

Curriculum for the award of the Degree of

# **Master of Science in Environmental Biology**

options:

- **Ecology & Evolution**
- **Plant & Microbial Sciences**
- **Applied Environmental Biology**
- **Teaching**

Accepted by the Faculty of Science and Medicine on 30.05.2022  
Revised version of 14.04.2025

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# 1 General Remarks

Major environmental problems, in particular global change and its consequences for biodiversity and ecosystem functioning, are intimately interconnected and pose a threat to our future. Solving these problems requires an integrative and synergistic approach in terms of both fundamental and applied research. The Department of Biology of the Faculty of Science and Medicine offers a multidisciplinary **Master of Science in Environmental Biology**. The program ranges from fundamental concepts in **ecology and evolution, molecular aspects of plant and microbial sciences to applied solutions for environmental policies and sustainable development**. It provides students with state-of-the-art training and background in conceptual, technical, and applied aspects of environmental biology, from genes to ecosystems.

Master students are integrated into active research teams and can thus gain extensive experience in basic and applied academic research in environmental biology. Students will have the opportunity to choose between four options: **Ecology & Evolution, Plant & Microbial Sciences, Applied Environmental Biology, and Teaching**.

This curriculum introduces the course structure of the MSc study programme in environmental biology, which offers four options of specialization. It is based on the regulations of the Faculty of Science and Medicine governing the acquisition of the title of Master of Science (hereafter called Regulations).

The Regulation of 30 May 2022 for the award of the Bachelor of Science and Master of Science degrees establishes a limit on the duration of Bachelor's and Master's studies, as well as of the minor study programmes (<https://www.unifr.ch/scimed/fr/rules/regulations>).

## 1.1 Academic Titles and Programme of Study

The Faculty of Science and Medicine of the University of Fribourg awards the official academic title of **Master of Science in Environmental Biology**, subsequently called **MSc**, to students who have successfully completed their respective study programme and obtained the title of Bachelor of Science (BSc) or a recognized equivalent.

Graduates of this program will be well prepared for careers inside and outside academia, e.g., in university research and higher education, teaching, agroindustry, federal research institutes and offices (including institution such as Agroscope, FIBL, HAFL, HEPIA, BAFU, BLW, WSL), cantonal offices, private foundations or small-scale businesses. The Master's degree in Environmental Biology also paves the way to doctoral studies (PhD) in this subject area (depending on the institution, additional requirements might apply). When accompanied by a subsidiary subject in a discipline figuring on higher secondary school curricula, the MSc, option Teaching, allows students to follow a complementary didactics programme leading to the qualification as a higher secondary school teacher (*Diplôme d'enseignement pour les écoles de maturité (DEEM) / Lehndiplom für Maturitätsschule (LDM)*).

Candidates in possession of a BSc in Biology of the University of Fribourg or any other Swiss university are admitted to the MSc course of studies (Art. 8 of the Regulation). This is also the case for Bachelors of biochemistry, provided they have chosen the necessary courses in their BSc curriculum. Candidates in possession of a BSc degree from abroad, in a different subject or of equivalent degrees (e.g. after graduating from an engineering school) can also be admitted to the MSc study programme by a decision of the Faculty of Science and Medicine to be made in each individual case. Provisional admission can be granted and depends on the fulfilment of additional requirements set by the Faculty (cf. Section 2.4).

## 1.2 Course Structure

The MSc study programme in Environmental Biology spans three or four semesters depending on the option corresponding to either 90 or 120 ECTS credits.

The programme consists of four options:

- Ecology & Evolution (EE) (120 ECTS)
- Plant & Microbial Sciences (PMS) (120 ECTS)
- Applied Environmental Biology (AEB) (120 ECTS)
- Teaching (TE) (90 ECTS)

The three first options are oriented toward research, while the latter is suited for students who want to become school teachers.

Each option consists of three modules:

- Master courses: 50 ECTS for EE, PMS, and AEB; 37.5 ECTS for TE.
- Master thesis related activities: 10 ECTS for EE, PMS, and AEB; 7.5 ECTS for TE.
- Master thesis: 60 ECTS for EE, PMS, and AEB; 45 ECTS for TE.

The course language will be English. An agreement with the Universities of Bern and Neuchâtel (BeNeFri convention) allows students to take elective courses in these institutions and to have them credited for the study program in Fribourg.

The MSc courses can only be assessed and recognized after successful completion of the BSc.

### 1.2.1 Description of the options

The Master of Science in Environmental Biology offers four options. These options are complementary, but also contain shared courses, and students have the opportunity, next to a set of mandatory courses, to customize their study plan according to their interests. The EE, PMS, and AEB options focus on research; the TE option is appropriate for students who would like to become teachers. The four options are:

1. *Ecology & Evolution* (EE, 120 ECTS). This option is centred on the conceptual and empirical aspects of ecology and evolution. It covers fundamental areas ranging from population, community to ecosystems ecology; theoretical ecology and evolution; eco-evolutionary feedback dynamics; evolutionary and population genetics; evolutionary and ecological genomics; behavioural ecology; the evolution of life histories and aging; as well as phylogenetic analyses of organismal relationships. Research groups in these areas work on a variety of study systems and use a broad range of experimental, observational, and theoretical approaches. Biological systems include various insects; birds; plants and their microorganismal communities; microbial soil communities; relict tree species; threatened aquatic species; invasive species; and alpine vegetation ecosystems. Methods encompass laboratory experiments; field observations and experiments; genomics and bioinformatics; statistical analyses; computer simulations and theoretical modelling.

2. *Plant & Microbial Sciences* (PMS, 120 ECTS). This option focuses on the molecular aspects of plant health and development and includes the study of plant-associated microbiota. It covers an exciting range of subjects such as molecular signalling systems, resistance and tolerance of plants to biotic and abiotic stress, the molecular basis of immunity, interactions between plants and their symbionts, plant microbiota, biological control, chemical communication, as well as plant biotechnology. To address questions in these areas, research teams use various well-established model plants (*Arabidopsis*, *Petunia*, tobacco) and plants of agronomical relevance (potato, tomato, grapevine). They rely on a wide array of methods including biochemistry, molecular biology, genetics, genomics, proteomics and metabolomics as well as cellular imaging. For projects oriented towards field application, researchers collaborate with agronomical research institutions such as Agroscope, FiBL (Forschungsinstitut für biologischen Landbau), the agricultural school in Grangeneuve, as well as with industries.



3. *Applied Environmental Biology* (AEB, 120 ECTS). This option addresses important applied facets of environmental biology, especially in terms of biological invasions, conservation biology and sustainable crop protection; it also addresses the consequences of global change. In collaboration with the Environmental Sciences and Humanities Institute, students have the opportunity to learn about major current issues in environmental ethics, policy making and sustainable development. Research methods in this area include for example field and laboratory experiments; database mining and meta-analyses; computer simulations; as well as working out policy recommendations. Researchers in this field (working mostly on applied aspects of ecology and microbiology) collaborate with applied research institutions such as Agroscope, FiBL (Forschungsinstitut für biologischen Landbau), or CABI. This master option also offers the opportunity to carry out either a short research internship or the master project in such a partner research institution.
4. *Teaching* (TE, 90 ECTS). This option combines core courses from the 3 research options and aims at giving a general overview of the Environmental Biology Master programme. It is strictly reserved for students who need to acquire 30 additional ECTS credits in another domain to apply for the education as teachers at secondary level II (DEEM/LDM). These students can also choose one of the 120 ECTS options, or change from the 90 ECTS to a 120 ECTS option while still in their 1<sup>st</sup> or 2<sup>nd</sup> semester of Master studies.

### 1.3 Acquired Skills

The master students in this program will acquire cutting-edge knowledge and skills in basic and applied aspects of environmental biology, from genes to ecosystems. The program emphasizes the development of both scientific and soft skills, e.g., independent analytical thinking, problem-solving, critical evaluation and analysis of data, oral and written communication, and the ability to work in a team. Courses are accompanied by discussions, student presentations and project writing exercises. The master thesis is carried out in one of the research teams, possibly in collaboration with other research institutions, giving students the opportunity to experience all aspects of the daily life of a research scientist. Students also have the opportunity to present their work during a research seminar.

### 1.4 Assessment of Courses and Acquisition of ECTS Credits

Acquisition of ECTS credits occurs in three steps: assessment of the courses, grouping of courses into validation package, and awarding the respective credits.

Exercises are assessed following the criteria given at the beginning of the course. Admission to the exam corresponding to a lecture course can be subject to meeting the requirements of the corresponding exercise class. **Assessment** of lectures is made by an oral and/or written exam, whose type and duration are regulated in an appendix of this curriculum. Exams take place during the official exam periods (sessions) in winter, summer, and autumn. Students register via the students' web portal MyUniFR (<https://my.unifr.ch>), within the stipulated delays for each exam according to the on-line procedure. The marks range from 6 (highest mark) to 1 (lowest mark). An exam marked below 4 can be repeated once at the next exam session at the earliest.

**Validation packages** comprise multiple, separately assessed courses. The Regulation determines the number of these package whereas this curriculum determines their content. There are two validation packages:

- The *first package* consists of the master courses and the master thesis related activities;
- The *second package* (60 ECTS or 45 ECTS credits) consists of the Master Thesis Module.

The conditions for validation of ECTS credits are described in the Regulation.

Students can acquire more ECTS credits than needed for the *first package* (45 or 60 ECTS), provided these do not exceed 20% of the credits foreseen for a given package. Further additional ECTS credits will be validated separately. The chronological order of validation is decisive.

Changing from one option to another is possible provided that:

- 1) the average of the grades acquired in the current validation package is at least 4.0.
- 2) the prerequisites to access the new option are met.

After the validation, upon request, the Dean's office will issue transcripts of records in which exam results and awarded credits are acknowledged, provided the exam fee has been paid.

## 1.5 Ethics and Science

Ethical principles are an integral part of a scientific education. Accepted international conventions must be respected during research and while documenting all scientific work whether it be a project, a lecture, a thesis, or a report. In particular, every external source of information (articles, lectures, web pages, etc.) must be correctly cited. Every student of the Faculty of Science and Medicine has to sign a formal commitment to restrain herself/himself from plagiarism.

In this context, the Faculty has established two compulsory courses that must be completed during the course of study in order to validate the degree. These courses are listed below:

Detailed descriptions can be found at: <https://www.unifr.ch/scimed/en/integrity>

### 1. Basic orientation and research in the library (part 1)

The aim is to learn about the specific objectives and methods of documentary research.

This course must be completed during the first semester of study. You will only be able to view your results after you have successfully completed this course and submitted the signed 'Declaration of Scientific Integrity' form.

### 2. Systematic research and document management (part 2)

The aim is to prepare and carry out documentary research in a systematic and comprehensive manner.

This training must be completed before or during your Bachelor's or Master's degree. It is compulsory in order to validate your Bachelor's or Master's degree.

## 1.6 Regulations and Additional Information

Detailed information about studying Biology can be found in the documents referenced on the web page <http://www.unifr.ch/scimed/en/plans> which can also be obtained from the Office of the Department of Biology.

## 2. Master of Science

### 2.1 Courses Units

For each option, the *Master in Environmental Biology* offers a series of obligatory (O), recommended (R), and elective (E) courses. The courses are divided into research skills and core scientific courses. The research skill courses aim at developing skills in biostatistics and modelling, experimental and laboratory work, bioinformatics, as well as literature study and scientific writing. The core scientific courses provide fundamental and advanced scientific knowledge in environmental biology.

The students follow the obligatory courses (O) according to the options they have chosen. They then complete their list of courses (50 ECTS for the EE, PMS, and AEB options; 37.5 ECTS for the TE option) with recommended (R) and elective (E) courses. It is advised to choose courses from the list of recommended (R) courses, but elective (E) courses can be chosen as well. Section 3 provides a table summarising the list of all course (O, R, and E)

If prerequisites are met, students can also replace ECTS credits from recommended courses by ECTS credits from elective courses among those offered in the study plans of the *Master in Molecular Life and Health Sciences* and the *Master in Bioinformatics and Computational Biology*. For the full list of courses offered in these master programs, please see the respective study plans. In addition, master level courses at the Universities of Berne and Neuchâtel can also be chosen as elective courses through the BeNeFri convention. An elective course not listed in the study programme may also be taken. In this latter case, the student must consult the study advisor.

Note that some courses require prerequisites, which are explicitly stated at the end of the descriptions (sections 2.2.1 and 3). Some courses are also given in alternance every two year (biennially) with another course. It is recommended to attend the courses given annually during the 1<sup>st</sup> year of the master.

**2.1.1 Option Ecology & Evolution**

[Version 2024, validation packages : PV-SBL.0000109, PV-SBL.0000110]

| Code                                                                                                                                                                                                               |                                                                      | Semester | Tot. h. | ECTS |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------|---------|------|
| Obligatory courses                                                                                                                                                                                                 |                                                                      |          |         |      |
| Research skills                                                                                                                                                                                                    |                                                                      |          |         |      |
| SBL.20001                                                                                                                                                                                                          | Biostatistics I - generalized linear models and mixed effects models | AS       | 28      | 3    |
| SBL.20002                                                                                                                                                                                                          | Biostatistics II - multivariate analysis                             | AS       | 28      |      |
| The students must follow at least one of the two <i>Biostatistics</i> courses. They can follow both courses; in this case, they will be credited 3 ECTS for obligatory courses and 3 ECTS for recommended courses. |                                                                      |          |         |      |
| SBL.06002                                                                                                                                                                                                          | Classical models in biology (lecture)                                | SS       | 28      | 3    |
| SBL.06003                                                                                                                                                                                                          | Classical models in biology (exercises)                              | SS       | 14      | 1    |
| SBL.20005                                                                                                                                                                                                          | Critical reading                                                     | AS+SS    | 28      | 3    |
| SBL.00410                                                                                                                                                                                                          | Scientific writing                                                   | AS       | 28      | 3    |
| Scientific core courses                                                                                                                                                                                            |                                                                      |          |         |      |
| SBL.20031                                                                                                                                                                                                          | Community ecology                                                    | SS       | 28      | 3    |
| SBL.20032                                                                                                                                                                                                          | Population and evolutionary dynamics                                 | SS       | 28      | 3    |
| SBL.20034                                                                                                                                                                                                          | Evolutionary genomics                                                | SS       | 28      | 3    |
| SBL.00205                                                                                                                                                                                                          | Ecological field course                                              | Summer   | 11 days | 5    |
| Total ECTS for obligatory courses                                                                                                                                                                                  |                                                                      |          |         | 27   |

**Recommended courses**

Beside the following list of recommended courses, students can also choose elective courses.

*Research skills*

|           |                                                     |    |        |     |
|-----------|-----------------------------------------------------|----|--------|-----|
| SBL.00504 | Basics in Biostatistics                             | AS | 14     | 1.5 |
| SBL.00427 | Visual communication of data                        | SS | 8      | 1   |
| SBL.30001 | Introduction to R                                   | AS | 24     | 2   |
| SBC.07110 | Introduction to UNIX and BASH                       | AS | 40     | 2.5 |
| UniBe     | Introduction to high-performance computing          | AS | 2 days | 1   |
| SBC.07107 | Bioinformatics (practical + in silico) <sup>1</sup> | AS | 42     | 3   |

*Scientific core courses*

|           |                                                               |        |         |   |
|-----------|---------------------------------------------------------------|--------|---------|---|
| SBL.30004 | Organization and annotation of Eukaryote genomes <sup>2</sup> | AS     | 6 days  | 3 |
| SBL.20041 | Global change biology                                         | AS     | 28      | 3 |
| SBL.20037 | Invasion biology                                              | AS     | 28      | 3 |
| SSE.00433 | Principles of environmental ethics (advanced) <sup>8</sup>    | AS     | 28      | 3 |
| SBL.20038 | Research internship                                           | Summer | 1 month | 4 |

**Minimum ECTS for recommended and elective courses****23****Thesis-related activities**<sup>1</sup> Prerequisite: SBC.07110, *Introduction to UNIX and BASH*, and *HPC* from UniBe<sup>2</sup> Prerequisite: SBC.07110, *Introduction to UNIX and BASH*.<sup>8</sup> Taught every second year (even-numbered years)



| <b>Code</b>                                     |                                                           | <b>Semester</b> | <b>Tot. h.</b> | <b>ECTS</b> |
|-------------------------------------------------|-----------------------------------------------------------|-----------------|----------------|-------------|
| SBL.20083                                       | Research group meetings in environmental biology (4 sem.) | 3 sem.          | 3x14           | 3           |
| SBL.20081                                       | Research seminars in environmental biology (4 sem.)       | 4 sem.          | 4x14           | 5           |
| SBL.00431                                       | Seminars in biology (4 sem.)                              | 4 sem.          | 4x14           | 2           |
| <b>Total ECTS for thesis-related activities</b> |                                                           |                 |                | <b>10</b>   |
| <b>Master thesis</b>                            |                                                           |                 |                |             |
| SBL.05001                                       | Master thesis (3 sem.)                                    | 18 months       |                | <b>60</b>   |
| <b>Total ECTS</b>                               |                                                           |                 |                | <b>120</b>  |

**2.1.2 Option Plant & Microbial Sciences**

[Version 2024, validation packages : PV-SBL0000111, PV-SBL.0000112]

| Code                                                                                                                                                                                                               |                                                                      | Semester | Tot. h. | ECTS |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------|---------|------|
| Obligatory courses                                                                                                                                                                                                 |                                                                      |          |         |      |
| Research skills                                                                                                                                                                                                    |                                                                      |          |         |      |
| SBL.20001                                                                                                                                                                                                          | Biostatistics I - generalized linear models and mixed effects models | AS       | 28      | 3    |
| SBL.20002                                                                                                                                                                                                          | Biostatistics II - multivariate analysis                             | AS       | 28      |      |
| The students must follow at least one of the two <i>Biostatistics</i> courses. They can follow both courses; in this case, they will be credited 3 ECTS for obligatory courses and 3 ECTS for recommended courses. |                                                                      |          |         |      |
| SBL.20003                                                                                                                                                                                                          | Methods in plant pathogen interactions                               | AS       | 50      | 4    |
| SBL.20004                                                                                                                                                                                                          | Introduction to metabolomics: data acquisition and processing        | SS       | 30      | 2    |
| SBL.00125                                                                                                                                                                                                          | Light and fluorescence microscopy for life sciences                  | AS       | 28      | 3    |
| SBL.00451                                                                                                                                                                                                          | Introduction to mass spectrometry and proteomics                     | AS       | 8       | 1    |
| SBL.20005                                                                                                                                                                                                          | Critical reading                                                     | AS+SS    | 28      | 3    |
| SBL.00410                                                                                                                                                                                                          | Scientific writing                                                   | AS       | 28      | 3    |
| Scientific core courses                                                                                                                                                                                            |                                                                      |          |         |      |
| SBL.20035                                                                                                                                                                                                          | Structure and functions of host-associated microbiota                | SS       | 28      | 3    |
| SBL.00323                                                                                                                                                                                                          | Plant biotechnology                                                  | SS       | 28      | 3    |
| SBL.00308                                                                                                                                                                                                          | Plant development: the life of a sessile organism                    | SS       | 12      | 1.5  |
| SBL.00307                                                                                                                                                                                                          | Symbiosis: how plants and microbes communicate                       | SS       | 12      | 1.5  |
| Total ECTS for obligatory courses                                                                                                                                                                                  |                                                                      |          |         | 28   |

**Recommended courses**

Beside the following list of recommended courses, students can also choose elective courses.

*Research skills*

|           |                                               |    |    |     |
|-----------|-----------------------------------------------|----|----|-----|
| SBL.00504 | Basics in biostatistics                       | AS | 14 | 1.5 |
| SBL.00427 | Visual communication of data                  | SS | 8  | 1   |
| SBL.30001 | Introduction to R                             | AS | 24 | 2   |
| SBL.06002 | Classical models in biology (lecture)         | SS | 28 | 3   |
| SBL.06003 | Classical models in biology (exercises)       | SS | 14 | 1   |
| SBL.00419 | Advanced imaging <sup>3</sup>                 | SS | 8  | 1   |
| SBL.00452 | Advanced quantitative proteomics <sup>4</sup> | SS | 8  | 1   |
| SBC.07110 | Introduction to UNIX and BASH                 | AS | 40 | 2.5 |

<sup>3</sup> Prerequisite: SBL.00125, *Light and fluorescence microscopy for Life Sciences*.<sup>4</sup> Prerequisite: SBL.00451, *Introduction to mass spectrometry and proteomics*.

| Code                                                     |                                                            | Semester  | Tot. h. | ECTS       |
|----------------------------------------------------------|------------------------------------------------------------|-----------|---------|------------|
| SBC.07107                                                | Bioinformatics (practical + in silico) <sup>5</sup>        | AS        | 42      | 3          |
| UniBe                                                    | Introduction to high-performance computing                 | AS        | 2 days  | 1          |
| SBL.00425                                                | Metagenomics data analysis <sup>6</sup>                    | SS        | 14      | 1          |
| <i>Scientific core courses</i>                           |                                                            |           |         |            |
| SBL.00418                                                | Microbial metabolism and genetics                          | SS        | 8       | 1          |
| SBL.20039                                                | In vivo biochemistry: visualization of transport           | AS        | 12      | 1.5        |
| SBL.00411                                                | Signalling and Transport                                   | AS        | 8       | 1          |
| SBL.20041                                                | Global change biology                                      | AS        | 28      | 3          |
| SSE.00433                                                | Principles of environmental ethics (advanced) <sup>8</sup> | AS        | 28      | 3          |
| SBL.20038                                                | Research internship                                        | Summer    | 1 month | 4          |
| <b>Minimum ECTS for recommended and elective courses</b> |                                                            |           |         | <b>22</b>  |
| <b>Thesis-related activities</b>                         |                                                            |           |         |            |
| SBL.20083                                                | Research group meetings in environmental biology (4 sem.)  | 3 sem.    | 3x14    | 3          |
| SBL.20081                                                | Research seminars in environmental biology (4 sem.)        | 4 sem.    | 4x14    | 5          |
| SBL.00431                                                | Seminars in biology (4 sem.)                               | 4 sem.    | 4x14    | 2          |
| <b>Total ECTS for thesis-related activities</b>          |                                                            |           |         | <b>10</b>  |
| <b>Master thesis</b>                                     |                                                            |           |         |            |
| SBL.05001                                                | Master thesis (3 sem.)                                     | 18 months |         | <b>60</b>  |
| <b>Total ECTS</b>                                        |                                                            |           |         | <b>120</b> |

<sup>5</sup> Prerequisite: SBC.07110, *Introduction to UNIX and BASH*, and *HPC* from UniBe<sup>6</sup> Prerequisite: SBC.07110, *Introduction to UNIX and BASH*.

**2.1.3 Option Applied Environmental Biology**

[Version 2024, validation packages : PV-SBL.0000113, PV-SBL.0000114]

| Code                                                                                                                                                                                                               |                                                                      | Semester | Tot. h. | ECTS |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|----------|---------|------|
| Obligatory courses                                                                                                                                                                                                 |                                                                      |          |         |      |
| Research skills                                                                                                                                                                                                    |                                                                      |          |         |      |
| SBL.20001                                                                                                                                                                                                          | Biostatistics I - generalized linear models and mixed effects models | AS       | 28      | 3    |
| SBL.20002                                                                                                                                                                                                          | Biostatistics II - multivariate analysis                             | AS       | 28      |      |
| The students must follow at least one of the two <i>Biostatistics</i> courses. They can follow both courses; in this case, they will be credited 3 ECTS for obligatory courses and 3 ECTS for recommended courses. |                                                                      |          |         |      |
| SBL.20005                                                                                                                                                                                                          | Critical reading                                                     | AS+SS    | 28      | 3    |
| SBL.00410                                                                                                                                                                                                          | Scientific writing                                                   | AS       | 28      | 3    |
| Scientific core courses                                                                                                                                                                                            |                                                                      |          |         |      |
| SBL.00205                                                                                                                                                                                                          | Ecological field course                                              | Summer   | 11 days | 5    |
| SBL.20041                                                                                                                                                                                                          | Global change biology                                                | AS       | 28      | 3    |
| SBL.20037                                                                                                                                                                                                          | Invasion biology                                                     | AS       | 28      | 3    |
| SSE.00433                                                                                                                                                                                                          | Principles of environmental ethics (advanced) <sup>8</sup>           | AS       | 28      | 3    |
| Total ECTS for obligatory courses                                                                                                                                                                                  |                                                                      |          |         | 23   |

**Recommended courses**

Beside the following list of recommended courses, students can also choose elective courses.

*Research skills*

|           |                                                               |    |        |     |
|-----------|---------------------------------------------------------------|----|--------|-----|
| SBL.00504 | Basics in biostatistics                                       | AS | 14     | 1.5 |
| SBL.00427 | Visual communication of data                                  | SS | 8      | 1   |
| SBL.30001 | Introduction to R                                             | AS | 24     | 2   |
| SBL.06002 | Classical models in biology (lecture)                         | SS | 28     | 3   |
| SBL.06003 | Classical models in biology (exercises)                       | SS | 14     | 1   |
| SBL.20003 | Methods in plant pathogen interactions                        | AS | 50     | 4   |
| SBL.20004 | Introduction to metabolomics: data acquisition and processing | SS | 30     | 2   |
| SBL.00125 | Light and fluorescence microscopy for Life Sciences           | AS | 28     | 3   |
| SBC.07110 | Introduction to UNIX and BASH                                 | AS | 40     | 2.5 |
| SBC.07107 | Bioinformatics (practical + in silico) <sup>7</sup>           | AS | 42     | 3   |
| UniBe     | Introduction to high-performance computing                    | AS | 2 days | 1   |
| SBL.00425 | Metagenomics data analysis                                    | SS | 14     | 1   |

*Scientific core courses*

|           |                   |    |    |   |
|-----------|-------------------|----|----|---|
| SBL.20031 | Community ecology | SS | 28 | 3 |
|-----------|-------------------|----|----|---|

<sup>7</sup> Prerequisite: SBC.07110, *Introduction to UNIX and BASH*, and *HPC* from UniBe<sup>8</sup> Taught every second year (even-numbered years)

| <b>Code</b>                                              |                                                           | <b>Semester</b> | <b>Tot. h.</b> | <b>ECTS</b> |
|----------------------------------------------------------|-----------------------------------------------------------|-----------------|----------------|-------------|
| SBL.20035                                                | Structure and functions of host-associated microbiota     | SS              | 28             | 3           |
| SBL.00323                                                | Plant biotechnology                                       | SS              | 28             | 3           |
| SBL.00308                                                | Plant development: the life of a sessile organism         | SS              | 12             | 1.5         |
| SBL.00307                                                | Symbiosis: how plants and microbes communicate            | SS              | 12             | 1.5         |
| SSE.00453                                                | Responsibility in green political theory (advanced)       | AS              | 28             | 4           |
| SBL.20038                                                | Research Internship                                       | Summer          | 1 month        | 4           |
| <b>Minimum ECTS for recommended and elective courses</b> |                                                           |                 |                | <b>27</b>   |
| <b>Thesis-related activities</b>                         |                                                           |                 |                |             |
| SBL.20083                                                | Research group meetings in environmental biology (4 sem.) | 3 sem.          | 3x14           | 3           |
| SBL.20081                                                | Research seminars in environmental biology (4 sem.)       | 4 sem.          | 4x14           | 5           |
| SBL.00431                                                | Seminars in biology (4 sem.)                              | 4 sem.          | 4x14           | 2           |
| <b>Total ECTS for thesis-related activities</b>          |                                                           |                 |                | <b>10</b>   |
| <b>Master thesis</b>                                     |                                                           |                 |                |             |
| SBL.05001                                                | Master thesis (3 sem.)                                    | 18 months       |                | <b>60</b>   |
| <b>Total ECTS</b>                                        |                                                           |                 |                | <b>120</b>  |

**2.1.4 Option Teaching**

[Version 2024, validation packages : PV-SBL.0000115, PV-SBL.0000116]

| Code                                                                                                                                                                                            |                                                            | Semester | Tot. h. | ECTS |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------|---------|------|
| Obligatory courses                                                                                                                                                                              |                                                            |          |         |      |
| Research skills                                                                                                                                                                                 |                                                            |          |         |      |
| SBL.20005                                                                                                                                                                                       | Critical reading                                           | AS+SS    | 28      | 3    |
| SBL.00410                                                                                                                                                                                       | Scientific writing                                         | AS       | 28      | 3    |
| Scientific core courses                                                                                                                                                                         |                                                            |          |         |      |
| SBL.20035                                                                                                                                                                                       | Structure and functions of host-associated microbiota      | SS       | 28      | 3    |
| SBL.00323                                                                                                                                                                                       | Plant biotechnology                                        | SS       | 28      |      |
| The students must follow at least one of these two courses. They can follow both courses; in this case, they will be credited 3 ECTS for obligatory courses and 3 ECTS for recommended courses. |                                                            |          |         |      |
| SBL.20041                                                                                                                                                                                       | Global change biology                                      | AS       | 28      | 3    |
| SBL.00502                                                                                                                                                                                       | General concepts for biology teachers                      | SS       | 8       | 1    |
| SSE.00433                                                                                                                                                                                       | Principles of environmental ethics (advanced) <sup>8</sup> | AS       | 28      | 3    |
| Total ECTS for obligatory courses                                                                                                                                                               |                                                            |          |         | 16   |

**Recommended courses**

Beside the following list of recommended courses, students can also choose elective courses.

*Research skills*

|           |                                                                      |    |    |     |
|-----------|----------------------------------------------------------------------|----|----|-----|
| SBL.00504 | Basics in biostatistics                                              | AS | 14 | 1.5 |
| SBL.20001 | Biostatistics I - generalized linear models and mixed effects models | AS | 28 | 3   |
| SBL.20002 | Biostatistics II - multivariate analysis                             | AS | 28 | 3   |
| SBL.00427 | Visual communication of data                                         | SS | 8  | 1   |
| SBL.06002 | Classical models in biology (lecture)                                | SS | 28 | 3   |
| SBL.06003 | Classical models in biology (exercises)                              | SS | 14 | 1   |
| SBL.00125 | Light and fluorescence microscopy for life sciences                  | AS | 28 | 3   |

*Scientific core courses*

|           |                         |        |         |   |
|-----------|-------------------------|--------|---------|---|
| SBL.20031 | Community ecology       | SS     | 28      | 3 |
| SBL.00205 | Ecological field course | Summer | 11 days | 5 |
| SBL.20037 | Invasion biology        | AS     | 28      | 3 |

|                                                          |  |  |  |             |
|----------------------------------------------------------|--|--|--|-------------|
| <b>Minimum ECTS for recommended and elective courses</b> |  |  |  | <b>21.5</b> |
|----------------------------------------------------------|--|--|--|-------------|

**Thesis-related activities**

|           |                                                           |        |      |   |
|-----------|-----------------------------------------------------------|--------|------|---|
| SBL.20084 | Research group meetings in environmental biology (3 sem.) | 2 sem. | 2x14 | 2 |
| SBL.20082 | Research seminars in environmental biology (3 sem.)       | 3 sem. | 3x14 | 4 |



| <b>Code</b>                                     |                              | <b>Semester</b> | <b>Tot. h.</b> | <b>ECTS</b> |
|-------------------------------------------------|------------------------------|-----------------|----------------|-------------|
| SBL.00432                                       | Seminars in biology (3 sem.) | 3 sem.          | 3x14           | 1.5         |
| <b>Total ECTS for thesis-related activities</b> |                              |                 |                | <b>7.5</b>  |
| <b>Master thesis</b>                            |                              |                 |                |             |
| SBL.05002                                       | Master thesis (2 sem.)       | 12 months       |                | <b>45</b>   |
| <b>Total ECTS</b>                               |                              |                 |                | <b>90</b>   |

## 2.2 Course Contents of the Master Programme

### 2.2.1 Lecture Courses

#### 2.2.1.1 Research skills

##### Statistics and modelling:

- **Basics in biostatistics** (SLB.00504; 1.5 ECTS; lecture with exercises). This course aims at teaching basic knowledge in data management, statistics, and analysis. Specifically, it introduces fundamental concepts such as population, sample, standard error, confidence interval, Type I and Type II errors and p-value. We then look at the statistical tools most commonly used in biology, such as Student's t-test, ANOVA (1 and 2 factors; repeated measures), correlation, linear regression, sample size determination, and more. This course cannot be taken together with SBL.00075, or if SBL.00075 has already been validated.
- **Biostatistics I - generalized linear models and mixed effects models** (SBL.20001; 3 ECTS, lecture with exercises). Students will learn basic and advanced techniques in biostatistics, they will perform exercises with data from ecological experiments. Specifically, the following topics will be introduced: linear, Poisson, and Binomial regression; AIC, BIC, model selection, and model averaging; random effects and mixed effects models; correlation structure (e.g., time series, spatial, phylogeny). This course is given biennially and alternates with *Biostatistics II - multivariate analysis*.
- **Biostatistics II - multivariate analysis** (SBL.20002; 3 ECTS, lecture with exercises). Students will learn basic and advanced techniques in multivariate analyses, they will perform exercises with data from ecological experiments. Specifically, the following topics will be introduced: data type and transformation; similarity and distance matrices; Mantel and partial Mantel tests; clustering techniques; principal component analysis (PCA), correspondence analysis (CA), and non-metric multidimensional analysis (NMDS); redundancy analysis (RDA) and canonical correspondence analysis (CCA); multivariate analysis of variance (MANOVA); co-correspondence analysis (COCA); the fourth-corner problem. This course is given biennially and alternates with *Biostatistics I - generalized linear models and mixed effects models*.
- **Visual communication of data** (SBL.00427; 1 ECTS, lecture). The goal of the course *Visual communication of data* is to provide students with the theoretical background and practical skills needed to design and create efficient graphics that fairly present quantitative data. The course content includes an overview of classical and less classical graphic types available, guidelines on how to choose the best representation based on the type of data, tricks to emphasize specific messages without inducing bias, as well as major pitfalls to avoid. Practical exercises are carried out using Excel and other simple software.
- **Classical models in biology (lecture)** (SBL.06002; 3 ECTS; lecture). The use of simple models to describe the behaviour of biological phenomena has been of great help for their understanding and has often driven researchers to new ideas. Here we will show how to go from the phenomenon to a model and what can be learned using this process. In particular, some of the following models will be introduced: the Malthus and the Verhulst growth models of population; ages-structured population and the Leslie matrix; the Kermack-McKendrick model in epidemiology; Bernoulli's model on vaccination; the Lotka-Volterra model; the Luria-Delbrück model.
- **Classical models in biology (exercises)** (SBL.06003; 3 ECTS; exercises). The students will learn how to implement in R some of the models seen during the lecture *Classical models in biology*.

**Experimental:**

- **Methods in plant pathogen interactions** (SBL.20003; 4 ECTS; practical). This practical course gives an overview of the different methodological approaches used to study plant pathogen interactions and plant diseases. It includes the setup and monitoring of infection assays, the observation of different developmental stages of pathogenic organisms, and the analysis of the plant defense reactions (staining/microscopy of pathogen progress and of the production of reactive oxygen species; q-PCR analysis of defense gene expression; HPLC analysis of defense-related hormones).
- **Introduction to metabolomics: data acquisition and processing** (SBL.20004; 2 ECTS; lecture with practical). This course is a theoretical and practical introduction to metabolomics (the large-scale study of small molecules in complex mixtures). It will cover extraction methods, sample preparation, separation techniques and chromatography, detection procedures and data analysis (quantitative and qualitative). A particular focus will be given to mass spectrometry-based metabolomics of specialized metabolomes and its applications in environmental biology and natural products research. The course includes a practical part on GC or LC-MS (Gas Chromatography or Liquid Chromatography coupled to Mass Spectrometry) and data processing.
- **Light and fluorescence microscopy for Life Sciences** (SBL.00125; 4 ECTS; lecture). Fluorescence microscopy has become one of the core techniques in biological research. Its applications range from the study of the expression of specific molecular markers with high spatial resolution in single cells to the probing of cell functions in living organisms. Constant progress in microscope design and in fluorescent probe development has led to a large choice of applications based on the principles of fluorescence microscopy. This course will aim at giving an understanding of key concepts of the main techniques used in life sciences. It will also insist on practical issues essential for a productive use of these techniques in biological and biomedical research. The number of participants is limited. Therefore, priority will be given as follows: first priority if the teaching unit is obligatory in the study plan. Second priority if it is recommended. Third priority for all others.
- **Advanced imaging** (SBL.00419; 1 ECTS; lecture). Fluorescence microscopy has become the preferred imaging tool for biological systems due to its capability to visualize specifically the target biomolecules under conditions compatible with life, like room temperature, liquid environment and irradiation with visible light. Fluorescence microscopy also provides very high sensitivity down to the detection of single molecules. As drawback, as it happens with any a far-field optical technique, the spatial resolution is limited by the wavelength of light to a few hundreds of nanometres (the so-called diffraction limit). Remarkably, in the mid 2000s, a series of imaging methods using fluorescence readout were developed that deliver images with resolution beyond the diffraction limit. These methods, called super-resolution fluorescence microscopy or far-field fluorescence nanoscopy and whose pioneers were awarded with the Nobel Prize in Chemistry in 2014, have revolutionized biological imaging and continued to be developed until the present day. In this lecture we will revise the working principles of super-resolution microscopy and its development from the first generation of methods up to the newest methods capable of achieving 1 nm resolution under ambient conditions. We will discuss the performance and technical aspects of the necessary hardware and sample preparation for each one of the different modalities of super-resolution microscopy existing today. Also, we will perform experiments hands-on to obtain super-resolved fluorescence images, including the acquisition and analysis of data. Prerequisite: SBL.00125, *Light and fluorescence microscopy for Life Sciences*.
- **Introduction to mass spectrometry and proteomics** (SBL.00451; 1 ECTS; practical). This course teaches theoretical and practical principles of mass spectrometry (MS)-based proteomics. It introduces principals of MS analysis of peptides and proteins. Current mass analysers and underlying physical principals are introduced in lectures. Hands-on analyses of mass spectra are performed in a practical course.
- **Advanced quantitative proteomics** (SBL.00452; 1 ECTS; practical). This course follows *Introduction to mass spectrometry and proteomics* (prerequisite). It introduces quantitative MS-based proteomics principles in lectures. In a practical course proteomics experiments are performed and data is analysed by current bioinformatics approaches. After both courses, the participants will be able to design and perform MS-based proteomics experiments and to analyse respective data. Prerequisite: SBL.00451, *Introduction to mass spectrometry and proteomics*.

**Bioinformatics:**

- **Introduction to R** (SBL.30001; 2 ECTS; lecture with exercises). This course introduces the basic usage of the statistical programming language R. The focus will be on data structures (vectors, matrices and data frames), import / export of data, basic plotting, writing of functions and scripts for reproducible data analysis. The course will be largely “hands-on” and does not require any prior knowledge on R.
- **Introduction to UNIX and BASH** (SBC.07110; 2.5 ECTS; lecture with exercises). The students will learn the basics of computing and programming, with an emphasis on UNIX operating system and command-line examples. They will learn BASH scripting using modern tools, including regular expressions. This course is a prerequisite for SBC.07107 (*Bioinformatics (practical + in silico)*), SBL.00425 (*Metagenomics data analysis*), and SBL.30004 (*Organization and annotation of Eukaryote genomes*). Note that this course aims at introducing the computer skills needed for bioinformatics and, therefore, the students are highly encouraged to complete it with one of the three courses mentioned above.
- **Bioinformatics (practical + in silico)** (SBC.07107; 3 ECTS; practical). This course will allow the students to sequence a genome and analyse real genomic data. The goal is to identify potential mutations responsible for the phenotype. Prerequisite: SBC.07110, *Introduction to UNIX and BASH* and *Introduction to high-performance computing* (UniBe).
- **Metagenomics data analysis** (SBL.00425; 1.5 ECTS; lecture with exercises). Students will learn the basic principles of metagenomics data analysis and their associated methods. The course will cover the targeted methods (16S, ITS) as well as the Whole Genome/Transcriptome Sequencing methods, both in prokaryotes and eukaryotes. Students will learn which kind of data could be extracted from metagenomics analysis and how to analyse and represent these data. Prerequisite: SBC.07110, *Introduction to UNIX and BASH*.
- **Introduction to high-performance computing** (also listed as “HPC” in this study plan). This lecture with exercises introduces the use of high-performance computing centers, with a focus on the IBU cluster. Prerequisite: SBC.07110, *Introduction to UNIX and BASH*.

**Soft skills:**

- **Critical reading** (SBL.20005; 3 ECTS; seminar). In this seminar, MSc students in Environmental Biology will discuss recent literature in the field and learn how to review papers. Students will participate in scientific discussions and reviewing of original research articles, and acquire skills in presenting and defending scientific arguments in a group. This seminar has to be taken for two semesters.
- **Scientific writing** (SBL.00410; 3 ECTS; lecture with exercises). In a first part consisting of a few lectures, students will be introduced to the publication business and the art of writing scientific articles. In a second part, they will practice writing a scientific text.
- **English course for Master students**. We do not provide a specific title, as this can vary depending on the current offer from the Language Center and the student's proficiency. The selected course(s) help(s) Master's students in scientific disciplines develop the English language skills relevant to their studies and future careers. Target level must be B2-C2. An online placement test is necessary to find the right course for your level.

More info: <https://www.unifr.ch/centredelanguages/en/courses/semester/>

2.2.1.2 Scientific core courses**Ecology and evolution:**

- **Community ecology** (SBL.20031; 3 ECTS; lecture). This course will start with a reminder of basic concepts (ecological niche, integrated community model) and the introduction of a more recent theory (Vellend's theory of ecological communities). The following topics will then be discussed: communities in a changing environment; species interactions and coexistence; biodiversity ecosystem-functioning relationships; ecological networks; and metacommunities. This course is given biennially and alternates with *Population and evolutionary dynamics*.
- **Population and evolutionary dynamics** (SBL.20032; 3 ECTS; lecture). This course focuses on the ecological and evolutionary dynamics of populations. In the 1st part students will study basic and advanced concepts of population dynamics, including population growth and growth rates, age-structured models (Leslie matrix; Euler-Lotka equation), limiting factors and density-dependence, and demographic principles of life-history evolution. In the 2nd part, students will be introduced to evolutionary dynamics, including replicator dynamics in population genetics, the principles of evolutionary game theory and adaptive dynamics. Students will learn, for example, the key concept of fitness landscapes and how they are defined from the underlying population dynamics. They will then study the evolution of fitness landscapes and, in particular, how selection acts on different evolutionary strategies. The students are expected to have a basic knowledge (BSc level) of ecology, evolutionary biology, and population genetics. This course is given biennially and alternates with *Community ecology*.
- **Evolutionary genomics** (SBL.20034): This course (lecture with exercises) examines the main factors that shape the evolution of plant and animal genomes. In particular, it discusses various approaches for assessing patterns of genomic variation in natural populations and the evolutionary and ecological processes affecting them. Students will population genetical statistics and about computational tools for analysing genetic variation at the genome-level, including for example the estimation of genome-wide population structure and tests of selection.
- **Organization and annotation of Eukaryote genomes** (SBL.30004; 3 ECTS; lecture with exercises) This course examines the main evolutionary processes shaping the organization plant and animal genomes. It compares and operates complementary approaches to characterize gene models as well as transposable element in model and non-model organisms. Using adequate tools to identify duplicated sequences and 'junk DNA', it will also address how to benefit from genomic variation. A mix of lectures and practical exercises will enable students to take advantage of current approaches to robustly describe and understand Eukaryote genomes. Prerequisite: SBC.07110, *Introduction to UNIX and BASH*.
- **Evolution workshop in Guarda** (SBL.20040; 3 ECTS; lecture with exercises; block course of 5 days). This course is an extramural block course (1 week) involving Swiss and foreign graduate students, as well as invited professors. As part of small working groups that are centred on common scientific interests, and in interaction with the teachers, the students design research projects and write and present grant proposals. The goal is to learn to discuss science, develop scientific arguments and questions, develop a research plan, and write research proposals. Students who are interested in following this course should contact Prof. Thomas Flatt ahead of time ([thomas.flatt@unifr.ch](mailto:thomas.flatt@unifr.ch)). More information, as well as the registration deadline can be found at <http://evolution.unibas.ch/teaching/guarda/index.htm>.
- **Ecological field course** (SBL.00205; 5 ECTS; practical with excursions; block course of 11 days usually after June exam session). It is a project-oriented field course taking place at a research field station. With the support of the teachers, the students learn to develop their own research projects, carry them out, and present and write up the results. Participants must have followed at least one course on general ecology (SBL.00013 or similar). For logistic reasons, the number of participants is limited to 12 persons.

- **Tropical biology association (TBA) field course** (XAF.00001; 10 ECTS; internship; block course of 28 days). This is a project-oriented international summer field course in tropical Africa or Southeast Asia. It is organised by the Tropical Biology Association (<http://www.tropical-biology.org/>). The courses take place in summer / fall every year. Each year TBA runs month-long courses in tropical ecology and conservation for students at advanced undergraduate or early postgraduate level who have a keen interest, but little experience, in tropical biology. The TBA courses provide practical training and experience in the tropics with an emphasis on building skills and understanding. The Department of Biology can support 2 students per year to attend this course. There is no guaranteed admission to this course. Students who are interested in attending a TBA course should please contact and make an appointment with Prof. Thomas Flatt ahead of time ([thomas.flatt@unifr.ch](mailto:thomas.flatt@unifr.ch)). This course can be used as a replacement for the *Ecological field course*. Note that in the case where the student would like to follow the *Ecological field course* as well, she/he cannot be credited the ECTS points for the *Ecological field course*. Note that it is not possible to cumulate the ECTS credits for the *Tropical biology association (TBA) field course* and of the *Research internship*; in case a student follows both courses, she/he will be credited 10 ECTS in total.

### Plant & Microbial Sciences:

- **Structure and functions of host-associated microbiota** (SBL.20035; 3 ECTS; lecture). Students will be introduced to the concept of holobionts and metaorganisms. They will learn how microbiomes are assembled and structured in different host organisms, including plants, animals and humans. They will discover the functions these microbiomes fulfil for their hosts and how we can leverage on these microbiome-encoded functions to address current challenges, e.g. in plant and human health.
- **Plant biotechnology** (SBL.00323; 3 ECTS; lecture). In this course your memory of the basic methods and associated problems of plant transformation will be refreshed. This is followed by an introduction of new methods and technology related to genome engineering. Finally, we will have a look at selected examples of plant biotechnology in commercial applications as well as basic science. This course is given biennially and alternates with *Plant development: the life of a sessile organism* and *Symbiosis: how plants and microbes communicate*.
- **Plant development: the life of a sessile organism** (SBL.00308; 1.5 ECTS; lecture). This course describes central issues of developmental programmes involved in embryogenesis, root, shoot, and flower development. The emphasis will be on hormonal control of morphogenesis and pattern formation, and on the determinants of organ identity. This course is given biennially and alternates with *Plant biotechnology*.
- **Symbiosis: how plants and microbes communicate** (SBL.00307; 1.5 ECTS; lecture). This course deals with the mutual recognition between the plant and the microbial partner, and with the coordination of their development. In general, the course consists of short introductory lectures followed by critical examination of the recent literature on the topic. The goal is to show how scientific knowledge is generated and interpreted. This course is given biennially and alternates with *Plant biotechnology*.
- **Microbial metabolism and genetics** (SBL.00418; 1 ECTS; lecture). This course treats various aspects of microbial genetics with the focus on bacteria, fungi, and oomycetes. It deals with fundamental aspects of microbial genetics and applied aspects related to disease or beneficial mutualistic interactions. Furthermore, important examples of metabolic pathways will be discussed in the context of microbial life and interactions with the biotic and/or abiotic environment.
- **In vivo biochemistry: Visualization of transport** (SBL.20039; 1.5 ECTS; lecture) This course is meant for Master students that have a strong interest in understanding protein functionality on a biochemical and cell biological level. Contents will cover chemical indicators, reporters, sensors, fluorescently labelled substrates, click-chemistry of transport substrates, imaging of radiolabelled substrates and Immunolocalization of transport substrates. The course will offer a theoretical introduction into the methods currently used for the visualization of membrane transport using mainly examples from the plant field but is also accessible for “non-plant” master students.

- **Signalling and Transport** (SBL.00411; 1 ECTS; lecture). This course will focus on plant signal transduction at first place but will also compare bacterial and plant signalling pathways over membrane. Students will learn functional differences between the plant receptors and bacterial sensors. As a side effect they will be also be taught how structural models can be visualized. By comparing typical mammalian signal transduction pathways, such as G-protein coupled receptors or Toll-like innate immune receptors, with leucine-rich repeat (LRR) receptor(-like) kinases, it will be explained how plants differently sense steroid hormones over membranes. This course will compare eukaryotic signal transduction in plant, bacterial and mammalian systems, and is thus also recommended also for “non-plant” master students.

#### Applied environmental biology:

- **Global change biology** (SBL.20041; 3 ECTS; lecture). How is biodiversity affected by environmental challenges? Describing the evolutionary ecology of organisms from local to global scales, this course provides an overview of processes that shape the origin, expansion and extinction of species and communities in space and time. Through series of lectures and personal work, it compares the underpinnings of biodiversity across varied ecosystems such as drought-related deserts, Mediterranean regions and alpine ranges in order to organize main drivers of variation in a coherent framework. Building on such an integrated approach of biological responses to past environmental changes is key to understand and interpret the current distribution of biodiversity and to appraise and manage future challenges under global changes. This course is given biennially and alternates with *Invasion biology*.
- **Invasion biology** (SBL.20037; 3 ECTS; lecture). Biological invasions are a global phenomenon and are considered as one of the major drivers of global change. Alien species can threaten native species and ecosystems, as well as human economy and well-being. This course covers the ecological, evolutionary and socio-economic implications of biological invasions. In particular, the following topics are covered: the invasion process, transport, pathways, introduction, establishment, persistence, evolution, spread, impacts, management. This course is given biennially and alternates with *Global change biology*.
- **Principle of environmental ethics (advanced)** (SSE.00433; 3 ECTS; lecture). In the field of the environment, ethical studies generally focus on the justification of environmental measures, but rarely on the ethical problems that arise during their implementation. This lecture presents the method of principlism and analyses the implementation of certain environmental challenges. These change each semester the course is taught.
- **Research internship** (SBL.20038; 4 ECTS; internship). During the course of their master curriculum (preferably between semesters), students have the opportunity to increase their practical work experience by carrying out a research internship of four weeks. To discover other research environments, students are encouraged to carry out this internship at an external research institution (e.g. Agroscope, FiBL, CABI). In such cases of external hosting institution, the internship should be co-supervised by a group leader from the Department of Biology. A report should be written at the end of the internship, summarizing the research question, the work carried out and the results obtained. Note that it is not possible to cumulate the ECTS credits for the *Tropical biology association (TBA) field course* and of the *Research internship*; in case students follows both courses, they will be credited 10 ECTS in total. This course cannot be taken by the students following the Teaching option.
- The teaching unit *General concepts for biology teachers* (**SBL.00502**) consists in a personal work aimed at refreshing the knowledge in biology acquired at Bachelor and Master levels. The student reviews his or her course notes with the aim of being able to explain general concepts **simply, concisely and clearly**. The questions are of a general nature and cover the following teaching units: SBL.00001 ; SBL.00002 ; SBL.00040 ; SBL.00041 ; SBL.00074; SBL.00013, SBL.00021 ; SBL.00045 ; SBL.00063 ; SBL.00014 and SBL.00019. The exam can also be taken in German or in French.



## 2.2.2 Master thesis related activities

The master thesis related activities include the **Research group meetings in environmental biology**, the **Research seminars in environmental biology**, and the **Seminars in biology**. The *Research group meetings* are an immersion into the daily life of the research group chosen by the students for their master thesis. The *Master in Environmental Biology* organises a weekly *Research seminar*. This is an internal seminar where researchers (including the master students, PhD students, post-doctoral researchers) present their research progress. During the *Seminars in biology*, which is shared with the *Master in Molecular Life and Health Sciences*, national and international speakers are invited to present their research.

Students are expected to participate regularly to these meetings and seminars. They must present the advancement of their master thesis at least once during the **Research seminars in environmental biology**. It is recommended to give the presentation during the 2<sup>nd</sup> or the 3<sup>rd</sup> semester of study.

For the EE, PMS, and AEB options, the students follow the following variations: **Research group meetings in environmental biology (4 sem.)** (SBL.20083, 3 ECTS) during 3 semesters; **Research seminars in environmental biology (4 sem.)** (SBL.20081, 5 ECTS) during 4 semesters; and **Seminars in biology (4 sem.)** (SBL.00431, 2 ECTS) during 4 semesters.

For the TE option, the students follow the following variations: **Research group meetings in environmental biology (3 sem.)** (SBL.20084, 2 ECTS) during 2 semesters; **Research seminars in environmental biology (3 sem.)** (SBL.20082, 4 ECTS) during 3 semesters; and **Seminars in biology (3 sem.)** (SBL.00432, 1.5 ECTS) during 3 semesters.

## 2.2.3 The Master Thesis

The master thesis is a scientific project carried out by the student under the supervision of a group leader with research activities related to environmental biology within the Department of Biology.

Students must choose a research group and be accepted during the first semester of their master studies. The group leader will be their supervisor for the master thesis. To facilitate this choice, students are encouraged to familiarize themselves with the research carried out in the different research groups either before starting their studies or during the first weeks of their master study, e.g., by following the *Research seminars in Environmental Biology*, or by talking to the group leader or to the group members. A Master thesis in an external research institute (e.g. Agroscope, FiBL, CABI) can be supervised by more than one person, but the principal supervisor must be a principal investigator of the Department of Biology..

In general, students are expected to establish a research strategy, plan the project, carry out the research, analyse the results, write a report (which can be in the form of a scientific publication), and make an oral presentation of their thesis. The master thesis is evaluated with a grade, which includes the practical work, the written report, and the final oral presentation.

If a thesis is evaluated as insufficient (less than 4.0), students have the option to begin a new master thesis in another research group. In this case, students need to continue to attend and participate to the master thesis related activities.

For the EE, PMS, and AEB options the Master thesis is credited 60 ECTS (Master thesis (3 sem.), SBL.05001). For the TE option the Master thesis is credited 45 ECTS (Master thesis (2 sem.), SBL.05002). The duration of the Master thesis work is counted according to the calendar year, not the academic year: SBL.05001 takes 18 months and SBL.05002 takes 12 months full time, including 5 weeks of vacation per year, and the time that students spend to take lectures and seminars of the corresponding study plan. The duration of the Master thesis can be slightly extended, provided that both the student and the group leader mutually agree, and that the achievement of the project requires an extension of a few months.



## 2.3 Examinations of the MSc and Validation

The teaching units of the Master programme can only be examined (and the ECTS credits acquired) after students have completed all requirements for their Bachelor degree.

The **Validation Package MScBL1** comprises the master courses and the master thesis related activities. **Validation Package MScBL2** comprises the master thesis. With the validation of the **MScBL1 and MScBL2** packages, students obtain the degree of Master of Science in Environmental Biology, option Ecology & Evolution, Plant and Microbial Sciences, Applied Environmental Biology, or Teaching.

## 2.4 Admission Procedure to the Master Programme

The acceptance to a Master program in Environmental Biology may be granted provided the following two conditions have been met by the applicant:

- Satisfying the University admission requirements as defined in the *Règlement concernant l'admission à l'Université de Fribourg* that can be found at: <https://www.unifr.ch/apps/legal/fr/document/274904>
- The student possesses a Bachelor of Science in Biology from the University of Fribourg, a Bachelor of Science in Biochemistry from the University of Fribourg (provided they have chosen the necessary courses in their BSc curriculum), or an academic degree judged equivalent by the Faculty of Science and Medicine.

For candidates with degrees that are not judged equivalent by the Faculty of Science and Medicine, the Commission for Students' Requests will decide on eligibility (*Commission des requêtes des étudiant·e·s*, Dean's Office, Faculty of Science and Medicine, Chemin du Musée 8, CH-1700 Fribourg, Switzerland).

Based on the candidate's academic qualification, the Commission for Students' Requests can accept the application on the condition that additional requirements are fulfilled, provided they are of a minor scope and can be completed simultaneously with the Master studies. Otherwise, access is denied, or applicants can be admitted to a *pre-master programme* and can begin the Master programme only after having fulfilled the requirements initially set for the pre-master. Final acceptance to the Master programme for a qualifying student depends on the successful completion of the additional requirements.

The MSc in Molecular Life and Health Sciences and the MSc in Environmental Biology are formally considered as two distinct programmes of a **MSc in Biology**. Students who have been excluded from either a Master in Biology, a MSc in Molecular Life and Health Sciences, a MSc in Environmental Biology, or equivalent, are not eligible to apply.

### 3. Appendix: Table summarizing all master courses

EE = Ecology & Evolution

PMS = Plant & Microbial Sciences

AEB = Applied Environmental Biology

TE = Teaching

The courses are O (obligatory), R (recommended), E (elective), - not possible

The biennial courses are paired: biennial AX with biennial BX

biennial AX: given for the 1<sup>st</sup> time during the academic year 2021/2022 and then every two years

biennial BX: given for the 1<sup>st</sup> time during the academic year 2022/2023 and then every two years

| Code | Type | Title of the teaching unit | ECTS | EE | PMS | AEB | TE | Semester | Annual / Biennial | Prerequisite |
|------|------|----------------------------|------|----|-----|-----|----|----------|-------------------|--------------|
|------|------|----------------------------|------|----|-----|-----|----|----------|-------------------|--------------|

#### Research skills

##### Statistics and modelling

|           |                        |                                                                      |     |       |       |       |   |        |             |                                |
|-----------|------------------------|----------------------------------------------------------------------|-----|-------|-------|-------|---|--------|-------------|--------------------------------|
| SBL.00504 | lecture with exercises | Basics in biostatistics                                              | 1.5 | R     | R     | R     | R | Autumn | annual      | Cannot be taken with SBL.00075 |
| SBL.20001 | lecture with exercises | Biostatistics I - generalized linear models and mixed effects models | 3   | O / R | O / R | O / R | R | Autumn | biennial A1 | SBL.00075 or SBL.00504         |
| SBL.20002 | lecture with exercises | Biostatistics II - multivariate analysis                             | 3   | O / R | O / R | O / R | R | Autumn | biennial B1 | SBL.00075 or SBL.00504         |
| SBL.00427 | lecture                | Visual communication of data                                         | 1   | R     | R     | R     | R | Spring | annual      |                                |
| SBL.06002 | lecture                | Classical models in biology (lecture)                                | 3   | O     | R     | R     | R | Spring | annual      |                                |
| SBL.06003 | exercises              | Classical models in biology (exercises)                              | 1   | O     | R     | R     | R | Spring | annual      |                                |

##### Experimental

|           |                        |                                                               |   |   |   |   |   |        |        |                      |
|-----------|------------------------|---------------------------------------------------------------|---|---|---|---|---|--------|--------|----------------------|
| SBL.20003 | practical              | Methods in plant pathogen interactions                        | 4 | E | O | R | E | Autumn | annual |                      |
| SBL.20004 | lecture with practical | Introduction to metabolomics: data acquisition and processing | 2 | E | O | R | E | Spring | annual |                      |
| SBL.00125 | lecture                | Light and fluorescence microscopy for Life Sciences           | 3 | E | O | R | R | Autumn | annual |                      |
| SBL.00419 | lecture                | Advanced imaging                                              | 1 | E | R | E | E | Spring | annual | SBL.00125 obligatory |
| SBL.00451 | practical              | Introduction to mass spectrometry and proteomics              | 1 | E | O | E | E | Autumn | annual |                      |
| SBL.00452 | practical              | Advanced quantitative proteomics                              | 1 | E | R | E | E | Spring | annual | SBL.00451 obligatory |

##### Bioinformatics

|           |                        |                                            |     |   |   |   |   |        |        |                                   |
|-----------|------------------------|--------------------------------------------|-----|---|---|---|---|--------|--------|-----------------------------------|
| SBL.30001 | lecture with exercises | Introduction to R                          | 2   | R | R | R | E | Autumn | annual |                                   |
| SBC.07110 | lecture with exercises | Introduction to UNIX and BASH              | 2.5 | R | R | R | E | Autumn | annual |                                   |
| SBC.07107 | practical              | Bioinformatics (practical + in silico)     | 3   | R | R | R | E | Autumn | annual | SBC.07110; HPC (UniBe) obligatory |
| SBL.00425 | lecture with exercises | Metagenomics data analysis                 | 1   | E | R | R | E | Spring | annual | SBC.07110 obligatory              |
| UniBe     | Lecture with exercises | Introduction to high-performance computing | 1   | R | R | R | E | Autumn | annual | SBC.07110 obligatory              |

## Curriculum of the Master of Science in Environmental Biology

### Soft skills

|                       |                        |                                       |       |   |   |   |   |                 |             |                         |
|-----------------------|------------------------|---------------------------------------|-------|---|---|---|---|-----------------|-------------|-------------------------|
| SBL.20005             | seminar                | Critical reading (2 semesters)        | 3     | O | O | O | O | Spring + Autumn | biennial A2 |                         |
| SBL.00410             | lecture with exercises | Scientific writing                    | 3     | O | O | O | O | Autumn          | biennial B2 |                         |
| UniFr Language Center | -                      | English course(s) for Master students | Max 6 | E | E | E | E | Spring + Autumn | annual      | Check your level online |

### Scientific core courses

#### Ecology & Evolution

|           |                          |                                                  |    |   |   |   |   |        |             |                      |
|-----------|--------------------------|--------------------------------------------------|----|---|---|---|---|--------|-------------|----------------------|
| SBL.20031 | lecture                  | Community ecology                                | 3  | O | E | R | R | Spring | biennial A3 |                      |
| SBL.20032 | lecture                  | Population ecology and evolutionary dynamics     | 3  | O | E | E | E | Spring | biennial B3 |                      |
| SBL.20034 | Lecture with exercises   | Evolutionary genomics                            | 3  | O | E | E | E | Spring | annual      |                      |
| SBL.30004 | lecture with exercises   | Organization and annotation of Eukaryote genomes | 3  | R | E | E | E | Autumn | annual      | SBC.07110 obligatory |
| SBL.20040 | internship               | Evolution workshop in Guarda                     | 3  | E | E | E | E | Summer | annual      |                      |
| SBL.00205 | practical with excursion | Ecological field course                          | 5  | O | E | O | R | Summer | annual      | SBL.00013 or similar |
| XAF.00001 | internship               | Tropical Biology Association (TBA) field course  | 10 | E | E | E | E | Summer | annual      |                      |

#### Plant & Microbial Sciences

|           |         |                                                       |     |   |   |   |       |        |               |  |
|-----------|---------|-------------------------------------------------------|-----|---|---|---|-------|--------|---------------|--|
| SBL.20035 | lecture | Structure and functions of host-associated microbiota | 3   | E | O | R | O / R | Spring | biennial A7   |  |
| SBL.00323 | lecture | Plant biotechnology                                   | 3   | E | O | R | O / R | Spring | biennial B6   |  |
| SBL.00308 | lecture | Plant development: the life of a sessile organism     | 1.5 | E | O | R | E     | Spring | biennial A6.1 |  |
| SBL.00307 | lecture | Symbiosis: how plants and microbes communicate        | 1.5 | E | O | R | E     | Spring | biennial A6.2 |  |
| SBL.00418 | lecture | Microbial metabolism and genetics                     | 1   | E | R | E | E     | Spring | Annual        |  |
| SBL.20039 | lecture | In vivo biochemistry: visualization of transport      | 1.5 | E | R | E | E     | Autumn | biennial A8   |  |
| SBL.00411 | lecture | Signalling and Transport                              | 1   | E | R | E | E     | Autumn | annual        |  |

#### Applied Environmental Biology

|           |            |                                               |   |   |   |   |   |        |             |  |
|-----------|------------|-----------------------------------------------|---|---|---|---|---|--------|-------------|--|
| SBL.20041 | lecture    | Global change biology                         | 3 | R | R | O | O | Autumn | biennial A5 |  |
| SBL.20037 | lecture    | Invasion biology                              | 3 | R | E | O | R | Autumn | biennial B5 |  |
| SSE.00433 | lecture    | Principles of environmental ethics (advanced) | 3 | R | R | O | O | Autumn | biennial B  |  |
| SSE.00453 | lecture    | Responsibility in green political theory      | 3 | E | E | R | E | Autumn | annual      |  |
| SBL.20038 | internship | Research internship                           | 4 | R | R | R | - | Summer | annual      |  |

#### General

|           |               |                                       |   |   |   |   |   |        |        |  |
|-----------|---------------|---------------------------------------|---|---|---|---|---|--------|--------|--|
| SBL.00502 | Personal work | General concepts for biology teachers | 1 | - | - | - | O | Spring | annual |  |
|-----------|---------------|---------------------------------------|---|---|---|---|---|--------|--------|--|

**Master thesis-related activities**

|           |         |                                                           |     |   |   |   |   |     |        |  |
|-----------|---------|-----------------------------------------------------------|-----|---|---|---|---|-----|--------|--|
| SBL.20083 | seminar | Research group meetings in Environmental Biology (4 sem.) | 3   | O | O | O | - | All | annual |  |
| SBL.20084 | seminar | Research group meetings in Environmental Biology (3 sem.) | 2   | - | - | - | O | All | annual |  |
| SBL.00431 | seminar | Seminars in Biology (4 sem.)                              | 2   | O | O | O | - | All | annual |  |
| SBL.00432 | seminar | Seminars in Biology (3 sem.)                              | 1.5 | - | - | - | O | All | annual |  |
| SBL.20081 | seminar | Research Seminars in Environmental Biology (4 sem.)       | 5   | O | O | O | - | All | annual |  |
| SBL.20082 | seminar | Research Seminars in Environmental Biology (3 sem.)       | 4   | - | - | - | O | All | annual |  |

**Master Thesis**

|           |             |                        |    |   |   |   |   |     |  |  |
|-----------|-------------|------------------------|----|---|---|---|---|-----|--|--|
| SBL.05001 | master work | Master Thesis (3 sem.) | 60 | O | O | O | - | all |  |  |
| SBL.05002 | master work | Master Thesis (2 sem.) | 45 | - | - | - | O | all |  |  |