



Radboud Summer School

Brain, Bacteria and Behaviour: Understanding the Gut-Brain Axis

Course programme

11 - 15 July 2022





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Course overview

Dates: 11 – 15 July 2022

Mode of study: on campus

Course fee: €650

Reduced fees:

- **€585** as an early bird discount for all applicants
- **€488** as an early bird discount for students and PhD candidates from and alumni of Radboud Summer School and Radboud University
- **€553** for students and PhD candidates from [partner universities](#) and Radboud University who apply after the early bird deadline (1 April 2022)

In this hands-on course you will learn the latest evidence on the role of commensal gut microbiota in the gut-brain axis, and how to study interactions between gut microbiome and brain functioning, behaviour and psychiatric diseases.

To understand behaviour, we often think only of studying the brain. However, there is another key system, almost always overlooked, involved in the normal functioning of the brain: the Gastro Intestinal (GI) system. The gut plays a key role in this relationship. Just like the brain, this organ has a large, independent nervous system, and it is in close communication with the brain through the gut-brain axis. Trillion of bacteria (the microbiota) live in our gut, with millions of genes (the microbiome). The gut microbiome is an important environmental factor that affects many physiological processes, such as cell proliferation and differentiation, behaviour, immune function and metabolism. More importantly, it may contribute to a wide variety of diseases, including cancer, inflammatory diseases, metabolic diseases, responses to pathogens, and importantly for this course: psychiatric diseases.

Due to rapid developments in genetic sequencing methods, we can now investigate bacterial life in the gut. This has led to a new line in cognitive, behavioural and psychiatric research that studies the gut microbiome-brain axis.

This course is targeted to participants interested in designing, conducting and interpreting research on the associations between the gut microbiome, brain and behaviour. This course is mainly intended for participants with a background in (cognitive) neuroscience, psychology and psychiatry. However we welcome other backgrounds, provided that participants are willing to read about basic neuroscience principles before the course.

During assignments, participants learn from each other, making use of their different backgrounds. At the end of the course, participants will have a good understanding of the promises and pitfalls of studying the gut microbiome in relation to brain health, and will have the basic skills to design and conduct studies investigating the role of the gut in mental health, cognition and behaviour.

Topics in the course include:

- The (Systems) Biology of the Microbiota and the various routes of gut-brain communication.
- The role of the Microbiota -Gut-Brain Axis in behaviour and mental health.
- Key modifiers of the gut microbiome (nutrition, stress, age, gender and host genes).
- Current methodological approaches to analyse Microbiota -Gut-Brain Axis based hypothesis (data collection, bacterial DNA extraction, bioinformatic and statistical tools).



- Practical sessions aimed to analyse 16s RNA-gene microbiome data and associating it with brain imaging data and cognitive tasks.
- Lectures and practicals will be taught by national and international experts in the field, including dr. Clara Belzer (Wageningen University), dr. Leo Lahti (University of Turku, Finland), dr. Tom Ederveen (Radboudumc), prof. dr. Aletta Kraneveld (Utrecht University), prof. dr. Jonathan Swann (University of Southampton, UK).

Course Leaders



Dr. Alejandro Arias Vasquez

Principal Investigator, Psychiatry & Human Genetics
Radboud University Medical Center

Alejandro Arias Vásquez was born in Colombia, obtained his PhD in Genetic Epidemiology in 2006, is a Principal Investigator (since 2015) and Associate Professor in Biological Neuropsychiatry in Radboud University Medical Center since 2019.

'My research activities are imbedded within three domains: (i) Genetic Epidemiology, (ii) Effects of the Gut Microbiota in neurodevelopment, and (iii) High order analysis methods of complex traits. For over 15 years, my drive towards the discovery of genetic determinants of psychiatric disease has led me through a road full with exciting breakthroughs. My work on neuropsychological traits and neurodevelopmental disorders (mainly ADHD and ASD) allowed me to establish, at Radboud University Medical Center, the biological and statistical relevance of quantitative behavioral traits in the search for disease genes. The main contribution of this work has been to set-in a new research approach for brain imaging genetics (via my work in the ENIGMA consortium) that is currently considered one of the "standard" ways to analyse brain imaging genetics data.

Since 2013, I set-up a one-of-a-kind collaboration (in RUMC) between psychiatry, brain imaging, behaviour, genetics and microbiology in order to investigate, for the first time, the relationship between gut bacteria (the microbiota) and Neurodevelopmental disorders (ADHD, ASD and ID) and related behaviour in humans. This pioneering work has received support from the NWO through a Food & Cognition personal grant and the EU-H2020 program through an European Training Network and a Research & Innovation Action call. The latter is the Eat2beNICE project (<http://newbrainnutrition.com/>).

Currently, my group applies complex statistical analytical methods with a focus on maximizing the prediction and classification power of multiple biological markers (i.e. genes, microbiota) and integrating them with environmental, clinical, cognitive, and neuroimaging (brain structure and function) information in order to better characterize NDDs.'



Dr. Mirjam Bloemendaal

postdoctoral researcher

Psychiatry & Human Genetics, Radboud University Medical Center

Dr. Mirjam Bloemendaal is trained as a neuropsychologist and obtained a PhD in cognitive neuroscience at the Donders Institute for Brain, Cognition and Behaviour. Here she focused on the role of dopamine in cognitive control functions such as impulse control and working memory, specifically in healthy aging. In this period she got intrigued by the influence of nutrition and gut microbiota on cognitive performance and mental health. She moved to a medical food company working as a



researcher on clinical trials assessing the effects of nutritional products on nutritional biomarkers, brain health and cognitive functioning. Currently she studies the gut-immune-brain axis in cognitive functioning in the context of stress, aging and neurodevelopmental disorders.



Dr. Jeanette Mostert

Associate Principal Lecturer, Department of Genetics
Radboud University Medical Center

Dr. Jeanette Mostert is a neurobiologist, science communicator and associate principal lecturer. She obtained her PhD at the Radboudumc Nijmegen and Donders Institute for Brain, Cognition and Behaviour in 2016, where she investigated heterogeneity in functional brain connectivity and behaviour of adults with ADHD. She subsequently focused on teaching at the Bachelor program Psychobiology of the University of Amsterdam, where she also obtained her teaching qualification (BKO). Currently she works at the department of genetics as science communication advisor where she helps researchers to translate their work to the general public. Her focus is on adult ADHD and the role of the gut-brain axis in psychiatric behaviour. She fulfils several teaching roles at the Radboudumc and Radboud University.

Learning Outcomes

After this course you are able to:

- Understand the basic concepts of the gut microbiome biology.
- Explain the various routes through which the gut and the brain influence each other.
- Understand the pros and cons of using several bioinformatics pipelines for analysing and interpreting 16s RNA gut microbiome data.
- Design an experiment to investigate how the gut microbiome influences brain functioning / behaviour.

Level of participant

- Master
- PhD
- Post-doc
- Professional

This course is designed for

Early career scientists and in the fields of neuroscience and psychiatry (or related disciplines) who are interested in learning about the gut-brain-axis and the basics of conducting studies linking parameters from the gut microbiome to neural and behavioural measures.

Admission Requirements

Participants are expected to have a basic understanding of statistics (regression) and a working understanding of research methods (animal or human experiments). Experience with the statistical analysis program R is highly recommended. Students who are not familiar with this program are required to go through online tutorials before the course. Also a (strong) background in behavioural science/psychiatry



including knowledge about neurobiology and anatomy of the brain is recommended. Suggested reading materials will be provided for those participants who need to update their knowledge before the course.

Admission Documents

- Motivation Letter
- CV

Dates

11 – 15 July 2022

Application Deadline

1 June 2022

Mode of study

This course will be offered **on campus**.

Participant Testimonials

"The most positive aspect was the change of experience, meeting new people from all around the world and expanding on existing knowledge."

"The most positive aspect of Radboud Summer School was the multicultural and dynamic teaching environment."

The lectures were really nice and well structured, but I really enjoyed the hands on work as well

I enjoyed the whole course, but I liked the morning coffee very much and group discussion, both with the attendees and the participants. The atmosphere was so lovely, that apart from learning it was just a really nice time.

Certificate

You will be awarded a certificate of attendance for actively participating and successfully completing all assignments. The certificate will state the amount of ECTS credits earned.

ECTS credits

Student workload at Dutch universities is expressed in ECTS credits. ECTS stands for European Credit Transfer and Accumulation System, a system widely used throughout the European Union. In the Netherlands, each ECTS credit represents 28 hours of work. We would like to point out that recognition of credits is at the discretion of your home institution. For this course you can earn 2 ECTS credits.



Study load

- | | |
|----------------------------------|----------|
| • Pre-course assignments/reading | 10 hours |
| • Class attendance | 20 hours |
| • Self-study | 12 hours |
| • Practicals | 12 hours |
| • Presentation(s) | 2 hours |

Total	56 hours
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Assessment

During the course, students will work in small groups on assignments to analyse gut microbiome data. They will also be requested to prepare and give short presentations based on small group assignments. Active participation during lectures and assignments is required from all participants. Failing to do so will result in exclusion from the course. Credits are only awarded to those that participated in the full course. Students will not receive a grade.

Brightspace

During Radboud Summer School, you will have access to our online learning environment Brightspace. One month before the summer course starts you will receive more information about Brightspace and how to access it. In your online course you will find the schedule and course related documents and or reading materials.

Literature

Pre-course literature:

For all participants:

- Morgan, X. C. & Huttenhower, C. Chapter 12: Human Microbiome Analysis. *PLoS Comput. Biol.* **8**, (2012).
- Lefkowitz, E. J. & Morrow, C. D. Getting Started with Microbiome Analysis: Sample Acquisition to Bioinformatics. (2015).
- Cryan, J. F. & Dinan, T. G. Mind-altering microorganisms: the impact of the gut microbiota on brain and behaviour. *Nat. Rev. Neurosci.* **13**, 701–712 (2012).
- Valles-colomer, M. et al. Microbiota in Quality of Life and Depression. *Nat. Microbiol.* (2019). doi:10.1038/s41564-018-0337-x
- SA, Dam. et al. The role of the gut-brain axis in ADHD. *Gastroenterology* 1–21 (2019).
- Aarts, E. et al. Gut microbiome in ADHD and its relation to neural reward anticipation. *PLoS One* 12, 1–17 (2017).

For those with no/little background in neuroscience:

- Jenkinson, M., Chappell, M., Jenkinson, M. & Chappell, M. An Brain Anatomy Introduction to for Neuroimaging Neuroimaging Analysis.
- Chapter 5: Brain Imaging. In: Fundamentals of Cognitive Neuroscience (2013).
<https://www.sciencedirect.com/science/article/pii/B9780124158054000059>



- Arnsten, A. F. T. & Rubia, K. Neurobiological circuits regulating attention, cognitive control, motivation, and emotion: Disruptions in neurodevelopmental psychiatric disorders. *J. Am. Acad. Child Adolesc. Psychiatry* 51, 356–367 (2012).
- LaBar, K. S. & Cabeza, R. Cognitive neuroscience of emotional memory. *Nat. Rev. Neurosci.* 7, 54–64 (2006).

Preliminary day-to-day programme

Monday 11 July: Getting familiar with the gut microbiome

9:30 – 11:00 *Opening of Summer School (organised by RSS)*

11:00 – 11:30 **Welcome** and introduction to the summer school – by dr. Alejandro Arias Vasquez

11:30 – 12:30 **Interactive Lecture:** The (systems) biology of gut microbiota & modifiers of the gut microbiome - by dr. Clara Belzer

12:30 – 13:30 *Lunch break (+ getting to know each other)*

13:30 – 14:30 **Applications of GBA research:** The role of *Akkermansia* in health - by dr. Clara Belzer

14:30 – 14:45 *Coffee break*

14:45 – 17:15 **Demonstration :** Overview of key concepts in microbiota data science & Importing data to R for interactive analysis - by prof. dr. Leo Lahti

17:15 – 17:30 **Check out:** What did you learn today?

17:30 – 18:00 *[optional] Extra time for questions, help and discussion*

Tuesday 12 July: Getting our hands dirty – first analysis steps

9:00 – 9:15 **Check in:** How are you doing?

9:15 – 11:30 **Lecture & Demonstration:** Community diversity & similarity. Estimating, comparing, and visualizing alpha & beta diversity – by prof. dr. Leo Lahti & dr. Anna Aatsinki

11:30 – 12:00 *coffee break*

12:00 – 13:00 **Practical:** estimating and visualizing alpha diversity part 1

13:00 – 14:00 *Lunch break*

14:00 – 15:00 **Practical:** estimating and visualizing alpha diversity part 2

15:00 – 15:45 **Lecture** DNA isolation and 16S rRNA gene sequencing; bioinformatics step 1: from raw sequences to OTU table in a biom file – by dr. Tom Ederveen

15:45 – 16:00 *Coffee break*

16:00 – 16:45 **Lecture:** Microbiota analysis: association studies vs. causality; microbiota sequencing methods – by dr. Tom Ederveen

16:45 – 17:00 **Check out:** What did you learn today?

17:00 – 17:30 *[optional] Extra time for questions, help and discussion*

Wednesday 13 July: Diving deep into the gut-brain axis

9:00 – 9:15 **Check in:** How are you doing?

9:15 – 10:45 **Interactive Lecture:** Fundamentals of gut-brain axis communication (the 3 routes) – by Rochelys Diaz Heijtz

10:45 – 11:00 *Coffee break*

11:00 – 13:00 **Practical:** Estimating and visualizing beta diversity by prof. dr. Leo Lahti & dr. Anna Aatsinki

13:00 – 14:00 *Lunch break*

14:00 – 15:00 **Applications of GBA research:** the gut microbiota in early life - by dr. Anna Aatsinki

15:00 – 15:15 *Coffee break*



15:15 – 16:15 **Applications of GBA research:** Evidence for the influence of diet on gut microbiota and behaviour – *t.b.a*

16:15 – 16:30 *Coffee break*

16:30 – 17:15 **Applications of GBA research:** dr Rochelys Diaz Heijtz

17:15 – 17:30 **Check out:** What did you learn today?

17:30 – 18:00 *[optional] Extra time for questions, help and discussion*

Thursday 14 July: Mechanisms of the gut-brain axis

9:00 – 9:15 **Check in:** How are you doing?

9:15 – 10:15 **Applications of GBA research:** The role of the immune GBA route in autism – by prof. Aletta Kraneveld

10:15 – 10:30 *coffee break*

10:30 – 11:30 **Applications of GBA research:** Intestinal microbiota and their role in metabolism and gut-brain axis: using fecal transplantation to dissect causality– by prof. dr. Max Nieuwdorp

11:30 – 11:45 *coffee break*

11:45 – 12:30 **Applications of GBA research:** the gut microbiota and neurodevelopment – by dr. Mirjam Bloemendaal

12:30 – 13:30 *Lunch Break*

13:30 – 14:00 **Demonstration:** quantifying factors that drive community variation - by prof. Leo Lahti & dr. Anna Aatsinki

14:00 – 15:30 **Practical:** quantifying factors that drive community variation

15:30 – 15:45 *Coffee break*

15:45 – 17:15 **Demonstration & practical:** Differential abundance analysis - by prof. dr. Leo Lahti & dr. Anna Aatsinki

17:15 – 17:30 **Check out:** What did you learn today?

17:30 – 18:00 *[optional] Extra time for questions, help and discussion*

Day 5: Wrapping up what we learned

9:00 – 9:15 **Check in:** How are you doing?

9:15 – 10:15 **Practical:** Differential abundance analysis in practice

10:15 – 10:45 *Coffee break*

10:45 – 11:45 Wrap up of all practicals – by prof. dr. Leo Lahti

11:45 – 13:00 **Assignment:** Summarize what you learned this course in one or more memes & give a short presentation

13:00 – 14:00 *Lunch break*

14:00 – 15:30 **The future of GBA research** – by dr. Alejandro Arias Vasquez

15:30 – 16:00 Closure & Evaluations

16.00-18.00 *Farewell Ceremony and drinks afterwards (organised by RSS)*

Overall schedule Radboud Summer School

Radboud Summer School is more than an academic event, it also provides you with a unique opportunity to meet other international students and to broaden your horizon. Our participants come from all over the world and all have a different cultural and academic background. Our summer school will be the ideal environment to meet interesting new people within and outside of your academic discipline.



	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
08.30-09.00		Welcome Coffee/Tea	Coffee/Tea	Coffee/Tea	Coffee/Tea	Coffee/Tea
09.00-09.30						
09.30-10.00		Opening Ceremony				
10.00-10.30						
10.30-11.00			Coffee/Tea	Coffee/Tea	Coffee/Tea	Coffee/Tea
11.00-11.30						
11.30-12.00						
12.00-12.30		Lunch Distribution bikes	Lunch	Lunch	Lunch	Lunch Hand in bikes
12.30-13.00						
13.00-13.30						
13.30-14.00						
14.00-14.30						
14.30-15.00						
15.00-15.30	Registration of participants	Coffee/Tea	Coffee/Tea	Coffee/Tea	Coffee/Tea	
15.30-16.00						Coffee/Tea
16.00-16.30						Certificate Ceremony Farewell Reception
16.30-17.00						
17.00-17.30						
17.30-18.00						
18.00-18.30						
18.30-19.00		Course leaders diner/ Participants diner				
19.00-19.30						
19.30-20.00	Welcome reception		Quiz night	Pancake Boat		
20.00-20.30						
20.30-21.00						
21.00-21.30						

time slot for course activities
time slot for social events

Radboud Summer School is more than an academic event, it also provides you with a unique opportunity to meet other international students and to broaden your horizon. Our participants come from all over the world and all have a different cultural and academic background. The summer school organization has carefully selected various social activities to bring you in contact with each other and to introduce you to the beautiful city of Nijmegen.

You can sign up for the social events in the online application form. You can find an overview of the various social events on our website:

<https://www.ru.nl/radboudsummerschool/social-events/programme-overview/>

Application

You can apply for this course online. More information on how to apply and a link to the application form can be found here: <https://www.ru.nl/radboudsummerschool/application/how-to-apply/>



**Radboud
Summer School**



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