

## Offre n°2021-03660

# Post-Doctoral Research Visit F/M Statistical Learning of the Intestinal Microbiota Metabolism in Space and Time: Metamodelling for metabolic and PDE models coupling

*Le descriptif de l'offre ci-dessous est en Anglais*

Type de contrat : CDD

Niveau de diplôme exigé : Thèse ou équivalent

Fonction : Post-Doctorant

### A propos du centre ou de la direction fonctionnelle

The study of biology combines studies of forms (diversity) and modelling of processes (functional or evolutionary). Pleiade addresses the dual challenge of rapidly measuring relevant dissimilarities between biological objects and exploring the relationships between trait diversity and functional diversity at multiple scales. We develop algorithms, models, and software frameworks for applications in ecology, evolution and biotechnology.

### Contexte et atouts du poste

The position is funded by Inria and is part of the [Inria Exploratory Action SLIMMEST](#): Statistical Learning of the Intestinal Microbiota METabolism in Space and Time. This project consists in **two postdoc positions**: one scientist with a systems biology background, and a second with an applied mathematical background. Both scientists will work in close collaboration on an exciting project aiming at building a spatio-temporal numerical model of the gut microbiota. This particular offer concerns the **applied mathematician profile**.

The main objective of the SLIMMEST project is to resolve a numerical bottleneck in **spatio-temporal modeling of microbiotas: the coupling between microbe-scale metabolic models with community-scale dynamics described with PDE models**. The recruited person will develop machine learning techniques to build approximations of complex metabolic modelsto be used as a source function of a PDE model of the gut microbiota. The candidate will work in close collaboration with the other postdoc providing expertise in system biology, microbial metabolism, and community-wide metabolic network modeling.

The two recruited candidates will be members of the Pleiade team, a joint research group between Inria and [INRAE](#), in the beautiful city of [Bordeaux](#). [Pleiade](#) is an **interdisciplinary group** at the frontier of **computer science, mathematics, bioinformatics and biology**. One of our main research interests is to develop and validate new computational and numerical models for microbial ecology, that we dedicate to better understand the complex interactions occurring in complex communities of microorganisms known as microbiotas.

### Mission confiée

#### Assignments:

The **dynamics of a microbial community** is driven by the metabolism of its microorganisms, the interactions between those microorganisms, and spatio-temporal interactions between them and the environment. Mathematical and computational models of such dynamics are crucial to **build mechanistic hypotheses of the biological observations, as well as predict the evolution of the ecosystems, and actions to lead ecosystems in a desired state**. SLIMMEST will combine logic programming and metamodelling of metabolism in a scalable framework applied to communities of the gut microbiota.

This position is dedicated to the application of a **machine learning method** (RKHS metamodelling) to approximate metabolic quantitative models of microbial metabolism, known as FBA models (Orth et al.). The main goal is to provide **very fast and accurate approximations of metabolic model outputs** to be used as a source function of a PDE model of the gut microbiota. The idea is to adapt existing RKHS metamodelling methods in the context of metabolic modeling. Several options will be studied to improve the speed and quality of metamodel computation, including dimension reduction, HPC methods and incorporation of biological knowledge, in close collaboration with the other postdoc of the SLIMMEST

project. After learning of the metabolic models, a PDE model of a simplified murine gut microbiota (Lagkouvardos et al.) will be developed and analysed in collaboration with the second postdoc.

#### For a better knowledge of the proposed research subject:

- Arnaud Belcour et al. « Metage2Metabo, microbiota-scale metabolic complementarity for the identification of key species ». In : eLife 9 (2020), e61968. doi : 10.7554/elife.61968.
- Seth R Bordenstein et Kevin R Theis. « Host biology in light of the microbiome : ten principles of holobionts and hologenomes ». In : PLoS Biol 13.8 (2015), e1002226.
- Oliver Ebenhöh, Thomas Handorf et Reinhart Heinrich. « Structural analysis of expanding metabolic networks. » In : Genome informatics. International Conference on Genome Informatics 15.1 (2004), p. 35-45. issn : 0919-9454.
- Clémence Frioux, Simon M Dittami et Anne Siegel. « Using automated reasoning to explore the metabolism of unconventional organisms : a first step to explore host–microbial interactions ». In : Biochemical Society Transactions 48.3 (2020), p. 901-913. issn : 0300-5127. doi : 10.1042/bst20190667.
- Simon Labarthe et al. « A mathematical model to investigate the key drivers of the biogeography of the colon microbiota ». In : Journal of theoretical biology 462 (2019), p. 552-581.
- Ilias Lagkouvardos et al. « The Mouse Intestinal Bacterial Collection (miBC) provides host-specific insight into cultured diversity and functional potential of the gut microbiota ». In : Nature microbiology 1.10 (2016), p. 1-15.
- Orth, J. D., Thiele, I., & Palsson, B. Ø. (2010). « What is flux balance analysis? ». Nature biotechnology, 28(3), 245-248.
- Alberto Noronha et al. « The Virtual Metabolic Human database : integrating human and gut microbiome metabolism with nutrition and disease ». In : Nucleic Acids Research 47.D1 (2018), p. D614- D624. issn : 0305-1048. doi : 10.1093/nar/gky992.
- Clémence Frioux et al. « Scalable and exhaustive screening of metabolic functions carried out by microbial consortia ». In : Bioinformatics 34.17 (2018), p. i934-i943. issn : 1367-4803. doi : 10.1093/bioinformatics/bty588.

## Principales activités

### Main activities:

- Build fast and high-quality RKHS approximations of metabolic models of the murine gut microbiota.
- Develop dimension reduction methods to speed up RKHS computation.
- Build a PDE model of a simplified murine microbiota.
- Characterize the main functions and interactions that drive the community
- Analyse results of metamodelling by identifying and visualising metabolic functions provided by the simulations
- Share the results of the projects through scientific publications and code/documentation distribution

### Additional activities:

- Collaborate with the second post-doc of the project by providing expertise on PDE and applied mathematics.
- Participate in supervising students in the team.

## Compétences

### Technical skills and level required:

- Scientific computing for PDE solvers and applied mathematics.
- Python programming (or other scientific computing language)
- Real motivations for applications in biology
- Scientific writing

### Languages:

- English for scientific communication
- English or French for day to day work

### Relational skills:

- Ability to work in a collaborative environment
- Good communication skills (sharing results, supervising students)

Other valued skills: a background in statistics is not mandatory but would be a plus, and sufficient background in mathematics is required to learn new skills in statistical learning.

## Avantages

- Subsidized meals
- Partial reimbursement of public transport costs
- Possibility of teleworking and flexible organization of working hours
- Professional equipment available (videoconferencing, loan of computer equipment, etc.)
- Social, cultural and sports events and activities

- Access to vocational training

## Rémunération

2653€ / month (before taxes)

## Informations générales

- **Thème/Domaine :** Biologie numérique  
Calcul Scientifique (BAP E)
- **Ville :** Talence
- **Centre Inria :** [Centre Inria de l'université de Bordeaux](#)
- **Date de prise de fonction souhaitée :** 2021-10-01
- **Durée de contrat :** 2 ans
- **Date limite pour postuler :** 2021-08-31

## Contacts

- **Équipe Inria :** [PLEIADE](#)
- **Recruteur :**  
Labarthe Simon / [Simon.Labarthe@inria.fr](mailto:Simon.Labarthe@inria.fr)

## A propos d'Inria

Inria est l'institut national de recherche dédié aux sciences et technologies du numérique. Il emploie 2600 personnes. Ses 215 équipes-projets agiles, en général communes avec des partenaires académiques, impliquent plus de 3900 scientifiques pour relever les défis du numérique, souvent à l'interface d'autres disciplines. L'institut fait appel à de nombreux talents dans plus d'une quarantaine de métiers différents. 900 personnels d'appui à la recherche et à l'innovation contribuent à faire émerger et grandir des projets scientifiques ou entrepreneurial qui impactent le monde. Inria travaille avec de nombreuses entreprises et a accompagné la création de plus de 200 start-up. L'institut s'efforce ainsi de répondre aux enjeux de la transformation numérique de la science, de la société et de l'économie.

## L'essentiel pour réussir

The candidate should have a taste for interdisciplinary projects. He/she would ideally have a previous experience of mathematical modeling applied to life sciences.

The candidate would ideally have a PhD in applied mathematics in a field related to PDE, numerical analysis or scientific computing. A previous experience in statistical learning methods, parameter inference or data processing would be positively valued.

Background or previous experience in PDE computation would be a real asset.

**Attention:** Les candidatures doivent être déposées en ligne sur le site Inria. Le traitement des candidatures adressées par d'autres canaux n'est pas garanti.

## Consignes pour postuler

Thank you to send:

- CV
- Cover letter
- Support letters (mandatory)
- List of publication

### Sécurité défense :

Ce poste est susceptible d'être affecté dans une zone à régime restrictif (ZRR), telle que définie dans le décret n°2011-1425 relatif à la protection du potentiel scientifique et technique de la nation (PPST). L'autorisation d'accès à une zone est délivrée par le chef d'établissement, après avis ministériel favorable, tel que défini dans l'arrêté du 03 juillet 2012, relatif à la PPST. Un avis ministériel défavorable pour un poste affecté dans une ZRR aurait pour conséquence l'annulation du recrutement.

### Politique de recrutement :

Dans le cadre de sa politique diversité, tous les postes Inria sont accessibles aux personnes en situation de handicap.