

Faculty of Science and Engineering

Profile report: Theoretical Biology, Theoretische Biologie

- Discipline: theoretical biology, bio-mathematics, computational biology
- Level: Tenure-track assistant professor with education profile
- Fte: 0.8 – 1.0 fte

1. Scientific discipline

Theoretical biology is a broad, interdisciplinary field of research that employs theoretical analysis, and (mathematical and computational) modelling of living systems to investigate the principles that govern the structure and dynamics of biological systems in time and space, including their development and evolution. Theoretical research in biology contributes to biological insight, the generation of novel hypotheses and the validation of informal reasoning, in ways that complement experimental and observational approaches. Conversely, theoretical biology relies on insight from empirical data to guide model construction, and on experiments to confirm or refute hypotheses and predictions derived from theory.

2. Vacancy

This position is opened by the Board of the Faculty PT/gl/22/00306 and will be embedded in the Groningen Institute for Evolutionary Life Sciences (GELIFES). The criteria and conditions pertaining to the position are described in the document 'Assistant professor with an education profile'.

3. Selection committee (BAC)

- Prof. dr Rampal Etienne (Director GELIFES)
- Prof. dr Eddy van der Zee (GELIFES education director)
- Prof. dr Sander van Doorn (Program Director BSc Biology)
- Prof. dr Jocelien Olivier (Professor of Developmental Behavioral Neuroscience)
- Prof. dr. Katja Taxis (Program Director MSc Pharmacy)
- Prof. dr. Roeland Merks (Professor of Mathematical Biology; external member)
- student t.b.d.

Advisors: Nancy Clemencia-Lokai (HR), Dr. Sebastian Lequime (GELIFES)

4. Area of expertise

Biology has become a scientific discipline where progress is often limited by the ability to analyse and interpret complex interactions and patterns in the available (big) data, such as the interactions between biomolecules in the living cell, the feedback mechanisms in physiology that govern homeostasis and adaptation, behavioural interactions between individuals in social groups and their emergent patterns, or the networks of interactions between species in ecosystems. Theoretical biology confronts the challenge of deciphering biological complexity by (conceptual) modelling, allowing for a reduction of biological complexity to manageable proportions (simplification), controlled manipulations of systems that are difficult to achieve in real life (simulation experiments), and extrapolation of system dynamics over large

temporal or spatial scales and/or levels of biological organization (multiscale analysis, pattern formation and emergent phenomena).

Theoretical biologists use a variety of different types of models to study biological systems, ranging from (simplified) ordinary differential equation models describing for instance the dynamics of interacting prey and predator populations, to (more complex) individual-based simulation models that track collectives of entities that are equipped with decision rules for interacting with others, or multi-scale simulations that result in spatial pattern formation or other emergent phenomena. Biological models may involve interactions among processes at the molecular, genetic, physiological, organismal, group, population or ecosystem level, which may occur at timescales ranging from milliseconds to evolutionary time. Moreover, models are essential to integrate structural and dynamical, or mechanistic and functional aspects of biological systems. Research in theoretical biology is inherently interdisciplinary and collaborative, and requires familiarity with state-of-the-art quantitative methods (e.g., analysis of dynamical systems, computer simulation and other tools for computational analysis) as well as a solid understanding of biological principles, current developments in biological research, and the nature of biological experimental data.

The growing importance of quantitative biological disciplines such as data science, bio-informatics, and systems biology, underscores that theoretical biology deserves a strong position in a modern biology curriculum: now, more than ever, biology students need to be equipped with a sufficient basis in mathematics, computer science and statistics, in order to be prepared for the quantity and complexity of biological data that is collected in modern biological research; moreover, after having developed a basis of quantitative skills, students need to become familiar with modelling approaches in their own field of specialisation. The role of the theoretical biologist in the BSc curriculum is to identify across the full range of biological disciplines what knowledge and skills from mathematics and computer science are essential for biology students to master, and to make these accessible in broad introductory courses. Furthermore, since life sciences students – generally speaking – have a lower affinity to theory than students in the exact sciences, theoretical biologists must provide a solid programme of intermediate- to advanced-level training to prepare biology students for theoretical research at the MSc stage. Typically, these courses will cover different approaches to biological modelling (e.g., mathematical and computational), and conceptual theory development. These activities require a high commitment to education, broad biological expertise to be able to provide relevant biological context, a willingness to start from the development of elementary quantitative skills, and the didactic skills needed to create a classroom that promotes cross-disciplinary learning.

Theoretical biology is an important area of research in the Groningen Institute for Evolutionary Life Sciences (GELIFES), as it delivers a powerful perspective on complex biological data, biological interaction networks, dynamical feedbacks over short and long timescales, and emergent phenomena across levels of biological organization. Its contributions to the educational programmes comprise introductory courses in biomathematics and scientific programming, which form a foundation for quantitative methods in a broad range of biological disciplines, as well as electives throughout the Biology Bachelor and Master programmes that prepare students for performing research in mathematical biology and computational modelling.

The current position intends to strengthen GELIFES' contribution to the educational programmes in the area of theoretical biology; support the innovation of theory courses in

order to address the challenges of high student diversity and large cohort size; and promote the integration of quantitative skill development throughout the biology curricula. In addition, the appointed candidate is expected to contribute to research in theoretical biology, preferably in association with one of the current research lines in theoretical biology represented in GELIFES.

5. Embedding: institute (and expertise group)

The Groningen Institute for Evolutionary Life Sciences (GELIFES) aims to enhance the understanding of adaptive processes and the maladaptive consequences of their limitations, across all levels of biological organization (from molecules and genes to individuals and ecosystems), to inform the society and contribute solutions to societal problems. The institute has tight connections with the Faculty of Medical Sciences (FMS) and University Medical Centre Groningen (UMCG). It coordinates master programs in general biology, marine biology, ecology & evolution, and in medical and behavioural neurobiology. The candidate will have access to GELIFES' excellent facilities, including a high-performance scientific computing cluster and other state-of-the-art IT facilities.

GELIFES is organized in a non-hierarchical manner, and staff associate with one (or more) informal expertise groups, each consisting of several professors and assistant professors with their research teams. The tenure-track assistant professor is free to choose their expertise group. A likely candidate among the six available options is the expertise group *Theoretical Research in the Evolutionary Life Sciences* (TRES). Current research in this expertise group spans a range of theoretical modelling approaches and biological topics, with a focus on ecology and evolution. Research lines of the current TRES members cover stochastic models of macro-evolution and diversification; conflict, personalities, cooperation and social evolution; mechanisms of biological adaptation; self-organisation in social systems and evolutionary systems biology. Depending on their background and interest, the appointed candidate may also prefer to join one of the other GELIFES expertise groups: *Genomics Research in Ecology & Evolution in Nature* (GREEN), *Evolutionary Genetics, Development and Behaviour* (EGDB), *Behavioural and Physiological Ecology* (BPE), *Conservation Ecology* (CONSECO) or *Neurobiology*.

6. Local and (inter)national position

Local:

Collaboration between theoretical and empirical scientists in the different fields in the GELIFES institute, such as Evolutionary Genetics, Conservation Ecology, Behavioural & Physiological Ecology, or Neurobiology, is highly stimulated and welcomed. Collaborations with (empirical) research groups outside the institute such as the Bernoulli Institute (e.g. Artificial Intelligence, Data Science) and GBB also exist.

National:

GELIFES has a strong reputation in research and education in ecology, evolution, behaviour and neurobiology. GELIFES is the only life science institute in the Netherlands that specifically aims at integrating the study of physiological mechanisms with those of ecology and evolution. Many collaborations exist with other universities and research institutes in The Netherlands on a wide variety of topics, including the universities of Wageningen, Utrecht and Amsterdam and the Royal Dutch Academy Institute, Netherlands Institute for Ecological Research and the Netherlands Institute for Sea Research as well as the Naturalis Biodiversity Center. The TRES

group is nationally strong in theoretical biology, with collaborations with other theoretical groups at UvA and UU, but also many empirical groups at VU, WUR and Naturalis.

International:

GELIFES, unlike many other institutes in the world, specifically aims at the integration of ecological and evolutionary approaches with neurobiology and physiology in the Life Sciences. Research topics that are internationally recognized and relevant for the new staff member are, among others, the evolution and physiology of animal personalities and ageing, the mechanisms and function of social interactions, neurobiology of neuropsychiatric disorders, biological and seasonal clocks, microbial genetics and ecology, maternal effects, avian flyways & population dynamics, adaptation to climate change, facilitation in plant communities, ecological community resilience, genetics and evolution of life histories, both from empirical and theoretical perspectives.

In theoretical and computational biology the TRES group is internationally leading in macroevolution, evolutionary community ecology, evolutionary systems biology, speciation theory, cultural evolution and evolution of personalities, eusociality, sex, maternal effects, and ageing.

7. Expected contributions to teaching

The candidate is expected to contribute to the bachelor programs in Biology and the master programs in Biology and Ecology and Evolution. Existing education in which the assistant professor will be involved, include the courses Modelling Life (BSc Biology) and the MSc track Modelling in the Life Sciences (MSc Biology). S/he will also be involved in the development of new BSc courses in Ecological and Evolutionary Modelling and Python for Biologists, which are to replace the current Self-Organisation and Programming in C++ for Biologists BSc courses, respectively. In addition, the candidate will be expected to work on the integration of theory education with other educational activities, in order to create a coherent line of quantitative skill development throughout the curriculum, ranging from introductory elements in existing BSc courses, to field-specific applications in BSc and MSc level courses. The candidate is also expected to develop innovations in teaching in general, and in cross-disciplinary teaching specifically. This contribution to the curricular development will be supported by successful applications for grants for educational innovation. Finally, the candidate will contribute towards the supervision of individual research projects of bachelor and master students.

8. Expected contributions to research

The assistant professor is expected to establish a research line in theoretical biology, and to contribute to efforts in this area within the institute GELIFES. This can be done, for example, by establishing research collaborations with existing empirical or theoretical groups. The candidate is also expected to contribute to the supervision of PhD students, supported by personal research funding and/or through collaborative/consortium grants.

9. Expected contributions to the organization

The candidate is expected to have an active interest and to provide a positive contribution to the management and organizational tasks of the institute. At the level of FSE, the candidate will contribute to the organization of the faculty, for example by participating in working groups and committees in the area of education. The candidate will participate in relevant national and international organizations.