Neuroscience Learning Plan
Emory-Tibet Science Initiative

Overall approach

Our six-year curriculum promotes learning the basics of neuroscience and cognitive science in the context of the monastic life. In many ways, core concerns of the neurosciences speak to those of monastics following the Buddhist path of rigorous, systematic practices of internal examination for attainment of enlightened body, speech, and mind, or "right view". The unique nature of this project allows us also to search for and cultivate areas where Buddhism and cognitive science complement, contest, enhance our understanding of the mind. In this light, we chose topics in neuroscience and cognitive science that are relevant to both the core concepts in neuroscience and the interests of Buddhist monastics.

The Neuroscience curriculum draws upon what the monastics will learn in the other areas, especially from the Life Sciences and Philosophy of Science curricula, and deepens their understanding of both the scientific method and the findings from the neurosciences. Our goal is to benefit their monastic pursuits throughout their careers, and to build the grounds for fruitful exchange between western science and Buddhism in the service of humanity.

Selected topics

Neuroscience and cognitive science (here termed neuroscience) are evolving multidisciplinary endeavors that are both broad and deep. Therefore, we chose to focus our curriculum on core concepts and specific phenomena that exemplify typical neural processing, emphasizing humans. We focus particularly on sensation and perception, starting from how sensory organs capture information from the external world, all the way through how that information is processed in different neural pathways in the brain, and ultimately how cognitive processes use and motor systems act on that information. This approach speaks to central aspects of Buddhist epistemology that offer detailed, inquiry- and practice-based accounts of perception and experience.

Experiential / experimental context

Students learn best when they pursue questions that directly engage them. Group processes can amplify such learning, and we build on the advantage that monastics are extraordinarily adept at sharing and productively working in groups. Selected case studies and direct student engagement are used to scaffold student insight into processes of inquiry in the neurosciences, using exercises and projects done in teams. Like all sciences, neuroscience proceeds via hypothesis-driven questions. How do neuroscientists pose and investigate these questions? How do neuroscientists design experiments to test those questions? What kinds of data can we collect? And how do we evaluate and interpret those data?

Lecture discussions of concepts and evidence are keyed to the overarching questions: "How do we know?" and "How does this advance human self understanding and action?" Related student activities progressively build understanding and facility with the scientific method, so that what

begin as simple exercises become increasingly complex and substantive projects. As a result, the monastics will have develop their own hypotheses, designed experiments, carried them out, and analyzed their results on increasingly ambitious inquiries.

We propose to investigate the similarities and differences between neuroscience and Buddhism in several key discussions regarding the scientific method, including: What is the difference between correlation, and cause and effect? Can we find compatibility between science's focus on measurable phenomena and Buddhism's focus on existential or transcendent phenomena? What is the role of the self in the context of scientific experiments? Is it possible to prove that something is true? (We have learned that Buddhism and science differ markedly on this point.) If absolute proof is not possible, how can neuroscience build an adequate picture of sentience? Each year of the curriculum commences with a discussion around such questions, which then are woven into the content and student activities for that year. This process build cumulative conversations build on a growing mutual understanding.

Pedagogical approach

The Neuroscience curriculum will consist of both distance learning modules and in-person summer learning programs in India.

The distance learning component will facilitate monastics' knowledge and understanding of neuroscience, as well as participation in debates and activities designed specifically for students to engage the material as a group. They will have the opportunity to propose questions periodically over the Internet to be answered by the ETSI Neuroscience team, and have access to a topic-driven discussion platform for students at all monasteries.

The distance learning modules consist of short, focused teachings on specific topics, to be followed in a sequential order to build a narrative as concepts are introduced. Each module will address a specific topic, discuss the big questions involved in that topic, propose questions for discussion or debate, and ask the monastics to develop their own big questions.

The summer program will complement the distance learning modules by holding conversations that go deeper into the topics introduced in the modules. Discussions will be interwoven with hands-on demonstrations of experiments, thorough teachings on the scientific method, and computer lab activities will advance the monastics' understanding of how and why cognitive science investigates the mind, brain, and body.

Year 1 – Introduction to Neuroscience: Neurons, sensory organs, and the brain
Motivation: Our curriculum this year relies heavily on inputs from monastics involved in the ETSI, to build basic understandings of neuroscience and conceptual bridges to monastics' Buddhist studies and practices. A driving motivation for the year's curriculum draws from the mutual scientific and Buddhist concern with this question: What is sentience? Individual pedagogical sessions each are guided by their own related questions.

1. Neurons

    a. Big Questions: What is the nervous system made of? What are the principles on which nervous system activity is based?
    b. Lectures
        i. History of neuroscience
        ii. Neurons
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Training in use of clickers
        iii. Debate: Big questions of neuroscience
        iv. Computer lab: Action potentials
2. Sensation and perception
    a. Big Questions: Are colors real? Can individuals have the same experiences (qualia)? How can we experience different senses together?
    b. Lectures
        i. Sensory organs
        ii. Transduction of physical energies/chemicals
        iii. Neural pathways
    c. Activities
        i. Visual illusions
        ii. Sound source localization
        iii. Gymnema sylvestre tea
        iv. Blind spot demo
3. The human brain
    a. Big Questions: What does the brain do and how does it work? How does the brain organize the huge streams of incoming information? Is consciousness an emergent property? If so little comes to consciousness, what determines the contents of awareness?
    b. Lectures
        i. The branches of neuroscience
        ii. The human brain
        iii. Central and peripheral nervous systems
    c. Activities: explore phantom limb and alien hand syndroms
4. What does the brain do?
    a. Big Questions: How do we convert physical energies into subjective experiences? What are the rules for organizing this information? How do we learn? What guides our behaviors and actions?
    b. Lectures
        i. Interpreting and resolving ambiguity
        ii. Sensation and perception
        iii. Cognition: memory, concepts, language, decision making, reasoning
        iv. Motor system
    c. Activities
        i. Visual search task
        ii. Implicit / explicit memory tasks
5. Consciousness and the brain

    a. Big Questions: What is the neural basis for subjective experience? What are the levels of consciousness? Can consciousness be simulated on a computer? Are all animals conscious? What are the minimum requirements for consciousness?
    b. Lectures
        i. What we know
        ii. What we don't know
    c. Activities
        i. Exploring stages of sleep
        ii. Neural networks
6. Debate and review
    a. Debate
    b. Review session
7. Feedback and wrap-up
    a. Study time
    b. Final exam (clickers)
    c. Exam results, overall score, awards
    d. Closing party
    e. Set up for intersession (distribute study materials)

Year 2 – The science of knowing, understanding, and behaving

Motivation: This year's curriculum is motivated by the question of "How do we know?" How do we as living beings perceive and experience our worlds? But also, how do neuroscientists gain knowledge and understanding?

We use the visual system as an exemplar for how information is captured and processed.

1. Neuroscience: The science of knowing, understanding, and behaving
    a. Big Questions: How has understanding of sentience and the brain developed in western science? Why is neuroscience so new, compared to physics or biology?
    b. Lectures
        i. Introduction to neuroscience
        ii. How do we know? Information acquisition and analysis
        iii. Sensory systems; Vision as a model
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Re/training in use of clickers
        iii. Discussion: Weighing the evidence
2. The system: Structure and function
    a. Big Questions: What do the nervous system do? Why have a brain?
    b. Lectures
        i. Overview of anatomy
        ii. Organization of the nervous system
        iii. Navigating the brain: Terms for orientation
    c. Activities
        i. Demo: Night vision goggles
        ii. Computer lab: Functional Neuroanatomy and Brain Tutor
3. Mechanics of vision: From the eye to the brain

    a. Big Questions: How do we capture information about the world? Do our senses show us the "real world"?
    b. Lectures
        i. Anatomy of the eye and visual system in the brain
        ii. Reception and processing
        iii. Introduction to the scientific method
    c. Activities
        i. Case study of scientific method
4. Seeing things
    a. Big Questions: How does the brain make sense of sensations?
    b. Lectures
        i. Pathways and principles
        ii. Object recognition and the role of context
    c. Activities
        i. Visual illusions
        ii. Change blindness
5. Neurodevelopment
    a. Big Questions: If the brain is the most complex material phenomenon we know, how is it built?
    b. Lectures
        i. How a working brain is built: Components and processes
        ii. Principles: Plasticity, Darwinian processes
    c. Activities
        i. Prism goggles and vision adaptation
6. Introduction to social neuroscience
    a. Big Questions: How do our sensations relate to experience? How are humans able to communicate and relate to others?
    b. Lectures
        i. Vision and the emotional brain
        ii. The face as an organ of communication
        iii. Facial communication: Expression and recognition
    c. Activities
        i. Set up for intersession
        ii. Learning materials
        iii. Study neuroanatomy

Year 3 – Getting down to basics: Senses and responses

Motivation: The fundamental driver for this year's curriculum is the question: How does the nervous system work? Biochemical, molecular, and computational levels of explanation are unfamiliar to most monastics, but are intimately tied in to modern neuroscience. We build toward next year's question of how brain and body work together in experience and behavior.

1. Back to basics
    a. Big Questions
    b. Lectures
        i. Introduction to Year 2

        ii. Core concepts in neuroscience
        iii. Dialogues on mind; Studying neuroscience
        iv. The withdrawal (or flexor) reflex: A full neural pathway
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Re/training in use of clickers
        iii. Worksheet: Core concepts in neuroscience
        iv. Breakout groups / class discussion
        v. Reflexes, spinal cord anatomy
2. Electricity in the nervous system
    a. Big Questions: What is the role of electricity in the nervous system? How is it produced?
    b. Lectures
        i. Electricity in the brain
        ii. Action potentials: How neurons make electrical signals called
    c. Activities
        i. Movies of lab experiments
        ii. Discussion
        iii. Computer lab: Neurons in Action (from ion channels to action potentials)
3. Chemical neurotransmission
    a. Big Questions: How do chemicals produce action in the body? Can they affect our conscious experiences?
    b. Lectures
        i. Chemical transmission
    c. Activities
        i. Manipulation of chemical neurotransmission–skin temperature
4. Integration and sensation
    a. Big Questions: How are the myriad actions of individual neurons able to produce phenomena such as a percept? Does the nervous system act like a computer?
    b. Lectures
        i. How neurons integrate synaptic inputs
        ii. Nervous system in Tibetan medicine (Dr. Gyamtso)
    c. Activities
        i. Computer lab: From synapses to signaling
        ii. Mid-course clicker feedback session
5. Sensation, motor system
    a. Big Questions: How do our peripheral senses inform the brain? Does the brain regulate all our behaviors?
    b. Lectures
        i. Somatosensory system
    c. Activities
        i. Sense of touch: 2-point discrimination task
        ii. Reflex modulation
6. Basal ganglia
    a. Big Questions: How does brain activity drive our movements? How does the nervous system allow us to walk or react? Is all behavior conscious?

    b. Lectures
        i. Movement and the motor systems
        ii. Multiple motor systems in motor planning and motor control
    c. Activities
        i. Measuring electrical activity of muscles during motor tasks
        ii. Discussion
7. Posture and balance
    a. Big Questions: What is proprioception? How do we know where we are in space?
    b. Lectures
        i. Sensorimotor control of posture balance
    c. Activities
        i. Balance control and multisensory integration
        ii. Sensory conflict and sensorimotor illusions
        iii. Movement and movement disorders
8. Set up for intersession
    a. Activities
        i. Final exam (clickers)
        ii. Exam results, overall scores, awards
        iii. Closing party

Year 4 – Emotions and memory

Motivation: This year we address subjective experience, asking "Where do our feelings and thoughts come from?" and "How do we learn and remember?" We build a neuroscientific view of emotions and their actions that speak directly to monastics' understanding of them as inherently afflictive, and discuss the neuroscience of addiction to engage Buddhist emphasis on craving as the root of affliction. Neuroscience identifies the grounds for empathy. How does this fit in to the picture?

1. Introduction
    a. Big Questions: What are the scientific methods behind neuroscience? What does the brain look like?
    b. Lectures
        i. Emotions and memory
        ii. How do we know? Methods and logics in neuroscience
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Re/training in use of clickers
        iii. Neuroanatomy programs (review)
        iv. Using brain imaging data
2. How the brain produces emotion
    a. Big Questions: How are emotions produced? What is the relationship of emotion and consciousness?
    b. Lectures
        i. Emotions and the brain (systems)
        ii. Emotions and the brain: The example of fear
    c. Activities

        i. Emotion and memory (IAPS)
3. Memory
    a. Big Questions: How do we learn and remember? How is emotion related to memory? What does brain damage teach us?
    b. Lectures
        i. Introduction to memory
        ii. Physiology of memory
        iii. Overview of monoamine neurotransmitters
    c. Activities
        i. The case of Phineas Gage
        ii. Implicit memory (typing task)
        iii. Short term memory (visual task)
4. Afflictions of emotion
    a. Big Questions: Are emotions inherently afflictive? What causes addiction? Can addiction be cured?
    b. Lectures
        i. Reward systems in the brain and addiction
        ii. Afflictive emotions and drug addiction
        iii. Nervous system in Tibetan medicine (Dr. Gyamtso)
        iv. Depression
    c. Activities
        i. Implicit memory (follow-up task)
        ii. Discussion: Addiction
        iii. How do you recognize depression?
5. Emotion sharing and understanding
    a. Big Questions: How is it possible to know what someone else is feeling or thinking? Why do emotion and memory have synergistic or conflicting effects in our behavior? How do they help us be social? Is it possible or desirable to eliminate emotions?
    b. Lectures
        i. Empathy and compassion
        ii. Emotion and memory in action: Survival and sociality in non-human animals
        iii. Emotion and memory in action: Survival and sociality in humans
    c. Activities
        i. Research design: How effective are methods for cultivating empathy?
6. Feedback and wrap-up
    a. Study time
    b. Final exam (clickers)
    c. Exam results, overall score, awards
    d. Closing party
    e. Set up for intersession (distribute study materials)

Year 5 – Mind/Body and internal regulation

Motivation: This year we take up neuroscientific insights on issues of self regulation, relationships with the world, and the grounds of suffering and resilience, and self transformation.

We further explore questions about relationships of mind/brain and body, and how they work together in relating to and managing our internal and external circumstances. These big questions are explored through examination of biorhythms, resting states, attention regulation, and stress response systems. The discovery of neuroplasticity is probed. And monastics explore how brain plasticity sets the foundation for self transformation through practices such as meditation. Students engage in activities and experiments with heart rate monitors to explore these issues.

1. Regulation and adaptation
    a. Big Questions: How does the body/brain coordinate with external conditions to both accommodate challenges or opportunities and maintain well-being?
    b. Lectures
        i. How do we know? Subject and object of inquiry in science and Buddhism
        ii. Links between brain/mind and body
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Re/training in use of clickers
        iii. Debate planning
        iv. Clickers and introduction of mood data collection
2. Biorhythms
    a. Big Questions: How does the body/brain accommodate rhythms in nature such as day/night or seasons?
    b. Lectures
        i. Biological rhythms
    c. Activities
        i. Heart rate monitors
        ii. Motor memory (part 1)
        iii. Debate: All neurons are the same (paired debate)
3. Resting states
    a. Big Questions: Why do we sleep and dream? What is sleeping?
    b. Lectures
        i. Waking and sleeping
    c. Activities
        i. Motor memory (part 2)
        ii. Guess the sleep stage
        iii. Download heart rate monitor data; Begin analyses
4. Tuning in and tuning out
    a. Big Questions: How does the brain juggle all the different functions that it has? Is the brain composed of specialized parts that work together like a clock?
    b. Lectures
        i. Brain networks; Resting and attention
        ii. Exploring brain networks during meditation
    c. Activities
        i. Debate: Defend Buddhist and neuroscience views on memory (group debate)
        ii. Analyze daily heart rate data
        iii. Analyze heart rate data from debate

5. Meeting challenges
    a. Big Questions: How do brain and mind relate to ongoing bodily processes? What is stress? Is stress harmful? What is pain and where does pain come from?
    b. Lectures
        i. Meeting challenges: The stress response and health
        ii. Cardiovascular system in Tibetan medicine (Dr. Gyamtso / Men Tsee Kang)
        iii. Affiliation and social relationships
        iv. Suffering and solace: pain
    c. Activities
        i. Enter mood data, test hypotheses
6. The power of place and practices
    a. Big Questions: Can early experience and everyday practices change our brain and thus experiences? If so, how and how lasting are the effects?
    b. Lectures
        i. Power of context: Experience and life course development
        ii. Effects of personal practices on the brain
        iii. Power of practice: Meditation effects on the brain
    c. Activities
        i. Broad discussion on Buddhist ideas about concepts, self, etc.
        ii. Meditation and heart rate
        iii. Debate: The brain you were born with determines what you can learn and do
7. Feedback and wrap-up
    a. Final exam (clickers)
    b. Set up for intersession (distribute study materials)
    c. Exam results, overall score, awards
    d. Closing party

Year 6 – The mind at work / Doing science

Motivation: The final year brings it all together in understanding cognition and subjective experience. Students also participate in a thorough analytic review of the scientific process, as they design, implement and present a capstone project. The motivating questions for them are intellectual (What does neuroscience tell us about how we think and understand? How do these parallel or diverge in neuroscience or Buddhism?) and practical (What can I know through neuroscience?) Instructors work intensively with project groups at each step of the research process. Importantly, students learn the pursuit of meaningful scientific inquiry with limited resources. Lecture/discussions and projects are interwoven in successive sessions. We see all these as final steps to independent inquiry on students' own terms.

1. Scientific thought
    a. Big Questions: How do we know, in all senses? What are the logic and limits of scientific inquiry? How do science and Buddhism agree or disagree on criteria for validity?
    b. Lectures
        i. Scientific thought

    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Re/training in use of clickers
        iii. Project planning: Rubrics and work group assignments
        iv. Debate: Planning
2. Concepts
    a. Big Questions: What are concepts? Where do they come from? What is their role in thinking?
    b. Lectures
        i. Concepts: Introduction and structure
        ii. Concepts: Function and processing
    c. Activities
        i. Projects: Introduction and methods
        ii. Projects: Design and methods
        iii. Lego building (memory task)
3. Remembering
    a. Big Questions: How do we remember things? Is memory like a recording or movie? What can distort memory? Can memory be improved?
    b. Lectures
        i. Memory as reconstruction
    c. Activities
        i. Projects: Data collection
        ii. Lego building (reconstruction from memory task)
        iii. Lego memory task data analysis
4. Reasoning
    a. Big Questions: How do we reason and make decisions? What are the grounds for valid conclusions? What are causes of distorted reasoning?
    b. Lectures
        i. Reasoning in the world
        ii. Reasoning: Buddhism vs. cognitive science
    c. Activities
        i. Projects: Data analysis and write-up of results
        ii. Reasoning (IAT)
5. Language
    a. Big Questions: Why is it that humans use language? What makes this possible? Is language related to thought? Do people with different languages think differently?
    b. Lectures
        i. Language
    c. Activities
        i. Debate planning (formulate questions, arguments)
        ii. Paired debate: Concepts
        iii. Write-up of debate
6. The self
    a. Big Questions: What is the self? Are there material/neuroendocrine bases for the self? Can self be useful? Is it possible or desirable to eliminate the sense of self?
    b. Lectures

        i. The self
    c. Activities
        i. Broad discussion on Buddhist ideas about concepts, self, etc.
        ii. Projects: Write-up of results
7. Present and discuss research projects
    a. Big Questions: Why is critical evaluation so important in science? Are there similarities in Buddhist thought and practice? What are the scientific criteria for valid conclusions?
8. Review
    a. Review session
    b. Study time
    c. Final exam (clickers)
    d. Exam results, overall score, awards
    e. Closing party