

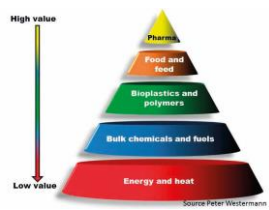
CIRCULAR Feedstock-opportunities for more efficient use of biological resources



- **Upgraded use of food waste;** WHO: 34% food lost globally!
- **Valorization of food-processing side-streams =>approx additional >20% wasted**
- **Improved use of crop residues –unlocking full potential of the entire crop plant**
- **Sustainable use of blue biomass, seaweeds & fish cut-offs; & forestry residues**
- **Upcycling of residual microbial biomass** from biological production (bacteria & fungi)
- **Making value from organic content of sludge and wastes**

Reference:

Lange, O'Connor et al., 2021: Developing Sustainable & Circular biobased Economy in EU. Front.Bioeng.Biotechnol. 2021



Unlocking the full potential of the many types of biomass

Key: **Fungal enzymes** are essential for conversion of all types of biomass

- The **Yellow Biomass**: Straw, corn-stover & wood chips
- The **Green Biomass**: Green grass & foliage and stems
- The **Blue Biomass**: Fish processing cut-offs & Seaweeds
- The **Red Biomass**: Slaughterhouse waste, blood & cut-offs
- The **Grey Biomass**: Agro-industrial side streams
- The **Brown Biomass**: Sludge & manure; household waste
- The **Purple gas-feedstock**: Making feed from methane- and food from CO₂

Reference: Berg, G. et al, 2020: Microbiome Definition Re-Visited: Old Concepts and New Challenges. Microbiome, 103

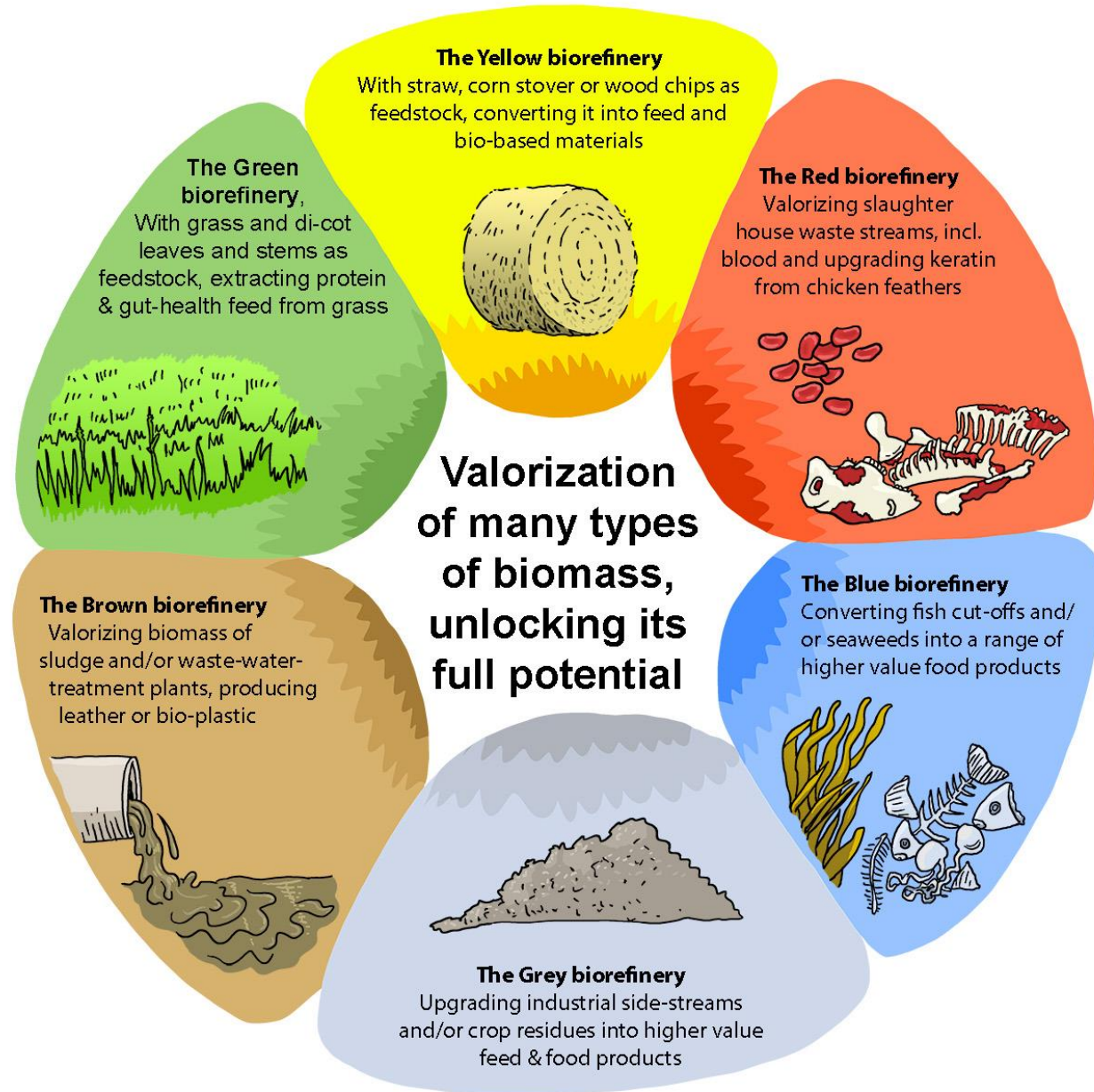
Biorefinery-valorization –producing also higher value food ingredients

In Biorefinery technologies:

Culture Collections
create value
and gives robustness

Lange, L., 2022:

Biorefinery
Business Models
In: Frontiers in
Sustainability



**Improved use of the Bioresources, "Circular & Bio-based"
impacts positively on:**

***Climate, Food security, Public Health, Biodiversity, and
Local Jobs -and Global Business!***

For all this:

**Discovery of new and improved Enzymes and Enzyme Blends
(for biomass conversion) are key!**

Function-targeted enzyme discovery is a paradigm shift!

CUPP, Conserved Unique Peptide Patterns

CUPP, a non-alignment, peptide-based functional annotation

- In evolution, certain parts of gene sequence is conserved for optimized fitness; resulting in shared peptide patterns between groups of different proteins
- CUPP analysis identify the unique peptide-pattern for each CAZyme function
- CUPP is available as automated web-based platform
- *Barrett, K & Lange, L, 2019: Peptide-based functional annotation of carbohydrate-active enzymes by conserved unique peptide patterns (CUPP). Biotechnology for biofuels 12 (1), 1-21. CUPP method, description and validation*
- *Barrett, K et al., 2020: Conserved unique peptide patterns (CUPP) online platform: peptide-based functional annotation of carbohydrate active enzymes, Nucleic Acids Research, 48, p110-115. Try it! It is online!*
- *Barrett, K.; Hunt, C. J.; Lange, L.; Grigoriev, I. V.; Meyer, A. S. Conserved Unique Peptide Patterns (CUPP) Online Platform 2.0: Implementation of +1000 JGI Fungal Genomes. Nucleic Acids Research 2023, 51 (W1), W108–W114*

The CUPP-based platform of methods

- **CUPP** peptide-based prediction of function
- **F;F Annotation**: Integrated annotation to **EC Function:Protein Family Observations** (the observation, mimicking evolutionary selection)
- **EPR, Enzyme Profile relatedness**, enabling cross taxonomy comparison and relatedness
- **Hotspot analysis**, summing up number of F;F observations (unique or total, including redundancy)

In progress:

- **Comparative CAZyme-blend digestive capacity composition analysis**
- **CUPP** for Functional annotation of the **Microbiome secretome!**
- **Culture collections**: F;F annotation of type strains & species complex?

EU investment BBI-JU 3.7 billion€-program, 2014-2021: Technologies & Biobased Products from residues & sidestreams

Unlocking full potential of the biomass, by cascading use:

- Producing higher value product, as food ingredients and Biostimuli; as well as materials & chemicals; using only the residuals for lower value products, e.g. bulk soil-improvers and fuels
- Upgrading all types of biomass, not just wheat straw and corn-stover

=> EU in lead in Biomass Conversion Technologies & Valorization😊

Telling the story about the EU Circular Biobased journey,

*Ruiz Sierra, A.; Zika, E.; Lange, L.; Ruiz de Azúa, P. L.; Canalis, A.; Mallorquín Esteban, P.; Paiano, P.; Mengal, P. The Bio-Based Industries Joint Undertaking: A High Impact Initiative That Is Transforming the Bio-Based Industries in Europe. New Biotechnology **2021**, 60, 105–112*

Lange, O'Connor et al., 2021: Developing Sustainable & Circular biobased Economy in EU. Front.Bioeng.Biotechnol.

Drastically new international development, 2022-2024 in the Global Bioeconomy

Actions taken by big Biomass-producing continents, 2022-2024

- **2022, China, Xi:** New 5-year plan, full valorization of the biomass. Earlier only Biofuel
- **2022, US, Biden, IRA,** Inflation Reduction Act: Attractive investments and funding to support upgraded use of biological resources
- **2023, G20,** Indian Chairmanship, Modi: Strong document on strengthening Bioeconomy and Biomanufacturing
- **2023, India, Modi:** Biomanufacturing -a new federal priority in India
- **2023/2024, Brazil:** New G20 and COP initiative! Reorganization of Government, for facilitating improved use of the bioresources
- **From 2022: Thailand, S. Korea,** developing upscaled biobased production , in close collaboration with **EU infrastructure (Delft)**



**EU reacted in 2024 to the new global interest
with a new high level Ursula von der Leyen
Strategy Document on
"EU Biotech & Biomanufacturing"**

Brussels, 20.3.2024
COM(2024) 137 final

**COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN
PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL
COMMITTEE AND THE COMMITTEE OF THE REGIONS**

**Building the future with nature: Boosting Biotechnology and Biomanufacturing in the
EU**

”EU Biotechnology & Biomanufacturing” document, Highlights & Pitfalls

- **Good News! Importance of Microbiomes for Health is included!**
- **Decision:** 2025, a new revised EU Bioeconomy Strategy to be published
 - notably, under Danish EU Chairmanship😊
- Many new initiatives to strengthen EU in this field
 - read the document!

Critical issues still to be addressed:

- Regulatory obstacles! Many new types of sustainable fermented food!
- New paradigm shift needed: Microbiome knowledge and use, to be taken seriously, for health and for One Health
- EU to be active in International collaboration within Bioeconomy
- International Knowledge sharing; ensuring food security and health!

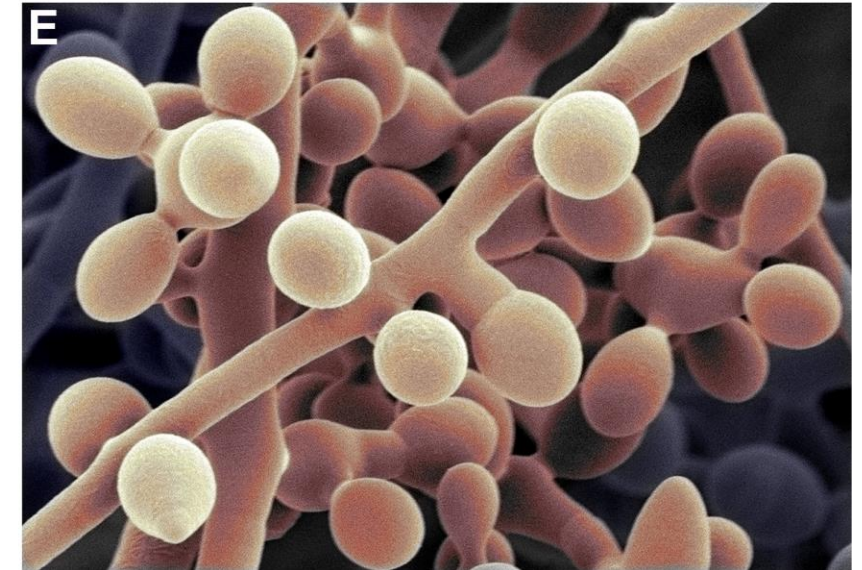
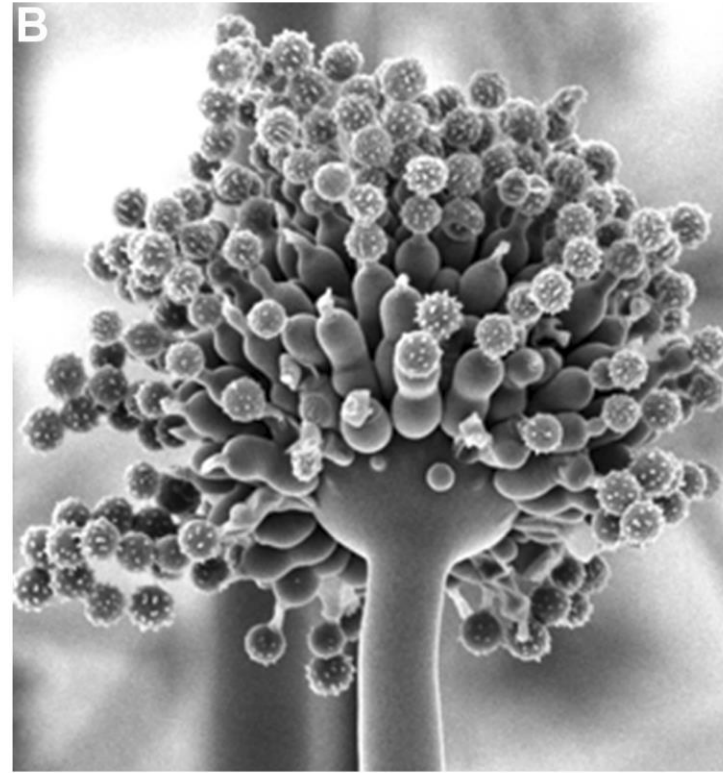
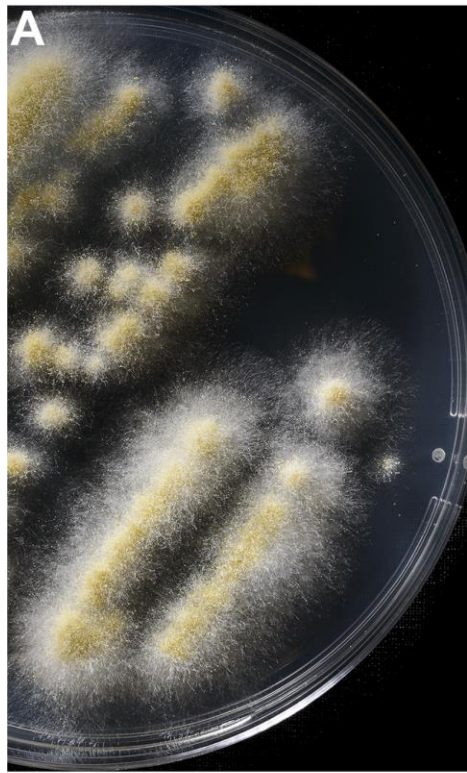
**The Fungal
Hall of Fame:
Biological
production:
Enzymes,
Insulin, Statins**

In future?

***Meat protein**

***Milk protein
from Yeast!**

***Microbiomes
used for
manufacturing?**



Time for action and impacting!

- **New Commission, 2024**
- **New Bioeconomy Strategy, 2025**
 - **Under Danish EU Chairmanship!**
 - **We prepare for a Bioeconomy Conference, strengthening use of new biorefinery technologies and biological solutions**

Proposal:

An open access Biosolutions Strain Collection

Each strain to be among the best suited for at least one specific and important function for improved use of the biological resources

3 CRITERIA:

- Among the most efficient, bacteria or fungi, for such function
- Nonpathogenic, no mycotoxins, and safe to handle, to grow and use!
- There should be no strings attached,
 - neither IP restrictions
 - nor issues with regard to the Nagoya Protocol

An Open Access Strain Collection for Biomanufacturing & Bioeconomy-relevant strains

Selection of Strains

- High yielding strains, producing a rich cocktail of biomass degrading enzymes
 - Documentation: The strain should be genome sequenced and its CAZyme profile should be annotated to both protein family and EC enzyme function
- Strains giving high yields in Biomanufacturing, growing efficiently in fermentors (bacteria or fungi)
- Strains documented to be easy to transform and giving high yields when used as recombinant production host
- Strains, superior for fermentation for conversion of residues, resulting in tasty, nutritious and antiinflammatory, gut-healthy food

External Funding is needed for developing such a strain collection

- The Culture collections (ECCO) to be encouraged to collaborate for developing suitable, ambitious and realistic “Open Access Biology” project applications
- Assemble a project consortium, which besides the culture collection experts includes leading specialists in all the different types of Functions here described
- Identify optimal types of funding, public or philanthropy
- Include all types of expenditures, sequencing, full functional annotation (both enzymes/CUPP and secondary metabolites/Antismash)
- Notably, including development of written protocols for growing the strains and for how to use the strains for each function, for food, feed, materials, chemicals

Additional Funding for providing such strains for free to climate-change stricken regions

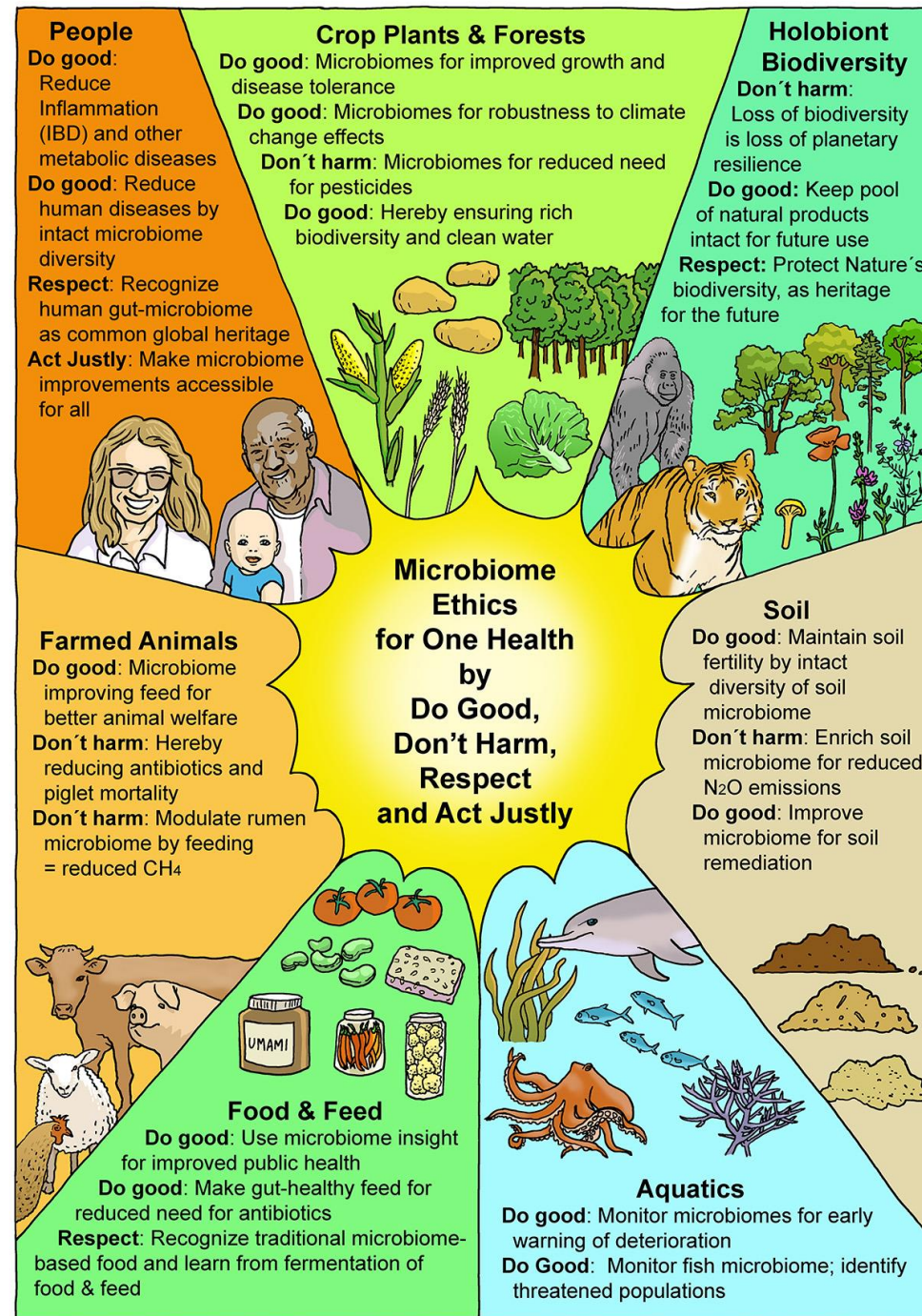
- In areas, where food production is challenged or compromised, due to climate change, an acute risk of hunger can develop
In such cases food aid is not enough
- The alternative, making food from residues and agro-industrial side-streams could possibly provide for restoring food security
- An Open Access Biosolution Strain Collection could make this possible

New Commission, 2024 & New EU Bioeconomy Strategy, 2025

- This is the time where opportunities can open and change of direction: Faster use of new knowledge & GREEN technologies!
- Let us work together for that EU takes lead in a global endeavor for improved use of the bioresources, for food security, nutrition and health as well as for substituting for fossils
- **Culture collections have an important role to play for enabling such development**

Lange, L.; Berg, G.; Cernava, T.;
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 Cotter, P.; D'Hondt, K.; Kostic, T.; Maguin, E.;
 Makhalanyane, T.; Meisner, A.; Ryan, M.;
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Microbiome Ethics, Guiding Principles for Microbiome Research, Use and Knowledge Management. *Environmental Microbiome* 2022, 17 (1), 50.





BioEconomy
Research & Advisory

Thanks a lot for your kind attention

Lene

