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. What do organisms need to know and do?

    a. Big Questions: What is the concordance between the biology and neuroscience tracks? What are the big questions in neuroscience? How do scientists seek to answer these questions? What phenomena can we study, and how do we measure them?
    b. Lectures
        i. Introductory convocation: concordance of 6 years' biology and neuroscience tracks
        ii. What do organisms need to know about the world?
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Understanding the Brain and Mind: Perspectives from Buddhism and from Neuroscience
        iii. What is sentience?
2. What is neuroscience?
    a. Big Questions: How do western scientists study the human brain, mind, and behavior? What can neuroscience teach us? What are its limitations?
    b. Lectures
        i. Overview of neuroscience, a multidisciplinary field
        ii. Modes of inquiry
    c. Activity
        i. Scientific method
        ii. Graphing exercise
3. What makes up 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?
    b. Lectures
        i. Overview of the human brain
        ii. Central and peripheral nervous systems
    c. Activity
        i. Building brains
4. What is a nervous system?
    a. Big Questions: How is the system organized to gather, transmit, and process information, then act on it? How do we convert physical energies into subjective experiences? What are the rules for organizing this information?
    b. Lectures
        i. What are nervous systems made of?
        ii. Components and connections
    c. Activities
        i. Mid-course review
        ii. Vocabulary quiz
5. Why is connectivity important?
    a. Big Questions: What is the neural basis for processing information? How do we learn? What guides our behaviors and actions?
    b. Lecture
        i. Neural connections
    c. Activity

        i. Brain charades
6. Why do brains evolve?
    a. Big Questions: Why do brains and nervous systems of creatures differ? What can this tell us about organic design or about the human brain?
    b. Lecture
        i. Brain evolution, comparative anatomy
    c. Activity
        i. Form and function
7. Catch-up, overview, and synthesis
    a. Recap of Big Questions
    b. Final review, question and answer session

8. Exam, evaluation, and wrap-up
    a. Review session
    b. Study time
    c. Final exam
    d. Exam results, overall score, awards
    e. Closing party

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. How does neuroscience study the senses?
    a. Big Questions: What is the concordance between the biology and neuroscience tracks? What is sensation? What is perception?
    b. Lectures
        i. Introductory convocation: concordance of 6 years' biology and neuroscience tracks
        ii. Review scientific method
        iii. Exercise: using graphs and tables Part 1
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Scientific method
        iii. Exercise: using graphs and tables
2. Touch, temperature, and pain
    a. Big Questions: What types of information do the senses capture? How does the design of senses determine what we can know about the world?
    b. Lectures
        i. The senses and related sensors: touch, temperature, and pain
    c. Activities
        i. Exercise: using graphs and tables Part 2 [practice, use examples]
3. How do we see? part I

    a. Big Questions: How do we capture information about the world? Do our senses show us the "real world"? What types of information does the visual system capture, and how?
    b. Lectures
        i. Anatomy of the eye and visual system in the brain
    c. Activities
        i. Visual illusions
4. How do we see? part II. Sensation to perception
    a. Big Questions: How does the brain make sense of sensations? How do our sensations relate to experience?
    b. Lectures
        i. Pathways and principles
        ii. Object recognition and the role of context
    c. Activities
        i. Mid-course review
        ii. Vocabulary quiz
5. Hearing
    a. Big Questions: What kinds of information is captured by the auditory system? How do we hear? How do we orient in space?
    b. Lectures
        i. The auditory system
    c. Activities
        i. Experiment: sound localization
6. Chemical senses
    a. Big Questions: What senses use chemical detection, and how? How are the senses similar to each other? How do they differ?
    b. Lectures
        i. Taste
        ii. Smell
        iii. Forms of information (energy, chemical) and modes to detect them
        iv. What humans can't detect that other animals can
    c. Activities
        i. Experiment: *Gymnema sylvestre* and taste
7. Catch-up, overview, and synthesis
    a. Recap of Big Questions
    b. Final review, question and answer session
8. Exam, evaluation, and wrap-up
    a. Review session
    b. Study time
    c. Final exam
    d. Exam results, overall score, awards
    e. Closing party

Year 3 – Getting down to basics: transmission, integration, and response

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: What is the concordance between the biology and neuroscience tracks? What is the nervous system made of? What are the principles on which nervous system activity is based?
    b. Lectures
        i. Introductory convocation: concordance of 6 years' biology and neuroscience tracks
        ii. How do neurons work?
        iii. Core concepts in neuroscience
        iv. Dialogues on mind; Studying neuroscience
    c. Activity
        i. Introduction of the teaching team, assign student working groups
        ii. Our sense of touch: two-point discrimination, Part 1
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. What are ion channels and resting membrane potential?
        ii. Action potentials and neuron signaling
    c. Activities
        i. Our sense of touch: two-point discrimination, Part 2
        ii. Computer lab: Neurons in Action (from ion channels to action potentials)
3. Neuronal activity
    a. Big Questions: What is the basis of neuronal action?
    b. Lectures
        i. What happens during an action potential?
    c. Activity
        i. Manipulation of chemical neurotransmission–sensing skin temperature
4. How do neurons communicate?
    a. Big Questions: How is information conveyed in the nervous system? How do chemicals produce action in the body? Can they affect our conscious experiences? Does the nervous system act like a computer?
    b. Lectures
        i. Modes of neurotransmission
        ii. How neurons integrate synaptic inputs
    c. Activities
        i. Mid-course review
        ii. Vocabulary quiz
5. How do we feel and move our bodies?
    a. Big Questions: How do our peripheral senses inform the brain? What is proprioception? How do we know where we are in space?
    b. Lectures
        i. Somatosensory system

    c. Activity
        i. Computer lab: Connecting virtual neurons
6. How do we act?
    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? Does the brain regulate all our behaviors?
    b. Lectures
        i. How do we move?
        ii. Movement and the motor systems
        iii. Multiple motor systems in motor planning and motor control
        iv. The withdrawal (or flexor) reflex: A full neural pathway
    c. Activity
        i. Experiment: How fast does information travel in the nervous system?
7. Catch-up, overview, and synthesis
    a. Recap of Big Questions
    b. Final review, question and answer session
8. Exam, evaluation, and wrap-up
    a. Review session
    b. Study time
    c. Final exam
    d. Exam results, overall score, awards
    e. 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 is the concordance between the biology and neuroscience tracks? What are the scientific methods behind neuroscience? What role does the brain play in what we know and feel?
    b. Lectures
        i. Introductory convocation: concordance of 6 years' biology and neuroscience tracks
        ii. Emotions and memory
        iii. How do we know? Methods and logics in neuroscience
    c. Activities
        i. Introduction of the teaching team, assign student working groups
        ii. Neuroanatomy programs
        iii. 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. Functional neuroanatomy software
        The case of Phineas Gage
        ii. Steps 1-5 of Day 5 memory task
3. 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. How do you recognize depression?
4. Memory
    a. Big Questions: How do we learn and remember?
    b. Lectures
        i. Introduction to memory
        ii. Physiology of memory
    c. Activities
        i. Vocabulary quiz
        ii. Review
5. Emotion and memory in action: survival and sociality
    a. Why do emotion and memory have synergistic or conflicting effects in our behavior? How do they help us be social?
    b. Lectures
        i. Emotion and memory in action: Survival and sociality in non-human animals
        ii. Emotion and memory in action: Survival and sociality in humans
    c. Activities
        i. Short term memory: analysis of data from Day 2
6. Emotion sharing and understanding
    a. Big Questions: How is it possible to know what someone else is feeling or thinking? Is it possible or desirable to eliminate emotions?
    b. Lectures
        i. Empathy and compassion
    c. Activities
        i. Mind in the Eyes Task
        ii. Research design: How effective are methods for cultivating empathy?
7. Catch-up, overview, and synthesis
    a. Recap of Big Questions

    b. Final review, question and answer session
8. Exam, evaluation, and wrap-up
    a. Review session
    b. Study time
    c. Final exam
    d. Exam results, overall score, awards
    e. Closing party

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: What is the concordance between the biology and neuroscience tracks? How does the body/brain coordinate with external conditions to both accommodate challenges or opportunities and maintain well-being?
    b. Lectures
        i. Introductory convocation: concordance of 6 years' biology and neuroscience tracks
        ii. How do we know? Subject and object of inquiry in science and Buddhism
        iii. Links between brain/mind and body
    c. Activities
        i. Pirate obstacle course (visual adaptation)
        ii. Start collecting activity and sleep records
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
        ii. In-class demo of HR monitors on instructor, translator, + 2 students
    c. Activities
        i. Heart rate monitors
        ii. Effects of physical activity and mental states on the body: debate
3. State and arousal regulation: wake and sleep
    a. Big Questions: How are wake and sleep regulated? Why do we sleep and dream?
    b. Lectures
        i. State and arousal regulation
        ii. Analysis of sleep and dream records
    c. Activities
        i. Sleep and dream records

4. Tuning in and tuning out
    a. Big Questions: How do we "pay attention"? 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. Attention: the focused brain
        ii. Tuning in and tuning out: the attending and "resting" brain
    c. Activities
        i. Review
        ii. Vocabulary activity and quiz
5. Meeting challenges
    a. Big Questions: How do brain and mind interact with ongoing bodily processes? What is stress? Is stress harmful?
    b. Lectures
        i. Meeting challenges: The stress response and health
    c. Activity
        i. Effects of debate: analysis of HR data from Day 2
6. Plasticity: the power of place and practices
    a. Big Questions: Can our everyday behaviors and settings change our brain? If so, how and how lasting are the effects?
    b. Lectures
        i. Power of practice: Effects of personal practices on the brain
        ii. Power of practice: Meditation effects on the brain
    c. Activities
        i. Daily experience and mood (analyze 5 days' data entered via WeChat)
7. Catch-up, overview, and synthesis
    a. Recap of Big Questions
    b. Final review, question and answer session
8. Exam, evaluation, and wrap-up
    a. Study time
    b. Final exam and program assessment
    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. Project planning: Rubrics and work group assignments
        iii. 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?
    b. Afternoon: Review session
8. Review
    a. Study time
    b. Final exam and program assessment
    c. Exam results, overall score, awards
    d. Closing party