Development Strategy

Faculty of Science, University of Zagreb

For the period 2015 – 2020

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Impressum

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Scientific research programmes were developed within the departments.

Layout, graphic design

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Contents

PMF and its surroundings

University of Zagreb, Faculty of Science (PMF)

The Faculty of Science of the University of Zagreb (PMF) is the leading scientific and education institution in the field of the sciences and mathematics in Croatia. Though PMF was not formally established until 1946, the teaching and research activities began much earlier, in 1876, in the Department of Science and Mathematics in what was then the Faculty of Philosophy. During its long history, PMF has made significant contributions to the development of the University, and also to Croatian science in general, while the education of professors in the fields of the sciences and mathematics continually contributes to improving the Croatian education system.

The accession of the Republic of Croatia into the European Union has opened an entire range of new possibilities for the sector of science and higher education, while also setting certain challenges that institutions are required to overcome. In particular, this refers to the development of scientific and teaching infrastructure, using the resources of the Structural Funds, which implies the joint activities of similar institutions and the consolidation of scientific capacities. On the other hand, the long-lasting recession that Croatia is going through and the lack of sufficient state funding earmarked for science and higher education also requires that institutions themselves take a more active role in seeking the funding required for further development. In addition to international sources, this implies stronger cooperation with the private sector. Accordingly, this document has been drafted and represents the strategic framework of the development of scientific, teaching and expert activities of PMF, and gives guidelines for development of organisation and operations, infrastructure and quality assurance systems for PMF in the period from 2015 to 2020.

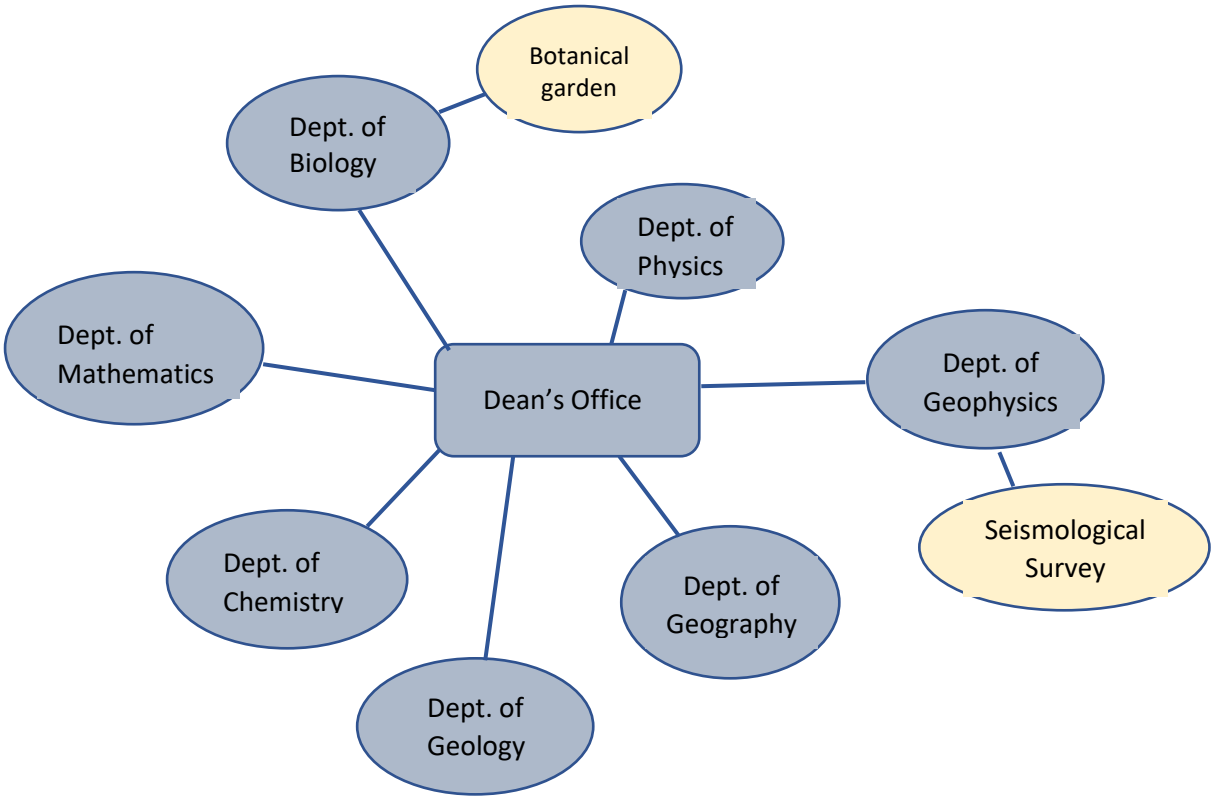
PMF will base its efforts towards the development of research infrastructure and creating a larger number of research groups that are competitive at the international level, launching interdisciplinary and multidisciplinary research in the fields of the natural and interdisciplinary sciences, raising the quality of teaching activities, and stimulating innovation activities and the establishment of a life-long learning system. As a specific benefit, PMF will take advantage of the opportunities of synergy in activities with related institution situated in the area of the future *North Campus* of the University of Zagreb.

This Strategy was adopted at the 5th regular session of the PMF Faculty Council held on 26 February 2015, and all PMF staff and student representatives participated in its creation. It represents our view to the future, in which our Mission remains unchanged, and our approach and our Vision are continuously adapted and improved in line with the circumstances that surround us.

Professor Zoran Curić, PhD

Dean, PMF

Organisation of PMF



PMF Activities

- Organisation and execution of the university study of mathematics, physics, chemistry, biology, geology, geography, geophysics and computer science
- Scientific research activities
- Execution of scientific and expert projects, technical documentation, analysis, attestations and expertise
- Expert tasks in environmental protection
- Expertise, standardisation of measurement procedures, measurements and quality control
- Library activities for the scientific and teaching needs of mathematics, physics, chemistry, biology, geology, geography and geophysics
- Organisation and execution of different forms of ongoing or short-term training of students and participants
- Breeding of laboratory animals, and keeping experimental and wild animals, plants and mushrooms, plant and animal cell cultures, or microorganism cultures
- Performing experiments on animals for the purpose of teaching and scientific research work
- Organising and holding scientific and expert conferences
- Publishing and information activities for the purposes of teaching, scientific or expert work
- Sale of textbooks and other printed materials needed for the performance of faculty tasks
- Conducting expert assessments for the appropriate activities in mathematics, physics, chemistry, biology, geology, geography, geophysics and computer science
- Provision of services for companies and other organisations where this serves the development of the core activities and implies the rational use of space and equipment
- Life-long learning in the fields of mathematics, physics, chemistry, biology, geology, geography, geophysics and computer science
- Performance of expert studies and teaching in the fields of mathematics, physics, chemistry, biology, geology, geography, geophysics and computer science

Teaching activities at PMF

As a constituent of the University of Zagreb, PMF provides high quality and effective university education in the fields of the natural sciences and mathematics through all three levels of university studies. The PMF study programmes are based on research and the newest scientific findings, and the execution of coursework include a substantial component of innovation and international cooperation. Among the most important values of PMF are its excellent and motivated students, whose knowledge and skills will become the drivers of economic and social development of the Republic of Croatia

- More than 4700 students
- More than 200 lecturers

Total number of study programmes and enrolled students at PMF in the 2013/14 academic year		
Study level	**Number of study programmes**	**Number of students**
Undergraduate university study	9	1928
Integrated undergraduate and graduate university study	8	829
Graduate university study	18	1185
Post-graduate university (doctoral) study	8	768
Post-graduate specialist study	1	24

Total number of students that graduated or received their doctorate in PMF university study programmes in the 2013/14 academic year	
Undergraduate university study	425
Integrated undergraduate and graduate university study	115
Graduate university study	405
Post-graduate university (doctoral) study	106
Post-graduate specialist study	

Scientific activity at PMF

Scientific activity at PMF is carried out in the area of the Natural Sciences (fields: Mathematics, Physics, Chemistry, Biology, Geology, Geophysics and Interdisciplinary natural sciences) and the Interdisciplinary area of science (Geography), and it accounts for about 20% of the total scientific production of the University of Zagreb. The PMF research profile is reflected in the scientific publications in leading scientific journals, in cooperation with leading international research groups and institutions, the significant number of national and international scientific projects and accompanying scientific infrastructure, the library fundus and periodicals. PMF is one of two institutions in the Republic of Croatia that is leader of a European Research Council (ERC) scientific project.

PMF – about 20% of the scientific production at the University of Science

Scientific publications by PMF staff published in the last 5 years and scientific projects	
Scientific papers in journals indexed in CC, WoS (SSCI, SCI-Expanded and A&HCI) and Scopus	2024
Total number of active scientific and development projects awarded by the Ministry of Science and Education	180
Total number of active scientific and development projects from other national sources	42
Total number of active scientific and development projects from international sources	27

Expert work at PMF, transfer of knowledge and technology

PMF is also recognised as an institution whose scientists, with their expertise and professional studies, aid in resolving a wide range of problems of various aspects of social life in the Republic of Croatia. Many professional projects have been initiated and successfully carried out at PMF in cooperation with public and state institutions, and with numerous economic entities, and many projects are currently ongoing. The expert work of the staff at PMF contributes to the development and overall betterment of society as a whole, and as such requires constant upgrading.

Expert papers by PMF staff published in the last five years and expert projects	
Total number of published expert papers	194
Total number of expert projects	82

PMF and International cooperation

International cooperation at PMF unfolds within the framework of interuniversity cooperation, joint international bilateral and multilateral projects (e.g. FP7, COST, NATO), and direct contacts between staff with foreign universities and research institutions in Europe and beyond. Financing of this cooperation is largely achieved through special international cooperation of the University of Zagreb or through research projects.

Total number of foreign stays by PMF staff in the period 2009 – 2014			
Type of visit	1 – 3 months	3 – 6 months	> 6 months
Scientific	178	13	31
Expert	2		
Teaching	4		

Total number of arrivals of foreign scientists in the period 2009 – 2014			
Type of visit	1 – 3 months	3 – 6 months	> 6 months
Scientific	18	1	7

Total number of scientific conferences organised by PMF and number of staff organised in the period 2009 - 2014		
Type of conference	Number of staff	Number of conferences
International scientific conferences in Croatia and abroad	39	74

Popularising science

The *Botanical Garden of the Department of Biology*, PMF is a monument of park architecture and a component of the protected cultural resources of the Republic of Croatia.

The specific activity of the Botanical Garden, as an "outdoor museum" differs from the fundamental scientific and teaching activities of PMF. The garden is the only segment of PMF to be constantly open to the public. Numerous events, educational and popularisation activities and publications are intended for the additional, life-long education of all visitors, particularly pupils and students. From telling tales from the world of flora, to the Children's vegetable and flower garden, to guided tours of the gardens, promotional events and concerts, to educational exhibits, workshops and lectures – more than 100,000 visitors come to the Garden each year. For example, during the five-day May event called *Botanical Garden and Arboretum Week*, some 1200 registered participants enjoy a series of organised activities, while the interest is many times higher!

Biology Night is a traditional event organised at the Department of Biology. This is a long and exciting night that offers experiments, demonstrations and play to share scientific facts about biology and live in all its forms and beauty to visitors in a creative manner. This event has been held since 30 March 2012, when the PMF management recognised what is best about *Biology Night* – the hard work and togetherness of professors and students.

The *Summer School for Young Physicists* is held every year by the Croatian Physicist's Society, and this year's edition is the 30th school to be held. The aim is to provide additional education for talented young pupils of primary and secondary schools, who are selected for participation by achieving the highest results in state physics competitions. The week-long school includes lectures by reputed and active scientists from Croatian (and occasionally foreign) universities and institutes, to teach students about the newest research in physics.

Physics Today – Open Door Days at the Department of Physics is a one-day popular science event held every spring at the Department of Physics. A series of popular lectures, workshops, demonstrations of intriguing physics phenomena and tours of research laboratories are aimed at achieving better contact between visitors and the exciting world of physics. Visitors are welcome individually or in organised groups, and can speak with our researchers to learn about the hottest research topics and more that they usually do not have the opportunity to discuss.

Physic Express is a project by the Student section of the Croatian Physics Society that started in 2005 with the aim of promoting physics and the natural sciences in general among youth in Croatia. The project is carried out by students of physics who want to share their areas of interest with primary and secondary school students from around the country. During their visits to schools, they demonstrate interesting experiments, hold lectures and stimulate interactive participation in scientific activities. Visits to schools can be organised online.

Geophysics Live is a traditional one-day event in which the professors and students of the Department of Geophysics introduce visitors to the world of geophysics – the world that surrounds us, a world that can at times be dangerous, sometimes beautiful, and certainly a world that we need

to learn about in order to protect it. In addition to interesting experiments, workshops and lectures, visitors also have the opportunity to see how it all began – more than 100 years ago.

Primatijada is a scientific and sports event for students and employees in the fields of the sciences and mathematics and aims to promote these sciences, bring scientists together and foster cooperation between different scientific fields, and support the effective scientific and economic development of Croatia.

The Department of Geology organises the Geology Afternoons as part of the *Open Door* event. On that occasion, a series of popular lectures and workshops will be held for a broad range of visitors, from preschool children to university students, and collections are opened, allowing visitors to view fossils and minerals under the microscope. The Department of Geology has organised the event *University for Children*, together with the society *Tonkica Palonkoca frrr* since 2012. This event includes a series of geological workshops for children in lower primary school grades.

Open Door Days of the Department of Geography is a popular science event organised every year at the Department of Geography. The event is aimed at familiarising the general public, and especially the school population, about the scientific research work at the Department of Geography, and about geography as a professor. The event offers interesting lectures on current topics in geography, and a range of workshops, such as those on orientation, the use of geographic maps and the use of geographic information systems (GIS).

Open Door Days of the Department of Chemistry is a traditional one-day popular science event held every spring since 2008 at the Department of Chemistry. It includes numerous lectures, educational workshops and tours of the fascinating *World of Chemistry*, and the simple and fun approach is aimed at bringing chemistry closer to all visitors. About 4000 people, mostly primary and secondary school pupils, attended the *Open Door* Days in 2014.

The performance *Magic in Chemistry* is a project by the Department of Chemistry that takes place once a year, since 2007. The show includes attractive chemistry experiments, aimed at popularising chemistry among preschool and young school children. More than 3000 children from numerous preschools and primary schools in Zagreb and neighbouring counties have attended the 16 editions of the show held so far. The show also includes a workshop where pupils have the opportunity to try out simple chemical experiments themselves.

Open Door Days at the Department of Mathematics is a one-day event held every year at the Department of Mathematics. This programme is intended for secondary school pupils, particularly those in the third and fourth grades who are interested in the study of mathematics. The programme presents the study programmes, and allows pupils to speak with professors, researchers and students, to learn about how and why to study mathematics at PMF at the University of Zagreb. Additional activities and workshops are planned for this year's event.

Publishing activities at PMF

In addition to editing journals published by PMF, the PMF scientists are also members of editorial boards of many journals by other publishers, including 21 journals cited in the *Web of Science*. PMF significant contributes to the publication of six expert journals (one in electronic format) and one professional website, intended above all for the popularisation of science and mathematics among primary and secondary school pupils, for the life-long learning of teachers and professors in the science subjects (geography, mathematics, computer science) in primary and secondary schools, and as an addition source of knowledge for students. The professional website and all six journals operate within the framework of the professional organisations Croatian Mathematics Society, Croatian Physics Society, Croatian Geographic Society and Croatian Natural Sciences Society, whose work mostly unfolds on the premises of PMF and/or in which membership and executive boards are dominated by PMF employees. These expert papers are subject to peer review and are published in Croatian.

Mission

- Top quality university education in the field of the natural science and mathematics, and the development of innovative teaching programmes and techniques based on research and the newest scientific accomplishments
- Life-long learning in the field of the natural sciences and mathematics in accordance with the *Bologna Process* and *Lisbon Declaration*, and in line with the needs of society.
- High quality, internationally relevant and competitively-based scientific research in the fields of the natural sciences and mathematics, with the promotion of new interdisciplinary and multidisciplinary areas of research
- Contribution to development of the economy and society as a whole, though the applied and developed scientific research within the national triangle created from cooperation with the business sector, especially industry and finance institutions.
- Recognising and stimulating excellence in all segments of activity, and nurturing academic freedom based on personal responsibility
- Promoting and popularising the natural sciences and mathematics in all segments of society with the aim of attracting younger generations towards the natural sciences.
- Contribution of PMF students to resolving health problems, popularising science and raising awareness of global social issues.
- Promoting ethical principles and affirmative, critical thinking, accepting social responsibility and initiating openness towards social changes.

The development and promotion of the natural sciences and mathematics at the University of Zagreb through participation in internationally relevant and competitively-based, applied and developmental research. Executing and improving innovative research-based teaching programmes. Contributing to science and education in the Republic of Croatia and the world through all its activities.

Vision

- PMF is the leading regional university institution for scientific research and expert work in the area of the natural sciences and mathematics, and the leader of development of the natural sciences and mathematics in the Republic of Croatia.
- PMF staff are involved in internationally relevant and competitively-based research, laying the foundation for the further development of the natural sciences and mathematics, and initiating applied and developmental research.
- High quality study programmes, scientific and expert work at PMF ensure ongoing advancements to the scientific and organisational infrastructure.
- PMF is largely housed at the *North Campus* of the University of Zagreb, where cooperation and synergy are formed with other constituents of the university and with public scientific institutions.
- University study programmes offered at PMF, University of Zagreb are based on science, innovation and the newest scientific findings to contribute to the social and economic development of the Republic of Croatia.
- Students and staff at PMF make up the academic community that enjoys the freedom of research and creation, mutual respect and trust, and mutual cooperation.

PMF is an internationally recognisable and relevant centre of excellence for scientific, teaching and expert work in the fields of the natural sciences and mathematics, and students and staff of PMF are included as equal participants in the European research areas.

SWOT Analysis

Strengths

- Long-standing tradition and reputation of PMF in university education, scientific research and expert work in the fields of the natural sciences and mathematics.
- Scientific excellence and international recognition of individual researchers, competitive research groups and results of their research.
- Intellectual potential of a large number of highly competent and motivated staff in scientific, teaching and associate positions, and a favourable ratio of teachers to students.
- Connections at the national and international level, with a substantial number of national and international scientific projects, and the accompanying scientific infrastructure, library fund and periodicals.
- Proximity to other University of Zagreb units and public scientific institutes, which ensures a stimulatory environment for scientific, teaching and expert work.
- Dialogue and acceptance of the needs of different Croatian regions (Osijek, Split, Dubrovnik, etc.) to expand natural history studies, primarily their development in the scientific fields and teaching activities.
- Establishment of strong connections at the local and regional levels in cooperation with public institutions (e.g., Hrvatske vode, national parks, Ruđer Bošković Institute, Institute for Physics, etc.) in the areas of sustainable development and information science.
- Active inclusion in the daily life of the citizens of the City of Zagreb and Republic of Croatia (Seismological Survey, Botanical Garden, etc.).
- Highly motivated, dedicated and conscientious students at all levels of study.

Weaknesses

- Existing spatial fragmentation and inappropriate spatial housing of parts of the natural sciences seriously hinders the performance of scientific and teaching activities, and adequate administrative support.
- The division of resources ultimately reduces connections between fields and scientific areas, which largely hinders the implementation of common standards and criteria, and negatively reflects on the indicator effects (quality), stimulating interdisciplinary study, and establishing joint research in the natural sciences.
- Lack of synergy between departments means there are weak opportunities for interdisciplinary and multidisciplinary research.
- Non-alignment between departments with regard to study programmes, resulted in irrational organization of classes.
- Insufficient number of scientific-teaching and junior researcher positions, and post-doctoral positions, which causes staff to be overburdened with teaching and administrative obligations.
- Complex organization causes multiplication of procedures, the quality of project administration is not yet at an appropriate level.
- Inadequate connections with alumni.
- Few partnership relationships with domestic and international scientific institutions and the economy.
- Inadequate interest of candidates for enrolment into scientific education study programmes.

Opportunities

- Modernisation of teaching and scientific programmes, and balancing of the existing enrolment quotas with the contemporary achievements and needs of society.
- Alignment with European positions on higher education, and internationalisation and increasing competitiveness of educational programmes at the international level.
- Financing research projects and doctoral candidates through funding of the *Croatian Science Foundation*.
- Financing research projects through funding from the EU funds and joint applications of projects with other Croatian or foreign institutions.
- Improvement of the scientific infrastructure through the application of projects for European structural funds and joint applications of projects with industry (e.g. *Met4Pharm*).
- Increasing incoming and outgoing mobility of students and faculty at the university, national and international level.
- Establishment of functional connections with other stakeholders in the education system, economy and media.
- Uniting the research capacities in the natural sciences, mathematics and biomedicine in the areas of the *North Campus* of the University of Zagreb.

Threats

- Spatial inequality of the fields of Biology, Geology and Geography within the central Horvatovac location.
- Reductions in funding from the state budget and lack of funds from non-budgetary sources.
- Insufficient number of new scientific-teaching and assistant positions and post-doctoral positions.
- Inadequate investments from the state budget for maintaining the existing infrastructure.
- Delays to the project to build the *North Campus* of the University of Zagreb.
- Inadequate legislative framework for the development of research work.
- Brain drain of high quality personnel leaving the Republic of Croatia.
- Loss of interest for the study of the natural sciences and the unattractive and poor social status of teaching professions.

Fundamental strategic goals

1. **Improve course quality and promote the significance of the educational process.**

   PMF will continually improve the existing and develop new innovative university study programmes based on the newest scientific discoveries and develop life-long learning education. These programmes will offer top quality university education in the field of the natural sciences and mathematics as the foundation of future development of science and society as a whole.

2. **Improve the quality of scientific research.**

   PMF will support excellence in scientific research as the basis for attractive financing from competitive national and international sources, and ensure the equal inclusion of its faculty members in the European Research Area. PMF will prepare and apply for EU structural projects to improve and modernise the experimental basis for competitive scientific research.

3. **Improve the quality of expert work, transfer of knowledge and technology**

   PMF is recognised as an institution whose scientists, through their expertise, are involved in resolving a diverse range of issues in different aspects of society in the Republic of Croatia. Many expert projects are successfully carried out at PMF in cooperation with public and state institutions and a series of economic entities. The expert work of PMF staff serves the development and general betterment of society as a whole, and aims at its ongoing advancement.

4. **Advancing infrastructure, organisation and management and the self-assessment system**

   Advancing all types of infrastructure, particularly spatial capacities and scientific infrastructure. It is necessary to improve the organisation and management and the self-assessment system to ensure optimal operations and the future development of PMF. For that purpose, a detailed analysis of the faculty organisation and management is required, with the aim of its optimisation.

5. **Increasing influence on the development of society as a whole and accepting social responsibility**

   It is a duty of PMF to participate in the development of society in the Republic of Croatia. This can be achieved through ongoing participation in popular science events, self-promotion for the purpose of increasing the validation of the natural sciences and mathematics, and participation in public information means at both the personal and faculty levels.

Areas of Strategic Activities

1. **Improve course quality and promote the significance of the educational process.**

Special goal	**❶.①.@1**	**Aligning current and developing new study programmes**
@ctivity	❶.①.@1	*Aligning and adapting course content at the division, department and faculty levels.*
@ctivity	❶.①.@2	*Improving existing study programmes.*
@ctivity	❶.①.@3	*Development of new study programmes.*
@ctivity	❶.①.@4	*Drafting the Standard of Professions and Standard of Qualifications*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❶.①.@1	Report* on conducted analysis of study programmes at the faculty level, with special emphasis on areas of possible rationalisation	Once annually/ continually	Vice-dean for Teaching† Committee for Teaching
❶.①.@2	Report on the number of study programmes and courses with altered course content and/or learning outcomes	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance
	Report on the number of course activities in cooperation with the economy and public sector	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance
❶.①.@3	Report on the number of new study programmes	Once annually/ continually	Vice-dean for Teaching Committee for Teaching Committee for Quality Assurance
❶.①.@4	Documents pertaining to the Standard of Professions and Standard of Qualifications, submitted for evaluation to the competent national bodies	Once	Faculty Council Vice-dean for Teaching Department Councils.

*All reports are submitted in writing or verbally.

†All terms with gender significance equally include the male and female genders.

Special goal	**❶.②.@1**	**Improving the quality assurance system for teaching and ongoing implementation of external evaluation and self-evaluation**
@ctivity	❶.②.@1	*Monitoring success of students during and after study.*
@ctivity	❶.②.@2	*Monitoring the rate of employment of students after graduation.*
@ctivity	❶.②.@3	*Conducting student surveys.*
@ctivity	❶.②.@4	*Establishment of the PMF Alumni.*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❶.②.@1	Report on success of studying.	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance ISVU Coordinators
❶.②.@2	Report on monitoring the rate of employment of students after graduation.	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance
❶.②.@3	Development of the annual student survey plan.	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance Administrative Services
	Annual report on the results of student surveys.	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance Administrative Services
❶.②.@4	Establishment of the PMF Alumni	Once	Dean Faculty Collegium Vice-dean for Teaching

Special goal	**❶.③.@1**	**Increasing mobility among PMF staff and students.**
@ctivity	❶.③.@1	*Increasing the availability of information for PMF staff and students, and students, teachers and researchers from abroad*
@ctivity	❶.③.@2	*Increase the international exchange of PMF staff and students and students, teachers and researchers from abroad*
@ctivity	❶.③.@3	*Increase the number of courses available in English, and develop and implement study programmes that are executed entirely in English*
@ctivity	❶.③.@4	*Modification of enrolment quotas in line with the surroundings.*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❶.③.@1	Analysis of the availability of information relevant for PMF staff and student mobility.	2015/2016	Vice-dean for International Cooperation
	Analysis of the availability of information relevant for the mobility of students, teachers and researchers from abroad.	2015/2016	Vice-dean for International Cooperation
❶.③.@2	Report on the number of PMF staff and students participating in international exchange.	Once annually/ continually	Vice-dean for Teaching Vice-dean for International Cooperation
	Report on the total number of students, teachers and researchers from abroad participating in international exchange.	Once annually/ continually	Vice-dean for Teaching Vice-dean for International Cooperation
	Report on the number of lectures held by foreign lecturers.	Once annually/ continually	Vice-dean for Teaching Vice-dean for International Cooperation
❶.③.@3	Report on the total number of courses available in English or another foreign language.	Once annually/ continually	Vice-dean for Teaching Vice-dean for International Cooperation
	Report on the evaluation procedure of study programmes performed entirely in English or another foreign language.	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance
❶.③.@4	Analysis of enrolment quotas in relation to time.	Once annually/ continually	Vice-dean for Teaching

Special goal	**❶.④.@1**	**Establishing a sustainable system of life-long learning.**
@ctivity	❶.④.@1	*Implementing professional development for primary and secondary school teachers.*
@ctivity	❶.④.@2	*Organising thematic workshops, courses and e-courses for the broader community (smart specialisation).*
@ctivity	❶.④.@3	*Recognising talented pupils in primary and secondary schools and their inclusion in advanced workshops, summer schools and preparations for international competitions.*
@ctivity	❶.④.@4	*Developing educational materials for primary and secondary pupils.*
@ctivity	❶.④.@5	*Providing scientific and expert support to popular science journals intended for primary and secondary pupils.*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❶.④.@1	Report on total number of thematic workshops held for professional development of primary and secondary school teachers.	Once annually/ continually	Vice-dean for Teaching Committee for Teaching Methodologies PriMaTeh Coordinator*
❶.④.@2	Report on conducted evaluation procedure of new life-long learning programmes.	Once annually/ continually	Vice-dean for Teaching Committee for Quality Assurance
	Report on the number of life-long learning programmes held.	Once annually/ continually	Vice-dean for Teaching
❶.④.@3	Report on workshops, summer school and competition preparations held.	Once annually/ continually	Vice-dean for Teaching Committee for Teaching Methodologies PriMaTeh Coordinator
❶.④.@4	Report on the total number and type of educational materials written for primary and secondary school pupils.	Once annually/ continually	Vice-dean for Teaching Committee for Teaching Methodologies PriMaTeh Coordinator
❶.④.@5	Report on contributions in popular science journals intended for pupils, written by PMF staff.	Once annually/ continually	Vice-dean for Teaching Committee for Teaching Methodologies

*PriMaTeh – Centre for the advancement of education in the fields of the natural sciences, mathematics and technical sciences, an organisational unit of PMF.

Special goal	**❶.⑤.@1**	**Improving teaching infrastructure**
@ctivity	❶.⑤.@1	*Analysis and monitoring the application of e-learning and implementation of modern technology in teaching at PMF*
@ctivity	❶.⑤.@2	*Support for e-learning students and staff at PMF*
@ctivity	❶.⑤.@3	*Increasing the fund of textbooks, scientific and expert literature*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❶.⑤.@1	Report on the number of courses that are conducted with e-learning, in accordance with the University of Zagreb classifications	Once annually/ continually	Vice-dean for Teaching Committee for Teaching
	Report on funds spent on the implementation of ICT in teaching at PMF.	Once annually/ continually	Vice-dean for Investments and Development
❶.⑤.@2	Establishment of a system of standardising the work of professors for the drafting of e-materials.	Once	Dean Faculty Collegium Vice-dean for Teaching
	Report on the number of workshops held dedicated to the implementation of ICT in the teaching process for PMF staff.	Once annually/ continually	Vice-dean for Teaching PriMaTeh Coordinator
❶.⑤.@3	Report on the total number of new textbooks, scientific and expert literature.	Once annually/ continually	Vice-dean for Teaching Library manager
	Report on the availability of scientific and expert journals.	Once annually/ continually	Vice-dean for Science and Doctoral Studies

2. Improving the quality of scientific research

Special goal	❷.①.**@1**	**Improving research and innovation activities**
@ctivity	❷.①.@1	*Increase the number of scientific projects obtained in competitions in the Republic of Croatia*
@ctivity	❷.①.@2	*Increase the number of scientific projects obtained in European competitions*
@ctivity	❷.①.@3	*Increase the number of scientific projects in cooperation with industry*
@ctivity	❷.①.@4	*Raise the innovation potential and establish a mechanism for knowledge transfer to the economy*
@ctivity	❷.①.@5	*Increase the number of invited lectures by foreign scientists*
@ctivity	❷.①.@6	*Publicly accessible overview of scientific projects with amounts of funding, final results and analysis of benefits for the community*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❷.①.@1	Report on applications for scientific projects in competitions in the Republic of Croatia, categorised according to fundamental, applied and development research.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
❷.①.@2	Report on applications for scientific projects in European competitions, categorised according to fundamental, applied and development research.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
❷.①.@3	Reports on scientific projects in cooperation with industry, categorised according to fundamental, applied and development research.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Assistant Department Heads for Science
❷.①.@4	Report on innovations and patents.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
	Report on applications on open innovation platforms in economic entities.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
❷.①.@5	Report on invited lectures held by foreign lecturers	Once annually/ continually	Vice-dean for Science and Doctoral Studies Vice-dean for International Cooperation
❷.①.@6	Report on the availability of data published on the PMF website and annual reports	Once annually/ continually	Vice-dean for Science and Doctoral Studies

Special goal	**❷.②.**	**Improve the support system for project application and implementation**
@ctivity	**❷.②.**@1	*Optimise the work of administrative services to ensure the easier administrative implementation of projects*
@ctivity	**❷.②.**@2	*Establish a financial system for application support and project implementation*
@ctivity	**❷.②.**@3	*Engagement of a larger number of persons for the systematic support in project application and implementation*

Activity	Key indicators	Timeframe	Responsible person or body
❷.②.@1	Conduct analysis of the work of administrative services.	Once	Dean Faculty Collegium Faculty Council
	Conduct reorganisation of the work of administrative services.	Once	Dean Faculty Collegium Faculty Council
❷.②.@2	Establish a joint financial fund to support project application and implementation.	Once	Dean Faculty Collegium Vice-dean for Finance
	Report on total resources paid into the joint financial fund.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Finance
❷.②.@3	Total number of persons engaged in the support system.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies

Special goal	❷.③	**Stimulate and recognise excellence in scientific work**
@ctivity	❷.③.@1	*Establish and award recognition for excellence in scientific work for the scientific research and teaching staff of PMF*
@ctivity	❷.③.@2	*Establish and award recognition for excellence in the scientific work of doctoral candidates*
@ctivity	❷.③.@3	*Include students in scientific work during their studies*
@ctivity	❷.③.@4	*Award recognition for excellence in the scientific work of students*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❷.③.@1	Report on awarded recognition for excellence in the scientific work of the scientific research and teaching staff of PMF	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
❷.③.@2	Report on the awarded recognition for excellence in the scientific work of doctoral candidates	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
❷.③.@3	Report on students included in scientific work during their studies	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
	Report on awarded recognition in competitions for the Rector's Award and Dean's Award	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
❷.③.@4	Report on the awarded recognition for excellence in the scientific work of students	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies

Special goal	❷.④	**Stimulate the formation of field, interdisciplinary and multidisciplinary competitive research groups**
@ctivity	❷.④.@1	*Stimulate the continuous cooperation of staff and scientific research groups with scientists from the best domestic and world universities, and scientific institutes.*
@ctivity	❷.④.@2	*Networking of PMF scientific research groups with regional and global research centres.*
@ctivity	❷.④.@3	*Inclusion of a larger number of PMF scientists in preparation of the project* Centre for Advanced Materials and Nanotechnology *in cooperation with the Ruđer Bošković Institute and the Institute for Physics for competitions of the European Regional Development Fund 2014 – 2020*
@ctivity	❷.④.@4	*Stimulate the creation of excellent research groups in specific fields*
@ctivity	❷.④.@5	*Stimulate the creation of interdisciplinary and multidisciplinary research groups for excellence in inter- and multidisciplinary research.*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❷.④.@1	Report on cooperation achieved between staff and scientific research groups with scientists from domestic and world universities and scientific institutes.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
❷.④.@2	Report on the number of regional and global research centres with which cooperation has been established.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
❷.④.@3	Report on the number of PMF scientists included in the drafting of feasibility studies.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
❷.④.@4	Report on excellent research groups in specific fields.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies
❷.④.@5	Report on the number of inter- and multidisciplinary research groups for excellence in inter- and multidisciplinary research.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies

Special goal	❷.⑤	**Improve the doctoral study programmes at PMF**
@ctivity	❷.⑤.@1	*Improve the existing and develop new study programmes in doctoral studies.*
@ctivity	❷.⑤.@2	*Stimulate the completion of dual doctorates and joint doctoral programmes with other domestic and foreign higher education institutions*
@ctivity	❷.⑤.@3	*Stimulate the mobility of doctoral candidates and professors in doctoral studies*
@ctivity	❷.⑤.@4	*Stimulate the mobility of foreign professors and scientists, with the aim of holding lectures in PMF doctoral studies.*
@ctivity	❷.⑤.@5	*Stimulate the completion of doctoral dissertations in cooperation with the private and public sectors.*
@ctivity	❷.⑤.@6	*Improve existing and establish new specialist postgraduate studies.*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❷.⑤.@1	Report on the number of amended courses in PMF doctoral studies.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
	Report on the number of amended study programmes in PMF doctoral studies.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
	Report on the number of new study programmes in PMF doctoral studies.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
❷.⑤.@2	Report on the number of new joint doctoral programmes at PMF doctoral studies.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
❷.⑤.@3	Report on the number of students and teachers in PMF doctoral studies who have participated in international exchange.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
❷.⑤.@4	Report on the number of foreign professors and scientists who have participated in foreign exchange.	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
❷.⑤.@5	Report on the number of doctoral dissertations achieved in cooperation with the private and public sector	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
❷.⑤.@6	Report on the number of amended specialist postgraduate study programmes	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies
	Report on the number of new specialist postgraduate study programmes	Once annually/ continually	Vice-dean for Science and Doctoral Studies Head of doctoral studies

3. Improve the quality of expert work, transfer of knowledge and technology

Special goal	❸.①.	**Improve expert activities**
@ctivity	❸.①.@1	*Increase the number of expert projects.*
@ctivity	❸.①.@2	*Stimulate the protection of intellectual property, copyrights and other related rights*
@ctivity	❸.①.@3	*Assistance in the establishment of spin-off companies.*
@ctivity	❸.①.@4	*Establishment and awarding recognition for excellence in expert work by PMF scientific research and teaching staff*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❸.①.@1	Report on the number of expert projects.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
❸.①.@2	Report on the protection of intellectual property, copyrights and other related rights.	Once annually/ continually	Vice-dean for Science and Doctoral Studies
❸.①.@3	Report on the establishment of spin-off companies.	Once	Administrative services Vice-dean for Science and Doctoral Studies
❸.①.@4	Report on awarding recognition for excellence in the expert work of PMF scientific research and teaching staff.	Once annually/ continually	Dean Faculty Collegium Vice-dean for Science and Doctoral Studies

4. Improve infrastructure, organisation and management, and self-assessment systems

Special goal	❹.①.	**Build and improve the spatial infrastructure as part of the *North Campus* project**
@ctivity	❹.①.@1	*Resolve the legal and property issues concerning the construction of the Biology, Geography and Geology (BGG) complex*
@ctivity	❹.①.@2	*Resolve legal and property issues concerning the expansion of the Physics and Geophysics buildings*
@ctivity	❹.①.@3	*Active cooperation at the University of Zagreb to prepare the locational permits for the* Centre for Advanced Materials and Nanotechnology (C2AMN)
@ctivity	❹.①.@4	*Preparation of documentation for the North Campus project applications, in the part pertaining to PMF.*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❹.①.@1	Report on the legal and property issues concerning construction of the BGG building.	Once annually	Vice-dean for Investments and Development
❹.①.@2	Report on the legal and property issues concerning expansion of the Physics and Geophysics building.	Once annually	Vice-dean for Investments and Development
❹.①.@3	Report on the preparation of the locational permits for the C2AMN	Once annually	Vice-dean for Investments and Development
❹.①.@4	Report on the preparation of documentation for the North Campus project application	Once annually	Vice-dean for Investments and Development

Special goal	❹.②.	**Improve and modernise scientific infrastructure**
@ctivity	❹.②.@1	*Active cooperation on the feasibility study for the C2AMN project application in structural fund competitions (partners: University of Zagreb, Ruđer Bošković Institute, Institute for Physics)*
@ctivity	❹.②.@2	*Prepare projects to equip PMF scientific laboratories for application to competitions for infrastructure projects in the European Regional Development Fund 2014 – 2020*
@ctivity	❹.②.@3	Connections with the private sector to submit project applications on industrial research and experimental development as the foundation for development of the Croatian economy, as part of the Operational programme Regional Competitiveness 2014 – 2020 from the European Regional Development Fund (ERDF)

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❹.②.@1	Report on cooperation in the feasibility study to submit the C2AMN project application	Once annually	Vice-dean for Science and Doctoral Studies
❹.②.@2	Report on submission of laboratory equipment projects to competitions for infrastructure projects of the European Regional Development Fund 2014 - 2020	Once annually	Vice-dean for Science and Doctoral Studies
❹.②.@3	Report on connections with the private sector to submit project applications on industrial research and experimental development as the foundation for development of the Croatian economy, as part of the Operational programme Regional Competitiveness 2014 – 2020 from the European Regional Development Fund (ERDF)	Once annually	Vice-dean for Science and Doctoral Studies

Special goal	❹.③.	**Analysis and optimisation of faculty organisation and management**
@ctivity	❹.③.@1	*Detailed analysis of organizational and management structures*
@ctivity	❹.③.@2	*Drafting the reorganisation plan of organisational and management structures and other legal documents*
@ctivity	❹.③.@3	*Improved alignment of activities, efficiency and strengthening the flow of information*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❹.③.@1	Conducted detailed analysis of organisational and management structures	2015/2016	Dean Faculty Collegium Administrative services
❹.③.@2	Developed reorganisation plan of organisational and management structures	2015/2016	Dean Faculty Collegium Administrative services
❹.③.@3	Report on improved alignment of activities.	Once annually/ continually	Dean Faculty Collegium Administrative services
	Report on improved efficiency	Once annually/ continually	Dean Faculty Collegium Administrative services
	Report on strengthening the flow of information.	Once annually/ continually	Dean Faculty Collegium Administrative services

Special goal	❹.④.	**Improvement of the information infrastructure**
@ctivity	❹.④.@1	*Better informatization of operations and focus on websites*
@ctivity	❹.④.@2	*Developing and maintaining the website in foreign languages*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❹.④.@1	Report on funds spent on informatisation	Once annually/ continually	Vice-dean for Finance
	Report on availability of information on websites	Once annually/ continually	Vice-dean for International Development
❹.④.@2	Report on development and maintenance of the websites in foreign languages	Once annually/ continually	Vice-dean for International Development

Special goal	**❹.⑤.**	**Improve the self-assessment system**
@ctivity	**❹.⑤.**@1	*Update existing rule books*
@ctivity	**❹.⑤.**@2	*Internal and external evaluations*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❹.⑤.@1	Annual plan of normative activities with assessed effect.	Once annually/ continually	Dean Faculty Collegium Administrative services
❹.⑤.@2	Report on internal evaluation	Once annually/ continually	Dean Faculty Collegium Committee for quality assurance
	Conducted analysis and report on external evaluation	Once annually/ continually	Dean Faculty Collegium Committee for quality assurance

5. Increasing the effect on the development of society as a whole and accepting social responsibility

Special goal	**❺.①.**	**Ongoing organisation and participation in popular science events**
@ctivity	❺.①.@1	*Organising events: Open Days, Biology Night, Magic in Chemistry, etc.*
@ctivity	❺.①.@2	*Participation in other popular science events (Science Festival, etc.)*
@ctivity	❺.①.@3	*Support for professional societies*
@ctivity	❺.①.@4	*Support of popular science magazines*
@ctivity	❺.①.@5	*Support for student organisations*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❺.①.@1	Report on organised events	Once annually/ continually	Vice-dean for teaching Vice-dean for science and doctoral studies Head of PriMaTeh
❺.①.@2	Report on participation in other popular science events	Once annually/ continually	Vice-dean for teaching Vice-dean for science and doctoral studies Head of PriMaTeh
❺.①.@3	Report on support for professional societies	Once annually/ continually	Vice-dean for teaching Vice-dean for science and doctoral studies
❺.①.@4	Report on support for popular science magazines.	Once annually/ continually	Vice-dean for science and doctoral studies
❺.①.@5	Report on support for student organisations	Once annually/ continually	Vice-dean for teaching Vice-dean for science and doctoral studies

Special goal	**❺.②.**	**Improved self-promotion and visual identity**
@ctivity	❺.②.@1	*Development of various promotional materials*
@ctivity	❺.②.@2	*Redesign of the PMF visual identity*
@ctivity	❺.②.@3	*Development of the PMF website and ongoing presence (Wikipedia, Facebook, Twitter, etc.)*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❺.②.@1	Report on development of promotional materials	Once annually/ continually	Dean Faculty Collegium
❺.②.@2	Report on conducted redesign of the visual identity	Once annually/ continually	Dean Faculty Collegium
❺.②.@3	Report on the development of the website and ongoing presence	Once annually/ continually	Dean Faculty Collegium

Special goal	❺.③.	**Ensure presence in public information channels**
@ctivity	❺.③.@1	*Ensure media presence at important events and popular science public and social events*
@ctivity	❺.③.@2	*Ongoing sending of press releases on important events and popular science public and social events*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❺.③.@1	Report on presence of media at important events and popular science public social events	Once annually/ continually	Dean Faculty Collegium
❺.③.@2	Analysis of media reporting on important events and popular science public social events	Once annually/ continually	Dean Faculty Collegium

Special goal	❺.④.	**Support and stimulate publishing activities**
@ctivity	❺.④.@1	*Work in international institutions and professional societies*
@ctivity	❺.④.@2	*Support the publication of international and domestic scientific journals*

Activity	**Key indicators**	**Timeframe**	**Responsible person or body**
❺.④.@1	Report on staff involved in the work of international institutions and professional societies	Once annually/ continually	Vice-dean for science and doctoral studies
❺.④.@2	Report on staff involved in the work of editorial boards of domestic scientific journals	Once annually/ continually	Vice-dean for science and doctoral studies Committee for publishing activities
	Report on staff involved in the work of editorial boards of international scientific journals	Once annually/ continually	Vice-dean for science and doctoral studies Committee for publishing activities

Scientific research programmes

Department of Biology

Division of Botany

Scientific research groups within the Division of Botany study algae and plants from various aspects: molecular and genetic, chemical and biochemical, physiological and pathophysiological, phylogenetic and evolutionary, geobotanical and ecological. The research ranges from analyses of distribution, habitats and ecological conditions that algae and plants live in, the study of bioactive compounds in plants with possible applications in phytotherapy, to analyses of genetic diversity of populations and species, and research is conducted both in the field and in the laboratory. A surprising large number of plant species, many of which are endemic, are found in such a small area as Croatia, and this has affected the course of research of our botanists. Understanding the structure and function of algae and plants, and the conditions and way of live is important for understanding the fundamental process of life, production of food, production of plant-based medicines, prevention and protection from plant allergens, improving the tourism offer of specific areas. According to the results achieved, the scientists in the Division of Botany are among the leading Croatian botanists, and are recognisable on the international scene. The Division of Botany houses two herbarium collections that are registered in the global database *Index Herbariorum* – Herbarium Croaticum and the Herbarium Ivo and Marije Horvat.

Aims:

- Raise awareness of the significance of plants and their biodiversity for the preservation of life on Earth
- Insight into the current state, threats and potential issues in conserving biodiversity
- Proposing management measures and the protection of individual species and specific botanically important areas to ensure quality life on Earth
- Results of research on the effect of food production, production of plant-based medicines, prevention and protection from plant allergens, and improving the tourism offer of certain areas
- Conserving and improving the Croatian cultural heritage, and providing education in plant identification through the maintenance and improvements to the herbarium collections

Department of Biology

Division of Animal Physiology

The research at the Division of Animal Physiology is aimed at preventing the growth of tumours and metastasis through angiogenesis inhibition, finding associates with the activation of VEGF, polarisation of macrophages, oxidative stress and angiogenesis. Analyses are conducted to determine how the level of oxidative stress impacts the level of DNA damage in the tumour cell and lymphocytes. Research on key molecular mechanisms will continue on the anti-inflammatory, antioxidative, phytoestrogen and regenerative effects of bioactive components of plants and bee products (polyphenols) in diabetes, osteoporosis, inflammatory diseases of the skin and intestines, and modulation of activities of intestinal microflora and its significance in the process of detoxification of carcinogenic and toxic compounds.

In the area of neurophysiology, research is ongoing to determine the consequences of perinatal exposure to altered serotonin concentrations, using an animal model perinatally treated with a serotonin degradation inhibitor (tranilcipromin) and in the human populations (persons with disorders on the autism spectrum). Immunohistochemical methods will be applied to examine the consequences of altered serotonin homeostasis in the central segment on the organisation of somatosensory system in the rat brain, and in the peripheral segment on the structure of bone marrow, kidney and liver. In humans, bone and blood parameters will be measured to investigate the influence of altered homeostasis of the peripheral serotonin on glucose metabolism, lipids and bone.

In the field of endocrinology and reproduction, research will examine the effects of different procedures of *in vitro* manipulation of reproductive cells on oxidative stress and genome stability.

In the field of food physiology and metabolism, research will examine the effects of intracellular accumulation of cholesterol on oxidative stress in the cell and organs. Toxicological in vivo and in vitro research will be conducted on the security of bioactive compounds and residues present in food.

Ecophysiological research will continue to study the populations of wild mammal species in Croatia (wolf, jackal, wild boar, red deer, otter, dolphin) using neutral and adaptive genetic markers. An ecophysiological behavioural cognitive study will be conducted on the behaviour of animals that enable survival in the environment, using a model of the Dinaric vole, a rodent endemic to the Western Balkans. Further research on animal behaviour will examine the mechanisms of action of applied matter on changes in cognition and behaviour in laboratory mice and rats.

Department of Biology

Division of Microbiology

Research at the Division of Microbiology will continue on bacteria, viruses, subviral agents and fungi. The main planned topics of research are:

1. Diversity and interaction of chestnut, pathogenic fungi causing chestnut blight and the virus that infects the fungus: effects on chestnut recovery
2. Epidemiology of the clinically important bacterial species *Acinetobacter baumannii*.
3. Molecular epidemiology, diversity and genotyping of the phytoplasma (genus 'Candidatus Phytoplasma') of economically important plant species in Croatia
4. Comparative and functional genomics of phytoplasma: genome plasticity, interaction with the host and mechanisms and strategies of pathogenicity
5. Genetic structure, molecular diversity and evolution of plant viruses with single- and double-chain RNA genomes
6. Molecular diversity and epidemiology of environmental viruses
7. Molecular diversity and population structure of viroids
8. Application of monolithic chromatograph in the research of viruses and virus nucleic acids

Department of Biology

Division of Molecular Biology

The Division of Molecular Biology includes a number of scientific research groups covering a range of research topics. The research interests of the **Stress biology group** examine the impacts of abiotic stress on plants, and understanding the plant response to stress at the cellular level, and at the chromosome, gene and protein levels. The oldest group in the division examines the **organisation and evolution of the plant genome** at the cytogenic and molecular level. The aim of this group in future research is to apply chromosome markers in phylogenetic research and in the organisation and evolutions of tandem DNA sequences and to determine their role in speciation. The **group that addresses the mechanisms of plant development** studies the sexual and asexual reproduction of plants using the models *Arabidopsis thaliana* and *Vitis vinifera*. Future research is directed at revealing the mechanisms and regulation of reproductive capacities of egg cells and somatic cells using RNA sequencing methods, reverse genetics, and methods to prove protein interactions. The group plans to apply the potential of somatic embryogenesis to obtain new desired traits for agriculture, without the use of genetic engineering techniques. The **biomedical research group** conducts research in the field of stem cells and their applications in regenerative orthopaedics, transcription regulation in the animal cells, and intercellular communication networks between tumour cells and the microenvironment. Future research will focus on the regulation of the plasminogenic activation system that manages remodelled tissue and analysis biopathology of haematological neoplasms based on a multidisciplinary approach. The research **group for bioinformatics** is involved in studies in metagenomics in systems biology using computer tools. Research is aimed at shedding light on the processes that take place in living creatures at the level of complete biological systems. The **epigenetic group** examines the regulation of protein glycosylation under normal physiological conditions and in complex human diseases. The purpose is to explain how the variability of protein glycosylation achieved through epigenetic regulation participates in the underlying state and different course of disease in the human population. For that purpose, modern methods of bisulphite sequencing and chromatin immunoprecipitation are applied. The goal is also to discover the functional importance of GWAS hits in IgG glycosylation, using the newest methods in genetic and epigenetic engineering, such as TALEN/CRISPR technology.

Department of Biology

Division of Zoology

The Division of Zoology deals with the study of the diversity, distribution, ecology, taxonomy, ecotoxicology, reproductive biology, phylogeny and phylogeography, ecological evolution and genomics, evolution and biogeographic properties of all parts of the fauna of the Republic of Croatia, and the processes that have given rise to such properties of fauna. These activities of the division, which include elements of expert and scientific work, are carried out through the independent activities of division staff, in cooperation with related institutions in Croatia and abroad. The fundamental research directions in the forthcoming period are:

- Ecotoxicological research aimed at studying the effects of pollution on organisms in the environment, and the development of specific biological methods for the faster and more accurate determination of negative anthropogenic effects. Laboratory research is continuing to determine the effects of individual pollutants on the course of cell differentiation and cell (ultra)structure in certain aquatic organisms.
- Phylogenetic and phylogeographic research from the biological and ecological aspects (above all climate and ecological changes in the environment) on present day distribution, taxonomy and phylogeny of arthropods (insects, crustaceans) and fish, flatworms, freshwater cnidarians and their endosymbionts, and research of the evolutionary aspects of symbiosis.
- Ecological research, including sinecological research of aquatic communities of benthos (freshwater and marine), plankton and nekton, and the properties of a range of aquatic biotopes. Applied research within the National monitoring programme of aquatic ecosystems as an initial strategy in the context of the EU Water Framework Directive. Bioindication, development of monitoring protocols, selection of groups of organisms for categorisation of aquatic habitats. Special areas cover fauna research, inventorying and invasive species.

Department of Physics

Division of Experimental Physics

Experimental research in condensed matter physics includes the preparation and investigation of structural, macroscopic and microscopic properties of a broad spectrum of modern materials. These include organic and inorganic materials, low dimensional conductors, oxide heterostructures, topological insulators, as well as materials that exhibit collective phenomena such as superconductivity and quantum magnetism, magnetic nano particles, single molecule magnets, complexes of magnetic ions, molecule-based magnets, multiferroics, alloys, complex magnetic structures, ionic conductors, ferromagnetic graphite, soft matter, metal cluster complexes and other materials of importance for basic or applied physics. Such a wide field of study requires various techniques to determine the microscopic structure (X-ray scattering, electronic microscopy), local features (nuclear magnetic and quadrupole resonance) and macroscopic properties (magnetic and electrical characteristics, magnetotransport, thermoelectric and thermodynamic properties, high-frequency transport) in a wide span of external conditions (including extreme conditions such as very high and low temperatures and intense magnetic fields). Macroscopic properties are deduced from measurements of static magnetisation, magnetic moment, AC susceptibility, resistance and magneto-resistance, Hall and Nernst effects, thermopower, microwave conductivity, nonlinear radio-frequent conductivity and magnetic properties in the electrical field.

Experimental research in atomic and molecular physics are focused on the study of atomic and molecular processes in the high-pressure discharge in metal vapours in the high-frequency discharges in noble gases, using conventional and laser spectroscopic methods.

Experimental nuclear physics research includes investigations of nuclear structure and properties of nuclei and hadrons, nuclear reactions of astrophysical and technological importance, and nuclear and particle processes of interest to the fundamental questions of quantum mechanics and the standard model. Studies are carried out in laboratories in Croatia and in specialized European and world accelerator centres. An important component is the application of nuclear methods in the study of materials, environment and medicine.

Research in the experimental physics of elementary particles on high energy is focused on research of quark gluon plasma on RHIC and LHC colliders, and spin-structure nucleons in the RHIC collider.

Research in the field of astrophysics is focused on the following topics: (a) the structure, development and interaction of stars, (b) the origin and development of galaxies, and (c) the properties of interstellar matter.

Physics education research includes investigations pupil and student comprehension of fundamental physics concepts, investigations in the field of educational neuroscience and development and testing of the new teaching strategies and materials.

Neurobiophysical research uses neurodynamic methods for functional brain imaging to explore sensory and cognitive processes, multi-sensory integration, and cortical plasticity in basic and translational studies.

Department of Physics
Theoretical Physics Division of Particles and Fields

Gravitation and black holes

General research on parity violating effects in gravity by studying holography, anomalies, entropy, black holes. The focus is in particular on the natural candidates for parity violating gravity interactions – the Chern-Simons terms, both pure gravitational and mixed gauge-gravitational ones - using extra-dimension models such as those inspired by the string theory. The expected outcome is a significant increase in understanding the consequences of parity violating gravitational interactions, not only in relation with possible CP violations, but also for other effects, e.g. for corrections to black hole entropy.

Research is also conducted on general properties of classical scalar and electromagnetic field in a curved spacetime: question of symmetry inheritance and the interaction between the fields and black holes.

Phenomenology of elementary particles and fields

The goal of this research is to study the fundamental strong force, as described by the theory of quantum chromodynamics (QCD) and physical processes happening at hadron accelerators, including electroweak production of as-yet-unseen particles at the large hadron collider (LHC). Thereby, we investigate models of new physics in which such new particles are introduced in attempts to explain neutrino masses and abundance of dark matter in the universe. To achieve these objectives, we study specific hadronic processes, both in the high-energy regime where strong force is weak enough for perturbative approach, as well as in regimes where non-perturbative features of QCD, such as confinement and chiral symmetry breaking come to the fore. Our focus is on processes measured by the range of experimental collaborations which facilitates close contact with reality and immediate testing of our results and ideas.

Department of Physics

Theoretical Physics Division of Condensed Matter

History of Physics

The main subject of research will be Croatian natural sciences communities, especially the community of physicists, in the period 1875-1950. The goal is to elucidate the scope, the structure and the dynamics of the community, in particular the influence of the development of natural sciences and mathematics studies on the Croatian society.

Graphene and related materials

This research is dedicated to graphene modelling, single and multi-layered systems, undoped, intercalated and doped systems, in particular doped with alkali and alkaline earth metals, mechanical deformed systems, graphene nanoribbons and carbon nanotubes. The research will include band structure and excitation spectrum calculations, transport and optical properties calculations (including ballistic conductivity, and plasmon excitations), Raman spectra and magnetic properties calculations, a study of pseudomagnetic fields effects created by mechanical deformation, a study of spatially inhomogeneous systems leading to charge/spin confinement. One part of this research is also related to studies of nanoelectromechanical systems (NEMS) where magnetic and pseudomagnetic fields affect the magnetic coupling and nanomechanics controlled via spin.

High temperature superconductors and related materials

The physical mechanisms of superconductor phases and other phenomena in these materials, even after two decades of intensive research, are still mostly unexplained. Our study will include the modelling of collective, transport and electromechanical properties, dependence of the dynamical conductivity and relaxation functions on frequency and temperature, temperature dependence of various transport coefficients, calculations of the imaginary part of the memory function, review how the electron-phonon scattering affects the electronic spectrum, the conductivity and Raman scattering. Our efforts will be dedicated to understand: i) the mechanism of doping and the emergence of free charge, (ii) the nature of the metallic response, (iii) the pseudogap appearance in the spectroscopic data (iv) and the nature of the magnetic response function. This is also related to the research of transition metal oxides, e.g. nickelates and iridates, aiming to design a technologically desirable materials, and to better understand the superconductivity phenomenon in different groups of high temperature superconductors.

Organic compounds deposited on surfaces and on small metal clusters.

This research includes the band structure calculations and how it affects spectroscopic data (optical absorption, EELS, photoemission, etc.) for organic molecules (benzene, terilene, fullerene, etc.) deposited on the surfaces of noble metals (eg. Au^{111}), or on metal clusters such as Au^{147}. The strong Coulomb interaction requires a solution of the Bethe-Salpeter equation that takes into account exciton creation and excited electron-hole interaction.

Layered transition metal dichalcogenides

In low-dimensional materials, including layered transition metal dichalcogenides, electron-electron and electron-phonon interactions give rise to various low temperature phases and phase transitions

(e.g. charge/spin density waves, superconductivity, metal-insulator transition, Peierls instability, structural superstructure, different magnetic phases, etc.) making them interesting to theoretical and experimental studies, but also for a possible technological application. This research will include ground state calculations, crystal structure optimization, band structure and excitation spectra calculations (phonon, magnon), and calculations of optical, transport and magnetic properties.

Theoretical research of new, mostly low-dimensional materials

The aim of this research is to understand the basic properties and new phenomena important for technological application, and to model them, allowing for a synthesis of future class materials having an impact on technological development.

Department of Physics
Division of Theoretical Physics

Nuclear structure

The aims of the research currently carried out in the field of theoretical nuclear physics at PMF are the development and application of new theoretical approaches, based on the theory of energy densities functions that enable precise modelling of the structure of quantum systems on the femtometre scale, including predictions of the properties of exotic femtosystems far from the valleys of nuclear stability that are still not accessible in experiments.

Linking nuclear physics with the theory of energy density function allows for the development and application of a universal microscopic approach to describing and modelling exotic quantum systems on the femtometre scale, and in establishing links between quantum chromodynamics and the wealth of phenomenology in nuclear physics. Models of nuclear structure based on energy density functions includes additional correlations arising from the re-establishment of broken symmetries and from fluctuation deformations of the atomic core. The general coordinate model and collective Hamiltonian model based on a relativistic density function is applied in the description of quantum phase transitions in atomic cores, phenomena associated with the evolution of scale structures in exotic nuclei, superheavy nucleus structures, and the properties of exotic exciting models in nuclei outside stability valleys. A key element for the precise modelling of the structure of exotic femtosystems are detailed numerical simulations on distributed and parallel computer systems. Therefore, the described research includes an important component in the development of effective numerical algorithms and distributed computer codes adapted for modelling exotic femtosystems.

Nuclear astrophysics

Nuclear astrophysics combines nuclear physics, elementary particle physics and astrophysics to research the processes occurring in the stars. A particularly important question is when, and under what conditions, are elements heavier than iron formed, as this is key to understanding the creation and composition of the Earth, the chemical evolution of the galaxies, and fundamental properties and interactions in atomic nuclei. A fundamental part of this research is the application of a self-supporting theoretical approach, based on relativistic energy density functions, descriptions of the properties of awakening and decay of atomic nuclei from stability valleys to binding limits. At the centre of the research are reactions important for the nucleosynthesis of heavy elements – the rapid acceptance of neutrons, reactions induced by neutrinos, beta-decay of unstable nuclei, and the acceptance of electrons. To describe this in detail, it is necessary to first understand the finite phases in the evolution of heavy stars – the explosion of supernovas and formation of neutron stars.

Optics and photonics

The research aims currently researched theoretically in the fields of optics and photonics at PMF are the design and development of new photonic structures for light propagation (electromagnetic waves) with intriguing properties, such as the emulation of artificial magnetic fields, researching optical non-linearities in new materials such as graphene, and understanding new non-linear occurrences in these materials, as well as the development of structures that support plasmon excitation with a higher density of electromagnetic energy on spatial scales less than the vacuum wavelength, while incurring the least possible losses. These aims are at the forefront of the global research in this field. The scientists of the Department of Physics aim to continue and strengthen

cooperation with the world's most prestigious institutions and scientists in the field, thorough joint scientific papers and projects. Scientific research that strives to meet these goals units the theory of classic electrodynamics and the physics of condensed matter and laser physics. Electromagnetic waves are studied in the presence of different materials, dielectrics and conductors, and their properties are used to design new phenomena and seek new effects with interesting properties, often with potential applications in sensors, optical devices, etc. This direction of research follows the development of new materials and applies the response functions of those materials (conductivity, dielectric response) to design new artificial photonic structures.

Ultracold atomic gases

The goals of theoretical research currently conducted in the field of ultracold atomic gases as PMF include designing new methods for creating artificial or synthetic magnetic fields for atoms, and understanding of multiparticle dynamics in unbalanced systems. These goals are at the forefront of research on this topic in the world. Scientific research that strives to meet these goals unites multiparticle quantum physics, the interrelationships of light and atoms, laser physics and fundamental quantum physics. Cooperation established with the Institute for Physics (IP) will be intensified in the coming period. Theoretical research (and also experimental in cooperation with IP) examines new techniques of creating artificial magnetic fields for cold atomic gases, and theoretical research on the quantum degeneration of ultracold atomic gases. In that direction, we research the quantum multiparticle dynamics in systems of reduced dimensionality that are well isolated from the environment and which can long retain the quantum coherence, which is usually not possible in solid state systems. In all direction, a strong emphasis is placed on analogies to optical systems, where our group also has a great deal of expertise.

Cell biophysics

The goals of the research of theoretical biophysics at PMF are revealing and understanding the physical principles that lead to self-organisation within the live cell, as the foundation of functioning of all living organisms. Key elements include the creation of the spindle apparatus in meiosis, the positioning and transport of organelles within the cell, and cell movement. In all these processes, the fundamental drivers are the molecular motors that interact with microtubules or actins. In studying these processes, theoretical models are designed, using known properties of molecular motors and microtubules obtained in in vitro experiments, and fundamental knowledge from classic mechanics, and statistical and non-linear physics. Once developed, models are tested analytically and numerically, and the obtained predictions are then experimentally tested. This research is performed in close cooperation with experimental groups at the Ruđer Bošković Institute and other global institutions.

Bioinformatics

Tandem repetitions account for the majority of the genome of all eukaryotes, and mostly occur in the area of centromeres and pericentromeric heterochromatin. In the genome of humans and higher primates, these repetitions are organised into symmetrical higher-order structures. Recent DNA research has shown that tandem repeats play an important role in the structural organisation of the chromosome, in cellular metabolism, speciation and gene expansion regulation, and increasingly raises the question of their formation and activity. The scientific activity of the bioinformatics group is focused on developing algorithms and computer applications for the identification, classification and analysis of all types of repetitions in the genomes of various eukaryotes, particularly in the

genome of humans, higher primates and Neanderthals. Analysis of tandem repetitions includes modelling the development of repetitive higher order structures, particularly in the area of sudden accelerations (phase transition). These hypothetical models facilitate our understanding of the evolution of entire gene sequences, genome organisation and the role of non-coding parts of the genome in the gene regulation network. Findings on the formation and means of activity of higher order structure may contribute to the direct application of these results in clinical research by revealing the causes of various diseases resulting from mutations within tandem samples.

Department of Geophysics

Meteorology and climatology

Using fundamental geophysics approaches (measurements and observations, numerical simulations and theoretical development), we continue to study atmospheric processes and phenomena at the small, medium and large scales. We also study the creation, transmission, distribution and deposition of pollutants in the air, the vertical structure of the urban and suburban border layers, dissipation of turbulent eddies, turbulence kinetics and potential energy budgets over complex terrains, and the three main classes of non-standard radio wave refraction in the atmosphere. We examined the air currents over complex coasts and mountains, including phenomena such as the winds (bora, jugo and maestral), deep convection and the development of fog. Due to the current interactions of the system atmospheric–sea, a part of the research on local and regional weather and climate is performed in conjunction with oceanographers, using advanced statistical methods and climate modelling of varying degrees of complexity. Certain numerical models (simulators) will also be modified, with the aim of improving the parameterisation of turbulence. Research will continue on climate variability and climate change in Europe. Special attention will be focused on the effects of atmospheric large-scale modes and the contribution of slower components of the climate system (sea, soil, ice) through the possible extended action of those modes. Physical mechanisms that enable such connections will be explored using numerical simulations using global and regional climate models, and statistical analysis of the measured data.

Oceanography

Future oceanographic research will focus primarily on data collection, not only at the permanent mareographic state at Bakar (established in 1929), but also as a part of special experiments that will use pressure mareographs, undulators and other equipment. All collected data will be analysed with the appropriate statistical methods, both standard and newly developed methods. Attention is given to a broad spectrum of marine processes, from long-term changes in sea level, to storm surges and coastal seiches to river outflows into the sea. Finally, diverse models will be developed and used to reproduce observations. For example, semi-empirical models will be used in considering sea level trends, two-dimensional barotrope models to analyse sea responses to atmospheric activity, and three-dimensional barocline models in the reproduction of sea properties, and sea movements in areas around river mouths.

Seismology

The Department of Geophysics of PMF is the only institution in Croatia to conduct seismological research, and therefore the research plan is essential diverse, though focused on research of the seismicity of Croatia. The Seismology Survey, in accordance with the available funding, will continue to increase the density of the basic seismograph network in Croatia, and will continue recording earthquakes, archiving digital seismographs, cataloguing earthquakes and sharing data with partners abroad. The scientific work will be focused on exhaustive research of specific areas (such as Mt. Velebit), with the aim of identifying seismogenic faults, their properties and role in the seismo-tectonic structure. Work will continue to examine anisotropic rates, attenuation properties and the structure of the core and upper mantle under Croatia, using contemporary inversion methods of seismological observations (receptor functions, tomographs using microseismic unrest and spatial waves, etc.). In the field of seismological engineering and earthquake engineering, work will continue to measure the dynamic properties of important structures so as to identify those that are threatened due to the appearance of building – ground resonance, and all tasks associated with revising the

assessments of the earthquake hazard in Croatia.

Geomagnetism

Research of geomagnetic fields in Croatia will continue with data collection at the only Croatian geomagnetic observative, which started operations in Lonjsko Polje in July 2012. The data from the observatory will serve in the theoretical analysis of the distribution of all magnetic elements, developing geomagnetic maps, modelling field anomalies in the Croatian area and their interpretation. Scientific work in geomagnetism will be strengthened with the modelling of geomagnetic fields in a limited area using spheric harmonic analysis on the spherical cap. With that, special attention is given to the development of sophisticated techniques for the construction of calibration curves, i.e. baselines, in the case of large degradation data primarily arising from temperature instabilities and errors in absolute observations. This most often occurs in observatories, like the Croatian one, which do not have stable temperature conditions secured for high quality measurements. Efforts will be invested in continuous upgrading of the measurement quality and standards at the observatory, to ensure that measurements are aligned with the requirements of INTERMAGNETA.

Department of Geography

Geomorphology and palaeoenvironment

Research of karst from the aspect of geomorphology and palaeoenvironment, i.e. the questions of the formation, evolution and recent dynamics of the karst relief, has traditionally been studied by a research group at the Department of Geography, PMF. The most recent research topics are associated with the influence of geological structures on the development of karst relief forms, clima-geomorphological research (e.g. measurements of the intensity of karst denudation) of the development of morphometric methods, and geomorphological mapping in the GIS environment. The karst relief is often under the influence of other morphogenetic processes, such as glacial processes that were important in the past. Therefore, one of the research aims is the analysis of glacial karst on the surface and in speleological structures. This period is directly associated with the different distribution of land and sea in the Adriatic region, which has a very important role in the reconstruction of palaeoenvironment properties during the late Pleistocene and Holocene. Therefore, we use different markers (geomorphological, biological, archaeological, and others) to reconstruct palaeoclimate properties and to define and explain the sea level oscillations. Changes to the environment and climate are also studied based on analyses of speleothems and tufa. This research is based on field work, and isotope methods are extremely important; these are conducted in conjunction with the Ruđer Bošković Institute. An important goal in this research group is the further development and equipping of the laboratory for physical geography and geomorphology.

Climatology, hydrogeography and geoecology research

Research is directed at planning the functional spatial organisation and sustainable development. The strategy is directed at fundamental and applied research, personnel development, knowledge transfer, technological development, procurement of computer, GIS and research equipment, and strengthening cooperation with domestic and foreign partners.

Research topics include:

- analysis of the influence of abiotic factors on ecosystems
- use of geomorphological, pedological, hydrochemical, anthropogenic and biological indicators are applied in the research and monitoring of the state of the environment
- inventories and evaluations are conducted of the hydromorphological state of flowing and standing waters, of riparian and catchment areas, and runoff regimes within the EU Water Framework Directive
- development of the hydrological atlas of the Republic of Croatia
- study of water resource management and water supply as part of sustainable regional development
- analysis of natural hazards
- microclimate research
- study of geological diversity and geoheritage
- ecosystems of settlements and anthropogenic geomorphology
- geographic aspects of nature conservation and conserving ecosystem services
- regionalisation on the basis of physical geography components of the landscape
- regional climate analyses
- city climates
- climate changes and the variability of climatic elements in the instrumental period
- influence of climate on geographic evaluation in space.

Urbanisation and regional development

Regional development of Croatia is based on an urban system, and therefore, special attention in the research is given to the network of towns and cities, the functional classification and role of cities in the administrative and territorial organisation of the country. Furthermore, the research will examine the differentiating characteristics, development potential and limitations of city surroundings. It will also shape recommendations and development measures to validate potential suburban areas in the future development of city regions. Furthermore, the research examines the city space itself, and its spatial structure (functional, morphological, social and cultural traits), including: quality of life, problem areas in the city, sustainable city development with an emphasis on sustainable (alternative) transport, spatial mobility, social space and cultural differentiation, segregation and the daily environment.

Methodological instrumentation of the research ranges from quantitative (GIS, field work) to qualitative methods (interviews, focus groups). Spatial imagination and mental maps are emphasized as the product of spatial daily practices, and therefore are an important part in researching the city space. The obtained results are important in improving spatial planning and regional development, validating spatial resources, functional integration and approaches to solving the problem of uneven regional development in Croatia. There is a potential for a broad spectrum of applicability of the research results in the commercial and public sectors, and the results will contribute to improving the quality of public policies.

Sustainable development and planning of rural and peri-urban areas in Croatia

From 42 to 48% of Croatia's total population lives in rural and peri-urban settlements, which cover 86 to 89% of the total national territory. Excluding such areas that directly surround large city regions, the Croatian rural environment is characterised by primarily unfavourable development traits, negative demographic situation and processes (depopulation, aging), and weaker infrastructural and economic development in comparison with urban areas. Meanwhile, the rural and peri-urban areas are of strategic interest as they are the most important areas for food production and locations of key natural resources. They are also important for other important functions, such as residential areas, various commercial activities, nature conservation, location of large infrastructure and energy facilities, recreation. Primarily negative development trends on the one hand, and alignment of all these functions on the other, often raises dilemmas and conflicts concerning their planning and sustainable development. Research to date has been focused on their exceptional typological diversity, in the sense of development processes (from rural peripheries to dynamic areas in city regions). This requires systematic, integral, multidimensional and an area specific-approach to their planning and development. Therefore, the research topics will focus on development of a conceptual framework for better understanding the differentiation of development in rural and peri-urban areas in Croatia, developing alternate scenarios for their future development, and shaping models of effective planning and sustainable development.

Demographic aspects of development in Croatia

The contemporary demographic development of Croatia is marked by unfavourable processes and structural properties, which has contributed to a reduction of the overall "human capital" as the main driver of socioeconomic development. The consequence of these processes is seen in the unevenness of regional development, the sustaining and deepening of the gap between the village and the city,

and between the centre and periphery, and in the uneven development of the network of settlements, etc.

In the (re)evaluation of the Croatian national territory, demographic potential plays a great role at all levels, as the total qualitative and quantitative, real and potential social and biological properties of the population. Accordingly, the research is focused on:

- recent changes in the spatial orientation; dynamic and structural properties of the population at all spatial levels;
- demographic development of marginal and problem areas;
- trends of population development in city region settlements;
- influence of demographic processes on planning education functions.

The aims of the research are:

- identification, evaluation and projection of the demographic potential of Croatia and its regions;
- determining the guidelines for shaping the population policies and strategies of uniform regional development of Croatia;
- proposed interventions in the school network and organisation of enrolment districts for primary and secondary schools that would ensure sustainability and rational organisation of the educational role.

Cultural landscape and spatial identity

Changes to the environment in the Republic of Croatia will be studied, particularly changes to land cover and changes in land use. The research will be focused on changes to the landscape, particularly the type of change that is visible using remote researching methods. The aim of the research is to develop deductive models that include physical changes to the environment (landscape) and sociogeographic and physical geography factors that affect the observed changes. The possibility of including human behaviour and the decision-making process will also be included in examining changes in land cover and land use.

The cultural landscape contains a combination of past and present, and of material and immaterial values, and as such is part of the heritage. These values are used to build the spatial identity (local, regional, national). The research will also include the perspective aspects of spatial identity, particularly at the regional level. Historical maps as a source will be used to research the border identity, as ambivalent regional identity in the past, specifically in the period from the early new age to today. Surveys and interviews and an analysis of media content will be used in research on the perspective scope and formative elements of today's traditional Croatian region.

Tourism and spatial development of Croatia

Tourism is one of the most important branches of the Croatian economy, with a tendency of even greater qualitative and quantitative growth, and a more pronounced spatial expansion from the leading coastal tourism destinations towards inland areas. An interdisciplinary approach to tourism research, the thematic interaction of space and tourism is very important, as all tourist attractions are strongly territorialised.

Therefore, a key goal of the research within this topic is to examine the interrelationship of space and tourism. This implies: a) the identification and evaluation of natural and anthropogenic spatial resources in the attraction basis of Croatian tourism, b) analysis of the spatial properties of tourism trends, and c) determining the spatial implications of tourism in the transformation of tourism areas

in Croatia – tourism localities, tourism towns, tourism regions, i.e. Croatian tourism destinations at all hierarchical levels.

The importance of such defined research is seen in the possibilities for the optimal design of tourism products offered in Croatian destinations, and focusing the spatial development of Croatia in the context of tourism, in line with the postulates of the desired sustainable development. Rational planning and management of space and its resources is exceptionally important in the turbulent transition period of Croatian tourism, due to pronounced globalisation in the European Union, when interest in spatial use is increasing in the many of the highly tourism developed parts of Croatia, due to the increasing numbers of potentially interested visitors.

Didactic processes in teaching geography and organising education

In this area, four main topics will be addressed.

1. Didactics in geographic education. The aim is to study the effectiveness of learning and teaching strategies, the applicability of teaching resources in achieving the learning outcomes, and the form and criteria of evaluating accomplishments. The research results should be included into the geography curriculum at all educational levels.
2. Subject curriculum in geography for primary and secondary education. The aim is to align geographic education in primary and secondary schools with the Croatian Qualifications Framework and the development of the scientific field of geography. Determine groups of learning outcomes on the basis of analysis of the current situation in the system, the labour market demands, and in accordance with the goals of the Strategy of Education, Science and Technology. Contribute to the application of the Croatian Qualifications Framework in the teaching and education system.
3. Initial education, training and professional development of teachers and geography professors in schools. The aim is to contribute to developing a professional standard, qualifications standard and improvement of the competencies for organised learning and teaching that is pupil-centred.
4. Educational resource and human resources in teaching geography. The aim is to continue researching the effects of demographic development on changes to the exploitation index and load coefficient of human resources in teaching geography at the level of enrolment districts and by region. Apply GIS-based analyses to design models that are applicable in redefining school networks, the initial education of teachers and geography teachers, human resources management, and in regional development.

Department of Geology
Division of Geology and Palaeontology

The scientific research programme in this division in the forthcoming period is based on results to date, and may be categorised into several related and complementary topics. The foundation is comprised of stratigraphic, palaeontological, sedimentological and palaeoecological research of the Dinarides and Pannonian basic, aimed at understanding the structure, creation and evolution of these areas through the geological past. Special attention will be place on researching the lithological and palaeontological characteristics of the Dinarides and Paratethys sediments (Neogene and Quaternary), detritus sediments of the Dinarides (flysch, molasse), stress events in the geological past (extinctions, impacts, glaciations, etc.), sedimentary interruptions in carbonate successions of the karst Dinarides, and the specificity of shallow-sea carbonate environments during the Jurassic, Cretaceous and Palaeozoic eras. Using the fossil records in the Palaeozoic, Mesozoic and Cenozoic rocks, the evolution of life on Earth can be studied. With the aim of explaining changes in the environment in the geological past, while actualist principles will be applied in the study of recent sediments and sedimentation in the Adriatic Sea, dynamics of coastal changes, and the reflection of climate changes and sea levels on the coast and coastal processes. Research will include remote sensing, field work, sampling, laboratory analyses and microscopic research.

Department of Geology

Division of Minerology and Petrography

The research in this division is focused on the areas: crystal chemistry properties of minerals and their applications in minerology, geology, materials science and environmental research, genesis and changes to rocks in the Republic of Croatia and neighbouring countries, Geochemical research of the environment with the aim of differentiating geogenic and anthropogenic factors that influence the distribution of metals and other important environmental compounds, with the aim of characterisation, remediation and managing threatened and sensitive environments, and research of the environment.

The main research topics are:

- Crystal chemistry properties of minerals with applications in minerology, geology, materials science and environmental research, with particular emphasis on clay and zeolites.
- Genesis and changes to rocks in the Republic of Croatia and neighbouring countries, with a look at the evolutionary models of development of the Pannonian, Dinaric and Adriatic areas, and the geochemistry research of lithostratigraphic units and geological structures and mineral deposit sites.
- Geoarchaeology – characterisation of archaeological materials using mineralogical methods.
- Geochemical research of the environment with the aim of differentiating geogenic and anthropogenic factors that influence the distribution of metals and other important environmental compounds, with the aim of characterisation, remediation and managing threatened and sensitive environments.

Department of Chemistry
Division of Analytical Chemistry

Various studies are planned to be performed at the Division of Analytical Chemistry for the purpose of developing sensitive and selective analytical methods based on the interactions between metals and ligands. The physicochemical properties of newly synthesized ligands in solid state and in solution will be determined by spectrometry methods (MS, NMR, UV-Vis, Raman), and these will further be applied for the extraction and spectrophotometric and/or spectrofluorimetric determination of metals. Research in the area of analytical atomic spectroscopy will be aimed at developing spectrometry with plasma sources, with the aim of improving the sensitivity of measurements of metals, semi-metals and selected non-metals present in low concentration areas, and achieving the assumptions of speciated analysis of bioactive elements. Spectrometric characterisation of element systems in bio-inorganic materials will involve monitoring the incorporation of trace metals in mineral structures. Atomic spectrometry (AAS, ICP-AES, ICP-MS) will be applied in the characterisation of the chemical composition of good, and biological, geological and archaeological samples, and nanomaterial samples. Methods will be determined of metal determination in real samples, for the purpose of determining the nutritional value and/or toxicity of samples and soil samples, to determine metal bioavailability. Research will be expanded to the study of metal bonds and the antioxidant activity of samples. Special emphasis will be placed on the optimisation of sample preparation prior to instrumental measurements. Analytical data obtained through atomic spectrometry will be further chemometrically processes for elemental fingerprinting of complex real samples. High performance liquid chromatography methods will be applied for analysis of real samples (food, dyes, pharmaceuticals, etc.). Advanced techniques (LC-NMR and LC-MS) will be used to analyse medicine contamination. Conformation analysis will be implemented to monitor the interactions between molecules and to design biological active compounds. Hydrogen bonds and their influence on the stability, structure and reactivity of molecules will also be examined. Process analysis techniques will be developed and applied. Spectroscopy of surface enhanced Raman scatter will be applied in the research of interaction of small organic molecules and nucleic acids, to study the influence of the morphological properties, size and shape of silver and gold nanoparticles on increasing the scatter significance.

Department of Chemistry

Division of Biochemistry

Within several scientific topics, we will examine the structure, function and mutual interaction of proteins and nucleic acids included in the translation of genetic messages. The research will be focused on the enzyme aminoacyl-tRNA-synthetases, which catalyse the esterification of transfer-RON to the appropriate amino acids. The efficient and accurate synthesis of aminoacylated tRNA is a key step in the process of protein biosynthesis in the cells of all organisms. Aminoacyl-tRNA synthetase from selected animals of different kingdoms will be selected for study, including bacteria, methanogenic archaea, plants and humans. Research will examine the mechanisms by which these enzymes catalyse the aminoacylation reactions, and their corrective functions that achieve a high degree of accuracy in catalysis. The mechanical interpretations are based on the kinetic parameters of biochemical reactions (obtained using methods of regular state and pre-regular state kinetics), determination of constants of substrate binding, and study of inhibitor action. The importance of the corrective mechanisms on different physiological conditions will be analysed *in vivo*. Interactions of aminoacyl-tRNA synthetase with small molecules, other proteins, nucleic acids and macromolecular complexes such as ribosomes. Various techniques and methods for the analysis of macromolecular interactions (thermophoresis, fluorescence spectrometry, isothermal titration calorimetry) will be used. Original and specifically altered forms of proteins will be prepared using genetic and protein engineering methods. With the basic role of aminoacyl-tRNA synthetase in the biosynthesis of proteins, special attention will be given to their additional non-canonical functions. Research will examine the role of plant enzymes in cell responses to abiotic stress. Prior research revealed a new family of proteins, homologues of the seryl-tRNA synthetase of a methanogenic type, that aminoacylate carrier proteins instead of tRNA. Using the example of selected representatives of these enzymes from symbiotic bacteria, the metabolic paths they take and their biological role in the cell will be examined. Genetic methods will be used to prepare deletion mutants, determine their phenotype properties and analysis of metabolomes, and contemporary bioinformation methods. In addition to the fundamental significance of this research in explaining biochemical processes, these issues are also interesting from the pharmacological perspective.

Department of Chemistry

Division of Physical Chemistry

Scientific work in the Division of Physical Chemistry is an inseparable part of the teaching process and includes the research in the fields of theoretical and computational chemistry, thermodynamics, chemical kinetics, electrochemistry, colloid and interface chemistry, macromolecular chemistry, chemometrics and education. In theoretical chemistry, quantum-chemical methods are used to calculate potential energy surfaces and dipole moment surfaces, which enables highly accurate determination of spectroscopic properties of molecules and reaction mechanisms. Interactions of biological macromolecules, as well as their structural and dynamical properties, are studied using force field based computational methods with purpose of understanding biochemical processes on molecular level. Thermodynamic investigations involve equilibria of ion association and complex forming reactions in solutions and on the surface. Structures of complexes and relevant thermodynamic parameters are determined by means of experimental and computational chemistry methods. Parallel kinetic investigations provide an insight into the reaction mechanisms. Investigations in the field of colloid and interface chemistry deal with the development of theoretical models and experimental techniques for the characterization of interfaces. Electrodes will be developed for measurement of surface potential. Aggregation, adsorption and electrical interfacial layer at the boundary between metal oxides and aquatic solutions of electrolytes and inert surface/aquatic solutions of electrolytes will be studied. In physical chemistry of macromolecules, properties of polyelectrolytes and proteins in solution are studied, as well as their adsorption on solid substrates. Formation and properties of polyelectrolyte complexes and multilayers are also investigated. Physical chemistry methods will examine atmospheric processes. Chemometric methods will be developed and applied to interpretation of complex experimental data and their reduction to significant parameters. Use is made of modern computer methods, chemometrics, spectrometry, (micro)calorimetry, potentiometry, conductometry, optical reflectometry, electrokinetics and acoustophoresis. Scientific work in the field of chemistry education is dedicated to developing a quantitative approach to chemical problems, based on clearly defined notions and their interrelations.

Department of Chemistry

Division of General and Inorganic Chemistry

The strategy of the Division of General and Inorganic Chemistry is based on the results and experience achieved and attained during the last decade of research through domestic and international research projects. Plans are in place to continue research in the field of new organic and coordination compounds, solid state chemistry, supramolecular chemistry and protein chemistry (*H. pylori* proteins and insulin derivatives) and other biologically active compounds. The research will encompass design, preparation and detailed structural spectroscopic and thermal characterization of the prepared compounds. Research on proteins will include cloning, purification, crystallization, and structural characterization. A variety of experimental methods shall be employed in order to study inter- and intramolecular interactions and their influence on molecular structure and properties.

The main objectives of the above research are:

- Fundamental research in the field of development of new, environmentally friendly, methods of preparation of organic, bioorganic and organometallic compounds;
- Potential application of novel methods of synthesis and materials with designer properties (e.g. optical, thermal or magnetic) in industry;
- New insight into the influence of study inter- and intramolecular interactions on the structure of solids;
- Structural characterisation of proteins for the purpose of obtaining new insight into the relationship between protein structure and function;
- Transfer of the obtained knowledge and experience into education an all levels from undergraduate to postgraduate study;
- Intensifying international collaboration though participation in European and bilateral research projects.

Department of Chemistry
Division of Organic Chemistry

The planned research in this Division is focused in two directions: the synthesis of bioactive organic molecules, and the study of organic reaction mechanisms in the condensed phase.

The first research area is focused on the synthesis of new bioactive compounds containing heterocyclic aromatic and nonaromatic substructures (derivatives of imidazole and quinuclidine) and their reactions with butyro-cholinesterases, based on the idea that these substances could serve as enzyme inhibitors, and therefore possibly be a foundation for new Alzheimer's drugs. Pyridone derivatives containing adamantane units will be tested as possible antitumor agents. Immunomodulating peptides, peptide-glycan fragments of adamantane or mannose. It is expected than mannosylation will increase and direct the immune reaction. Mannolysation of heterocyclics could lead to preparation of anti-adhesive agents capable of blocking E. coli, thereby preventing bacterial infections. The research also includes methods of molecular modelling methods.

The second area of research is focused on development of new conceptual frameworks for explaining mechanisms of thermal organic reactions in condensed phases. Understanding the principles of the reaction laws in the condensed state is of broad scientific interest, especially for chemists developing synthetic methods without the use of solvents.

The methodology of this research is based on inhouse discoveries and research of the mechanisms of nitroso-compound dimerization. Since these molecular systems also show a photochromic/thermochromic effect, it is expected that the synthesized molecular aggregates will possess dynamic properties that can be controlled externally, and thus applied in future systems of molecular electronics and smart materials. These molecules are also studied as possible building blocks for the self-organisation of mono- and multi-molecular layers and three-dimensional supramolecular structures.

Department of Mathematics

Division of Algebra and Fundamental Mathematics

Division activities are focused on the topics described below.

1. Recently, there was important progress in the Langlands program, namely, proof of the existence of the endoscopic transfer of local and global discrete series representations from the split classical groups to GL(n), mainly due to Arthur. The research in our group is coordinated with that development. We calculate Jacquet modules of the discrete series representations, which will enable the full understanding of the parabolically induced representations from the discrete series (generalized principal series). In the theory of automorphic forms, we develop explicit constructions based on the work of Arthur and Moeglin. In that way, we explicitly construct new series not only of the discrete series representations, but also of the isolated unitary representations.
2. The main research topics in the number theory group are the elliptic curves, modular forms, Diophantine equations, Diophantine approximations, and the application of the number theory in cryptography. We study the structure of the groups attached to the elliptic curves over rational numbers and over algebraic number fields. We examine the relations between arithmetic properties of the Fourier coefficients of the modular forms and arithmetic geometry. We research Diophantine m-tuples and their various generalizations, especially in the ring of integers of the fields of small degree. In the area of Diophantine approximations, we examine the problem of separation of the roots of polynomials and connections with the classifications of transcendental numbers. We also research into applications of the elliptic curves and Diophantine approximations in cryptography.
3. In this division there is a group that studies vertex-algebra theory and related infinite-dimensional Lie algebras. We study C_2 finite vertex-algebras which are closely related with mathematical physics and quantum group theory. Special emphasis is on the construction of new vertex-algebras, their representations and intertwining operators. The vertex operator theory is also used in constructions of the new combinatorial basis of representations of affine Kac-Moody Lie algebras, and in proving combinatorial identities. We also examine embeddings of finite dimensional Lie algebras and related conformal embeddings of affine vertex algebras.

Department of Mathematics
Division of Geometry

The main areas of scientific research in this division in the future period can be categorised into three thematic areas, that continue on the research from the previous five-year period.

1. Differential geometry of curves and surfaces in special ambient spaces

The purpose of the research is to study the differential geometry properties of curves and surfaces including Riemann manifolds as the Lorentz-Minkowski space, and Lorentz spatial forms and, in general, affine manifolds; spaces with degenerated metrics, such as isotropic spaces and three-dimensional manifold families, i.e. Thurston spaces. A deeper understanding of these geometries can be attained by studying their submanifolds with certain properties, such as special classes of surfaces of known curvature.

2. Finite geometries and design theory

In this area, we study the issue of the existence and classification of block designs and t-designs, symmetrical configurations, differential groups and designs over finite fields. For the purpose of reduction of combinatorial complexity of a problem, additional conditions are often set, in the form of the action of appropriate groups of automorphisms. Also, we will examine the different regular substructures in final projective and polar spaces. The research intensively uses algebraic and other theoretical methods, as well as computational techniques and methods. The development of algorithms and programs for the construction and classification of final structures is an important part of this research.

3. Geometric properties and special models of quasigroups

We examine the geometric properties of particularly interesting subclasses of idempotent medial (IM) quasigroups, particularly pentagonal quasigroups. One of the fundamental objectives is to determine the spectrum of all orders of the ultimate pentagonal quasigroups, and to extract similar results for other subclasses and establish associations with graphs, directional graphs and designs.

Department of Mathematics
Division of Mathematical Analysis

The division activities are described below.

1. Various forms of orthogonality in Hilbert C*-modules

The main objective of this topic is to continue studying the various forms of orthogonality on Hilbert C*-modules, particularly the Birkhoff-James orthogonality, strong Birkhoff-James orthogonalities and orthogonalities with respect to the internal project. Studying these topics includes a characterisation of various class elements of the Hilbert C*-modules in orthogonality terms, characterisation of overlap between modules that preserves a certain form of orthogonality, consideration of relations between various orthogonalities and similar problems.

2. The base framework between Hilbert spaces and Hilbert C*-modules

The primary goal consists of two parts: continuing research on the fundamental theories of base frames of Hilbert C*-modules. In particularly, we are planning to develop interrelations between the base frame and strict/external base frame of Hilbert C*-modules, and expand the results on perturbations of base frames in the context of Hilbert C*-modules, on the ultimate expansions of Bessel series to base frames and, in particular, to the Parseval bases, on the Riesz bases, etc.

3. Dirac cohomology of Harish-Chandrin modules and their application

Dirac cohomologies is a relatively new invariant of the Harish-Chandrin modules that contains much interesting information. In the coming period, the research will be focused on the following problems: studying representations obtained using Dirac inductions, special representations of discrete series, application of Dirac cohomologies to representation restriction problems; attempts to strengthen the Dirac inequalities with applications on the study of unitary representations, and calculating Dirac cohomologies of the highest weight unitary modules.

4. Inequality for positive linear functionals

The aim of this research is to examine inequalities that apply to positive linear functionalities, such as the Chebyshev and Grüss inequalities with two linear functions, etc. Quasilinearity, monotony and limited functional associated differences that appear in inequalities will be examined. Research will continue on the properties of the h-convex function.

Department of Mathematics
Division of Numerical Mathematics and Scientific Computing

The research interests in the division are divided into two groups: researchers studying numerical linear algebra, generalised spectral and singular value decomposition and its applications, and researchers who study the theorem of approximation, particularly spline approximations.

1. Generalised spectral single value decomposition

Over the past 25 years, algorithms have been developed for generalised spectral and singular value decomposition that has the property of relative accuracy. Division members have been involved in global trends since the start, developing algorithms for these issues. Early algorithms are always bound to the accompanying perturbation theory, proof of convergence, and the development of numerical software (sequential, and recently parallel). The developed algorithms are part of reputed libraries, such as LAPACK and SLICOT. Several researchers are working on problems in infinite spaces. Given the success and recognisability of the research group in the world, and the strong cooperation developed with many universities around the world, the development of accurate algorithms in numerical linear algebra remains our primary goal in the next five-year period.

2. Spline approximations

Part of the division members investigate approximations with a special type of spline function, such as Chebyshev splines, cycloid splines, tension splines, and q-splines. In addition to the development of new numerical algorithms for efficient computing of these splines, the theory of their approximation properties is developed, and based on them, algorithms for specific applications. These algorithms are applicable in various issues of advection and diffusion in geophysics, image processing and in medicine. This research group has very close ties with several Croatian universities, and with the University of Ljubljana. In the next five years, we plan to continue the theoretical and practical work on these issues, to improve the appropriate algorithms.

Department of Mathematics
Division of Applied Mathematics

The scientific activities of this division are focused on the development of mathematical models used in the natural, technical and biomedical sciences. Division activities are associated with mathematical modelling and mathematical analysis of tasks described using regular and partial differential equations that most often originate from continuum mechanics. This includes setup, analysis of properties (existence, uniqueness/non-uniqueness, correctness of the task, etc.) and numerical analysis of models. Research directions at the division are:

1. Development of techniques for partial differential equations (PDE)

We examine: homogenisation theory and application in optimal design and inverse tasks for PDE, Friedrich's system as a frame for studying different types of PDEs, analytical objects and tools for studying fundamental issues in PDE theory, weak topologies on function spaces and distributions, applications in PDEs, and properties of pseudo-differential operators and other techniques of microlocal analysis, and application on rapid averaging, rapid management, compactness of compensation, semi-classic analysis, etc.

2. Fluid mechanics

Research in this field includes mathematical modelling, analysis and numerical simulation of fluid flows in narrow domains (pipes, fissures) or in porous environments. Fluids can be Newtonian or micropolar, single- or multi-phase, and physical processes can be convective, diffusive, dispersive, conductive, isothermal or non-isothermal. Theoretical analysis is based on a priori assessments for initial equations and on various concepts of convergence and compactness. We apply asymptomatic analysis and homogenisation.

3. Elasticity theory

This research relates to extractions and justifications of lower-dimensional models in three-dimensional elasticity. Models for high elastic, plastic, and biodegradable materials are of interest. These models are the basic part in the creation of complex models composed of multiple structures, with possible different dimensions (stick or scale system).

4. Fluid and structure interactions

Due to their application in medicine, the analysis of the interaction of Newtonian fluids and elastic bodies modelled as thin (lower-dimension model) or thick (full three-dimensional model) bodies are of particular interest. Important questions include: existence, uniqueness, stability, solution regularity, design, implementation and analysis of numerical schemes, analysis of parabolic and hyperbolic systems.

Department of Mathematics
Division of Computational Science

1. *Online* combinatorial optimisation algorithms

Aim: to develop new deterministic or randomised algorithms for a known online problem, primarily a problem with the *k* server. These new algorithms must be better than the existing ones with regard to competitiveness or computing complexity. For new algorithms, mathematical analysis of their competitiveness and computing complexity is performed. Experimental evaluation of those parameters on the computer will also be conducted.

2. Distributed heuristics for NP-hard problems

Aim: to develop new distributed heuristics for problems such as vehicle direction (VRP), Hamilton cycle, etc. Thanks to cooperation of many simultaneous processes, these heuristics should be capable of resolving very large problems in an acceptable time frame. For new heuristics, experimental evaluation will be performed on the computer network. Their accuracy (deviations from optimum), calculation time and acceleration will be measured.

3. Robust combinatorial optimisation algorithms

Aim: to develop robust algorithms for selected optimisation problems in graphs and networks. Robust algorithms give acceptable solutions when there is an uncertainty in the input values, expressed through a series of possible "scenarios". For each observed robust variation of the selection optimisation problems, it is necessary to determine the class of computational complexity that this variation belongs to. For each algorithm, mathematic analysis of its computational complexity will be performed. Algorithms will also be evaluated on the computer.

4. Automatic translation

Aim: to prepare mono- and bilingual resources necessary for automatic translation. The prepared resources of graphic algorithms will be analysed and evaluated using relational databases. Development of a system of universal marking of words in the dictionary for the purpose of the proper marking of the appearance of words in the text.

5. Top computational competencies

Aim: systematic monitoring of new trends and steps forwards in disciplines relevant for teaching computer science at the Department of Mathematics. Disciplines of special interest are: programming languages, structure of data and algorithms, databases, computer networks, software engineering, parallel and distributed computing, formal languages and automation.

Department of Mathematics
Division of Probability Theory and Mathematical Statistics

Most scientific phenomena and daily life display an inherent non-specificity. Division scientists use stochastic and dynamic models to describe such behaviour. They rely on stochastic methods to gain insight, predict or make conclusions about this behaviour.
Research projects are aimed at improving the understanding of the role of chance in each of the five following problem groups:

1. Analysis and theory of potential Markov processes
We examine several issues relating to the theory of potential and analysis of trajectory properties of Lévy processes, processes that behave similar to Lévy processes, and Feller processes.

2. Stochastic methods in modelling heavy-tail phenomena
We plan to study tail behaviour of stationary processes, limit theorems for extremes and the sums of chance observations, and the application of the obtained results to analyse time series, in non-life insurance and other areas.

3. Stochastic methods in harmonic analysis
We plan to obtain a complete theory of general "tangled" multi-linear singular integral operators, and to use martingal methods in the characterisation of low permeable filters in wave theory.

4. Stochastic methods in biomedicine and social science issues
We plan to cooperate on the development of mathematical models of the growth of biological lenses (with S. Bassnett, WU in St. Louis), on the analysis of modified branching processes in telomer shortening (with I. Rubelj, IRB), to research the local asymptotic properties of approximate MLE diffusion parameters of drift, and to apply them to the adaptation of the von Bertalanffy model on tumour spheroid data (with Ž. Bajzer, Mayo Clinic), and to improve cooperation established on previous research in the areas of behavioural economics and innovation processes (with J. Cvitanićem, CALTECH, D. Prelecom, MIT, and S. Radas, EI).

5. Ergodic properties of expanded dynamic systems
The aim is to fully describe the invariant likelihood of measures of expanded differential equations on discrete and uninterrupted space, such as the Frenkel-Kontor model, reaction-diffusion equations, and the Navier-Stokes equation, and to statistically describe their dynamics.

Department of Mathematics
Division of Topology

The scientific interests in the division include fundamental research in certain areas of topology and dynamic systems. Planned research is focused in the following areas:

1. Dynamics and models of folded horseshoe maps

Symbolical dynamics and models of folded horseshoe maps. Periodic orbits, Dependence of topological entropy on parameters.

Aim: To study the strange attractor in chaotic dynamic systems of two-parameter (Henon map, Lozi map) families and general horseshoe-like maps of planes. The fact that the Henon-like attractors are models for the behaviour of diffeomorphisms with homoclinic tangencies make them universal structures in the emergence of chaos (though we still do not fully understand the horseshoe strange attractors).

2. Geometry collections of points in Euclidean and non-Euclidean spaces

Resolving the three conjectures of M. Atiyah and P. Sutcliffe (from 2001) on the hypothetical equivariance of a continuous map from the configuration space n of points C_n in the complex manifold flag $Flag_n$=U(n)U(1)x…xU(1). This Atiyah map directly connects classic mechanics with quantum mechanics (description of movement of n spin particles). We introduce mixed Atiyah determinants and prove that their sum is =n!. (For n=3 eight new fundamental dimensions in the geometry of hyperbolic triangles).

Aim: To prove the Atiyah-Sutcliffe conjectures in Euclidean (n≥5), hyperbolic (n≥4) and in the Minkowski space (n≥3).

3. Topology and computability

Investigation of the computable topologies, such as the theory of (semi)computable metric and topological spaces, manifolds and CW-complexes.

Aim: finding conditions in which the cross-section of the co-recursion of countable sets and computable continua containing computable points and issues of computability in Hilbert's cube.

4. Homotopy and forms of semitopological groups

Aim: to continue research in homotopy and the theory of the shape of semitopological groups that expand on the results of the article (2002) of the same name.

4a. Special numbers

Aim: to study certain classes of special sums of generalised Fibonacci series and to discover new Diophantine fours.

5. Connections between Hopf algebroids and Tsygan non-commutative differential calculi and examples from the topology of loop space

Aim: to develop geometric theories of characteristics classes for A-infinite algebras and applications, particularly on spatial modules, invariants in low-dimensional topology associated with topological quantum field theory.

Department of Mathematics
Didactics in Mathematics and Computer Science

The interests of the Chair for Didactics in Mathematics and Computer Science are fundamental research in the areas of mathematics and computer science teaching at all levels. Interests also include researching the understanding and application of fundamental mathematical concepts in the context of mathematics and other course subjects, particularly in the natural sciences.

1. Research of mathematical and computer science education

The aim of the research is to recognise, characterise and understand the appearance and processes that appear or can appear in learning and teaching mathematics and computer science at all levels of education process, by applying existing theoretical frameworks or developing new ones. The focus will be on educational studies (planned and implemented curricula) and studies of conceptual images (including preconceptions and misconceptions) and though processes that pupils and students in teacher training develop while learning mathematics and programming and in solving problem tasks.

2. Research implies fundamental mathematical concepts in the context of the natural sciences

Education research today has recognised many fundamental mathematical concepts and skills that pupils find difficult to comprehend. Meanwhile, their understanding and application is important for mathematics and physics, and other science subjects. To better connect mathematics with other subjects and to develop appropriate teaching content and methods that enable more sensible teaching, the aim is to research these concepts and the comprehension difficulties associated with them within mathematics and other natural science subjects, especially physics.