

MSc Track Geology and Geochemistry - 1e CONCEPT

In this track in depth knowledge of petrology, geochemistry, sedimentology, and tectonics is integrated to study key processes in the interior of the Earth and other planets.

1. *Description of the contents.* Geology and Geochemistry aims to combine state of the art studies in petrology, geochemistry, sedimentology, tectonics and geophysics to study the Earth and other planets. In the setup of Geology and Geochemistry, all disciplines are presented in an integrated manner. We aim to provide students with a broad background before focusing on specific subjects that are closely related to the research topics of the associated Earth Science staff members. Research topics cover the full breadth of geology and geochemistry, including (petroleum-related) carbonate sedimentology, volcanology, field-based igneous or metamorphic petrology, experimental lunar and planetary science, geochronology, geophysical fluid dynamics and isotope geochemistry applied to the interior of the Earth, forensic science and archeology. Hands-on use of state of the art experimental and analytical equipment is supported. The programme consists of 36 EC courses [including 2-week Alps excursion, sedimentology, petrology, geochemistry, and tectonics courses, a course in analytical and experimental techniques] , 12 EC in depth literature review, and 72 EC spread over two individual research projects / work placements.

2. *How does the track relate to other master programmes?* The track is unique in the Netherlands because Amsterdam (a) has a unique combination of analytical laboratories that enable studies of both geochronology and high temperature isotope geochemistry (b) is a national center of expertise for carbonate sedimentology (c) has unique facilities and expertise in volcanology, geophysical fluid dynamics and (experimental) petrology and (c) hosts the largest planetary science research community in the country. Utrecht University has an Earth Materials track that focuses more on deformation, and a Physics of the deep Earth and Planets track that has much more focus on deep Earth geophysics and that (unlike Amsterdam) is not supported by significant research in planetary interiors. The Utrecht Basins, Orogens and Crust-Lithosphere track contains very little if any geochemistry.

3. *Who do we educate?* Our alumni find PhD positions at the best institutes abroad, in the petroleum and steel industry, and in consultancy.

4. *Student numbers.* At present approximately 20 students enroll in this track every year, including several from abroad each year. This track size allows teachers to get to know you, and discuss science with you, on an individual basis very rapidly.

5. *Admission requirements.* Applicants with a Dutch BSc degree in Earth Science, with a geology (as opposed to geography) focus are admitted straight away. Students with a BSc in Future Planet Studies and Earth Science and Economics, and students holding other BSc degrees that provide incomplete backgrounds in geology and/or geochemistry can be provided with tailor-made catch-up study packages.

6. *Which groups are involved?* Staff of the Geology and Geochemistry cluster (VUA) (2.0/12)

MSc Track Earth Surface Dynamics - 1e CONCEPT (van vóór overleg met UvA)

In this track you obtain in depth knowledge of the complex relationships between physical geography, ocean and atmosphere dynamics, global change, land-surface processes, and geo-ecology to study the dynamics of the Earth's surface.

1. *Description of the contents.* Earth Surface Dynamics aims to combine state of the art studies of the recent geological record, physical geography, land-surface processes, ocean and atmosphere dynamics, climate change, geo-ecology, and the role of man in 'System Earth'. Students study the complex relationships between biogeochemical and geomorphological processes in terrestrial and aquatic settings, and the influences of climate change and direct human impact. These relationships are studied at different spatial and time scales. The elective options during the second semester and second year allow you to explore your own interests and specialize for the labour market. Students focus on measurement techniques, combining field inventories and monitoring programmes with laboratory experiments. They can also focus on computer simulations, remote sensing, or spatial statistics methods. The programme consists of 36 EC courses [including excursions, courses in analytical and experimental techniques, remote sensing, biogeochemical cycles, climate modelling], 12 EC in depth literature review, and 72 EC spread over two individual research projects / work placements.

2. *How does the track relate to other master programmes?* To be completed

3. *Who do we educate?* Our alumni find PhD positions at the best institutes abroad, as consultants in engineering companies or at local to national governmental organisations.

4. *Student numbers.* At present approximately 25 students enroll in this track every year, including several from abroad each year. This track size allows teachers to get to know you, and discuss science with you, on an individual basis very rapidly.

5. *Admission requirements.* Applicants with a Dutch BSc degree in Earth Science are admitted straight away, as are students with a degree in Earth Science and Economics or Future Planet Studies who completed a dedicated minor programme.

6. *Which groups are involved?* Staff of the Earth and Climate cluster (VUA) (approx 1.6/17) and staff of IBED (approx. 0.4/4)

The Master's programme Hydrology (VU)

Understanding the complex interactions between hydrological processes and society, and how this may change under global change

1. Description of the contents. The MSc Hydrology at the VU University Amsterdam Water is a MSc program that aims at educating students to understand the complex interactions between hydrological processes and the relation with society, and how this may change under future global change. Topics that are addressed in the program are: (1) How does the hydrological system function and how does it relate with climate, vegetation and society? (2) How can we ensure there is enough water available for every person? (3) Can we ensure water quality for agriculture, biodiversity and drinking water? (4) How can we minimize the impact of extreme flood events in dense urban areas?

The MSc programme Hydrology offers a unique program in The Netherlands where students learn to study hydrological processes and societal interactions from an integrated perspective, using real world examples. Our motto is: 'measuring is knowing', and in the first year, we offer 5 week fieldwork courses in the Netherlands and Luxembourg. For second year MSc Thesis subjects we offer a permanent field site in Kitui, Kenya. In the field courses, students learn to apply field measurements and theory into estimating water risk for society and explore management options to lower risk.

2. How does the track relate to other master programmes? It is unique in the Netherlands in that it applies theory into field work in Luxemburg and Kenya. Furthermore, it is also unique since in the program students learn to study the interaction between the water system and society, both in courses as in the field. Moreover, the economic component is explicitly addressed, for instance related to the value of water and cost-benefit analyses of measures in managing water. The WUR has a master programme Land and Water Management, which has a strong agricultural and governance focus. Utrecht has a Water Science and Management, which is also multi-disciplinary, but has no field work.

3. Who do we educate? (Or which profession have alumni?) The MSc programme prepares students for jobs related to research (university, knowledge institutes), with governments (water boards, municipalities) and business (consultancies). About 30% of the alumni found a job as a PhD student. Others found jobs in water management, education or consultancy.

4. Student numbers Recent numbers of students in the Hydrology master vary between 15 and 20. We aim at an average inflow of 25.

5. Admission requirements. In order to gain admission to one of our Master's programmes, you will need to have at least a Bachelor's degree from an accredited research university including at least three full years of academic study amounting to a minimum of 180 ECTS or equivalent. We do not

require a GRE or GMAT test score. Specific admission requirements for the MSc Hydrology programme:

- A BSc-level knowledge of physics, mathematics, chemistry and basic earth science subjects. The Admission Board decides on admission of any applicant, both Dutch and non-Dutch.
- Students with a Bachelor's degree in Earth Sciences - Geology or Physical Geography - from Dutch universities are eligible for admission with no specific course requirements in their optional programme component.
- Students with a Bachelor's degree in earth science related topics, such as Earth Sciences and Economics (VU) and Future Planet Studies (UvA), are eligible if they have enough (at least two) quantitative beta courses in their final year. Examples for Earth Sciences and Economics at VU include "Wis- en Natuurkunde", "Inleiding in de anorganische geochemie", "Geofysica en computermodellering", "Methoden en technieken voor economisch onderzoek". See the teaching and Exam Regulations for more details or contact the MSc coordinator for specific cases.
- Students with a natural sciences Bachelor's degree from Dutch universities may have an additional requirement in the form of a self-study course on the basics of earth sciences in order to be eligible. Contact the MSc coordinator for specific cases.

In case the applicant has deficiencies on various topics, it may be required to follow a pre-master's programme before being admitted to the MSc programme. This has to be determined on a case-by-case basis.

6. *Which groups are involved in this master track?* Two groups from the Vrije Universiteit are involved: Water and Climate Risk (Jeroen Aerts, Hans de Moel, Philip Ward, Ralph Lasage, Wouter Botzen); Group Eco hydrology (Han Dolman, Sija Stofberg, Jorien Vonk, Eddy Moors, Ype van der Velde, Martijn Westhoff).

The Master's track “Future Planet Ecosystem Science”

In FPES, we teach quantitative methods, and in-depth understanding of concepts of geo-ecological systems, needed to face the grand challenges regarding global change, the management of ecosystems, and their services upon which humans rely.

1. Description of the contents. Human impact on our planet has reached unprecedented proportions. This severely affects biodiversity, geo-ecosystems and the services they provide humanity with. We urgently need an in-depth understanding of the functioning of geo-ecosystems, to predict the effects of local and global change (land use, eutrophication, pollution, climate) and to successfully manage Earth's systems (through e.g. integrated land management, spatial planning, nature and soil conservation). Only then can we rely on the use of ecosystem services in a sustainable manner (provisioning, regulating, supporting, cultural services). This master track teaches cutting-edge, quantitative methods (including observations, experiments and modelling) through application of the methods to these global challenges and identifies where science falls short to meet them.

The program consists of 30 EC mandatory courses, 12 EC literature review, 0-24 EC elective courses, and 54-78 EC individual research projects. The courses that are offered within *FPES* are: Functions and vulnerability of geo-ecosystems; Grand Challenges of Human-Ecosphere Interactions; Quantitative Research Techniques; Research Workshop and Skills Lab; and elective courses such as Biogeochemical cycles; Land use, habitat structure and nature conservation; Ecosystem services; Modeling ecosystem dynamics; Earth observation and environmental monitoring.

2. How does the track relate to other master programs? This is a unique cross-disciplinary program on the interface of earth science, ecology, geography and environmental science. Earth Sciences (VU, UU) and Ecology and Evolution (RUG, UvA/VU) are mainly monodisciplinary. Limnology&Oceanography (UvA) is water oriented; Earth&Environment in Wageningen is focused on soil and water. Most environmental or sustainability studies concentrate on renewable energy and/or societal aspects of environmental management while *FPES* has a strong focus on integrated environmental management strategies informed by quantitative system dynamics assessment methods.

3. Who do we educate? We educate specialists with a profound knowledge of the functioning of geo-ecosystems who can cope with the cross-disciplinary nature of the global challenges we are facing. About 50% of our students will find a job as a PhD student. Others will develop their academic career in organizations such as the International Union for Conservation of Nature (IUCN), NGO's, environmental consultancies or sustainability business.

4. Student numbers We aim at 25 students per year.

5. Admission requirements. There is a limited capacity of max 30 students per year. All students will have an intake procedure. In general students with high grades in a BSc of Future Planet Studies (major AW or B), Earth & Economy, Earth Sciences or Biology, or Environmental Science should be well equipped to follow the programme. Students must be motivated to develop quantitative skills.

6. *Which groups are involved in this master track?* First estimate: CGE/TE (0.7/7.5), ESS/PLE (0.6/9.7), Environmental Geography (0.3/3.9), Systems Ecology (?/3.8), Animal Ecology (?/6.6), EB/EPS/PB (0.3/11) total (1.9+?/42.5) *getallen kloppen nog niet.*

The MSc track “Governance in the Anthropocene” (GTA)

Prepared by Pieter van Beukering and Philipp Pattberg

1. Description of the content:

Meeting the challenges of sustainable development requires action that changes the status quo: given the powerful interests at stake, this will require a deep and broad commitment from political and business leaders, civil society, and individual citizens. The MSc track “Governance of the Anthropocene” (GTA) aims to create an understanding among future sustainability experts where current trends are taking us, figure out what the causes are of these trends, and design new governance mechanisms that might change course of unsustainable trajectories. The MSc track GTA provides a specialization for students that want to develop in the societal domain of sustainability. The GTA track concentrates on sustainability issues in the Anthropocene at **different scales**.

- At the global level, international negotiations, multilateral organizations, international trade and migration are addressed.
- At the national level, public-private partnerships, environmental policies, economic instruments and natural capital are the focal topics.
- At the local level, environmental behavior, community based management, sustainable finance, and green entrepreneurship receive specific attention.

Typical methods that are taught in the GTA track include for example policy analysis, stakeholder analysis, risk analysis, economic valuation, and economic modelling. The range of environmental themes that the GTA track concentrates on includes among others water, energy and ecosystems. Moreover, the GTA track is truly **inter- and even transdisciplinary**. There is a strong need for more inter- and transdisciplinary approaches to environmental research, which require fundamentally new skills such as being able to work in diverse teams and have capabilities to constantly adapt to new enabling conditions. These skills are needed to meet the more integrated research challenges such as those defined in the context of Future Earth, but also the skill requested in new jobs in the commercial and policy-advice domains. |

2. How does the track relate to other master programs? The GTA track distinguishes from other MSc programs by the dominance of economic and political sciences in the program in combination with a sound biophysical and natural science foundation provided by natural scientist at the VU and the UvA. The GTA track differentiates from the problem-oriented one-year MSc Environment and Resource Management (ERM) through its stronger emphasis on learning academic research methods. Possible competing MSc programs in the Netherlands are shown in Table 1.

Table 1. Relevant MSc programs in the Netherlands

Naam opleiding	Brin-Isat	Vervaldatum CROHO 28-4-2015	Naam onderwijsinstelling
M Energy and Environmental Sciences	21PC-60608	30-6-2016	Rijksuniversiteit Groningen
M Environment and Resource Management	21PL-60045	30-7-2018	Vrije Universiteit Amsterdam
M Environment Sciences	22NC-60164	30-7-2018	Open Universiteit
M Environmental Sciences	21PD-60810	30-7-2020	Universiteit Utrecht
	21PI-60810	30-7-2020	Wageningen University
M Industrial Ecology	21PB-60415	6-9-2016	Universiteit Leiden
	21PF-60415	6-9-2016	Technische Universiteit Delft
M Milieu-Maatschappijwetenschappen	21PM-66839	30-7-2020	Radboud Universiteit Nijmegen
M Sustainability Science and Policy	21PJ-69315	3-7-2019	Universiteit Maastricht
M Urban Environmental Management	21PI-60110	30-7-2020	Wageningen University

3. *Who do we educate?* The GTA track educates gamma-experts in Governance in the Anthropocene. There is a good market for people with excellent skills in the governance domain of sustainability combined with a good understanding of the biophysical foundations. Such potential jobs are found in academia, the private and the public sector, and in civil society. EEE would become an educational pioneer under the overall Future Earth philosophy and attract a broad range of international students that especially come to Amsterdam for these inter- and transdisciplinary studies.

4. *Student numbers:* We estimate that a sustainable number of students for this track is between 25-30. The GTA track would be the ideal “doorstroom” programme for two strong interdisciplinary BSc programs, namely Future Planet Studies and Earth Science and Economy, which together attract BSc student numbers between 200 to 300 per year. Besides these predominantly Dutch students, GTA will actively target international so that a balance population of Dutch and foreign student will develop (i.e. 50:50).

5. *Admission requirements:* Applicants to this track should hold a BSc degree in political science, economics, sociology or an equivalent degree. Also students with a gamma major in the BSc Future Planet Studies or equivalent degree are eligible to the GTA track. A strong motivation and an average grade of 7.0 in the BSc degree are selection criteria for admission. Same standards apply for Dutch and international students. A future market assessment of the GTA track will be initiated to further tailor the programme towards the demand and supply of Governance in the Anthropocene.

6. *Available staff:* The FALW, and especially the IVM, has a long experience in interdisciplinary gamma education. It has a wide range of expertise and well trained and certified teachers. The majority of these teachers has excess capacity to be mobilized for the new GTA track. Moreover, new capacity is being recruited at the moment. Table 2 shows the current and expected teaching capacity. The majority of the teaching capacity will be provided by the Environmental Economics (EE) and Environmental Policy Analysis (EPA). Two other groups in the FALW-VU, Water & Climate (W&C) and Environmental Geography (EG), will also provide expertise and input in GTA.

Table 2. Teaching capacity for the “Governance in het Anthropocene” track

Name	Position	FTE	Specialisation
Core staff for “Governance in the Anthropocene”			
<i>Environmental Economics Group</i>			
Wouter Botzen	HL	1	Natural Hazards, Economics
Pieter van Beukering	UHD	0.9	Ecosystem services, Energy, Economics
Onno Kuik	UD	1	Trade, Energy, Economics
Frans Oosterhuis	Ond	1	Economic Policy
Julia Blasch	UD	0.8	Environmental behavior, Economics
Vacancy (per 1-9-2016)	UHD	1	Natural resource management, Economics
<i>Environmental Policy Analysis Group</i>			
Philipp Pattberg	HL	1	Earth governance
Dave Huitema	UHD	1	Water governance
Aysem Mert	UD	1	Ecosystem Governance
Vacancy (per 1-1-2017)	UD	1	Governance
<i>Environmental Geography Group</i>			
Peter Verburg	HL	1	Earth governance
Astrid Teefelen	UD	1	Environmental geography
Jasper van Vliet	UD	1	Environmental geography
Nienke Schulp	UD	1	Environmental geography
<i>Water & Climate Group</i>			
Jeroen Aerts	HL	1	Water and Insurance
Mark Bokhorst	UD	1	Earth Science & Economy
Philip Ward	UHD	1	Global change and risks
Hans de Moel	UD	1	Global change and risks

The Master's track Limnology and Oceanography

The Master's track in Limnology and Oceanography is devoted to the biology, chemistry and physics of aquatic ecosystems to better understand and protect the world's lakes, seas, and oceans.

1. Description of the contents. The Master's track L&O is all about the biology, chemistry and physics of water systems with studies in lakes, rivers, seas and oceans. This programme deals with both freshwater and marine ecosystems including topics such as impacts of climate change on freshwater and marine ecosystems, harmful algal blooms and water management, the role of aquatic microorganisms, the biodiversity of coral reef ecosystems, food-web interactions and fisheries, sediment-water interactions, the responses of aquatic organisms to changes in water quality.

The topics are investigated from different perspectives, ranging from molecular studies to laboratory experiments and field investigations, long-term monitoring and the development of advanced mathematical models. Among this wide range of opportunities, students select those topics and approaches that best fit the student's own interest.

The programme consists of 30-36 EC courses, 12 EC literature review, and 72-78 EC individual research projects. The courses that are offered within the L&O programme are: Introduction to Limnology and Oceanography, Ecological Water Management, Microbial Ecology, Ecotoxicology and Water Quality, Biological Oceanography, Benthic Ecology, and Coral Reef Ecology.

2. How does the track relate to other master programmes? It is unique in the Netherlands in that it devotes attention to both freshwater and marine ecosystems and integrates the scientific disciplines relevant to all aquatic ecosystems. The Rijksuniversiteit Groningen has a master programme Marine Biology, while Wageningen UR has Marine Biology as a speciality of the Biology Master. Nijmegen University has a speciality Water and Environment in the master Biology. Utrecht University has a master Marine Science and a master Water Science and Management.

3. Who do we educate? (Or which profession have alumni?) About 50% of the alumni found a job as a PhD student. Others found jobs in water management (e.g. water boards), education (e.g. secondary school) or consultancy (companies e.g. Royal HaskoningDHV or Witteveen & Bos)

4. Student numbers Recent numbers of students in the master track L&O vary between 25 and 30 per year.

5. Admission requirements. Applicants should hold: a Dutch Bachelor of Science degree or its equivalent in Biology. A Bachelor course in Aquatic Ecology and/or Marine Biology is required for all students. Students without such a Bachelor course can follow a self-tuition course combined with an intake interview before entry into the Master's programme. A Bachelor degree in Chemistry, Physics, Mathematics, Biomedical Sciences, Psychobiology or Future Planet Studies may also qualify, but the suitability and knowledge of a student will be assessed prior to admission. In case of deficiencies, following a pre-master's programme of Bachelor courses might be necessary. An interview may be part of the procedure. Additional requirements: a bachelor's Grade Point Average (GPA) of 6.5 or higher (according to the Dutch grading system); the Bachelor's degree obtained

within 4 years; a Bachelor's Thesis (experimental work) of at least 15 ECTS credits. The subject of the Bachelor's thesis must show affinity with, and advanced knowledge of, Marine and/or Aquatic Biology.

6. *Which groups are involved in this master track?* Mainly Aquatic Microbiology (Jef Huisman, Gerard Muijzer, Hans Matthijs, Maayke Stomp, Mark Vermeij, Petra Visser, Corina Brussaard, Lucas Stal; total contribution estimated on 45%) and Aquatic Environmental Ecology (Michiel Kraak, Harm van der Geest, Jasper de Goeij, Pim de Voogd, Piet Verdonschot; total contribution about 45%) are involved in this track. From other groups staff play roles as supervisor, assessor and examiner: Theoretical Biology (2%; André de Roos), Earth and Surface Processes (2%; John Parsons), Evolutionary Biology (4%; Hans Breeuwer, Katja Peijnenburg), Computational Geoecology (2%; Judy Shamoun-Baranes). Next year the group of Gerald Ganssen/Frank Peeters of the Department of Earth Sciences of the VU will be involved in the course Biological Oceanography and consequently also in supervision of individual research projects. A contribution of Prof. Jaap van der Meer (VU) would also fit very well in this master track and will be discussed.

The MSC track “Adaptation from Organisms to Ecosystem” (ADORE)

ADORE will breed the New Ecologists who can provide the fundamental science underpinning the adaptations and responses of our natural treasures, from organism to landscape, to our changing environment.

1. Description of the contents. In order to understand, anticipate and, where needed, help to mitigate impacts of environmental changes as a result of climatic/atmospheric change or human alteration of ecosystems, the *New Ecologist* needs to have a profound and up to date understanding of (1) how organisms vary in their traits reflecting evolutionary adaptation; (2) how, based on these traits, these organisms interact among themselves and with their environment (behavioral ecology, community dynamics, competition, eco-evolutionary dynamics, ecosystem engineering, facilitation, functional biodiversity, mutualisms, population dynamics, trophic interactions); (3) how changes in climate or human ecosystem use affect these organisms and their interactions, and impact ecosystem functions; (4) how, in turn, organisms and their interactions themselves feed back to their environment (soil, water, atmosphere, climate, biogeochemical cycling); (5) how ecosystem management and conservation actions can steer such changes in the desired direction. In this track we will put special focus on how to predict future community structure and ecosystem functions given particular climatic changes, human exploitation and conservation measures. We will also try to learn from the past (paleoecology) and link past evolution over geological time scales to eco-evolutionary dynamics relevant to biodiversity, community composition, ecosystem functions and conservation this century.

The focus will be on deepening the students’ understanding of ecological relations and evolutionary adaptation, with modules within each course on how to apply ecological theory in a particular profession (see below). Course tools include critical literature discussions in groups; small research projects involving ecological field and laboratory work and ecological modeling; writing a research proposal; writing an environmental change impact report.

2. How does the track relate to other master programmes?

This track will connect to the track on ‘Genes, genomes and evolution’ in that adaptive traits of organisms will be important. However, we will focus the scale from entire organisms all the way up to biome. Also, while case studies on aquatic ecosystems will feature occasionally, the focus will be on terrestrial ecosystems, from the Tropics via the subtropical and temperate zones to the Arctic. This will distinguish the track clearly from the Limnology and Oceanography track. Distinction from the Deep earth sciences track will be clear because of our focus on the upper earth surface still being influenced by organisms today. While opportunities for joint activities with the ‘Ecosystems at our service’ track are clear because of the common interest in environmental impact, this track will remain in the domain of ecology and evolution itself, with

particular emphasis on adaptation of organisms, populations and ecosystems. 'ADORE' will have fundamental ecological theory as the starting point but will apply this theory to specific environmental issues.

Nationally, this is the only MSc programme that combines ecology and evolution by (1) putting the variation in functional traits central, and by (2) both how traits underpin adaptation of organisms and ecosystems and how they influence their ecosystems. An urgent illustration of this concept is how traits drive species invasions into new ecosystems and how subsequently they alter those ecosystems.

3. *Who do we educate?* Typical *New Ecologist* careers targeted with this track include:

- Researcher at a university or national research institute with a strong international profile; the route towards this career must go via a PhD study and degree to follow this master track. At least 50 % of the participants are forecast to follow this route.
- Researcher at a regional research institute or national environmental management institutions with a more applied remit. This career can but does not need to go via a PhD.
- Researcher at an environmental consultancy that tackles the larger, often longer term environmental issues (i.e. beyond the straightforward monitoring of populations or small local areas of land/water). This career can but does not need to go via a PhD.
- Scientific advisor at nature conservation agency.

An educational variant will be possible through specific choice of courses and internships / teacher training, targeted towards a career as biology teacher at secondary school; or educator / public relations officer at higher academic institute, museum or nature education center.

4. *Student numbers* We aim at 25 students per year

5. *Admission requirements* To be added later

6. *Which groups are involved in this master track?*

Animal Ecology (0.5/6.6), Systems ecology (0.5/3.8), Population Biology (0.4/4?), Theoretical ecology (0.2?/5.6), Paleo-Ecology and Landscape Ecology (0.2?/5), Experimental Plant Systematics (0.1?/3.2), Evolutionary Biology (0.1?/4?)

The MSc track ‘Genes, genomes and evolution’

1. Description of the contents. This track addresses one of the major scientific challenges of our time, which is to understand how genetic variation influences the functioning and interaction of organisms. Such knowledge is crucial for our understanding of trait variation that governs ecological interactions and evolutionary processes, as well as for the success of breeding programs to optimize economically important crops. We provide the students with detailed insights in molecular biology and genome analysis to obtain an integrated view on plant and animal functioning, which is essential in modern biology. Students will be trained to apply fundamental knowledge about genetic variation for innovative use in plant breeding and animal ecology.

Major topics and skills covered in this track:

- Understand genetic, biochemical and cellular processes that underlie organismal functions from an evolutionary perspective
- Investigate how variation in these processes explain ecological interactions and speciation
- Apply fundamental knowledge about genetic variation in breeding programs
- Learn to generate and handle big datasets associated with genome-wide research and obtain insight in the most important bioinformatics analyses with relevant software packages

These skills will be trained in the context of the following research themes:

- Plant-herbivore interactions
- Evolutionary ecology of stress tolerance
- Improving pest resistance of plants
- Soil Ecological Genomics
- Evolutionary loss and gain of traits

2. How does the track relate to other master programmes?

With regard to available MSc tracks at other universities we conclude that this track uniquely integrates applied and fundamental research on functional variation in organisms at molecular/genome-, cellular and organismal level. All proposed topics can also be identified among MSc Biology programmes at other academic institutions. However, these are mostly presented as independent/individual specialization programs and are, as such, not integrated as a single dedicated MSc track. Therefore, we feel that we provide an appealing, competitive MSc track that covers most aspects of modern/new biology essential for a successful career development as an academic researcher.

3. Who do we educate?

The track prepares students for research positions as a PhD or at commercial breeding and genomics companies.

4. *Student numbers* We aim at 20 students per year.

5. *Admission requirements.*

Applicants should hold a Dutch Bachelor of Science degree or its equivalent in Biology with a minor in Biomolecular Sciences or a different minor including a genomics, evolutionary genetics or gene regulation course. A Bachelor degree in Biomedical Sciences may also qualify provided that they have sufficient evolutionary courses in their final year.

6. *Which groups are involved in this master track?*

Animal Ecology (0.5/6.6), Systems ecology (0.1/3.8), Evolutionary Biology (0.4/4?) Population Biology (0.2/4?), SILS (1?/8?)

Suggested courses

Compulsory

- Plant Breeding and Biotechnology. 6 EC, compulsory, coordinator Haring
or Environmental Genomics and Adaptation., 6 EC, elective, coordinator Roelofs
- Biotic Interactions. 6 EC, compulsory, coordinator Schuurink
- Suggested new course, hands-on Bioinformatic analyses (see below for details). 6 EC
- Master classes, 3 EC compulsory (merging GLS, IBED and VU-NOL)

Elective (select 12-18 EC)

- Abiotic stress. 6 EC, elective, coordinator Munnik
- Current Trends in Evolution. 6EC, elective, coordinator Groot
- Developmental Biology. 6 EC, elective , coordinator Koes

Above mentioned courses are already well developed and exist within the current GLS track and/or Ecology and Evolution track. It is suggested to adjust the content to provide a somewhat broader context.

Plant Breeding and Biotechnology could be reshaped in such a way that the first 2 weeks will be reserved for teaching general molecular biology and genomics information. Week 3 and 4 could be organized in two parallel programs: one fully dedicated to Plant Breeding and Biotechnology, and another one dedicated to molecular evolution of functional traits.

The remaining courses do not need to undergo major changes. I propose to evaluate whether a balanced input from either animal or plant molecular/genomic expertise can be provided.

Suggested new course

- Bioinformatics or Genomic data analysis, 6 EC compulsory. Hands-on analyses of Gene expression/RNaseq data, Population Genomic RAD tag/SNP analyses, GWAS (Genome-phenotype mapping) Apply state-of-the-art R packages. I suggest to set this up with the help of Bioinformatics

and Systems Biology at UvA in collaboration with Lecturers that can provide relevant datasets from existing research.

Practical Training

- Students are required to successfully complete two Research internships at UvA, VU or (inter)national partner labs. Moreover a MSc literature thesis is suggested.