

Progress Report 2021

1 Management Summary

The 9th year of the URPP Evolution in Action also marked the start of Phase III of the program. In 2021, the URPP Evolution in Action counted a total of 42 members and supported 9 distinct research projects as well as one Assistant Professor. The year was still strongly affected by the Covid-19 pandemic, which the URPP Evolution in Action managed to meet with flexibility and inventiveness. As a result, it was a successful year despite the difficult situation.

With the beginning of Phase III, the Assistant Professor in Plant Evolutionary Genomics entered the second half of her engagement with the URPP Evolution in Action. Additionally, 7 new PhD Students and 2 new Postdocs commenced working on research projects of the URPP Evolution in Action. By the end of the year, most collaborations and PhD committees were established, and the projects are running smoothly. Following a call for tender, a total of 5 Pilot Projects were selected for funding in 2021 and will be conducted in 2022.

A key characteristic of the URPP Evolution in Action is its agile network of scientists of the University of Zurich (UZH) that exchange knowledge and collaborate across scientific disciplines addressing evolutionary questions with molecular approaches. Central to this network are the many engagement opportunities provided within the URPP Evolution in Action. After many events had to be cancelled due to the Covid-19 pandemic in 2020, we were able to offer several activities, offline and online, in 2021. While we celebrated the beginning of Phase III with a virtual apéro, we were also able to offer opportunities for interactions in person, such as a social get-together in the museum exhibition *evolution happens!*. The 9th Annual Retreat of the URPP Evolution in Action could also take place on site at Rigi Kaltbad. It comprised the presentation and discussion of research projects, a keynote lecture by Laurent Excoffier, talks from new members and our bioinformatics support, a poster session, Faculty and PhD Student Meetings, and sufficient time for social exchanges. At this early stage of their projects, the Annual Retreat was especially rewarding and useful to the new PhD Students.

Most of the courses offered by the URPP Evolution in Action were still held online and were well attended. The bioinformatics support was continued in a hybrid format, with the possibility to reach out for support at any time via the online tool Slack. Also 1:1 meetings between the new PhD Students and the Coordination Office were offered to address questions of our junior scientists relating to administrative issues and uncertainties regarding the Covid-19 pandemic.

The public outreach activities of the URPP Evolution in Action in 2021 comprised the participation at the science fair *Scientifica* with workshops, lectures, and guided tours, as well as the opening and show of the museum exhibition *evolution happens!* at the Zoological Museum of the UZH. Both events received plenty of public attention, which resulted in a prolongation of the exhibition *evolution happens!* by two months.

2 Objectives

2.1 Objectives for the Reporting Year 2021

- **Launch of Phase III** of the URPP Evolution in Action, with new projects, PhD Students, and Postdocs: ensuring a smooth transition and good integration of all new projects, and promotion of a lively, interactive community life.
- Planning and realization of the **9th Retreat of the URPP Evolution in Action**, with a program featuring progress reports from all PhD and Postdoc projects, a keynote lecture, Faculty and PhD Student meetings, as well as a social program furthering the integration of old and new members and PhD Students.
- Finalization of the museum exhibition *evolution happens!* and its opening in June 2021 as a key **Public Outreach** activity. Acquisition of partnering museums to realize the exhibition's travel subsequent to the 6-months exhibition at the Zoological Museum of the UZH.
- Continuation of the successful **Seminar Series** of the URPP Evolution in Action, either as an online format or physically at various UZH departments.
- Planning and realization of **courses for the PhD Program Evolutionary Biology**, covering topics such as Next-Generation Sequencing, Concepts of Evolutionary Biology, Quantitative Trait Loci (QTL) Mapping, Genome-Wide Association Studies (GWAS), and Scientific Writing.
- Continuation of the highly successful **Bioinformatics Support Services** as well as resumption of the **Bioinformatics Tutorial Program**.
- **Open Call for Pilot Projects** in Phase III to promote young scientists by supporting innovative and/or high-risk pilot projects, to be conducted in 2022.
- Continuation of the **1:1 Meetings for all PhD Students** of the URPP Evolution in Action with one of the Program Co-Managers as a low-threshold opportunity for junior scientists to address any questions and issues.
- Organization of **Social Events** to further enhance interactions among students, members, research projects, and departments involved in the URPP Evolution in Action.
- Increasing **Social Media** use to further strengthen the reach (national and international) of the program and to offer our members an additional platform for exchange and dissemination of their research.

2.2 Achieved Objectives in 2021

- **Phase III** of the URPP Evolution in Action was successfully launched. 7 PhD Students and two Postdocs were employed to conduct research within 9 projects. The transition from Phase II went smoothly and all new projects were effectively integrated into the existing framework of member groups and collaborations.
- The **9th Retreat of the URPP Evolution in Action** was successfully conducted and comprised a program featuring progress reports from all PhD and Postdoc projects, a keynote talk, Faculty and PhD Student meetings, as well as a social program.
- **Public Outreach** activities of the URPP Evolution in Action included the museum exhibition *evolution happens!* and the participation at the science fair *Scientifica* 2021. Both outreach activities were very well attended. First partners to take over the exhibition, which was conceptualized as a "Wanderausstellung", have been identified.

- The **Seminar Series** of the URPP Evolution in Action was paused in 2021 due to organizational uncertainties as to the Covid-19 pandemic. As a substitution, the URPP Evolution in Action co-organized a virtual Workshop in Plant Science for researchers from Kyoto University and UZH.
- The URPP Evolution in Action planned and organized several **courses for the PhD Program Evolutionary Biology** and sponsored the Evolutionary Biology PhD Retreat 2021 with funds for a keynote speaker.
- The highly successful **Bioinformatics Support Services** were continued with a focus on individual support for the reduced number of projects in Phase III instead of a resumption of the broader Bioinformatics Tutorial Program that was conducted in Phase II.
- An **open Call for Pilot Projects** to promote young scientists by supporting innovative and/or high-risk pilot projects was launched, and of the 30 excellent proposals that were submitted, 5 were funded.
- **1:1 Meetings for all PhD Students** of the URPP Evolution in Action with one of the Program Co-Managers were conducted as a low-threshold opportunity for the junior scientists to address any questions and issues.
- A variety of **Social Events** to further enhance interactions among students, members, research projects, and departments involved in the URPP Evolution in Action were conducted.
- The URPP Evolution in Action increased the use of **Social Media** (mainly Twitter) to further strengthen the reach of the program and its members.

2.3 Objectives for 2022

- Planning and realization of the **10th Retreat of the URPP Evolution in Action** with a program featuring progress reports from all PhD and Postdoc projects, a keynote lecture, Faculty and PhD Student meetings, as well as a social program to further the integration of old and new members and junior scientists.
- Ensuring the display of the exhibition *evolution happens!* in other museums across Switzerland to make the key **Public Outreach** activity of the URPP Evolution in Action available to as many people as possible.
- Continuation of the successful **Seminar Series** of the URPP Evolution in Action, either as an online format or physically at various UZH departments.
- Planning and realization of **courses for the PhD Program Evolutionary Biology**, covering topics such as UNIX/Linux and Bash Scripting, Next-Generation Sequencing, Concepts of Evolutionary Biology, Genome-Wide Association Studies (GWAS), and Scientific Writing.
- Continuation of the highly successful **Bioinformatics Support Services**.
- Continuation of the **1:1 Meetings for all PhD Students** of the URPP Evolution in Action with a Program Co-Manager as a low-threshold opportunity for the junior scientists to address any questions and issues.
- Organization of **Social Events** to further enhance interactions among students, members, research projects, and departments involved in the URPP Evolution in Action.
- Increase the visibility of work published by members of the URPP Evolution in Action through the communication via **Social Media** and other **Media Releases**.
- Initial preparations for an **International Conference on Evolution in Action** at Monte Verità to take place in June 2023, including applications for additional funding, inviting keynote and invited speakers, organizing the registration process, and advertising the meeting.

3 Research

3.1 Research Projects

3.1.1 PhD and Postdoc Projects

During Phase III, the URPP Evolution in Action continues activities that have proven successful in creating an integrated research community with a focus on aspects that consolidate its achievements beyond its duration. The research profile of the URPP Evolution in Action has been sharpened with a focus on diversification and adaptation. To this end, the three research core areas of (i) pathogen and host co-evolution, (ii) polyploidy and epigenetics, and (iii) experimental evolution and modelling allow for both the follow-up of successful research ideas and the integration of new topics and approaches.

(i) Evolution of Pathogens, Parasites, and Pathosystems

*Mining Herbaria to Explore Phylogeography and Coevolution in Plant Pathosystems: the Case of the Irish Potato Famine Pathogen *Phytophthora infestans* and its Solanaceous Hosts*

PhD Student: Donikë Sejdiu

PhD committee: Simon Aeschbacher (Department of Evolutionary Biology and Environmental Studies, DEBES), Verena Schünemann (Institute of Evolutionary Medicine, IEM), Thomas Wicker (Department of Plant and Microbial Biology, IPMB), Daniel Wegman (University of Fribourg)

In this project, methodological approaches to increase the yield of pathogen DNA extracted from herbarium samples are being developed to obtain time-referenced information for phylogenomic and population genomic analyses of the evolutionary past of plant pathogens and their hosts.

The project aims at (1) identifying the geographic origin of early 20th-century *Phytophthora infestans* strains to both 18th-century and modern highly pathogenic strains, (2) tracing co-evolutionary changes at effector and resistance genes, and (3) assessing mating type and polyploidy as drivers of pathogen virulence. To this end, a first assay to establish the best micro-location on herbarium leaves for pathogen DNA sampling has been performed and a DNA capture approach to enrich for *P. infestans* is currently being developed. Additionally, more samples of mitochondrial DNA are collected to establish the best sampling strategy.

In parallel, the project investigates the evolutionary relationship between previously described *P. infestans* strains and the new subset of novel strains, for which sequenced mitochondrial genomes at 0.2-fold to 37.2-fold mean coverage have been recovered.

The bioinformatics approach for the investigation of degraded historical DNA reads needs more fine-tuning, and extracting sufficient amounts of template DNA from modern *P. infestans* strains for the enrichment has so far posed unexpected challenges in the laboratory. To address the later issue, the project receives support from experts in the phytopathology research group of Dr. Daniel Rigling at the Swiss Federal Institute for Forest, Snow and Landscape Research WSL.

Molecular Identification of Plant Immunity Genes Involved in Non-Host Resistance of Triticale to the Wheat Powdery Mildew Pathogen

Postdoc: Marion Müller

Supervisor: Beat Keller (IPMB)

Collaborators: Kentaro Shimizu (DEBES), Thomas Wicker (IPMB), Javier Sánchez-Martín (IPMB)

The general topic of this project is to understand the genetic basis of non-host resistance in plants against non-adapted pathogens. The goal of this project is to clone two immunity genes that underlie the non-host resistance of the cereal crop triticale against the non-adapted pathogen wheat powdery mildew (*Blumeria graminis* f. sp. *tritici*).

To this end, a cross between two triticale lines segregating for the two non-host immunity genes has been established and is currently being phenotyped with different diagnostic powdery mildew isolates. In parallel, a population of EMS-generated triticale mutants was developed and is being propagated in the field to clone the genes by mutation-based cloning. In the next steps, the triticale mutant population will be screened with specific diagnostic powdery mildew isolates to identify mutants affected in the non-host immunity genes. In addition, the F2 population between the triticale lines will be genotyped by SNP chip to determine the chromosomal location of the immunity genes.

Does Selection for Disease Resistance Vary along an Elevation Gradient?

PhD Student: Michael Rechsteiner

PhD committee: Anna-Liisa Laine (DEBES), Andreas Wagner (DEBES), Sergio Rasmann (University of Neuchâtel), Joy Bergelson (New York University), Florian Schiestl (Department of Systematic and Evolutionary Botany, ISEB)

Split into three projects, the study investigates causes and consequences of spatial variation in pathogen-imposed natural selection with the aim to empirically demonstrate that variation in disease resistance can be explained by spatially varying pathogen-imposed natural selection. The first field project has successfully been launched in summer 2021 and will continue until autumn 2022. Living material for the 2nd and partially the 3rd project has been collected during summer 2021 and is currently being prepared to start with projects 2 and 3 in spring/summer 2022. Data analysis in project 1 is currently being performed and more material for project 3 will be collected during summer 2022.

Investigating the Evolution of Mycobacterial Infections through the Combination of Biomolecular Methods

Postdoc: Shevan Wilkin

Supervisor: Verena Schünemann (IEM)

Collaborator: Matthew Collins (University of Copenhagen)

This project is exploring mycobacterial disease in the past (leprosy, tuberculosis) through a combined approach of aDNA and palaeoproteomics used to better understand active infections and immune response in archaeological individuals. The ultimate goal of this project is to improve identification of active ancient pathogen infections in past peoples, which will lead to additional mycobacterial genomes and widen our understanding of bacterial evolution.

Through protein analysis of bone and tooth samples from individuals with positive genomes for *Mycobacterium leprae*, specific biomarkers that are likely indicative of leprosy could be detected. As protein analysis is a lot less expensive than DNA sequencing, this offers a possible way to triage bone samples for those with active leprosy at the time of death.

The project has also been successful in greatly expanding the proteome of bone and tooth samples through a systematic approach in the optimization of collagen depletion and the researchers have been able to identify many immune proteins that have not previously been recovered from archaeological individuals.

Rapid Evolution of a Pathogen Recapitulates the Hybridization of Host Polyploid Wheat

PhD Student: Naoto-Benjamin Hamaya

PhD committee: Kentaro Shimizu (DEBES), Beat Keller (IPMB), Thomas Wicker (IPMB), Shuhei Nasuda (Kyoto University), Moeko Okada (Kobe University), Hiroyuki Kakui (Niigata University)

The project investigates rapidly evolving traits, namely the co-evolution of *Triticum aestivum* and *Blumeria graminis* f.sp. *tritici*, as well as the number of pollen grains in *T. aestivum* and *Arabidopsis thaliana* to identify QTLs/genes involved in resistance to powdery mildew in bread wheat, as well as genes regulating pollen number. To this end, four candidate genes in *A. thaliana* for the regulation of pollen number have been cloned and are being analyzed with complementation tests. The parental lines of the mapping population as well as the RILs of it for pollen number could already be phenotyped, while the sequencing of the different lines is currently being conducted.

In 2022 the phenotyping and sequencing data of the mapping population will be available and QTL mapping will continue. With the availability of the sequencing data, population genetics of the parental lines will commence.

(ii) Role of Polyploidy and Epigenetic Variation in Diversification and Adaptation

EpiPop - Investigating the Role, Stability, and Distribution of Epigenetic Variation in Populations of Arabidopsis thaliana

PhD Student: Alexander Plüss

PhD committee: Ueli Grossniklaus (IPMB), Simon Aeschbacher (DEBES), Hidetoshi Saze (Okinawa Institute of Technology)

The project investigates whether epigenetic diversity that correlates with gene expression is functionally relevant for plant adaptation in natural populations of the model plant *Arabidopsis thaliana*. To this aim, we are identifying segregating epialleles in natural populations in the region around Mainz/Frankfurt in Germany and will follow their frequency in selected populations during the course of this project.

The populations under study have successfully been identified and sampled in 2021, but not all samples could yet be processed. We are planning to use a microfluidics chip for high throughput qPCR analysis of the large number of samples, and it takes some time to optimize the workflow.

The Relative Contribution of Genetic and Epigenetic Variability to Adaptation

PhD Student: Lucas Waser

PhD committee: Peter Szövényi (ISEB), Ueli Grossniklaus (IPMB), Bernhard Schmid (DEBES)

The project explores the dynamics of genetic and epigenetic variation under selection pressure on a transgenerational scale to evaluate the potential and importance of genetic and epigenetic variation for rapid adaptation.

During the first year of the project, the conditions for the evolutionary experiment were optimized and the genetic lines to be used in the experiment have been selected. Due to contamination, the complete *Physcomitrium patens* plant stock had to be replaced, which caused a significant delay in designing the mutagenesis experiment.

(iii) Experimental Evolution and Modelling

Tracking Genomic and Phenotypic Changes Induced by Experimental Manipulation of Natural Pollinator Communities

PhD Student: Elisabeth Authier

PhD committee: Léa Frachon (ISEB), Simon Aeschbacher (DEBES), Florian Schiestl (ISEB), Tobias Züst (ISEB), Carolin Kosiol (University of St Andrews), Maxime Bonhomme (Paul Sabatier University - Toulouse III)

The project investigates adaptation of flowering generalist plants to disturbances in pollinator communities. To this end, phenotypic and genomic adaptive responses of *Brassica rapa* to temporal limited access to natural pollinator communities are studied. An experimental evolution experiment could be half-finished, and with it half of the phenotypic measurements have been collected. The project is currently lacking sufficient funds to perform all genome sequencing experiments that were initially planned.

Is Dolutegravir-Based Combination Antiretroviral Therapy Evolution Proof in Sub-Saharan Africa

PhD Student: Tom Loosli

PhD committee: Roger Kouyos (Institute of Medical Virology, IMV, Department of Infectious Diseases and Hospital Epidemiology, INF-USZ), Huldrych Günthard (IMV, INF-USZ), Matthias Egger (University of Bern), Urs Greber (Department of Molecular Life Sciences, DMLS)

The project addresses the emergence of drug resistance to the newly rolled-out antiretroviral drug dolutegravir (DTG) in people living with HIV in South Africa. The ultimate goal is to capture the HIV epidemic in South Africa, including resistance genotypes, to identify the mechanisms determining DTG resistance emergence and ultimately inform targeted, efficient public health interventions. The previously published mathematical model was adapted to hold information on “resistance phenotypes”, while accurately capturing the past HIV epidemic in South Africa. Concurrent projects including multiple cohorts, where valuable insights for the model parameterization can be gained, are progressing. The unavailability or – if available – uncertainty of key parameters, such as mutation rates and realized mutational pathways, introduce, in turn, large uncertainties in the model. While the project investigates those variables, it is planned to publish the model as a framework first, which will then be parametrized as data becomes available.

3.1.2 Assistant Professorship

While the program’s funding for Academic Fellow Matt Horton, Assistant Professor in Paleogenetics Verena Schünemann, and Associate Professor Mark Robinson ended with Phase II, support for the Assistant Professor in Plant Evolutionary Genomics, Anne Roulin, continues in Phase III.

Plant Evolutionary Genomics – Assistant Professor: Anne Roulin (IPMB)

Local adaptation represents the first step to biological diversification and speciation. Elucidating the genetic mechanisms underlying this process, therefore, constitutes a key question in the field of evolutionary biology. Mutations as well as chromosome rearrangements have been shown to be involved in this evolutionary process. However, to what extent other sources of genetic variation influence the evolution of natural populations remains poorly understood. To this regard, the aim of our project is to better understand how transposable element (TE) activation contributes to the evolution of natural populations.

In *Arabidopsis thaliana*, we have shown the activity of TE can lead to new insertions, which can provide a selective advantage. Specifically, one new insertion of the TE ONSEN enhances drought tolerance, suggesting that TEs can provide a fast answer to new or changing environmental conditions (Thieme et al. 2021).

In the grass model *Brachypodium distachyon*, we are investigating the link between environmental stress and TE activity using a population genomics approach. By making use of the diversity panel generated during the last five years (Skalska et al. 2020, Stritt et al. 2021), we showed that TE activity can be predicted (Thieme et al. in prep) and is TE family-specific.

Linking Environmental Stress to Transposable Element Activity and Fitness

Postdoc: Michael Thieme

Supervisor: Anne Roulin (IPMB)

Collaborators: Todd Blevins (University of Strasbourg), Vitek Latzel (Academy of Sciences of the Czech Republic)

The project aims at understanding cause and consequences of TE-mobility in the model plants *B. distachyon* and *A. thaliana* by identifying genetic and environmental factors that lead to transposition, and the harnessing of this knowledge to generate novel TE-insertions, which will facilitate the understanding of adaptive consequences of transposition in plants.

Only little evidence for the mobility of full-length elements in *B. distachyon* wild-type plants could be found, but the first mobile retroTE in an RdDM mutant of *B. distachyon* was detected. We are currently trying to understand under which conditions/tissue this TE gets mobilized.

Using mobilome-seq, we found many smaller (<2kb) extrachromosomal DNA circles. We are still trying to understand if the formation of these circles has a biological origin or could be an artifact of the used method.

3.1.3 Finalization of Phase II Research Projects and graduation of PhD Students

Of the 14 PhD Students funded in Phase II (2017 - 2020), a majority graduated in 2021:

January 14, 2021 – Felix Moerman: Understanding Invasions — From the Genetic Basis to the Ecological Dynamics of Spreading Populations

January 22, 2021 – Yagmur Erten: Life History Evolution under Cancer Risk

April 14, 2021 – Alexandre Figueiredo: The Ecology and Evolution of Bacterial Social Interactions and How They Shape Microbial Communities and Interactions with Hosts

June 8, 2021 – Enrique Rayo: Evolution of Microbial Communities Associated with Human Populations: Molecular Insights from Archaeological and Historical samples

July 23, 2021 – Luca Murer: Evolutionary Mutagenesis Provides Insight into Rhinovirus Genome Uncoating and Lipid Kinases in Replication

July 29, 2021 – Marion Müller: Genomic and Genetic Analysis of Host and Cultivar Adaptation in the Cereal Powdery Mildew Pathosystem

October 6, 2021 – Huyen Nguyen: The Immunoepidemiological and Evolutionary Dynamics of HIV-1 in the Swiss HIV Cohort Study

October 29, 2021 – Stephan Schmeing: Unravelling the Genetic Architecture and Population Diversity of Bottlenecked Dolphin Using New Sequence Technologies and Bioinformatics

November 16, 2021 – Jana Mittelstrass: Biotic and Abiotic Factors That Drive the Assembly of Microbiomes in Two Plant Hosts

December 17, 2021 – Xeniya Kofler: Pollinator-Mediated Mating System Shifts in *Brassica rapa*

3.1.4 Pilot Projects

The URPP Evolution in Action released a Pilot Project Call in July 2021 to promote interdisciplinary approaches to evolutionary questions. Proposals could be submitted by young scientists working in UZH research groups that are either members of the URPP Evolution in Action or have applied for membership. The funding per proposal was limited to CHF 20'000.

The purpose of the call is to fund innovative pilot projects setting the stage for subsequent larger grant applications. We received a total number of 30 applications, many describing excellent ideas. The Steering Committee of the URPP Evolution in Action evaluated all proposals and chose 5 projects for funding to be conducted in 2022:

Applicant: Stefano Bencivenga, Postdoc (IPMB)
Title of project: Identifying Male-Female Signaling Factors Involved Plant Speciation
Granted funding: CHF 20'000

Applicant: Gözde Çilingir, Postdoc (DEBES)
Title of project: Age Estimation by DNA Methylation in the Aldabra Giant Tortoise
Granted funding: CHF 20'000

Applicant: Javier Sánchez-Martín, Postdoc (IPMB)
Title of project: Interrogating Alien Chromatin Content of Long-Read Sequenced Bread Wheat Chromosomes for Rapid Resistance Gene Cloning
Granted funding: CHF 19'050

Applicant: Abhishek Meena, PhD Student (DEBES)
Title of project: Genes Involved in the Expression of Secondary Sexual Traits in Male *Drosophila prolongata*: A New Model Species for Sexual Selection Studies
Granted funding: CHF 19'910

Applicant: Vera Vollenweider, PhD Student (Department of Quantitative Biomedicine, DQBM)
Title of project: Pyobiotics: Using Pyoverdine to Revert Selection for Antibiotic Resistance
Granted funding: CHF 17'510

4 Scientific Activities and Outreach

4.1 Scientific activities

4.1.1 Scientific Retreat



The **9th Annual Retreat of the URPP Evolution in Action** took place with approx. 50 participants in Rigi Kaltbad during September 15-17, 2021. The scientific program was opened with a keynote talk by the invited speaker Laurent Excoffier, Professor at the Institute of Ecology and Evolution, University of Bern. Subsequently, PhD Students and Postdocs from Phases II and III as well as the Assistant Professor reported on work conducted in 15 different research projects of the URPP Evolution in Action. Moreover, three new members (Stefan Lüpold, Tobias Züst, Cyril Zipfel) introduced their research efforts related to the URPP Evolution in Action. In the evening of September 16, more research associated with the URPP Evolution in Action, such as the pilot projects granted during Phase II, was presented in a lively poster session. The Annual Retreat was further complemented with Faculty and PhD Student meetings, a bioinformatics workshop, and an info session from the Functional Genomics Center Zurich (FGCZ).

The program also offered a variety of social components including a hike to a nearby alp and many possibilities for informal exchange during meals, coffee breaks, and apéros. As previous URPP Evolution in Action retreats, the Annual Retreat 2021 was a dynamic and positive event with lots of lively discussions, and the feedback from the attendees was enthusiastic.

4.1.2 Bioinformatics Tutorials and Support

The Embedded Bioinformaticians Carla Bello (until June 2021) and Gregor Rot supported research of the URPP Evolution in Action with a variety of approaches:

Tutorials

The format of short tutorials as organized in previous years was reconsidered due to the reduction of the number of PhD Students (14 students in Phase II to 7 students in Phase III). The reduced student group presents an opportunity for an even more dynamic and personalized tutoring, in the form of one-on-one consultations on IT and bioinformatics topics of interest.

Classes

Teaching in 2021 was done over Zoom and Slack. The virtual environment for teaching was Docker. The combination of Zoom and Slack proved very successful. Slack provides an efficient platform for sharing knowledge and asking questions organized in channels, and to receive answers from colleagues and tutors in either private messages or discussion threads.

The bioinformatics team was involved in 3 online classes in 2021:

- **BIO609** (prerequisite to attend BIO610 and BIO634): Introduction to UNIX/Linux and Bash Scripting, 22 students, April 20, 2021,
- **BIO610**: Next Generation Sequencing, 17 students, April 21 – 22, 2021,
- **BIO634**: continuation of the 2-day class on Next Generation Sequencing (part one BIO610), exploring topics such as transcriptomes, variant calling and biological interpretation, 11 students, June 3 – 4, 2021.

PhD project presentations in the context of bioinformatics

In March and April 2021, the Phase III PhD Students were asked to give an introductory talk about their projects from the bioinformatics perspective. The short presentations were useful to the Embedded Bioinformaticians and served as a first basis for discussions and guidance on future bioinformatics challenges and plans, including sequence data storage, management, and analyses.

Bioinformatics and IT support

The Embedded Bioinformaticians provide continued support in terms of IT infrastructure (>60 TB data storage, computer cluster access, large mainframe access with 1TB RAM and 80 cores CPU) and bioinformatics (coding in python, R, shell, analysis of sequence data in context of methylation, variant calling, RNA analyses, enrichment analyses) on a flexible (Zoom, Slack, e-mail, in-person meetings, very short response time) and open basis (GitHub code, hands on tutoring on scripting and programming).

Bioinformatics parts of the PhD projects are followed-up individually. Data from the research projects is stored, and analyses results are shared over the front-end server accessible also outside the UZH network (secure access, for external collaborators). This work paradigm allows PhD Students to learn bioinformatics, scripting, and coding with the support of the Embedded Bioinformaticians, and if needed to outsource parts of the bioinformatics analyses to the Embedded Bioinformaticians or other researchers. It also facilitates the access to (and share of) data and results in one centralized place managed and provided by the URPP Evolution in Action.

4.1.3 Courses for the PhD Program in Evolutionary Biology

- Introduction to UNIX/Linux and Bash Scripting (**BIO609**); April 20, 2021; Lecturers: Carla Bello, Gregor Rot
- Next-Generation Sequencing for Model and Non-Model Species (**BIO610**); April 21 – 22, 2021; Lecturers: Kentaro Shimizu, Masaomi Hatakeyama, Sun Jianqiang, Jun Sese, Rie Shimizu Inatsugi, Shoji Tatsuma, Carla Bello, Gregor Rot
- Next-Generation Sequencing for Model and Non-Model Species 2: Transcriptomes, Variant Calling and Biological Interpretation (**BIO634**); June 3 – 4, 2021; Lecturers: Carla Bello, Gregor Rot
- QTL Analysis in *Arabidopsis* – Theory and Practical Applications; July 26 – 27, 2021; Lecturers: Ueli Grossniklaus, Tom Juenger
- Concepts in Evolutionary Biology (**BIO395**); October 25 – 26, 2021; Lecturers: Kentaro Shimizu, Michael Krützen, Catalina Pimiento Hernandez, Anne Roulin, Wolf Blanckenhorn, Anna Lindholm, Simon Aeschbacher, Andrei Papkou
- Scientific Writing for Evolutionary Biologists (**BIO555**); November 19 – 22, 2021; Lecturers: Hanna Kokko, Annegret Lesslauer

4.1.4 URPP Evolution in Action Seminars

Due to the uncertain dynamics of the Covid-19 pandemic, the seminar series of the URPP Evolution in Action remained inactive in 2021. Nevertheless, we put a lot of effort into the dissemination of information regarding events of interest to our community. To this end, lectures, talks, mini symposia, and workshops covering topics on Evolution in Action were regularly announced to our mailing list. The URPP Evolution in Action also co-organized the *Kyoto-Zurich Workshop in Plant Science 2021: Recent Developments in Fundamental and Applied Plant Molecular Biology*, which took place December 6 and 13, 2021. During the workshop, PIs from Kyoto University and the University of Zurich presented their work, followed by discussions and an exchange of ideas to foster future interactions. The workshop was initiated to serve as potential steppingstone for strengthening and launching collaborative research including student exchanges.

4.1.5 International Conference on Evolution in Action

The URPP Evolution in Action plans an international conference as a central scientific event during Phase III. The aims of this event will be to bring together researchers from our own community and international researchers who use similar approaches, and to improve the understanding between scientists trained in genomics and in evolutionary biology, respectively. This understanding across disciplines is a core topic of the URPP Evolution in Action, but also for scientists worldwide working in these areas. In October 2021, we applied for a conference slot in 2023 at Monte Verità in Ascona, a setting that greatly stimulates discussions. Our proposal was granted in December 2021 with the opportunity to hold the conference in June 2023.

4.2 Outreach activities

4.2.1 Museum exhibition *evolution happens!*

The museum exhibition *evolution happens!* is the key public outreach element of the URPP Evolution in Action. It has been in planning since 2014 and was an essential activity proposed in the Development and Financial Plan for Phase II of the URPP Evolution in Action. The development of the concept, the identification of suitable research from the URPP Evolution in Action to be presented in the exhibition, and the development of most of the exhibition's content happened during Phase II (2017 – 2020) in close collaboration with the Zoological Museum of the UZH. The exhibition opened its doors on June 15, 2021. To meet the high public demand, the duration of the exhibition was extended for two months. Eventually, it was on display at UZH's Zoological Museum until the end of February 2022.

The exhibition *evolution happens!* comprises a total of 7 stations, four of which feature research currently conducted by members of the URPP Evolution in Action. The stations are framed by an intro and an outro animation and visitors can leave their impressions on a large post-it wall when exiting the exhibition. The exhibition is further supplemented by a mobile app featuring two games that are being projected live onto big screens in the exhibition.

The exhibition has been well-visited and the accompanying program with guided tours and workshops has been utilized by a good number of people. In 2021, more than 20 guided tours and 10 workshops for a variety of audiences, such as the general public, school classes, and groups from (non-)governmental bodies (e.g., other museums, nature conservation associations, departments of universities, or the SNSF) have been conducted in the exhibition. In collaboration with researchers from the Work Package 3 (Informal Education) of the COST Action EuroScitizen, we quantified the knowledge transfer generated with *evolution happens!*. Using observations and questionnaires, we collected data to identify types and amounts of information conveyed by the exhibition.

In a next step, the exhibition will start traveling to other museums in Switzerland. As of November 2022, *evolution happens!* will be shown in the Naturmuseum Solothurn.

4.2.2 Scientifica

At the science fair *Scientifica* in September 2021, the URPP Evolution in Action contributed to the public outreach efforts of ETH and UZH with a series of short lectures, a guided tour, and workshops. All activities took place at the Zoological Museum of the UZH and combined the *Scientifica* topic of "synthetic naturally" with aspects of Evolution in Action, e.g., by focusing on the domestication of crops.

4.2.3 Social Media

The URPP Evolution in Action attends to a Twitter account (@uzh_evolution) since 2018 and has employed it to retweet or like stories from its members to increase their online visibility. With the intensification of social media employment in public outreach efforts, we decided to expand our Twitter routine by an increased active usage. To this end, we have started to provide own content, such as the communication about the museum exhibition *evolution happens!* or Twitter threads introducing the new PhD cohort from Phase III, directly from the Twitter account of the URPP Evolution in Action. In 2021, we could increase our Twitter visibility from 200 profile visits per month (until March 2021) to more than 1000 visits per month (as of April 2021).

5 Academic Career Development

5.1 Academic Career Development for Young Academics

Most of the budget granted to the URPP Evolution in Action is used to fund young academics at several career stages. In Phase III, the URPP Evolution in Action is set to provide salaries and research consumables for 7 PhD Students and 3 Postdocs as well as one Assistant Professor, hence contributing substantially to their career development at the financial level. We also foster young academics by awarding grants for short-term research projects, where proposals can be handed in by PhD Students and Postdocs of the research groups participating in the URPP Evolution in Action. These Pilot Project calls have proved to be very successful in enabling young scientists to develop their own research ideas, in forming new collaborations across the borders of research groups and institutes, and in obtaining their own funding for pilot projects. In 2021, the URPP Evolution in Action released a new call for Pilot Project Proposals and funded a total of 5 projects.

Next to the direct financial support, we provide a network supporting young academics in the field of Evolutionary Biology and maintain an atmosphere of lively interactions across the borders of faculties, departments, and seniority. To this end, we organize social events and see such activities deliberately to grant young academics access to a community of experienced researchers. An established format of the URPP Evolution in Action is the “Informal Get-Together”, which could, in part, be resumed with a virtual apéro in March 2021, and an onsite social event at the museum exhibition *evolution happens!* in September 2021. A third event planned for late November unfortunately had to be cancelled due to the fifth wave of the Covid-19 pandemic. Additionally, we resumed the “Very Informal Get-Togethers” with the PhD Students of the URPP Evolution in Action, providing an additional basis for exchange for this peer group.

The URPP Evolution in Action is dedicated to closely support the young researchers in the program’s projects. At the beginning, all PhD Students of Phase III had a PhD Student from Phase II assigned as mentor to support their start at UZH. Towards the end of the year, one of the program co-managers met each PhD Student individually to provide a low-threshold opportunity for the young scientists to address any questions and issues. Moreover, the Embedded Bioinformaticians of the URPP Evolution in Action support all PhD projects from the beginning, such that experimental design, probe preparation, and analysis methods are optimally adapted to the questions asked. In doing so, the Embedded Bioinformaticians themselves expand their research experience, and the wealth of data available from several projects allows them to develop productive research activities of their own. We have taken care to enable a close contact between the Embedded Bioinformaticians of the URPP Evolution in Action and the bioinformatics community at UZH. The URPP Evolution in Action Embedded Bioinformaticians regularly work in the von Mering (DMLS) and Wagner (DEBES) groups, respectively, where they are in touch with the newest developments in bioinformatics research and take part in the weekly group meetings. This approach allows for a continued transfer of knowledge at the forefront of current research topics and trends in bioinformatics.

The PhD Students in the URPP Evolution in Action have the possibility to engage with the URPP Evolution in Action in various ways. At our retreats, they are invited to formulate their needs in a meeting specifically dedicated to this aim. Furthermore, the PhD Students have elected a representative who serves on the Steering Committee of the URPP Evolution in Action.

5.2 Gender Equality Development

Hiring of personnel is on an equal opportunity basis and according to the “Gender Equality Action Plan UZH” guidelines. We emphasize our equal opportunity efforts in all job advertisements and the gender ratio in the URPP Evolution in Action is balanced among the applicants for positions and grants. In the past, we have appointed outstanding women scientists as Assistant Professors, thereby providing excellent role models. In 2021, Chiara Barbieri, a female young group leader, was elected as member of the Steering Committee following Frank Rühli’s resignation.

We aim at a balanced gender ratio in the list of our invited speakers for seminars and keynote lectures, too. This is also reflected in our application for an International Conference at Monte Verità, which proposed equally many female and male keynote and invited speakers from universities across the globe.

We support efforts to create a family-friendly work environment, for instance by enabling part-time work. Also in 2021, the Covid-19 pandemic demanded increased flexibility, especially for parents working in home office. The URPP Evolution in Action supported such flexibility for its members, especially regarding working hours to create best possible conditions to work from home.

6 Publications

6.1 Peer-Reviewed Publications in 2021

Abrouk M, Athiyannan N, Müller T, Pailles Y, Stritt C, [Roulin AC](#), [...] [Keller B](#), Krattinger SG (2021). Population genomics and haplotype analysis in spelt and bread wheat identifies a gene regulating glume color. *Communications Biology* 4:375. **Open Access**

Aguirre-Fernández G, [Barbieri C](#), Graff A, Pérez de Arce J, Moreno H, [Sánchez-Villagra MR](#) (2021). Cultural macroevolution of musical instruments in South America. *Humanities and Social Sciences Communications* 8:208. **Open Access**

Akiyama R, Sun J, Hatakeyama M, [Lischer HEL](#), [...] [Shimizu KK](#), [Shimizu-Inatsugi R](#) (2021). Fine-scale empirical data on niche divergence and homeolog expression patterns in an allopolyploid and its diploid progenitor species. *New Phytologist* 229(6):3587-3601. **Open Access**

Bai Y, Caussin E, Leo S, Bosshardt F, Myachina F, [Rot G](#), [Robinson MD](#), Lehner CF (2021). A cis-regulatory element promoting increased transcription at low temperature in cultured ectothermic *Drosophila* cells. *BMC Genomics* 22:771. **Open Access**

Baumann C, Pfrengle S, Münzel SC, Molak M, Feuerborn TR, Breidenstein A, [...] Bocherens H, Schuenemann VJ (2021). A refined proposal for the origin of dogs: the case study of Gnrishöhle, a Magdalenian cave site. *Scientific Reports* 11:5137. **Open Access**

Brown JA, Mbunkah HA, Lejone TI, [...] Metzner KJ, Günthard HF, Labhardt ND, [Kouyos RD](#), [Tschumi N](#) (2021). Emergence of Human Immunodeficiency Virus-1 Drug Resistance During the 3-Month World Health Organization-Recommended Enhanced Adherence Counseling Period in the CART-1 Cohort Study. *Open Forum Infectious Diseases* 8(5).

[Figueiredo ART](#), [Wagner A](#), [Kümmerli R](#) (2021). Ecology drives the evolution of diverse social strategies in *Pseudomonas aeruginosa*. *Molecular Ecology* 30(20):5214-5228. **Open Access**

[Flores-Rueda AM](#), Fiscalini F, Roth M, [Grossniklaus U](#), Städler T (2021). Endosperm and Seed Transcriptomes Reveal Possible Roles for Small RNA Pathways in Wild Tomato Hybrid Seed Failure. *Genome Biology and Evolution* 13(8). **Open Access**

Frangedakis E, Shimamura M, Villarreal JC, Li FW, Tomaselli M, Waller M, Sakakibara K, Renzaglia KS, [Szövényi P](#) (2021). The hornworts: morphology, evolution and development. *New Phytologist* 229(2):735-754.

Frangedakis E, Waller M, Nishiyama T, Tsukaya H, Xu X, Yue Y, Tjahjadi M, Gunadi A, Van Eck J, Li F-W, [Szövényi P](#), Sakakibara K (2021). An Agrobacterium-mediated stable transformation technique for the hornwort model *Anthoceros agrestis*. *New Phytologist* 232(3):1488-1505. **Open Access**

Gerber R, [Robinson MD](#) (2021). Censcyt: censored covariates in differential abundance analysis in cytometry. *BMC Bioinformatics* 22:235. **Open Access**

Halstead-Nussloch H, Tanaka T, Copetti D, Paape T, Kobayashi f, Hatakeyama M, [...] [Shimizu KK](#), Handa H (2021). Multiple Wheat Genomes Reveal Novel Gli-2 Sublocus Location and Variation of Celiac Disease Epitopes in Duplicated α -Gliadin Genes. *Frontiers in Plant Sciences* 12:715985. **Open Access**

Hewitt T, [Müller MC](#), Molnár I, Mascher M, Holušová K, Šimková H, Kunz L, [...] [Keller B](#), Lagudah E, Zhang P (2021). A highly differentiated region of wheat chromosome 7AL encodes a *Pm1a* immune

receptor that recognizes its corresponding *AvrPm1a* effector from *Blumeria graminis*. *New Phytologist* 229(5):2812-2826. **Open Access**

Huang R, Sonesson C, Germain P-L, Schmidt TSB, Von Mering C, Robinson MD (2021). *treeclimbR* pinpoints the data-dependent resolution of hierarchical hypotheses. *Genome Biology* 22:157. **Open Access**

Lankheet I, Vicente M, Barbieri C, Schlebusch C (2021). The performance of common SNP arrays in assigning African mitochondrial haplogroups. *BMC Genomic Data* 22:43. **Open Access**

Leigh DM, Lischer HEL, Guillaume F, Grossen C, Günther T (2021). Disentangling adaptation from drift in bottlenecked and reintroduced populations of Alpine ibex. *Molecular Ecology Resources* 21(7):2350-2363. **Open Access**

Lütge A, Zypych-Walczak J, Brykczynska Kunzmann U, Crowell HL, Calini D, Malhotra D, Sonesson C, Robinson MD (2021). CellMixS: quantifying and visualizing batch effects in single-cell RNA-seq data. *Life Science Alliance* 4(6). **Open Access**

Manser B, Koller T, Praz CR, Roulin AC, [...], Keller B, Sánchez-Martín J (2021). Identification of specificity-defining amino acids of the wheat immune receptor Pm2 and powdery mildew effector *AvrPm2*. *The Plant Journal* 106(4):993-1007.

Matsumae H, Ranacher P, Savage PE, Blasi DE, Currie TE, Koganebuchi K, Nishida N, Sato T, Tanabe H, Tajima A, Brown S, Stoneking M, Shimizu KK, Oota H, Bickel B (2021). Exploring correlations in genetic and cultural variation across language families in northeast Asia. *Science Advances* 7(34). **Open Access**

Milosavljevic S, Kuo T, Decarli S, Mohn L, Sese J, Shimizu KK, Shimizu-Inatsugi R, Robinson MD (2021). ARPEGGIO: Automated Reproducible Polyploid EpiGenetic Guidance workflow. *BMC Genomics* 22:547. **Open Access**

Mittelstrass J, Sperone FG, Horton MW (2021). Using transects to disentangle the environmental drivers of plant-microbiome assembly. *Plant, Cell & Environment* 44(12):3745-3755. **Open Access**

Müller MC, Kunz L, Graf J, Schudel S, Keller B (2021). Host Adaptation Through Hybridization: Genome Analysis of Triticale Powdery Mildew Reveals Unique Combination of Lineage-Specific Effectors. *Molecular Plant-Microbe Interactions* 34(12):1350-1357. **Open Access**

Ng KKS, Kobayashi MJ, Fawcett JA [...] Shimizu KK (2021). The genome of *Shorea leprosula* (Dipterocarpaceae) highlights the ecological relevance of drought in aseasonal tropical rainforests. *Communications Biology* 4:1166. **Open Access**

Nguyen H, Thorball CW, Fellay J, Böni J, Yerly S, [...], Günthard HF, Kouyos RD, The Swiss HIV Cohort Study (2021). Systematic screening of viral and human genetic variation identifies antiretroviral resistance and immune escape link. *eLife* 10:e67388. **Open Access**

Pfrenkle S, Neukamm J, [...] Schuenemann VJ (2021). Mycobacterium leprae diversity and population dynamics in medieval Europe from novel ancient genomes. *BMC Biology* 19:220. **Open Access**

Roquis D, Robertson M, Yu L, Thieme M, Julkowska M, Bucher E (2021). Genomic impact of stress-induced transposable element mobility in Arabidopsis. *Nucleic Acids Research* 49(18):10431-10447. **Open Access**

Schmeing S, Robinson MD (2021). ReSeq simulates realistic Illumina high-throughput sequencing data. *Genome Biology* 22:67. **Open Access**

Shimizu KK, Copetti D, Okada M, Wicker T, Tameshige T, Hatakeyama M, Shimizu-Inatsugi R, [...] Handa H (2020). De Novo Genome Assembly of the Japanese Wheat Cultivar Norin 61 Highlights Functional Variation in Flowering Time and *Fusarium*-Resistance Genes in East Asian Genotypes. *Plant and Cell Physiology* 62(1):8-27. **Open Access**

Stritt C, Thieme M, Roulin AC (2021). Rare transposable elements challenge the prevailing view of transposition dynamics in plants. *American Journal of Botany* 108(8):1310-1314. **Open Access**

Szövényi P, Gunadi A, Li FW (2021). Charting the genomic landscape of seed-free plants. *Nature Plants* 7:554-565.

Urban C, Blom AA, Pfrengle S, Walker-Meikle K, Stone AC, Inskip SA, Schuenemann VJ (2021). One Health Approaches to Trace *Mycobacterium leprae*'s Zoonotic Potential Through Time. *Frontiers in Microbiology* 12:762263. **Open Access**

6.2 Books and Book Chapters

Paro R, Grossniklaus U, Santoro R, Wutz A (2021). Introduction to Epigenetics. Learning Materials in Biosciences. Cham: Springer Nature Switzerland AG. **Open Access**

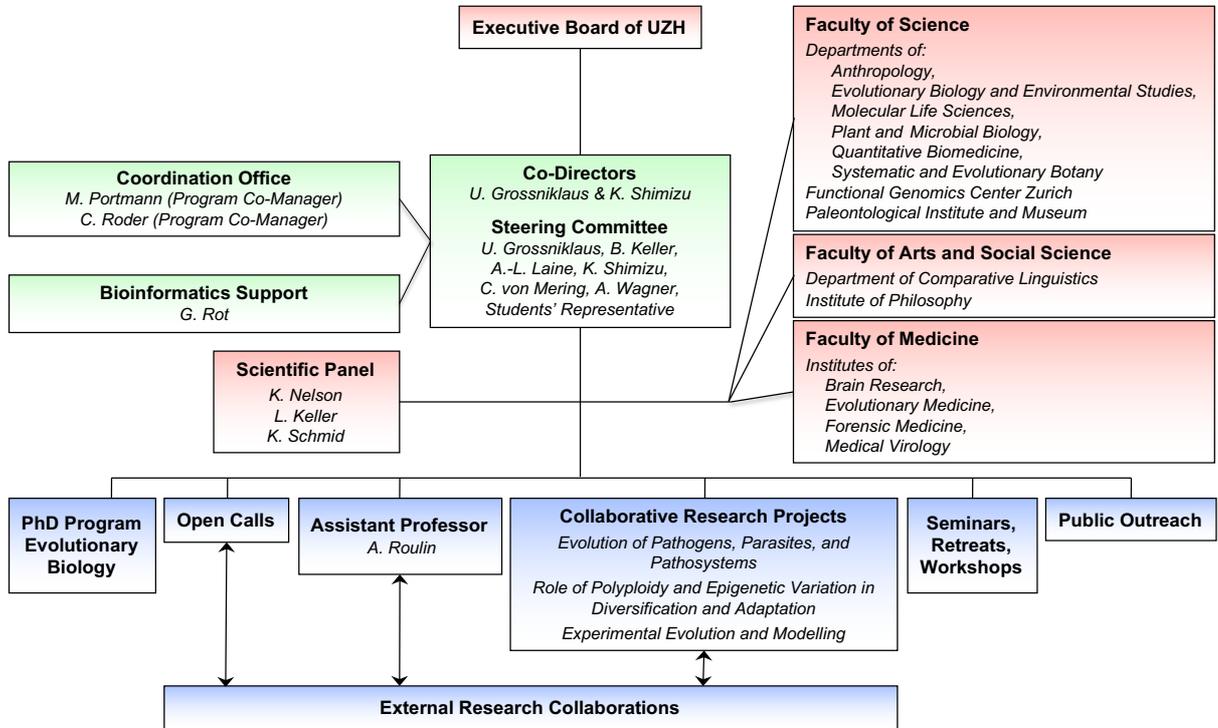
Stritt C, Roulin AC (2021). Detecting Signatures of TE Polymorphisms in Short-Read Sequencing Data. In: Cho J. *Plant Transposable Elements*. New York: Springer 177-187.

Thieme M, Roulin AC (2021). Identification of Active Transposable Elements in Plants: The Mobilome-Seq Approach. In: Cho J. *Plant Transposable Elements*. New York: Springer 95-102.

6.3 Open Science

The URPP Evolution in Action supports open science efforts to ensure a consistent and meaningful structure of research data that is stored centrally and accessible as well as usable for others. To this end, we support initiatives that enable scientists to disseminate their findings in a transparent and rapid way. Members of the URPP Evolution in Action, for example, frequently use the bioRxiv platform to provide their manuscripts as open-source preprints to the world-wide scientific community. Most manuscripts published in the framework of the URPP Evolution in Action are Open Access.

7 Structures



8 Third-party Funds

8.1 Newly approved third-party funding

Léa Frachon / Claraz-Schenkung – CHF 1'500 for field equipment

Beat Keller / Functional analysis of host-specific disease resistance in wheat / SNSF Project funding (Div. I-III) / 01.2022 – 01.2025 / CHF 923'047

Roger Kouyos (co-investigator) / HIV-1 subtype-specific drug resistance in patients failing dolutegravir-based first-line, second-line or third-line regimens: multiregional cross-sectional study / NIH (R01 Grant) / 2021 – 2024 / USD 2'461'630 (USD 179'680 for UZH)

Lucas Waser / Claraz-Schenkung – Travel grant for conference attendance

8.2 Ongoing third-party funding

8.2.1 Swiss National Science Foundation – Divisions I to III

Balthasar Bickel, Kentaro Shimizu (co-applicants) / Out of Asia: Linguistic Diversity and Population History / SNSF Sinergia / 09.2019 – 08.2023

Beat Keller / Molecular analysis of disease resistance specificity in cereals / SNSF Project funding (Div. I-III) / 01.2019 – 12.2021

Rolf Kümmerli / An evolutionary ecology approach to disarm bacterial pathogens, control infections, and understand polymicrobial interactions inside hosts / SNSF Project funding (Div. I-III) / 12.2018 – 11.2022

Mark Robinson / Beyond the average: computational tools for discovery in high-throughput single cell datasets / SNSF Project funding (Div. I-III) / 11.2017 – 10.2021

Mark Robinson (co-applicant) / Defining the identity and differentiation pathways of the immune-stimulating fibroblastic tumor stroma / SNSF Sinergia / 01.2018 – 12.2021

Mark Robinson (project partner) / Road-mapping the serrated pathway of colon tumorigenesis: Step 2: Impact on clinical management of precancerous colorectal lesions. / SNSF Project funding (Div. I-III) / 05.2018 – 04.2022

Mark Robinson (project partner) / Stromal Cell Niches at the Nexus of the Innate Lymphoid Cell Interactome / SNSF Project funding (Div. I-III) / 01.2019 – 12.2022

Anne Roulin / Impact of transposable elements on plant population evolution: insight from the model grass species brachypodium distachyon / SNSF Project funding (Div. I-III) / 10.2019 – 09.2023

Verena Schünemann / Towards the origins of syphilis / SNSF Project funding (Div. I-III) / 11.2019 – 10.2022

Kentaro Shimizu / Evolutionary functional genomics of selfing and polyploid speciation / SNSF Project funding (Div. I-III) / 12.2018 – 11.2022

8.2.2 Swiss National Science Foundation – Divisions IV

Balthasar Bickel, Kentaro Shimizu (co-applicant) / NCCR Evolving Language / 2020 – 2023

8.2.3 EU

Ueli Grossniklaus / Unlocking epigenetic variation to breed sustainable crops in a changing climate / RESPONSE Doctoral Programme, Marie Skłodowska-Curie Grant

8.2.4 Industry

Mark Robinson / Single cell RNA sequencing of blood and cerebrospinal fluid samples (CSF) from progressive multiple sclerosis patients treated with anti-CD20 (Ocrevus) therapy / F. Hoffmann-La Roche AG / 04.2020 – 03.2022

8.2.5 Others

Kentaro Shimizu / Constructing models to confer environmental robustness by developing multiomics technology of polyploid species / Japan Science and Technology Agency / 10.2016 – 03.2022

Rie Shimizu-Inatsugi / Collaboration at the Center for Ecological Research / Kyoto University / 04.2020 – 03.2021

8.3 Newly funded projects

Jasmin Winkler / Sonderausstellung “evolution happens!” / Ernst Göhner Stiftung

8.4 Ongoing projects

Matthew Horton / Identifying the plant genes that shape the leaf metabolome and microbiome / PSC Syngenta Fellowship, 09/2019 – 08/2022

Hanna Kokko / Museum Exhibition "Evolution in Action" / SNSF Agora, 12/2019 – 11/2021