Faculty of Science and Engineering

Profile report: Theoretical/computational biology, Theoretische/computationele biologie

- Discipline: Theoretical biology, computational biology (Modelling and model analysis in ecology & evolution, behaviour & neurosciences, integrative biology, complex adaptive systems or other relevant fields in biology).
- Level: Tenure-track assistant or associate professor with research profile
- Fte: 0.8 – 1.0 fte

1. Scientific discipline

Theoretical biology is a broad, interdisciplinary field of research that employs theoretical analysis, 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, complementing some of the intrinsic limitations of 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 generated through theoretical analysis and computational modelling.

2. Vacancy

This position is opened by the Board of the Faculty (PT/gl/21/00867) 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 a research profile'.

3. Selection committee (BAC)

- Prof. dr. Rampal Etienne (Scientific director GELIFES, Professor Theoretical and Evolutionary Community Ecology)
- Prof. dr. Theo Elzenga (Education director GELIFES, Professor Ecophysiology of Plants)
- Prof. dr. Sander van Doorn (Program director BSc Biology and Associate Professor Evolutionary Systems Biology, GELIFES)
- Prof. dr. Joana Falcao Salles (Professor Microbial Community Ecology, GELIFES)
- Prof. dr. Simon Verhulst (Professor Evolutionary Biology of Ageing, GELIFES)
- Prof. dr. Kirsten ten Tusscher (external member, Professor Computational Developmental Biology, UU)
- Si Nguyen Mai (student member)

Advisors: Mevr. Marlies Beuving (HR), Prof. dr. Robbert Havekes (Professor Neuroscience of Memory and Sleep, 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.

Current theoretical research in GELIFES spans a range of approaches and biological topics, with a focus on ecology and evolution. Present foci include: 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; research collaborations exist with a large number of empirical groups within the institute and beyond, e.g., in behavioural and animal ecology, evolutionary genetics, microbial ecology, bioinformatics, systems chemistry, psychology and business science. The present position is intended to strengthen theoretical research in GELIFES. The new staff member may reinforce the current emphasis on theory development in ecology and evolution, for instance, by bringing in expertise in evolutionary developmental biology, systems ecology modelling, evolution of culture and language, or other fields that are complementary to the research of remaining theoretical staff members. Alternatively, s/he may bring in expertise in other fields of theoretical biology relevant to GELIFES, such as computational neuroscience, integrative biology or complex adaptive systems theory.

Theoretical biology is a discipline that also makes substantial contributions to the biology curriculum. In order to prepare students in the life sciences for the sheer quantity and complexity of biological data that is collected in modern biological research, they need to be equipped with a sufficient foundation in statistics, mathematics and computer science. Moreover, the specific group of biology students who decide to specialize in theoretical biology, need to be equipped with intermediate to advanced-level training in biological modelling as well as mathematical and computational model analysis. Teaching theoretical biology, mathematical and computational modelling to biology students requires sufficient biological expertise to provide biological context, a willingness to start from the development of elementary quantitative skills and didactic skills 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 powerful tools for the analysis of complex biological data, biological interaction networks, dynamical feedbacks over short and long timescales, and emergent phenomena across levels of biological organization. This position will contribute to the theoretical research in GELIFES, either by strengthening its current research focus on modelling in ecology and evolution, or by broadening its profile towards other fields of theoretical biology, such as computational neuroscience, developmental biology, collective systems or complex adaptive systems. The new staff member's theoretical research should be firmly embedded in biology, allowing close collaborations with experimental groups in GELIFES and fruitful interactions with BSc and MSc students in our educational programmes in biology and life sciences.

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 society and contribute solutions to societal problems. The institute has close connections with the Faculty of Medical Sciences (FMS) and the University Medical Centre Groningen (UMCG). It coordinates master programs in evolution and ecology as well as in medical and behavioural neurobiology.

GELIFES is organized in a non-hierarchical manner, and staff associate with one (or more) informal expertise groups. The tenure-track assistant professor is free to choose their expertise group. GELIFES currently has six expertise groups, each consisting of several principal investigators with their groups: *Theoretical Research in Evolutionary Life Sciences* (TRES), *Genomics Research in Ecology & Evolution in Nature* (GREEN), *Evolutionary Genetics, Development and Behaviour* (EGDB), *Behavioural and Physiological Ecology* (BPE), *Conservation Ecology* (CONSECO) and *Neurobiology*.

The new staff member will have access to GELIFES' excellent facilities, including IT facilities for large data processing.

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.

<u>International</u>:

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 new staff member is expected to contribute to the Bachelor's and Master's programmes in Biology, and (depending on biological expertise) to the Master's programmes in Behaviour, Cognition and Neuroscience, Biology, Biomolecular Sciences, Ecology and Evolution, or Marine Biology. Existing education in which the assistant professor will be involved include 'BSc Research Project' (in Ecology & Evolution / Integrative Biology or Behaviour & Neuroscience) and the MSc track Modelling in the Life Sciences (MSc Biology). In addition, the new staff member may contribute to teaching field-specific applications of theoretical biology and modelling in BSc and MSc level courses across the curriculum, be involved in the courses Modelling Life (BSc Biology), and contribute to the development of a new intermediate-level biological modelling course (replacing the course Self-organization). The new staff member is also expected to supervise research projects of individual master students.

8. Expected contributions to research

The new staff member is expected to develop a research line in theoretical biology and/or computational modelling, focused on ecology and evolution, behaviour and neuroscience, integrative biology, complex adaptive systems, or another area of biology that is central to the research mission of GELIFES.

The new staff member should establish an independent and line of research of high quality that is internationally recognized and strengthens the international position of GELIFES. The expertise areas and skills of the new staff member should be complementary to that of the tenured staff at the institute.

The research should lead to high-quality publications and presentations at scientific conferences. Core tasks also include supervision of PhD students and postdocs in the relevant area of research and the acquisition of external funds.

9. Expected contributions to the organization

The new staff member 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 new staff member will contribute to the organization of the faculty, for example by

participating in working groups and committees in the area of education. The new staff member will participate in relevant national and international organizations, and contribute to the dissemination of scientific knowledge to society through outreach activities.