alternative sources (e.g. from side streams and including upstream process to make them compliant with standards to use on food production)	High	60	demonstration - flagship
Bioprocess design, optimization,	Develop efficient bioprocess for optimization of parameters for high productivities of target molecule, include process control, digital twines, machine learning, online control)	Very High	250	demonstration - flagship
Final molecule characterization structural, chemically, stability, functional characterization, bioactivity, biodigestibility/ bioassesibility	Develop product composition and analytics to determine molecule identity and structural similarity with native molecule, as well as nutritional, safety, stability (including thermical stability) of the final product,	Very High	240	demonstration - flagship
Tech Development & Environment	Develop standards for conducting, as well as perform LCAs/TEAs	Medium	40	support
Consumers & Markets	Generate regional and global consumer and market analyses	Medium	20	support
Society & Governance	Assess benefits and challenges for PF adoptors, as well as policies to improve outcomes	Medium	10	support
			680	

Figures with stars (*) indicate potential requirements for large-scale infrastructure (e.g. pilot plants) which is not included in costs here

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6.4 Gas Fermentation

Gas fermentation is an emerging while promising technology platform, already, turning a mixture of carbon monoxide (CO), carbon dioxide (CO_2), methane (CH_4), and hydrogen (H_2), into specific ingredients and proteins, without mobilizing any natural feedstock. Using gases instead of purified sugars as a feedstock for fermentation can potentially cut operating costs and reduce pressure on arable land, lower feedstock expenses, simplify sterilization, allow for longer campaigns, and potentially leverage waste or byproduct gases.

Key Challenges & Priorities

- Microbial Strain Robustness & Engineering
- If biology is efficient, the inputs can be costly. Generating green Hydrogen requires electrolysis (energy-intensive), and sourcing clean Methane or capturedCO^2 requires purification technologies to remove contaminants (like sulfur or tars) that poison the microbes.
- Designing intrinsically safe industrial plants is a massive capital hurdle. It requires sophisticated sensor networks, explosion-proof zones and precise gas mixing control, which adds complexity to the "Scale-up" phase.
- The industry must validate novel reactor designs (e.g., loop reactors, gas-lift reactors, or pressurized systems) that maximize the volumetric mass transfer coefficient without skyrocketing electricity costs.
- Energy-Efficient Biomass Harvesting: the bacteria in gas fermentation are extremely small (single-cell), making it difficult to separate from the water (fermentation broth).
- Unlike precision fermentation where the protein is often floating in the liquid, Single Cell Protein (SCP) is usually inside the cell. The rigorous cell walls must be broken (lysed) to access the protein and improve digestibility for humans/animals.
- Sensory profile: Microbial biomass can naturally have "off-notes"—often described as metallic, fishy, or yeasty.
- Life Cycle Assessment (LCA) Transparency: If sustainability may become the main selling point of gas fermentation, accurately measuring the carbon footprint, water footprint, and land use efficiency of the entire integrated system.

TRL & Timeline

- TRL 3–5 (2025–2028): Pilot optimisation.
- TRL 6–8 (2028–2035): Demonstration and FOAK deployments.

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Investment needs

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity/ Project Level
Microbial strain selection	Screen, establish and develop efficient microbial strains suitable for utilising carbon from gas phase (includes genome sequencing with suitability evaluations)	High	70	Demonstration
Solid-state fermentation feedstock optimization	Develop integreation of gas phase compounds (C, O, N etc.) and other nutrients (N, micronutrients8 to culture media	High	150*	Demonstration
Bioprocess scale-up	Development of the unit operations of the bioprocess (electrolyser, bioreactors, scale-up systems and downstream processing)	High	250*	Demonstration
Ingredient characterisation & functionalization	Analytics: including composition, safety (e.g. toxicity, allergenicity assays) and bioavailability studies; Functionality improvement	High	150	Demonstration
Techno-economics & Environment	Performing LCAs/TEAs	Medium	50	Support
Society	LCA, consumer engagement and acceptance, ethics, policies and regulation	Medium	30	Support
		Medium	10	Support
			710	

Figures with stars (*) indicate potential requirements for large-scale infrastructure (e.g. pilot plants) which is not included in costs here

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6.5 Plant Molecular Farming

Plants can be engineered to serve as biofactories to grow and "express" proteins, enzymes, and other bioactive compounds that can be extracted post-harvest. Plant molecular farming is a low-cost production system, easily scalable via existing agriculture systems and infrastructures. It can be a long-term and strategic bet for Europe with a competitive edge if scaled properly.

Key Challenges & Priorities

- GMO terminology confusion (need distinctions)
- Access to filed testing (GMO)
- Valorisation beyond food applications in feed and/or biosolutions: development of microbial products for plants like biostimulants or biocontrol products
- Stable and efficient expression of molecules of interest in genetically modified plants, need robustness in engineered strains
- Downstream processing barriers, Process optimisation for downstream extraction.
- Bioavailability of extracted components qualification, research gaps
- Regulatory barriers, regulation of NGT's
- Adjacent industries spill-over into health and pharma; shared tech platforms
- TRL development timeline and investment needs estimation

TRL & Timeline

- TRL 3–5 (2025–2029): Pilot optimisation, reactor design validation, safe plant engineering.
- TRL 6–8 (2029–2038): Demonstration units, FOAK commercial deployments, integration with renewable gas and CO_2 sources.

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Investment needs

- Significant CAPEX for pressurized, intrinsically safe reactors and gas-handling systems (€30–70M per FOAK plant).
- R&D for strain robustness, gas purification, and energy-efficient harvesting (€10–20M per programme).
- Infrastructure for green hydrogen, biogenic methane, and CO_2 capture integration.
- Estimated €300–500M (2025–2038) to achieve commercial competitiveness in Europe.

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity/ Project Level
Plant cell culture technology	Development of plant cell culture technologies for the target plant species, including regeneration of plants from cell cultures	High	70	R&D - Demonstration
Genetic engineering	Development of genetic engineering tools including transformation protocols (e.g. CRISPR/Cas), genome sequencing of target species for targeted integration of encoding genes	High	100	R&D - Demonstration
GM-plant characterization	Analytics: including composition, safety (e.g. toxicity, allergenicity assays) and bioavailability studies	Medium	70	R&D - Demonstration
Breeding programs, cultivation	Breeding of elite lines, cultivation trials and strategies (field or containment) and post-harvest processing	medium	30*	R&D - Demonstration
Techno-economics & Environment	Standardization of global LCA evaluation, performing LCAs/TEAs	Low	10	Support
Society	LCA, consumer engagement and acceptance, ethics, policies and regulation	Medium	30	Support
Economics	Generate regional and global consumer and market analyses	Medium	20	Support
			330	

Figures with stars (*) indicate potential requirements for large-scale infrastructure (e.g. pilot plants) which is not included in costs here

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6.6 Animal Cell and Tissue Cultivation

Animal Cell and Tissue Cultivation offer the promise to producing meat, fish or animal fats made of animal genes and cells, without the need to slaughter animals, and in a controlled environment, reducing the risk of bacterial contamination and foodborne illnesses. Recent LCA analysis tend to show that producing cultivated meat emits much fewer emissions than traditional farming,

Key Challenges & Priorities

- Stable cell line supply, gold-standard lines
- Scaffold interaction knowledge
- Plant cell culture R&I
- Bioreactor design and scale-up.
- Culture media cost reduction and feedstock diversification.
- Fat–muscle co-culture complexity
- Texture + flavour challenges; improved flavour precursors
- Downstream processing to achieve consistency in taste and texture.
- Automation and robotization: scaling up to industrial levels while reducing costs
- Sustainability perception (energy)
- Consumer acceptance
- Regulatory sandboxes
- Regulatory barriers
- Lack of collaboration / siloed development; Open shared knowledge (NL example)
- Gaps in data standardization for AI & omics
- Cross-sector leverage and spill-over into pharma and regenerative medicine

TRL & Timeline

- TRL 3–6 (2025–2027): Pilot / CDMO optimisation.
- TRL 6–8 (2027–2035): Demonstration and FOAK deployments for some companies.

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Investment needs 2025-2235

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity / Project Level
Cell sourcing & preparation	Establish reliable and efficient cell lines	Very High	100	Demonstration
Media & culture support materials	Develop low-cost food-grade media or other cell culture media components (including to explore side streams and their upgrade to comply with food safety requirements, as well the development of specific growth factors production technology), support edible materials (e.g. carriers' scaffold, bioinks and new manufacturing strategies including required equipment design)	Very High	500*	R&D - Demonstration
Bioreactors & process design	Develop efficient bioreactor and bioprocess for generating cell mass	High	300*	R&D - Demonstration
Product formulation & analytics	Develop product composition and analytics to determine cell identity, nutrition, safety and process performance (this includes specific antibody development)	Medium -High	300	R&D - Demonstration
Tech Development & Environment	Develop standards for conducting, as well as perform LCAs/TEAs	Medium	25	Support
Consumers & Markets	Generate regional and global consumer and market analyses	Medium	10	Support
Society & Governance	Assess benefits and challenges for CM adopters, as well as policies to improve outcomes	Medium -High	25	Support
			1260	

Figures with stars (*) indicate potential requirements for large-scale infrastructure (e.g. pilot plants) which is not included in costs here

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6.7 Plant Cell and Tissue Cultivation

Plant Cell and Tissue Cultivation rely on the fact that many plant parts have the ability to regenerate into a whole plant, holding enormous potential for sustainable and efficient production of high-value compounds, with consistent quality and steady supply. It can be a valuable solution for crops at risk, under the pressure of climate change or for producing bio-based high valuable components at the portion of its sustainable impact.

Key Challenges & Priorities

- Genetic stability of cell line at scale
- The Growth Rate Barrier: Plant cells are notoriously slow. While bacteria double every 20 minutes, plant cells often take 2–5 days to double.
- Developing media formulations or mechanical strategies that keep the cells as a fine suspension (single cells or small clusters) to maximize surface area and productivity, preventing the reactor from becoming a slurry of dead biomass.
- Reducing the cost of media
- Despite its potential, this technology faces persistent challenges, including low protein yields and technical hurdles in process development.
- Downstream Processing: "Pharma-grade" lysis is too expensive. The food industry needs scalable cell disruption (e.g., bead milling, enzymatic hydrolysis, or pulsed electric fields) that break the wall to release the nutrient without generating heat that degrades the flavor or color.
- Sensory profile: Plant cells produce secondary metabolites for defense, often resulting in bitter (saponins) or astringent (polyphenols) profiles.
- Very complex regulatory landscape

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Investment needs 2025-2235

Research Domain	Description of primary goals	Priority for 2035	Funding Level (€M)	Maturity / Project Level
Establishment of PCTCs	Plant cell and tissue cultures generation procedures, and biomass production, development of cell banking (e.g. cryopreservation) technologies for the target plant species, including regeneration of plants from cell cultures	High	50*	R&D - Demonstration
Genome editing and genetic engineering	Development of genome editing & genetic engineering tools (e.g. CRISPR/Cas), genome sequencing of target species for targeted integration of encoding genes	High	100	R&D - Demonstration
Bioprocess scale-up	Develop efficient bioreactor and bioprocess including optimization of medium composition (including side stream -based feedstocks), scale-up, automation and on-line monitoring and downstream processing	High	170*	R&D - Demonstration
Characterization of cell lines; Functionalization	Analytics: including composition, safety (e.g. toxicity, allergenicity assays) and bioavailability studies; Functionalization strategies	High	50	R&D - Demonstration
Techno-economics & Environment	Standardization of global LCA evaluation, performing LCAs/TEAs	Medium	30	Support
Society	LCA, consumer engagement and acceptance, ethics, policies and regulation	Medium	30	Support
Economics	Generate regional and global consumer and market analyses	Medium	10	Support
			440	

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6.8 Enzymatic Bioconversion

Microbial bioconversion is about converting agricultural side-streams, byproducts or waste into bio solutions or high-value proteins, lipids and ingredients using microbes, closing nutrient loops and reducing imports for feed. It can provide a range of intermediate products, including glucose, galactose, mannose, xylose, and arabinose, which can be relatively easily processed into value-added bioproducts.

Key Challenges & Priorities

- Priority for regional value chains with high biomass streams.
- Standardization of feedstock sourcing.
- Industrial availability of feedstocks: allocation of biomass resources is a critical issue, as biomass is used for various purposes.
- Need more robust microorganisms that cope with impurities and feedstock variability.
- Scaling laboratory successes to industrial levels can be challenging due to differences in conditions and the need for consistent performance.
- Costs associated with developing and maintaining bioconversion systems can be high, impacting their economic feasibility.
- Valorization of effluents to recover materials and formulate feedstock, adding circularity to achieve zero-waste processes.
- Environmental approvals
- Harmonised regulation.

TRL & Timeline

- TRL 6–8 (2026–2035): Demonstration and FOAK deployments.

Investment needs 2025-2035

- Investments in regional bioconversion hubs, pre-treatment, and feedstock standardisation (€10–30M per site).
- R&D for robust microbial and enzymatic systems able to process variable side-streams (€5–10M per programme).
- Scale-up of continuous bioconversion lines and zero-waste valorisation of effluents.
- Regulatory approval, safety validation, and harmonised standards for food and feed applications.

Estimated total: €150–250M to reach TRL 8 and establish competitive European bioconversion capacity.

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6.9 Algae & Aquatic Biotech

Micro-algae are a versatile platform providing proteins, lipids (including DHA, EPA and Omega-3–6–9), pigments, and functional ingredients, but scale-up, regulatory approval and cost remain challenging. There are already mature companies supplying algae and the infrastructure to markets in the EU and associated Countries. However, several challenges exist to fully integrate and expand this viable sector.

Key Challenges & Priorities

- Strain Development & Traits: productivity, robustness, lipid/protein ratio tuning, resistance to contamination (bacteria, fungi, grazers), and microbiome engineering (e.g., tailored microbiomes) to enhance growth stability.
- Increasing EU and other worldwide species list for novel food status of algal species for safe human/food chain food consumption.
- Feedstock & Energy Inputs: heterotrophic sugar demand vs. autotrophic sunlight/ CO_2 capture; renewable energy integration and circular systems including Integrated Multitrophic Aquaculture (IMTA) and wastewater treatment.
- Pilot plants are spread out and often not supported once research grants are finished in 3-5 year cycle.
- Electricity kWh costs in EU are high – Algal companies in Iceland take advantage of lower energy tariffs. Greater support for solar powered plants is required to improve this.
- Process Engineering: light distribution in PBRs, harvesting/dewatering costs, nutrient recycling.
- Feedstock diversification (heterotrophy, autotrophy, hybrid systems), also heterotrophically in standard (dark) bioreactors.
- Challenge in high yield production
- Contamination risk significantly higher in continuous systems
- Scaling remains difficult due to high CAPEX and OPEX
- Limited access to food-grade, scalable DSP (drying, freezing capacity)
- Downstream Processing: Cascade biorefinery approaches for the sequential extraction of proteins, lipids, pigments, and carbohydrate-rich residues, ensuring zero-waste valorisation. While products such as spirulina, algal oils, proteins, pigments and antioxidants such as astaxanthin are already on the market, scaling algae cultivation for bulk food and feed remains challenging due to high production costs, energy intensity, and complex downstream processing.
- Integration challenges: Retrofitting into existing food/feed industries.
- Sustainability: high water and energy demand remain unresolved; need for LCA benchmarks.
- Early detection technologies: Development of molecular kits for the rapid identification of biological contaminants (grazers, parasites) to enable timely mitigation strategies.

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- Challenges in taste and nutrition optimization
- Market & Adoption: Overcoming "pond scum" consumer perceptions, scaling from nutraceuticals to mainstream food/feed.
- Regulatory & Safety: Food approval and labelling of algal proteins and lipids, allergenicity testing
- Leveraging EU aquaculture partnerships such as AlgaEurope, EU4Algae, EABA
- Engaging with national/international algal culture collections for the sector, eg CCAP-UK Culture Collection for Algae and Protozoa (www.ccap.ac.uk); or Spanish Bank of Algae (BEA-Banco Español de Algas) for secure collections and deposits.
- Market-pull mechanisms for omega-3 sovereignty
- Perhaps missing is the "harmful algae bloom" sector – this has a huge impact on fisheries but depends on if we are limiting land based or not.
- LCA of enclosed controlled reactors is still not carbon favorable
- Non-native species contamination risks in local environment, eg, how are large scale spills mitigated and monitored.
- Requires a mix of skilled workforce, but a lot of the roles can be carried out with basic training.

TRL & Timeline

- TRL 1-3: (2007-onwards) constant research into screening algal species for suitable traits/environmental risk assessments; growth media optimization for industry scale
- TRL 4-6 (20286–2035): System design and testing at very large-scale growth facilities for food and feed products
- TRL 7-9 (2030–2035): Larger scale growth facilities for food and feed products
- TRL 9 (2026 onwards): companies in EU already have addressed these issues but are few and far between and costs high for large scale CAPEX
- Link to EU4Algae, EABA initiatives and outputs: https://maritime-forum.ec.europa.eu/theme/blue-economy-and-fisheries/blue-economy/eu4algae_en

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Investment needs

- Regulatory mechanisms that facilitate use of EU products (e.g. biostimulants) in EU, rather than cheaper, imported certified products from geographies with lax regulation.
- Does the sector need an equivalent of the EU Common Agricultural Policy to secure funding and prices for people in EU to grow and process these ingredients?
    - 1: increased or better supported large scale production scale and technology test beds for industry throughout EU.
    - 2: regulation and market development (I expect most of the larger food/ ingredient producers in EU know of the potential of algal products and I expect much of it comes down to price per kg of the ingredients and feed safely/provenance as to why not seeing algal pigments in food ingredients.
    - 3: research and development into new strains and products – making use of multiomic platforms and phenotyping (50million)

6.10 Cross-Platform Technology Enablers

Key Challenges & Priorities

- Feedstock
    - Cataloguing of plant-based inputs, agricultural side streams and marine and fishery byproducts (from fishing, aquaculture, and fish processing)
    - Comprehensive, open-access catalogue(s) of plant-based raw materials and ingredients, including fibers, starches, oils, and proteins, along with their sensory, nutritional, safety, and functional properties.
    - **Feedstock diversification** is vital to achieve resilience and sustainability targets while avoiding dependence on glucose as the primary carbon source.
    - Open-access mapping of feedstock streams — including food, agriculture, forestry and marine side-streams — is needed to identify regional sourcing opportunities.
    - Competition for biomass is growing, requiring **strategic allocation and circularity policies**.
    - Establish relationships between plant sources, ingredient attributes, and flavour profiles to guide the engineering of biosynthetic pathways for improved food product quality.
    - Evaluate and catalogue potential major side streams of novel protein production and create ways to convert them into inputs for other food and non- food (e.g., packaging, chemicals) products.

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- Genetics & Genomics
    - Cataloguing cells that enhance the flavour, texture, nutrition, and other key functional properties of protein-rich biomass and formulated food products
    - Strain development must prioritise robust microorganisms capable of dealing with variable feedstocks and impurities. A triple optimisation approach:
        - Process optimisation
        - Microorganism engineering
        - Feedstock diversification

- Microbiome Engineering
    - Microbiome engineering will enable the design of microbial consortia and host–microbe interactions that improve fermentation performance, enhance flavour and nutritional attributes, and increase tolerance to impurities in diverse feedstocks. Advances in metagenomics, strain–strain interaction modelling, and synthetic ecology can unlock more resilient, efficient, and predictable bioprocesses across platforms.

- Feedstock Pretreatment, Circular Feedstock System
    - Robust pretreatment technologies are needed to convert heterogeneous side-streams into consistent, fermentable inputs while maximising nutrient recovery. Building circular feedstock systems requires integrating biomass valorisation across industries, ensuring every output—fractions, residues, and effluents—can be upcycled into food, feed, materials, or energy. This approach strengthens resource security, reduces waste, and supports Europe's strategic autonomy.
    - Foster partnerships in the agri-food and closely allied sectors to commercialize technologies designed to convert side streams and byproducts into high-value products.
    - To ensure the entire system is sustainable and circular, Europe must also address valorisation of GMO biomass residues and support compliance with evolving waste-handling requirements.

- Bioreactors
    - Develop lower-cost food-grade bioreactors using novel materials (beyond stainless steel) is urgent to reduce CAPEX and enable competitive production.
    - Develop low-cost, modular and mobile bioprocessing technologies adapted to fragmented value chains
    - Retrofitting ("brownfield projects") could reduce capital costs and speed up deployment but requires strategic coordination.
    - Develop and optimize cost-effective co-culture strategies and non-standard production systems (e.g., solid phase) to enhance protein and

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biomass outcomes by reducing the impact of metabolic wastes and maximizing the efficient growth of organisms.

- Downstream Processing
    - Downstream processing innovation: more efficient purification, reduced drying costs, scalable solutions for wet biomass such as freezing.
    - Bioprocess scalability: many promising biotech solutions fail to scale due to non-linear behavior in microbial growth, metabolite production, and downstream processing. Scale up is both an engineering and a biological challenge - however, often the engineering takes over, and the biology is unfunded or minor funded, need to address this balance. Emphasis should be placed on predictive biology scale-up models and modular bioreactor design.
    - Advance understanding of how processing changes affect interactions between ingredients and together influence the resulting physicochemical, sensory, safety, and nutritional properties of the end product.

- Process Monitoring
    - Product & scale-up relevance: omics-data as input for optimization of bioprocesses to enhance yield and reduce variability, for industrial process development so that fermentation & bioconversion scale faster and with regulatory assurance
    - Frameworks for automating and digitizing bioprocesses with advanced sensors and real-time process analytical technologies

- AI & Omics : Digitalisation will be key to accelerate innovation and reduce risk
    - Metagenomics, multi-omics, and bioinformatics for the selection/ characterization, e.g., of strains.
    - Computational models of cell types (e.g., metabolic and systems biology models) feed into bioprocess modelling, media development, and process optimization.
    - Omics and AI-based process control, real-time contamination monitoring, and digital twins for USP + DSP should be integrated into new demonstration plants. Integrate AI/ML with process modelling for automation and predictive control.

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6.11 Systemic Enablers

Key Challenges & Priorities

- Workforce and skills needs:
  - Fermentation specialists, bioprocess engineers
  - Downstream processing specialists (e.g., for purification, separation, and concentration of bioproducts)
  - Formulation experts who can ensure product stability, functionality, and consumer acceptability
  - Regulatory experts,
  - Consumer communication specialists,
  - Systems thinking and entrepreneurial capacity.

- Skills & education
  - Develop an EU Biotech Skills Framework with four clusters:
    (a) Systems & Sustainability, (b) Bioprocess & Scale-up, (c) Data/AI & Quality, (d) Market, Regulation & Adoption.
  - Create a Regulatory Knowledge and Sandbox Track (case-based modules + placements).
  - Launch operator and technician upskilling pathways for labs and pilot-plant operators.
  - Build Biotech Academy modules:
    - Primers ("Biotech for Non-Biotech", "AI in Biotech")
    - Bootcamps (scale-up, downstream, data/AI, communication)
    - Field placements & residencies at pilot sites
    - Commercialization studios linking scientists, chefs, retailers, and consumers.

- Regulation
  - Clear, science-based and predictable EU regulatory frameworks for Novel Foods, GMOs/NGTs, labelling, and a functional, risk-proportionate definition of biocontrol active substances.
  - Creation of a unified EU biocontrol zone, reflecting pest mobility and climate change realities, to ensure equal and timely access to biocontrol solutions for farmers across all Member States.
  - Streamlining of re-registration procedures for biocontrol products, with re-registration required only where new scientific evidence justifies a risk review. This would significantly reduce administrative burden, free national resources, and accelerate access to innovation.
  - Deployment of regulatory sandboxes at national and EU levels to support startups and SMEs in preparing high-quality dossiers, testing products

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under real-world conditions, engaging with consumers, and generating regulatory-relevant evidence.

- Earlier and structured dialogue between innovators and regulators, including pre-submission guidance and joint scientific advice, to reduce uncertainty, improve dossier quality, and shorten time to authorisation.
- Improved coordination between Member States and EFSA, including mutual learning and shared assessments, to reduce fragmentation and duplication in authorisation processes.
- Regulatory pathways proportionate to risk and innovation type, especially fermentation-derived ingredients, microbial products, and low-risk biocontrol solutions, ensuring safety while enabling speed and competitiveness.

- Sustainability, LCA, standards
  - Sustainability and environmental impact standards and mutually agreed calculation methodologies
  - Harmonised EU sustainability and environmental impact standards specifically designed for food and feed biotechnology, including fermentation-derived ingredients, microbial products, algae-based inputs, and biotech-enabled feed solutions.
  - Food- and feed-specific Life Cycle Assessment (LCA) methodologies, enabling fair and transparent comparison between biotech-derived ingredients and conventional agricultural and animal-based production systems.
  - Clear guidance on LCA system boundaries and allocation rules for food and feed biotech, including treatment of co-products, side-stream valorisation, feed-to-food loops, and energy sourcing.
  - Standardised sustainability metrics and datasets adapted to food-grade production, supporting innovators at pilot, demonstration, and FOAK stages without imposing disproportionate data burdens.
  - Recognition of dynamic sustainability performance, allowing sustainability assessments to reflect scale-up effects, process optimisation, and increasing use of renewable energy over time.
  - EU-recognised frameworks for sustainability claims and labelling for food and feed biotech products, ensuring consumer transparency while avoiding misleading or inconsistent claims.
  - Alignment of sustainability criteria with funding and procurement mechanisms for food and feed innovation, incentivising low-impact, circular, and resource-efficient biotech solutions.
  - Accessible sustainability tools and guidance for SMEs and startups, supporting compliance and responsible innovation without disadvantaging early-stage actors.

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- TEA frameworks, standards
    - Sustainability and environmental impact standards and mutually agreed calculation methodologies

- Consumer Acceptance & Market Pull
    - Transparent, science-based communication frameworks for agri-food and feed biotechnology, enabling consistent, factual and accessible information on safety, sustainability, nutritional benefits and production methods.
    - Harmonised terminology and labelling approaches for biotech-derived food and feed products, reducing consumer confusion and avoiding fragmented national interpretations that hinder market uptake.
    - Early and meaningful consumer engagement mechanisms, including dialogue, deliberation and co-creation, ensuring that societal values, ethical considerations and cultural contexts are reflected in innovation pathways.
    - Market validation and demand-generation instruments, such as public procurement, living labs, and controlled market pilots, to test consumer response and accelerate adoption of safe and sustainable biotech solutions.
    - Support for evidence-based claims on health, sustainability and functionality, enabling companies to substantiate benefits without creating unrealistic expectations or greenwashing risks.
    - Inclusion of farmers, food processors and retailers as market shapers, recognising their role in adoption, trust-building and scaling of agri-food and feed biotech innovations.
    - Incentives for first market deployment, including risk-sharing mechanisms and support for early adopters, to bridge the gap between regulatory approval and commercial uptake.
    - Integration of consumer and market insights into innovation funding and policy design, ensuring that technological development is aligned with real market needs and acceptance dynamics.

- Collaboration with Primary production
    - Structured partnerships between biotech innovators and primary producers (farmers, cooperatives, aquaculture operators, and feed producers) to ensure technologies respond to real agronomic, economic, and operational needs.

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- Co-development and on-farm validation of biotech solutions, including feed additives, biostimulants, microbial products, and fermentation-derived inputs, under real production conditions.
- Fair and transparent value-sharing models, ensuring that primary producers benefit economically from participation in biotech-enabled value chains.
- Integration of primary production into circular feedstock systems, enabling farmers and aquaculture operators to act as suppliers of side-streams and co-products for biotech processes.
- Knowledge exchange and capacity building, supporting producers in understanding, adopting, and managing biotech-enabled inputs and practices.
- Alignment with existing advisory services and farmer networks, embedding biotech solutions into trusted extension and support structures.
- Incentives and risk-sharing mechanisms for early adoption, reducing economic uncertainty for producers engaging with novel biotech applications.
- Inclusion of primary production perspectives in innovation governance, ensuring farmer and producer voices are represented in decision-making and priority-setting.

- Infrastructure Gaps:
  - Dual infrastructure strategy required to support scale-up across TRLs:
    - TRL 3–5: distributed regional pilot facilities to test local biomass and reduce techno-economic risk for SMEs and startups
    - TRL 6–8: a limited number of pan-European FOAK demonstration plants to validate industrial deployment
  - Modular and scalable production platforms needed to adapt to different feedstocks, processes, and product requirements in food and feed biotechnology.
  - Open-access pilot and demonstration platforms to enable feasibility studies, process validation, and scale-up trials across biotechnology domains.
  - Insufficient visibility and accessibility of existing EU pilot and demo facilities, requiring a comprehensive mapping of the European infrastructure landscape to address access costs and fragmentation.
  - Rural and peri-urban areas represent strategic locations for biomass valorisation and circular bioeconomy deployment, requiring tailored infrastructure solutions and instruments.
  - Access, not availability, is the main bottleneck:
    - RTOs, startups, SMEs, and large enterprises often lack the financial means to pay service fees

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        - Lead times for existing facilities are often short, while building new infrastructure can cause unnecessary delays
    - Priority investments should focus on enabling use of existing infrastructure, including:
        - Upgrading pilot plants with innovative reactors, downstream processing equipment, and digital tools
        - Voucher-based access schemes and shared booking platforms
        - Harmonised systems for facility availability and access conditions
    - These measures will reduce fragmentation, increase utilisation, and accelerate progression from pilot to FOAK and industrial scale-up.

- Public engagement and consumer dialogue
    - Transparent communication, citizen involvement, addressing perceptions of "synthetic" or "unnatural."

- Financing & Risk-Sharing
    - High cost of deployment remains a critical barrier: the transition from pilot to demonstration and pre-commercial scale represents the main "innovation valley of death." While most economic value and job creation occur post-pilot, this phase carries high technical, regulatory, and market risk, requiring stronger regional–EU co-financing and coordinated scale-up ecosystems.
    - Blended finance instruments across all TRL stages, combining grants, equity, quasi-equity, loans, and guarantees to crowd in private capital while reducing risk exposure for first movers.
    - Dedicated risk-sharing mechanisms for FOAK and demonstration projects, including public guarantees, first-loss tranches, and revenue-stabilisation tools to de-risk early industrial deployment.
    - Improved access to scale-up capital for SMEs and startups, addressing late-stage funding gaps that are not covered by traditional venture capital or project finance.
    - Alignment of public funding, investment, and infrastructure access, ensuring that financial support is coupled with access to pilot, demo, and manufacturing facilities.
    - Regional investment platforms and co-investment vehicles, leveraging local strengths while enabling cross-border and pan-European scale-up.
    - Clear and predictable funding pipelines, allowing innovators to plan multi-year scale-up trajectories and reducing fragmentation across EU and national instruments.

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- Collaboration, tech transfer
    - Tech transfer: bridging the gap between academic innovation and industrial application requires better tech transfer mechanisms and training programs. Coordination with platforms such as EU-CONEXUS, fostering a bidirectional EU-wide framework that aligns industry demands with academic advances and translates them into tangible food-biotech solutions.
- Policy support mechanisms
    - Clear and stable long-term policy signals to support investment and scale-up of agri-food and feed biotech.
    - Better alignment of EU and national policies across agriculture, food, bioeconomy, and climate frameworks.
    - Integration of agri-food and feed biotech into CAP, Farm to Fork, and Bioeconomy policies as enablers of sustainability and resilience.
    - Targeted policy support for FOAK and scale-up projects, including permitting facilitation and coordinated public action.
    - Use of public procurement and lead-market instruments to accelerate first market deployment.
    - Structured dialogue between policymakers, industry, farmers, and civil society to ensure policies reflect real-world needs and societal expectations.

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7. R&I Pathways & Value Chain Applications

7.0 Scope and Value Chains targeted

The EU AgriFood Biotech Alliance aims at supporting the deployment of advanced biotechnologies and at addressing the technical, sustainability, resilience, and nutritional challenges of its applications across agriculture bio-solutions, food and feed products and ingredients.

Targeted Markets & Value Chains

- Agriculture bio-solutions: leveraging bioprocessing for soil health, crop resilience, biocontrol / bio nutrition / bio stimulation.
- Feed industries: cattle, sheep, goat, poultry, aquaculture, pet food.
- Food industries: ingredients and additives, dairy, meat, egg, fish, bakery, beverages, dietary supplements, special nutrition (infant, elderly, clinical), snacks.

Products in Scope

- Alternative proteins (fermentation-derived, plant-enhanced, insect protein, cultivated meat or cell-based).
- Lipids & oils: omega-3/6/9 fatty acids, microbial oils, algal-derived DHA and EPA sustainable palm oil substitutes.
- Vitamins & amino acids: microbial production for food and feed fortification.
- Enzymes & biocatalysts: for processing, nutritional enhancement, flavour, or fragrance.
- Functional ingredients: probiotics, post-biotics, bioactive peptides, bioactive molecules, prebiotic oligosaccharides. ferments (for baking, beverages, for dairy...).
- Technological/sensory additives: fermentation-derived sweeteners, flavour enhancers, colourants, stabilisers, texture agents,

Out of scope:

- Pharmaceuticals.
- Insect-derived proteins.

This scope ensures focus on high-impact and feasible pathways, while aligning with Europe's comparative strengths in biomass, fermentation, and functional food innovation.

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7.1 Market Applications: Feed & Agri-Biosolutions

Challenges & Opportunities

Advanced biotechnologies will play an essential role in enabling a more resilient feed sector, improving animal health, and reducing Europe's dependency on imported fertilisers and feed protein. However, innovation is needed to scale and reduce cost, and to accelerate access to farms and fields.

Main Challenges

- High reliance on imports for key inputs (fertilisers, soy).
- Commercial viability constrained by low margins in agriculture.
- Adoption barriers: limited trust and knowledge among farmers
- Fragmented and evolving regulatory frameworks (esp. biostimulants).
- Limited integration of One Health, soil health and food safety in product design.
- Lack of financial models to support transition on-farm.

Technology Priorities for Feed & Agri Market Applications

Biostimulants / Biosolutions

- Priority R&I: Mechanism-of-action discovery; performance stability across EU pedo-climatic zones; region-adapted strains via EU soil microbiome DB.
- Scale-up focus: Continuous bioprocessing for cost; field analytics for real-time performance; DSP for stable formulations.
- Regulatory science: Harmonised mode-of-action evidence packages; unified EU placing-on-market pathway.

Feed proteins & additives

- Circular proteins: Valorise agri/marine side-streams via BF/PF/ bioconversion; safety and feed-grade standards for PF side-streams.
- Soy replacement (aquafeed): Demo programmes comparing LCA, FCR, growth; optimise amino-acid profiles with PF-derived components.
- GHG reduction: Prebiotic and functional additives to cut ruminant methane; validate on-farm with robust MRV.

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Cross-cutting Enablers needed

- Predictable and unified regulatory pathways.
- EU Soil Microbiome Database (open but governed) to accelerate region-fit product design, databases for local soil microbiomes and microbial functionality.
- Valorisation of agri-food waste and forestry by-products for feed and additives.
- Grants-to-use existing infrastructure (CMOs, RTO pilots) + targeted equipment upgrades.
- Regional circular biorefineries integrating **food–feed–soil** systems.
- Regulatory sandboxes and distributed network of pilot farms and testing fields; Build open testing networks across Europe to validate biosolutions under diverse agro-climatic conditions. Stronger farmer engagement models: Co-development and demonstration farms; Derisking tools for adoption (insurance, service models, contracts); farmer adoption design: co-creation, training, service models, and incentive pilots (e.g., outcome-based payments for verified benefits).
- Digital and omics backbone: Common datasets for strain/media optimisation, process twins, and regulatory dossiers. Advanced analytics to decode mechanisms of action and meet future regulations.
- Framework and monitoring procedures to document links between technology and measurable farm impact.
- Predictable and unified regulatory pathways; cleared NGT regulatory environment; establish harmonised EU approval pathways for microbial biosolutions.
- Foster cross-sector collaborations between food biotech and agri-input companies.
- Effective science and risk communication.

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Expected Impacts

Impact Area	Outcome	Indicators
Resilience	Reduced dependency on imported fertilisers & feed	Import reduction
Sustainability	Improved soil health and lower livestock emissions	Carbon, nutrient indicators
Adoption	Increased farmer uptake of biosolutions	Adoption rate on-farm
Resilience	Diversified feed protein sources	# commercial alt-feed solutions
Health	Better soil, crop and animal health, resulting in better food	Protein quality, micronutrient density, reduced residues
Climate & Nature	Emissions and land-use reduction	LCA metrics
Rural Inclusion	Farmers benefiting from transition	# contracts, income stability
Time to market	aster progression from pilot → commercial	Time from TRL 5→8, number of approvals
Sovereignty	Leadership in innovation	Patents, publication, startup creations
Jobs & Skills	More industrial bioprocessing jobs in Europe	Workforce growth in scale-up facilities

Illustrative outcome KPIs (mapping to Chapter 7 value chains)

- Feed: ≥15% substitution of fishmeal/soy in select aquaculture value chains by 2030.
- Biosolutions: approval time reduced by ≥20% where harmonised dossiers are used; yield/resilience gains verified in multi-site EU trials.
- Sustainability: ≥20% GHG reduction in pilot ruminant systems using validated prebiotic programmes.

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7.1.1 Agriculture Biosolutions

Environmental and market context

Agricultural biosolutions — including biostimulants, biofertilisers, and biopesticides — are rapidly emerging as sustainable alternatives to chemical inputs.

As a proof, the global biostimulant market has hit $4.47 billion as it shifts from "opportunistic" growth to "more science-based market development," according to research firm DunhamTrimmer's 2025 Global Biostimulant Market Report. Projected CAGR through 2030 reach 10%. Europe lags in fourth place and "has not reached critical mass to elevate overall trajectories"; growing interest in CE certification interest could reignite growth.

Challenges

- Regulatory fragmentation: EU rules for biostimulants and biopesticides remain fragmented and slow, hindering market uptake【Joint European Forum on IPCEI, 2025). EU rules should support EU-produced biostimulants and biopesticides, rather than undermining the EU market with cheaper imports.
- Scalability: many biosolutions demonstrate efficacy in trials but fail at scale due to variable soil, climate, and crop conditions.
- Cost competitiveness: chemical fertilisers and pesticides remain cheaper at scale.
- Farmer adoption: requires training, trust, and demonstration of ROI under real conditions.

Potential biotech solutions

- Microbial consortia that enhance nitrogen fixation, phosphorus solubilisation, or stress resilience.
- Biopesticides derived from precision fermentation (e.g. Bacillus strains producing insecticidal metabolites).
- Molecular farming of natural compounds with bioprotective effects.
- Algae-based biostimulants and biopesticides for soil health and crop resilience.

Strategic R&I priorities

- Develop scalable fermentation and formulation technologies to produce biostimulants at industrial scale.
- Build open testing networks across Europe to validate biosolutions under diverse agro-climatic conditions.
- Establish harmonised EU approval pathways for microbial biosolutions.
- Foster cross-sector collaborations between food biotech and agri-input companies.

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7.1.2 Feed Additives

Environmental and market context

Feed is the largest input cost in livestock and aquaculture production, often accounting for 60–70% of total costs. Current feed additives (e.g. vitamins, amino acids, enzymes, probiotics) are mostly imported from Asia, creating strategic dependencies for the EU. Moreover, some additives such as fishmeal and antibiotics have negative environmental or health externalities, including overfishing, antimicrobial resistance, and GHG emissions from inefficient digestion.

Challenges

- Dependency on imports of vitamins, amino acids, and enzymes (e.g. >90% of EU vitamins imported from China【FAO 2018╎source】).
- Regulatory hurdles in authorising novel microbial or precision-fermentation derived additives.
- Performance vs cost trade-off: feed additives must deliver measurable feed efficiency gains or animal health benefits at very low per-unit costs.
- Consumer perception: although feed additives are upstream, transparency and trust (e.g. "antibiotic-free") increasingly matter for downstream food labelling.

Potential biotech solutions

- Microbial fermentation of amino acids (lysine, methionine, tryptophan), vitamins (B2, B12), enzymes (phytase, xylanase), and fatty acids (EPA/DHA from algae).
- Probiotics, prebiotics, and postbiotics to improve gut health, immune function, and feed conversion. Methane-reducing additives (e.g. precision-fermented bromoform analogues, algae-derived compounds).
- Valorization of fish processing byproducts and discards as both a sustainability imperative and a source of novel ingredients, including hydrolysates and bioactive peptides derived from fish byproducts as additional feed ingredients.

Strategic R&I priorities

- Valorisation of agro-food side-streams into feed additives.
- Develop next-generation probiotics and algae-derived functional ingredients (e.g., for gut immune modulation), tailored to species-specific microbiomes.
- Scale microbial production of vitamins and enzymes at competitive cost levels
- Full aquaculture feed substitution with microbial/algal proteins, replacing fishmeal at scale.
- Demonstrate methane-reducing feed additives at commercial farm scale.
- Harmonise LCA methodologies to compare environmental benefits of feed additives.

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- Cross-sector roadmap and infrastructure:
    - Omega-3 and specialty lipids (microalgae and microbial oils) ; Algae-Oils EU Plant: industrial-scale omega-3 and lipid production for infant nutrition and aquaculture feed.
    - Feed proteins (aquaculture and poultry); Circular Biomass Fermentation Hub: microbial protein from agro-waste for aquaculture and poultry feed.
    - Dairy proteins (precision-fermented casein, whey); European Precision-Dairy Flagship: FOAK demo producing casein/whey at industrial scale, integrated with downstream drying/processing.
    - Shared Fermentation & DSP Hub: A cross-sector demo facility (food–pharma–cosmetics) to maximise CAPEX utilisation and spill-over innovation.
    - Clinically validated functional bioactives (postbiotics, peptides) bridging food and health sectors.

7.2 Market Applications: Ingredients

Challenges & opportunities

Biotechnology-enabled ingredients are a critical growth market for Europe's food and feed sectors, from functional proteins and fibres to vitamins, flavourings, and bioactives. However, ingredient innovation struggles to reach scale and regulatory approval, preventing promising technologies from creating market traction.

Europe must diversify its lipid (edible oils) and protein sources — not to increase total consumption, but to reduce land pressure, improve nutrition, and strengthen sovereignty. Biotech solutions can deliver highly functional and sustainable proteins — but market adoption remains slow.

Main Challenges

- Fragmented value chain with limited system coordination
- Cost structures remain high vs conventional protein supply chains
- Consumer acceptance dependent on taste, texture, and perception of "processing"
- Strong incumbent livestock lobbying influences policy and terminology rules
- Farmers lack integration, incentives, and clear roles in the transition
- Scale-up financing and feedstock variability create uncertainty
- Limited visibility of commercial use-cases for emerging ingredients across industries

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- Lack of food-grade pilot and demo facilities at relevant scale (kg → tonne batches)
- High downstream processing costs and limited purification capabilities
- Regulatory pathways (e.g., EFSA dossiers) lack clarity and standardisation
- Funding gap for companies facing long regulatory timelines and scale-up costs
- Difficulty combining scientific excellence with industrial engineering and productisation
- Cost competitiveness vs. conventional imported alternatives

R&I Opportunities

- Minimal-processing strategies for improved nutritional integrity
- Advanced food design: texture, functionality, digestibility, flavour release
- Mapping and unlocking EU side-streams for fermentation feedstocks
- Plant cell cultivation to reduce cost and land intensity
- Improved allergenicity understanding and management
- Techno-economic and safety modelling to support industrial investment decisions
- Shared or rentable pilot infrastructure with GMP-/food-compliant processing lines
- Digital and AI-assisted design to accelerate functionality testing and reduce failed batches
- Valorisation of side-streams as feedstocks for ingredient production
- Partnerships between startups and corporates to secure market pull during scale-up
- Innovation in novel protein and fibre applications (e.g., microbial fibres, yeast extracts)
- Downstream processing and machinery
- Innovative industrial access models (vouchers, access funding, shared plants)
- Innovation in novel protein and fibre applications (e.g., microbial fibres, yeast extracts)
- Better integration of techno-economic and regulatory requirements from TRL 3 onward

Enablers Needed

- Support for blended/hybrid products to accelerate consumer acceptance
- Engagement strategies with chefs, retailers and food service
- Scalability and market demand sizing need stronger evidence
- Stronger economic incentives for industrial uptake
- Skills pipeline for food-grade scale-up and formulation

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- Shared pilot plants with food safety certification to avoid market delays
- EU-funded voucher schemes for access to infrastructure and expert services
- Public–private "living labs" for sensory testing before regulatory approval
- Innovation challenges to accelerate customer validation for startups
- Regulatory sandboxes and early dialogue mechanisms with EFSA
- Consumer-facing transparency and safety communication measures

Expected Impacts

Impact Area	Outcome	Indicators
Climate & Nature	Emissions and land-use reduction	LCA metrics
Nutrition	Higher nutrient density in mainstream foods	Nutritional profiles
Market Growth	Increased uptake of diversified proteins	Sales and category penetration
Rural Inclusion	Farmers benefiting from transition	# contracts, income stability
Sovereignty	Leadership in innovation	Patents, publication, startup creations
Competitiveness	Europe becomes a global hub for biotech ingredients	Share of EU-produced ingredients in EU market
Time to market	aster progression from pilot → commercial	Time from TRL 5→8, number of approvals
Resilience	Reduced reliance on non-EU imports	import dependency metrics
Jobs & Skills	More industrial bioprocessing jobs in Europe	Workforce growth in scale-up facilities

7.2.1. Lipids & Oils

Environmental Limitations of Conventional Lipids

- Palm oil: the most widely used vegetable oil globally, but strongly associated with deforestation, biodiversity loss, and high CO_2 emissions.
- Fish oil: key source of omega-3 fatty acids (DHA, EPA), but largely dependent on unsustainable fishing practices and aquaculture feed cycles.
- Soy and rapeseed oils: less carbon-intensive than palm oil but linked to land-use change and heavy pesticide/fertilizer use.

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- Vegan and vegetarian sources of algal oils and lipids (fish DHA and EPA comes from the algae they eat, the fish do not make it naturally)
- Nutritional gap: conventional oils often lack optimal fatty acid profiles for human health, contributing to imbalanced omega-6/omega-3 ratios in diets.

Challenges for Lipid & Oil Alternatives

- Replicating functional performance: lipids provide essential texture, mouthfeel, and stability in processed foods (e.g., bakery, dairy, confectionery).
- Nutritional equivalence: alternatives must supply essential fatty acids (omega-3, omega-6, omega-9) without introducing trans fats or instability.
- Cost & scalability: algal and microbial oils remain more expensive than palm or soy oils.
- Consumer trust: acceptance depends on clarity of nutritional value and sustainability claims
- Regulatory harmonization for the use of marine byproducts in food and feed, to facilitate market uptake and cross-border collaboration

Solutions through Advanced Biotechnology

- Microbial fermentation: production of structured oils (e.g., cocoa butter equivalents, tailored fatty acids) using yeasts or algae.
- Algal cultivation: high-efficiency production of DHA/EPA-rich oils as substitutes for fish oil in supplements and aquaculture feed.
- Marine byproducts (e.g., fish oil from processing discards) may contribute to a sustainable lipid strategy.
- Molecular farming: engineering crops to produce omega-3 fatty acids, reducing dependence on marine ecosystems.
- Tailored lipid engineering: synthetic biology allows custom fatty acid compositions designed for specific health or functional needs (e.g., infant formula, clinical nutrition).
- Hybrid formulations: blending biotechnological oils with conventional plant oils to balance cost and nutrition.

Cost Expectations

- Algal oils: projected 30–40% price decline by 2030, enabling wider use in aquaculture and nutrition markets.
- Precision-designed microbial oils: higher CAPEX today but scalable through fermentation platforms already used in food enzymes.
- Palm oil alternatives: microbial or yeast-derived oils could reach parity with certified sustainable palm oil within 10–15 years, if pilot and demonstration investments accelerate.

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Strategic Potential

- Reduce deforestation pressures by lowering palm oil dependency.
- Protect marine biodiversity by cutting reliance on forage fish for aquaculture.
- Improve dietary health by supplying stable, bioavailable omega-3 fatty acids.
- Enhance EU food sovereignty by decreasing imports of tropical oils and marine-derived lipids.

7.2.2. Bio-flavours

Environmental Limitations

Conventional flavour production often relies on resource-intensive agricultural crops, volatile harvest yields, and geographically concentrated supply chains, increasing vulnerability to climate change and biodiversity loss. Extraction of natural flavours can require large volumes of water, solvents, and biomass, while synthetic flavour production depends on petrochemical inputs with associated carbon footprints. These factors limit sustainability and resilience, reinforcing the need for bio-based, circular alternatives.

Challenges for bio-flavours

- Enables valorisation of under-used European biomass (e.g., fruit skins, herb residues, marine side-streams)
- Taste, aroma and texture gaps slow consumer acceptance
- High cost compared with synthetic or commodity flavourings
- Downstream processing and stability constraints at scale
- Limited food-grade pilot infrastructure for fermentation and DSP
- Rapid flavour development using omics + AI for sensory prediction
- Regulatory uncertainty: "natural", Novel Food, GM/NGT categories
- Fragmentation between biotech R&D, food formulators, and culinary experts. In-process sensing for flavour precursors and contaminants

Solutions through Advanced Biotechnology

- Fermentation and bioconversion using regional fruit, vegetable, marine, and herbal side-streams.
- Engineering of cell factories for higher yields, specificity, and tailored flavour profiles.
- Synthetic biology and metabolic pathway optimisation to produce complex aroma compounds.

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- AI-assisted enzyme and strain design to accelerate development and enhance efficiency.
- Real-time sensing and process control to optimise precursor formation and minimise contaminants.
- Integrated downstream processing for improved purity, stability, and cost-effective recovery.
- Circular production systems reducing reliance on imported botanicals and petrochemical synthetics.

Cost Expectations

- Algal oils: projected 30–40% price decline by 2030, enabling wider use in aquaculture and nutrition markets.

Strategic Potential

- Higher EU market share in natural flavour/aroma ingredients
- New industrial capacity based on European biomass
- Faster time-to-market for food biotech innovations
- Jobs in high-value sensory ingredient production

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7.3. Proteins

Challenges & opportunities

Europe must diversify its protein sources — not to increase total protein consumption, but to reduce land pressure, improve nutrition and strengthen sovereignty. Biotech solutions can deliver highly functional and sustainable proteins — but market adoption remains slow.

Main Challenges

- Fragmented value chain with limited system coordination
- Cost structures remain high vs conventional protein supply chains
- Consumer acceptance dependent on taste, texture, and perception of "processing"
- Strong incumbent livestock lobbying influences policy and terminology rules
- Farmers lack integration, incentives, and clear roles in the transition
- Scale-up financing and feedstock variability create uncertainty

R&I Opportunities

- Minimal-processing strategies for improved nutritional integrity
- Advanced biorefinery of microbial biomass (e.g., algal protein extracted from the same batch as the algal oils, thereby improving affordability of both)
- Advanced food design: texture, functionality, digestibility, flavour release
- Mapping and unlocking EU side-streams for fermentation feedstocks
- Plant cell cultivation to reduce cost and land intensity
- Improved allergenicity understanding and management
- Techno-economic and safety modelling to support industrial investment decisions

Enablers Needed

- Support for blended/hybrid products to accelerate consumer acceptance
- Engagement strategies with chefs, retailers and food service
- Scalability and market demand sizing need stronger evidence
- Stronger economic incentives for industrial uptake
- Skills pipeline for food-grade scale-up and formulation
- Shared pilot plants with **food safety certification** to avoid market delays

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Expected Impacts

Impact Area	Outcome	Indicators
Climate & Nature	Emissions and land-use reduction	LCA metrics
Nutrition	Higher nutrient density in mainstream foods	Nutritional profiles
Market Growth	Increased uptake of diversified proteins	Sales and category penetration
Rural Inclusion	Farmers benefiting from transition	# contracts, income stability
Sovereignty	Leadership in innovation	Patents, publication, startup creations
Competitiveness	Europe becomes a global hub for biotech ingredients	Share of EU-produced ingredients in EU market
Time to market	aster progression from pilot → commercial	Time from TRL 5→8, number of approvals
Resilience	Reduced reliance on non-EU imports	import dependency metrics
Jobs & Skills	More industrial bioprocessing jobs in Europe	Workforce growth in scale-up facilities

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7.3.1 Meat Proteins

Environmental Limitations of Meat

Meat production remains one of the most resource-intensive and environmentally damaging sectors of the food system. Globally:

- Without intervention, global demand for meat is projected to increase by 14% by 2030, with especially strong growth in middle-income countries. This trend directly conflicts with climate targets and land-use constraints
- Land use: livestock feed production uses ~77% of agricultural land.
- Water: meat production accounts for more than 30% of global freshwater consumption.
- Greenhouse gases: beef and lamb generate some of the highest GHG emissions per calorie of any food product, with beef emitting ~27 kg CO_2e per kg of meat — over five times more than poultry and more than ten times plant-based proteins.
- Deforestation and biodiversity loss: expansion of grazing land and soybean cultivation for feed remains a leading driver of Amazon deforestation.
- Inefficiency of Resource Conversion. Feed-to-protein conversion rates are poor — it takes several kilograms of plant protein to produce one kilogram of animal protein — making meat a resource-inefficient food source compared to plant or microbial proteins.
- Climate resilience: animal-based systems are particularly vulnerable to climate shocks—heat stress and drought reduce milk yields and feed availability
- Zoonotic and Health Risks: Intensive farming systems increase risks of zoonotic disease outbreaks, antibiotic resistance, antimicrobial, and pollution from concentrated animal feeding operations (CAFOs).
- Social Problems of Meat Production and Consumption
    - Labour Conditions and Inequality
      Meatpacking and livestock sectors often rely on low-paid, precarious migrant labour under unsafe conditions — an issue seen globally.
    - Rural Dependence and Economic Vulnerability
      Rural communities reliant on livestock may be economically fragile and face social disruption from automation or protein transition.
- Public Health and Diet-Related Diseases :High meat consumption, especially processed meat, is linked to cardiovascular disease, obesity, and cancer, placing strain on public health systems.
- Animal Welfare and Ethical Issues: Industrial farming practices raise widespread concerns over animal suffering, confinement, and humane treatment — leading to ethical opposition.
- Cultural Identity and Food Justice: In many societies, meat is associated with tradition, masculinity, or prosperity. Shifts away from meat can provoke cultural resistance and require sensitive social transitions.

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- Global Inequality: While high-income countries face overconsumption, low-income regions often lack access to sufficient protein, creating ethical and distributive tensions in global food systems.

Challenges for Alternative Meat Proteins

Developing alternatives to meat proteins faces a distinct set of barriers:

- Taste and texture: meat provides complex sensory attributes (flavour, chewiness, juiciness) that are difficult to replicate.
- Cultural embeddedness: meat consumption is deeply rooted in dietary traditions and social practices.
- Nutritional profile: meat remains a dense source of high-quality protein, iron, zinc, and vitamin B12, which must be matched in alternatives.
- Cost competitiveness: plant-based and microbial alternatives often carry higher costs, limiting mass adoption.
- Scaling challenges: biomass fermentation and cellular agriculture require significant CAPEX for fermentation and bioreactor infrastructure, often stalled at pilot scale ("valley of death")
- Market reluctance to new products and technologies asking for dedicated policy incentives: (carbon taxes, protein subsidies)
- Health risks of consuming large amounts of ultra-high-processed food still largely unknown

Solutions through Advanced Biotechnology

- Biomass fermentation: scalable microbial protein sources (e.g., Fusarium venenatum for mycoprotein), already showing strong consumer acceptance.
- Precision fermentation: production of meat-associated proteins (e.g., myoglobin, haem proteins) to enhance flavor and color in hybrid meat products.
- Cell and tissue cultivation: research into tissue engineering techniques can provide spillovers for other food biotech fields.
- Hybrid products: combining plant matrices with fermentation-derived proteins to replicate taste, texture, and nutrition while reducing costs; Hybrid approaches are especially promising: combining plant-based bulk with fermentation-derived flavour and nutritional enhancers could achieve 50–70% GHG reduction compared to conventional beef while improving consumer acceptance.

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Cost Expectations

- Current status: biomass fermentation products (e.g., mycoprotein) are already cost-competitive in some markets. Precision-fermented meat proteins remain expensive but are projected to halve in cost within the next decade.
- Scaling bottleneck: cultivated meat technologies face CAPEX > €100M per facility and operating costs that make €40–80/kg a realistic range today.
- Consumer willingness to pay: surveys indicate limited willingness to pay >10–20% premium for meat alternatives, underscoring the importance of cost parity.

7.3.2 Fish Proteins

Environmental Limitations of Fish & Aquaculture

While fish is often seen as a "sustainable" protein, its production poses growing challenges:

- Overfishing: 35% of global fisheries are exploited beyond sustainable levels.
- Aquaculture feed: relies heavily on fishmeal and fish oil, leading to circular sustainability problems.
- Pollution: aquaculture contributes to nutrient run-off, antibiotics use, and local ecosystem damage.
- Carbon footprint: wild-caught fish have lower GHG intensity than beef but are highly variable by species and practice.
- Energy and Fresh-Water Use (Inland Aquaculture): Fresh-water aquaculture competes with agriculture for limited water and often leads to salinisation of soils. Energy use in recirculating systems (RAS) can be substantial, especially in colder climates such as Northern Europe.
- Pollution: aquaculture contributes to nutrient run-off, antibiotics use, and local ecosystem damage.
- Rising sea temperatures due to climate change also amplify disease outbreaks and algal blooms in coastal aquaculture, forcing higher chemical use and mortality rates.
- Carbon footprint: wild-caught fish have lower GHG intensity than beef but are highly variable by species and practice. Intensive systems (salmon, shrimp) emit methane and nitrous oxide from feed and pond sludge; energy use is high for aeration, chilling, and transport.
- Microplastics and Contaminants: Farmed and wild fish accumulate microplastics, dioxins, and heavy metals, especially in polluted coastal zones.

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Challenges for Fish Alternatives

- Sensory replication: replicating the delicate flavour and texture of fish is highly complex.
- Nutritional profile: fish is a key source of omega-3 fatty acids (DHA, EPA), micronutrients (iodine, selenium).
- Cost competitiveness: plant-based fish alternatives remain niche and often priced at a premium.
- Scaling biotechnologies: precision fermentation and algal production of omega-3s require CAPEX and consumer trust.

Solutions through Advanced Biotechnology

- Algal fermentation: microbial or algal production of DHA and EPA as alternatives to fish oil, already applied in infant formula.
- Hybrid seafood products: combining plant-based bulk with fermentation-derived flavour enhancers.
- Precision fermentation: production of fish-specific proteins (e.g., collagen, myosin) to enhance texture in hybrid seafood.
- Plant molecular farming: engineering plants to produce omega-3s or fish proteins for large-scale, low-cost input streams.

Cost Expectations

- Algal omega-3 oils: already scaling, with costs projected to decline 30–40% by 2030.
- Precision-fermented fish proteins: still early-stage, but cost reduction pathways mirror dairy proteins (50–60% decline expected with scale).
- Consumer willingness: seafood alternatives can target premium niches first (e.g., sushi, supplements) before mass adoption.

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7.3.3 Dairy Proteins

Environmental Limitations of Dairy

Global demand for dairy proteins has risen by 18% in the past decade, driven by growing middle classes and changing dietary patterns. This trend places enormous pressure on ecosystems:

- Land use: 77% of arable land is dedicated to livestock feed production.
- Water use: >40% of global agricultural water is consumed by dairy-related production.
- Climate impact: Livestock accounts for 20% of all anthropogenic GHG emissions; dairy alone contributes more than the aviation sector.
- Biodiversity loss: Expansion of dairy leads to deforestation and soil degradation, undermining long-term food security.

Challenges for Alternatives

Replacing dairy proteins is complex due to:

- Taste and texture widely preferred and culturally embedded.
- Functional properties: milk proteins are highly versatile (e.g., foaming, binding, melting).
- Nutritional content: casein and whey are highly digestible, rich in essential micronutrients (calcium, B2, B12, phosphorus, zinc).
- Dietary guidelines: dairy remains a recommended staple in many national health policies.

Solutions through Precision Fermentation

- Hybrid products: blending plant-based bases (e.g., oat drink) with precision-fermented milk proteins can reduce GHG emissions by 50–90% compared to conventional milk
- Health benefits: lactose-free by design — relevant as 68% of the global population is lactose intolerant.
- Nutritional parity: precision-fermented casein and whey replicate dairy's functional and nutritional properties.
- Environmental benefits: reduced land use, lower antimicrobial use, improved animal welfare.

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Cost Expectations

- Consumer acceptance is tied to price competitiveness. Surveys suggest that consumers will not pay significant premiums for animal-free dairy.
- Break-even is expected once carbon costs are included in dairy pricing.
- Expert forecasts (CIFS 2024 survey) project 40–60% cost reduction in precision-fermented bulk milk protein within 10 years, making parity feasible by the early 2030s.

7.3.4. Egg Proteins

Environmental Limitations of Egg Production

Egg production is generally considered more efficient than red meat but still carries significant sustainability burdens:

- Land and feed: poultry production relies heavily on soy and maize, driving land-use change in exporting countries.
- Water: water footprint of eggs is estimated at ~3,300 liters per kg.
- Emissions: eggs generate ~4.8 kg CO_2e per kg, higher than legumes or microbial proteins.
- Animal welfare: caged systems continue to dominate globally, raising ethical and consumer concerns.

Challenges for Egg Alternatives

- Functional properties: eggs are irreplaceable in many recipes (foaming, gelling, emulsifying). Replicating these multifunctional roles is technically challenging.
- Nutritional equivalence: eggs provide complete protein and essential micronutrients (vitamin D, B12, choline).
- Consumer acceptance: While plant-based egg substitutes exist, adoption remains limited due to flavour and texture.
- Scaling precision solutions: recombinant proteins (e.g., ovalbumin via precision fermentation) remain high-cost and under regulatory scrutiny.

Solutions through Advanced Biotechnology

- Precision fermentation: microbial production of egg proteins (e.g., ovalbumin, lysozyme) can replicate functionality in baking and food processing.
- Hybrid formulations: combining plant matrices (e.g., pea protein) with recombinant proteins to enhance texture and emulsification.
- Bioactive additives: biotechnology-derived choline and vitamin D fortification to ensure nutritional parity.

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These solutions can reduce the GHG footprint of egg proteins by up to 80% while eliminating animal welfare concerns.

Cost Expectations

- Current plant-based alternatives are cost-competitive but limited in performance.
- Precision fermentation eggs are expected to fall in cost by 50–60% in the next decade, achieving price parity with conventional eggs if supported by scaling investments.

7.4. Fibers & Sugars

Environmental Limitations of Conventional Sugar & Fibre Production

Global demand for sugar and dietary fibres continues to grow due to reformulation pressures and increasing consumer awareness of metabolic and gut health. Yet conventional production systems are environmentally and socially burdensome.

- Land use & monocropping: Sugarcane spans over 26 million hectares globally, typically in monocultures that contribute to soil degradation and biodiversity loss.[1]
- Water intensity: Sugarcane requires 1,500–3,000 L of water per kg of refined sugar.[2] Many key producing regions (India, Pakistan, Brazil) already face acute water scarcity.[3]
- Climate impact: Refined sugar generates 0.4–0.8 kg CO_2e per kg depending on agricultural practices and processing.[4]
- Labour & social risks: Manual sugarcane harvesting remains associated with poor labour conditions and heat exposure.[5] EU due-diligence rules classify sugarcane among high-risk commodities.[6]
- Health-driven reformulation pressures: Growing regulatory measures (sugar taxes, HFSS restrictions) and WHO recommendations[7] are accelerating demand for functional fibres and low-calorie sweeteners. Over 65 countries have introduced sugar taxation schemes.[8]

Challenges for Alternatives

Despite the urgency for sugar reduction and fibre fortification, replacing sucrose and scaling fibre usage involves technical and regulatory limitations.

- **Functional performance limitations:** Sucrose provides sweetness, bulk, viscosity, browning, and mouthfeel — functionalities that few alternatives deliver simultaneously.[9]
- **Taste and sensory drawbacks:** Natural sweeteners such as stevia or monkfruit often introduce off-notes, bitterness, or lingering sweetness.[10]

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- **Digestive tolerance:** Plant-derived fibres (inulin, FOS) may cause bloating or discomfort at doses required for functional claims.[11]
- **Regulatory constraints:** Rare sugars (e.g., allulose) enjoy favourable status in the US but still face restrictive EU regulations.[12]
- **Supply limitations:** Stevia and other natural low-calorie sweeteners rely on agricultural extraction with limited yields and inconsistent quality.[13]
- **Evolving Understanding of Functional Fibres & Personalised Nutrition :** Recent advances in nutrition science have repositioned fibres as bioactive health modulators rather than simple bulking agents.
- **Broader health benefits:** Functional fibres are now linked to:
  - mental wellbeing (via the gut–brain axis),
  - cardiovascular health,
  - appetite and satiety regulation,
  - skin health through microbiome-mediated mechanisms.[24]

  This creates new opportunities for innovation across beverages, snacks, dairy, sports nutrition, and medical foods**.**
- **Invisible fibres enabling clean-label formulation:** Technology is increasingly focused on designing "invisible fibres" — ingredients with minimal impact on taste, texture, and colour. These allow manufacturers to improve nutritional profiles without compromising sensory experience.
- **Personalised nutrition and microbiome-driven design:** Growing scientific understanding of microbiome–ingredient interactions is enabling:
  - tailored fibre solutions for GLP-1 support,
  - formulations that reduce GI discomfort,
  - population-specific fibres (e.g., age, metabolic status, geography),
  - targeted modulation of microbial taxa associated with metabolic or inflammatory health outcomes.[25]

  Companies now apply strain–substrate matching and demographic microbiome datasets to design more precise and effective fibre solutions.
- **Microstructural engineering:** Across the industry, the theme is consistent: small molecular or structural tweaks create significant functional changes. Adjusting:
  - chain length,
  - branching degree,
  - degree of polymerisation,
  - glycosidic bond positioning

  can dramatically alter solubility, viscosity, sweetness perception, and sensory performance. Precision control of these structures is now central to next-generation fibre functionality.

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Solutions Through Advanced Biotechnology

Advanced biotechnology enables the development of low-impact, highly functional sugars and fibres that outperform plant-derived or synthetic alternatives.

1. Precision Fermentation of Novel Sugars

Microbial or enzymatic pathways allow the scalable production of:

- allulose,
- tagatose,
- mannose derivatives

with up to 90% reductions in land and water use compared to conventional sugar cultivation.[14] These sugars deliver sucrose-like sweetness with superior metabolic profiles and reduced caloric impact.[15]

2. Microbial Production of Prebiotic Fibres

Fermentation-derived GOS, FOS, XOS and emerging precision-designed fibres offer:

- microbiome-targeted benefits,
- reduced GI discomfort,
- consistent purity and quality,
- tunable viscosity for specific food applications.[16]

3. Enzymatic Sugar Modification for On-Site Reformulation

Advanced enzyme systems enable:

- in-matrix conversion of sucrose into lower-glycaemic sugars,
- creation of rare sugars from commodity feedstocks,
- clean-label sugar reduction without additives.[17]

4. Engineered Fibres with Custom Functional Profiles

Biotech-based design allows the creation of fibres optimised for:

- fat replacement,
- improved satiety,
- enhanced mouthfeel in reduced-sugar products,
- stabilisation in beverages and dairy analogues,
- prebiotic specificity for targeted consumer groups.[18]

5. Environmental & Social Benefits

Fermentation-based production dramatically lowers:

- land use (90–99%),
- water demand (80–95%),

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- GHG emissions (40–80%).[19]
  It also eliminates field burning, pesticide exposure, and labour exploitation risks associated with sugarcane.

Cost Expectations

Near-term (0–5 years)

Fermentation-derived rare sugars remain 2–5× more expensive than sucrose.[20]

Invisible fibres and structurally modified fibres command a premium due to early-stage production.

Mid-term (5–10 years)

Bioprocess optimisation and scale-up are projected to reduce costs by 40–60%, enabling blended applications that reach parity in beverages, bakery, and dairy.[21]

GOS, FOS, and XOS are expected to decline in cost 30–50% as microbial yields and downstream processing improve.[22]

Long-term (>10 years)

EU regulatory alignment around allulose and precision-fermented ingredients is expected to unlock large-scale investment and drive cost convergence.[23]

Personalised fibre solutions may remain premium-priced but will gain traction in medical nutrition, performance foods, and metabolic health categories.

7.5. Territorial agrifood value chains

Challenges & opportunities

As biotechnology will impact up to 60% of what is grown, fed or transformed, it will reshape every agrifood category and value chain. New territorial agri-food value chains will emerge and better link innovation pathways with local production structures, cultural identity and biodiversity, powered by regional innovation infrastructure hubs that will emerge.

Innovation models are designed mainly for more developed and industrialzed agricultural systems, making it difficult to transfer to fragmented, depopulating and infrastructure-constrained regions. These territories require specific pathways which would significantly strengthen the inclusiveness and European competitivness overall.

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Solutions through Advanced Biotechnology

- Regional innovation infrastructure nods and hubs around universities, shared laboratories and pilot bioprocessing platforms, accessible facilities for SMEs and start-ups in peripheral and rural areas.
- specific pathways and instruments to support structurally constrained territories and environments, i.e. significantly strengthen inclusiveness
- low-cost, modular and mobile bioprocessing technologies adapted to fragmented, decentralized small and medium-scale territories and processing models
- Coordinating schemes and knowledge sharing tools to ensure pan-European action plans

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8. Regulatory Challenges

Unblocking market access for advanced protein innovation in Europe

The global landscape analysis demonstrates that regulation is emerging as a decisive competitive differentiator for protein diversification ecosystems. Regions such as Singapore, Israel, the US, and South Korea have adopted focused, enabling and strategically aligned regulatory frameworks, positioning themselves as international first-launch destinations for novel proteins. Europe, despite its scientific excellence and strong food safety culture, still faces fragmentation, uncertainty and delay that hinder scale-up and European-first commercialisation.

8.1 What we learn from Global Leaders

Examples from the landscape analysis show successful ecosystems share a common approach to regulatory innovation:

Region	Regulatory Enablers	Supporting evidence
Singapore	Clear safety pathway for cultivated and fermentation foods + regulatory partnership zones	Approved first cultivated products; €280M Singapore Food Story supporting commercialisation
South Korea	Regulatory-Free Special Zone for cultivated foods	€13M funding + 5-year sandbox enables rapid testing and approvals
Israel	Pro-active government facilitation for novel food approvals; regulator–industry collaboration	IIA investment stimulates precision fermentation and cellular ag ecosystems
United Kingdom	Updated guidelines for cultivated meat; exploring international regulatory convergence	First approvals in Europe (pet food) + evolving food-safety rules to reduce time-to-market Deployment of regulatory sandboxes in coordination with FSA and research centers
United States	National support via USDA+DARPA; state-level enforcement varies	Demonstrates risk of misalignment; some states even banning cultivated foods
UAE	Pioneering Regulatory Framework for Novel Foods	new regulatory framework will establish a comprehensive, streamlined registration system for novel foods
NL	Regulatory sandboxes	Deployment of regulatory sandboxes in cultivated meat

Key lesson: Regulatory ambition needs both direction and coherence across levels of governance to create global advantage.

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8.2 Where Europe stands today

The analysis highlights core EU challenges linked to regulatory fragmentation:

- **No dedicated EU policy framework** for protein diversification — regulation is scattered across food, agriculture, bioeconomy, and climate strategies
- **Uneven implementation across Member States** — divergent interpretations of Novel Foods requirements slow investment decisions
- **Long and unpredictable authorisation timelines** — innovators first launch in APAC or North America
- **Insufficient enablers for circular feedstocks** and advanced biomanufacturing routes (e.g. gas-fermentation, marine side-stream valorisation)
- **Limited regulator–industry collaboration structures** compared to innovation hubs elsewhere
- **Political sensitivity** with livestock sectors if not positioned as complementary, a challenge also observed in Canada and Australia

These gaps result **in innovation leakage** — European discoveries are industrialised and scaled in more supportive regulatory environments.

8.3 Strategic Objectives for the EU Regulatory System

Drawing on best global practices, Europe must evolve toward:

1. Predictable, timely pathways for Novel Foods and bioprocess-derived proteins
2. Aligned guidance for plant, fermentation, and cultivated protein safety dossiers
3. Regulatory sandboxes for demonstration-scale biomanufacturing (mirroring Korea/Singapore, NL and UK)
4. Circular feedstock authorisation to unlock climate-smart inputs
5. Science-based labelling & naming frameworks to build consumer confidence
6. Structured regulator/industry/academia collaboration platforms building mutual understanding early

These shifts are essential to deliver on food security, strategic autonomy and competitiveness imperatives.

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8.4 Priority Workstreams for the Alliance SRIA on regulation

A regulatory innovation agenda **delivering impact in the 2025–2030 window**:

Workstream	What it addresses	Global benchmark
WS1 — Accelerated Market Access	Reduce Novel Foods review times; early scientific advice; support to SME's submissions, proportional risk tiers	Singapore, UK
WS2 — Enabling Circular Bioproduction	Harmonised rules for side streams, CO_2 & waste valorisation	Australia (pulse valorisation)
WS3 — Fit-for-Purpose Frameworks for Fermentation & Cellular Agriculture	GMO/GMM clarity, food-grade routes	Israel, US
WS4 — Transparent & Fair Labelling	Consumer trust, nutrition confidence	Canada positioning learnings
WS5 — EU Regulatory & Standards Sandbox	Conduct product tastings, collect feedback and data and pilot approvals under controlled conditions	South Korea Special Zone NL, UK

8.5 KPIs for Regulatory Competitiveness by 2030

Metric	Today	2030 Target
Time-to-market for novel proteins	3–7+ years	≤18–24 months
EU-first product launches	Low	>60% of EU-born innovation launched in EU
Side-streams authorised for food/feed	Fragmented	Harmonised EU-wide
Regulator–industry joint guidance docs	Ad hoc	Stable annual programme
Regulatory science workforce	Limited	+50% expertise expansion in EFSA + MS

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8.6 The Alliance's Role

The Alliance will support an approach that positions regulation as a force-multiplier, not a bottleneck. In close collaboration with other key industry associations, EuropaBio being the leading one, the Alliance will actively contribute to:

- Lead regulatory science collaborations to co-generate safety and LCA evidence
- Deliver policy harmonisation proposals aligned with the EU Biotech Initiative
- Convene structured dialogue between regulators, industry, and consumer experts
- Advocate EU funding for critical R&I and demonstration-scale approvals
- Support Member States in adopting coherent interpretations and implementation

Conclusion

Europe can no longer rely solely on scientific excellence; regulatory competitiveness is now a critical battleground in global protein innovation. By adopting targeted regulatory innovation — informed by lessons from global leaders — Europe can unlock industrial scaling, reduce reliance on imports, and secure leadership in the future of sustainable proteins.

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9. Enabling Mechanisms

9.0 Why Enablers matter

Science and innovation alone are not enough. Even with breakthrough discoveries, Europe will fail to capture the benefits of agri-food and feed biotechnology unless the right enabling conditions are in place. Scaling new technologies requires shared infrastructure, financing models that de-risk investment, regulatory clarity, skills, and market demand. These enabling mechanisms are the bridge between laboratories and markets, ensuring that innovations move from pilots to industrial deployment. Without them, promising technologies risk remaining stuck at demonstration stage or scaling outside Europe.

Building on this understanding, the EU Agri-Food & Feed Biotech Alliance will focus on the following core enabling mechanisms:

- Collaborative R&I and Ecosystem Coordination
  - Pre-competitive collaboration with industry players, philanthropic organisations and strategic seed funds
  - Alignment of EU and national programmes (Horizon Europe, MSCA, EIT, Eureka, I3, Regional Innovation Valleys)
  - Joint Undertakings and IPCEI-type approaches for food and feed biotech
  - Shared watch, foresight and predictive modelling to guide priorities
- Infrastructure, Labs & Facilities
  - Coordination of expertise, laboratories and facilities across Europe
  - Open labs, shared pilots and demonstration plants
  - Access to CROs, CDMOs and specialised biotech service providers
  - AI and omics platforms and an EU agri-food biotech data space
- Financing & Risk-Sharing
  - Dedicated Financing Working Group
  - Blended finance across TRLs (grants, equity, loans, guarantees)
  - EIC, EIB, EIF, ECBF and regional funding instruments
  - Infrastructure bonds, green bonds and carbon-related schemes
  - Booster programmes and FOAK support mechanisms
- Market Uptake & Demand Creation
  - Matchmaking teams, conferences and pitch events
  - Marketplace for projects and investment opportunities
  - Offtake agreements, volume guarantees and advanced market commitments

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Consumer acceptance and food environment initiatives

- Regulation, Standards & Sustainability
  - Regulatory sandboxes and expert networks
  - Support to regulatory submissions
  - Development of standards and frameworks (taxonomy, labelling, LCA, TCA)
  - Alignment with food safety and environmental requirements
- Skills, Education & Talent
  - Biotech Academy for agri-food and feed applications
  - Strategic skills intelligence
  - Competency and capacity-building programmes
  - Innovation practice groups, demo sites and peer-to-peer learning
  - Strong links between academia, startups, SMEs, corporates and research organisations
- Governance & Delivery
  - Alliance Think Tank and Policy Think Tank
  - Working groups (Financing, Infrastructure, Market Uptake)
  - Accelerators and programmes (e.g. FoodBioX, Booster Programmes)
  - Continuous alignment between vision, SRIA, roadmap and implementation

This set of enabling mechanisms ensures that agri-food and feed biotech innovation can scale in Europe, mobilise investment, reach markets, and deliver tangible impact for competitiveness, sustainability and food system resilience.

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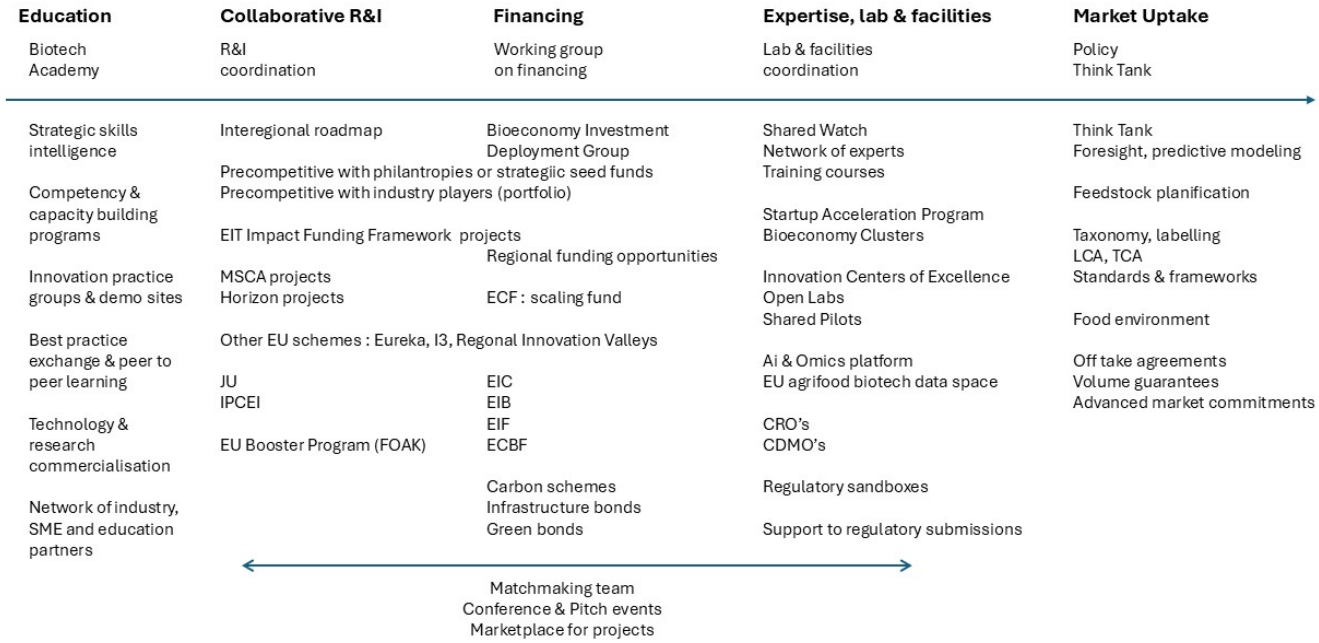
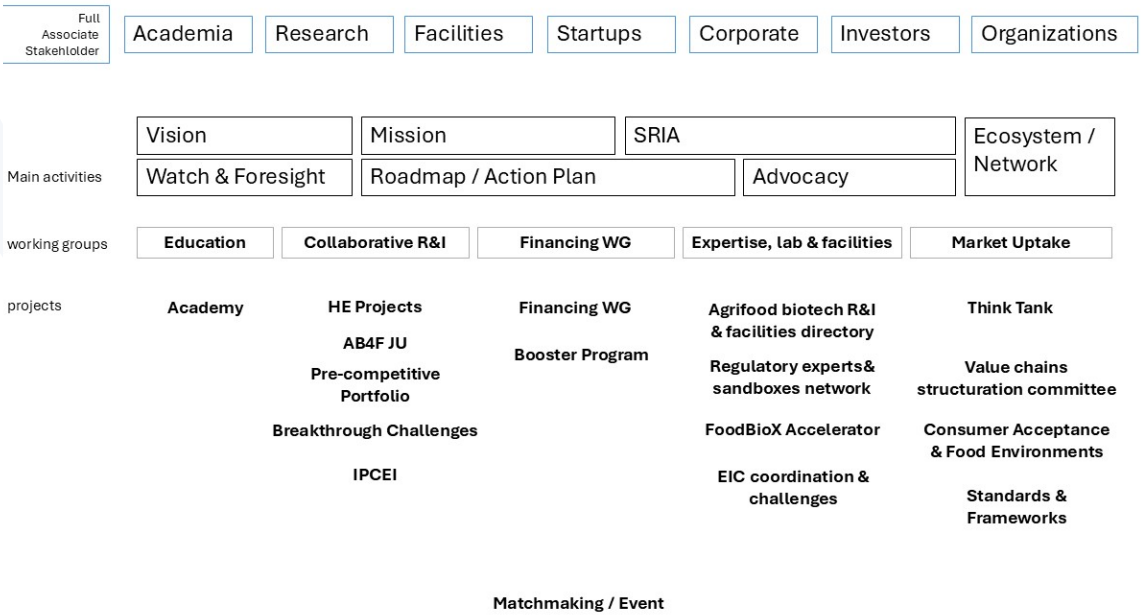
EU AgriFood Biotech Alliance – enabling mechanisms





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9.1 Skills and Talent Development and Transfer

The challenge:

Europe's bioeconomy is a 554 bn EUR engine for jobs and growth. But skills shortages are already costing us 20-27 bn EUR a year in unrealized value. That's about 3-4% lost productivity due to a mismatch between education and industry. The EIB and the European Commission call this a strategic brake on competitiveness and a bottleneck for innovation. According to the CBE JU SRIA, the shortage of skilled professionals is one of the main barriers to industrial uptake of bio-based solutions. Without targeted interventions, this skills gap will widen: the EU Green Jobs report projects that demand for green skills will grow by 18-25% by 2030, while supply remains insufficient. In food biotech in particular, bioprocess engineers, regulatory scientists, fermentation specialists, and biotech communicators are rare. Without industry aligned up- and reskilling programmes and education and training institutions and a future-ready talent pipeline willing to enter and shape the sector, innovation cannot scale.

The solution:

The next 5-7 years are decisive to secure Europe's leadership in sustainable biotech innovation. The focus now has to be on securing the future of European Biotech by raising the attractiveness of the sector and equipping the next and current workforce with the skills, tools and networks they need to develop and lead innovation in that area.

We propose that this will be done in the following ways:

- Localized storytelling and awareness raising campaigns and public engagement programs about food biotech, its applications (lab to table) and potential career pathways to build trust and raise the attractiveness of the sector.
- **Biotech Academy (EIT Food):** Develop modular, competency based, certified learning pathways and train 100,000+ professionals by 2035, covering technical, regulatory, systems thinking and entrepreneurial skills.
- Including **professional re- and upskilling programmes** for existing and future sector employees to adapt to biotech-driven models and support research commercialisation.
- **Regional Skills Hubs**: Training tailored to regional needs, ensuring inclusivity across Europe, i.e. in France, Poland, Portugal, UK, Germany, NL.
- **Bioregional Living Labs** for pilot-scale learning and farmer-consumer interfaces.
- EU Biotech Mobility and Apprenticeship Scheme for all (SME-and start-up friendly, life-long learning focused, modular).
- Stackable micro-credentials jointly issued by HEIs and industry.
- Placements, internships, or mobility schemes for more hands-on experience.
- Best practice exchange via deep dives, and innovation practice groups.

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- **Cross-KIC Collaboration**: Align with EIT Health and EIT Manufacturing to ensure workforce pipelines are integrated across food, health, and industry.

Target Audiences

We envisage different engagement levels per audience to encourage lifelong learning and ensure transferability:

- High school students (11+ yrs) → awareness and trust
- **Students/Postdocs** → credential and placement pipelines
- **SMEs/Start-ups/Corporates** → regulatory and scale-up skills
- **Farmers** → biotech literacy and partnership roles
- **Operators/Technicians** → hands-on up- and reskilling
- **Public servants & investors** → biotech and regulatory fluency
- **Educators, chefs, media** → shape consumer demand and trust

Expected Impacts / KPIs

- Increase the number of trained operators, new credentials, placements, and biotech jobs.
- Faster **lab-to-plant transitions** and fewer TRL 5-8 drop-offs.
- **Improved regulatory quality** via trained authorities and VCs.
- Increased capacity to anticipate future needs and ability to act within the sector.
- Strengthened collaboration and best practice exchange.
- **Higher consumer trust** and literacy on novel foods.
- **Regional cohesion** through living-lab networks and widening-region skills programmes.
- **Investment confidence** and lower perceived risk through shared learning infrastructure.

EU Added Value: A pan-European skills and talent pipeline ensures Europe retains future ready talent and reduces brain drain to the US and Asia.

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9.2 Collaborative R&I Activity Types and Funding Mix

The challenge: R&I funding for food and agri-biotech have been much to low, innovation relying mostly on private and VC funding since 10 years. Agrifood biotech need research to help unveil future key breakthroughs, test, document and support the best paths and solutions tht will make our food systems better. Europe and its dense a varied ecosystem of research centers and facilities has a role to play. The Alliance should orchestrate the roadmap of actions that can build on such competitive advantages and help drive the adequate funding allocation to the the right topics and schemes, while also fostering private co-funding and implication.

The solution: **To ensure balanced progress, the Alliance will design and orchestrate a roadmap of actions that builds on EU competitive advantages and its dense and vivid R&I ecosystem to motivate and recommend the adequate funding allocation to the right topics and schemes, while also mobilizing private contributions and co-funding.**

9.2.1. R&I roadmap coordination

One of the main tasks of the Alliance will be the design and the update of a living roadmap of R&I projects, seizing all opportunities to support R&I for agrifood biotech and coordinating them as much as possible to avoid duplication and fragmentation. To maximize coordination, the Alliance should

- Setup a dedicated **R&I Roadmap Coordination Council**, gathering representatives of each type of EU R&I actors – academia, research centers, facilities, startups, corporate, funders
- This council should become legitimate to also deploy interregional coordination across main EU territories and ecosystems, with a special attention less developed territory
- This all shall be done in **close collaboration with key organisations** and institutions with a responsibility to coordinate R&I road mapping in Europe:
    - SCAR
    - European Science Alliance for Agriculture and Food (ESAAF)
    - EFFOST
    - IBISBA, MIRRI
    - ETP FoodForLife

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9.2.2. R&I Project Mix

The funding portfolio should reflect the different TRL stages:

- Supporting Actions (CSA): Standards, regulations, SME engagement, data platforms, LCA/TEA tools (15% of the funding).
- R&D Projects (TRL 3–5): Applied research directly linked to demonstration needs (25% of the funding).
- Demonstration Projects (TRL 6–7): End-to-end value chain validation, bridging pilot to commercial deployment (30% of the funding).
- Flagship Projects (TRL 8): FOAK plants operating on an industrial scale, de-risking high-CAPEX investments (30% of the funding).

9.2.3. R&I Roadmap and Financing schemes

The portfolio should include the largest variety of funding models:

- **Precompetitive programs and/or challenges designed with the support of philanthropies, regional and strategic seed funds** to address key bottlenecks or moonshot challenges
- The Alliance can inspire from various regional initiatives to motivate the creation of **a precompetitive and a competitive portfolio with industry players**, around common R&I topics of interest to advance the whole industry
- The **EIT Food Impact Funding Framework** schemes can serve as a model for some actions, as it's been experienced in November 2025 with a first Biotech Innovation Call
- **Horizon Europe funding architecture and schemes is planned to be continued in the forecasted Framework Program 10**, with a funding allocation forecasted
    - to be multiplied by up to 2 for Pillar 1 (research incl. MSCA projects),
    - to be maintained as it is for Pillar 2 - Horizon projects – but with a focus on a renamed key theme "Health, biotechnology, agriculture, bioeconomy" which should enable to rebalance funding to more food topics than it's been the case for these past 10 years– and with complementary schemes that shall be mobilised efficiently : Eureka, I3, Regonal Innovation Valleys
    - To be multiplied by up to 3 for Pillar 3, through an enhanced EIC program that can not only address entrepreneurs but also consortia and a revamped scheme to support "innovation ecosystems" and public private partnerships (incl. Joint undertaking and IPCEI, see after)
    - With a new Pillar 4 with a substantial budget allocation dedicated to support infrastructures and widening actions
- Embedded in the future Framework Program 10 is the newly announced **European Competitiveness Fund (ECF)** to support investments to accelerate innovation and lead the global race for clean and smart technologies and to

secure supply chains of the EU. It shall serve as a continuation to fill the valley of death gap and support scale-ups, being deployed in 5 main areas, including one named Health, biotechnology, agriculture, bioeconomy (mirroring Pillar 2) and with a projected € 20B allocation. The fund targets a broad range of beneficiaries, including:

  - SMEs and large companies in the High Tech, Energy, and Manufacturing industries.
  - Research institutions and innovation hubs working on advanced technologies.
  - Public-private partnerships aiming to strengthen EU industrial capacity.

- Among key partnership schemes the Alliance will explore building is t**he Joint Undertaking (JU)**. Building on the experience and feedback of the most emblematic ongoing JU, i.e. CBE-JU , and the success of the very few CBE-JU calls which have been addressing topics in food and agriculture in the past 4 years (only 6% of total funding allocation), the Alliance will develop a proposal dedicated to the key topics of food, feed and ag bio-solutions applications.
- In 2024, EU decided for the creation of an **Important Projects of Common European Interest (IPCEI**) dedicated to biotechnology, with 3 complementary streams: Biobased Chemicals, Biobased Materials, and Biotechnologies for Food and Feed, the last having motivated the interest and commitment of 11 EU countries. The Alliance will coordinate with local stakeholders motivated to participate in such a valuable scheme to make sure to well algin initiatives with the future roadmap of the Alliance itself.

9.3 Financing

9.3.1. Finance Foresight and Modeling

The Bioeconomy Strategy unveiled in November 2025 proposes expanding access to pilot and demonstration plants, establishing a Bioeconomy Investment Deployment Group that will convene the Commission, the European Investment Bank Group and private investors, and introducing blended-finance schemes to help de-risk projects such as fermentation facilities and biorefineries. The Alliance will work hand in hand with IBISBA and related stakeholders to participate in the deployment of such strategy with related initiatives and projects that should be included in the future roadmap of the Alliance.

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The solution:

- **An EU Agrifood Biotech Investment Deployment Council:** gathering representatives of key EU public investment players – EIC, EIB, ECBF- and private investors to foster reflection and synergies
- **An EU Agrifood Biotech Funding Monitoring Platform:**Keep track of all funding and investments in the sector and regularly update funding needs for the category on the long term.
- **Support the creation an EU agrifood carbon emissions trading scheme.** Like transferable tax credits, allocated carbon credits that alternative protein companies could resell would provide a straightforward method for raising funds when necessary. Carbon offtakes would also help with upfront investments, as they could be used as collateral for funders.
- **Coordinate discussions on Tax incentives, Carbon Tax :** recommend fiscal instruments coordinated with research or industrial innovation policy to shape future markets; establish a supplier transition mechanism to offset the costs of converting to bio-based production through matched tax relief

9.3.2. Finance and Investment Models

The challenge: Food biotech innovations are perceived as high-risk, leading to underinvestment. Many promising European start-ups relocate to the US or Asia where funding is more readily available.

The solution:

- **The Alliance will engage itself in the deisgn and build of a €2B Public–Private Partnership that should take the form of a Joint Undertaking to be ready for submission to the new FP10 to come in 2028.**
- **Through its Agrifood Biotech Investment Deployment Council, the Alliance will also engage in mobilising at least €1B Public–Private Portfolio over 10 years** across EU programs (Horizon Europe, InvestEU, LIFE, IFF), Member States, corporate and philanthropic capital.
- The Agrifood Biotech Investment Deployment Council will pay special attention to design innovative **blended Finance Instruments**: Use public funds to derisk investments and crowd in private capital.
- The Alliance will explore how to structure **cascade funding schemes for SMEs** to channel resources directly to start-ups and scale-ups via calls that the Alliance will help structure and manage.
- **Philanthropic and Impact Capital**: The Alliance wants to become expert in leveraging Europe's growing pool of ESG funds for sustainability-linked biotech investments and become their partner of reference. This could be effectuated via **the creation of an EU Booster Program or of Breakthrough Challenges** (like the ones initiated by Sprin-d)

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- **Foster the creation of an EU Agrifood Biotech Booster Program**, (as recommended by the 2025 EIB Scaling-up Biobased Industry in EU Report), which would inspire from successful initiatives like the Breakthrough Energy Catalyst Fund, or the BPI France Première Usine program,
- **Set up a strong coordination with EIC** to
    - foster the creation of regular **future EIC Challenges addressing agrifood biotech gaps and bottlenecks**, similar to the ones that have already been conducted in 2024 and 2025
    - steup a fluid **fast track program for entrepreneurs** having benefited from the acceleration support of the Alliance
- **Liaise and coordinate with EIB to support bioeconomy projects/ventures with venture debt investments under InvestEU and with the European Circular Bioeconomy Fund (**ECBF) model to enable high-risk investment in early-stage bio-based ventures. (as inspired by the 2025 EIB Scaling-up Biobased Industry in EU recommendation report)

EU Added Value: A pan-European co-investment strategy prevents fragmentation, maximises leverage, and builds investor confidence.

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9.3.3. Financing Scale Up

The challenge: Most European start-ups and SMEs lack access to industrial-scale facilities for fermentation, bioprocessing, and molecular farming. Building individual plants is capital-intensive (often €50–200M), beyond the reach of early-stage companies.

The solution:

- **Shared Demonstration Plants:** Develop 15–20 large-scale demo plants across Europe by 2035, co-funded by public and private actors.
- **AgriFood Biotech Hubs**: Where relevant and needed, regional shared infrastructures where SMEs can test and scale processes.
- **Retrofitting brownfield sites**: Converting underused industrial sites into biotech facilities to reduce CAPEX and accelerate deployment.
- Make sure to structure a solid coordination with EU financial bodies - EIC, EIB, ECBF – and national and regional funds, and with other key financing programs – CBE-JU, future IPCEI's

EU Added Value: Shared infrastructure ensures efficiency, avoids duplication, and enables equal access across Member States, including Central and Eastern Europe.

9.3.4. Market Creation Toolkit

The challenge: Most European start-ups and SMEs lack access to industrial-scale facilities for fermentation, bioprocessing, and molecular farming. Building individual plants is capital-intensive (often €50–200M), beyond the reach of early-stage companies.

The solution:

- **Value chains structuration committee:** strengthen collaboration across the entire value chain—from producers to retailers—to co-elaborate solutions to facilitate and accelerate adoption; facilitate structured meetings with all value-chain actors to coordinate expectations, timelines, and responsibilities.
- **An AgriFood Biotech-Preferred Procurement Scheme** should be designed, beginning with categories and products where bio-based alternatives are already proven and regulatory pathways are well established; identification of most valuable institutional bodies and agencies – incl. national health services – and private actors – foodservice, retailers - that could be targeted and included in such a process ; design & experiment pilot contract
- **Off-take agreements:** even if not a common tool in the CPG sectors, it can apply for certain product categories (biosolutions for ex.) or for some future value chain of geostrategic importance for EU or for some territories

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- **Infrastructure Bonds** are debt securities issued to finance long-term infrastructure projects such as roads, railways, and ports. Municipalities or corporations can issue these bonds, which are prevalent in countries like Australia, Chile, India, Kazakhstan and the United States. A notable feature of infrastructure bonds is their long maturity period (up to 30 years), aligning with the extended timelines of infrastructure projects.
- **Green Bonds,** a subset of ESG bonds, which include green, social and sustainability bonds, specifically designed to function like traditional bonds that would fund projects with positive climate or sustainability benefits. Note that Europe is the world's largest issuer of green bonds, accounting for nearly half of green bonds issued worldwide to date.

9.4 Expertise, lab & facilities

9.4.1. Knowledge sharing

The challenge: biotechnology applied to food and agriculture is still a nascent topic but very vivid and complex. Given the benefits and implication, it can have; knowledge sharing is foundational for any collaborative activity.

The solution:

- **Shared Watch Platform:** to keep track and be able to share any relevant and up to date info on any topic relevant to the Alliance: policy, regulation, R&I, relevant industry reports, investment, funding opportunities, ecosystem initiatives, … This platform shall not substitute to existing initiatives but serve as an open database of all relevant news as support to entrepreneurs and decision makers.
- **Directory of experts, tools and facilities:** in collaboration with existing initiatives like IBISBA or Pilots4U.

9.4.2. Biotech hubs and shared infrastructures

The challenge: Biotechnology projects need strong science and access to facilities and equipment to elaborate and scale.

The opportunity:
By building hubs and bridges across regions, Europe can accelerate R&I and entrepreneurship.

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The solution:

- **Establish a coordination with key stakeholders: IBISBA, MIRRI, CBE-Pilots4U**
- **Shared pilots and Infrastructure**: Analyse, recommend and facilitate demonstration plants and fermentation hubs across Europe, maximising CAPEX efficiency. Conduct a comprehensive regional analysis to identify key strengths, resources, and opportunities for each hub. This will include mapping existing capabilities and assessing regional assets such as agricultural resources, talent pools, and existing biotech infrastructure.
- **Foster the creation of blueprints for pilot-scale and demo facilities** that can be adapted to various regions. Share these blueprints widely to facilitate the rapid development of infrastructure that meets the needs of local stakeholders such as food developers and manufacturers, consumers, chefs, farmers, researchers, and educators.
- **Support to the creation or the transition of Centres of Excellence and Centres of Competence** in advanced agrifood biotech. These key innovation infrastructures aim to attract highly qualified researchers within a triple helix arrangement, involving public organisations, private companies, universities and clusters, to generate leading applied research, experimental development, and technological innovations in sectors prioritised in the country's Research and Innovation Strategies for Smart Specialisation (RIS3). It shall build around existing Centres and well coordinate with education activities.

9.4.3. Startup Acceleration

The challenge: If Europe is a fertile ground for innovation, science and entrepreneurship, all entrepreneurs in the field experience two valleys of death – pre-commercialisation gap and scale-up gap- and often complain about fragmentation, eased access to resources – funding and collaboration. .

The solution:

- **Establish a coordination of EU agrifood biotech hubs, acceleration programs and facilities**, incl. BBEU
- **Coordinate the creation of an EU repository of CRO's and CDMO's** to support experimentation and scaleup
- **Explore how to build coordinated actions and programs with EIC** to accelerate the scale up of EU agrifood biotech champions; align frameworks on breakthrough needs, contribute to the deployment of solid challenges and to fast-track critical solutions.
- **FoodBioX Acceleration Journey** : a full continuum of support for startups, from early to scale-up stage, building on EIT Food experience of entrepreneurship programs. It would deliver a complete set of programs and resources to support EU agrifood biotech entrepreneurs all along their journey, combining coaching,

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networking, promotion, open innovation, experimentation co-funding, facilitated access to experts and dedicated facilities, sandboxes, living labs.

9.4.4. IA & Omics

The challenge: natural processes incl. Fermentation or cell culture are a black box. Fermentation scale is not a straight journey. A lot of resources can be wasted in unsuccessful experimentations which failures are difficult to document.

The solution: omics adapted to synthetic biology have been made great progress these past 10 years while AI tools and models are emerging to facilitate a better understanding and documentation of nature-based mechanisms.

- **Establish a coordination with key stakeholders: IBISBA, MIRRI**
- Contribute to the creation of **a EU data space for agrifood biotech** and related frameworks to collect and share data in confidence
- **Establish open access databases and repositories to catalog information** (e.g.,nutritional, safety, sensory attributes) and specimens of various raw materials and ingredients, bioprocesses, and tools generated through all the above R&D efforts to accelerate innovation and reduce duplication.
- **Building germplasm repositories and biobank facilities a**s critical resources, providing access to existing and new sources of variation to improve economically important traits like disease resistance, nutrient rich content, productivity, and climate adaptability.(*as stated in US Casa-Bio recommendations)*
- **Support the development of robust data management systems, advancement of critical databases, standards for data collection protocols.** Contribute to a roadmap and standardized frameworks for various open-access databases and repositories, ensuring continuous updates and contributions from academia, industry, non-profits, and relevant government agencies.
- **Support the development of frameworks for automating and digitizing bioprocesses with advanced sensors and real-time process analytical technologies** ; integrate AI/ML for automation, predictive control, and optimization of bioprocesses to enhance yield and reduce variability. Establish virtual models (e.g., digital twins) tailored to bioprocesses at various scales, enabling real-time monitoring, process optimization, and predictive maintenance

9.4.5. Regulatory challenges

The challenge:

The challenge: Europe's regulatory frameworks, particularly the Novel Foods Regulation, are often slow and unpredictable. This delays product launches and deters investors. Since 2025, Netherlands and the UK are deploying initiatives to structure and deploy

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regulatory sandboxes for cultured meat and seafood or for precision fermentation products.

The solution:

- **Secure dialogue and continuous engagement with EFSA and DG SANTE**
- **Support to regulatory approval**: compile critical knowledge and digital resources to help entrepreneurs navigate a complex regulatory landscape; build a vibrant community of Novel Food innovators, regulatory and scientific experts to provide support through complex regulatory journey, taking NFX UK as an aspiration.
- **Regulatory Sandboxes:** help design and deploy controlled environments where new biotech solutions can be tested with consumers and regulators in real time.

EU Added Value: Regulatory innovation ensures consumer safety while enabling Europe to compete globally on speed-to-market.

9.5 Policy and Market Uptake

9.5.1. EU Agrifood Biotech Policy Governance Recommendations

As stated in the newly unveiled EU Biotech Act I for the Health Biotech sector, we recommend the **creation of a European AgriFood Biotechnology Steering Group,** composed of representatives of Member States and the Commission and its tasks, which include facilitating communication among Member States, the Commission, and various stakeholders to ensure biotechnology projects are recognised and implemented effectively.

Similarly, as recommended in the EU Biotech Act I for Health Biotech, **we recommend and propose that the Alliance would participate to the coordination of an EU AgriFood biotechnology support network of national and regional antennas** to support biotechnology projects and innovators in navigating regulatory procedural pathways relevant to health biotechnologies and identifying opportunities for funding, scaling up and networking, leveraging and complementing the activities of existing national and European networks that support SMEs, start-ups and scaleups, and innovators

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9.5.2. Foresight & Forecasting

The challenge: this industry and technology are still nascent but will have a major impact across all value chains, industries and territories.

The solution:

- **Establish a Think Tank** program that can constantly update foresight projections for the industry and manage regular reviews of the SRIA and the roadmap of the Alliance.
- **Provide evidence-based recommendations to ensure an adequate integration of agrifood biotech into the EU's future strategies,** starting with the Biotech Act.
- **Participate to nurture policymakers with robust foresight** – in the sense of predictive modeling - **impact assessments, and consumer insights**.
- **Robust market forecasting for biotech-derived products** is needed to anticipate challenges, plan supply, and guide investment decisions.
- **Coordinate actions with key EU stakeholders: EuropaBio, industry organisations,**

9.5.3. Standard & Frameworks

The challenge: Biotechnology is a critically sustainable platform to reduce environmental impact of food systems, but it needs to be well assessed and documented to build consumer trust.

The solution:

- **Harmonisation across Member States**: Avoid fragmented implementation of EU directives.
- **Compile and validate LCA and TEA data on novel protein manufacturing** to guide sustainable, cost-effective process design and scaling. Contribute to a roadmap and standardized frameworks for various open-access databases and repositories, standards for data collection protocols Develop a comprehensive decision-making framework for evaluating technological, economic, and sustainability readiness, tested and validated across multiple food protein production innovations.
- **Support the development of the sustainability scoring systems** - from CSRD to product labeling - that will ensure trust and science-based comparability across all value chains

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9.5.4. Consumer acceptance and adoption

The challenge: Technology is only part of the key success factors of innovation. There is a clear need to improve knowledge and understanding of the levers that will ensure consumer acceptance and adoption

The solution:

- **Keep alive and develop a Consumer Observatory (EIT Food)**: Make sure to consolidate and share knowledge on consumers expectation, habits and attitude toward novel food ; use insights to co-design innovation pathways together with citizens, integrating their expectations and concerns early in the research and policy process ; pilot a voluntary and ambitious roadmap for social science research.
- **Foster more funding in social sciences R&I** to better understand how new ingredients and food processes reveal a complex interplay between ecological awareness, technological neophobia, cultural aversion to food and gender differences in shaping dietary choices in the context of climate change
- **Support the creation of food environments:** empowering the 'middle part' of the food system, including retailers, food services, cooks and caterers to identify the enabling factors for positive transformative change to healthy sustainable diets; assessing the tools and instruments (e.g. policy measures, incentives, existing and new promotion and marketing approaches, pricing policies) necessary to increase and vary the provision of alternative foods ;
- **Coordinate a retailer engagement committee and related programs** to facilitate market entry, experimentations and access to shelf space.
- **Transparency in Labelling**: Ensure clear, science-based communication of biotech foods. Support citizen-led monitoring, open data, and traceable supply chains to enable informed choices and collective oversight.

9.5.5 Public Trust and Citizen Engagement

The challenge: Without citizen acceptance, biotech products will not succeed – regardless of scientific merit. Consumer concerns often focus on "unnaturalness," safety, and transparency.

The solution:

- **Coordinate with consumers associations – SAFE, EUBIC - and learn from EU projects - BTrust**
- **Engage trusted voices—scientists, nutritionists, and especially chefs—as key ambassadors.** Adequate training will be required to ensure coherent communication**.**
- **Narratives and Storytelling (for Dialogue):** Reframe biotech as natural, Replace persuasion with **conversation**. Reframe biotechnology within real-life contexts —

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sustainability, local culture, and food identity — through collaboration with chefs, educators, artists, and influencers who foster two-way engagement rather than marketing.

- **Support the development of Living Labs, foster co-creation with Citizens**: Involve consumers in foresight, testing, and communication. Treat the public not as consumers of technology, but as partners shaping its direction and purpose.

EU Added Value: By building trust, Europe can lead not only in technology, but also in values-based innovation aligned with citizens' expectations. The goal is not to make citizens *accept* biotechnology, but to **make biotechnology acceptable** through democratic participation, transparency, and responsiveness to social values

9.5.6. Cross-Sector Collaboration

The challenge:

Food biotech shares common technologies (fermentation, cell cultivation, molecular farming, microbial bioconversion) with other high-growth sectors such as pharmaceuticals, cosmetics, biomaterials, and sustainable chemicals. Today, these sectors often work in silos, leading to duplicated investments, under-utilised infrastructure, and missed opportunities for knowledge transfer.

The opportunity:
By building bridges across sectors, Europe can unlock new efficiencies, accelerate deployment, and strengthen sovereignty across multiple strategic value chains.

The solution:

- **Knowledge Transfer**: Applying regulatory science, safety standards, and clinical-grade quality assurance from pharma to food biotech accelerates approvals and builds trust.
- **Funding Synergies**: Pooling investment across bio-based sectors (through blended EU funds and cross-sector PPPs) increases leverage and reduces risk.
- **Market Expansion**: Ingredients and proteins developed for food biotech may also find applications in nutraceuticals, cosmetics, or therapeutics, improving ROI.
- **Cross-KIC Collaboration**: Joint work between EIT Food, EIT Health, EIT Manufacturing, and Climate KIC to create holistic bioeconomy strategies.
- **Cross-Sector knowledge sharing**: the connection with fundamental knowledge in other sectors (medical sector, water sector, technology sector) that must be established, deepened and spill-overs managed
- How do we make cross-sector projects emerge?
    - Design cross-sector calls and challenge-driven missions that require participation from multiple bio-based sectors.

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- Develop shared technology platforms and demonstrators (e.g. fermentation, cell cultivation, bioconversion, downstream processing) open to food, health, materials and industrial biotech actors.
- Enable joint access to infrastructure and facilities, with harmonised rules and funding mechanisms that support cross-sector use.
- Activate cross-KIC collaboration (EIT Food, EIT Health, EIT Manufacturing, Climate KIC) to build integrated bioeconomy project pipelines.
- Support targeted matchmaking and knowledge transfer, embedding regulatory and standards expertise early to facilitate spill-overs and multi-market deployment.

EU Added Value:
Cross-sector collaboration ensures that Europe remains competitive not only in food biotech, but across the entire life sciences and bioeconomy spectrum, reinforcing technology sovereignty and maximising public investment impact.

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Case Study 1: Precision Fermentation Across Food, Pharma, and Cosmetics

Precision fermentation is a prime example of how cross-sector collaboration can unlock efficiency and accelerate scale-up.

Food applications: Producing milk proteins (casein, whey) for sustainable dairy alternatives.

Pharma applications: Producing recombinant proteins and enzymes for vaccines, insulin, or therapeutic peptides.

Cosmetic applications: Producing collagen or hyaluronic acid as sustainable, animal-free ingredients for skincare.

Shared enablers:

All three sectors rely on **large-scale fermentation infrastructure, bioprocess engineers, and downstream processing expertise.**

Regulatory knowledge from pharma (e.g. quality assurance, clinical testing standards) can inform and accelerate food biotech approval processes.

A **multi-sector demonstration facility** could serve food, pharma, and cosmetics simultaneously, reducing CAPEX, improving utilisation rates, and strengthening Europe's sovereignty in biotech.

The opportunity for Europe:
By pooling resources across sectors, Europe could create biofoundries and fermentation hubs that serve as cross-sector platforms, making the EU more competitive while reducing duplication of effort. This approach not only lowers costs but also builds stronger talent pipelines and increases return on investment for public and private funders

Case Study 2: Molecular Farming – Food, Nutraceuticals, and Pharma

- **Food & nutraceuticals:** Plants engineered to produce functional proteins such as lactoferrin or omega-3 fatty acids for food fortification.
- **Pharma:** The same molecular farming platforms can produce therapeutic proteins or antibodies at scale.

Shared enablers: Controlled agricultural production systems, plant biotech expertise, and downstream purification facilities.

Opportunity for Europe: By investing in molecular farming infrastructure, Europe strengthens both its nutritional resilience (affordable, healthy proteins) and its pharma sovereignty (cost-effective biologics).

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10. Funding Architecture and Governance

10.1. Why a Public-Private Partnership?

To realise Europe's ambition in Advanced Biotech for Food (and joining forces with Food4All), a robust and stable collaboration model is required. Fragmented initiatives, limited financing, and inconsistent governance have long slowed down the scale-up of food biotech solutions. Europe risks falling behind global competitors (USA, China, UK) if it does not create a mechanism that pools resources, aligns strategies, and guarantees long-term impact.

The Institutional Public-Private Partnership (iPPP) model provides such a mechanism. It ensures that public objectives (sustainability, sovereignty, health) are matched by private commitment (innovation, industrialisation, investment). This model has already proven its value in initiatives such as the Clean Hydrogen JU, the Innovative Medicines Initiative (IMI), and the Circular Bio-based Europe (CBE JU), which have all mobilised billions of euros in high-impact projects across Europe.

10.2. Governance Pyramid: From Alliance to JU

The JU governance pathway will be structured in three phases:

1. **EU Agri-Food Biotech Alliance (2024–2026)**
    - Informal coalition of industry, academia, and civil society coordinated by EIT Food.
    - Purpose: ecosystem mapping, stakeholder engagement, early SRIA drafting.
    - Output: political and industry commitment, Letters of Intent (LOIs).

2. **A dedicated Joint Undertaking in Agri-Food and Feed (2028–2035)**
    - Building a unified European effort: Engaging with relevant initiatives and stakeholders to promote alignment, prevent duplication, and strengthen collaboration (Food4All and CBE JU)
    - Purpose: launch calls, fund projects, and monitor results.
    - Scope: fund research, demonstration, and flagship plants across Europe to catalyze innovation and bring solution to market faster.

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10.3. Financial Commitments

The JU will be established with matched contributions from the European Commission and a private consortium:

- European Commission (Public Partner):
  - €1 billion in cash dedicated to project funding (2028–2035).
  - 50% of the JU's operational costs (~€2.5M/year).
- Private Consortium (Private Partner):
  - €1 billion in kind, through R&I investments in selected projects (covering non-reimbursed costs).
  - 50% of JU's operational costs in cash (~€2.5M/year).

This dual system guarantees both financial leverage and shared ownership.

10.4. How Industry Will Contribute

Industry participation is twofold:

1. Through projects:
   - Companies submit proposals to JU calls and, if selected, co-finance their projects by covering a share of costs not reimbursed by the JU (in-kind contributions).
2. Through "private consortium" membership:
   - Companies collectively cover the JU's operational costs (cash contributions).
   - Ensures legal and financial commitment, securing the credibility of the private partner.

10.5. Timeline and Milestones

- 2026: Secure European Commission endorsement.
- 2027: Establish the private partner as the legal entity.
- January 2028: Official launch of the JU.
- 2028–2035: JU operational phase, with annual calls, monitoring, and evaluation.
- December 2035: End of Partnership, impact assessment, and transition to post-JU structures.

10.6. Lessons from other JUs

The governance and funding architecture builds on lessons from existing partnerships:

- CBE JU (Circular Bio-based Europe): proved the importance of strong industry association (BIC) to guarantee legitimacy and funding leverage.
- IMI (Innovative Medicines Initiative): showed the value of combining EU priorities with industry-driven R&I to accelerate health innovation.
- Clean Hydrogen JU: highlighted the role of flagship demonstration projects in de-risking industrial-scale innovation.

JU combines these lessons with a unique focus on food biotechnology, ensuring Europe leads in this critical sector.

10.7. Why this matters

The proposed governance ensures:

- Clarity: clear roles for Commission, private entity, and JU.
- Commitment: legally binding contributions from both sides.
- Continuity: a 7-year framework with predictable funding.
- Credibility: builds on proven EU partnership models.
- Impact: de-risking investment, accelerating industrialisation, and making Europe a world leader in food biotech.

10.8. Prioritisation Framework

Advanced biotechnologies are not a single technology but a portfolio of complementary innovations. Together, they form the building blocks of a more sustainable, competitive, and sovereign European food system. By setting clear priorities, Europe can:

- Direct investments to areas with highest systemic impact (climate, health, sovereignty).
- Accelerate industrial deployment via shared infrastructure and demonstration plants.
- Align regulation with innovation pathways to speed approvals.
- Reduce fragmentation and ensure SMEs, corporates, and Member States move in the same direction.

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To guide decision-making, the SRIA will adopt a prioritisation framework based on:

1. Systemic impact (climate, health, sovereignty).
2. Technology readiness (short, medium, long-term deployment).
3. Investment leverage potential (capacity to attract private co-investment).
4. European added value (alignment with policy, global competitiveness).

This ensures that the SRIA directs resources to the areas where Europe can lead, while not neglecting longer-term bets.

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11. Expected Impact and Legacy

The AgriFood Biotech Alliance and its enabling mechanism, the Joint Undertaking (JU), are designed not only to deliver short-term outputs, but to establish the long-term foundations for Europe's leadership in food biotechnology. Their impact spans five interconnected domains: economic growth, sovereignty, sustainability, health, and reputation.

11.1 Economic Growth and Competitiveness

Alliance impact (broad):

- Mobilisation of a €2–3 billion public–private investment portfolio across multiple enabling mechanisms (JU, IPCEIs, structural funds, private capital).
- Development of a thriving European biotech SME and startup ecosystem, linked with large-scale corporates and research centres.
- Creation of regional biotech hubs (e.g. in Nordics, Central and Eastern Europe, Southern Europe) linked through the Alliance's governance structure.

JU-specific contribution:

- Financing of 15–20 flagship demonstration and industrial plants between 2028–2035.
- Leverage ratio of 1:2–1:3 private to public investment, generating an estimated €5–7 billion in total project value.
- Job creation: 20,000 direct and 60,000 indirect jobs in biotech manufacturing, R&D, and supply chains.

Reference: PwC (2025), McKinsey (2025).

11.2 Sovereignty and Strategic Autonomy

Alliance impact (broad):

- Diversification of Europe's protein supply, reducing import dependency from regions such as North and South America.
- Development of strategic reserves of biotech production capacity (pilot and demo plants) to secure food resilience in crisis scenarios.

JU-specific contribution:

- TBD in 2026

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11.3 Sustainability and Climate Impact

Alliance impact (broad):

- Contribution to EU Green Deal and Farm to Fork targets by reducing the environmental footprint of protein production.
- Deployment of technologies that cut land use for protein by up to 70% and reduce agricultural water demand by up to 50%.
- Valorisation of agricultural and food industry side-streams, advancing circular bioeconomy models.

JU-specific contribution:

- GHG emission reduction of 40–90% compared to conventional dairy and meat proteins (depending on product category).
- Rollout of 10+ pilot plants valorising agro-food residues for use as feedstocks in precision fermentation.
- Standardised LCA and TEA methodologies are embedded in funded projects to ensure accountability and transparency.

11.4 Health and Nutrition

Alliance impact (broad):

- Integration of biotech innovation into public health and nutrition strategies (e.g., personalised diets, healthy ageing, prevention of non-communicable diseases).
- Enhanced citizen engagement and trust through transparent governance and the EIT Food Consumer Observatory.

JU-specific contribution:

- Increased availability of affordable, lactose-free dairy alternatives through precision fermentation.
- Development of functional ingredients (e.g. probiotics, post-biotics, bioactive peptides) supporting gut health across age groups.
- Contribution to EU dietary guidelines by enabling reformulation of foods with higher protein quality (e.g. DIASS metrics).

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11.5 Reputation and Global Leadership

Alliance impact (broad):

- Positioning of Europe as a global hub for sustainable food biotech, comparable to US leadership in digital and China's leadership in green manufacturing.
- Creation of a "Team Europe" brand that unites research, industry, policy, and civil society behind a common biotech vision.
- Expansion of EU influence in international fora (FAO, OECD, Codex Alimentarius, WHO).

JU-specific contribution:

- Establishment of EU flagship projects visible at global scale (e.g., microbial dairy, precision-fermented feed proteins, molecular farming of vitamins).
- Attraction of foreign direct investment into European biotech hubs.
- Strengthening EU credibility as a leader in safe, regulated, and trusted biotech solutions, reinforcing citizen trust.

11.6 Legacy: Europe as Biotech Frontrunner by 2050

By 2050, the combined impact of the Alliance and the JU will:

- Establish Europe as the world leader in food biotechnology, securing resilience and competitiveness.
- Ensure that European citizens benefit from healthier, more sustainable diets, aligned with cultural diversity.
- Leave behind a permanent institutional capacity ("private consortium", EU biotech hubs, demo plants) that continues to drive innovation beyond the Partnership's formal duration.

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12. Types of projects to be deployed through the JU

The Joint Undertaking will deploy a balanced portfolio of projects across the full innovation spectrum—from research and applied R&D to demonstration and flagship-scale industrial deployment. This portfolio is designed to systematically bridge the "valley of death" and accelerate the commercialization of food and feed biotechnology solutions.

The four complementary project categories foreseen are: Flagship Projects, Demonstration Projects, R&D Projects, and Supporting Projects. Together, these categories will ensure that Europe moves from laboratory innovation to industrial-scale deployment while de-risking investment, catalyzing private capital, and enabling SMEs and startups to thrive within the ecosystem.

12.1 Flagship Projects (TRL 8)

Flagship projects will represent the first-of-a-kind industrial-scale units within value chains that demonstrate economic viability. They are the culmination of years of upstream research and demonstration activities and are essential for proving the scalability and competitiveness of breakthrough biotechnologies.

- TRL focus: Primarily TRL 8.
- Role in the ecosystem: Flagships provide proof that value chains can operate on a commercial scale. They are indispensable to secure investor confidence and paving the way for second-generation plants at lower capital cost and lower risk.
- Challenges: These projects entail significantly higher costs and risks than demonstration plants due to scale-up complexity, capital intensity, and operational uncertainties. They require innovative financing models and public-private co-investment to proceed.
- Expected number: 15–20 flagships over the JU lifetime (indicative target, subject to stakeholder input).
- Example areas: precision-fermentation-derived dairy proteins, microbial lipids as palm oil substitutes, large-scale biomass fermentation platforms.

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12.2 Demonstration Projects (TRL 6–7)

Demonstration projects are the last pre-commercial step before full industrial deployment. Their purpose is to validate the technical, economic, and environmental feasibility of innovative processes and products under near-industrial conditions.

- TRL focus: TRL 6–7.
- Role in the ecosystem: Demonstrators generate essential performance data for the design and risk-assessment of flagship projects. They form the backbone of the JU portfolio by ensuring continuity between R&D and flagship deployment.
- Revenue profile: Demonstration units typically generate little or no revenue, making them high-risk investments without public support. This justifies JU funding intervention.
- Scale requirements: Demonstrators must be mature enough to prove scalability and produce reliable technical and sustainability data for subsequent industrial roll-out.
- Example areas: pilot-scale microbial fermentation for functional ingredients, algae-based feed additives, hybrid protein formulation processes.

12.3 R&D Projects (TRL 4–5)

Research & Development projects will provide the applied scientific foundation required to address technical challenges identified in demonstration projects and to prepare new innovations for scale-up.

- TRL focus: TRL 4–5 (applied research and pilot-scale validation).
- Role in the ecosystem: These projects ensure a continuous pipeline of innovation feeding into higher-TRL demonstration and flagship activities.
- Focus areas:
    - Conversion of biomass into food and feed bioproducts.
    - Novel strain engineering, microbial chassis development, and new feedstock valorisation pathways.
    - Next-generation cell-culture media and process intensification approaches.
- SME Engagement: Dedicated cascade funding mechanisms will be introduced to facilitate SME participation and strengthen entrepreneurial ecosystems.

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12.4 Supporting Projects (CSA / RIA cross-cutting issues)

Supporting projects will address the systemic enablers required for large-scale uptake of food biotechnology across Europe.

- Focus areas:
    - Digitalisation & AI/omics tools: development of databases, predictive modelling, and digital twins.
    - Feedstock accessibility: mapping and assessment of agricultural and agri-food side streams.
    - LCA & TEA methodologies: harmonised standards for environmental and techno-economic assessments.
    - Regulatory science: development of standards, guidelines, and evidence to support EFSA and EU regulatory frameworks.
    - Clustering and networking: building pan-European clusters to connect SMEs, corporates, and academia.
    - Social sciences, consumer acceptance, food envrionments
    - SME cascade funding: targeted instruments to lower entry barriers for innovative small players.

12.5 Funding Logic and Budget Allocation

Given the capital-intensive nature of biotechnology scale-up, the JU will distribute funding across the four categories with a deliberate bias towards demonstration and flagship activities, while still reserving sufficient resources for upstream R&D and systemic enablers.

- Flagship (IA) projects: 30%
- Demonstration (IA) projects: 35%
- R&D (RIA) projects: 20%
- Supporting (CSA) projects: 15%

This distribution ensures a strong pipeline of technologies (R&D), a critical mass of validation activities (demonstration), large-scale proof of competitiveness (flagships), and the systemic conditions (supporting projects) needed for widespread uptake.

13. Roadmap 2025–2035: From Vision to Deployment

13.1 Roadmap for the Alliance

From Q1 2026, the Alliance moves from strategy to coordinated delivery — reducing fragmentation and preparing Europe for a scalable agri-food biotech partnership.

Phase 1 – SRIA Activation & Alignment (Q1–Q2 2026)

- Formal validation of the SRIA and engagement by Alliance partners.
- Structured engagement with the European Commission and key Member States.
- Alignment discussions with complementary initiatives to reduce fragmentation and clarify scope.
- Co-creation of enabling mechanisms

Outcome: SRIA recognised as a shared European reference framework.

Phase 2 – Alliance Delivery & Coordination (Q2–Q3 2026)

- Establish light governance and thematic working groups aligned with SRIA priorities.
- Launch early Alliance actions/ enabling mechanisms : pilot access, regulatory science, skills initiatives, FoodBioX experimentation).
- Mobilise regional and national funding for early TRLs (3–5).
- Structure the ecosystem and the partnership models

Outcome: Demonstrated impact through coordination and early delivery.

Phase 3 – JU Co-Design & Investment Readiness (2026–2027)

- Co-develop the JU SRIA jointly with other initiatives.
- Consolidate a critical mass of partners and investment-ready flagship concepts.
- Engage investors and EU institutions on blended finance and governance
- Structure first Challenges and Portfolio to be initiated by end 2026.

Outcome: JU-ready framework with strong political and industrial backing.

Phase 4 – Transition & Continuity (2028 onwards)

- Alliance acts as ecosystem coordinator and pipeline feeder to the JU.
- Continuous SRIA updates and expansion into health, nutrition, and feed domains.

Outcome: Long-term coherence and impact beyond individual funding instruments

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13.2 Roadmap for a JU

The proposed Joint Undertaking (JU) should be guided by a clear, phased, and time-bound roadmap that translates strategic ambition into concrete implementation. This roadmap ensures alignment and coordination between the European Agri-Food Biotech Alliance, the European Commission, Member States, research organisations, industry, and SMEs. It also provides clarity and predictability for investors, innovators, and policymakers.

Phase I: Foundation and Strategic Alignment (2025–2027)

2025

- Consolidation of the European Agri-Food Biotech Alliance and preparation of input materials and evidence base to inform a future JU applied to agri-food and feed

2026

- Co-development of the JU Strategic Research & Innovation Agenda (SRIA), explicitly joining forces with complementary initiatives in the agri-food and feed space (notably Food4All and CBE JU) to ensure alignment, reduce fragmentation, and avoid duplication.
- Political engagement with the European Commission and Member States to build consensus around the creation of a JU focused on agri-food and feed biotechnology.
- Launch of EU-wide skills and workforce initiatives (e.g. Biotech Academy), targeting up to 100,000 professionals trained in advanced food and feed biotechnology.
- 2027
- Establishment of the private legal entity/association, with founding members from industry, academia, SMEs, and innovation intermediaries.
- Finalisation of JU SRIA v1.0, aligned with FP10 priorities, EU policy objectives, and Member State interests.

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Phase II: JU Preparation and Formal Launch (2027–2028)

Mid-2027

- Negotiation of the partnership agreement between the private entity and the European Commission.

Late 2027

- Finalisation of governance structures, operational model, and budget commitments.

January 2028

- Official launch of the Agri-Food and FEed JU as an institutionalised Public–Private Partnership (iPPP).

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