Curriculum Bachelor Brain Science

Introduction to Brain Science (4 credits)

This course aims to give a historical perspective on several research traditions that have been important in getting to the level of understanding of the brain that we currently have. At the same time, the course aims to present a view of the future in brain research. The course intends to show how we can use computational models to understand how the brain works and how our minds function based on biology.

Genes, Proteins, and Evolution (4,5 credits)

This course will teach students about the structure and function of eukaryotic cells, which are the building blocks of living organisms. Students will also learn about important molecules like DNA, RNA and proteins and how they work together in cells. We will explore how things in the environment can influence genes, which in turn affect how cells work and even our behaviour. This helps us connect cell biology with psychology. Furthermore, this course will introduce students to the key principles of evolution.

In this course you will also do practical experiments in a lab (partly extending in period 2).

Linear Algebra and Calculus I (3 credits)

Brain science rests on a solid basis in mathematics. This first part of this course will provide foundations of linear algebra that are needed for the analysis as well as computational modelling of brain data and related behavioural data. The course will introduce students to the concepts of vectors, spaces, matrices and their operations, including sums, products, inversion, eigenvalue decomposition and linear systems of equations.

Introduction to Cognitive Neuroscience (4 credits)

This course explores cognitive psychology, which focuses on understanding how our minds works. It covers topics such as attention, memory and action. Over the past fifty years, cognitive psychology has shown that we can understand mental processes in a mechanical way. As cognitive psychology evolved, it became clear that these mental functions have biological links in the brain. This connection gave rise to cognitive neuroscience, a field that combines psychology and neuroscience.

This course gives an introduction to how our biology underpins our thinking. Additionally, the course shows how cognitive neuroscience connects to math concepts.

This course lays the foundation for year 2 courses where students will learn more about tools used in cognitive psychology, including behavioural experiments, neuroimaging and brain stimulation.

Cellular Interactions and Metabolism (4,5 credits)

This cellular biology course focuses on individual cells and how they work. It covers topics such as how cells get energy, their interactions and communication. It starts with the basics of chemistry and how enzymes work in biochemical reactions. Then, students will explore how cells get, store and use energy. Furthermore, the course explores how the brain helps maintain the body's balance, called homeostasis. Next, students will dive into cell signalling, which is how cells communicate with each other. Students will also discover the critical roles played by specific molecules and proteins in cognitive functions, such as vision and memory.

In the course, students will do practical lab exercises (partly extending in period 3).

This course is a building block for understanding brain science and connects to *'Introduction to Cognitive Neuroscience'*.

Linear Algebra and Calculus II (3 credits)

Mathematics is fundamental to brain science. In this second part of the course, students will learn essential calculus skills necessary for analysing and modelling brain data and related behaviours. Additionally, the course provides practical applications of these concepts in the context of brain science.

Neuroanatomy (2 credits)

In this skill course, students will explore the anatomy of the central and peripheral nervous systems. They will study both the macro and microanatomy of the brain through hands-on practical sessions. While the main focus is on the human brain, students will also make comparisons with the brains of rodents and other species, which are important models in modern neuroscience. During these sessions, students will directly handle brain specimens, including sheep brain preparations, and examine real rodent neurons under microscopes. This unique experience allows students to compare brain cells from different structures and observe details such as dendritic spines, the foundations of neuronal connections.

Project Year 1 – Part I and Part II (3 credits)

In this project-based course, spanning eight weeks divided into two 4-week blocks (in Period 3 and 6), students can opt for a variety of projects. Students choosing an empirical research project will go through various stages of the scientific cycle in small groups, supervised by a researcher. In a number of cases, students may also work with publicly available data sets that may be suitable for testing a specific hypothesis that emerged after reading relevant literature. In addition, students may opt for a project leading to a product or application, which may consist, for example, of writing software to implement an experimental design, to design a specific stimulus or to develop a function for an app. The core idea of this Project course is that students experience the various stages in the empirical cycle. Teamwork is an important aspect of the Project experience.

Part II continues the work from Part I. students will complete data collection or product development, perform analysis and report their findings through written and oral presentations.

Principles of Perception (4 credits)

This course provides an introduction to the basics of perception, with a focus on vision and hearing. It explorers how our brains turn visual and auditory information into our perceptions of the world. The course covers the neural processes behind perception, including sensory structures and the biological principles involved. It lies at the intersection of biology (with a neural focus) and psychology (emphasizing visual, auditory and multisensory perception). Additionally, it connects neural mechanisms to math and programming exercises.

Brain Cells (4 credits)

In this course, students will explore how cells in the brain work, considering their structure and development. Neurons are the brain’s basic building blocks, and other supporting cells play important roles. While the course mainly focuses on the biology of these cells, it also connects how these cells function to our perception and thinking, bringing biology into psychology. In some parts of the course, students will use math to describe how cells work. This math knowledge also prepares them for more advanced math in the future.

Students will also learn about scientific tools used to study and record brain cells. This course builds a strong foundation for all the neuroscience courses in the programme.

Advanced Calculus & Dynamical Systems (4 credits)

In this course students will delve into advanced calculus, essential for analysing and modelling brain and behavioural data. Students will also learn about dynamical systems theory, covering topics such as differential equations and multivariate calculus. Brain scientists need these skills to analyse complex data and create mathematical descriptions of brain processes over time and space.

The Motor System (4 credits)

This course introduces students to the motor system, how it produces movement, and the different brain structures involved. Students will also learn about the brain structures responsible for motivation, action selection and movement optimisation. The course explores how these systems work together and their connection to sensory input. It emphasises the relationship between what we perceive and how we act. This course bridges concepts from biology and psychology, and it connects with the mathematical knowledge students have gained.

Learning and memory (4 credits)

The goal of this course is to provide students with a basic understanding of human memory from both psychological and biological perspectives. The course emphasises the historical significance of key discoveries in the field of learning and memory. At the same time, the course offers an (introductory) methodological perspective, with attention for more traditional methods, but also new technology. The course also integrates a psycho-biological approach with computational models. By the end of this course, students will have a solid foundation for more advanced courses in the Learning & Memory learning line in Year 2.

Probability Theory (3 credits)

In this course, students will learn the fundamental concepts of probability theory and basic statistiscs. These skills are crucial for brain scientists who need to analyse complex data and describe biophysical processes over time and space. Students will gain a foundation in probabilistic modelling and the use of random variables to model brain science experiments. By the end of the course, students will be equipped to tackle problems involving probabilities and assess their outcomes.

Programming I (4 credits)

This course introduces students to programming, a fundamental tool for brain scientists. Programming allows them to manipulate and visualise neural processes and data and turn theoretical ideas into practical applications. By the end of this course, students will be able to apply mathematical functions and computational principles to create programmes and simplified computational models.

Writing and Presenting I (1 credit)

Throughout Year 1 and 2, students will receive training to improve their written and oral communication skills. This includes various writing formats and presentation skills focusing on scientific communication. Communication training is integrated into content courses, with written and oral assessments and feedback from examiners, tutors and peers. Additionally, this course provides standardized instruction and guidelines for different communication formats use in the curriculum.

Mentor-guided Portfolio Building (2 credits)

In Year 1, and throughout the programme, students will receive mentorship focused on building portfolios and self-improvement. Mentorship includes individual and group sessions for mentor and peer feedback. All aspects of the programme, including assessments, are used to help students set and analyse long-term goals. These goals can cover various competencies.

In the early years (year 1 and 2), goals primarily relate to mastering the curriculum. Towards the end of Year 2 and in Year 3, goals shift to include electives, thesis topics, personal growth and lifelong learning. Students also have opportunities to interact with alumni, network, and explore career options through events involving academic, research, government and industry professionals.