National and Kapodistrian University of Athens
Dept. of Biology, Section of Ecology and Systematics

Microbial Culture Collections as valuable resources for promoting Bioeconomy

The ATHUM Culture Collection of Fungi

Zacharoula (Zapi) Gonou-Zagou

BIO economy
THIRD BIOECONOMY COURSE
UNIVERSITY OF SOUTH BOHEMIA
MAY 21 – 25, 2018

Microbial Culture Collections

as valuable resources for promoting Bioeconomy

Bioeconomy

"The knowledge-based production and utilization of *biological resources, innovative biological processes* and principles to *sustainably* provide goods and services across all economic sectors'

Bioeconomy Summit 2015

Natural resources

Biotic* resource

stemming from living organisms (plants, animals, microorganisms) and organic materials

Abiotic resources

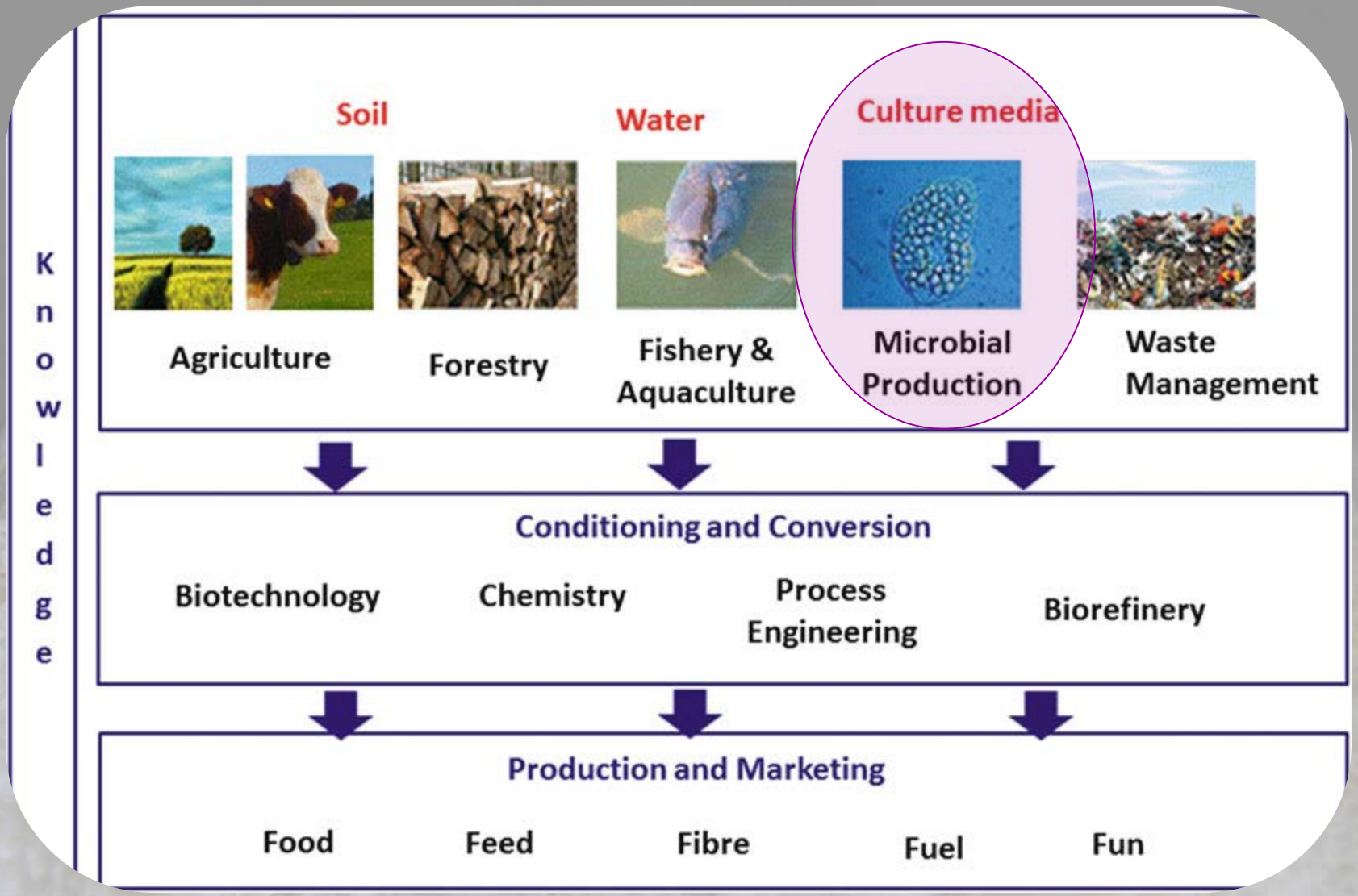
air, soil, water, sunlight, inorganic material-minerals

*Biotic, biological, biogenic, bio-based

Biological resources

All resources
containing non-fossil, organic carbon,
from living plants, animals, microorganisms or
organic waste streams

Whole organism, part of it or derivative



The resource substitution perspective of the bio-economy (BOR 2010)

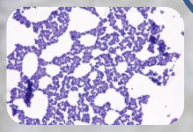
Microbes-Microorganisms

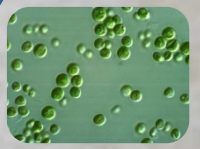
Diverse taxonomic groups

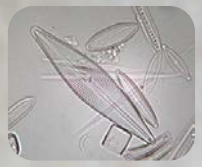
Fungi

Bacteria

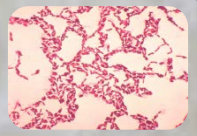
Algae







Archaea



Microorganisms

- Are abundant and diverse

10^7 procaryotic species

Curtis et al. 2002

$6x10^5$-10^7 fungal species

Cannon 1997

13,500 procaryotic species

www.bacterio.net

365,300 fungal species

Robert et al. 2013

Microorganisms

- Are abundant and diverse
- Inhabit different environments
- Participate in biotic interactions
- Are flexible, resilient
- Have high metabolic potential

✓Succesful organisms

✓Have wide impact on biosphere -Play crucial ecological role

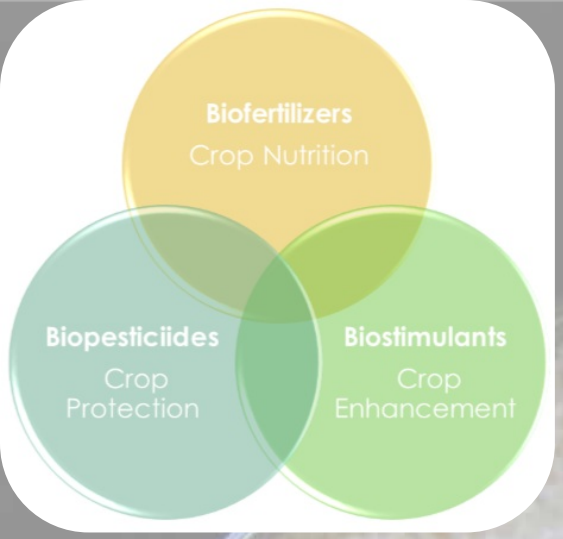
✓Determine structure and function of ecosystems

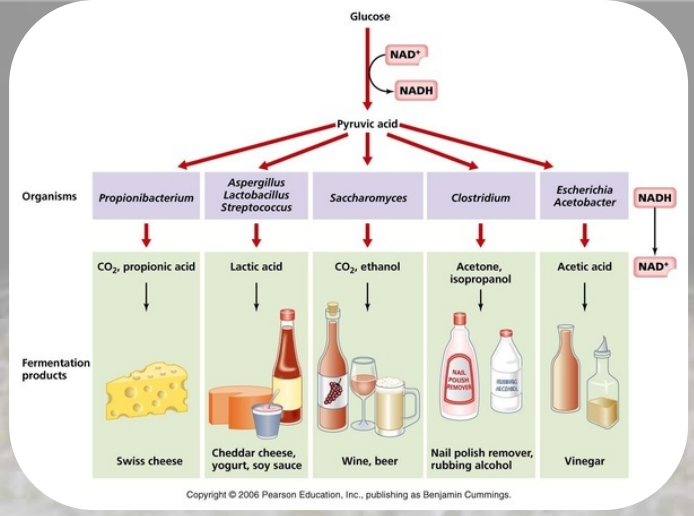
Microorganisms-microbial resources

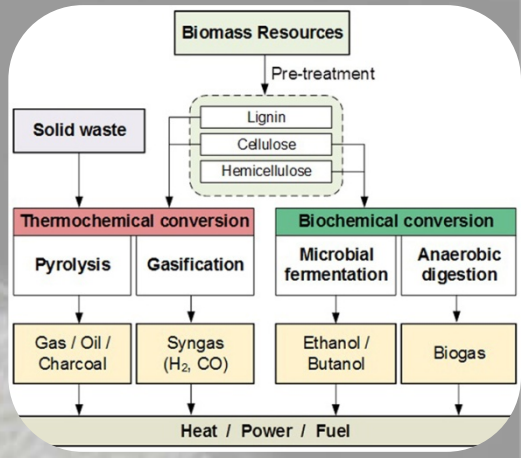
- Principal component of biological resources
- Essential raw material
- Early use for humankind benefit
- Full potential unknown-underexploited
- Unparalleled source of unexplored innovative solutions

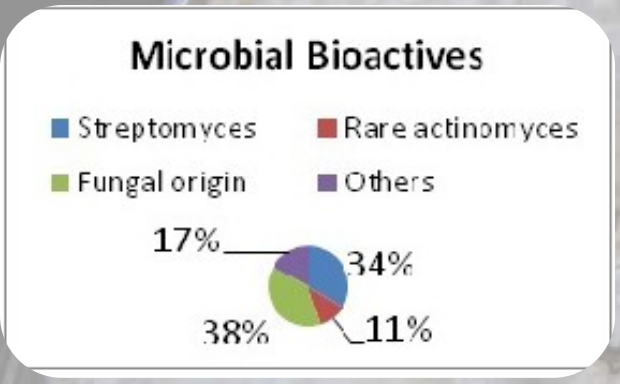
✓Meet worlds greatest challenges within sustainability

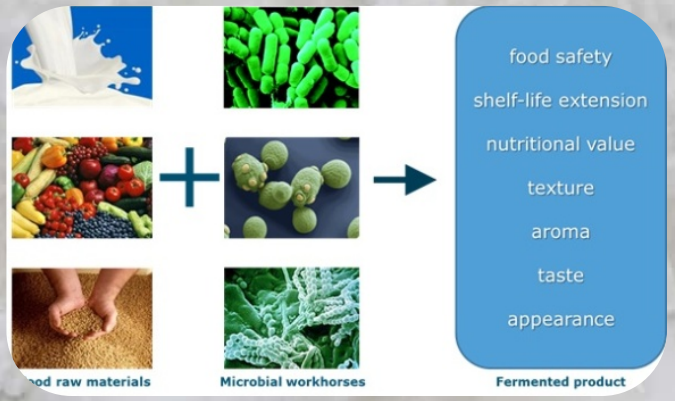
Agriculture Health Food-feed Energy Nanotechnology

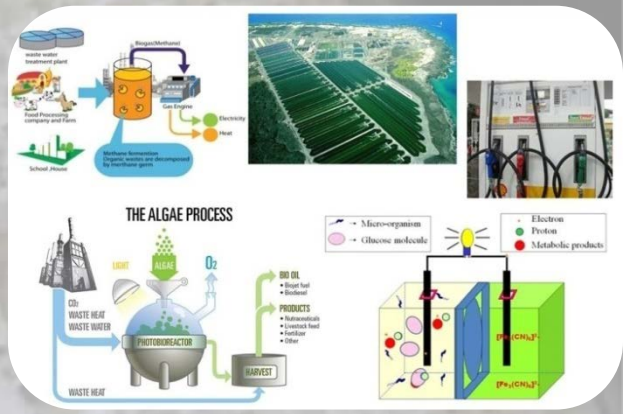

Biofertilizers
Crop Nutrition
Biopesticiides
Crop Protection
Biostimulants
Crop Enhancement

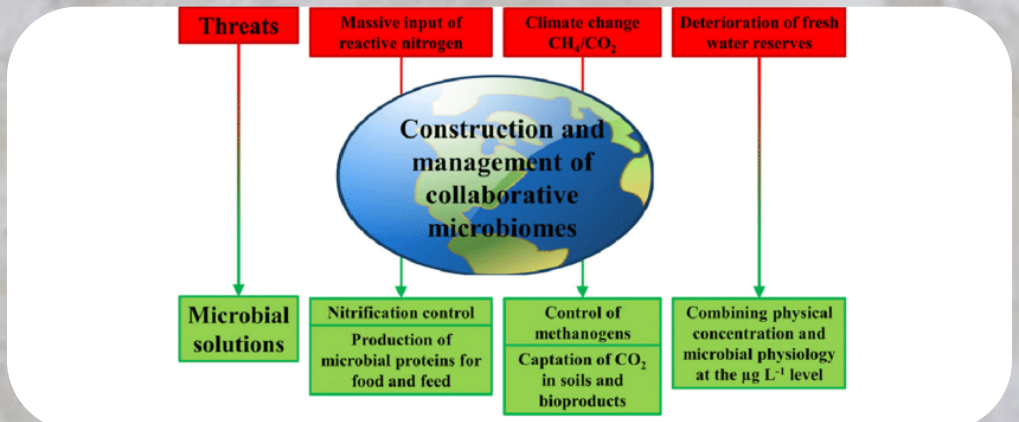

Glucose
NAD+
NADH
Pyruvic acid
Organisms
Propionibacterium
Aspergillus Lactobacillus Streptococcus
Saccharomyces
Clostridium
Escherichia Acetobacter
NADH
NAD+
Fermentation products
CO2, propionic acid
Lactic acid
CO2, ethanol
Acetone, isopropanol
Acetic acid
Swiss cheese
Cheddar cheese, yogurt, soy sauce
Wine, beer
Nail polish remover, rubbing alcohol
Vinegar
Copyright © 2006 Pearson Education, Inc., publishing as Benjamin Cummings.


Biomass Resources
Pre-treatment
Solid waste
Lignin
Cellulose
Hemicellulose
Thermochemical conversion
Biochemical conversion
Pyrolysis
Gasification
Microbial fermentation
Anaerobic digestion
Gas / Oil / Charcoal
Syngas (H2, CO)
Ethanol / Butanol
Biogas
Heat / Power / Fuel


Microbial Bioactives
Streptomyces
Rare actinomyces
Fungal origin
Others
17%
34%
38%
11%


food safety
shelf-life extension
nutritional value
texture
aroma
taste
appearance
Microbial workhorses
Fermented product


THE ALGAE PROCESS
PHOTOBIOREACTOR
HARVEST
Micro-organism
Glucose molecule
Electron
Proton
Metabolic products


Threats
Massive input of reactive nitrogen
Climate change CH4/CO2
Deterioration of fresh water reserves
Construction and management of collaborative microbiomes
Microbial solutions
Nitrification control
Production of microbial proteins for food and feed
Control of methanogens
Captation of CO2 in soils and bioproducts
Combining physical concentration and microbial physiology at the µg L-1 level

Microorganisms-microbial resources

•Principal component of biological resources

•Essential raw material

•Early use for humankind benefit

Full potential unknown & underexploited

•Unparalleled source of unexplored innovative solutions

✓Meet worlds greatest challenges within sustainability

Agriculture Health Food-feed Energy Nanotechnology

Secure in Culture Collections

Culture Collections

- Public, open collections
- Maintain strains for future research & application
- Safeguard biodiversity, ex-situ conservation
- Provide access to microbial resources, data, expertise
- Ensure correct & valid taxonomy, offer authentication

Microbial Biological Resource Centers (mBRCs)

(quality-driven management according to OECD guidelines)

Culture Collections

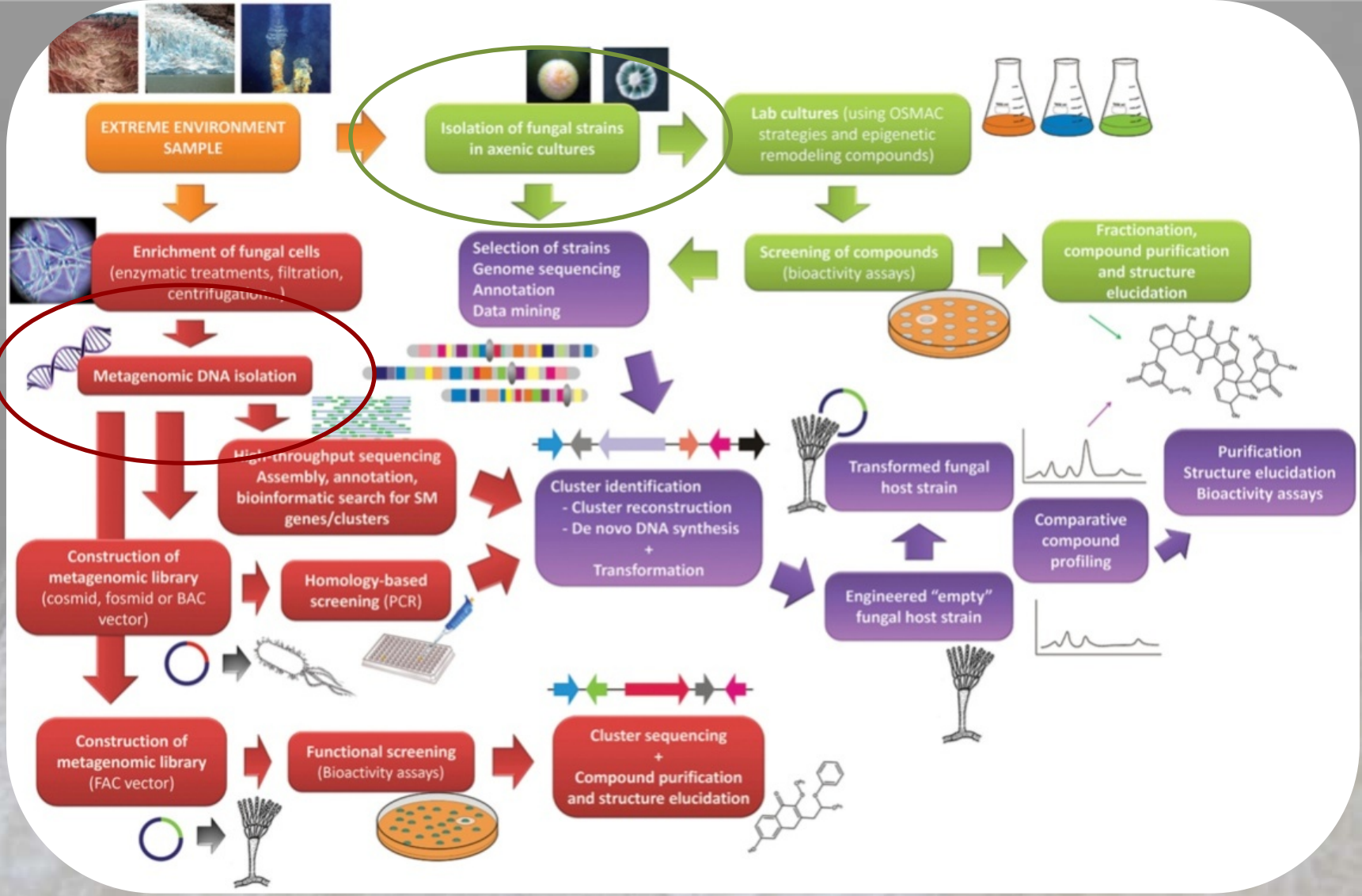
709 CC in WDCM (World Data Centre for Microorganisms)
220 in Europe

1,070,000 Bacteria 747,000 Fungi & Yeasts

0.5 million strains are supplied by CC registered in WDCM

<0.1% of prokaryote strains published are deposited in CC

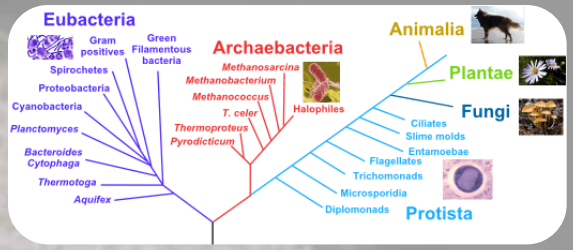
70% of strains used in published research are not from CC



Culture Collections Genomic Collections

Biorepositories

FUNGI

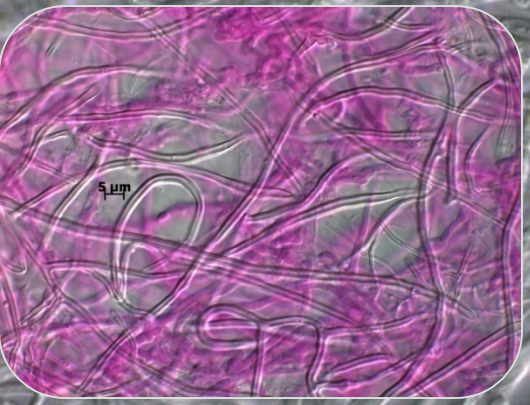


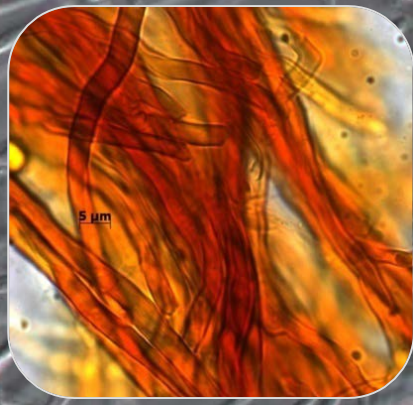
✓Distinct Kingdom

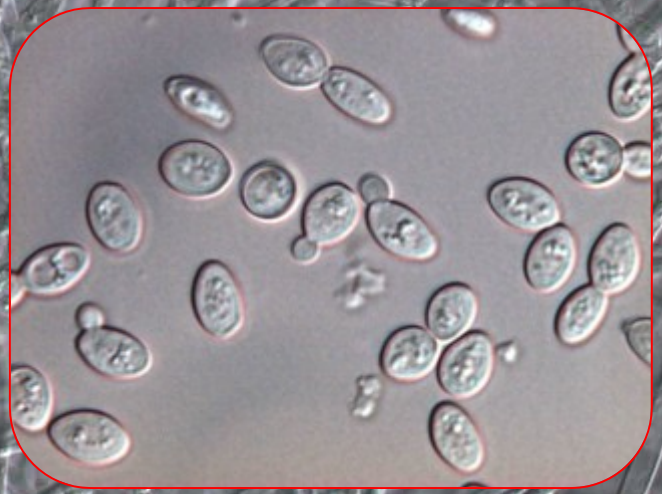
✓Thallus mycelium consisting of hyphae or unicellular

Hyphae -Mycelium

wall of chitin







10 µm

Yeasts=unicellular fungi

1µ = 0,001 mm

ZΓ

FUNGI

✓Distinct Kingdom

✓Thallus mycelium consisting of hyphae or unicellular

✓Reproduction sexual and asexual with numerous spores

✓Nutrition by absorption of organic material through hyphae

✓Production of secondary metabolites

✓Living in all sorts of environments and substrates

FUNGI

applications

Environment

Agriculture-Forestry

- Biostimulants
- Biofertilizers
- Biodegradation-bioconversion
- Bioremediation
- Biomineralization of heavy metals
- Biocontrol

Food-Feed

- Fermentations-food processing
- Mycoprotein-SCP
- Organic acid production
- Flavours, aromas, dietary supplements
- cultivated mushrooms

Health

Pharmaceuticals

- Antibiotics
  - penicillin
  - cephalosporins
- Cyclosporines
- Bioactive compounds
- Statines

Others

- Energy
- Detergens
- Biostoning, biofinishing
- Cosmetics – “leather” products

FUNGI

ATHens **U**niversity **M**ycetotheca

Culture Collection of Fungi

Dried Specimen Collection of Fungi

Member of

ECCO (European Culture Collections' Organization)

WFCC (World Federation for Culture Collections)

WDCM (World Data Centre for Microorganisms)

FUNGI

ATHens **U**niversity **M**ycetotheca

Culture Collection of Fungi

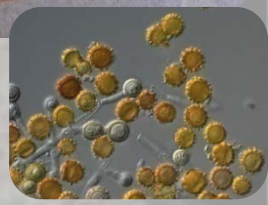
Indigenous strains of

Ascomycota

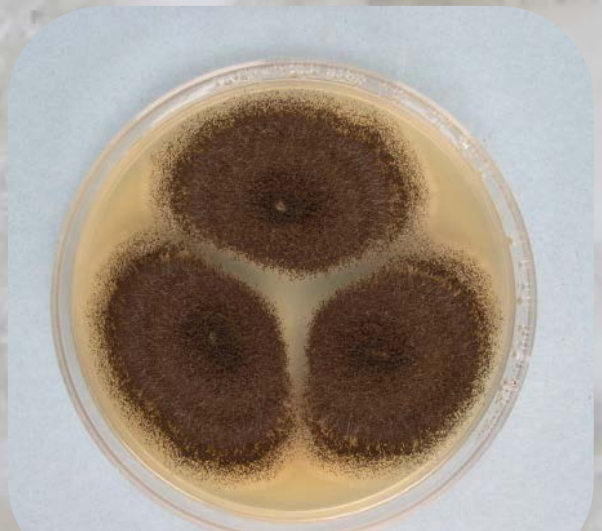
Basidiomycota (mushrooms)

Zygomycota

ATHUM



Ascomycota



Basidiomycota

ATHUM

Zygomycota

ATHUM ATHUBA UOA/HCPF

Network of Microorganism Collections
University of Athens

Hellenic Microbial Resource Collections Network

MIRRI

MIcrobial Resource Research Infrastructure

MIRRI is the pan-European research infrastructure for microbial resources launched in 2012

MIRRI aims to support research, development and applications in the field of biotechnology by provision of high quality microorganisms, associated data and the broad expertise of the partners

Currently more than 40 public bio-repositories and research institutes from 19 European countries collaborate to establish MIRRI as an European Research Infrastructure Consortium (ERIC) under EU law.

MIRRI in Europe

Partner*

Collaborating Parties+

Faculty of Science
CHARLES UNIVERSITY IN PRAGUE

Charles University Prague

CCF Culture Collection of Fungi

HELLENIC REPUBLIC
National and Kapodistrian University of Athens
EST. 1837

ATHUM

MIRRI

MIcrobial Resource Research Infrastructure

- MIRRI's vision is to be a unique pan_European high-performance platform adding value to known and yet unknown microbial diversity and exploiting novel sources and knowledge to discover and disclose for **bio-economy and bioscience.**

- MIRRI aims to generate solutions to societal and environmental challenges by stimulating interaction between academia and **bio-industry**

MIRRI

MIcrobial Resource Research Infrastructure

MIRRI Mission Statement:

MIRRI serves **Bioscience and Bio-industry** users by facilitating access to a broad range of high quality bio-resources and data in a legal compliant way. By offering access to human expertise and providing a collaborative platform for long-term sustainability of microbial biodiversity MIRRI will increase knowledge and promote professional development.

At the European level (EU/ESFRI), MIRRI creates synergies with other RIs whilst globally it collaborates with to other microbial resource RIs.

MIRRI underpins national interests supporting the protection of the investment, empowering **bio-economy** growth and increasing the competitiveness of the country.

Concluding…..

✓The diversity of microorganisms is largely unknown and untapped

✓A lot and hard work is needed for discovering, isolating, preserving and identifying the microorganisms, as well as studying their properties

✓In times of declining financial resources it is important to unite and harmonize the efforts, develop common strategies and establish new organizational structure to meet the challenges of the microbial revolution

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Pictures

ΙΠ = I. Pyrri, ΖΓ = Z. Gonou

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Thank you



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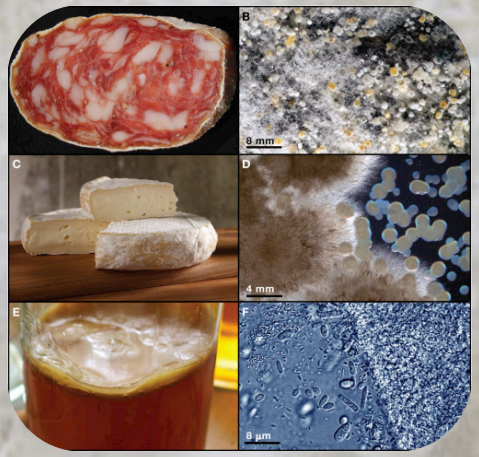
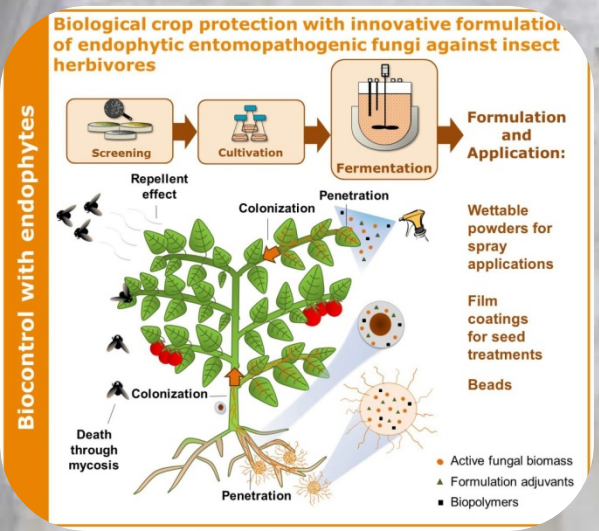
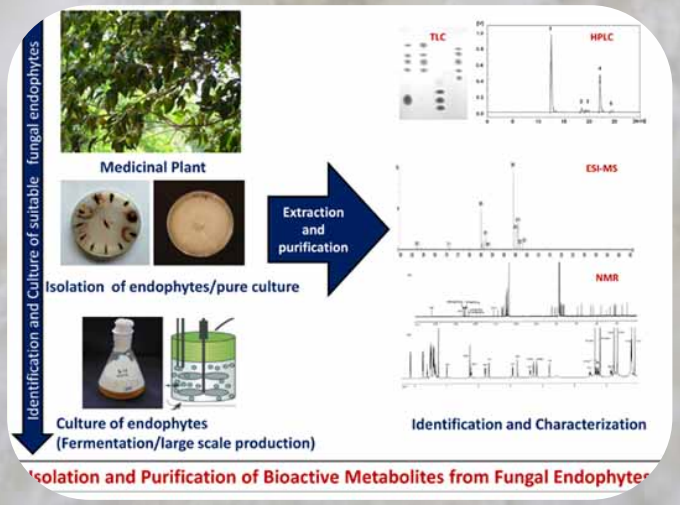
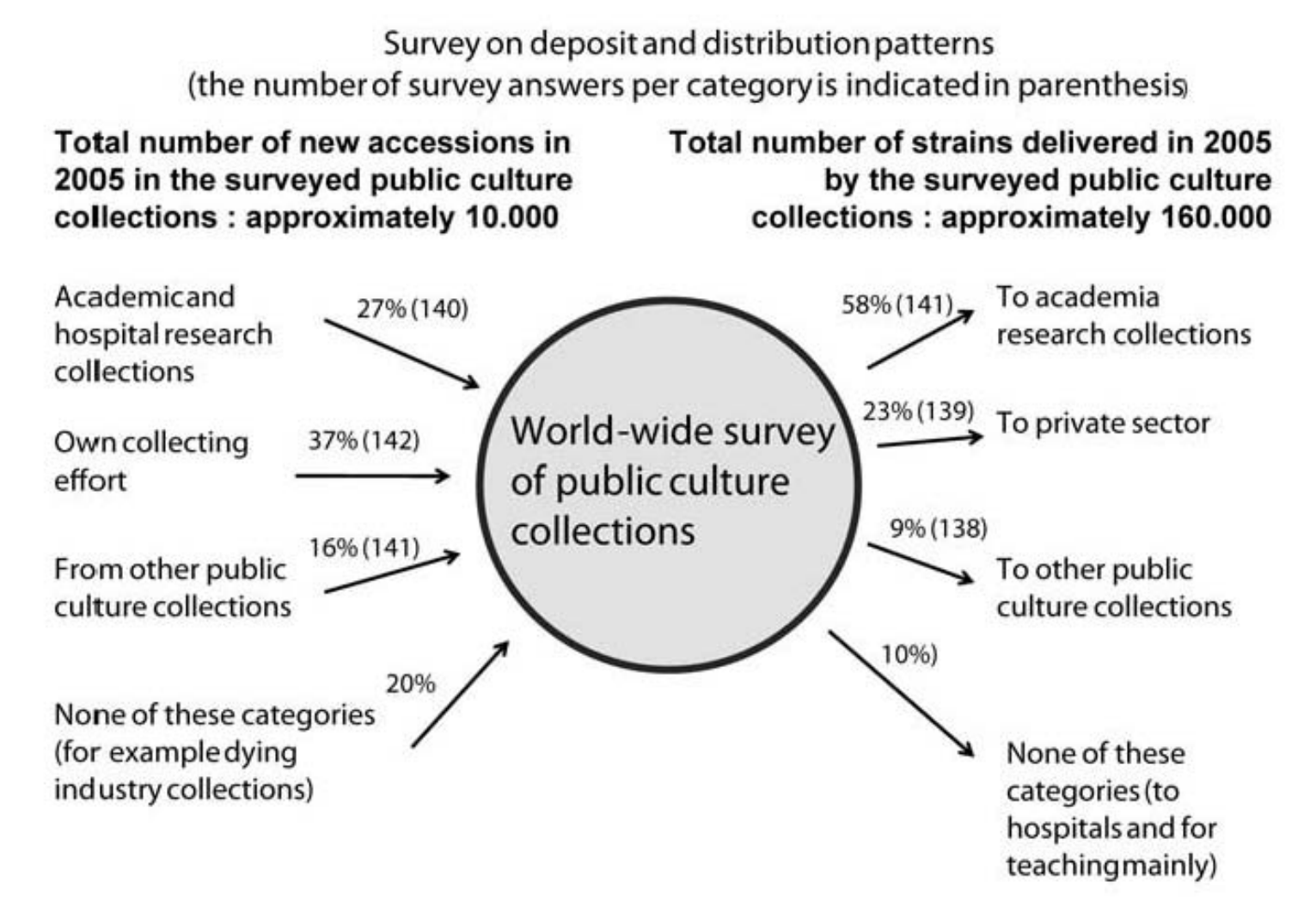

B
8 mm
C
D
4 mm
E
F
8 µm

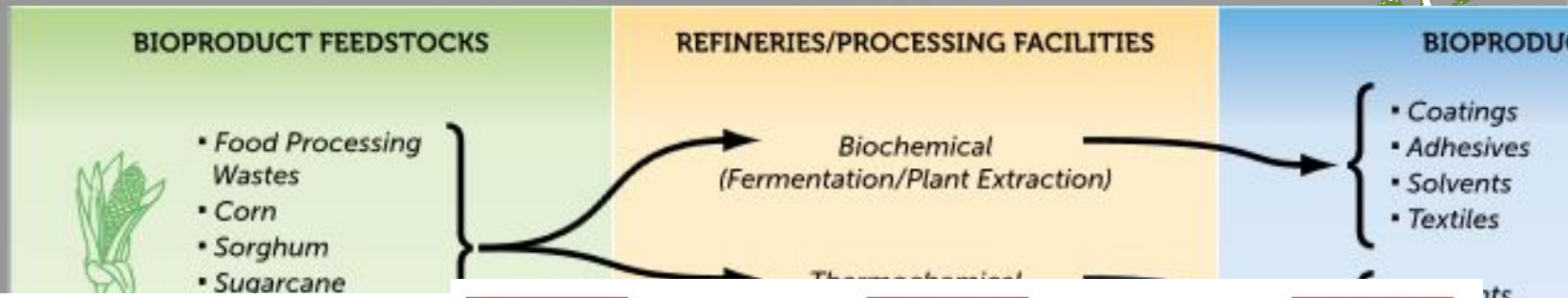

Protein and peptides
Pigments
Probiotics
PUFA
Oleaginous Microbes
Marine Microorganisms
Bioactive compounds
Pharmaceuticals
Carbohydrates
Genetic modifications
Polysaccharides
Monosaccharaides


Biocontrol with endophytes
Biological crop protection with innovative formulation of endophytic entomopathogenic fungi against insect herbivores
Screening
Cultivation
Fermentation
Formulation and Application:
Repellent effect
Colonization
Penetration
Wettable powders for spray applications
Film coatings for seed treatments
Beads
Colonization
Death through mycosis
Penetration
Active fungal biomass
Formulation adjuvants
Biopolymers

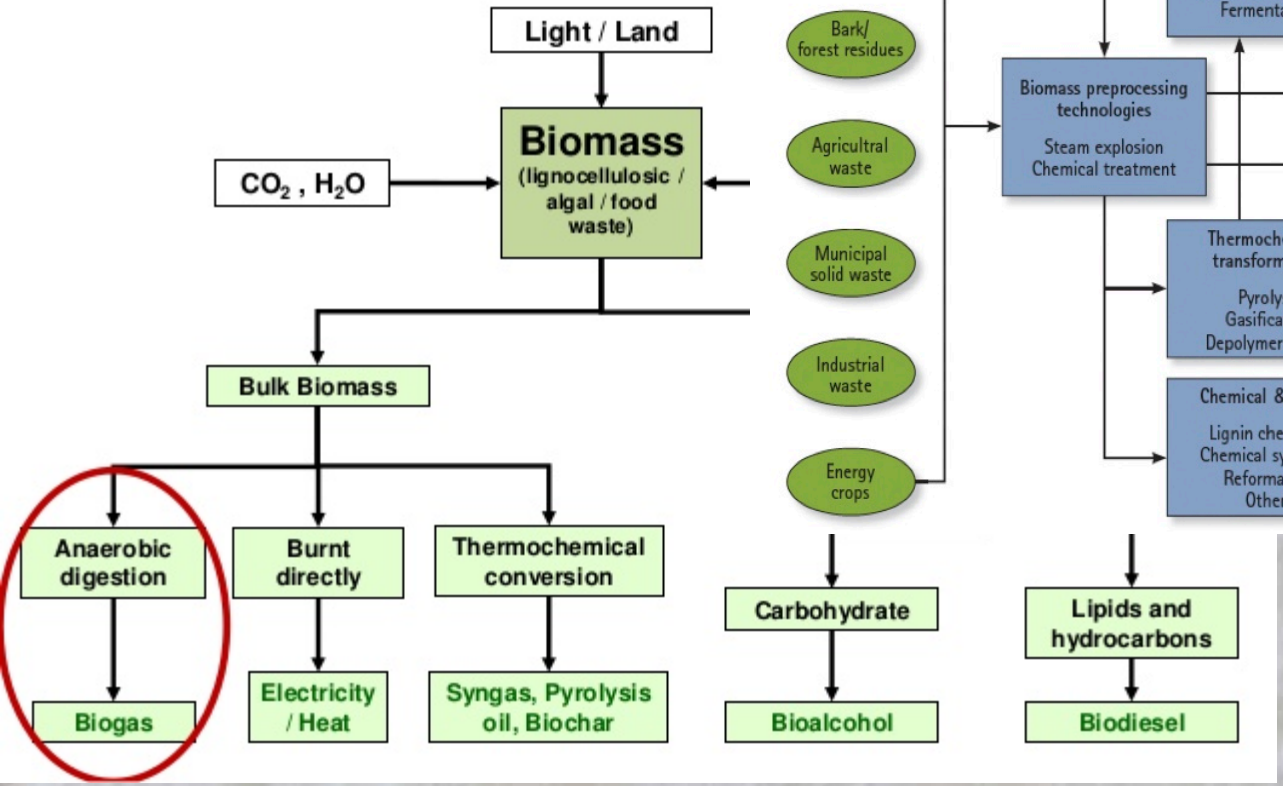

Identification and Culture of suitable fungal endophytes
Medicinal Plant
Isolation of endophytes/pure culture
Extraction and purification
Culture of endophytes (Fermentation/large scale production)
TLC
HPLC
ESI-MS
NMR
Identification and Characterization
Isolation and Purification of Bioactive Metabolites from Fungal Endophytes

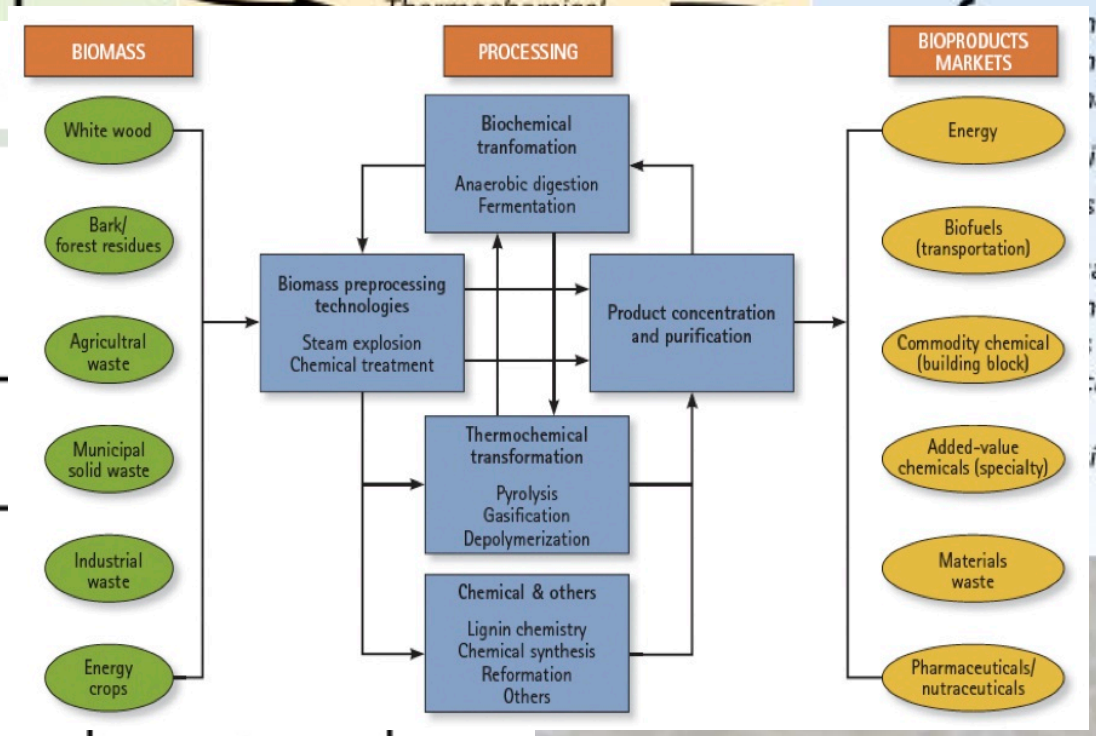
Culture Collections

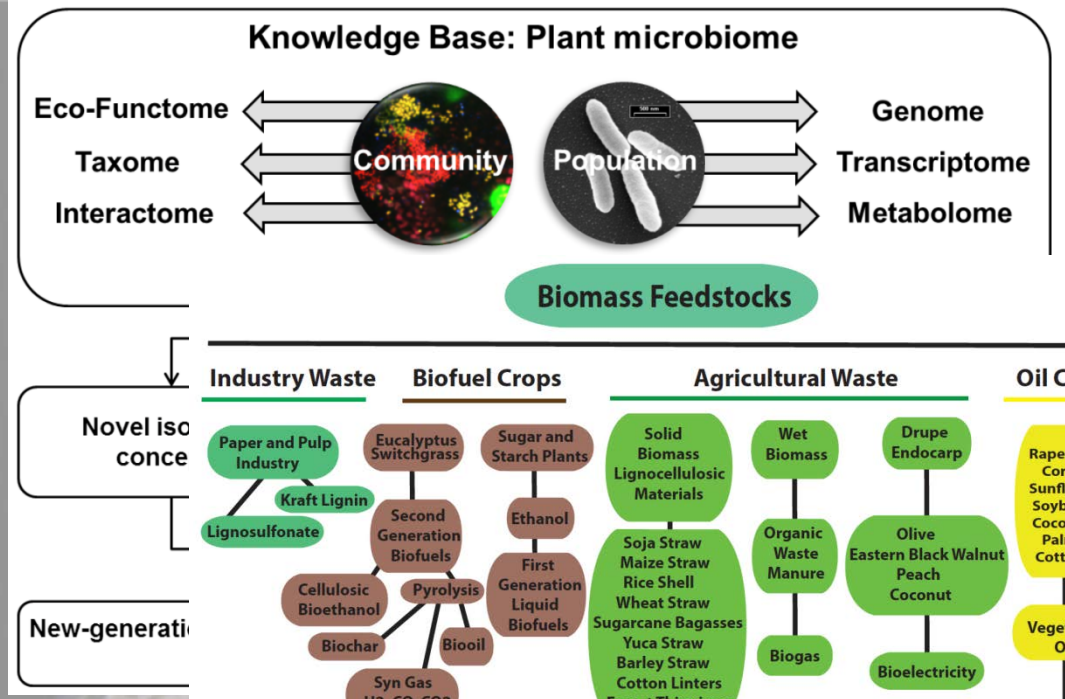


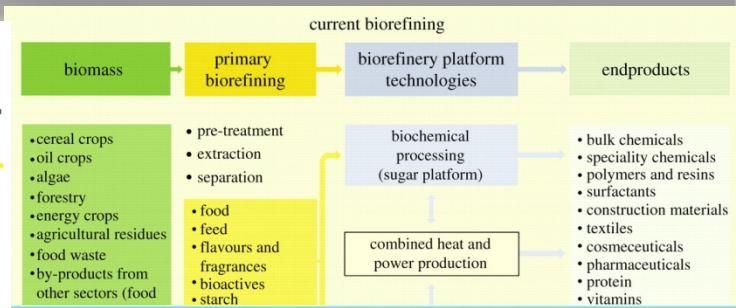


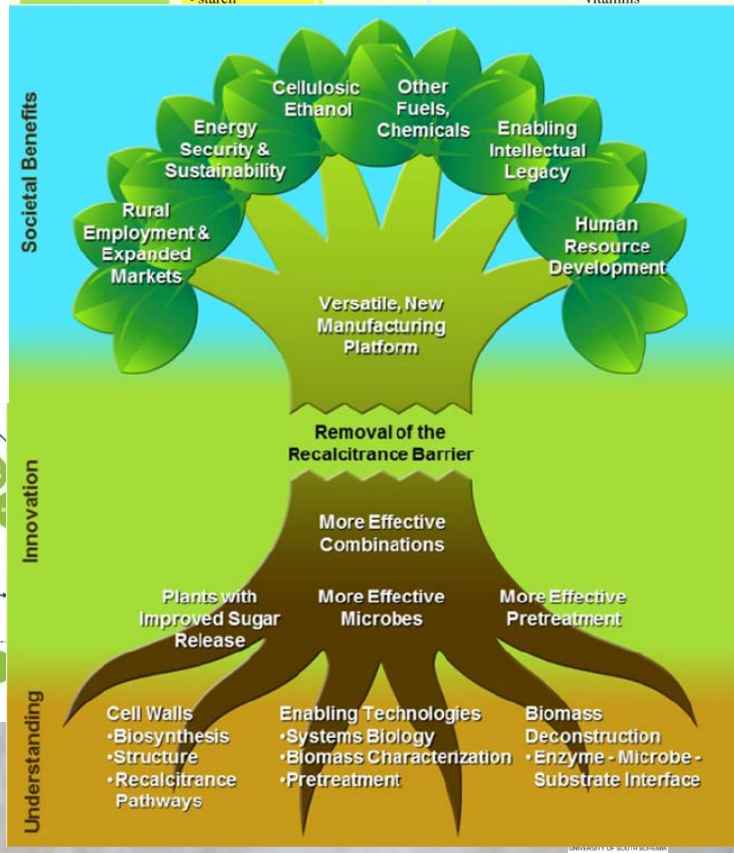
Case Study 1: Biomass to






Knowledge Base: Plant microbiome
Eco-Functome
Taxome
Interactome
Community
Population
Genome
Transcriptome
Metabolome
Biomass Feedstocks
Novel iso
conce
New-generati
Industry Waste
Biofuel Crops
Agricultural Waste
Oil Crops
Paper and Pulp Industry
Kraft Lignin
Lignosulfonate
Eucalyptus Switchgrass
Second Generation Biofuels
Cellulosic Bioethanol
Pyrolysis
Biochar
Biooil
Syn Gas H2, CO, CO2
Sugar and Starch Plants
Ethanol
First Generation Liquid Biofuels
Solid Biomass Lignocellulosic Materials
Soja Straw
Maize Straw
Rice Shell
Wheat Straw
Sugarcane Bagasses
Yuca Straw
Barley Straw
Cotton Linters
Forest Thinnings
Second Generation Biofuels
Cellulosic Bioethanol
Bio-hydrogen
Synthetic Biofuels
Wet Biomass
Organic Waste Manure
Biogas
Drupe Endocarp
Olive
Eastern Black Walnut
Peach
Coconut
Bioelectricity
Rapeseed
Corn
Sunflower
Soybean
Coconut
Palm
Cotton
Vegetable Oil
BioDiesel


current biorefining
biomass
primary biorefining
biorefinery platform technologies
endproducts
•cereal crops
•oil crops
•algae
•forestry
•energy crops
•agricultural residues
•food waste
•by-products from other sectors (food
• pre-treatment
• extraction
• separation
• food
• feed
• flavours and fragrances
• bioactives
• starch
biochemical processing (sugar platform)
combined heat and power production
• bulk chemicals
• speciality chemicals
• polymers and resins
• surfactants
• construction materials
• textiles
• cosmeceuticals
• pharmaceuticals
• protein
• vitamins


Societal Benefits
Cellulosic Ethanol
Other Fuels, Chemicals
Energy Security & Sustainability
Enabling Intellectual Legacy
Rural Employment & Expanded Markets
Human Resource Development
Versatile, New Manufacturing Platform
Innovation
Removal of the Recalcitrance Barrier
More Effective Combinations
Plants with Improved Sugar Release
More Effective Microbes
More Effective Pretreatment
Understanding
Cell Walls
•Biosynthesis
•Structure
•Recalcitrance Pathways
Enabling Technologies
•Systems Biology
•Biomass Characterization
•Pretreatment
Biomass Deconstruction
•Enzyme - Microbe - Substrate Interface


BIOINDUSTRIAL PARTNERS
RENMATIX PLANTROSE PROCESS
COMMUNICATION
BIOMASS FEEDSTOCKS
INTERMEDIATE PLATFORMS