Katedra Mikrobiologii Przemysłowej i Środowiskowej

Informator

Department of Industrial and Environmental Microbiology is formed by four research team:

1. Supervisor:
dr hab. Mariusz Trytek, prof. UMCS

Mentors and doctoral students:
dr Anna Gromada
mgr Mateusz Kutyła

2. Supervisor:
dr hab. Adrian Wiater, prof. UMCS

2a. Supervisor: **dr Kamila Wlizło**

Mentors:
mgr Katarzyna Próchniak

3a. Supervisor:
dr hab. Jolanta Jaroszuk-Ściseł, prof. UMCS

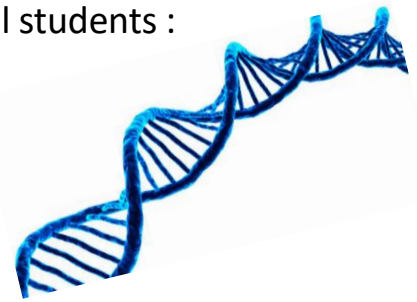
Mentors:
dr Artur Nowak
mgr Anna Słomka

3b. Supervisor: **dr Ewa Ozimek**

3c. Supervisor: **dr hab. Małgorzata Majewska**

4. Supervisor:
prof. dr hab. Monika Janczarek

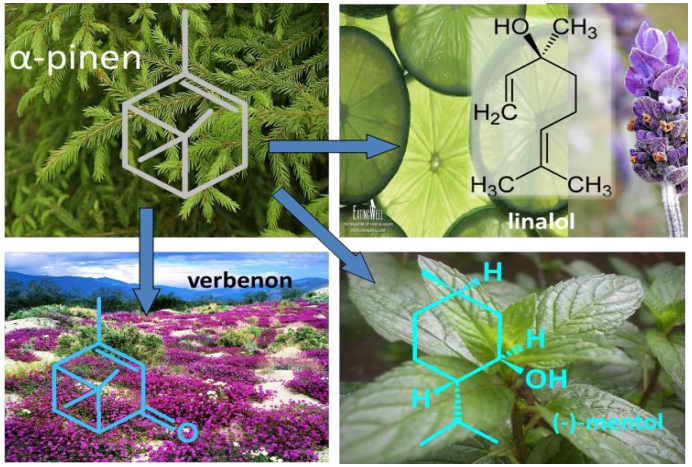
Mentors and doctoral students :
mgr Marta Kozieł

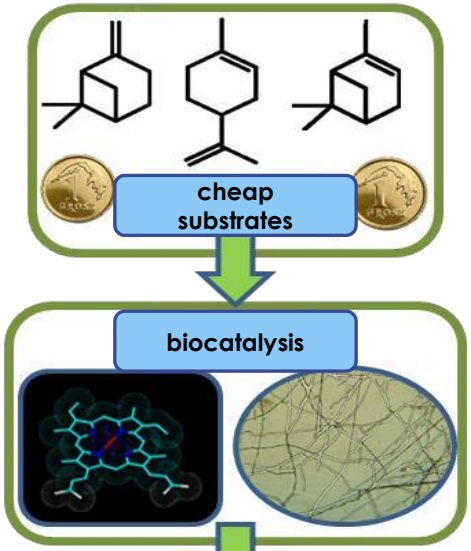


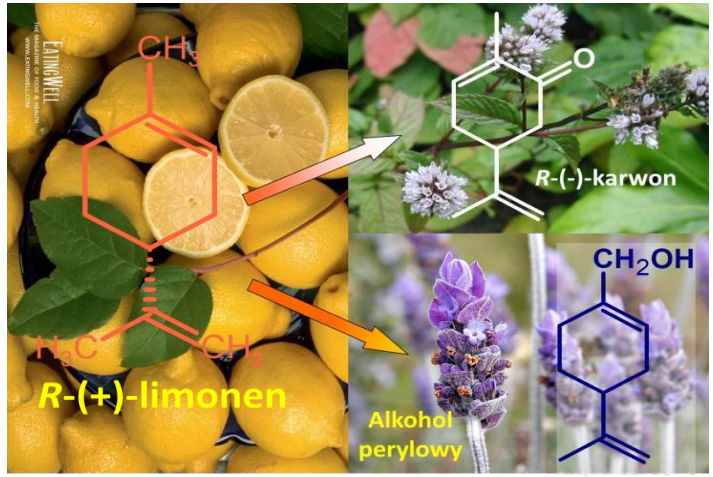
Research by professor Mariusz Trytek's group

1. Biotransformation of terpenoids

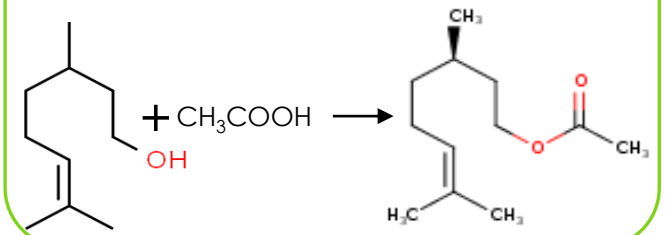
The research aims to develop biotechnological ways of producing valuable bioactive products for use in the food, pharmaceutical and perfume industries. Experiments are performed on laboratory and bioreactor scale using cheap and natural precursors, e.g. limonene, pinene, citronellol, myrtenol. Determination of biological activity of the obtained compounds (anticancer, antifungal and antibacterial activity).







Studies on biocatalytic esterification of terpenic alcohols

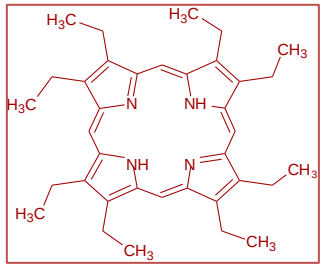


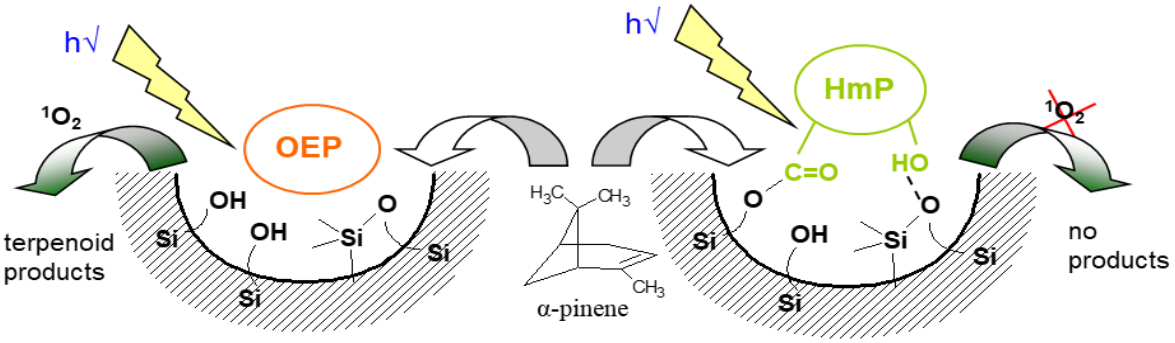
In our studies we use psychrotrophic filamentous fungi characterised by high biocatalytic activity at low temperatures (e.g. *Mortierella minutissima*, *Chrysosporium pannorum*).

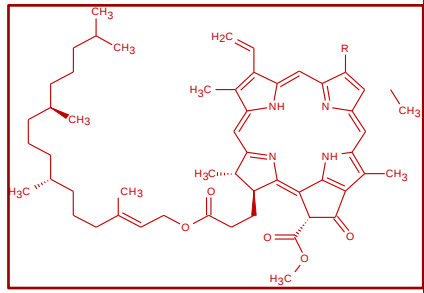
Methodological part of the research: preparation of biocatalyst, lyophilisation, extraction of biotransformation products with organic solvents, their concentration and analysis by gas chromatography-mass spectrometry (GC-MS).

Research by professor Mariusz Trytek's group

2. Photo-oxidation of terpenes in biomimetic systems

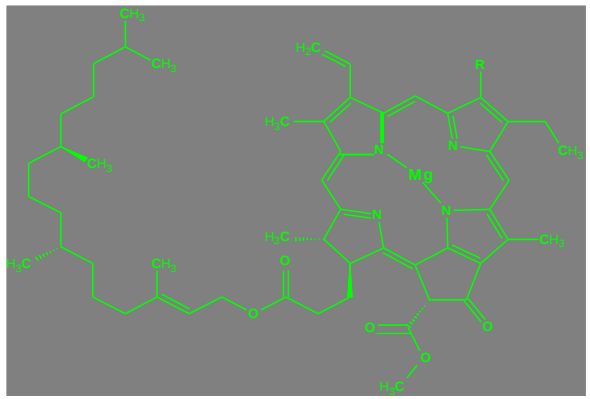


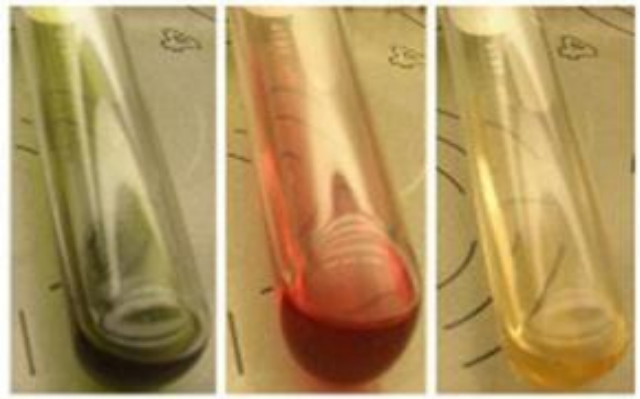




The aim of the research is to develop an efficient method for terpenes oxidation, using biomimetic catalysts - natural porphyrin derivatives (e.g. chlorophylls and pheophytins), synthetic porphyrins, and modified porphyrins of natural origin, e.g. protoporphyrin IX. The research will also include immobilisation of the most active biocatalysts in silica matrices obtained by sol-gel method. Analytical techniques such as UV/Vis spectroscopy, visible light and infrared spectrofluorimetry as well as gas chromatography and mass spectrometry will be used.

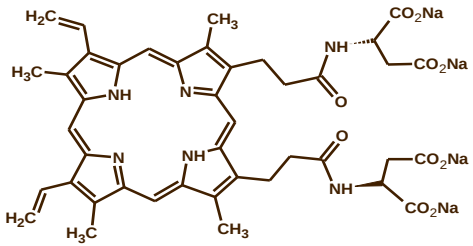
The research is conducted in collaboration with the Department of Inorganic Chemistry, the Department of Organic Chemistry of Maria Curie-Skłodowska University and the Institute of Organic Chemistry of the Polish Academy of Sciences.



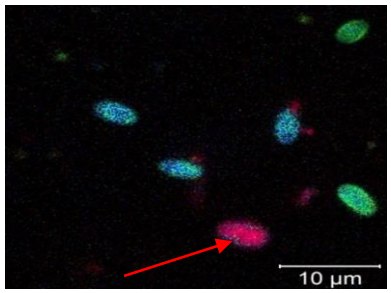


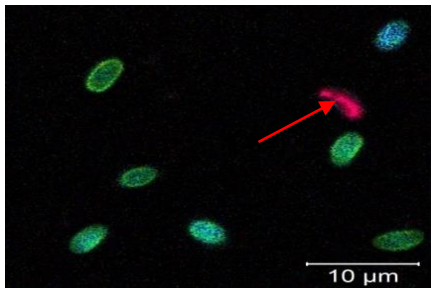
Research by professor Mariusz Trytek's group

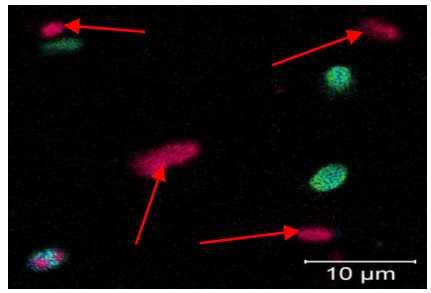
3. Effect of porphyrinoid compounds on the activity of intracellular parasites of Nosema spp.

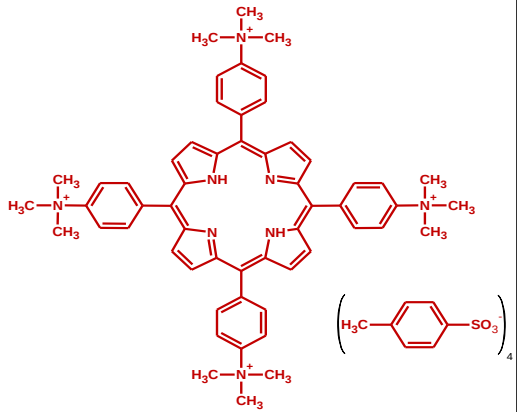


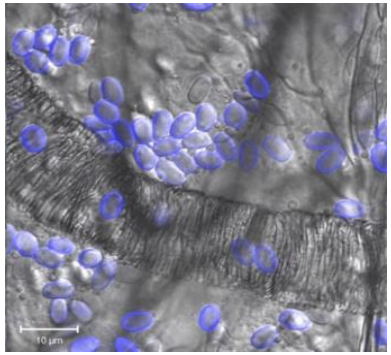
Research on the inactivation of *Nosema* spores causing the contagious honey bee disease nosema - which contributes to the extinction of bee colonies.











- Research is conducted using:
  - ✓ Light microscopy,
  - ✓ Scanning fluorescence microscopy,
  - ✓ Scanning electron microscopy (SEM)

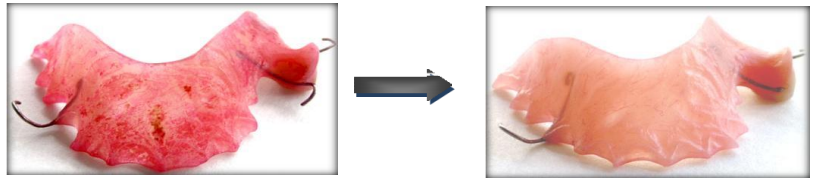
Research are conducted in collaboration with the University of Life Sciences in Lublin, Institute of Organic Chemistry of the Polish Academy of Sciences, Institute of Immunology and Experimental Therapy, PAS in Wrocław, Department of Molecular Biology, Department of Immunobiology, Department of Cell Biology of the Faculty of Biology, Department of Biology and Biotechnology, Maria Curie-Skłodowska University.

Research of professor Adrian Wiater's group

1. Plaque-degrading enzymes

Mutanases are the only group of enzymes that have the ability to degrade mutans, the polymers that make up plaque, which is the cause of tooth decay. The bacteria that cause tooth decay grow in the form of a biofilm (plaque) which, in addition to them, includes a matrix made up of bacterial polymers. The structure of these polymers is crucial to the biofilm's ability to cause caries, as it affects its physical and biochemical properties.

These polymers increase the adhesion of microorganisms to teeth and to each other, i.e. they bind the biofilm together; they serve as a reserve energy source for bacteria; they protect microorganisms from hostile environmental influences and determine what enters and leaves the biofilm. Of the numerous polymers that make up dental plaque, the following play a decisive role in causing tooth Decay water-insoluble, fibrous, and therefore difficult to remove α-1,3-glucan, called mutan.



The elimination of this plaque component through its breakdown by mutanase can be used to prevent and combat tooth decay. Microbial mutanase can be used as an active substance in oral care products such as mouthwashes, toothpastes, dental gels, chewing gums, etc.

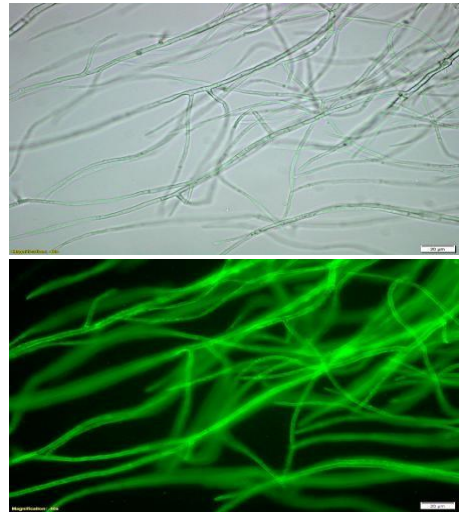
Natural anti-caries

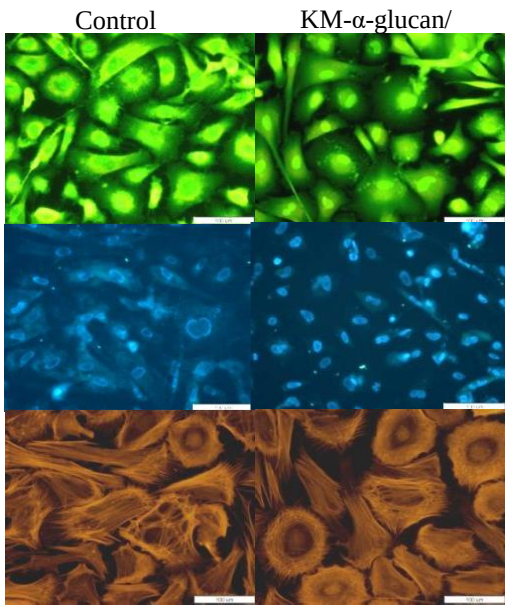
As a result of cooperation with, among others, the Department of Pharmacognosy of the Medical University of Białystok, the Department is working on phytochemical research on selected plant species and the assessment of their anti-caries activity.

So far, it has been found that various extracts from selected Potentilla species can be a source of bioactive substances, mainly polyphenolic compounds such as tannins, phenolic acids and flavonoids with antitumour effects. The investigated preparations may prevent caries, as they show inhibitory effect on streptococcal glucosyltransferase activity, limit bacterial biofilm formation in vitro and have diverse antibacterial activity, thanks to these features they may be a component of pharmacological agents used in the prevention and treatment of caries. Further research will focus on bioactive substances also isolated from other plants and other antimicrobial substances.

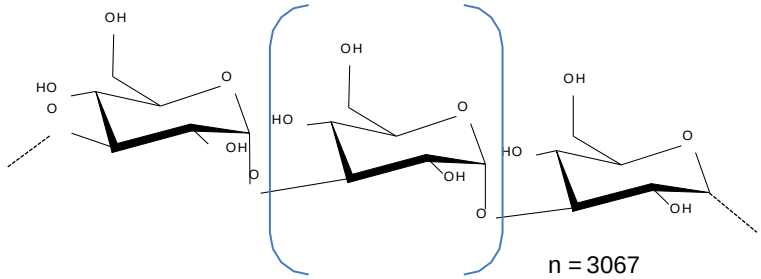
2. Studies on the biological activity of fungal (1→3)-α-D-glucans

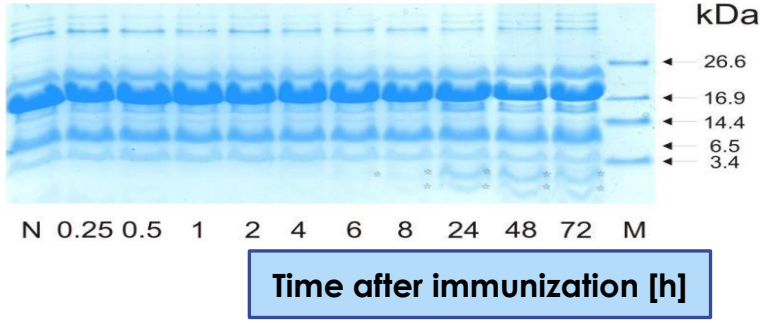
The aim of this study is to evaluate the biological potential of (1→3)-α-D-glucans. These polymers are isolated from vegetative mycelium and fruiting bodies of macrofungi.
(1→3)-α-D-glucans are used, among others, as a carrier of hydrolytic enzymes, heavy metal ion sorbents, stimulators of plant and animal immunity induction, a source of oligosaccharides with prebiotic potential or structural components of biodegradable coatings.

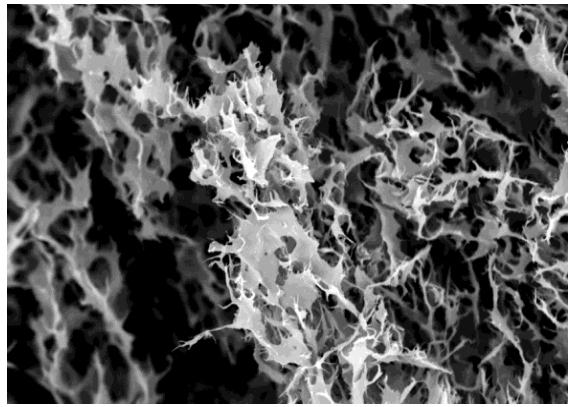




Human intestinal epithelial myofibroblasts (CCD-18Co)

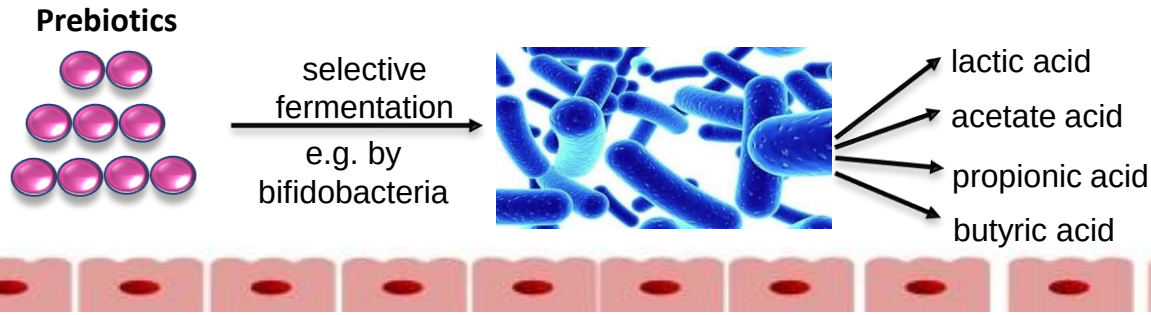


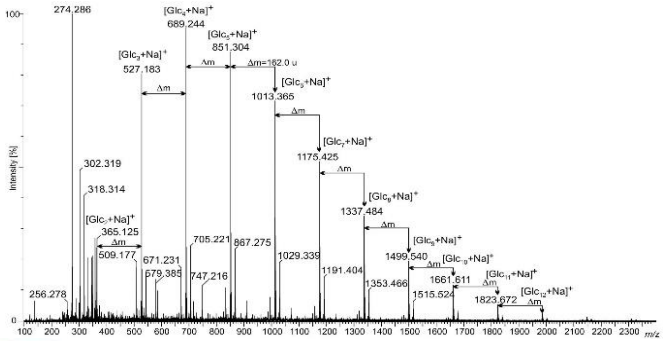




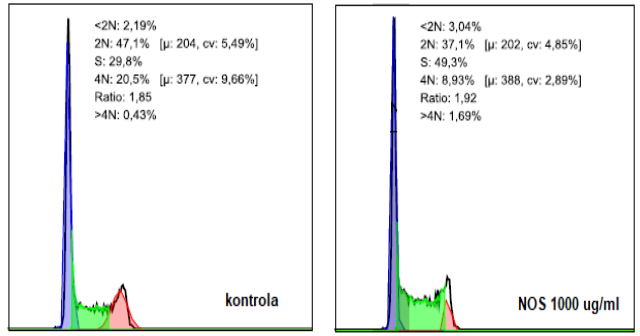
Research of professor Adrian Wiater's group

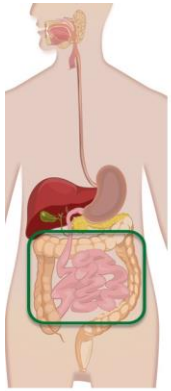
3. Nigerooligosaccharides - new compounds with prebiotic properties



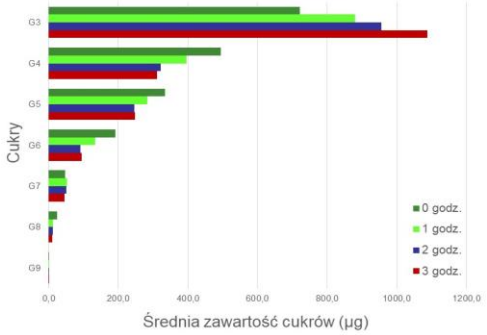


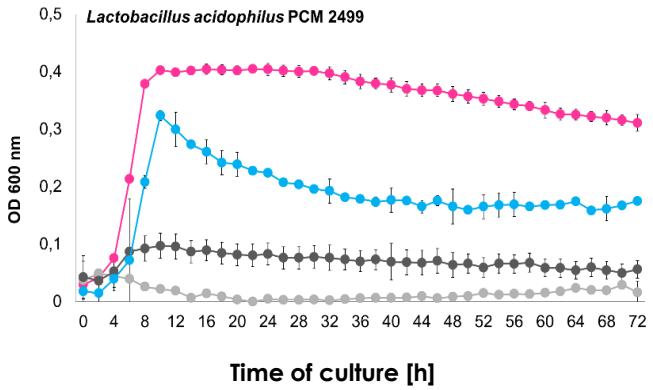
Prebiotics are selectively fermented food ingredients that enable specific changes in the composition and/or activity of the microflora of the gastrointestinal tract, thus having a beneficial effect on the health of the host. Prebiotics include, among others, oligosaccharides, i.e. carbohydrates with low molecular weight. Such compounds include the poorly known nigerooligosaccharides. These compounds are obtained by controlled hydrolysis of fungal (1→3)-α-D-glucans, isolated from fruiting bodies of macrofungi. Currently, in-depth studies with nigerooligosaccharides are being conducted in our Department to verify the 5 basic requirements for prebiotics as defined by Wang [Food Research International, 2009, 42, 8-12].

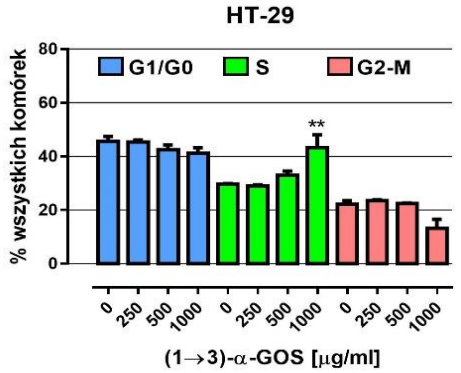




Digestion of (1→3)-a-d-glucoligosaccharides under conditions simulating intestinal activity







Examples of titles of diploma theses in the field of industrial microbiology

Supervisor	Thesis topics
	Master thesis
dr hab. Mariusz Trytek, prof. UMCS	1. Biotransformation of β-pinene using the psychrotrophic fungus *Chrysosporium pannorum* 2. Biotransformation of α-pinene using selected porphyrins as catalysts in heterogeneous systems with addition of cationic surfactant CTAB 3. Optimisation of lipase biosynthesis conditions using the fungus Chrysosporium pannorum A-1 4. Screening of porphyrin and terpenoid compounds for growth inhibition of *S. cerevisiae* mutants with deletion of MAP1 and MAP2 genes 5. Optimization of myrtenol biotransformation conditions in a photocatalytic system
dr. hab. Adrian Wiater, prof. UMCS	1. Structural characterization of (1→3)-α-D-glucans from *Penicillium lanosum* and *P. notatum* mycelium and evaluation of their ability to biosorb heavy metals. 2. Selection of optimal conditions for purification of a fungal mutanase by affinity chromatography on α-(1→3)-glucan 3. Characterisation and function of (1→3)-α-D-glucanase from *Trichoderma viride* 4. The effect of extracts of selected species of *Potentilla* on the growth of streptococci, their synthesis of mutans and the formation of carious films with their participation 5. Evaluation of the anticancer activity of polysaccharides obtained from aqueous extracts of fruiting bodies of the birch whitethorn *Fomitopsis betulina*
	Bachelor thesis
dr hab. Mariusz Trytek, prof. UMCS	1. Use of polysaccharides isolated from fruiting body fungi in cancer control 2. Tejxobactin as a representative of a new group of antibiotics
dr. hab. Adrian Wiater, prof. UMCS	1. Directions for improvement of brewer's yeast
dr Kamila Wlizło	1. Personalised food 2. Application of polysaccharides in breast cancer therapy

Research topics in environmental microbiology

biological protection of plants

bio-fertilisation and biostimulation

bioremediation of soil and water

development of methods and biopreparations that reduce:

- use of synthetic pesticides
- use of mineral fertilisers
- contamination by heavy metals, petroleum products and other xenobiotics

through

- eradication of diseases, mainly fungal fusariosis, of crops (mainly cereals)
- increase the use of soil phosphorus and potassium resources by plants
- microbiological degradation and transformation processes

by mechanism of

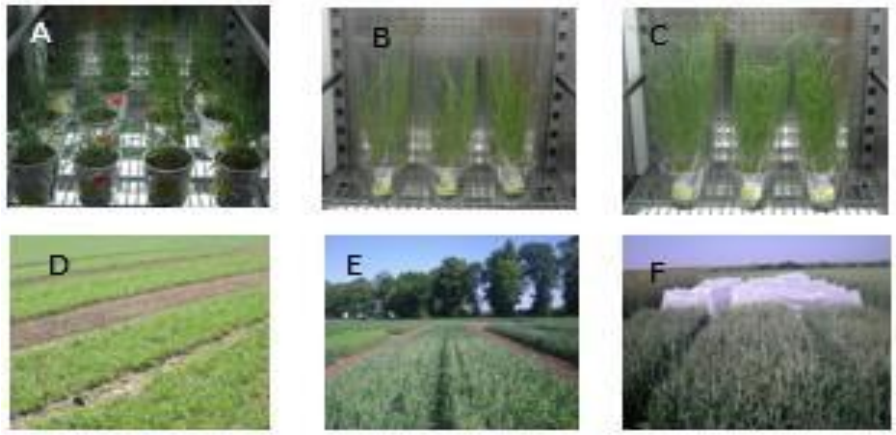
- pathogens growth inhibition
  - direct through microoranisms and their metabolites
  - indirect through elicitors
- microbiological release, dissolve, complexity
- immobilisation, stabilisation, extraction
  - microbiological - based
  - plant-based
  - microbiological-plant -based

WITHIN THE FRAMEWORK OF ENVIRONMENTAL RESEARCH, WE OFFER:

Gain practical skills in:

- ✓ isolation, purification and cultivation of fungi and bacteria, biochemical analysis, spectrophotometric methods
- ✓ determination of enzyme activity in vitro and in vivo (soil, plants)
- ✓ purification and characterisation of enzymes;
- ✓ determination of microbial and plant secondary metabolites, e.g. phytohormones; chelating compounds
- ✓ determination of ecophysiological profiles of micro-organisms
- ✓ determination of cytological changes associated with pathogenesis and induction of resistance;
- ✓ differentiation of heavy metal occurrence forms;
- ✓ determining the bioavailability of heavy metals;
- ✓ determination of concentrations of heavy metals and xenobiotics (petroleum derivatives) in the environment;
- ✓ formulation of microbial vaccines and bio-fertilisers on suitable media;
- ✓ preparation and characterisation of fungal, bacterial and plant cell wall and extracellular polymers

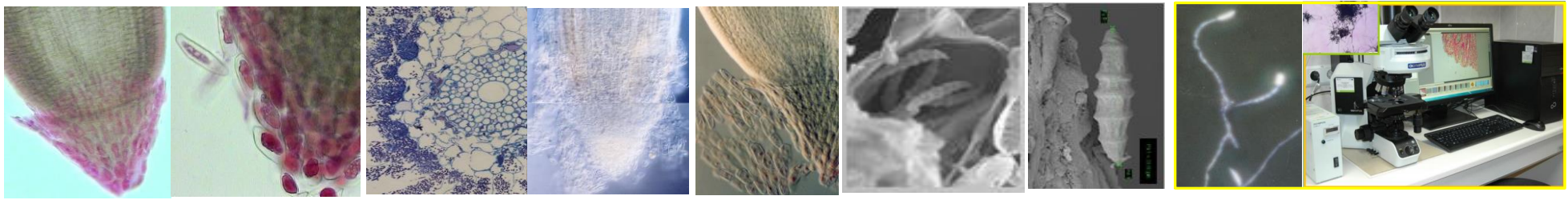
testing of plant protection and fertiliser biopreparations under phytotron, greenhouse and field conditions



(1) Phytotronic: inoculated rye and wheat seedlings at early tillering stage (A), rye at late tillering stage (B), wheat at late tillering stage (C),

(2) field: wheat at the tillering stage grown from grain treated with F. culmorum strains (D), rye inoculated by seed treatment (E) and at the milk maturity stage (F)

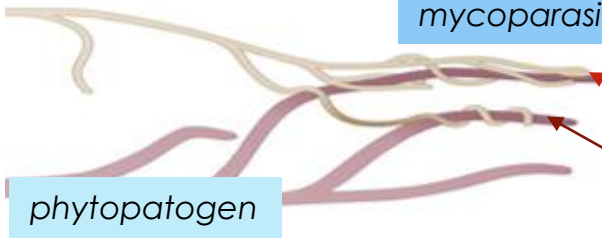
cytological preparation and documentation of microscopic images



Fluorescence microscope

Research of professor Jolanta Jaroszuk-Ściseł's group

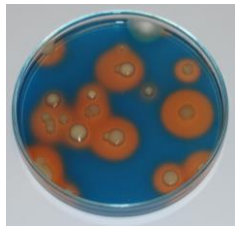
1. Biological protection by direct and indirect methods (induction of plant resistance by elicitors) and plant growth stimulation



Direct mechanisms

mycoparasitism **competition**

1a. Papilla-like strucutres
1b. Spiral strands - „coils"

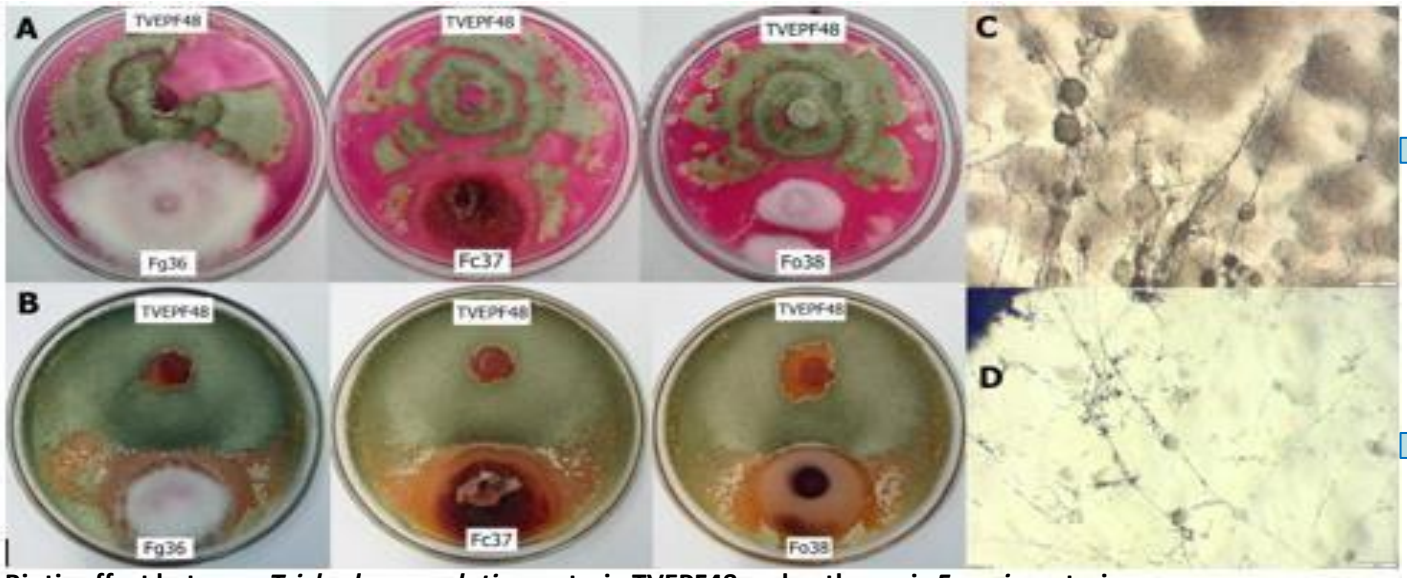


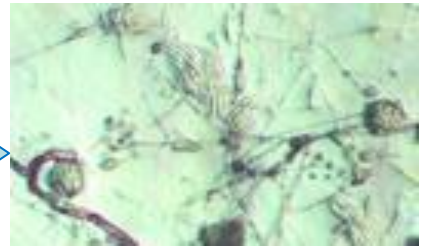
Eradication of diseases (mainly fungal) of crops (mainly cereals)

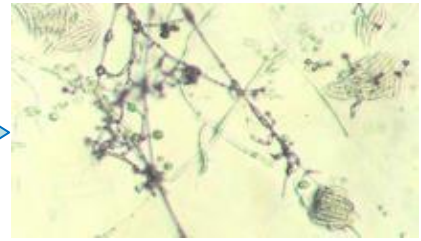
Patogens growth inhibition

DIRECT through microorganisms and their metabolites	INDIRECT through elicitors

DEVELOPMENT AND TESTING OF BIOPREPARATIONS FOR PLANT PROTECTION AND GROWTH STIMULATION





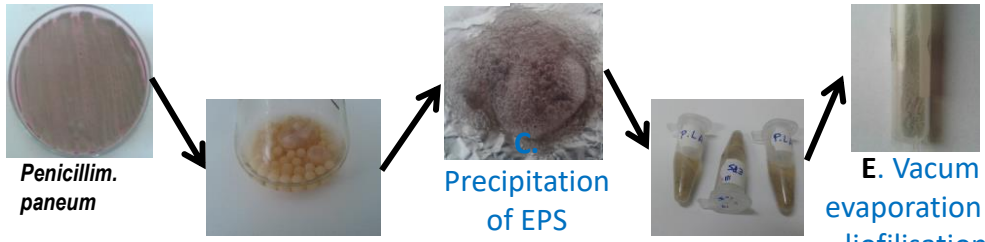


Biotic effect between *Trichoderma velutinum* strain TVEPF48 and pathogenic *Fusarium* strains
on Martin's medium (A); on PDA medium (B); growth inhibition of pathogenic *Fusarium* strains: *F. graminearum* (Fg36), *F. culmorum* (DEMFc37) and *F. oxysporum* (DEMFc38) on both media with the effect of colony encirclement and inhibition zone formation; microscopic image (LM) of the effect of strain TVEPF48 on pathogenic strain F. culmorum Fc37 - *T. velutinum* strain TVEPF48 (dark and thin filaments) interacts with filaments and phialides of macroconidia of *F. culmorum* Fc37 surrounding them and causing cell wall lysis (C, D).

Research of professor Jolanta Jaroszuk-Ściseł's group

2. Research on preparation of exopolymers and their use in bioremediation and biocontrol of plants

Preparation of EPS



Penicillim. paneum

A. Inoculum

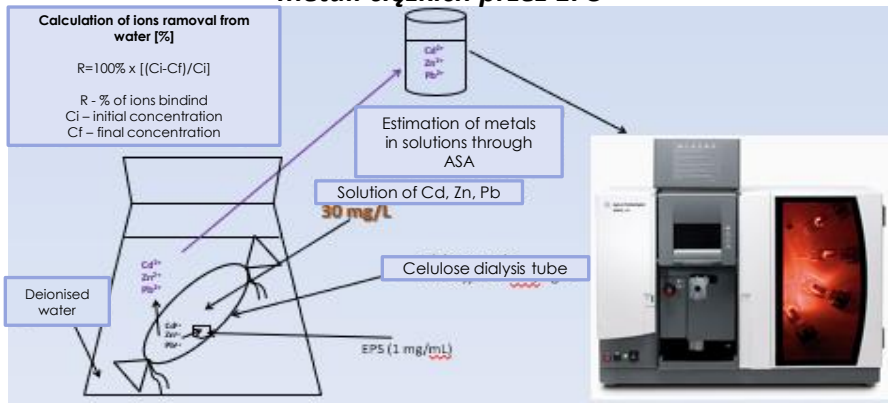
B. Inoculation and culture

C. Precipitation of EPS using 98% ethanol

D. Separation of EPS from culture liquid

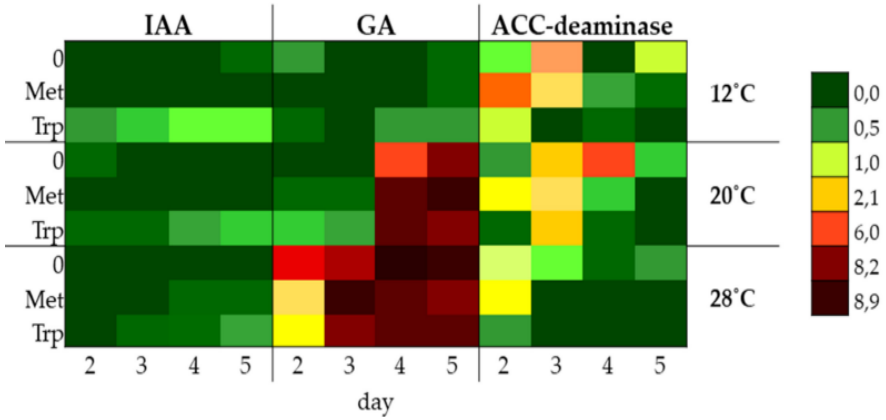
E. Vacum evaporation or liofilisation, estimation of dry mass of EPS

Schemat oznaczania poziomu chelatowania jonów metali ciężkich przez EPS



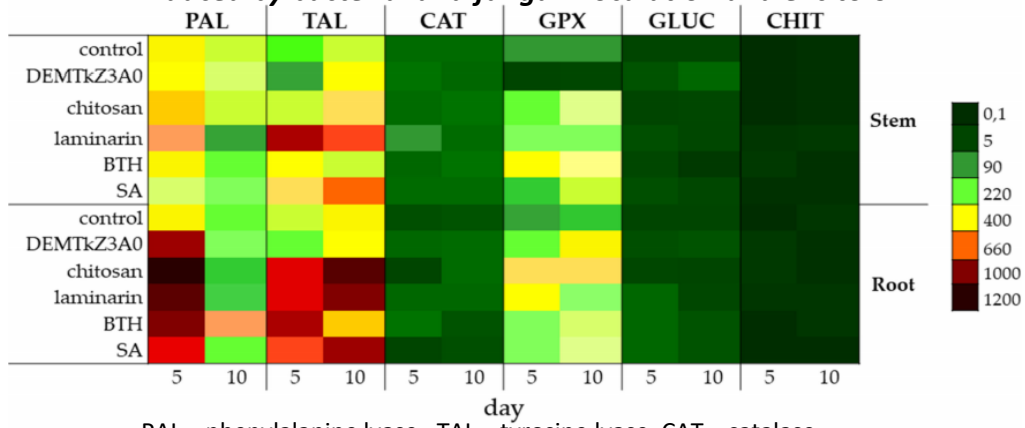
3. Research on microbial regulation of phytohormones and induction of plant immunity

Comparison of phytohormone production and ACC deaminase activity under different bacterial and fungal culture conditions



Concentration of IAA, GA, activity of ACC-deaminase

Comparison of resistance marker levels in roots and stems of plants induced by bacterial and fungal inoculation and elicitors



PAL—phenylalanine lyase , TAL—tyrosine lyase, CAT—catalase, GPX—guaiacol peroxidase, GLUC—glucanase, CHIT—chitynase

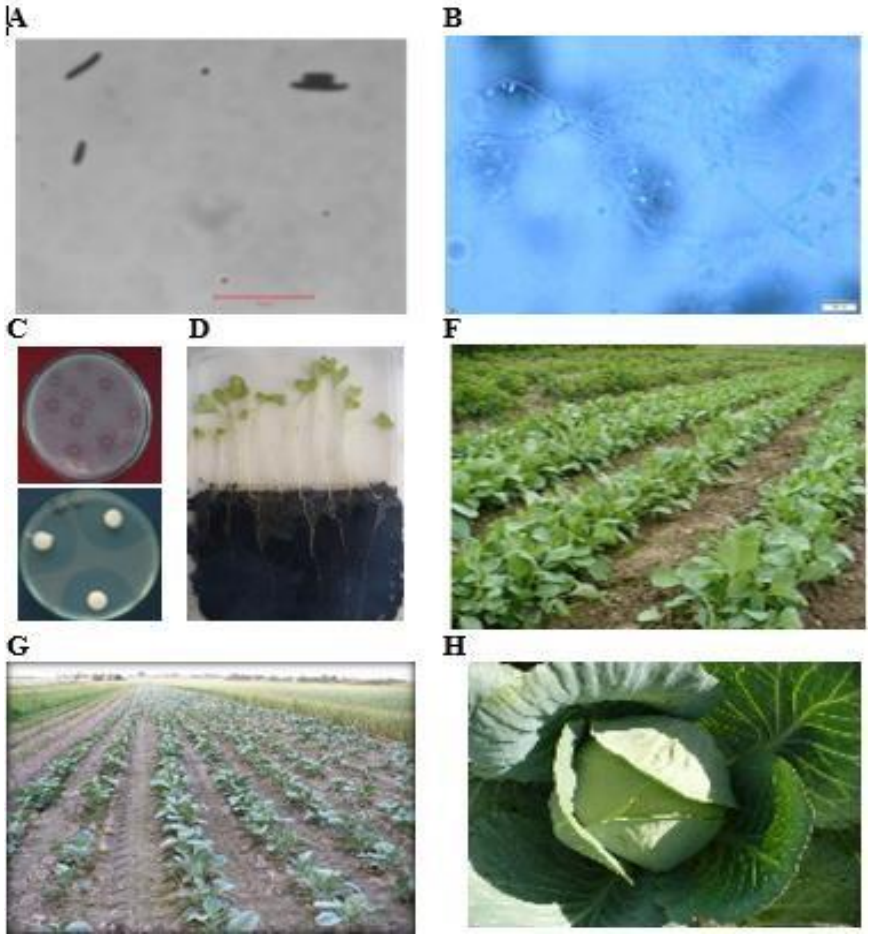
Doctor Ewa Ozimek's research

BIOFERTILISATION AND BIOSTIMULATION

1. Development of biopreparations and methods to reduce environmental contamination by mineral fertilisers

2. Increasing plant use of soil **FOSOPHOR** and **POTASSIUM**

3. MICROBIOLOGICAL
- ✓ release
- ✓ dissolve
- ✓ complexity



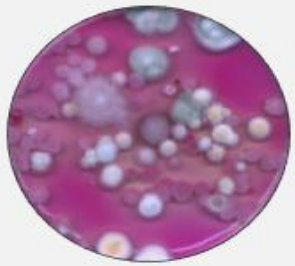
Use of selected PSM (Phosphate Solubilizing Microorganisms) fungal strains in biofertilization

Pseudomonas luteola BN0834, PSM strain isolated from soil near Skierniewice - photo taken with Axiovert200M microscope equipped with LSM 5 PASCAL head, in Nomarsky contrast (A); *Mortierella alpina* 2 PSM strain, selected from Spitzbergen soils; photo taken with Olympus BX53 light microscope (B); Selection of bacterial and fungal PSM strains (C); Testing of selected PSM strains in a phytotron experiment in Fitobox (D); Application of selected PSM strains in the production of seedlings of white cabbage (*Brassica oleracea* L. convar capitata - medium late variety) to increase the fraction of bioavailable P - field experiment (F); White cabbage obtained in field cultivation from seedlings obtained from PSM grafted seeds (G, H)

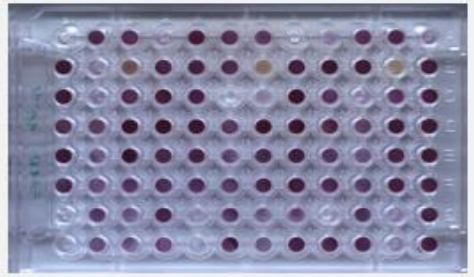
Doctor Małogrzata Majewska's research

1. Assessment of microbial biodiversity of heavy metal contaminated environments (establishment of liquid and plate cultures of microorganisms)

Collection of material from a heap subjected to reclamation by afforestation



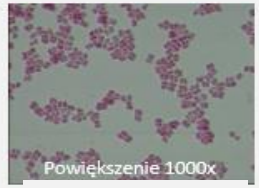
Diversity of baterial and fungal colonies isolated from material sample



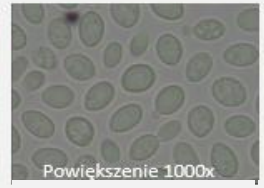
Metabolic diversity of microorganisms estimaed using Biolog®Ecoplate

2. Metabolism, interactions and use of microorganisms in soil bioremediation (macroscopic and microscopic observations, biochemical analyses)

Cultures showing interactions between bacteria and fungi

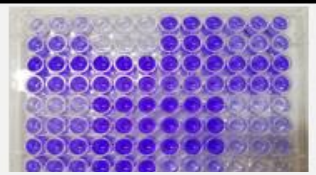


bacteria



yeast

filamentous fungi



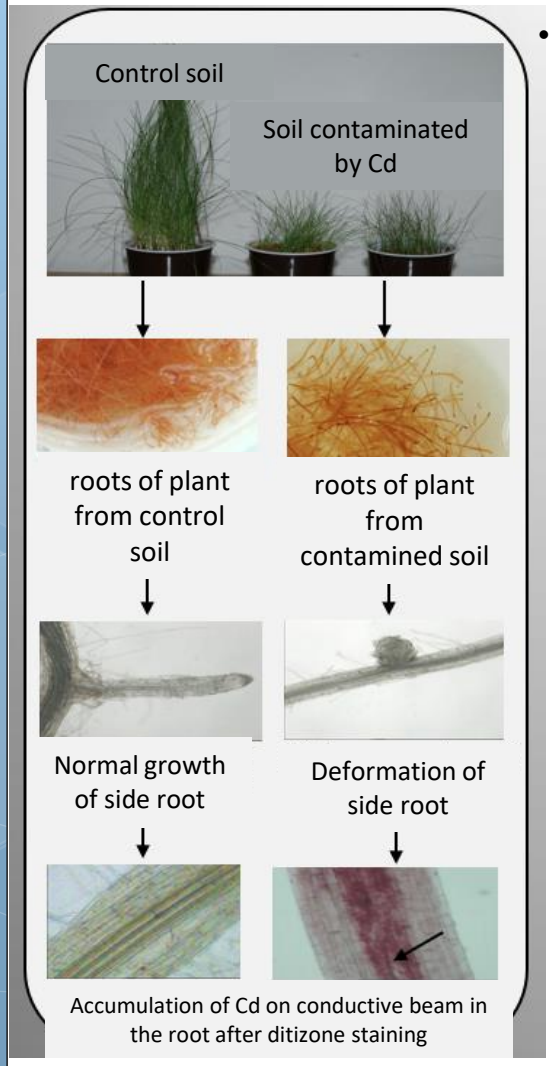
Biofilm stained with crystal violet

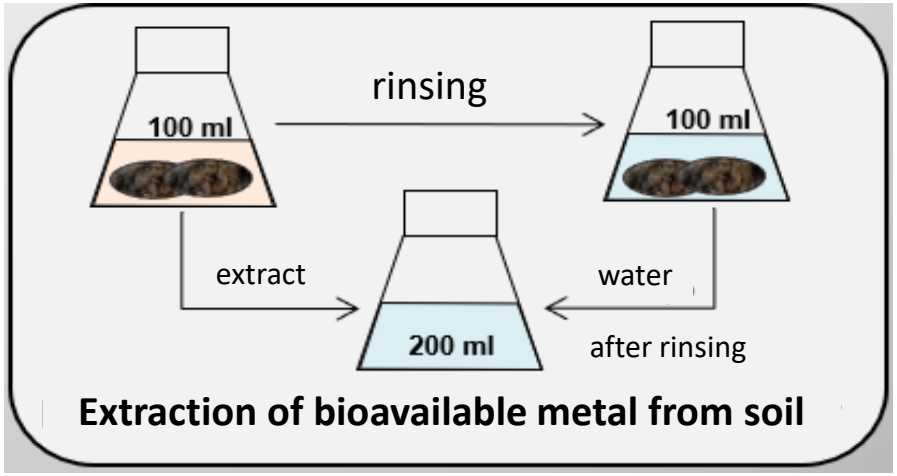
Biochemical API test to determine the ability of microorganisms to assimilate, ferment or degrade specific chemical compounds

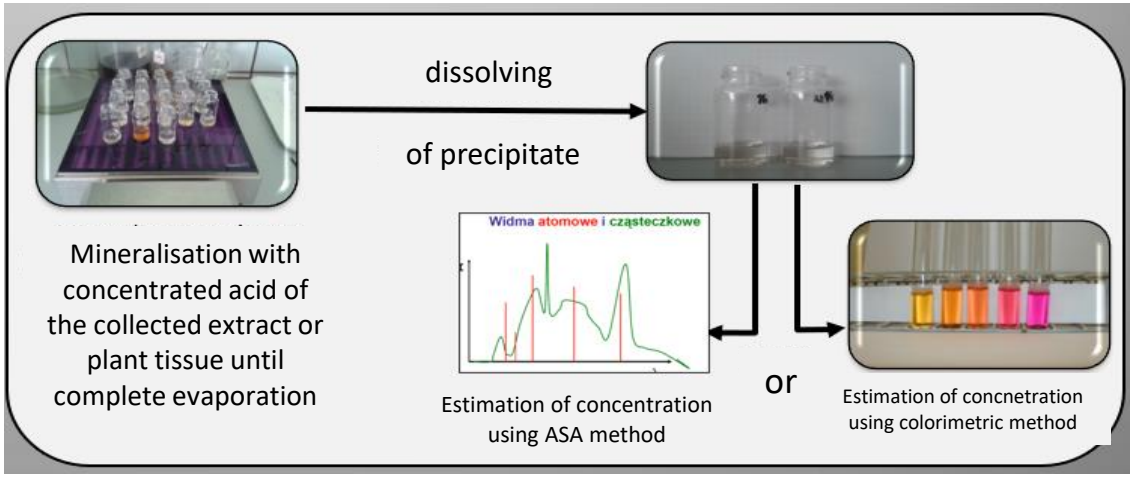
Doctor Małogrzata Majewska's research

3. Assessment of bioavailability of metals in contaminated soils and their bioaccumulation in plant tissues

- macroscopic and microscopic observations
- simple and sequential extractions of heavy metals from soil
- mineralisation and determination of Cd concentration (spectrophotometric or ASA method)





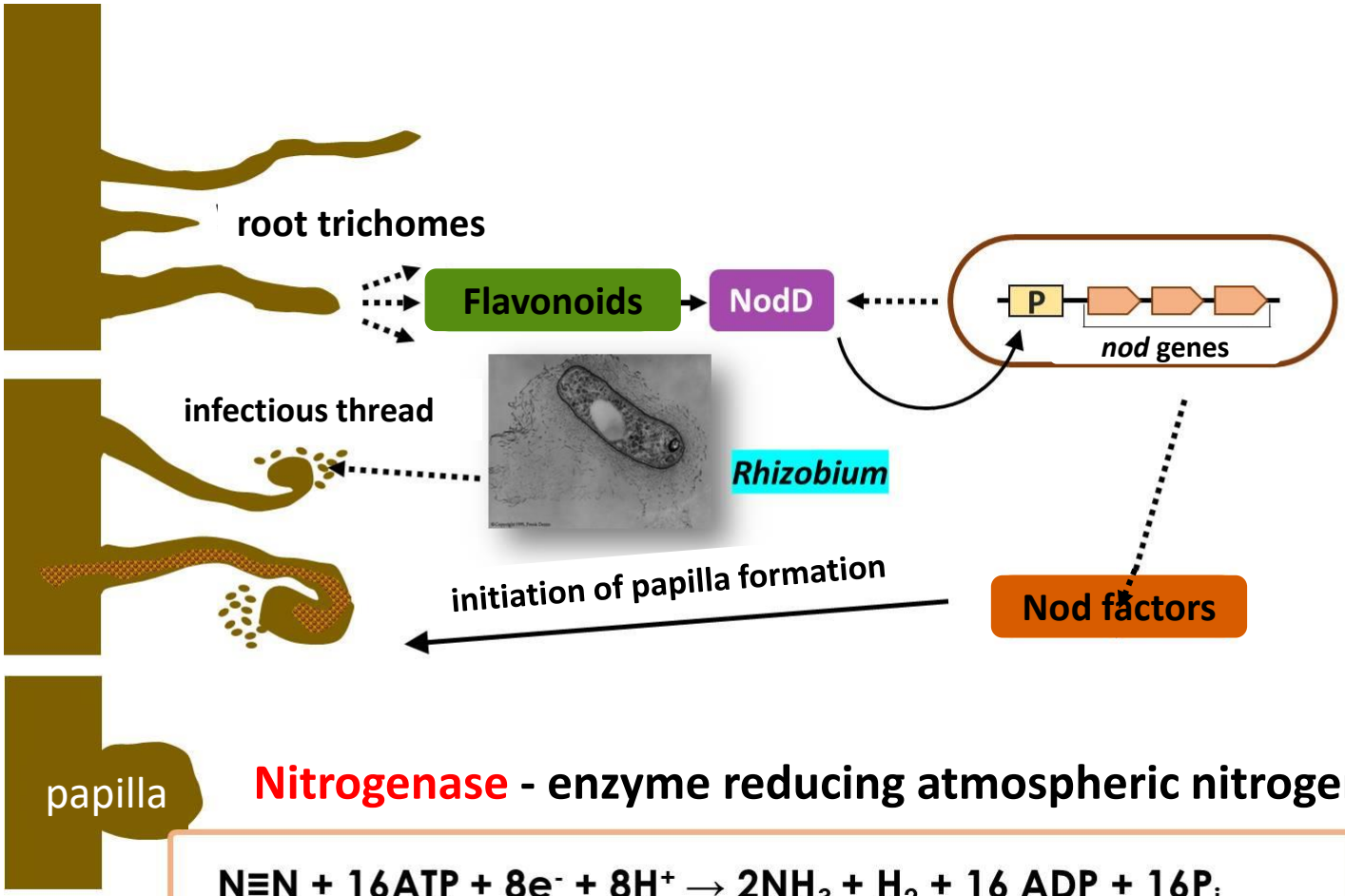


Examples of titles of diploma theses in the field of environmental microbiology

Superviosr	Thesis topics
	Master thesis
dr hab. Jolanta Jaroszuk-Ściseł, prof. UMCS	1. Effect (biotic effect) of Gram negative bacterial strains of *Pseudomonas* (*P. luteola, P. fluorescens*) and *Chryseobacterium* sp. on the growth of three phytopathogenic strains of *Fusarium* spp. 2. Effects (biotic effect) of Bacillus sp. on the growth of phytopathogenic strains of *Fusarium* spp. (*F. culmorum*, *F. graminearum, F. oxysporum*) 3. Exopolymers and growth rate of *Fusarium* spp. (*F. oxysporum, F. avenaceum, F. graminearum*) on heavy metal (Cd, Pb, Zn) media 4. Exopolymers and growth rate of fungi *Trichoderma* spp. (*T. harzianum, T. koningiopsis, T. reesei*) on heavy metal (Cd, Pb, Zn) media
dr hab. Małgorzata Majewska	1. Biofilm formation in the presence of Cd, Cu, Pb and Zn by bacteria isolated from Spitsbergen soils 2. Sensitivity of bacteria isolated from Spitsbergen soils to heavy metals 3. Sorption of cadmium by selected soil components in the presence of humic acids 4. Antifungal activity of selected bacterial strains isolated from Spitsbergen soils 5. Antagonism of bacteria isolated from Spitsbergen soils towards fungi of the genus Fusarium
dr Ewa Ozimek	1. Metabolic activity of soils inoculated with *Mortierella* spp. strains studied (in vitro) at different temperatures
	Bachelor thesis
dr hab. Jolanta Jaroszuk-Ściseł, prof. UMCS	1. Shaping the microbiome and the physical and chemical properties of the soil environment by biocontrol and bionavigation biopreparations 2. Usable microbial polymers of different composition and microbial degradation of natural and synthetic polymers 3. Antimicrobial substances - directions of the search for new compounds and mechanisms
dr hab. Małgorzata Majewska	1. Cometabolism phenomenon in bioremediation of soils contaminated with organic xenobiotics 2. The role of the plant microbiome in the phytoremediation of contaminated soils
dr Ewa Ozimek	1. Microbiological pollution of urban air 2. Plastic pollution of aquatic environments 3. Role and origin of indolyl-3-acetic acid in nature 4. Bacteria in the human small intestine

Research of professor
Monika Janczarek's group

Study of symbiotic interactions Rhizobium - faba bean plant



Nitrogenase - enzyme reducing atmospheric nitrogen

$$N{\equiv}N + 16ATP + 8e^- + 8H^+ \rightarrow 2NH_3 + H_2 + 16\ ADP + 16P_i$$

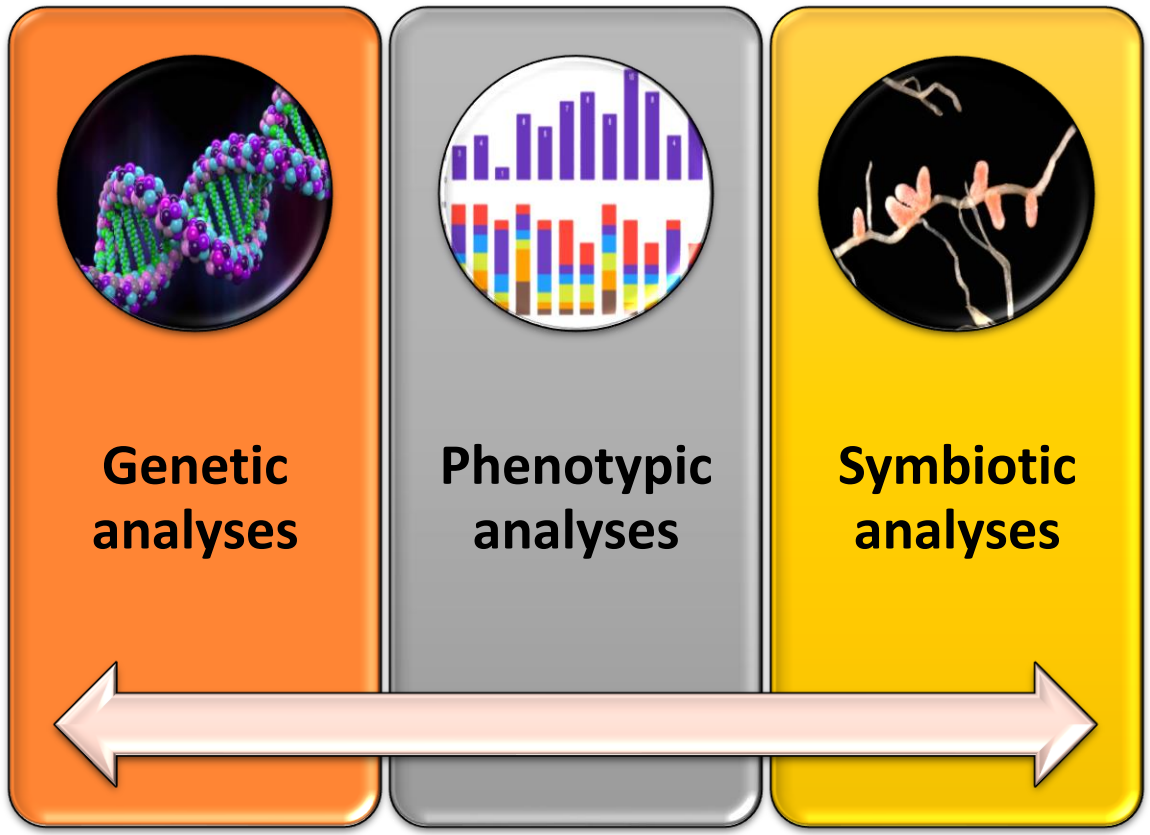
The total global N_2 fixation by the symbiotic BNF process is about **200 million tonnes per year**

Meadow clover (*Trifolium pratense*)

Research of professor Monika Janczarek's group

•Research topics:

1. Genetic and facultative characterisation of meadow clover microsymbionts from two climate zones: subpolar and temperate,
2. Characterisation of the exopolysaccharide (EPS) biosynthetic pathway of *Rhizobium leguminosarum*: functional analysis of proteins involved in EPS synthesis and regulation of this proces,
3. Investigating the effects of heavy metals on the symbiosis of R. leguminosarum bv. trifolii with clover and the role of EPS in the adaptation of these bacteria to different stress conditions, including low temperature and heavy metal stress.



The research will be partly carried out within the project " Investigation of genetic and functional diversity of grass clover (Trifolium pratense) microsymbionts from two climate zones: subpolar and temperate in order to identify strains with potential use in agriculture" (no. 2018/31/B/NZ9/00663) funded by the National Science Centre

Examples of titles of diploma theses in the field of genetics

Supervisor	Thesis topics
	Master thesis
prof. dr hab. Monika Janczarek	1. Determination of surface properties of *Rhizobium leguminosarum* bv. *trifolii* 24.2 wild-type strain and its derivatives differing in the level of EPS synthesis 2. Phenotypic characterisation of *Rhizobium leguminosarum* strains isolated from root papillae of red clover 3. PCR analysis of genes involved in quorum sensing and polysaccharide synthesis of *Rhizobium leguminosarum* bv. *trifolii* 4. Effect of environmental factors on the expression of genes involved in polysaccharide synthesis of *Rhizobium leguminosarum* bv. *trifolii* 5. Transcriptional analysis of the gmsA gene involved in glucomannan synthesis in *Rhizobium leguminosarum* bv. *trifolii* 6. Characterisation of the pssA gene involved in the synthesis of the exopolysaccharide of *Rhizobium leguminosarum* bv. *trifolii*
	Bachelor thesis
prof. dr hab. Monika Janczarek	1. Mitochondrial DNA and its application in forensic science and medicine 2. Signals of *Fabaceae* plants involved in symbiosis with *Rhizobiaceae* 3. Molecular signals, surface structures and extracellular proteins of rhizobia involved in symbiosis with fabaceae 4. Bacterial biofilms and their role in chronic diseases 5. Characteristics of bacteria of the genus Pantoea and their biotechnological potential 6. Quorum-sensing phenomenon in Gram-negative bacteria