F1. Advances in Neuroscience & Neuroethics

Chapter Objectives

As our knowledge of the brain increases we are able to alter its function; therefore, it becomes important to integrate neuroscience and neuroethics into the foundations of learning. This chapter aims to:

1. **Introduce the nervous system.**
2. **Point to a diversity of neuroethics.**
3. **Draw attention to the revolutionary nature of current research.**
4. **Discuss Parkinson's disease to highlight major issues of ethics in neuroscience.**

F1.1. The Human Nervous System

Neuroscience is the study of the nervous system. The nervous system is made up of the central nervous system (CNS) and the peripheral nervous system (PNS). The central nervous system consists of the brain and spinal column; the peripheral nervous system includes the cranial and spinal nerves and an extensive network of motor and sensory nerve cells – or neurons – interconnecting all parts of the body (see Figure). The brain functions as the main coordinating centre for nervous activity and so controls, directs and integrates all nerve impulses of the human body. It controls physical functions like movement, balance and breathing, and mental functions like our behaviors, emotions and intelligence. The CNS, therefore, is the physical substance that provides us with genetically determined ways of behaving and also ways of changing this behaviour.

The brain is really the enlarged anterior part of the vertebrate CNS, which is enclosed within the cranium of the skull. It is composed of billions of interconnected neurons that transmit information to one another and to peripheral neurons throughout the body by means of chemical and electrical signals (see Chapter F2). In short, the nervous system receives, interprets and integrates information from the outside world, or from within the body, and then formulates appropriate responses for target organs such as muscles and glands. Appropriate, graduated responses in the target organs are produced as follows: the more neurons that are involved in signaling a muscle to contract in your arm for example, the larger the contraction will be. If the arm is involved in lifting a weight, the heavier the weight the more nerve fibres are activated to enable the muscle to lift the greater load. While many neurons are excitatory in nature, that is, they enhance responsiveness of their target, others are inhibitory. The inhibitory neurons reduce the responsiveness at their target in order to prevent a buildup of stimulating signals. For instance, to smoothly pull your hand towards your shoulder both inhibitory and excitatory responses are needed so that some muscles are inhibited while others are excited.

The brain is always active therefore it requires a large percentage of the body's oxygen

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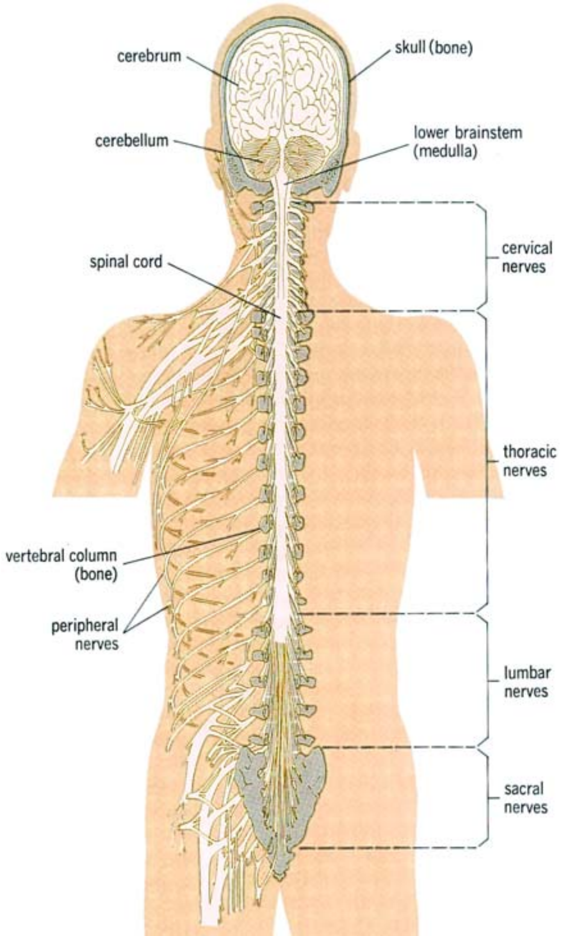
supply and oxygen-delivering blood circulates through at an average flow of 650-700 ml per minute. A disruption of the oxygenated blood supply (ischemia) to specific areas of the brain may bring on a stroke and consequent dysfunction of the damaged brain tissue.

With new technologies, it has become possible to understand healthy brain function and its dysfunction in disease. Neuroscience is an area of scientific investigation that includes many specializations concerned with growth, development, and function of the nervous system. Consequently, neuroscientists have to be knowledgeable in a range of subjects including anatomy, physiology, biochemistry, molecular biology, pharmacology, computer science and neuroethics.



The nervous system viewed from behind.

The nervous system is composed of the central nervous system or brain and spinal cord, and the peripheral nervous system. The peripheral nervous system is a series of pathways that transmit impulses between the central nervous system and the other body tissues (figure adapted from Woodburne, R. 'Essentials of Human Anatomy'. Oxford University Press, N.Y. 1965).

F1.2. Body or Mind – Where is the Difference?

Our environments (internal and external) are being monitored continuously by the sense organs. The sense organs (e.g., eye, ear, nose, taste bud) collect information and convert it into nerve impulses. Only when impulses reach the central nervous system are they interpreted and 'sensed' as light, sound, smell, taste and so on. Different parts of the brain are responsible for interpreting different impulses. For example, you may 'see stars' from a blow to the head simply indicating that the light interpreting region of the brain has been stimulated.

Meditation Exercise: Close your eyes and concentrate on the space inside your head for a while. Visualize a lemon, visualize cutting it into segments, visualize slowly sucking on the segments – one by one …... What sensations are you experiencing? Concentrate on taste, saliva flow, colors and shapes – please write them down after the exercise. Did your mind create physical changes in your body? Do you feel that your mind is separate from your body? Can you imagine measuring love or anger in the same way as you can tastes, heart beat or breathing? The more doctors and scientists learn about the inner workings of the mind, the more they realize that there is no mind-body dualism – mind and body are inseparable. Thoughts and emotions are the result of complex electrochemical interactions within and between nerve cells which, in turn, communicate with the rest of the body. For example, the disembodied voices of schizophrenia and the low-self esteem of depression are generated by distortions in brain chemistry. Mental states and physical wellbeing are intimately connected. An unhealthy body can lead to an unhealthy mind, and an illness of the mind can trigger or worsen diseases in the body. Researchers are learning how these distortions arise, how to lessen their severity and, in some cases, how to correct them.

Q1: Scientists believe that the human ability to be ethical has evolved over hundreds of thousand of years. Do you agree or disagree?

F1.3. Neuroethics

Neuroethics is a new field that deals with the pros and cons of research conducted on the brain as well as the social, legal and ethical implications of treating or manipulating the mind. Neuroethicists propose that we consider the ethics now rather than wait until new technologies have been developed and are being used. Access to information is an important consideration but there are also wide implications for the rights of the individual.

Brain scans can identify early signs of brain disease and risk factors for mental health. New advances in brain scans use blood flow, and tend to focus on basic brain processes. Interestingly, scientists are expanding on traditional research into general brain functions, organization and evolution to explore the more subtle functions which make us individuals. For example, advances in neuroimaging technology may improve our ability to make predictions about an individual's future. Scientists will learn how different patterns of brain images, taken under varying circumstances, strongly correlate with different future behaviors or conditions. Advances in neuroimaging will provide access to the mental processes involved in recalling a memory, whether true or fabricated, and assist neurologists to differentiate between the two (see Chapter F2). Future neuroimaging will provide insights into individual traits such as intelligence, cognitive abilities, personality characteristics such as violence and addiction, and mental illness. Specific neuroimages may also predict the onset of particular neurodegenerative diseases such as Alzheimer's and Parkinson's.

Prediction of the onset of a particular disease potentially could lead to prevention of onset or early treatment. However, there are many ethical concerns that must be considered before the potential is exploited.

Q2. Accurate predictions could lead to useful preventative interventions but what if those predictions are wrong or misleading?
Q3. Should you feel guilty for a crime you might commit?

Q4. What happens if the information about your potential to commit a crime or

become ill gets into the wrong hands such as private businesses and insurance companies?

We now know that the prefrontal cortex of the cerebral cortex is responsible for cognition, emotional regulation, control of impulsive behavior and moral reasoning. Should the prefrontal cortex be damaged or its function impaired by risk factors such as alcohol or stress, an individual may be unable to appropriately regulate his/her behavior despite knowing right from wrong.

Q5. Are criminals whose prefrontal cortex is damaged responsible for their criminal behavior?

Q6. Should they be punished or rehabilitated?

Q7. If scientists can read your thoughts, do you think that they can also change them?

Note of Interest: Gifted children use their brains in completely different ways to most of us. Their brains are far more active and they generate many more connections compared with the average ability brain.

F1.4. Finger-Printing - Can Machines Read Your Mind?

As technology continues to develop, there is the potential that machines could be created that are capable of reading an individual's thoughts and memories. Presently, the polygraph is used to detect lying. Detection is done by recording involuntary responses such as heart rate, blood pressure and sweating. But can a machine that measures brain activity accurately detect lying? More sophisticated brain fingerprinting techniques are being developed that can reveal a person's knowledge of an event or incident (see section F2.1).

If a device could accurately measure hidden knowledge, how should it be used? Do the benefits of this technology – as in detecting criminals or terrorists or company employees who cannot be trusted – outweigh the possible harms? If this technology is forced on an individual, or done without consent, what happens to their right of privacy against mental intrusion? Modern neuroscience poses many dilemmas because the brain is who we are – it's our personality, consciousness, behavior, ideas and spirituality. How and what we think, feel and act is very personal and often we choose not to reveal every aspect of ourselves. Is modern neuroscience opening up a Pandora's Box?

Q8. If brain machines manage to interpret the very secrets of the brain, what uses will it be put to and who will have the controls?

Q9. Who should have the right to the information in your brain? Lawyers, doctors, family members, employers, insurance companies, marketing agencies, government intelligence organizations?

F1.5. Case Study: Parkinson's Disease

Parkinson's disease is a neurodegenerative disorder caused by damaged or dead dopamine cells in the region of the brain that controls balance and coordinates muscle movement. Dopamine is an inhibitory neurotransmitter that is responsible for ensuring that signals between the brain and muscles are coordinated to allow for smooth and fluid movements. As dopamine neurons begin to die, the line of communication between the brain and the muscles cannot be regulated effectively, and the brain is no longer able to control muscle movement. Symptoms include tremors in the hands, face and legs; stiffness of the limbs and trunk; slowed movement and speech; and impaired balance and coordination.

It is well established that the loss of dopamine cells resulting in Parkinson's has genetic as well as environmental causes. With current technology, it is possible to screen for one specific Parkinson's gene but the process is complicated and costly. At the moment, the test is only useful for those who are likely to exhibit early onset of the disease; that is, showing symptoms at about 30 years of age. Research may soon lead to similar tests that can effectively screen for those people susceptible to the disease, regardless of time of onset and it may even be possible to screen for the disease prenatally. This could reduce the incidence of the disease by selectively screening fetuses and carrying to term only those who do not carry the gene.

Embryologists continue in their efforts to develop safer and more reliable screening methods for severe genetic disorders, but for many conditions having a certain gene, or gene combination, merely means that the carrier has a heightened risk of developing that genetic illness. This especially holds true for the lifestyle diseases such as heart disease and cancer, where risk of expression will have to be evaluated in an environmental context. Chapter F3 section F3.4 details how health and wellbeing interact among genes, living conditions and behavioural habits.

F1.6. Intracerebral Grafting of Fetal Stem Cells for Parkinson's

Another important challenge to neuroscience is the application of stem cells to repair neurological damage - particularly important in Parkinson's disease. Stem cells are cells that have the potential to grow and develop into specialized cell types, such as neurons. There are two main sources of stem cells – embryonic stem cells and adult stem cells. Recently scientists were able to take a special type of stem cell from rat embryos and successfully treat a Parkinson's-like disease in rats. Neural stem cells that can develop into nervous tissue were injected into rats which showed about a 75% improvement in motor function 80 days after treatment. Can we as a society ignore the potential benefits of this kind of research?

A prominent ethical topic is the use of aborted fetal brain tissue containing the required stem cells. Several nations have provided ethical guidelines for the use of embryos and fetuses in clinical and experimental research. These guidelines advocate that the decision to abort a fetus should be wholly independent from the decision to use that fetus in research. This guideline is designed to reduce the chance of a fetus being aborted solely for the purpose of providing organs. Under these guidelines organ donation from an aborted fetus is considered no different from donation from a deceased child or adult.

Q10. A number of the potential therapies for the treatment of Parkinson's disease are quite controversial. For example, stem cell treatment would require large numbers of aborted embryos. Is it ethical to pursue such research when the condition may be managed with drugs?

Q11. If neuroscience could provide a safe and accurate prenatal screening test for Parkinson's disease, is it ethical to use this information to decide whether to keep or abort a pregnancy?