PSY 207
Introduction to Physiological Psychology

Course Manual

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COURSE MANUAL

Introduction to Physiological Psychology

PSY207

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Vice-Chancellor's Message

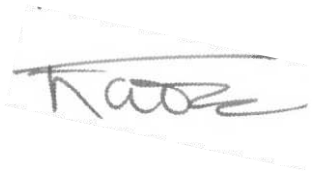
The Distance Learning Centre is building on a solid tradition of over two decades of service in the provision of External Studies Programme and now Distance Learning Education in Nigeria and beyond. The Distance Learning mode to which we are committed is providing access to many deserving Nigerians in having access to higher education especially those who by the nature of their engagement do not have the luxury of full time education. Recently, it is contributing in no small measure to providing places for teeming Nigerian youths who for one reason or the other could not get admission into the conventional universities.

These course materials have been written by writers specially trained in ODL course delivery. The writers have made great efforts to provide up to date information, knowledge and skills in the different disciplines and ensure that the materials are user-friendly.

In addition to provision of course materials in print and e-format, a lot of Information Technology input has also gone into the deployment of course materials. Most of them can be downloaded from the DLC website and are available in audio format which you can also download into your mobile phones, IPod, MP3 among other devices to allow you listen to the audio study sessions. Some of the study session materials have been scripted and are being broadcast on the university's Diamond Radio FM 101.1, while others have been delivered and captured in audio-visual format in a classroom environment for use by our students. Detailed information on availability and access is available on the website. We will continue in our efforts to provide and review course materials for our courses.

However, for you to take advantage of these formats, you will need to improve on your I.T. skills and develop requisite distance learning Culture. It is well known that, for efficient and effective provision of Distance learning education, availability of appropriate and relevant course materials is a *sine qua non*. So also, is the availability of multiple plat form for the convenience of our students. It is in fulfillment of this, that series of course materials are being written to enable our students study at their own pace and convenience.

It is our hope that you will put these course materials to the best use.



Prof. Isaac Adewole

Vice-Chancellor

Foreword

As part of its vision of providing education for "Liberty and Development" for Nigerians and the International Community, the University of Ibadan, Distance Learning Centre has recently embarked on a vigorous repositioning agenda which aimed at embracing a holistic and all encompassing approach to the delivery of its Open Distance Learning (ODL) programmes. Thus we are committed to global best practices in distance learning provision. Apart from providing an efficient administrative and academic support for our students, we are committed to providing educational resource materials for the use of our students. We are convinced that, without an up-to-date, learner-friendly and distance learning compliant course materials, there cannot be any basis to lay claim to being a provider of distance learning education. Indeed, availability of appropriate course materials in multiple formats is the hub of any distance learning provision worldwide.

In view of the above, we are vigorously pursuing as a matter of priority, the provision of credible, learner-friendly and interactive course materials for all our courses. We commissioned the authoring of, and review of course materials to teams of experts and their outputs were subjected to rigorous peer review to ensure standard. The approach not only emphasizes cognitive knowledge, but also skills and humane values which are at the core of education, even in an ICT age.

The development of the materials which is on-going also had input from experienced editors and illustrators who have ensured that they are accurate, current and learner-friendly. They are specially written with distance learners in mind. This is very important because, distance learning involves non-residential students who can often feel isolated from the community of learners.

It is important to note that, for a distance learner to excel there is the need to source and read relevant materials apart from this course material. Therefore, adequate supplementary reading materials as well as other information sources are suggested in the course materials.

Apart from the responsibility for you to read this course material with others, you are also advised to seek assistance from your course facilitators especially academic advisors during your study even before the interactive session which is by design for revision. Your academic advisors will assist you using convenient technology including Google Hang Out, You Tube, Talk Fusion, etc. but you have to take advantage of these. It is also going to be of immense advantage if you complete assignments as at when due so as to have necessary feedbacks as a guide.

The implication of the above is that, a distance learner has a responsibility to develop requisite distance learning culture which includes diligent and disciplined self-study, seeking available administrative and academic support and acquisition of basic information technology skills. This is why you are encouraged to develop your computer skills by availing yourself the opportunity of training that the Centre's provide and put these into use.

In conclusion, it is envisaged that the course materials would also be useful for the regular students of tertiary institutions in Nigeria who are faced with a dearth of high quality textbooks. We are therefore, delighted to present these titles to both our distance learning students and the university's regular students. We are confident that the materials will be an invaluable resource to all.

We would like to thank all our authors, reviewers and production staff for the high quality of work.

Best wishes.

Professor Bayo Okunade

Director

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Contents

About this course manual

Introduction to Physiological Psychology PSY207 has been produced by University of Ibadan Distance Learning Centre. All course manuals produced by University of Ibadan Distance Learning Centreare structured in the same way, as outlined below.

How this course manual is structured

The course overview

The course overview gives you a general introduction to the course. Information contained in the course overview will help you determine:

- If the course is suitable for you.
- What you will already need to know.
- What you can expect from the course.
- How much time you will need to invest to complete the course.

The overview also provides guidance on:

- Study skills.
- Where to get help.
- Course assignments and assessments.
- Margin icons.

We strongly recommend that you read the overview *carefully* before starting your study.

The course content

The course is broken down into Study Sessions. Each Study Session comprises:

- An introduction to the Study Session content.
- Study Session outcomes.
- Core content of the Study Session with a variety of learning activities.
- A Study Session summary.
- Assignments and/or assessments, as applicable.
- Bibliography

Your comments

After completing Introduction to Physiological Psychology we would appreciate it if you would take a few moments to give us your feedback on any aspect of this course. Your feedback might include comments on:

- Course content and structure.
- Course reading materials and resources.
- Course assignments.
- Course assessments.
- Course duration.
- Course support (assigned tutors, technical help, etc.)

Your constructive feedback will help us to improve and enhance this course.

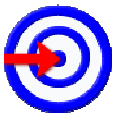
Course Overview

Welcome to Introduction to Physiological Psychology PSY207

Physiological psychology offers studies on the interactions between physical and chemical processes in the body and mental states or behaviour. It provides the foundational basis for theory building for which scientific explanations could be provided to clarify and contextualise human behaviour.

As a follow-up to the foundational course "Introduction to Psychology/ Psychobiological Basis of behaviour," Physiological psychology explores the relationships between the anatomical layout of organs, the relationship between possible changes in cells, organs and tissues and tissues functioning, which by extension determines human mental functioning, and ultimately human behaviour. The course, therefore, serves as background for which scientific explanations to various human behaviour is provided.

Course outcomes



Outcomes

Upon completion of Introduction to Physiological Psychology PSY207 you will be able to:

- *describe* the physiology of the nervous system
- *analyse* the physiological system involved in behaviour.
- *point out* the behavioural consequence of damage to the nervous system.

Timeframe

How long?

This is a 15 week course. It requires a formal study time of 45 hours. The formal study times are scheduled around online discussions / chats with your course facilitator / academic advisor to facilitate your learning. Kindly see course calendar on your course website for scheduled dates. You will still require independent/personal study time particularly in studying your course materials.

How to be successful in this course

As an open and distance learner your approach to learning will be different to that from your school days, where you had onsite education. You will now choose what you want to study, you will have professional and/or personal motivation for doing so and you will most likely be fitting your study activities around other professional or domestic responsibilities.

Essentially you will be taking control of your learning environment. As a consequence, you will need to consider performance issues related to time management, goal setting, stress management, etc. Perhaps you will also need to reacquaint yourself in areas such as essay planning, coping with exams and using the web as a learning resource.

We recommend that you take time now—before starting your self-study—to familiarize yourself with these issues. There are a number of excellent resources on the web. A few suggested links are:

- http://www.dlc.ui.edu.ng/resources/studyskill.pdf

  This is a resource of the UIDLC pilot course module. You will find sections on building study skills, time scheduling, basic concentration techniques, control of the study environment, note taking, how to read essays for analysis and memory skills ("remembering").
- http://www.ivywise.com/newsletter_march13_how_to_self_study.html

  This site provides how to master self-studying, with bias to emerging technologies.
- http://www.howtostudy.org/resources.php

  Another "How to study" web site with useful links to time management, efficient reading, questioning/listening/observing skills, getting the most out of doing ("hands-on" learning), memory building, tips for staying motivated, developing a learning plan.

The above links are our suggestions to start you on your way. At the time of writing these web links were active. If you want to look for more, go to www.google.com and type "self-study basics", "self-study tips", "self-study skills" or similar phrases.

Need help?

Help

As earlier noted, this course manual complements and supplements PSY207at UI Mobile Class as an online course.

You may contact any of the following units for information, learning resources and library services.

Distance Learning Centre (DLC)
University of Ibadan, Nigeria
Tel: (+234) 08077593551 – 55
(Student Support Officers)
Email: ssu@dlc.ui.edu.ng

Head Office
Morohundiya Complex, Ibadan-Ilorin Expressway, Idi-Ose, Ibadan.

Information Centre
20 Awolowo Road, Bodija, Ibadan.

Lagos Office
Speedwriting House, No. 16 Ajanaku Street, Off Salvation Bus Stop, Awuse Estate, Opebi, Ikeja, Lagos.

For technical issues (computer problems, web access, and etcetera), please send mail to webmaster@dlc.ui.edu.ng.

Academic Support

Help

A course facilitator is commissioned for this course. You have also been assigned an academic advisor to provide learning support. The contacts of your course facilitator and academic advisor for this course are available at onlineacademicsupport@dlc.ui.edu.ng

Activities

Activities

This manual features "Activities," which may present material that is NOT extensively covered in the Study Sessions. When completing these activities, you will demonstrate your understanding of basic material (by answering questions) before you learn more advanced concepts. You will be provided with answers to every activity question. Therefore, your emphasis when working the activities should be on understanding your answers. It is more important that you understand why every answer is correct.

Assessments

Assessments

There are three basic forms of assessment in this course: in-text questions (ITQs) and self assessment questions (SAQs), and tutor marked assessment (TMAs). This manual is essentially filled with ITQs and SAQs. Feedbacks to the ITQs are placed immediately after the questions, while the feedbacks to SAQs are at the back of manual. You will receive your TMAs as part of online class activities at the UI Mobile Class. Feedbacks to TMAs will be provided by your tutor in not more than 2 weeks expected duration.
Schedule dates for submitting assignments and engaging in course / class activities is available on the course website. Kindly visit your course website often for updates.

Bibliography

Readings

For those interested in learning more on this subject, we provide you with a list of additional resources at the end of this course manual; these may be books, articles or websites.

Getting around this course manual

Margin icons

While working through this course manual you will notice the frequent use of margin icons. These icons serve to "signpost" a particular piece of text, a new task or change in activity; they have been included to help you to find your way around this course manual.

A complete icon set is shown below. We suggest that you familiarize yourself with the icons and their meaning before starting your study.

 Activity	 Assessment	 Assignment	 Case study
 Discussion	 Group Activity	 Help	 Outcomes
 Note	 Reflection	 Reading	 Study skills
 Summary	 Terminology	 Time	 Tip

Study Session 1

The Meaning and Scope of Physiological Psychology

Introduction

This Study Session introduces you to the meaning and scope of the field of physiological psychology. Highlights include the scientific basis of views in physiological psychology with emphasis on the relevance of findings in earlier scientific experiments in gaining a better understanding in the field.

Learning Outcomes

When you have studied this session, you should be able to:

1.1 define physiological psychology.
1.2 explore various scientific experiments related to various aspects of human functioning.
1.3 apply knowledge about the various research investigations in explaining human behaviour.

1.1 Meaning of Physiological Psychology

Physiological psychology is the science that studies the biological bases of behaviour. For this reason, physiological psychology is sometimes referred to as biological psychology, biopsychology, or psychobiology. This means that the physiological psychologist studies the biological factors (as opposed to economic, social, or cultural factors) that cause or constitute behaviour.

Although the expression biological bases of behaviour refers to a large number of physiological processes, contemporary usage equates biological bases with neural substrates (Davis et al 1988). Consequently, physiological psychology today is a synonym of behavioral neuroscience rather than a synonym of psychobiology as it used to be in the 1950s.

A contemporary definition of physiological psychology would refer, therefore, not to the biological bases of behaviour but to the neural substrates of behavior (including the special class of behavior called mental activity). The name physiological psychology has been adopted by numerous authors, although several alternative names have been proposed, such as biopsychology, psychobiology, neuropsychology,

neurobehavioral science, behavioral neuroscience, and others. In certain instances, names that might seem alternative names actually designate subspecialties of physiological psychology, such as neuropsychology, psychophysiology, and neuroethology.

1.2 Scope of Physiological Psychology

Physiological psychologists study behavioral phenomena that can be observed in nonhuman animals. They attempt to understand the physiology of behavior: the role of the nervous system, interacting with the rest of the body (especially the endocrine system, which secretes hormones), in controlling behavior. They study such topics as sensory processes, sleep, emotional behavior, ingestive behavior, aggressive behavior, sexual behavior, parental behavior, and learning and memory. They also study animal models of disorders that afflict humans, such as anxiety, depression, obsessions and compulsions, phobias, psychosomatic illnesses, and schizophrenia.

Although physiological psychology is the original name for this field, several other terms are now in general use, such as biological psychology, biopsychology, psychobiology, and behavioral neuroscience. Physiological psychology belongs to the larger field of neuroscience. Neuroscientists concern themselves with all aspects of the nervous system: its anatomy, chemistry, physiology, development, and functioning. The research of neuroscientists ranges from the study of molecular genetics to the study of social behavior.

Most professional physiological psychologists are employed by colleges and universities, where they are engaged in teaching and research. Others are employed by institutions devoted to research – for example, laboratories owned and operated by national governments or by private philanthropic organisations. A few works in industry, usually for pharmaceutical companies that are interested in assessing the effects of drugs on behavior. To become a professor or independent researcher, one must receive a doctorate. Nowadays, most physiological psychologists spend two years in temporary postdoctoral position, working in the laboratory of a senior scientist to gain more research experience. Two other fields often overlap with that of physiological psychology: neurology and experimental neuropsychology. Neurologists are physicians involved in the diagnosis and treatment of diseases of the nervous system.

1.2.1 Experiments related to various aspects of human behaviour

A number of examples and counter-examples of typical experimental studies will help delineate the boundaries of physiological psychology. Two of the most vivid examples of the study of the neural basis of behavior are the evocation of visual and auditory experiences by electrical stimulation of specific sites on the cerebral cortex in humans and the evocation of what seems to be the ultimate sensation of pleasure by stimulation of diencephalic structures in rats. On the other hand, the study of the areas of the brain involved in muscular movements evoked

by electrical stimulation of the motor cortex would belong to neurology or neurophysiology rather than physiological psychology, since only the neural component (and not the behavioral one) is being investigated. Analogously, the evocation of thermoregulatory behaviour by thermal stimulation of the hypothalamus belongs to physiological psychology, whereas the study of electrophysiological characteristics of thermal receptors in the brain does not.

Naturally, this distinction implies no attribution of scientific merit or of conceptual incommensurability. Electrophysiology is as scientifically important as physiological psychology, and an electrophysiological experiment that investigates, for instance, the firing characteristics of thermal receptors in the monkey's hand is extremely valuable for physiological psychology if the results are correlated with results from psychophysical experiments on thermal discrimination in humans. The same may be said about the study of the relationship between the electrical activity of single neurons in the inferior colliculus of the newborn mouse and the ability of these animals to respond to acoustic stimuli.

Many additional examples may be given: the mapping of brain regions that are active during ingestive behavior and the inhibition of ingestive behaviour by infusion of nutrients directly into the rat brain are examples of research in physiological psychology. On the other hand, the study of the effects of changes in taste and nutrient content of food on ingestive behavior in humans and the study of how taste aversion is learned in rats belong to behavioural psychology or regulatory physiology rather than to physiological psychology, since only the behavioural component (and not the neural one) is being investigated. Analogously, the investigation of the effects of cerebellar lesions on emotional behavior in rats, or of cortical lesions on sensory discrimination, or of hippocampal lesions on memory, or of cortical lesions on learning capability, or of hypothalamic lesions on thermoregulatory behavior are all examples of research in physiological psychology. On the other hand, the study of the sensory determinants of suckling behavior in weanling rats, or of social relations among non-human primates, or of the punishment procedure in operant conditioning, or of the behavioral thermal preference of the rat belong to behavioral psychology and ethology rather than to physiological psychology. As before, this distinction implies no attribution of scientific merit or of conceptual incommensurability.

Purely behavioral studies are just as important as studies that examine the neural correlates of behavior. In fact, physiological psychology, behavioral psychology, neurophysiology, and regulatory physiology are all interrelated sciences. Except for the few exceptions described later on in this book, all of these sciences contribute to the advancement of our knowledge of how the animal body (including the brain) performs the various tasks required for the survival of the individual and the species and for the enjoyment of human existence.

Reading Activity

Time allowed 20 minutes

Read more about socio-behavioural experiments such as the Stanley Milgram's obedient experiment, Jose Delgado's experiment on monkeys and other experiments on electrical stimulation of the brain.

Links: http://explorable.com/social-psychology-experiments

http://www.spring.org.uk/2007/11/10-piercing-insights-into-human-nature.php

Note your findings in your journal

1.2.2 Application to human behaviour

Suppose a biological psychologist were to tell you that the anger you experience is merely a reflection of a pattern of activity in your brain, and that the romantic attraction you feel toward someone is the result of activity in another area of your brain. The psychologist goes on to say that you are better at English that at algebra because the left half of your brain is a few millimeters thicker than the right half, and explains each of your other behaviours in terms of your other features of your brain. Would you feel opposed to these explanations?

Even though explaining these may be a little difficult at times, it is largely plausible. However, it is additionally necessary to make a distinction between two types of biological explanation: i.e. biological factors that force a behavior to occur and biological factors that enable a behavior to occur. In some cases, the properties of the brain or the rest of the body could force a behavior to occur. For example, people sweat because they become too hot. The pupil of the eye constrict in presence of bright light. In some other cases, biological influence may make a behavior possible but not absolutely necessary. For example, the properties of your brain may predispose to aggression, but you may choose to caution yourself from attacking someone else.

Study Session Summary

Summary

In this Study Session, you learnt that the field of physiological psychology seeks to explain animal and human behavior from biological perspective. It stresses the relationship between changes in animal and human hsitochemistry on internal mechanism for controlling responses to internal and external stimuli, and by extension human functioning depicted in overt and overt behaviours.

Assessment

Assignment

1. Define physiological psychology.
2. With the use of various scientific experiments explain 2 experiments related to various aspects of human functioning
3. Apply knowledge about the various research investigations in explaining human behaviour

Bibliography

Readings

Colman, A. M. (2003). *Oxford Dictionary of Psychology*. Oxford: Oxford University Press

Waugh, A., and Grant, A. (2002). *Anatomy and Physiology in Health and Illness.* (9th ed.). Edinburgh, Churchill Livingstone.

Study Session 2

The Mind-Brain Relationship

Introduction

Many are yet to believe that our thoughts and actions are the result of the result of physical processes in the brain. There is a relationship between our mind and our brain. Our conscious minds control our behaviours while our action is governed by a series of chemical processes in the brain.

This Study Session teaches that most behaviours of animals and human beings are responses to neuronal changes and activities in the brain. In other words, what we do are practical reflections of the response of the brain to incoming stimulus.

Learning Outcomes

When you have studied this session, you should be able to:

2.1 describe the relationship between the mind and the brain.

2.2 highlight experimental evidences to relate the mind to the brain, and vice versa.

2.1 Experimental Evidences Relating the Mind to the Brain

The mind could be said to be product of brain activities. It is, however, difficult to affirm that the mind is controlled by neural processes in the brain. However, there is incontrovertible evidence that various kinds of brain damage lead to specific changes in behavior and losses of sensory capacity. With this, it could be inferred that brain damage could lead to mind damage. Evidences from electrical stimulation of the brain also support behavioural effects of electrical stimulation of the brain.

2.1.1 Control of behaviour by electrical stimulation of the brain

Fritzch and Hitzig in (1870) reported that mild electrical stimulation of portions of the cerebral cortex of a dog could cause muscle movements. At low intensities, the electrical current stimulated discrete, limited movements, especially on the side of the body opposite the stimulation. Based on the specific point stimulated, the dog would move its neck,

back, abdomen, tail, leg, or some other parts of its body. They also found that continuous stimulation of the same point consistently elicited the same response. The result of the experiment was validated in experiments performed in many other species.

The above experiment explains that electrical activity occurs naturally in the brain at all times. This electrical activity is caused by nerves sending messages from the sense organs. Their impulses combine with electrical activity already present in the other areas of the brain to produce activity in other areas, which then activate still other areas. In furtherance of this study, Fritzch and Hitzig demonstrated that some activity in specific areas of the brain control specific patterns of movement.

2.1.2 Electrical stimulation of more complex behaviours

(A) von Holst and von St. Paul (1960) experiment

von Holst and von St. Paul (1960) also found that electrical stimulation of the brain can evoke not only simple muscle movements but also more complex sequences of behaviour, particularly if the animal is awake during the stimulation and free to move about. Working with chickens, von Holst and von St. Paul (1960) implant electrodes on the skull of chickens to hold them in place. These electrodes were connected to wires through which weak electric current was passed to the brain of the chickens while the animal was alive, awake and moving about.

The physiological psychologists found that stimulation of various areas of the brain elicited such behaviours as feeding, drinking, grooming, turning the body to one side, sleeping, sitting, escape flight and aggressive attack. The behaviour elicited depended on the exact location of the electrode and the intensity of the stimulation (stronger current could stimulate more cells). The elicited behaviour also varied depending on the environmental stimuli. For instance, in later experiments with rats, stimulation of certain areas led to eating if only food were present (Valenstein, Cox, Kakolewski, 1970). Similarly, Hess (1944) find that electrical stimulation of certain areas could induce an animal to fall asleep suddenly.

(B) Jose Delgado (1969) experiment

Jose Delgado (1969) introduces some technological advances that permitted him to investigate the electrical stimulation of a wider variety of behaviours. He advance the experiments of von Holst and von St. Paul (1960) by attaching permanent electrodes connected to a monkey's skull via an electrical stimulator. He found that stimulation of some points produced normal coordinated walking, walking in circles, running, falling asleep, cessation of spontaneous movement, or loss of appetite. Also, following a five-second stimulation of the sub-cortical area, there was a stereotyped behavior lasting 10 -14 seconds. In the experiment, the monkey changed its facial expression, turned its head to the right side, stood up on two feet, circled to the right, walked on two feet to a pole in the center of the room, climbed the pole and then came down, growled, threatened and sometimes attacked another monkey, and finally approached the group in a friendly manner and then resumed normal behaviour. For as many as 20,000 times that this stimulation was repeated, the monkey repeated the behavioural response 20,000 times.

Delgado also performed another experiment in 1963 to test aggression among monkeys.

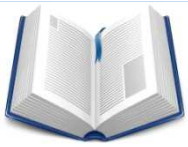
Electrical Stimulation of the Human Brain

It is unethical to experiment on human brains. However if ethical guidelines are followed, there are a few of medical purposes that permit the experimental observation of electrical stimulation of human brains, especially following animal trials.

Electrical stimulation has most often been used with humans in an attempt to treat epilepsy, a syndrome caused by abnormal electrical discharge in the brain. The abnormal activity originates in a damaged or malfunctioning area of the brain called the focus of epilepsy. The focus is located in different places for different individuals. The abnormal discharge spreads outward from the focus until a large portion of the cerebral cortex is involved possibly causing uncontrollable body jerks. Surgical excision may be required especially where drug treatment failed.

Only the part to be incised is anaesthetised, leaving the patient conscious in the process. The first step is to discover the focus. In order to do this, the surgeon exposes part of the brain and then applies an electrode to stimulate a few areas in the cortex, one after the other. Eventually, as the surgeon stimulates a point, the patient says "that makes me feel the same way I feel when I'm about to have one my seizures". This point can be identified as the focus of the epilepsy. The surgical procedure is then advanced and the focus removed surgically, leading to a cessation of epileptic seizures in the patient. The surgeon can also observe the reaction of the patient to the stimulation of other areas before finally succeeding in identifying the focus of epilepsy.

Since electrical stimulation of the brain can elicit not only sensations and movements but also emotional changes, it appears that the activity of the brain is responsible for what we call the mind since the results of brain stimulation provides an evidence for this conclusion.



Reading Activity

Time allowed
20 minutes

Read about Delgado's experiment on aggression in monkeys; and relate the concept of mind brain relationship to the psychoanalytic theory of personality.

Links: http://en.wikipedia.org/wiki/Jos%C3%A9_Manuel_Rodriguez_Delgado

http://psychology.about.com/od/theoriesofpersonality/a/consciousuncon.htm

Note your findings in your journal

Study Session Summary

Summary

In this Study Session, we have noted the following:

- The "mind" is just another way of saying "brain activities". Despite existing ambiguities, the mind could be observed like a physical entity, separate from the body. This is why it is possible to observe the mind of other people.
- Evidences abound that various kinds of brain damage lead to specific changes in behaviour and losses of sensory capacity. Brain damage may therefore relate to mind damage.
- Evidences arising from the study of the behavioural effects of electrical stimulation of the brain also support this viewpoint.
- One of such evidences is the experiment performed in 1870 by Fritzch and Hitzig where they found that mild, non destructive electrical stimulation of portions of the cerebral cortex of a dog could cause muscle movements. With this it was found that behaviour could be controlled by electrical stimulation of the brain.
- Jose Delgado (1969) introduces some technological advances that permitted him to investigate the electrical stimulation of a wider variety of behaviours. He finds that stimulation of some points produced normal coordinated walking, walking in circles, running, falling asleep, cessation of spontaneous movement, or loss of appetite.
- Electrical stimulation of the brain can elicit not only sensations and movements but also emotional changes, it appears that the activity of the brain is responsible for what we call the mind.

Assessment

Assignment

1. Explain the meaning of "mind-brain relationship".
2. How does the brain control human behaviour?
3. 3. Describe an experiment to explain the concept of "mind-brain" relationship?

Study Session 3

Organization of the Human Body

Introduction

The human body is made of cells, tissues, organs and systems. Within cells are other components such as nutrients, water, and other chemicals. These function interrelated in an effort to maintain physiological and psychological homeostasis. A basic knowledge of these functions will be discussed in this session, so that you can understand, assess and predict human behaviours.

Learning Outcomes

When you have studied this session, you should be able to:

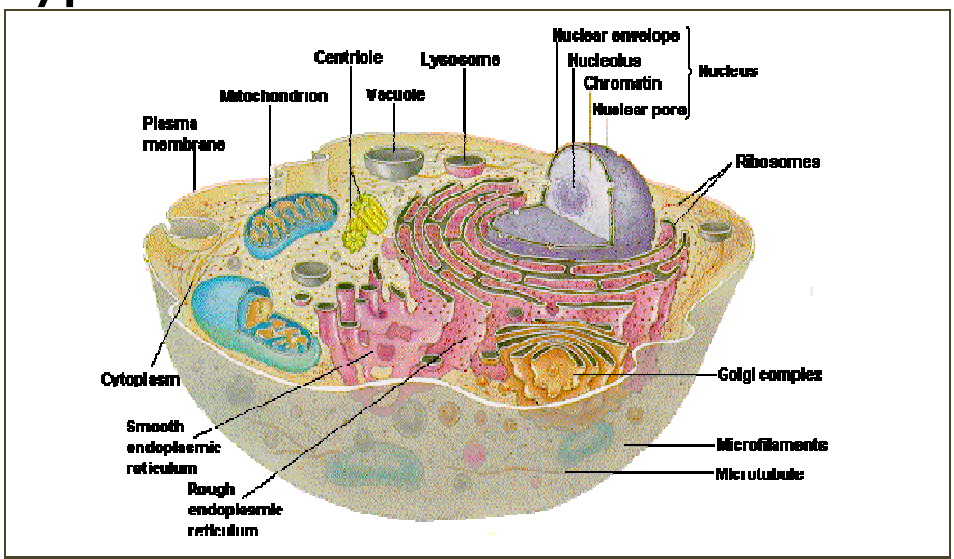
3.1 describe the components of a human cell.

3.2 explain the functions of the component parts of a human cell.

3.3 Explain the components of the cell environment.

3.1 The Typical Human Cell

Fig 3.1 A typical human cell



The cell is the simplest level of organisation in a human body. The cell is the simplest level of organization in a human body. Cells are the basic structural and functional units of the human body. There are many different types of cells such as an egg cell, sperm cell, and muscle cell, rod cells in the eye, hair cells and nerve cells as shown above.

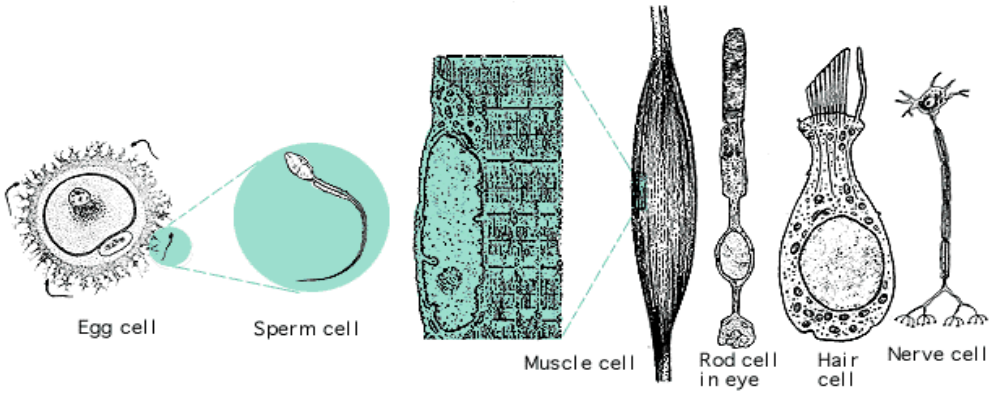
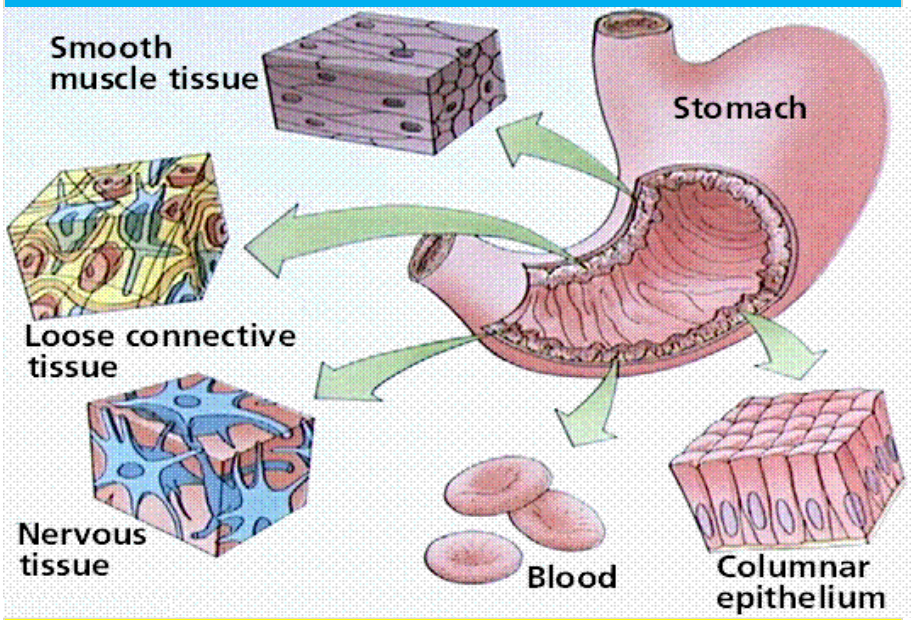


Fig 3.1 Human cells. Source: http://www.nigms.nih.gov/news/science_ed/whatart1.html

Tissues
A tissue is a group of cells that perform a specific function. The basic types of tissues in the human body include muscle, connective, nervous, and columnar tissues, among others. These are shown below.



Organs
An organ consists of 2 or more tissues that perform a particular or similar function. Examples include the heart, liver, stomach, and so on.

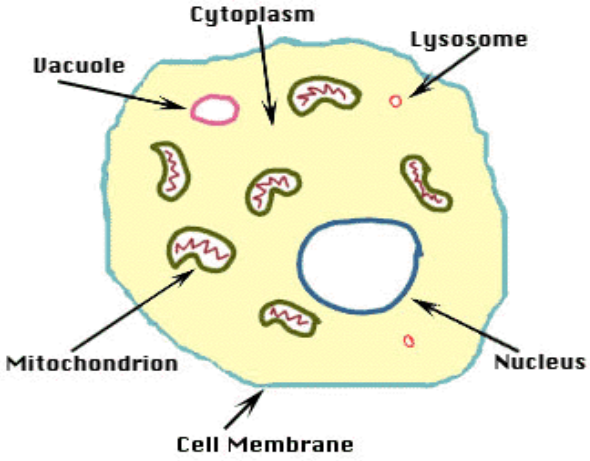
Systems
A system is made of an association of organs that have a common function. The major systems in the human body include: digestive, nervous, endocrine, urinary, reproductive, respiratory, and circulatory systems.

Explore the human body at: - http://www.innerbody.com/

3.2 Parts of Human Cells

There are two types of cells that make up all living things on earth: prokaryotic and eukaryotic. **Prokaryotic cells** like bacteria, have no 'nucleus', while **eukaryotic cells** are like those of the human body, do. So, a human cell is enclosed by a cell or plasma membrane. Enclosed by that membrane is the cytoplasm (with associated organelles) plus a nucleus, as shown in Fig 3.2.

Fig 3.2 Parts of human cell



3.2.1 Cell Membrane

The cell / plasma membrane encloses every human cell. In terms of structural layout, the cell membrane has 2 primary building blocks. These include protein (about 60% of the membrane) and lipid, or fat (about 40% of the membrane). The primary lipid layer is called phospholipid, and molecules of phospholipid form a 'phospholipid bilayer' (two layers of phospholipid molecules). This bilayer forms because the two 'ends' of phospholipid molecules have very different characteristics: one end is polar (or hydrophilic) and the other one (the hydrocarbon tails below) is non-polar (or hydrophobic):

Fig 3.3a Cytoplasm inside of cell

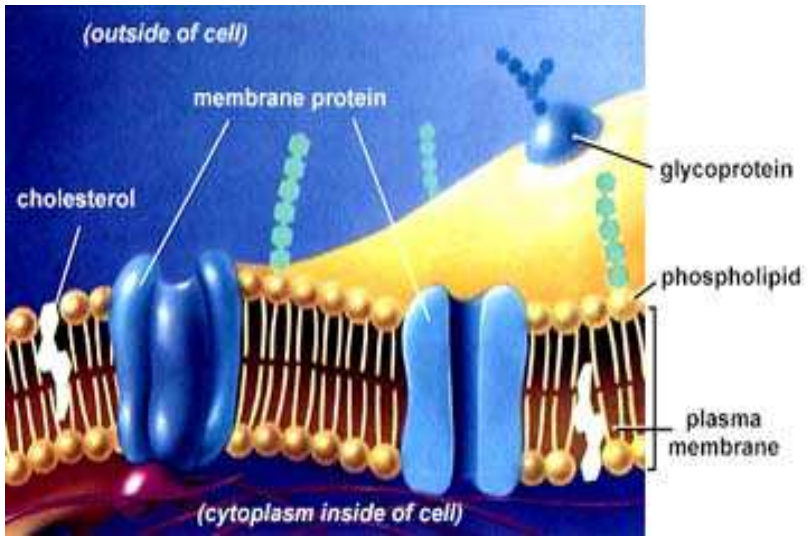
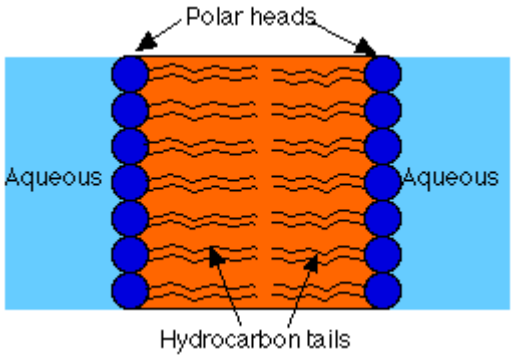


Fig 3.3b Phospholipid bilayer

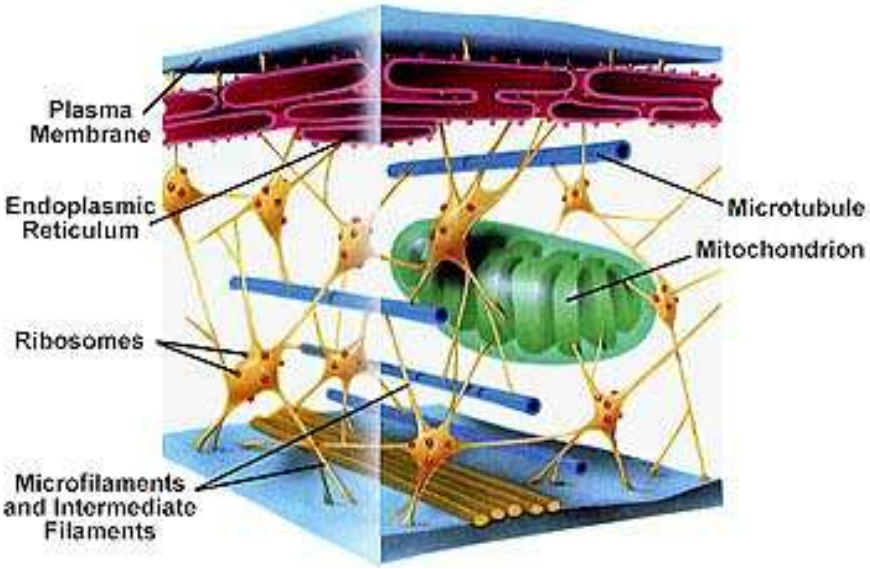


Functions of the cell membrane include: supporting and retaining the cytoplasm, and supporting and retaining the cytoplasm. In order to perform the latter function, it is important to note that the cell is separated from its environment and needs to get nutrients in and waste products out. Some molecules can cross the membrane without assistance, most cannot. Water, non-polar molecules and some small polar molecules can cross. Non-polar molecules penetrate by actually dissolving into the lipid bilayer. Most polar compounds such as amino acids, organic acids and inorganic salts are not allowed entry, but instead must be specifically transported across the membrane by proteins.

Cell membranes also facilitate communication, recognition/perception and selective transportation of compounds across cell membranes. For this, they require the expenditure of energy.

3.2.2 Cytoplasm and Organelles

Cytoplasm consists of a gelatinous solution and contains microtubules which serve as a cell's cytoskeleton and organelles (literally 'little organs').



3.2.3 Nucleus

Cells also contain a nucleus within which is found DNA (deoxyribonucleic acid) in the form of chromosomes plus nucleoli within which ribosomes are formed.

3.2.4 Cell organelles

These include: endoplasmic reticulum, Golgi complex, lysosomes,

Endoplasmic reticulum: It comes in 2 forms: smooth and rough; The surface of rough ER is coated with ribosomes; the surface of smooth ER is not. Functions include: mechanical support, synthesis (especially proteins by rough ER), and transport.

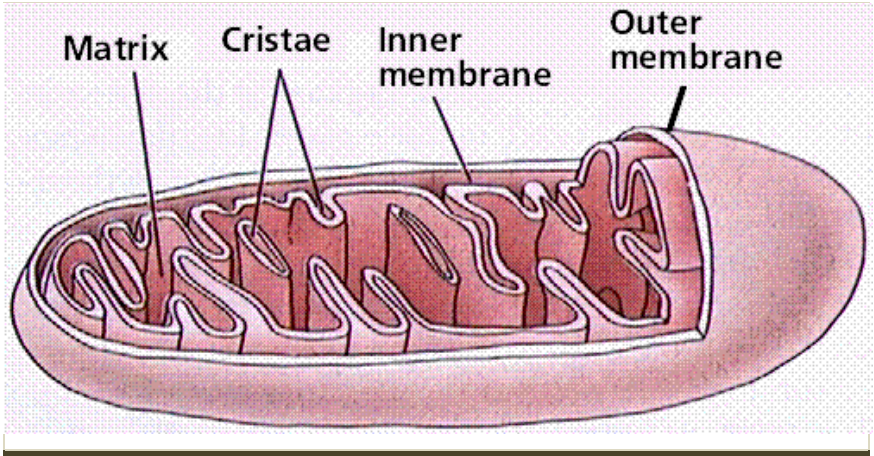
Golgi complex: consists of a series of flattened sacs (or cisternae). Functions include: synthesis (of substances likes phospholipids), packaging of materials for transport (in vesicles), and production of lysosomes.

Lysosomes: These are membrane-enclosed spheres that contain powerful digestive enzymes. Functions include destruction of damaged cells (which is why they are sometimes called 'suicide bags') and digestion of phagocytosed materials such as bacteria.

3.2.5 Mitochondria

They have a double-membrane: outer membrane and highly convoluted inner membrane.

Fig 3.3 Inner structure of Mitochondria



The inner membrane has folds or shelf-like structures called cristae that contain elementary particles; these particles contain enzymes important in ATP production. The primary function is production of adenosine triphosphate (ATP).

Other parts of the cell are:

Mitochodria: These are small round or rod –shaped bodies found in the cytoplasm of most cells. They produce enzymes for the conversion of food to energy.

Ribosomes: Are composed of rRNA (ribosomal RNA) and protein. The primary function includes production of proteins.

Centrioles. They are paired cylindrical structures located near the nucleus. They play an important role in cell division

Deoxyribonucleic acid (DNA) controls cell function via transcription and translation (in other words, by controlling protein synthesis in a cell).

3.3 Components of the Cellular Environment

3.3.1 Water

Water comprises 60 - 90% of most living organisms (and cells). They are important because it serves as an excellent solvent and enters into many metabolic reactions. Ions = atoms or molecules with unequal numbers of electrons and protons. They are found in both intra- and extra-cellular fluid. Examples of important ions include sodium, potassium, calcium, and chloride.

3.3.2 Carbohydrates

They are about 3% of the dry mass of a typical cell. They are composed of carbon, hydrogen, and oxygen atoms (e.g., glucose is C6H12O6). They are an important source of energy for cells. Types include: monosaccharides (e.g., glucose) - most contain 5 or 6 carbon atoms, disaccharides which contains 2 monosaccharides linked together. Examples include sucrose (a common plant disaccharide is composed of the monosaccharides glucose and fructose) and lactose (or milk sugar; a disaccharide composed of glucose and the monosaccharide galactose),

and polysaccharides. Polysaccharides have several monosaccharides linked together. Examples include starch (a common plant polysaccharide made up of many glucose molecules) and glycogen (commonly stored in the liver).

3.3.3 Lipids

These constitute about 40% of the dry mass of a typical cell. They are composed largely of carbon & hydrogen. They are generally insoluble in water, and involved mainly with long-term energy storage. Other functions are as structural components (as in the case of phospholipids that are the major building block in cell membranes) and as "messengers" (hormones) that play roles in communications within and between cells. Sub-classes include: triglycerides which consist of one glycerol molecule + 3 fatty acids. A phospholipid is a phosphate group (-PO4) substitutes for one fatty acid and these lipids are an important component of cell membranes. Steroids include testosterone, oestrogen and cholesterol

3.3.4 Proteins

These constitute about 50 - 60% of the dry mass of a typical cell. They have two functional categories = structural (proteins part of the structure of a cell like those in the cell membrane) and enzymes. Enzymes are catalysts. Enzymes bind temporarily to one or more of the reactants of the reaction they catalyse. In doing so, they lower the amount of activation energy needed and thus speed up the reaction.

Study Session Summary

Summary

A summary of our discussion in this Study Session is as follows:

1. Cells are the basic structural and functional units of the human body.
2. A tissue is a group of cells that perform a specific function.
3. An organ consists of 2 or more tissues that perform a particular or similar function
4. A system is made of an association of organs that have a common function. The major systems in the human body include: digestive, nervous, endocrine, urinary, reproductive, and respiratory and circulatory systems.
5. There are two types of cells that make up all living things on earth: prokaryotic and eukaryotic.
6. There are two types of cells that make up all living things on earth: prokaryotic and eukaryotic. Prokaryotic cells like bacteria, have no 'nucleus', while eukaryotic cells which are like those of the human body, do.
7. The cell / plasma membrane encloses every human cell. Functions of the cell membrane include: supporting and retaining the cytoplasm, and supporting and retaining the cytoplasm. Cell membranes also facilitate communication, recognition/perception and selective

transportation of compounds across cell membranes. For this, they require the expenditure of energy.

8. There are other structures such as the cytoplasm, and organelles
9. The nucleus contains the DNA (deoxyribonucleic acid) in the form of chromosomes plus nucleoli within which ribosomes are formed.
10. The endoplasmic reticulum It comes in 2 forms: smooth and rough. Functions include: mechanical support, synthesis (especially proteins by rough ER), and transport.
11. The Golgi complex consists of a series of flattened sacs (or cisternae). Functions include: synthesis (of substances likes phospholipids), packaging of materials for transport (in vesicles), and production of lysosomes
12. Lysosomes are membrane-enclosed spheres that contain powerful digestive enzymes. Functions include destruction of damaged cells (which is why they are sometimes called 'suicide bags') and digestion of phagocytosed materials such as bacteria.
13. Ribosomes are composed of rRNA (ribosomal RNA) and protein. The primary function includes production of proteins.
14. Centrioles are paired cylindrical structures located near the nucleus. They play an important role in cell division
15. Deoxyribonucleic acid (DNA) controls cell function via transcription and translation (in other words, by controlling protein synthesis in a cell).
16. Mitochondria are small round or rod –shaped bodies found in the cytoplasm of most cells. They produce enzymes for the conversion of food to energy.
17. The component parts of the cellular environment include: Water, Carbohydrates, Lipids, and Proteins

Assessment

Assignment

1. Draw and clearly label a typical human cell.
2. Mention the functions of the labelled parts.
3. Describe the component parts of a cell environment .

Study Session 4

Nervous System

Introduction

This Study Session introduces to you: the general structure and function of neurones. Highlights include the classification of neurons and functions of neurones. Also included are the major characteristics of neurones.

Learning Outcomes

When you have studied this session, you should be able to:

4.1 describe neurons.

4.2 identify various types of neurons.

4.3 mention the major characteristics of neurones.

4.4 describe the process of synaptic transmission.

4.5 outline the concept of action potential.

4.6 describe the process of neurotransmission.

4.7 relate the concept of myelin sheath to salutatory conduction.

4.1 Neurones

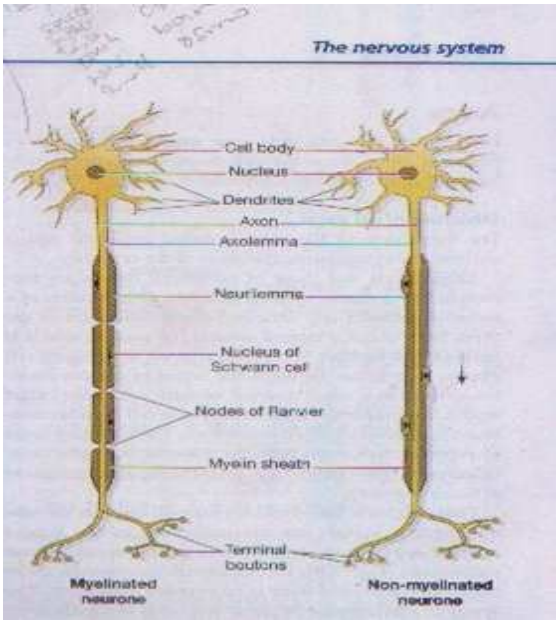
4.1.1 Structure of the Neurone

Neurones are commonly referred to as nerve cells. It is the basic structural unit of the nervous System. They are organised to form complex networks that perform the functions of the nervous system. Each neurone consists of a cell body and its processes, one axon and many dendrites. Bundles of axons bound together are called nerves. Neurones can not divide. For survival, they need a continuous supply of oxygen and glucose. Unlike many other cells neurons can synthesise chemical energy adenosine tri phosphate (ATP) only from glucose.

The nervous system carries out its functions effectively and extremely rapidly since information and instructions travel speedily as electric impulses along nerves from one part of the body to another almost instantaneously. The neurons are responsible for the electrical activities of the nervous system.

In order to function, the nervous system relies on nerve impulses, or action potentials, which are similar to tiny electrical charges which it maintains throughout the length of the neurone.

Fig 4.1 Structure of the neurone



A neurone consists of a nucleus, a membrane, mitochondria, ribosomes, endoplasmic reticulum, vacuoles and other structures typical of animal cells. The membrane limits the flow of materials between the inside of the cell and the outside environment. A few chemicals such as water, oxygen, and carbon dioxide, flow fairly freely across the membrane, while other substances flow fairly poorly, or not at all.

Neurons are electrically excitable cells generally comprised of one or more dendrites, a single soma, a single axon and one or more axon terminals. The dendrite is one of the two types of synapses, the other being the axon terminal buttons. Dendrites form protrusions in response to the axon terminal buttons. These protrusions, or spines, are designed to capture the neurotransmitters released by the presynaptic neuron. They have a high concentration of activated channels. It is, therefore, here where synapses from two neurons communicate with one another. These spines have a thin neck connecting a bulbous protrusion to the main dendrite. This ensures that changes occurring inside the spine are less likely to affect the neighbouring spines. The dendritic spine can, therefore, with rare exception, act as an independent unit.

The dendrites then connect onto the soma. The soma houses the nucleus, which acts as the regulator for the neuron. The fluid inside the cell membrane is known as the cytoplasm. The mitochondrion is the site for the metabolic activities that provide energy the cell requires for its activities. Ribosomes are for producing protein molecules. Some ribosomes float freely, others are attached to the endoplasmic reticulum. Vacuoles are fluid filled bubbles inside the cell.

Unlike the spines, the surface of the soma is populated by voltage activated ion channels. These channels help transmit the signals generated by the dendrites. Emerging out from the soma is the axon

hillock. This region is characterized by having an incredibly high concentration of voltage activated sodium channels. It is generally considered to be the spike initiation zone for action potentials. Multiple signals generated at the spines, and transmitted by the soma all converge here.

Immediately after the axon hillock is the axon. This is a thin tubular protrusion traveling away from the soma. The axon is insulated by a myelin sheath. Myelin is composed of Schwann cells that wrap themselves multiple times around the axonal segment. This forms a thick fatty layer that prevents ions from entering or escaping the axon. This insulation both prevents significant signal decay as well as ensuring faster signal speed. This insulation, however, has the restriction that no channels can be present on the surface of the axon. There are, therefore, regularly spaced patches of membrane which have no insulation. These nodes of Ranvier can be considered to be 'mini axon hillocks' as their purpose is to boost the signal in order to prevent significant signal decay. At the furthest end, the axon loses its insulation and begins to branch into several axon terminals. These axon terminals then end in the form the second class of synapses, axon terminal buttons. These buttons have voltage activated calcium channels which come into play when signaling other neurons.

The fluid inside the cell membrane is known as the cytoplasm. The mitochondrion is the site for the metabolic activities that provide energy the cell requires for its activities. Ribosomes are for producing protein molecules. Some ribosomes float freely, others are attached to the endoplasmic reticulum. Vacuoles are fluid filled bubbles inside the cell.

Nerve Cell bodies

The distinctive feature that sets a neurone apart from other cells is its shape. The cell body is called the neurone cell body, or soma, and the processes are called dendrites and axons. Nerve cell bodies are microscopic.

They form the grey matter of the nervous system and are found at the periphery of the brain and in the center of the spinal cord. The cell body contains the nucleus, some ribosomes and mitochondria and other structures found in most cells. Much of neural metabolic processes take place in the body. Nerve cell bodies vary in size and in shape. They range in the diameter from 0.005mm to 0.1mm in mammals and up to a full millimeter in some invertebrates.

Dendrites

Dendrites are short, thin, highly branched cytoplasmic extensions of a neurone. They taper from their bases to their tips. Dendrites are the input part of the neurone. When stimulated, they generate small electric currents that are conducted to the neurone cell body.

Axons

Each nerve cell has only one axon, carrying nerve impulses away from the cell body. They are usually longer than the dendrites, sometimes as long as 100cm.

Large axons and those of peripheral nerves are surrounded by a myelin sheath which contain Schwann cells arranged along the length of the axon.

Concentric layers of plasma membrane of Schwann cells wrap around the length of myelinated axons. There are tiny areas of exposed axolemma between adjacent Schwann cells, called nodes of Ranvier, which assists the rapid transmission of nerve impulses.

4.2 Properties of Neurones

Neurones have 2 major properties, which are: irritability and conductivity.

1) Irritability is the ability of neurons to initiate nerve impulses in response to stimuli from outside the body, e.g., touch, loud noise, etc. or inside the body such as a huge and drastic blood loss may cause lead to a reduction in blood pressure, or the inhalation of toxic gases may trigger the vomit center in the brain.
2) Conductivity means the ability of a neurone to transmit an impulse.

4.3 Types of Neurones

Neurones are classified according to their function or structure. Neurones could also be classified based on whether it has myelin sheath or not.

Classification of neurons according to their function or structure.

The functional classification is based on the direction in which the action potentials are conducted. Sensory or Afferent neurons conduct action potentials towards the central nervous system (CNS), while motor, or efferent neurons conduct action potentials away from the CNS toward muscles or glands. Interneurones or association neurons conduct action potentials from one neurone to another within the CNS. The structural classification scheme is based on the number of processes that extend from the neurone cell body. This includes:

1. Multipolar neurons: They have many dendrites and a single axon. The dendrites vary in number and in their degree of branching. Most of the neurons within the CNS and motor neurons are multipolar.

2. Bipolar neurons: They have 2 processes, i.e. a dendrite and an axon. The dendrite is often specialised to receive the stimulus, and the axon conducts action potentials to the CNS. Bipolar neurons are located in some sensory organs, such as in the retina of the eye and in the nasal cavity.

3. Unipolar neurons: They have a single process extending from the cell body. One branch extends to the CNS, and the other extends to the periphery and has dendrite-like sensory processes. The two branches

function as a single axon. The sensory receptors respond to stimuli resulting in the production of axon potentials that are transmitted to the CNS.

Classification according to possession of myelin sheath.

1) Myelinated neurons have myelin sheath which serves as an insulator and also to increase its speed of conducting nerve impulses.
2) Unmyelinated neurons do not possess myelin sheath hence do not possess the properties described above.

4.2 Synaptic Transmission

The nervous system is composed of billions of specialised cells called neurons. Efficient communication between these cells is crucial to the normal functioning of the central and peripheral nervous systems. In this section we will investigate the way in which the unique morphology and biochemistry of neurons makes such communication possible.

The cell body, or soma, of a neuron is like that of any other cell, containing mitochondria, ribosomes, a nucleus, and other essential organelles. Extending from the cell membrane, however, is a system of dendritic branches which serve as receptor sites for information sent from other neurons. If the dendrites receive a strong enough signal from a neighboring nerve cell, or from several neighbouring nerve cells, the resting electrical potential of the receptor cell's membrane becomes depolarizsed. Regenerating itself, this electrical signal travels down the cell's axon, a specialized extension from the cell body which ranges from a few hundred micrometers in some nerve cells, to over a meter in length in others. This wave of depolarization along the axon is called an action potential.

Most axons are covered by myelin, a fatty substance that serves as an insulator and thus greatly enhances the speed of an action potential. In between each sheath of myelin is an exposed portion of the axon called a node of Ranvier. It is in these uninsulated areas that the actual flow of ions along the axon takes place.

The end of the axon branches off into several terminals. Each axon terminal is highly specialized to pass along action potentials to adjacent neurons, or target tissue, in the neural pathway. Some cells communicate this information via electrical synapses. In such cases, the action potential simply travels from one cell to the next through specialised channels, called gap junctions, which connect the two cells.

Most cells, however, communicate via chemical synapses. Such cells are separated by a space called a synaptic cleft, and thus cannot transmit action potentials directly. Instead, chemicals called neurotransmitters are used to communicate the signal from one cell to the next. Some neurotransmitters are excitatory and de-polarise the next cell, increasing the probability that an action potential will be fired. Others are inhibitory, causing the membrane of the next cell to hyperpolarize, thus decreasing the probability of that the next neuron will fire an action potential.

4.2.1 Process of Synaptic Transmission

The process by which this information is communicated is called synaptic transmission and can be broken down into four steps. These are:

1. *Synthesis and storage of neurotransmitters:* First, the neurotransmitter must be synthesized and stored in vesicles so that when an action potential arrives at the nerve ending, the cell is ready to pass it along to the next neuron.

2. *Neurotransmitter Release*: Next, when an action potential does arrive at the terminal, the neurotransmitter must be quickly and efficiently released from the terminal and into the synaptic cleft.

3. *Neurotransmitter Postsynaptic Receptors:* The neurotransmitter must then be recognized by selective receptors on the post synaptic cell so that it can pass along the signal and initiate another action potential. Or, in some cases, the receptors act to block the signals of other neurons also connecting to that postsynaptic neuron.

4. *Inactivation of Neurotransmitters*: After its recognition by the receptor, the neurotransmitter must be inactivated so that it does not continually occupy the receptor sites of the postsynaptic cell. Inactivation of the neurotransmitter avoids constant stimulation of the postsynaptic cell, while at the same time freeing up the receptor sites so that they can receive additional neurotransmitter molecules, should another action potential arrive.

Most neurotransmitters are specific for the kind of information that they are used to convey. As a result, a certain neurotransmitter may be more highly concentrated in one area of the brain than it is in another. In addition, the same neurotransmitter may elicit a variety of different responses based on the type of tissue being targeted and which other neurotransmitters, if any, are co-released. The integral role of neurotransmitters on the normal functioning of the brain makes it clear to see how an imbalance in any one of these chemicals could very possibly have serious clinical implications for an individual. Whether due to genetics, drug use, the aging process, or other various causes, biological dysfunction at any of the four steps of synaptic transmission often leads to such imbalances and is the ultimately source of conditions such as schizophrenia, Parkinson's disease, and Alzheimer's disease.

4.3 Action Potential

In neurophysiology, the action potential is the primary electrical signal generated by nerve cells and arises from changes in the permeability of the nerve cells axonal membranes to specific ions. Action potentials (also known as a nerve impulses or spikes) are pulse-like waves of voltage that travel along several types of cell membranes. The best understood example is generated on the membrane of the axon of a neurone, but also appears in other types of excitable cells, such as cardiac cells, and even plant cells.

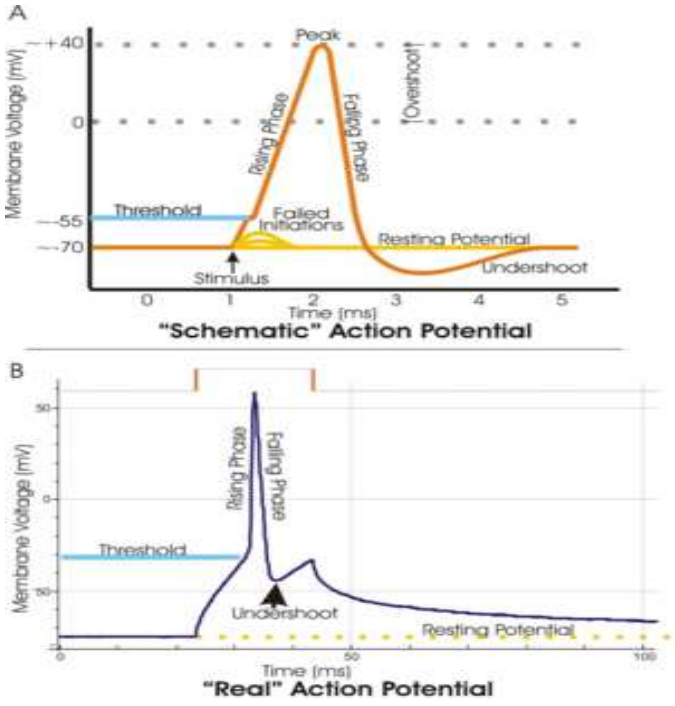
A typical action potential is initiated at the axon hillock when the membrane potential is depolarised sufficiently (i.e. when its voltage is increased sufficiently). As the membrane potential is increased, both the

sodium and potassium ion channels begin to open up. This increases both the inward sodium current and the balancing outward potassium current. For small voltage increases, the potassium current triumphs over the sodium current and the voltage returns to its normal resting value, typically −70 mV (Bullock, Orkand, and Grinnell, 1977).

However, if the voltage increases past a critical threshold, typically 15 mV higher than the resting value, the sodium current dominates. This results in a runaway condition whereby the positive feedback from the sodium current activates even more sodium channels. Thus, the cell fires, producing an action potential. Once initiated, the action potential travels through the axon. Since the axon is insulated, the action potential can travel through it without significant signal decay.

Nevertheless, to ensure the signal does not fail, regularly spaced patches, called the nodes of Ranvier, help to boost the signal. The process here is much the same as that at the axon hillock. The action potential depolarises the membrane patch at the node of ranvier, sparking another action potential there. In effect, the action potential is created afresh at each node of ranvier. The axon then branches along its length, and the action potentials travel down each branch. At this point, the axon sheds its insulation, and instead, the action potential is propagated by the voltage activated sodium channels. Here, the inward current may not quite suffice to trigger a new action potential in some of these branches. The action potential may thus fail. Action potentials that do reach the ends of the axon generally cause the release of a neurotransmitter into the synaptic cleft. This may combine with other inputs to provoke a new action potential in the post-synaptic neuron or muscle cell.

Fig 4.2 Action potential



The principal ions involved in an action potential are sodium and potential cations; sodium ions enter the cell, and potassium ions leave, restoring equilibrium. Relatively few ions need to cross the membrane for

the membrane voltage to change drastically. The ions exchanged during an action potential, therefore, make a negligible change in the interior and exterior ionic concentrations. The few ions that do cross are pumped out again by the continual action of the sodium-potassium pump, which, with other ion transporters, maintains the normal ratio of ion concentrations across the membrane. Calcium cations and chloride anions are involved in a few types of action potentials, such as the cardiac action potentials and the action potential in the single-celled alga Acetabularia, respectively. Figure A. Schematic view of an idealised action potential illustrates its various phases as the action potential passes a point on a cell membrane.

Figure B. Actual recordings of action potentials are often distorted compared to the schematic view because of variations in electrophysiological techniques used to make the recording:

Fig 4.3 Ions and the forces driving their motion

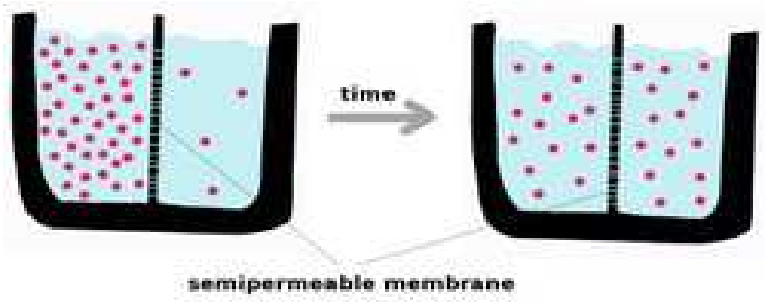


Figure 4A. Schematic view of an idealised action potential illustrates its various phases as the action potential passes a point on a cell membrane.

Figure 4B. Actual recordings of action potentials are often distorted compared to the schematic view because of variations in electrophysiological techniques used to make the recording: Ions (circles) will flow across a membrane from the high concentration to the low concentration, causing a current. However, this creates a voltage across the membrane that opposes the ions' motion. When this voltage reaches the equilibrium value, the flow of ions stops.

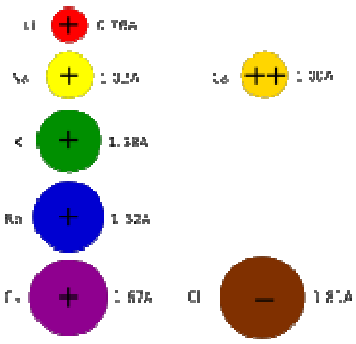
Electrical signals within biological organisms are generally driven by ions. The most important cations for the action potential are sodium (Na^+) and potassium. (K^+), Both of these are *monovalent* cations that carry a single positive charge Bullock, Orkand, and Grinnell, 1977). Action potentials can also involve calcium (Ca^{2+}), which is a *divalent* cation that carries a double positive charge (Mummert and Gradmann,1991). The chloride anion (Cl^-) plays a major role in the action potentials of some algae, but plays a negligible role in the action potentials of most animals.

Ions cross the cell membrane under two influences: diffusion and electric field. It is possible to start off with a simple example whereby two solutions are separated by a porous barrier. Let us further call these two solutions A and B. In this case, diffusion will ensure that they will eventually mix into equal solutions. This mixing occurs because of the difference in their concentrations. The region with high concentration will diffuse out towards the region with low concentration. To further the example, let solution A have 30 sodium ions and 30 chloride ions. Also, let solution B have only 20 sodium ions and 20 chloride ions. Assuming

the barrier allows both types of ions to travel through it, and then a steady state will be reached whereby both solutions have 25 sodium ions and 25 chloride ions. If, however, the porous barrier is selective to which ions are let through, then diffusion alone will not determine the resulting solution. Returning to the previous example, it is necessary to construct a barrier that is only permeable to sodium ions. Since solution B has a lower concentration of both sodium and chloride, it will attract both ions from solution A. However, only sodium will travel through the barrier. This will result in an accumulation of sodium in solution B. Since sodium has a positive charge, it will make solution B more positive relative to solution A. This makes it less likely for sodium ions travel from solution A to solution B. This constitutes the second factor controlling ion flow, namely electric fields. The point at which this electric field completely counteracts the force due to diffusion is called the equilibrium potential. At this point, the net flow of this specific ion (in this case sodium) is zero. The hydrophobic cell membrane prevents charged molecules from easily diffusing through it, permitting a potential to exist across the membrane.

Cell membrane

Each neuron is encased in a cell membrane. This membrane is nearly impermeable to ions. To transfer ions into, and out of the neuron, the membrane provides two structures (Lieb and Stein, 1986). Ion pumps use the cell's energy to continuously move ions in and out. They create concentration differences (between the inside and outside of the neuron) by transporting ions against their concentration gradients (from regions of low concentration to regions of high concentration). The ion channels then use this concentration difference to transport ions down their concentration gradients (from regions of high concentration to regions of low concentration). However, unlike the continuous transport by the ion pumps, the transport by the ion channels is non continuous. They only open and close in response to signals from their environment. This transport of ions through the ion channels then changes the voltage of the cell membrane. These changes are what bring about an action potential. As an analogy, ion pumps play the role of the battery that allows a radio circuit (the ion channels) to transmit a signal (action potential).



Despite the small differences in their radii, ions rarely go through the wrong channel. For example, sodium or calcium ions rarely pass through a potassium channel (Schmidt-Nielsen, 1997).

Membrane Potential

The cell membrane acts as a barrier which prevents the inside solution (intra-cellular fluid) from mixing with the outside solution (extra-cellular

fluid). These two solutions have different concentrations of their ions. Furthermore, this difference in concentrations leads to a difference in charge of the solutions. This creates a situation whereby one solution is more positive than the other. Therefore, positive ions will tend to gravitate towards the negative solution. Likewise, negative ions will tend to gravitate towards the positive solution. To quantify this property, one would like to somehow capture this relative positivity (or negativity). To do this, the outside solution is set as the zero voltage. Then the difference between the inside voltage and the zero voltage is determined. For example, if the outside voltage is 100 mV, and the inside voltage is 30 mV, then the difference is 70 mV. This difference is what is commonly referred to as the membrane potential.

The neurone is selectively permissible to the passage of chemicals. That is, it permits, some molecules to pass but not others. Water, carbon dioxide, urea, and a few other small molecules cross the membrane fairly freely in either directions at all times. However, most molecules, especially large ones, can not cross at all. A few important ions, such as potassium, chloride, and sodium, enter at a controlled rate through pores (gates) in specialised proteins embedded in the membrane. The potassium and chloride pores permit potassium and chloride ions to pass at a moderate rate. When the membrane is at rest, the sodium ions are closed. An occasional sodium ion sneaks through one of the potassium pores, but the total flow of sodium is greatly restricted.

Resting Potential

In the absence of any outside disturbance, the membrane is electrically polarised: that is, the part of the neurone inside the membrane has an electrical potential slightly negative with respect to the outside. When measured it could be observed that the inside of the neurone has a potential somewhat in the range of -30 millivolts (mV) relative to the outside. This is known as the resting membrane potential of the neurone.

The sodium-potassium pump is highly responsible for the resting potential. This pump actively transports sodium ions out of out of the cell while simultaneously drawing potassium into the cell. It ejects three sodium ions while bringing in two potassium ions. Since both sodium and potassium ions carry a +1 charge, the result of the pump is a net movement of positive ions out of the cell (Kalat, 1988).

Ion Pumps

The ionic currents of the action potential flow in response to concentration differences of the ions across the cell membrane. These concentration differences are established by ion pumps, which are integral membrane proteins that carry out active transport, i.e. use cellular energy (ATP) to pump the ions against their concentration gradient. Such ion pumps take in ions from one side of the membrane (decreasing its concentration there) and release them on the other side (increasing its concentration there). The ion pump most relevant to the action potential is the sodium–potassium pump, which transports three sodium ions out of the cell and two potassium ions in. Consequently, the concentration of potassium ions K^+ inside the neuron is roughly 20-fold larger than the outside concentration, whereas the sodium concentration outside is

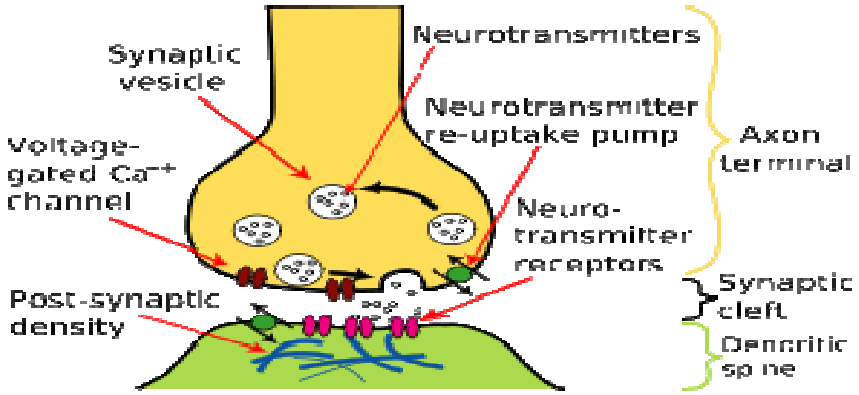
roughly nine-fold larger than inside. Similarly, other ions have different concentrations inside and outside the neuron, such as calcium, chloride and magnesium.

Ion pumps influence the action potential only by establishing the relative ratio of intracellular and extracellular ion concentrations. The action potential mainly involves the opening and closing of ion channels, not ion pumps. If the ion pumps are turned off by removing their energy source, or by adding an inhibitor such as ouabain, the axon can still fire hundreds of thousands of action potentials before their amplitudes begin to decay significantly. In particular, ion pumps play no significant role in the repolarisation of the membrane after an action potential.

4.3.1 Action Potential Initiation

Before considering the propagation of action potentials along axons and their termination at the synaptic knobs, it is helpful to consider the methods by which action potentials can be initiated at the axon hillock. The basic requirement is that the membrane voltage at the hillock be raised above the threshold for firing. There are several ways in which this depolarisation can occur.

Fig 4.4 Action potential initiation



When an action potential arrives at the end of the pre-synaptic axon (upper part), it causes the release of neurotransmitter molecules that open ion channels in the post-synaptic neuron (green). The combined excitatory and inhibitory postsynaptic potentials of such input can begin a new action potential in the post-synaptic neuron.

Neurotransmission

Action potentials are most commonly initiated by excitatory postsynaptic potentials from a presynaptic neuron. Typically, neurotransmitter molecules are released by the presynaptic neuron. These neurotransmitters then bind to receptors on the postsynaptic cell. This binding opens various types of ion channels. This opening has the further effect of changing the local permeability of the cell membrane, and thus the membrane potential. If the binding increases the voltage (depolarises the membrane), the synapse is excitatory. If, however, the binding decreases the voltage (hyperpolarises the membrane), it is inhibitory. Whether the voltage is decreased or increased, the change propagates passively to nearby regions of the membrane (as described by the cable equation and its refinements). Typically, the voltage stimulus decays

exponentially with the distance from the synapse and with time from the binding of the neurotransmitter. Some fraction of an excitatory voltage may reach the axon hillock and may (in rare cases) depolarise the membrane enough to provoke a new action potential. More typically, the excitatory potentials from several synapses must work together at nearly the same time to provoke a new action potential. Their joint efforts can be thwarted, however, by the counter-acting inhibitory postsynaptic potentials.

Neurotransmission can also occur through electrical synapses. Due to the direct connection between the excitable cells in such cases, an action potential can well be transmitted directly from one cell to the next. Rectifying channels ensure that action potentials only move in one direction through an electrical synapse.

Sensory Neurons

In sensory neurons, an external signal such as pressure, temperature, light, or sound is coupled with the opening and closing of ion channels, which in turn alter the ionic permeabilities of the membrane and its voltage. These voltage changes can again be excitatory (depolarising) or inhibitory (hyperpolarizing) and, in some sensory neurons, their combined effects can depolarise the axon hillock enough to provoke action potentials. Examples in humans include the olfactory receptor neuron and Meissner's corpuscle, which are critical for the sense of smell and touch, respectively. However, not all sensory neurons convert their external signals into action potentials; some do not even have an axon! Instead, they may convert the signal into the release of a neurotransmitter, or into continuous graded potentials, either of which may stimulate subsequent neuron(s) into firing an action potential. For illustration, in the human ear, hair cells convert the incoming sound into the opening and closing of mechanically gated ion channels, which may cause neurotransmitter molecules to be released. Similarly, in the human retina, the initial photoreceptor cells and the next two layers of cells (bipolar cells and amacrine cells) do not produce action potentials; only the third layer, the ganglion cells, produce action potentials, which then travel up the optic nerve.

Myelin Sheath and Saltatory Conduction

The axons of some neurons are ensheathed in myelin, a fatty (i.e. lipid-rich) insulating material that increases the speed and energy efficiency of action potential conduction. Axons are myelinated by specialised cells, Schwann cells and oligodendrocytes that wrap themselves multiple times around segments of axon. The gaps between these segments are known as the nodes of Ranvier.

Myelin prevents ions from entering or leaving the axon along myelinated segments. Myelination is found mainly in vertebrates, but an analogous system has been discovered in a few invertebrates, such as some species of shrimp. As a general rule, myelination increases the conduction velocity of action potentials and makes them more energy-efficient. However, not all neurons in vertebrates are myelinated. Whether saltatory or not, the mean conduction velocity of an action potential ranges from 1 m/s to over 100 m/s, and generally increases with axonal diameter.

Action potentials cannot propagate through the myelinated segments of the axon, since no ions can flow across the membrane there. Instead, the ionic current from an action potential at one node of Ranvier provokes another action potential at the next node; this hopping of the action potential from node to node is known as saltatory conduction. Although the mechanism of saltatory conduction was suggested in 1925 by Ralph Lillie, the first experimental evidence for saltatory conduction came from Ichiji Tasaki and Taiji Takeuchi and from Andrew Huxley and Robert Stämpfli. By contrast, in unmyelinated axons, the action potential provokes another in the membrane immediately adjacent, and moves continuously down the axon like a wave.

Since the ionic currents are confined to the nodes of Ranvier, far fewer ions leak across the membrane, saving metabolic energy. This saving is a significant selective advantage, since the human nervous system uses approximately 20% of the body's metabolic energy.

The length of axons' myelinated segments is important to the success of saltatory conduction. They should be as long as possible to maximise the speed of conduction, but not so long that the arriving signal is too weak to provoke an action potential at the next node of Ranvier. In nature, myelinated segments are generally long enough for the passively propagated signal to travel for at least two nodes while retaining enough amplitude to fire an action potential at the second or third node. Thus, the safety factor of saltatory conduction is high, allowing transmission to bypass nodes in case of injury. However, action potentials may end prematurely in certain places where the safety factor is low, even in unmyelinated neurons; a common example is the branch point of an axon, where it divides into two axons.

Some diseases degrade myelin and impair saltatory conduction, reducing the conduction velocity of action potentials. The most well-known of these is multiple sclerosis, in which the breakdown of myelin impairs coordinated movement.

4.2.2 Action Potential Termination

Chemical synapses

Action potentials that reach the synaptic knobs generally cause a neurotransmitter to be released into the synaptic cleft. Neurotransmitters are small molecules that may open ion channels in the postsynaptic cell; most axons have the same neurotransmitter at all of their termini. The arrival of the action potential opens voltage-sensitive calcium channels in the presynaptic membrane; the influx of calcium causes vesicles filled with neurotransmitter to migrate to the cell's surface and release their contents into the synaptic cleft. This complex process is inhibited by the neurotoxins tetanospasmin and botulinum toxin, which are responsible for tetanus and botulism, respectively

Electrical Synapses

Electrical synapses between excitable cells allow ions to pass directly from one cell to another, and are much faster than chemical synapses. Some synapses dispense with the "middleman" of the neurotransmitter, and connect the presynaptic and postsynaptic cells together. When an

action potential reaches such a synapse, the ionic currents flowing into the presynaptic cell can cross the barrier of the two cell membranes and enter the postsynaptic cell through pores known as connexins. Thus, the ionic currents of the presynaptic action potential can directly stimulate the postsynaptic cell. Electrical synapses allow for faster transmission because they do not require the slow diffusion of neurotransmitters across the synaptic cleft. Hence, electrical synapses are used whenever fast response and coordination of timing are crucial, as in escape reflexes, the retina of vertebrates, and the heart.

Neuromuscular Junctions

A special case of a chemical synapse is the neuromuscular junction, in which the axon of a motor neuron terminates on a muscle fiber. In such cases, the released neurotransmitter is acetylcholine, which binds to the acetylcholine receptor, an integral membrane protein in the membrane (the *sarcolemma*) of the muscle fiber. However, the acetylcholine does not remain bound; rather, it dissociates and is hydrolysed by the enzyme, acetylcholinesterase, located in the synapse. This enzyme quickly reduces the stimulus to the muscle, which allows the degree and timing of muscular contraction to be regulated delicately. Some poisons inactivate acetylcholinesterase to prevent this control, such as the nerve agents sarin and tabun, and the insecticides diazinon and malathion.

Muscular Action Potentials

The action potential in a normal skeletal muscle cell is similar to the action potential in neurons. Action potentials result from the depolarisation of the cell membrane (the sarcolemma), which opens voltage-sensitive sodium channels; these become inactivated and the membrane is repolarized through the outward current of potassium ions. The resting potential prior to the action potential is typically −90mV, somewhat more negative than typical neurons. The muscle action potential lasts roughly 2–4 ms, the absolute refractory period is roughly 1–3 ms, and the conduction velocity along the muscle is roughly 5 m/s. The action potential releases calcium ions that free up the tropomyosin and allow the muscle to contract. Muscle action potentials are provoked by the arrival of a pre-synaptic neuronal action potential at the neuromuscular junction, which is a common target for neurotoxins.]

Neurotoxins

Tetrodotoxin is a lethal toxin from the pufferfish that inhibits the voltage-sensitive sodium channel, halting action potentials. Several neurotoxins, both natural and synthetic, are designed to block the action potential. Tetrodotoxin from the pufferfish and saxitoxin from the *Gonyaulax* (the dinoflagellate genus responsible for red tides) block action potentials by inhibiting the voltage-sensitive sodium channel; similarly, dendrotoxin from the black mamba snake inhibits the voltage-sensitive potassium channel. Such inhibitors of ion channels serve an important research purpose, by allowing scientists to "turn off" specific channels at will, thus isolating the other channels' contributions; they can also be useful in purifying ion channels by affinity chromatography or in assaying their concentration. However, such inhibitors also make effective neurotoxins, and have been considered for use as chemical weapons. Neurotoxins

aimed at the ion channels of insects have been effective insecticides; one example is the synthetic permethrin, which prolongs the activation of the sodium channels involved in action potentials. The ion channels of insects are sufficiently different from their human counterparts that there are few side effects in humans. Many other neurotoxins interfere with the transmission of the action potential's effects at the synapses, especially at the neuromuscular junction.

Study Session Summary

Summary

In this Study Session, we noted that:

1) Neurones are cells organised to form complex networks that perform the functions of the nervous system
2) A neurone consists a nucleus, a membrane, mitochondria, ribosomes, endoplasmic reticulum, vacuoles and other structures typical of animal cells.
3) The nucleus is responsible for regulating the activities of the cell including reproduction.
4) Neurones have 2 major properties, i.e. irritability and conductivity.
5) Dendrites are short, thin, highly branched cytoplasmic extensions of a neurone.
6) Each nerve cell has only one axon, carrying nerve impulses away from the cell body.
7) Neurones have 2 major properties, i.e. irritability and conductivity.
8) Neurones are classified according to their function or structure. Neurones could also be classified based on whether it has myelin sheath or not.
9) The wave of depolarization along an axon is called an action potential.
10) Some cells communicate information via electrical synapses. In such cases, the action potential simply travels from one cell to the next through specialized channels, called gap junctions, which connect the two cells.
11) The process by which information is communicated is called synaptic transmission and can be broken down into four steps. The steps are: Synthesis and storage of neurotransmitters, neurotransmitter release, recognition of the neurotransmitter by selective receptors on the post synaptic cell, and inactivation of neurotransmitters.
12) The action potential is the primary electrical signal generated by nerve cells and arises from changes in the permeability of the nerve cell's axonal membranes to specific ions. Action potentials (also known as a nerve impulses or spikes) are pulse-like waves of voltage that travel along several types of cell membranes.
13) A typical action potential is initiated at the axon hillock when the membrane potential is depolarized sufficiently (i.e. when its voltage is increased sufficiently).
14) The principal ions involved in an action potential are sodium and potential cations; sodium ions enter the cell, and potassium ions

leave, restoring equilibrium. Ions cross the cell membrane under two influences: diffusion and electric field. In a neural cell membrane neurons are encased. This membrane is nearly impermeable to ions. To transfer ions into, and out of the neuron, the membrane provides two mechanisms: Ion pumps and creation of concentration differences

15) Several neurotoxins, both natural and synthetic, are designed to block the action potential.

Assessment

Assignment

1. Define neurones
2. Classify neurones
3. Mention five functions of neurons
4. Explain the concept of synaptic transmission
5. Use illustrations to explain concepts related to action potential
6. Describe the process of neurotransmission
7. Relate the concept of myelin sheath to salutatory conduction

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Study Session 5

The Brain and the Human Behaviour

Introduction

Is it possible that everything one is, does, and experiences is a function of the brain? In this Study Session, you will examine the structure and functions of the human brain.

Learning Outcomes

When you have studied this session, you should be able to:

5.1 Describe the structural layout of the brain.

5.2 Draw, label and describe the functional parts of the brain.

5.1 The Structure of the Brain

The brain is an input-output device: give it a stimulus, and it will process it and respond. The alternative view is that the brain is simply doing its own thing, and stimuli act to modulate its activity, rather than direct it. Since the first perspective is an easier one to approach experimentally, it has received most of the attention, but the paper presents evidence that the alternative view should not be ignored. Just about every measure of brain function detects spontaneous, organised activity even when the owner of the brain does not appear to be doing anything—in fact, this kind of activity has been detected when people are under anesthesia. The second key observation is that, even on the simplest tests, the same individual will perform differently when the test is repeated. It is needful to explore if these two were linked: is human action influenced by spontaneous brain activity?

Most human activities, behaviours and characteristics are products of human responses to inflow of stimulus as well as responses to messages received by the brain. The series of activities culminating into behaviour is coordinated by the nervous system. It is the bodys' decision and communication center.

The nervous system is made of the central nervous system (CNS), i.e. the brain and the spinal cord, and the peripheral nervous system (PNS), i.e. the spinal nerves. Together they control every part of our daily life, from breathing and blinking to helping to memorise facts for a test. Nerves reach from the brain to the face, ears, eyes, nose, and spinal cord and from the spinal cord to the rest of our body. Sensory nerves gather information from the environment every second; send the information to

the spinal cord, which speedily sends the message to the brain. The brain then makes sense of that message and fires off a response. Motor neurons deliver the instructions from the brain to the rest of the body.

The brain weighs about 1.7kg in a normal adult and receives about 15% of circulating blood per minute. A six seconds interruption of that flow causes unconsciousness and irreversible brain damage within a few minutes. It is composed of two broad classes of cells; many billion neurons and glia. Glial cells are in form of astrocytes, oligodendrocytes and ependymal cells. Neural and glial cells contain several different cell types which perform different functions. Glial cells insulate the myelin, provide structure to the neuronal network, manage waste, and clean up neurotransmitters. Most types of glia in the brain are present in the entire nervous system. Exceptions include the oligodendrocytes which myelinate neural axons (a role performed by Schwann cells in the peripheral nervous system). The myelin in the oligodendrocytes insulates the axons of some neurons. White matter in the brain is myelinated neurons, while gray matter contains mostly cell soma, dendrites, and unmyelinated portions of axons and glia. The space between neurons is filled with dendrites as well as unmyelinated segments of axons; this area is referred to as the neutropil.

The brain is made of three main parts: the forebrain, mid-brain, and hindbrain. The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system). The mid-brain consists of the tectum and tegmentum. The hindbrain is made of the cerebellum, pons and medulla. Often the midbrain, pons, and medulla are referred to together as the brainstem.

In mammals, the brain is surrounded by connective tissues called the meninges, a system of membranes that separate the skull from the brain. This three-layered covering is composed of (from the outside in) the dura mater, arachnoid mater, and pia mater. The arachnoid and pia are physically connected and thus often considered as a single layer, the pia-arachnoid. Below the arachnoid is the subarachnoid space which contains cerebrospinal fluid, a substance that protects the nervous system. Blood vessels enter the central nervous system through the perivascular space above the pia mater. The cells in the blood vessel walls are joined tightly, forming the blood-brain barrier which protects the brain from toxins that might enter through the blood.

The brain is bathed in cerebrospinal fluid (CSF), which circulates between layers of the meninges and through cavities in the brain called ventricles. It is important both chemically for metabolism and mechanically for shock-prevention. For example, the human brain weighs about 1-1.5 kg or about 2-3 lb. The mass and density of the brain are such that it will begin to collapse under its own weight if unsupported by the CSF. The CSF allows the brain to float, easing the physical stress caused.

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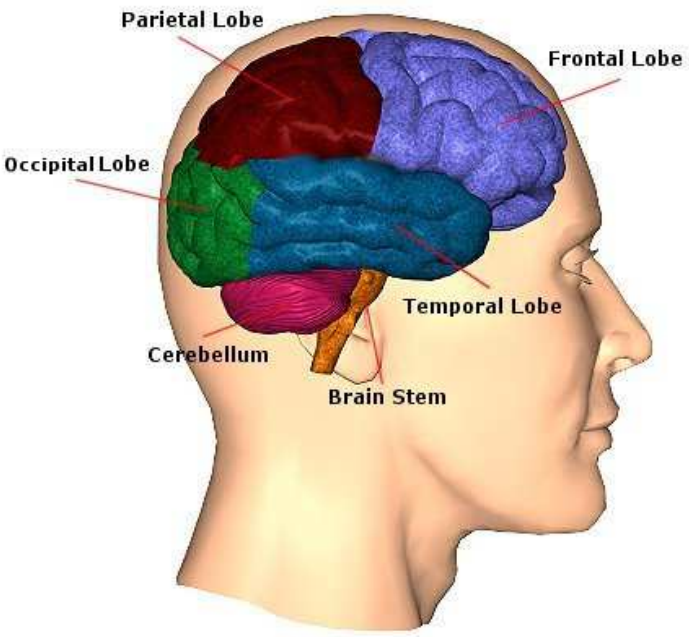
CSF. The CSF allows the brain to float, easing the physical stress caused by the brain's mass.

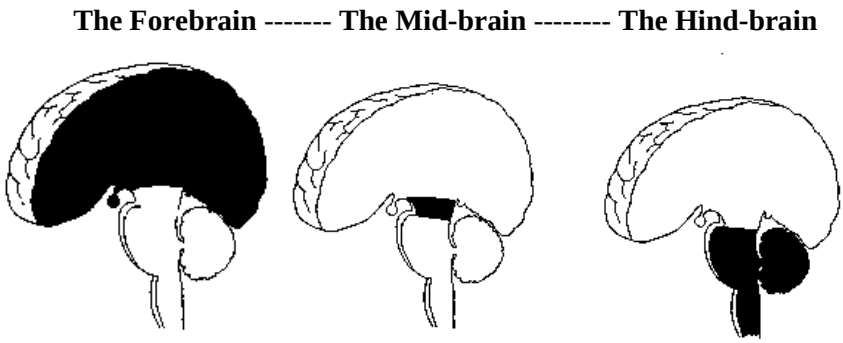
Fig 5.1 Relationship between the nervous system and the brain



5.2 Functional Parts of the Brain

The brain can be divided into three basic units: the forebrain, mid-brain and the hind-brain.

Fig 5.2 Parts of human cell



The hindbrain includes the upper part of the spinal cord, the brain stem, and a wrinkled ball of tissue called the **cerebellum**. The hindbrain controls the body's vital functions such as respiration and heart rate. The cerebellum coordinates movement and is involved in learned rote movements. When you play the piano or hit a tennis ball you are activating the cerebellum. The uppermost part of the brainstem is the mid-brain, which controls some reflex actions and is part of the circuit involved in the control of eye movements and other voluntary movements.

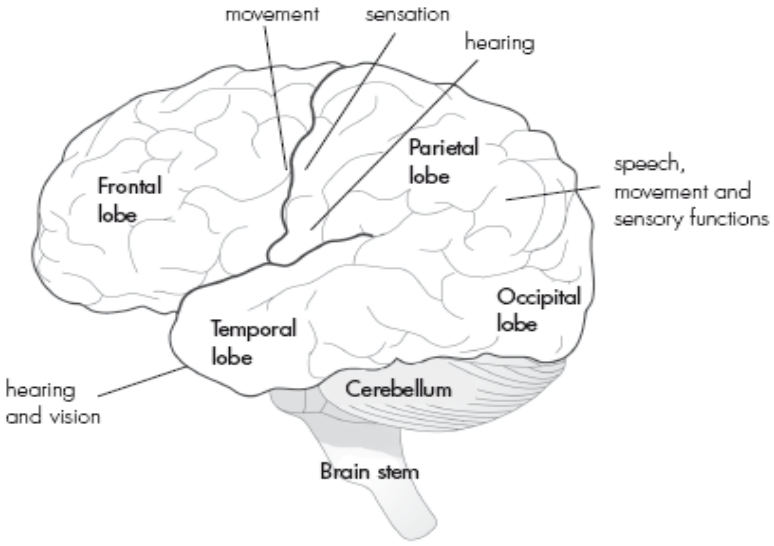
5.2.1 The Forebrain

The Cerebrum: It is the major part of the forebrain. This is the largest and most developed part of the human brain. It is concerned with all higher mental functions, such as thinking and memory, planning, recognise friends, play games etc. It is made up of two halves or hemispheres.

The cerebrum is split into two halves (hemispheres) by a deep fissure. Despite the split, the two cerebral hemispheres communicate with each other through a thick tract of nerve fibers that lies at the base of this fissure. Although the two hemispheres seem to be mirror images of each other, they are different. For instance, the ability to form words seems to lie primarily in the left hemisphere, while the right hemisphere seems to control many abstract reasoning skills.

For some as-yet-unknown reason, nearly all of the signals from the brain to the body and vice-versa cross over on their way to and from the brain. This means that the right cerebral hemisphere primarily controls the left side of the body and the left hemisphere primarily controls the right side. When one side of the brain is damaged, the opposite side of the body is affected. For example, a stroke in the right hemisphere of the brain can leave the left arm and leg paralysed.
Each cerebral hemisphere is divided into four areas, known as lobes: the frontal, parietal, temporal and occipital lobes. Each lobe controls a different range of activities.

Fig 5.3 The lobes and functions of the brain



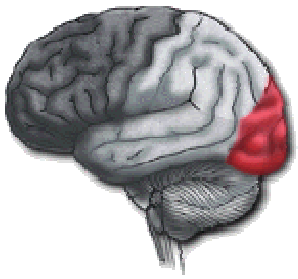
Cerebral Cortex: The outermost layer of the cerebral hemisphere which is composed of gray matter. Cortices are asymmetrical. Both hemispheres are able to analyse sensory data, perform memory functions, learn new information, form thoughts and make decisions. The cortex is grey because nerves in this area lack the insulation that makes most other parts of the brain appear to be white. The folds in the brain add to its surface area and, therefore's increase the amount of grey matter and the quantity of information that can be processed.
Left cerebral Hemisphere: Sequential Analysis: systematic, logical interpretation of information. Interpretation and production of symbolic

information: language, mathematics, abstraction and reasoning. Memory stored in a language format.

Right Hemisphere: Holistic Functioning: processing multi-sensory input simultaneously to provide holistic picture of one's environment. Visual spatial skills, holistic functions such as dancing and gymnastics are coordinated by the right hemisphere. Memory is stored in auditory, visual and spatial modalities.

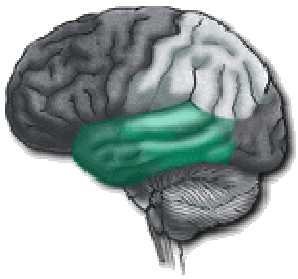
Parietal Lobe: Is responsible for processing of sensory input, sensory discrimination. It is also concerned with body orientation as well as primary / secondary somatic area. Any disorder of this area could cause inability to discriminate between sensory stimuli, inability to locate and recognize parts of the body (neglect). Severe injury to the structure could cause inability to recognise self, disorientation of environment space as well as inability to write.

Fig 5.4 Occipital Lobe



Primary visual reception area, Primary visual association area: Allows for visual interpretation. Disorders of the area could cause Primary Visual Cortex: loss of vision opposite field. Visual Association Cortex: loss of ability to recognize object seen in opposite field of vision, flash of light, stars.

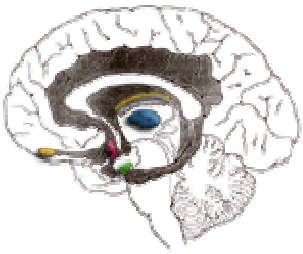
Fig 5.4 Temporal Lobe



Is the auditory receptive and also the association area. It is responsible for expressed behaviour. Language: Receptive speech. Memory: Information retrieval . Disorders of the area could cause Hearing deficits. Agitation, irritability, childish behavior. Receptive/ sensory aphasia. Loss of sense of smell. Agitation, loss of control of emotion. Loss of recent memory.

Limbic System: Sex, rage, fear; emotions. Integration of recent memory, biological rhythms. Hypothalamus.

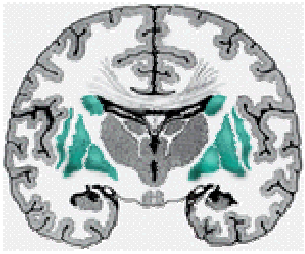
Fig 5.5 Limbic system



Olfactory pathways: Amygdala and their different pathways. Hippocampi and their different pathways.

Basal Ganglia

Fig 5.6 Subcortical grey matter nuclei



Processing link between thalamus and motor cortex. Initiation and direction of voluntary movement. Balance (inhibitory), Postural reflexes. Part of extra-pyramidal system: regulation of automatic movement. Disorders of the structure could result in Movement disorders: chorea, tremors at rest and with initiation of movement, abnormal increase in muscle tone, difficulty initiating movement.

Cerebrum : This is the largest area of the brain and is concerned with all higher mental functions, such as thinking and memory. It is made up of two halves or hemispheres. The right cerebral hemisphere controls the left side of the body and the left cerebral hemisphere controls the right side of the body. Each cerebral hemisphere is divided into four areas, known as lobes: the frontal, parietal, temporal and occipital lobes. Each lobe controls a different range of activities.

Other (sub-cortical) areas of the forebrain

Hypothalamus

Responsible for motivated behaviours such as: feeding, drinking, temperature regulation, sexual behavior, fighting and activity level. It regulates secretion of hormones through its effects on the pituitary gland by being sensitive to alteration in the level of pituitary hormones and also by releasing hypothalamic hormones that also affect the pituitary. It has receptors for detecting variations in the levels of certain hormones such as the pituitary.

Thalamus

All sensory information and other information projects first into the thalamus and the cerebral cortex or other areas. Olfactory information the olfactory bulb instead of the thalamus. The thalamus is a way station of information on the way to the cerebral cortex or other areas.

Basal Ganglia

They are located on the left and right of the thalamus. This includes the caudate nucleus, putamen and globus palidus. These structures are damaged in Parkinson's disease, Huntington's disease, and other conditions that impair movement. The structures do not control movement directly, but send messages through the thalamus and the hind brain to the cerebral cortex.

The Hippocampus is located between the thalamus and the cerebral cortex. It has a role in learning and memory.

The ventricles

The 4 ventricles are responsible for the flow and circulation of cerebro-spinal fluid round the cranial cavity and the spinal cord.

5.2.2 The Mid-brain

It makes up a smaller proportion of total brain size in humans and other mammals than it does in birds, reptiles and amphibians. The roof of the mid-brain is called the tectum. On the two sides of the tectum are the superior and the inferior conniculus which are important routes for sensory information. Under the tectum, i.e. at its floor is the tegmentum. They include the nuclei for the third and forth cranial nerves; parts of the reticular formation and extensions of the pathways for the between the forebrain and the spinal cord or hindbrain. The substantia nigra is also located in the area, deterioration of which causes Parkinson's disease.

5.2.3 The Hind-Brain

This consists of the medulla, pons, and the cerebellum. The hind-brain, mid-brain, and central structures of the forebrain constitute the brainstem.

Cerebellum − This is the back part of the brain and is concerned with balance and coordination, i.e. movement. These activities are carried out automatically (subconsciously) by this area of the brain and are not under a person's control.

Brain stem − This controls the basic functions essential to maintaining life, including blood pressure, breathing, heart-beat and also eye movements and swallowing. It is the bottom part of the brain and connects the cerebral hemispheres to the spinal cord.

The medulla oblongata is located just above the spinal cord. It could be regarded as an enlargement of the spinal cord. It controls breathing, heart rate, vomiting, salivation, coughing sneezing, and other vital reflexes by means of the cranial nerves. It connects the cranial nerves from the spinal cord to the brain.

The pons lies just anterior to the medulla. It serves as the bridge for nerve fibers between the right and left sides of the brain (mostly into the cerebellum).

The reticular formation or raphe system. These are constituents of the medulla and the pons. They send axons to the forebrain to control sleep and arousal.

Study Session Summary

Summary

This is a summary of our discussion in this Study Session:

1) The brain is made of three main parts: the forebrain, mid-brain, and hind-brain.
2) The forebrain consists of the cerebrum, thalamus, and hypothalamus (part of the limbic system).
3) The mid-brain consists of the tectum and tegmentum.
4) The hindbrain is made of the cerebellum, pons and medulla. Often the mid-brain, pons, and medulla are referred to together as the brainstem
5) The Cerebrum is the major part of the forebrain. This is the largest and most developed part of the human brain. It is concerned with all higher mental functions, such as thinking and memory, planning, recognise friends, play games, etc. It is made up of two halves or hemispheres.
6) The cerebrum is split into two halves (hemispheres) by a deep fissure. The right cerebral hemisphere primarily controls the left side of the body and the left hemisphere primarily controls the right side.
7) Each cerebral hemisphere is divided into four areas, known as lobes: the frontal, parietal, temporal and occipital lobes. Each lobe controls a different range of activities.
8) The Mid-brain makes up a smaller proportion of total brain size in humans and other mammals than it does in birds, reptiles and amphibians. The substantia nigra is also located in the area, deterioration of which causes Parkinson's disease.
9) The Hind -brain consists of the medulla, pons, and the cerebellum. The hindbrain, mid brain, and central structures of the forebrain constitute the brainstem.
10) The cerebellum is the back part of the brain and is concerned with balance and coordination, i.e. movement. These activities are carried out automatically (subconsciously) by this area of the brain and are not under a person's control.
11) The Brain stem controls the basic functions essential to maintaining life, including blood pressure, breathing, heart beat and also eye movements and swallowing. It is the bottom part of the brain and connects the cerebral hemispheres to the spinal cord.
12) The medulla oblongata is located just above the spinal cord. It could be regarded as an enlargement of the spinal cord. It controls breathing, heart rate, vomiting, salivation, coughing sneezing, and other vital reflexes by means of the cranial nerves. It connects the cranial nerves from the spinal cord to the brain.
13) The reticular formation or raphe systems are constituents of the medulla and the pons. They send axons to the forebrain to control sleep and arousal.

Assessment

Assignment

1. Draw and label functional parts of the brain.
2. Describe the structural layout of the brain.
3. Describe the functional parts of the brain**.**
4. Describe the component parts of the forebrain, midbrain, and hindbrain.
5. Highlight the functions of the the Cerebrum.
6. Explore the functional differences in the forebrain, midbrain, and hindbrain.
7. Describe the basic functions of the brain stem.

Study Session 6

Neurotransmitters and Behaviour

Introduction

In this Study Session, we will examine the relationship between neurotransmitters and behaviour. Specifically, we will explore how neurotransmitters inform behaviour.

Learning Outcomes

When you have studied this session, you should be able to:

6.1 outline the mechanism of impulse transmission.

6.2 describe the major types of neurotransmitters and their functions.

6.3 explain Dale's Law.

6.4 discuss neurotransmitters, brain disorders, and medications.

6.5 explain the relationship between drug addiction, transmitters and behaviour

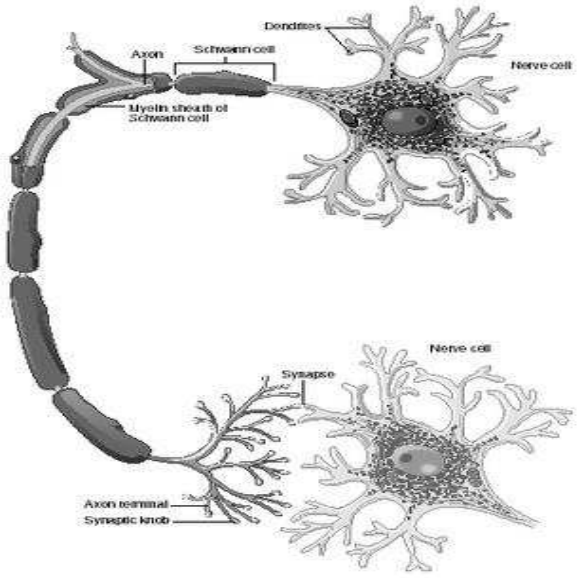
6.1 Mechanism of Impulse Transmission

Neurotransmitters are chemicals located and released in the brain to allow an impulse from one nerve cell to pass to another nerve cell. There are approximately 50 neurotransmitters identified. There are billions of nerve cells located in the brain, which do not directly touch each other. Nerve cells communicate messages by secreting neurotransmitters. Neurotransmitters can excite or inhibit neurons (nerve cells). Some common neurotransmitters are acetylcholine, norepinephrine, dopamine, serotonin and gamma aminobutyric acid (GABA). Acetylcholine and norepinephrine are excitatory neurotransmitters while dopamine, serotonin, and GABA are inhibitory. Each neurotransmitter can directly or indirectly influence neurons in a specific portion of the brain, thereby affecting behavior.

A nerve impulse travels through a nerve in a long, slender cellular structure called an axon, and it eventually reaches a structure called the presynaptic membrane, which contains neurotransmitters to be released in a free space called the synaptic cleft. Freely flowing neurotransmitter molecules are picked up by receptors (structures that appear on cellular surfaces that pick up molecules that fit into them like a "lock and key") located in a structure called the postsynaptic membrane of another nearby neuron. Once the neurotransmitter is picked up by receptors in the postsynaptic membrane, the molecule is internalised in the neuron and the

impulse continues. This process of nerve cell communication is extremely rapid.

Fig 6.1 Nerve cell communication



Once the neurotransmitter is released from the neurotransmitter vesicles of the presynaptic membrane, the normal movement of molecules should be directed to receptor sites located on the postsynaptic membrane. However, in certain disease states, the flow of the neurotransmitter is defective. For example, in depression, the flow of the inhibitory neurotransmitter serotonin is defective, and molecules flow back to their originating site (the presynaptic membrane) instead of to receptors on the postsynaptic membrane that will transmit the impulse to a nearby neuron.

The mechanism of action and localisation of neurotransmitters in the brain has provided valuable information concerning the cause of many mental disorders, including clinical depression and chemical dependency, and in researching medications that allow normal flow and movement of neurotransmitter molecules.

6.2 Major Types of Neurotransmitters

1. Acetylcholine: Affects arousal, attention, memory, motivation, movement. Too much can cause spasms or tremors. Too little can cause paralysis or torpor.

2. Dopamine: Inhibits wide range of behaviour and emotions, including pleasure. Implicated in schizophrenia and Parkinson's disease.

3. Serotonin: Inhibits virtually all activities. The transmitter is important for sleep onset, mood, eating behavior.

4. Norepinephrine: Affects arousal, wakefulness, learning, memory, mood.

5. Endorphins and Enkephalins: Inhibits transmission of pain messages.

6.3 Dale's Law

No single neurone releases all these transmitters. In fact, it was long believed that each neurone stores and releases only one transmitter. This generalisation was known as Dales Law. Recent knowledge has proved that this is not perfectly true, however all branches of an axon releases the same transmitter. Dale's Law applies to the transmitters that the presynaptic end of a neurone releases, not to the transmitters that the post synaptic side receives. Although a neurone releases only one or two transmitters, it may receive a number of different transmitters at various synapses. Neurones that release a particular transmitter are clustered together, not scattered randomly throughout the brain.

Diet and synthesis of transmitters

Every synaptic transmitter is synthesised in the appropriate neurons from constituents that come from the diet. Under normal circumstances, the brain maintains fairly constatnt levels of each transmitter during periods. Nevertheless if the diet has a high or low concentration of the precursors necessary for making a particular transmitter, the brain may produce a slightly higher or lower than usual amount of that transmitter.

Acetylcholine is synthesised from choline, which is available in cauliflower and milk. Choline can also be made from lecithin. A component of egg yolks, liver, soybeans, butter, peanuts, and several other foods. Most proteins contain only small amounts of the amino acid tryptophan, the precursor of serotonin. Carbohydrates cause an increase in the release of insulin.

6.4 Neurotransmitters, Mental Disorders, and Medications

Schizophrenia

Impairment of dopamine-containing neurons in the brain is implicated in schizophrenia, a mental disease marked by disturbances in thinking and emotional reactions. Medications that block dopamine receptors in the brain, such as chlorpromazine and clozapine, have been used to alleviate the symptoms and help patients return to a normal social setting.

Depression

In depression, which afflicts about 3.5% of the population, there appears to be abnormal excess or inhibition of signals that control mood, thoughts, pain, and other sensations. Depression is treated with antidepressants that affect norepinephrine and serotonin in the brain. The antidepressants help correct the abnormal neurotransmitter activity. A newer drug, fluoxetine (Prozac), is a selective serotonin reuptake inhibitor (SSRI) that appears to establish the level of serotonin required to function at a normal level. As the name implies, the drug inhibits the re-uptake of serotonin neurotransmitter from synaptic gaps, thus increasing

neurotransmitter action. In the brain, then, the increased serotonin activity alleviates depressive symptoms.

Alzheimer's Disease

Alzheimer's disease, which affects an estimated four million Americans, is characterised by memory loss and the eventual inability for self-care. The disease seems to be caused by a loss of cells that secrete acetylcholine in the basal forebrain (region of brain that is the control center for sensory and associative information processing and motor activities). Some medications to alleviate the symptoms have been developed, but presently there is no known treatment for the disease.

Generalised Anxiety Disorder

People with generalised anxiety disorder (GAD) experience excessive worry that causes problems at work and in the maintenance of daily responsibilities. Evidence suggests that GAD involves several neurotransmitter systems in the brain, including norepinephrine and serotonin.

Attention-Deficit/Hyperactivity Disorder

People affected by attention-deficit/hyperactivity disorder (ADHD) experience difficulties in the areas of attention, overactivity, impulse control, and distractibility. Research shows that dopamine and norepinephrine imbalances are strongly implicated in causing ADHD.

Hint

Substantial research evidence also suggests a correlation of neurotransmitter imbalance with disorders such as borderline personality disorders, schizotypal personality disorder, avoidant personality disorder, social phobia, histrionic personality disorder, and somatisation disorder.

6.5 Drugs, Transmitters and Behaviour

Cocaine and crack cocaine are psychostimulants that affect neurons containing dopamine in the areas of the brain known as the limbic and frontal cortex. When cocaine is used, it generates a feeling of confidence and power. However, when large amounts are taken, people "crash" and suffer from physical and emotional exhaustion as well as depression.

Opiates, such as heroin and morphine, appear to mimic naturally occurring peptide substances in the brain that act as neurotransmitters with opiate activity called endorphins. Natural endorphins of the brain act to kill pain, cause sensations of pleasure, and cause sleepiness. Endorphins released with extensive aerobic exercise, for example, are responsible for the rush that long-distance runners experience. It is believed that morphine and heroin combine with the endorphin receptors in the brain, resulting in reduced natural endorphin production. As a result, the drugs are needed to replace the naturally produced endorphins and addiction occurs. Attempts to counteract the effects of the drugs involve using medications that mimic them, such as nalorphine, naloxone, and naltrexone.

Alcohol is one of the depressant drugs in widest use, and is believed to cause its effects by interacting with the GABA receptor. Initially anxiety is controlled, but greater amounts reduce muscle control and delay reaction time due to impaired thinking.

Neurotransmitter systems

Neurons expressing certain types of neurotransmitters sometimes form distinct systems, where activation of the system causes effects in large volumes of the brain, called volume transmission.

The major neurotransmitter systems are the noradrenaline (norepinephrine) system, the dopamine system, the serotonin system and the cholinergic system.

- Drugs targeting the neurotransmitter of such systems affect the whole system, which explains the mode of action of many drugs.
- Cocaine, for example, blocks the reuptake of dopamine, leaving these neurotransmitters in the synaptic gap longer.
- Prozac is a selective serotonin reuptake inhibitor (SSRI), hence potentiating the effect of naturally released serotonin.
- AMPT prevents the conversion of tyrosine to L-DOPA, the precursor to dopamine; reserpine prevents dopamine storage within vesicles; and deprenyl inhibits monoamine oxidase (MAO)-B and thus increases dopamine levels. Diseases may affect specific neurotransmitter systems. For example, Parkinson's disease is at least in part related to failure of dopaminergic cells in deep-brain nuclei, for example the substantia nigra. Treatments potentiating the effect of dopamine precursors have been proposed and effected, with moderate success.

Transmitter systems, origin and effects

- Noradrenalin originates from locus coeuleus and lateral tegmental field. It influences arousal.
- Dopamine originates from dopamine pathways in the mesocortical pathway. It is responsible for motor system, cognition and nausea.
- Serotonin system originates from the caudal dorsal raphe nucleus, rostral dorsal raphe nucleus, It is respoinsible for increased introversion, mood, satiety, body temperature and sleep, while decreasing nociception.
- Cholinergic system originates from the basal optic nucleus of Meynert, medial septal nucleus. It is responsible for learning learning, short-term memory and arousal.

Study Session Summary

In this Study Session, you learnt the following:

- Neurotransmitters are chemicals located and released in the brain to allow an impulse from one nerve cell to pass to another nerve cell.
- There are approximately 50 neurotransmitters identified.

Summary

- Neurotransmitters can excite or inhibit neurons (nerve cells).
- Some common neurotransmitters are acetylcholine, norepinephrine, dopamine, serotonin and gamma aminobutyric acid (GABA).
- Acetylcholine and norepinephrine are excitatory neurotransmitters while dopamine, serotonin, and GABA are inhibitory.
- Each neurotransmitter can directly or indirectly influence neurons in a specific portion of the brain, thereby affecting behaviour.
- Once the neurotransmitter is released from the neurotransmitter vesicles of the presynaptic membrane, the normal movement of molecules should be directed to receptor sites located on the postsynaptic membrane.
- However, in certain disease states, the flow of the neurotransmitter is defective.
- Dale's Law posit that no single neurone releases all transmitters. In fact, it was long believed that each neurone stores releases only one transmitter. This generalisation was known as Dales Law.
- Every synaptic transmitter is synthesized in the appropriate neurons from constituents that come from the diet.

Assessment

Assignment

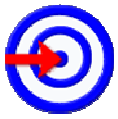
1. Describe the mechanism of impulse transmission
2. Mention major types of neurotransmitters and their functions
3. Explain Dale's Law
4. Highlight neurotransmitters, brain disorders, and medications
5. Relate drugs to transmitters and behaviour.

Study Session 7

Endocrine Glands and Behaviour

Introduction

In this Study Session, you will examine endocrine glands and how they influence behaviour.



Learning Outcomes

When you have studied this session, you should be able to:

7.1 identify the endocrine glands in human beings.

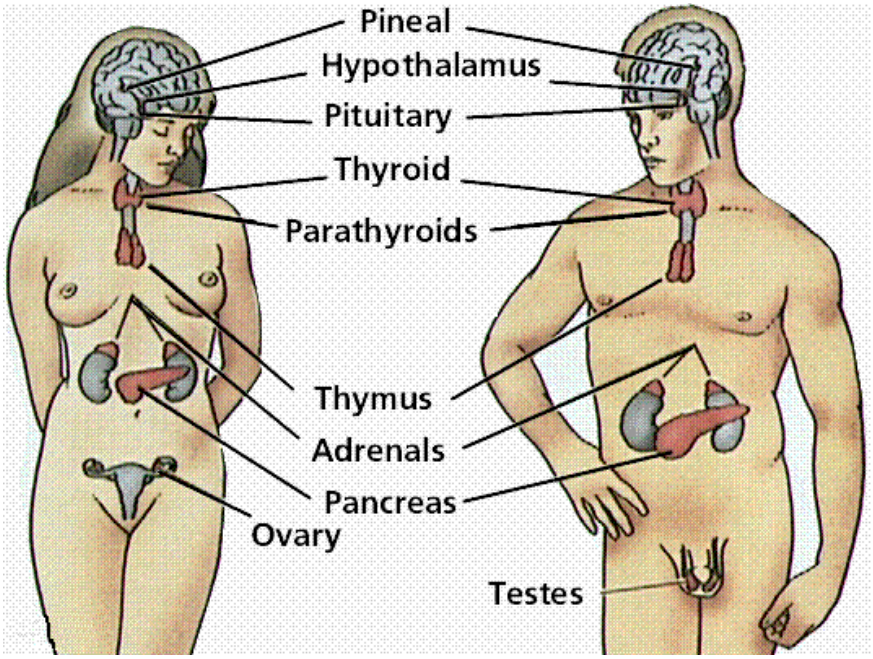
7.2 mention the functions of each of the endocrine glands.

7.3 highlight conditions of over-secretion and under secretion of hormones of endocrine glands

7.1 The Endocrine System

The endocrine system, in association with the nervous system and the immune system, regulates the body's internal activities and the body's interactions with the external environment to preserve the internal environment. This control system permits the prime functions of living organisms—growth, development, and reproduction—to proceed in an orderly, stable fashion; it is exquisitely self-regulating, so that any disruption of the normal internal environment by internal or external events is resisted by powerful countermeasures. When this resistance is overcome, illness ensues.

Each endocrine gland also has a rich supply of blood vessels. This is important not only because nutrients are delivered to the gland by the blood vessels but also because the gland cells that line these vessels are able to detect serum levels of specific hormones or other substances that directly effect the synthesis and secretion of the hormone the gland produces. In addition to traditional endocrine cells, specially modified nerve cells within the nervous system secrete important hormones into the blood. These special nerve cells are called neurosecretory cells, and their secretions are termed neurohormones to distinguish them from the hormones produced by traditional endocrine cells. Neurohormones are stored in the terminals of neurosecretory cells and are released into the bloodstream upon stimulation of the cells.



This is a group of ductless glands that regulate body processes by secreting chemical substances called hormones. Hormones act on nearby tissues or are carried in the bloodstream to act on specific target organs and distant tissues. It is important to distinguish between an endocrine gland, which discharges hormones into the bloodstream, and an exocrine gland, which secretes substances through a duct opening in a gland onto an external or internal body surface. Salivary glands and sweat glands are examples of exocrine glands. Both saliva, secreted by the salivary glands, and sweat, secreted by the sweat glands, act on local tissues near the duct openings. In contrast, the hormones secreted by endocrine glands are carried by the circulation to exert their actions on tissues remote from the site of their secretion.

Most hormones are one of two types: protein hormones (including peptides and modified amino acids) or steroid hormones. The majority of hormones are protein hormones. They are highly soluble in water and can be transported readily through the blood. When initially synthesised within the cell, protein hormones are contained within large biologically inactive molecules called prohormones.

An enzyme splits the inactive portion from the active portion of the prohormone, thereby forming the active hormone that is then released from the cell into the blood. There are fewer steroid hormones than protein hormones, and all steroid hormones are synthesized from the precursor molecule cholesterol. These hormones (and a few of the protein hormones) circulate in the blood both as hormone that is free and as hormone that is bound to specific proteins. It is the free unbound hormone that has access to tissues to exert hormonal activity.

Hormones act on their target tissues by binding to and activating specific molecules called receptors. Receptors are found on the surface of target cells in the case of protein and peptide hormones, or they are found within the cytoplasm or nuclei of target cells in the case of steroid hormones and thyroid hormones. Each receptor has a strong, highly

specific affinity (attraction) for a particular hormone. A hormone can have an effect only on those tissues that contain receptors specific for that hormone. Often, one segment of the hormone molecule has a strong chemical affinity for the receptor while another segment is responsible for initiating the hormone's specific action. Thus, hormonal actions are not general throughout the body but rather are aimed at specific target tissues.

A hormone-receptor complex activates a chain of specific chemical responses within the cells of the target tissue to complete hormonal action. This action may be the result of the activation of enzymes within the target cell, interaction of the hormone-receptor complex with the deoxyribonucleic acid (DNA) in the nucleus of the cell (and consequent stimulation of protein synthesis), or a combination of both. It may even result in the secretion of another hormone.

The amounts of hormones are maintained by feedback mechanisms that depend on interactions between the endocrine glands, the blood levels of the various hormones, and activities of the target organ. Hormones act by regulating cell metabolism. By accelerating, slowing, or maintaining enzyme activity in receptor cells, hormones control growth and development, metabolic rate, sexual rhythms, and reproduction.

7.1.1 Types of Endocrine Glands

The endocrine glands are:

- 1 pituitary gland
- 1 thyroid gland
- 4 parathyroid glands
- 2 adrenal (suprarenal) glands
- 1 Pancreas (islets of Langerhans)
- 1 pineal gland or body
- 1 thymus gland
- The gonads, i.e. 2 ovaries in females and 2 testes in the male

7.1.2 Endocrine Glands and their Specific Characteristics

The Pituitary Gland

The pituitary gland, or hypophysis, is located near the base of the brain. It secretes many hormones and controls the function of other endocrine glands. The production and release of the various pituitary hormones are regulated in turn by small peptide-releasing hormones from the hypothalamus of the brain. The pituitary gland has both anterior and posterior portions, with each secreting separate hormones, meaning different functions.

The hormones of the anterior pituitary gland are:

- The thyroid stimulating hormone (TSH) which stimulates the growth of the thyroid gland
- The luteinizing (LH) which is a gonadotrophic hormone necessary for increasing the production of

- progesterone in females and testosterone in males.
- The follicle stimulating hormone (FSH) which is a gonadotrophic hormone necessary for increasing the production of oestrogen and maturation of ovum in females, and production of sperm in males.
- The adreno corticotropic hormone (ACTH) which increases the secretion of steroid hormones by adrenal gland. It helps in regulating sleep pattern
- Prolactin.

The functions of the anterior pituitary gland hormones are as follows:

1) The growth hormone stimulates growth of body tissues especially the long bones and skeletal muscles.
2) The TSH stimulates the growth of the thyroid gland.
3) The LH is a gonadotrophic hormone necessary for increasing the production of progesterone in females and testosterone in males.
4) The FSH is a gonadotrophic hormone necessary for increasing the production of oestrogen and maturation of ovum in females, and production of sperm in males.
5) The ACTH increases the secretion of steroid hormones by adrenal gland. It helps in regulating sleep pattern.
6) Over-secretion of the hormones of the anterior pituitary gland causes gigantism (very tall people) and acromegaly (coarse facial features, enlarged tongues and large hands and feet). Undersecretion causes dwarfism, lack of sexual development, obesity and sterility.

The hormones of the posterior pituitary gland are:

1) Prolactin (especially in pregnancy) stimulates milk production
2) Oxytocin acts upon the mammary glands of female mammals to cause milk release (expulsion) in response to suckling by the young. It also stimulates the uterus to contract at the end pregnancy to aid expulsion of the offspring
3) Anti-diuretic hormone or vasopressin reduces urine output by increasing the permeability to water of the distal convoluted and collecting tubules of the nephrones of the kidneys. It also constricts blood vessels and raises blood pressure.

Hint

Under-secretion of the hormones of the posterior pituitary causes *diabetes insipidus.*

The Pineal Gland

It produces melatonin which contributes to regulation of circadian rhythm of the body including sleep activity cycles. It also hinders the growth and development of sex organs before puberty.

The Thyroid Gland

It produces throxine and triiodothyronine which increases metabolic rate, facilitates growth and maturation. Oversecretion of thyroid hormones causes thyrotoxicosis, while undersecretion causes cretinism in children and myxoedema in adults.

The Parathyroid Gland

The parathyroid glands derive their name from the fact that in mammals they are embedded within the thyroids. They produce parathormone which are essential for life, as they regulate the concentration of calcium ion in blood and other extracellular fluids. Oversecretion causes reabsorption of calcium from the bones, thereby raising blood calcium level (hypercalcaemia). If calcium is too low, the animal goes into tetanic convulsions and dies, whereas if calcium is too high, abnormal calcification and stone formation can occur. Parathyroid hormone is a protein hormone that raises the blood calcium levels (hypercalcemia). The hormone acts upon bone to cause the release of calcium and phosphate, and upon the kidney to increase the reabsorption (conservation) of calcium and excretion of phosphate.

The Adrenal Cortex

It produces steroid hormones from cholesterol. The hormones that it produces are collectively called corticosteroids, which are gluco cortocoids, mineralocorticoids and sex hormones:

- Glucocorticoids are essential for life, regulating metabolism and responses to stress.
- Mineralocorticoids produce aldosterone which maintains the water and electrolytes of the body by stimulating sodium reabsorption and potassium excretion.
- The sex hormone produces androgen similar to the ones produced by the testis. Oversecretion of glucocorticoids cause Cushing's syndrome characterized by painful deposit of fats on the face (moon face), and muscle wasting as a result of excessive protein catabolism among others. Under-secretion of glucocorticoids causes glucose uptake and muscle weakness.

Over-secretion of mineralocorticoids results in failure of the kidneys to regulate the level of sodium, potassium and water excretion. Excessive secretion of mineralocorticoids will cause excessive reabsorption of sodium and water, and excessive excretion of potassium.

The Adrenal Medulla

The gland produces epinephrine and norepinephrine. The effects of these hormones are similar to the effects of the sympathetic nervous system. They increase the heart rate, increases the blood pressure, divert blood to essential organs, increase the metabolic rate and dilate the pupils. This prepares the body for emergencies. The effects of oversecretion of epinephrine and nor-epinephrine include deposition of fats in the lumen of blood vessels, hypertension, excess blood sugar, nervousness, etc.

The Pancreas

It produces insulin and glucagon. Insulin is required for reducing the blood levels of stored nutrients, especially glucose after absorption. The hormone increases the entry of glucose into cells as well as increasing the storage of fats. Glucagon increases conversion of stored fats to glucose. Undersecretion of insulin causes diabetes mellitus.

The Gonads

Probably the best-studied endocrine glands are the gonads, the testes of the male and the ovaries of the female. The gonads are regulated by the follicle-stimulating hormone and luteinizing hormone from the adenohypophysis.

In the male, follicle-stimulating hormone stimulates the initiation of sperm formation by the testis tubules, and luteinizing hormone acts on the nearby Leydig cells of the testis to produce testosterone, the principal male sex hormone.

Testosterone acts by a paracrine mechanism to cause the final maturation of sperm, and by way of the blood to stimulate development of the male reproductive system and secondary sex characteristics.

In females, the follicle-stimulating hormone stimulates the growth of the ovarian follicles at the beginning of each reproductive cycle. As the follicles grow, they produce estradiol. Increasing levels of estradiol cause feedback inhibition of gonadotropin-releasing hormone. High levels of estradiol also have an unusual positive feedback effect upon the hypothalamus and adenohypophysis to cause a surge in the secretion of luteinizing hormone, which results in ovulation. The corpus luteum, a remnant of the ovulated follicle, produces both estradiol and the second major female sex hormone, progesterone. Progesterone is necessary for the maintenance of a quiescent uterus during pregnancy, and both estrogen and progesterone are important in the regulation of the female reproductive cycle. Estradiol is also essential for the growth and maturation of the female reproductive system and secondary sex characteristics. In both males and females, the sex hormones affect reproductive behaviour.

The Pineal Gland

It contains light-sensitive receptors to regulate the body in response to changes in light exposure. The pineal gland produces the hormone melatonin, which regulates daily cycles and rhythms, such as sleeping and waking patterns. Melatonin is secreted in the dark hours of the night. As a result, during the longer nights of the winter months, the pineal produces and secretes melatonin in higher levels than in summer months.

The Thymus

The thymus secretes the hormone thymosin, which stimulates maturation of cells used by the immune system to defend the body against disease. The thymus is particularly large in children but shrinks with the onset of puberty.

Hormones can also be classified into three categories, which are:

1) Protein hormones (are composed of strings or combination of amino acids)
2) Steroid hormones (are composed not of amino acids, but of four interconnected rings of carbon atoms) different steroid hormones vary in number and kinds of atoms attached to the rings.
3) Amine hormones (are compounds composed of single amino acid.

Hence, their alias, "monoamine" hormones.

Class	Hormones
Protein hormones	Adrenocorticotropic hormone (ACTH) Follicle stimulating hormone (FSH) Luteinizing hormone (LH) Thyroid stimulating hormone (TSH) Growth hormone (GH) Prolactine Insulin Glucagon Oxytocin Vasopressin (arginine vasopressin AVP; antidiuretic hormone, ADH) Releasing hormones such as :Corticotropin- releasing hormone (CRH) Gonadotropin- releasing hormone (GnRH)
Amine hormones	Epinephrine (adrenaline) Norepinephrine (NE) Thyroid hormone Melation
Steroid hormones Gonadal Adrenal	Estrogens (e.g estradiol) Progestins (e.g progesterone) Androgens(testosterone,dihydrotestosterone) Glucocorticoids (e.g cortisol) Mineralocorticoids (e.g adolsterone)

Study Session Summary

Summary

In this Study Session, we you learnt that the endocrine system is a body control system composed of a group of glands that maintain a stable internal environment by producing chemical regulatory substances called hormones. The endocrine system includes the pituitary gland, thyroid gland, parathyroid gland, adrenal or supra renal gland, pancreas, ovary, testis / testicle, thymus gland, and pineal gland.

Assessment

Assignment

1. Differentiate between endocrine and exocrine glands.
2. Draw a human diagram to show the location(s) of all endocrine glands.
3. Distinguish between anterior and posterior pituitary hormones stating the function(s) of each.
4. Highlight the possible consequences of underactivity and overactive of each endocrine gland.

Study Session 8

Drugs and Behaviour

Introduction

In this Study Session, we will examine the effect of drugs on human behaviour.

Learning Outcomes

When you have studied this session, you should be able to:

8.1 define drugs.

8.2 describe the effects of psychostimulants on human behaviour.

8.3 mention the influence of sedatives on human behaviour.

8.4 describe the effect of sedatives on human behaviour.

8.5 describe the effects of hallucinogens on human behaviour.

8.6 describe the effects of anti-depressants on behaviour.

8.1 Meaning of Drugs

The study of drugs called pharmacology is rooted in the Greek word pharmakon having three principal meanings as (1) a charm (an object thought to have magical effect (2) a poison (3) a remedy or medicine. Drugs are also called psychoactive agent or medicine used in treatment of a disease.

Drugs are chemicals, they work in the brain by tapping into the brain's communication system and interfering with the way nerve cells normally send, receive and process information.Some drugs, such as marijuana and heroine, can activate neurons because their chemical structure mimics that of a natural neurotransmitter. This similarity in structure "fools" receptors and allows the drugs to lock onto and activate nerve cells.

Although these drugs mimic brain chemicals, they don't activate nerve cells in the same way as a neurotransmitter, and they lead to abnormal messages being transmitted through the nasal network. Other drugs, such as amphetamine or cocaine, can cause the nerve cells to release abnormally large amounts of natural neurotransmitters or prevent the normal recycling of these brain chemicals. This disruption produces a

greatly amplified message, ultimately disrupting communication channels.

The difference in effect can be described as the difference between someone whispering into the ear and someone whispering into the microphone. When drugs are taken either orally intravenously by inhalation or otherwise, they act on the functioning of the brain as thereafter they affect the brain and behavior by changing synaptic transmission. In careful consideration of what drugs are and how they affect human behavior the neurotransmitters which are released from the terminal buttons of neuron which diffuse across synaptic clefts will be carefully analysed and other drugs behaviour will also be considered not forgetting drug dependence, drug abuse and withdrawal symptoms which are some of the behaviour of drugs in the body.

8.2 Classification of Drugs

To a behavioural scientist drugs can be classied by molecular structure, biochemical actions, and behavioural effects. This can be illustrated as follows:

Drugs Classified by Molecular Structure	Drugs Classified by Biochemical Actions	Drugs Classified by Behavioural Effects
Amino acids	Receptor blockers	Pscycho-stimulants
Monoamines	Mimickers	Sedatives
Benzodiazepines	Synthesis inhibitors	Hallucinogens
Alcohols	False transmitters	Antidepressants

Psychologists are more interested in classification involving the behavioral effect of drugs. Many of such could produce some alteration in behavior (or physiology) such as increasing arousal level, combating depression, lowering blood pressure, and so on.

8.3 Psycho-Stimulants

Psychomotor stimulants are a group of drugs, including cocaine, amphetamine, methylphenidate, ephedrine and cathinone that produce wakefullness and arousal and stimulate behavior. Their current clinical use is limited to treatment of specific sleep disorders such as narcolepsy, and certain childhood behavioural problems such as attention deficit disorder. More importantly, the psychomotor stimulants are a class of drugs widely self-administered for non-medical reasons.

8.3.1 History of Psychostimulants

Psychomotor stimulants have been used throughout recorded history and in almost all parts of the world. There are records of Chinese physicians using the ephedra plant *Ephedra vulgaris* to produce Ma Huang over 5000 years ago. The active ingredient, ephedrine, was isolated in the 1880s but it was not characterised until the 1920s. There is evidence that Indians of South America chewed leaves of the Coca plant *Erythroxylon coca* as many as 2000 years ago. The active ingredient, cocaine, was first isolated in the 1800s. Cocaine, in its various forms including powder, freebase and crack, is currently one of the most popular street drugs in western society. In East Africa and the Middle East, leaves of the Khat shrub *Catha edulis* have been chewed for their stimulant effects for at least 700 years and this practice continues to be widespread among young men of this regions. The active ingredient in Khat, (-)-cathinone, was not isolated until the 1970s.

The use of cocaine for medical purposes was popularized by Sigmund Freud in the 1880s, who suggested that it was a miracle drug, with uses ranging from local anesthesia to the treatment of depression, indigestion, asthma, neurosis, syphilis and drug and alcohol addiction. Based in part on Freud's endorsement the use of cocaine became very popular. It was widely prescribed by physicians and even appeared in popular tonics, including Coca Cola (although coca leaves are still an ingredient in Coca Cola, the cocaine is removed before they are used in the drink). Presently, the only approved medical use of cocaine is as a local anesthetic.

The characterisation of ephedrine in the 1920s led to an interest in developing and testing similar drugs. Ephedrine was being widely used to treat asthma and there was an interest in finding a synthetic substitute for this drug. Amphetamine, a drug similar in structure and activity to ephedrine, arose from this interest. Although amphetamine had been synthesised almost 40 years earlier, the interest in ephedrine led to the further characterization and use of this drug. Since then, many analogs of amphetamine have been developed and characterized, including the popular street drug, methamphetamine.

Amphetamines have been widely used for their stimulant effects. They were used in World War II, by the United States as well as others, to decrease fatigue and increase alertness of soliders. Truck drivers have used them for decades to increase wakefullness and altertness and allow them to drive for long distances without stopping for rest. Likewise, these stimulants have been popular with college students wishing to stay awake and study for exams.

The first condition for which amphetamine was used clinically was narcolepsy. Although it is not curative, it revolutionised therapy for this condition by making the patients relatively symptom free. Since then amphetamines have been used at various times to treat Parkinson's disease, depression, epilepsy, psychopathic states, attention deficit-hyperactivity disorder, and obesity. Because of their ability to decrease appetite, amphetamines were widely prescribed for many years for individuals wishing to lose weight. Because of their risk of abuse and dependence, use of stimulants has been considerably reduced over the

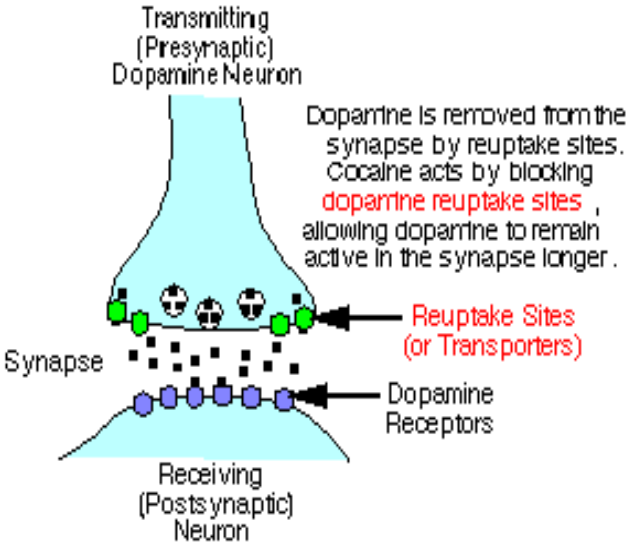
years and newer more effective agents have been demonstrated to work in treating some of these conditions.

8.3.2 Behavioural Effects of Stimulants

Psychomotor stimulants, most notably cocaine and amphetamine, produce a characteristic stimulation of behaviour in both humans and experimental animals. At low to moderate doses these drugs induce wakefulness, increase activity, decrease appetite and stimulate the sympathetic nervous system. In humans, these doses also produce feelings of euphoria, well-being and self-confidence. The latter effects are reflected in experimental animals as powerful reinforcing actions. In appropriate experimental situations animals will work extremely hard, sometimes to the point of death, to obtain these drugs.

At higher doses the psychomotor stimulants produce stereotypic behaviours. Stereotypic behaviors are typically brief and highly patterned behavioral repertoires produced in a repetitive manner. Stereotypies in humans produced by high doses of stimulants include repetitive or continuous arranging of objects, bathing, house cleaning, mechanical work, grooming, and persistent repetition of words or sentences. At very high doses the psychomotor stimulants produce a psychosis characterized by vivid hallucinations and paranoid ideation, often indistinguishable from paranoid schizophrenia.

Fig 8.1



Mechanism of action of stimulants: Psychomotor stimulants produce their characteristic behavioral effects by increasing synaptic activity of the monoamine neurotransmitters, dopamine, norepinephrine and serotonin. They are called indirect agonists because their primary effect is to increase the ability of the neurotransmitters to act, without having a direct effect on the postsynaptic receptors for these neurotransmitters. Although producing slightly different cellular and molecular effects, the final outcome for each drug in this class, an increase in monoamine activity, is quite similar.

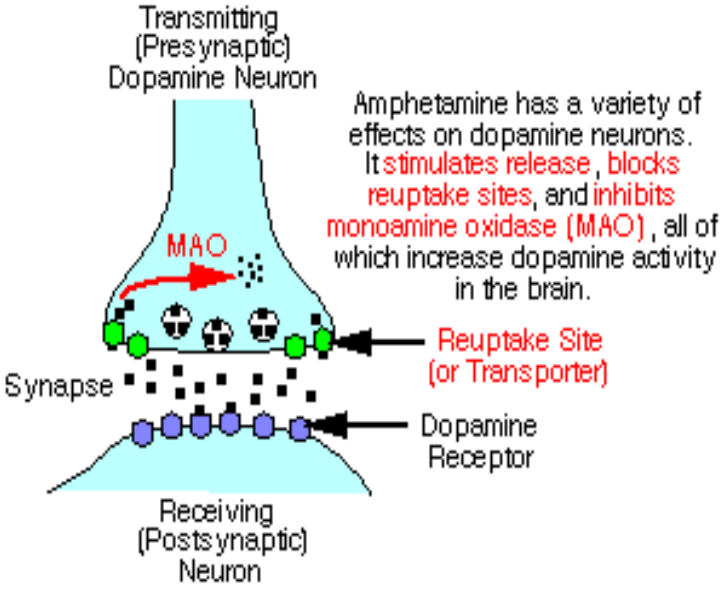
Cocaine acts primarily by blocking the reuptake of monoamines. Reuptake is the first step in the process by which monoamines are

destroyed in the brain. After they are released, these neurotransmitters are actively transported back into the cell from which they were released. By blocking reuptake cocaine increases the length of time that the monoamines can activate their receptors.

Amphetamine has more varied cellular effects than cocaine, increasing the activity of monoamines in several important ways:

- Amphetamine stimulates the release of dopamine and norepinephrine from catecholamine nerve terminals, increasing the amount of these neurotransmitters in the synapse.
- Like cocaine, amphetamine also inhibits reuptake of the catecholamines, increasing their ability to activate receptors.
- In addition, amphetamine inhibits monoamine oxidase, the enzyme responsible for the destruction of monoamine neurotransmitters, further increasing the availability of these neurotransmitters.
- Finally, there is some evidence that amphetamine may directly activate catecholamine receptors, further contributing to monoaminergic activity.

Fig 8.2



Psychopharmacological research has revealed the specific brain areas and neurotransmitters responsible for the behavioral effects of psychomotor stimulants. The most prominent monoamine neurotransmitter involved in the effects of these drugs is dopamine, which is responsible for the powerful reinforcing effects, the increase in activity, and the stereotypic and psychotogenic effects. Increased dopamine activity in a forebrain region known as the nucleus accumbens mediates the reinforcing effects and the motor stimulant effects of the psychomotor stimulants. Dopamine in this brain region also appears to mediate the psychotogenic effects produced by high doses of these drugs. Increased dopamine activity in an adjacent forebrain region, the striatum (or caudate-putamen), is responsible for the stereotypic effects of the stimulants.

8.4 Sedatives and Behaviour

Sedative and hypnotic drugs are central nervous system depressants. They depress behavior, moderate excitement, induce calmness, and may produce drowsiness or even loss of consciousness. The sedative-hypnotics are used clinically as antianxiety agents, muscle relaxants, antiepileptics, and as preanesthetic medications. Drugs in this category include barbiturates, benzodiazepines, and anesthetics.

8.4.1 History of Sedative Hypnotic

In 1903, barbital, a derivative of barbituric acid, was introduced. Its sleep-inducing and anxiolytic effects made it very popular in clinical medicine. It soon became popular as a treatment for anxiety and as the first sleeping pill. In 1912, phenobarbital was introduced.

Phenobarbital, in addition to sedative-hypnotic properties, has anticonvulsant properties and has become one of the most important pharmacological treatments for epilepsy. The success of barbital and phenobarbital spawned the synthesis of over 2,500 barbiturates. Of these many barbiturate analogues, only about 20 are still on the market. The effects of these various barbiturates are generally similar, differing primarily in potency and duration of action.

The partial separation of sedative-hypnotic-anesthetic from anticonvulsant properties, found in phenobarbital, led researchers to search for agents with more selective effects on the functions of the CNS. In the late 1930's, relatively nonsedative anticonvulsants were developed (e.g., phenytoin and trimethadione). In 1957 the first benzodiazepine, chlordiazepoxide (Librium) was synthesized. Benzodiazepines have demonstrated the ability to relieve symptoms of anxiety with relatively little interference with cognitive function or wakefulness. Benzodiazepines and barbiturates share very similar properties but the benzodiazepines have demonstrated to have a much safer pharmacological profile. Benzodiazepines have therefore replaced barbiturates for most uses, particularly for treatment of anxiety and sleep disturbances.

8.4.2 Behavioural Effects of Sedatives in Man

Sedative-hypnotic drugs depress behavior, moderate excitement, and induce calmness. These drugs depress the central nervous system, however, they usually produce therapeutic benefits at far lower doses than those causing substantial generalised depression of behavior.

Barbiturates have a wider and more powerful effect on the central nervous system than the other sedatives. The barbiturates can produce varying degrees of depression of the CNS, ranging from mild sedation to general anesthesia. In low doses barbiturates have a calming effect, and some of the barbiturates (e.g., phenobarbital) have demonstrated selective anticonvulsant properties. In moderate doses they produce a drunken euphoric state, similar to alcohol. Sedation and sleep result from increased doses, and even higher doses produce surgical anesthesia. Because of their ability to produce sedation and decrease sleep latency, barbiturates were popular in the treatment of insomnia prior to the advent

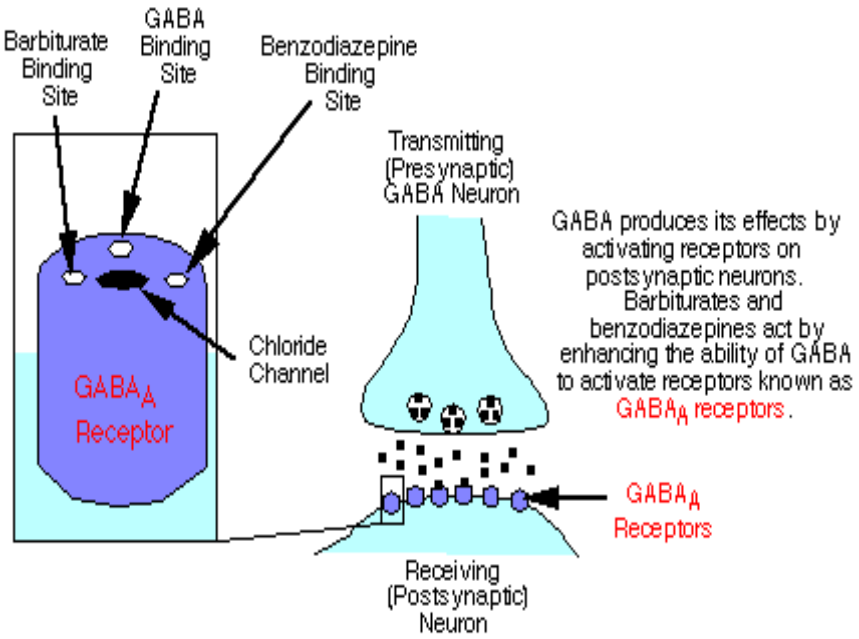
of benzodiazepines. However, because of the high incidence of tolerance and physical dependence following chronic use and the relatively high danger of overdose, these drugs are rarely used today for the treatment of anxiety or sleep disturbances.

Benzodiazepines share the sedative-hypnotic properties, but produce fewer side effects than barbiturates. Like barbiturates, benzodiazepines have also been reported to produce anticonvulsant effects. In addition, these drugs are used clinically as muscle relaxants, antiepilieptic agents, and to produce sedation before operative procedures. The antianxiety effects of benzodiazepines are more selective than those of other sedative-hypnotics -- they relieve anxiety at lower doses and thus produce minimal sedation and motor impairment. The benzodiazepines are currently the most important class of drugs for treatment of anxiety and sleep disorders.

Mechanism of action of sedatives

Barbiturates and benzodiazepines act similarly to produce depression of central nervous system function and behavior. Both classes of drugs enhance the ability of the inhibitory neurotransmitter, gamma aminobutyric acid (GABA), to activate a type of receptors known as GABA-A receptors. These drugs increase the effectiveness of GABA by altering the receptor so that GABA can bind more easily, an effect known as allosteric regulation. Activation of the GABA-A receptor opens an ion channel, allowing negatively charged chloride ions to enter the cell, producing an inhibition of neuronal activity.

Fig 8.3



In addition to barbiturates and benzodiazepines, ethanol appears to produce depression of central nervous system function, in part by enhancing the ability of GABA to bind to the GABA-A receptor. This may explain why these three classes of drugs potentiate one another other's effects and why tolerance to one results in cross-tolerance to another.

Examples of benzodiazepines include: Diazepam with the trade name Valium, Alprazolam with the trade name Xanax, and Chlordiazepoxide with the trade name Librium. Examples of non-Benzodiazepines include: Buspirone with the trade name Buspar, Chloral hydrate with the trade name Noctec, and Zolpidem tartrate with the trade name Ambien.

8.5 Hallucinogens

A hallucinogen is a general group of pharmacological agents that can be divided into three broad categories: psychedelics, dissociatives, and deliriants. These classes of psychoactive drugs have in common that they can cause subjective changes in perception, thought, emotion and consciousness. Unlike other psychoactive drugs, such as stimulants and opioids, these drugs do not merely amplify familiar states of mind, but rather induce experiences that are qualitatively different from those of ordinary consciousness. These experiences are often compared to non-ordinary forms of consciousness such as trance, meditation, and dreams.

Hollister's criteria for establishing that a drug is hallucinogenic is (Glennon, 1994),

- in proportion to other effects, changes in thought, perception, and mood should predominate;
- intellectual or memory impairment should be minimal;
- stupor, narcosis, or excessive stimulation should not be an integral effect;
- autonomic nervous system side effects should be minimal; and
- addictive craving should be absent.

An anti-depressant is a psychiatric medication used to alleviate mood disorders, such as major depression and dysthymia and anxiety disorders such as social anxiety disorder. People with a depressive illness will experience a therapeutic effect to their mood; however, this will not be experienced in healthy individuals. Drugs including the monoamine oxidase inhibitors (MAOIs), tricyclic anti-depressants (TCAs), tetracyclic antidepressants (TeCAs), selective serotonin reuptake inhibitors (SSRIs), and serotonin-norepinephrine reuptake inhibitors (SNRIs) are most commonly associated with the term. These medications are among those most commonly prescribed by psychiatrists and other physicians, and their effectiveness and adverse effects are the subject of many studies and competing claims.

Most typical anti-depressants have a delayed onset of action (2–6 weeks) and are usually administered for anywhere from months to years. Despite the name, anti-depressants are often used to treat other conditions, such as anxiety disorders, obsessive compulsive disorder, eating disorders, chronic pain, and some hormone-mediated disorders such as dysmenorrhea. Some of these uses are FDA-approved and some are off-label. Alone or together with anticonvulsants (e.g., Tegretol or Depakote), these medications can be used to treat attention-deficit hyperactivity disorder (ADHD) and substance abuse by addressing underlying depression. Also, antidepressants have been used sometimes to treat snoring and migraines.

Hallucinogens, also known as ‘psychedelic’ drugs, are drugs that change the way a person perceives the world. Hallucinogens affect all the senses and cause hallucinations-seeing or hearing things that do not exist or are distorted. A person's thinking, sense of time and emotions can also be altered.

There are many different kinds of hallucinogens. Some occur naturally, in trees, vines, seeds, fungi and leaves, while others are manufactured in laboratories. Hallucinogens include LSD, ‘magic mushrooms’, mescaline, PCP (phencyclidine). Naturally occurring hallucinogens have been used since ancient times by various cultures throughout the world, particularly by the indigenous peoples of North and South America, for their mystical and spiritual associations.

Hallucinogens became very fashionable in the United States and Europe in the 1960s, when many young people were pursuing greater personal freedom and questioning old values and ideas.

8.5.1 Types of Hallucinogens

Lysergic Acid Diethyl Amide (LSD): LSD ('acid' or 'trips') is one of the most commonly used hallucinogens . It was invented in 1938 and explored as a treatment for some mental illnesses. During the 1960s, LSD became the drug of choice of the ‘hippy’ culture. Since then its use has declined, but there is some recent evidence of increased popularity.

In pure state, LSD is a white and odourless powder. It usually comes in the form of a liquid or as tablets or capsules, squares of gelatine or blotting paper. LSD is swallowed, sniffed, injected or smoked. It is very potent, with small amounts causing strong effects. For easier handling, LSD is often diluted with another substance, such as sugar, or soaked onto sheets of blotting paper.

Phencyclidine (PCP): PCP (‘angel dust’): As well as effects similar to LSD, the effects of PCP include euphoria and numbness. Heavy use can cause PCP psychosis, with aggression, paranoia and violent or suicidal behaviour.

Methylenedioxy methamphatamine (MDMA/Ecstacy): Ecstasy is like both amphetamines and hallucinogens in chemical structure and effect. It is usually swallowed, but sometimes is also injected. Ecstasy can have hallucinogenic properties when used in high quantities.

Magic mushrooms (or ‘golden top’ mushrooms): They have the active ingredient psilocybin. They can be eaten fresh, cooked or brewed into a 'tea'. Small quantities cause relaxation and slight changes in mood, but larger quantities can cause stomach pain, nausea and vomiting, shivering, a numbing of the mouth and dizziness. People can mistake poisonous mushrooms for those containing psilocybin. Certain kinds of these poisonous mushrooms can cause death or permanent liver damage within hours of ingestion. A number of other mushrooms and plants that grow in Australia have hallucinogenic properties but also have dangerous, toxic side effects when sufficient qualities are used to give the psychedelic effect. These include datura (the belladonna plant) and fly agaric mushrooms.

Cannabis (marijuana): In small quantities, cannabis is a depressant drug that slows down the body's systems. Very strong cannabis preparations or larger quantities of cannabis can cause mild hallucinogenic effects. These can lead to anxiety or panic in the user.

8.5.2 Effects of Hallucinogens

The effects of any drug (including hallucinogens) vary from person to person. It depends on many factors, including the person's size, weight and health, how much and how the drug is taken, whether the person is used to taking it , whether other drugs are taken, whether use is combined with drinking alcohol, the environment in which the drug is taken; for example, whether the person is alone or with others, such as at a party.

More than with any other drug, the effects of hallucinogens vary greatly from person to person, and from occasion to occasion. It is hard to know how the hallucinogenic experience, or 'tripping', will affect the person. Days, weeks or even years after using the drug, some people have a repeat experience of the effects (flashbacks). The user may see intense colours and other hallucinations. Flashbacks can be sparked by the use of other drugs, or by stress, fatigue or physical exercise. The flashback experience can range from being pleasant to producing severe feelings of anxiety. They are usually visual and last for a minute or two.

Hallucinogens affect the brain: Hallucinogens alter the brain perceives time, reality, and the environment around you. They also affect the way you move, react to situations, think, hear, and see. This may make you think that you are hearing voices, seeing images, and feeling things that don't exist.

Hallucinogens affect the heart: The use of hallucinogens leads to an increase in heart rate and blood pressure. Hallucinogens can put you in a coma. They can also cause heart and lung failure. Hallucinogens affect your well-being. The use of hallucinogens may change the way you feel emotionally. They may cause you to feel confused, suspicious, and disoriented. Use of PCP may interfere with hormones related to normal growth as well as with the learning process.

Hallucinogens affect self-control: The impact of hallucinogens varies from time to time, so there is no way to know how much self-control you might maintain. They can cause you to mix up your speech, lose control of your muscles, make meaningless movements, and do aggressive or violent things.

Hallucinogens and Pregnancy: The use of hallucinogens seems to be linked to an increased risk of miscarriage. There may also be a higher incidence of birth defects among babies born to women using hallucinogens.

Hallucinogens and Driving: It is illegal to drive while under the influence of any drug, including hallucinogens. Breaking this law carries penalties including disqualification from driving, fines and/or imprisonment. It is also extremely dangerous to drive after using hallucinogens. Perception of space and time is distorted and the user may 'see' things that will cause erratic driving. The combination of drugs and alcohol can make driving significantly more dangerous.

Treatment Options A number of drug treatment options are available. Some treatment options include counselling and withdrawal (detoxification) and. Residential programs are available.

8.6 Anti-Depressants and Behaviour

Antidepressants are a class of psychotherapeutic drugs that are used to treat major depression. The therapeutic effect of anti-depressants aims at the restoration of mood and behavior. The major types of drugs included in this class are the monoamine oxidase inhibitors, tricyclic antidepressants, selective serotonin reuptake inhibitors and atypical antidepressants.

8.6.1 What is Depression?

Major depression is one of the most common psychiatric disorders afflicting humankind. It has been estimated that 7 to 12% of men and 20 to 25% of women will experience a major depressive episode in their lifetime. However, because of stigma, misunderstandings about the seriousness and treatability of the disorder, and the tendency of both patients and physicians to focus on physical rather than psychological symptoms, it often goes undiagnosed and untreated. The cost of depression in terms of loss of function, work missed and treatment has been estimated to be $16 billion per year in the United States alone. The human cost is significant as well, with as many as 80% of attempted suicides attributed to major depression.

It is important to distinguish major depression from normal fluctuations in mood in response to daily events. Although nearly everyone experiences a depressed mood on occasion, major depression is characterized by extreme and inappopriate, or chronic and unremitting changes in mood and behavior. The diagnosis of major depression is based on clinical symptoms. To be considered 'clinically' depressed, individuals must exhibit at least five symptoms from a list of nine depressive symptoms (DSM-IV). At least one of the symptoms must be either (1) depressed mood, or (2) loss of interest or pleasure.

Major depression is believed to arise from disturbances in brain neurotransmitter systems. As stated in recent public service announcements by the National Alliance for Research on Schizophrenia and Depression (NASRAD), depression is a "flaw in chemistry, not character". Antidepressant drugs help restore the chemistry of the brain so that normal mood and behavior can take place.

8.6.2 History of Anti-Depressants

The first two classes of drugs used to treat major depression, the monoamine oxidase inhibitors (MAOIs) and the tricyclic anti-depressants were discovered by serendipity. Iproniazid, the first modern anti-depressant, was originally developed as an antitubercular drug in the early 1950's. In addition to its ability to treat tuberculosis, iproniazid was observed to elevate mood and stimulate activity in many patients. These effects led researchers to investigate the ability of iproniazid to treat the symptoms of depression. After promising preliminary findings reported in 1957, iproniazid was prescribed widely to patients with major depression. Within the first year it was available as an antidepressant, 400,000 thousand depressed people were treated with iproniazid.

Subsequent studies demonstrated the ability of this drug to block the activity of monoamine oxidase, the enzyme that destroys the monoamine neurotransmitters (norepinephrine, serotonin and dopamine). Although iproniazid is no longer used as an anti-depressant because of toxic side-effects, the effectiveness of this drug led to further interest in the idea that depression might be alleviated by appropriate drugs.

The first tricyclic antidepressant, imipramine, was originally developed in a search for drugs useful in the treatment of schizophrenia. Although clinical trials demonstrated a lack of effect in treating schizophrenia, an astute clinician decided to examine its effectiveness in depressed patients. Early studies in 1957 and 1958 reported that imipramine significantly alleviated symptoms in patients with major depression. Interestingly, although imipramine elevated mood and increased energy in depressed patients, the drug proved to be sedating in individuals without major depression. These effects led to the idea that imipramine was selectively reversing the depression, rather than simply producing a general activating effect. Subsequent biochemical studies on imipramine demonstrated that this drug increased the activity of the monoamine neurotransmitters, norepinephrine and serotonin, by inhibiting their reuptake into neurons.

The monoamine oxidase inhibitors and tricyclic anti-dpressants, although having different modes of action, have as their primary effect an increase in the activity of monoamines in the brain. This observation, together with other findings, led to monoamine theory of depression -- the idea that

depression arises from a deficit in norepinephrine and/or serotonin activity, and that antidepressants work by normalising this deficit. This theory led to the development of the next major class of antidepressants, the selective serotonin reuptake inhibitors (SSRIs). In order to develop an antidepressant that worked effectively on the symptoms of depression, but that did not have the side effects of the MAOIs or the tricyclics, a systematic search was begun for drugs that selectively enhanced activity of one monoamine, but not others. The first SSRI, fluoxetine (Prozac) was released in 1987. This drug and other SSRIs, as the name imply, selectively inhbit the reuptake of serotonin, and thereby increase serotonin activity in the brain.

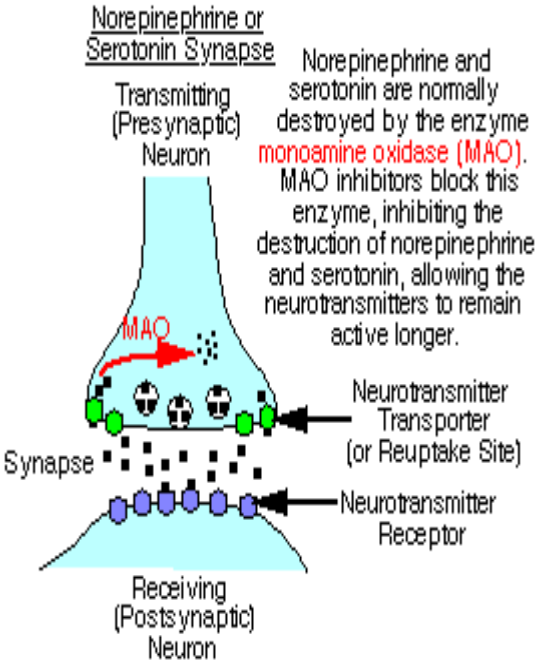
8.6.3 Current Theories of Antidepressant Action

Monoamine Hypothesis

Shotrly after the first anti-depressant drugs were introduced they were demonstrated to increase the availability of the monoamine neurotransmitters, norepinephrine and serotonin. Monoamine oxidase inhibitors (MAOIs), as the name implies, inhibit the enzyme monoamine oxidase (MAO). This enzyme is the primary enzyme responsible for the inactivation of monoamines after they are released from neurons. Blockade of MAO therefore increases the ability of norepinephrine and serotonin to act in the brain. Tricyclic anti-depressants inhibit reuptake of norepinephrine and serotonin, while selective serotonin reuptake inhibitors (SSRIs) inhibit reuptake of serotonin selectively. Following release from neurons, norepinephrine and serotonin are actively transported back into the neurons from which they are released, in a process known as reuptake. In addition to inactivation by MAO, reuptake

is one of the most important processes by which monoamines are inactivated in the brain. Blockade of reuptake therefore increases the ability of norepinephrine and/or serotonin to act in the brain. The majority of anti-depressants thus have as their principal effect an increase in the activity of serotonin and/or norepinephrine. These findings form the basis of the monoamine hypothesis of depression. Since antidepressant drugs increase the activity of monoamines, this hypothesis suggests that depression is primarily the result of a monoamine deficit. Although the monoamine hypothesis is pleasing in its simplicity, it has several major flaws. First, it has been difficult to detect consistent abnormalities in monoamine function in depressed patients. Additionally, some anti-depressants, such as iprindole and bupropion, are at best weak inhbitors of monoamine uptake. Finally, this hypothesis does not account for the temporal discrepancy between the acute effects of the antidepressant drugs on monoamine systems, which occur within minutes to hours, and the therapeutic benefits which typically occur only after two to six weeks of administration. Because of these flaws in the classical monoamine hypothesis other hypotheses have been proposed. The majority of these hypotheses still suggest a disturbance in monoamine function, however the disturbance is considered to be more complex than a simple deficit in brain monoamines. Chronic administration of antidepressants is thought to produce adaptations in monoamine systems, correcting the disturbance responsible for depression. These hypotheses therefore account for the need to administer antidepressants for several weeks to achieve therapeutic benefits.

Fig 8.4



8.6.4 Mechanism of Action of Anti-Depressants

Monoamine Oxidase Inhibitors

This class of drugs inhibits the activity of monoamine oxidase (MAO), the enzyme that destroys monoamine neurotransmitters (norepinephrine, dopamine or serotonin) in synapses. The inhibition of this enzyme allows these neurotransmitters to remain active in the brain longer, thereby correcting a presumed deficit in monoamine function.

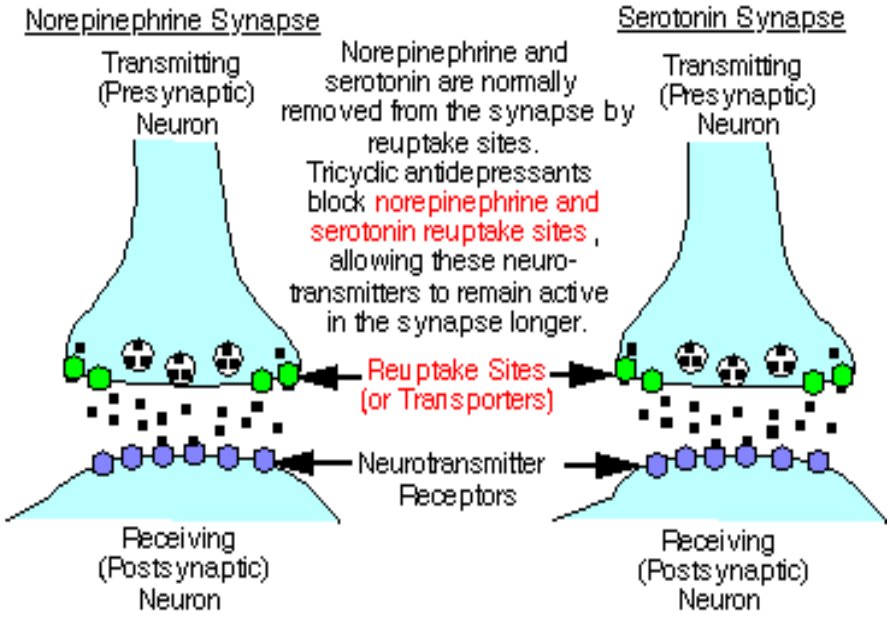
Unfortunately, MAO inhibitors have the potential for producing a harmful side effects known as the "cheese effect". Some foods, such as aged cheeses and red wines contain pressor amines, substances similar to catecholamines. These amines are normally deactivated by a form of MAO that is present in the blood. The cheese effect occurs when a person treated with MAO inhibitors eats food containing pressor amines. These amines simulate the sympathetic nervous system, increasing heart rate and blood pressure. This reaction can cause blood pressure to increase enough to produce intracranial bleeding or cardiovascular collapse. Therefore, unless strict dietary guidelines are followed, risk of hypertensive crisis is significant. However, when appropriate precautions are exercised, MAOIs are safe and effective anti-depressants.

The three MAOIs marketed in the U.S. irreversibly inhibit both forms of monoamine oxidase found in the body, MAO-A and MAO-B. MAO-A preferentially destroys norepinephrine and serotonin, while MAO-B selectively destroys phenethylamine. When administered initially, MAO inhibitors transiently elevate the cytoplasmic and vesicular concentrations of neorpinephrine, dopamine, and serotonin. This activates a feedback loop that reduces the synthesis of these monoamines. If administration continues, there is a reduction in the number and activity of ß-adrenergic receptors, as well as in the number of alpha2-adrenergic and serotonergic receptor sites. Examples of this group of antidepressants include: Phenelzine with the trade name Nardil, Tranylcypromine with the trade name Parnate, and Isocarboxazid with the trade name Marplan.

Tricyclic Anti-depressants

Tricyclic anti-depressants inhibit the reuptake of the neurotransmitters serotonin and norepinephrine into their respective nerve terminals. Reuptake is the first step in the process of deactivating these neurotransmitters in the brain. After serotonin and norepinephrine are released from neurons, they are removed from the extracellular space by transporters (also known as reuptake sites) located on the cell membrane. The tricyclic anti-depressants block these transporters. By inhibiting reuptake, the drugs allow serotonin and norepinephrine to remain active in the synapse longer, thereby correcting a presumed deficit in the activity of these transmitters.

Fig 8.5 Synapse

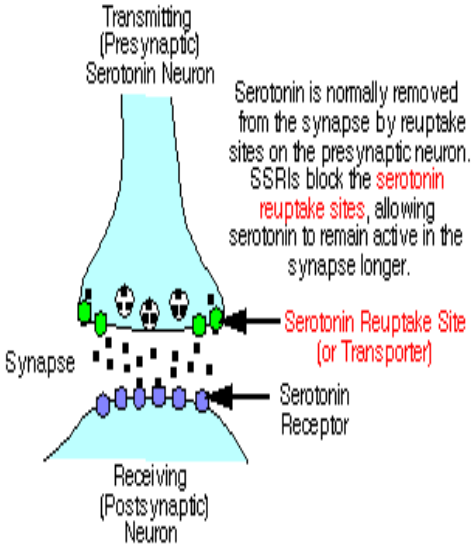


It includes examples such as Imipramine with the trade name of Tofranil, Desipramine with the trade name Norpramin, Amitryptyline with the trade name Elavil/Endep, and Trimipramine with the trade name Surmontil.

Selective Serotonin Reuptake Inhibitors

The SSRIs, as their name implies, inhibit reuptake of serotonin. Reuptake is the first step in the process of deactivating this neurotransmitter in the brain. After serotonin is released from neurons, it is removed from the extracellular space by transporters, or reuptake sites, located on the cell membrane. SSRIs block serotonin reuptake sites, allowing serotonin to remain active in the synapse longer, thereby correcting a presumed deficit in the activity of this neurotransmitter.

Fig 8.6



They include examples such as Fluoxetine with the trade name Prozac, Fluvoxamine with the trade name Levox, and Paroxetine with the trade name Paxil. Atypical Anti-depressants include: Bupropion with the trade name Wellbutrin, and Venlafaxine with the trade name Effexor.

8.6.5 Behavioural Effects of Antidepressants on Humans

Monoamine Oxidase Inhibitors

The MAO inhibitors are effective drugs for the treatment of major depression, atypical depression and panic or phobic disorders. The efficacy of MAO inhibitors is generally equivalent to the other classes of antidepressant drugs, and like other antidepressants, MAOIs may take anywhere from two to six weeks to produce therapeutic effects.

Tricyclic Antidepressants

The name tricyclic is a little misleading, referring to the three ring chemical structure of many of the drugs of this class. Drugs included in this class may actually contain anywhere from one to four rings. From the 1960's until the late 1980's, tricyclic antidepressants were the drugs of choice for the treatment of depression in the United States, and they are still widely used for moderately to severely depressed patients. Tricyclic anti-depressants elevate mood, increase physical activity, normalise appetite and sleep patterns, and reduce morbid preoccupation in 60% - 70% of patients with major depression. Like the other classes of anti-depressants, therapeutic effects of the tricyclics may take from two to six weeks to appear. Often, the first symptom to subside is insomnia, followed a few days later by an increase in activity and an improvement in concentration and memory. Improvement in mood does not usually occur until later.

Selective Serotonin Reuptake Inhibitors

Selective serotonin reuptake inhibitors (SSRIs) represent a relatively new class of antidepressant drugs. These drugs are refered to as "clean" drugs because they primarily affect only serotonin (in contrast to MAOIs and tricyclics which affect other monoamines). Because SSRIs are more targeted, they have a lower incidence of some of the side effects associated with tricyclic antidepressants and MAOIs (e.g., blurred vision, dizziness, constipation, dry mouth). More important to their current popularity, SSRIs have less potential for overdose than the tricyclics or MAOIs, and are, therefore, considered safer than these other drug classes. Although some reports suggest that SSRIs may have more rapid actions than the tricyclics or the MAOIs, this does not appear to be the case. Like the other classes of anti-depressants clinical response to the SSRIs may take anywhere from two to six weeks to appear.

Study Session Summary

Summary

In this Study Session, we discussed the following:

- Drugs are chemicals, they work in the brain by tapping into the brain's communication system and interfering with the way nerve cells normally send, receive and process information.
- Drugs can be classified by molecular structure, biochemical actions, and behavioural effects. Classification of drugs according to behavioural effects is of interest to psychologists. This includes: psychostimulants, sedatives, hallucinogens and antidepressants.
- Psychostimulants are a group of drugs, including cocaine, amphetamine, methylphenidate, ephedrine and cathinone that produce wakefullness and arousal and stimulate behaviour. Most notably cocaine and amphetamine, produce a characteristic stimulation of behaviour in both humans and experimental animals. Psychomotor stimulants produce their characteristic behavioural effects by increasing synaptic activity of the monoamine neurotransmitters, dopamine, norepinephrine and serotonin. They are called indirect agonists because their primary effect is to increase the ability of the neurotransmitters to act, without having a direct effect on the postsynaptic receptors for these neurotransmitters. Amphetamine has more varied cellular effects than cocaine, increasing the activity of monoamines in several important ways.
- Reuptake is the first step in the process by which monoamines are destroyed in the brain.
- Sedative and hypnotic drugs are central nervous system depressants. They depress behaviour, moderate excitement, induce calmness, and may produce drowsiness or even loss of consciousness. The sedative-hypnotics are used clinically as anti-anxiety agents, muscle relaxants, antiepileptics, and as preanesthetic medications. Drugs in this category include barbiturates, benzodiazepines, and anesthetics. These drugs depress behaviour, moderate excitement, and induce calmness. They depress the central nervous system; however, they usually produce therapeutic benefits at far lower doses than those causing substantial generalised depression of behaviour.
- Hallucinogens, also known as 'psychedelic' drugs, are drugs that change the way a person perceives the world. Hallucinogens affect all the senses and cause hallucinations-seeing or hearing things that do not exist or are distorted. A person's thinking, sense of time and emotions can also be altered. Types of Hallucinogens include: Lysergic Acid Diethyl Amide (LSD), Phencyclidine (PCP): PCP ('angel dust'): Methylenedioxymethamphatamine (MDMA/Ecstacy).
- The effects of any drug (including hallucinogens) vary from person to person. It depends on many factors, including the person's size, weight and health, how much and how the drug is

taken, whether the person is used to taking it, whether other drugs are taken, whether use is combined with drinking alcohol, the environment in which the drug is taken; for example, whether the person is alone or with others, such as at a party.

- Anti-depressants are a class of psychotherapeutic drugs that are used to treat major depression. The therapeutic effect of anti-depressants aims at the restoration of mood and behavior. The major types of drugs included in this class are the monoamine oxidase inhibitors, tricyclic antidepressants, selective serotonin reuptake inhibitors and atypical antidepressants.

Assessment

Assignment

1. Define drugs.
2. Describe the effects of psychostimulants on human behaviour.
3. Mention the influence of sedatives on human behaviour**.**
4. Define anti-depressants.
5. Describe the effects of hallucinogens on human behaviour.

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Study Session 9

Physiological Basis of Learning

Introduction

Life is a process of continual changes from infancy to adolescence to adulthood and death; we are changing and not static. Many factors produce those changes. One of the most important factors is the process of learning. In this Study Session, we will explore how we learn new information, new attitudes, new skills and fears through our experiences. We also learn to understand new concepts, to solve problems in new ways.

Learning Outcomes

When you have studied this session, you should be able to:

9.1 define learning.

9.2 relate the brain to learning.

9.1 Definition of Learning

Learning has been defined as a relatively permanent change in behavior resulting from experience. From the above, it is obvious that learning does not imply temporary changes caused by motivation, fatigue, maturation diseases, injury or drugs. Each of these factors can alter behaviour, but none qualifies as learning. Learning in other words is the process through which experience leaves its mark on behaviour. It is thus the means by which animals alter old behavior and develop new behaviours, the better way to adapt to changing environments. Nearly everything we become in our lives is the result of learning.

9.2 Early Learning Theories Linking Brain Areas Involved with Learning

Ivan Pavlov's concept of classical conditioning lent itself very well to theorising the physiological basis of learning in which a stimulus elicits a response produced by some other stimuli. Pavlov believed that classical conditioning reflected a strengthened connection between a brain area that represents CS activity and a brain area that represents UCS activity. Because of that strengthened connection, any excitation of the CS center flows to the UCS center evoking the unconditional response.

This theory provoked Karl Lashley to test this highly influential hypothesis. He said he was searching for the engram- (the physical representation of learning). He reasoned that if learning depends on new or strengthened connections between the two brain areas, then a knife cut somewhere in the brain should interrupt that connection and abolish the learned response. He trained rats on a variety of mazes and a brightness discrimination task and there made one or more deep cuts in varying locations in the rats' cerebral cortexes (Lashley 1929, 1950). However, none of knife cuts impaired rat performance as much as he had expected. Evidently, the types of learning that he studied did not depend on strengthened connections across the cortex.

Lashley also tried to find out whether any portion of the cerebral cortex is more important than others for learning. He trained rats on mazes before or after he removed large portions of their cortex. The lesions impaired the rats' performance but amount of retardation depended more on the amount of brain damage than on its location. Learning and memory apparently did not rely on a single cortical area.

Pavlov's theories also stimulated Donaid Hebb to process a mechanism for change at a synapse. Hebb suggested that, when the axon of neuron (cell A) repeatedly or persistently takes part in firing (cell B), some growth process or metabolic change takes place in one or both cells that increase the subsequent ability of axon A to excite cell B (Hebb, 1949). In other words, an axon that has successfully stimulated cell B in the past becomes even more successful in the future.

The implication is that if axon A fires at the same time as some other axon, say axon C, the combined effect on B may be great, perhaps even producing an action potential. One might think of axon A as the CS and axon C as unconditioned stimulus (UCS). The pairing of activity in axons A and C causes cell B to increase its responsiveness to A. Hebb was noncommittal about where the change occurred; the terminal of axon A might grow, the dendrites of cell B might grow, or a chemical change might occur in one or the other. The synapse that increases in effectiveness because of simultaneous activity in the pre-synaptic and post synaptic neurons is called Hebbian synapse.

Donald Hebb (1949) went further to make distinction between short-term memory and long term memory. According to him, short- term memory is memory for events that have just occurred while long term memory is memory for events that do not currently occupy your attention; to recall them, you must retrieve them from storage.

Thompson and his colleagues carried out experiments based on Lashley's goal of localizing an engrain in the vertebrate brain to be able to say "Here is the spot where this particular kind of learning occurs". They localised that engrain, not in the cerebral cortex, where Lashley sought it, but in the cerebellum. Thompson and his colleagues were studying classical conditioning of eyelid responses in rabbits. They presented first a tone (CS) and then a puff of air (UCS) to the cornea of the rabbits' eyes. At first a rabbit blinks at the air puff, but not at the tone; after repeated pairings, it blinks at the tone by itself. That is, classical conditioning takes place. At various points in this procedure, the investigators recorded the activity from various brain cells to determine whether or not they change

their responses as learning takes place (McCormick and Thompson, 1984).

They consistently found changes in cells in one nucleus of the cerebellum, the lateral interpositus nucleus. That is, at the start of training, those cells show very little response to training tone, but as learning proceeds, the cell responses increase (Thompson, 1986). Furthermore, damage to the lateral interpositus nucleus causes a permanent loss of the conditioned response (McCormick and Thompson, 1984).

The fact that damaging a brain area prevents a learned response does not necessarily mean that the learning took place in that area, (the area could be receiving information from some other areas that changed its responses during learning). To test the role of the cerebellum in learning, two sets of investigators temporarily suppressed activity in the lateral interpositus nucleus at the start of the training, either by cooling the area or by injecting a drug into it. They then presented the CS and the UCS as usual and found no learning. Finally they waited for the effects of the cooling or the drugs to wear off and continued training. At that point, the rabbits began to learn but they show no 'savings' that is they learned at the same speed as animals that had received no previous training, since the training took place while the relevant brain area was inactive. The implication is that cerebellum may be central to variety of conditioned responses, learned motor skills and even intellectual skills in humans, as well as in rats (Bracke-Tolkmitt et al 1989).

9.3 Learning and the Nervous System

Two basic assumptions underlie the search for the neural basis of learning. The first is that learning can take place only in animals that possess a nervous system. The second is that the brain, at least in higher animals is the true seat of learning.

Not everyone, has taken these assumptions for granted, several investigators, for instance, have tried to demonstrate that single celled animals (animals that have no nervous system) can learn. In one well known study for instance, Kandel (1979) studied paramecia. They were placed in a tube in which illumination at the center differed from the illumination at the two ends. Whenever the paramecia swam from the center into either end zone, the animal received a shock, when they returned to the center of the tube, the shock was terminated. After a number of trials in this procedure, the paramecia behaved as if they had learnt to avoid the shock when they approached a boundary between the center and end-zone, they immediately turned back to the center zone. Here clearly, was a change in behaviour (a change that seemed to indicate that paramecia are capable of learning).

But did this change in behavior truly indicate learning? In this instance, the answer is no, and it is important to know why. The findings of this illustrate a phenomenon known as pseudolearning, (a result that appears on the surface to suggest learning, but is due instead to non-learning factors). The flaw in the procedure in this instance was that when paramecia are shocked, they secrete metabolic droppings that are aversive

in their own right, and when these droppings are present, the paramecia will avoid them. This means that no learning was needed to elicit the turning behavior. The proof is that when the boundaries were changed after training, but the droppings were not changed, the paramecia made the turning response to the droppings and were seemingly oblivious of the new boundaries (Kandel, 1979).

Learning and the Brain

While no one has yet proved conclusively that learning can take place without nervous system, studies have indicated that learning can take place without the brain, although the implications of these studies are not entirely clear.

It has shown for instance, that if you decapitate to cut off the head of a person or around an earthworm, (which has a group of neural cells thought to be primitive brain at the anterior end of its body) its learning ability will be impaired, but some learning nonetheless takes place. Even when the worms are decapitated after training, they show the ability to retain learned information (Ratner, 1962). It appears then that in the worm, learning is not confined to the primitive brain, but occurs in nervous spread throughout the lower regions of the body.

What is true of the earthworm is also true apparently of the Cockroach. In one classic experiment, Horridge (1962) finds that headless cockroaches could be conditioned to control their leg movements sufficiently to avoid the shock that came whenever a led dropped into water. There was of course, the need to determine whether or not this behavioral change could be attributed to performance effects such as motor impairment caused by the repeated shocks. To find out, Horridge (1962) includes a control group of headless cockroaches that received the same number of shocks as the learning groups, but with one exception; the shocks were delivered randomly, sometimes when the leg dropped into water and sometimes when it did not. When the control group was finally given the opportunity to avoid shock, it showed no signs of avoidance behavior and this confirmed that the avoidance behaviour shown by the learning group was not merely the result of motor impairment produced by repeated shocks.

Despite the discoveries, however, conclusions regarding the role of the brain in learning must be guarded. Some learning may indeed take place without the brain, but it has been clearly established that the higher up you move in the phylogenetic ladder, the more the brain particularly the cortex expands and the greater the animal's capacity to learn on this basis, it is reasonable to assume that learning for all intents and purposes calls for an intact brain and in particular the cortex especially in higher animals.

The cortex and Learning

Ivan Pavlov was among the first researchers to suggest that the cortex plays a dominant role in learning in higher animals. Pavlov speculated that during learning:

1) The tone stimulates sensory input that travels to the auditory cortex.

2) The food stimulates sensory input that travels to the food area in the cortex and also stimulated the motor reflex that causes salivation.

The circuits that underlie audition, eating and salivation are built into the nervous system; they are reflexive. But in the process of exciting these reflexive circuits, according to Pavlov, a new connection is formed between the two areas in the cortex (the tone area and the food area). This new connections account for learning. That is the tone's ability after conditioning, to excite impulses that travel to the food area and initiate salivation.

The focal point of the Pavlov's theory is the assumption that during classical conditioning a new connection is formed between the two areas in the cortex, and this new connection is the physiological basis of learning. Lashley (1939) is biased towards the Pavlovian view and tried to find empirical evidence that the cortex contains connections that area formed during conditioning. Lashley's approach was to prepare rats surgically by destroying various parts of the cortices and then to train the rats in a variety of maze learning tasks. His reasoning was that if Pavlov was correct and learning does indeed depend on the formation of new connections in the cortex, disruption of these connections should prevent learning.

However, Lashley found that removing parts of the cortex did not interfere with learning as much as he thought it would. He discovered that animals often learned as readily without parts of the cortex as they did with those parts intact. He therefore proposed that learning does not depend on specific circuits located in specific areas of the brain, but that the circuits that underlie the associative process are distributed diffusely throughout the brain. Thus, according to Lashley, if parts of the brain are damaged, the intact remaining tissue continues to carry on the function, an ability he referred to as ***equipotentiality***.

In recent years, it has become increasingly clear the Lashley's view of an associative circuit diffused throughout the brain is essentially incorrect, and that Lashley, for all his brilliance as a scientist, was simply a victim of technology that was unequal to the task. A new training procedure developed by Gormezano, and Marshall (1983) uses rabbits as subjects and consults of classical conditioning of rabbits' nictitating membrane response (the so-called third eyelid that some mammals possess). The rabbit is an ideal subject for neural recording experiments because with mammals' restraints, a rabbit will remain virtually motion-less (except for its nictitating membrane response) for up to two hours.

The Role of the Hippocampus in Learning

Thompson (1992) works on physiological basis of learning, focusing on one brain area particularly the hippocampus. The hippocampus is an area located in each cerebral hemisphere beneath the temporal lobe of the cortex. Thompson procedure involved recording from neurons in the hippocampus, delivers a brief tone (the conditioned stimulus) and follows this tone by a puff of air to the eyes (the unconditioned stimulus). The puff of air produced the unconditioned nictitating membrane response. After repeated training trial, Thompson's rabbits eventually make the conditioned nictitating membrane response to the tone alone. The logical

conclusion is that a new association has been made between the tone and the nictitating membrane response.

But to what extent does the hippocampus activity correlates with the appearance of the conditioned response? During the first few training trials there is neither hippocampal activity nor a conditioned nictitating membrane response to the tone, there is an unconditioned nictitating membrane response to the puff. But once the rabbit has been conditioned to perform the nictitating membrane response to the tone, hippocampal activity also appears to the tone.

Thompson's findings present a strong case for a hippocampal connection to learning. The fact that hippocampal connection does not appear during the initial training trials, even through the tone, the puff and the unconditioned nictitating membrane response to the puff are present, rules out the possibility that hippocampal activity is the result of either sensory or motor processes. The fact that hippocampal activity appears on later training trials, during conditioned responding, provides strong evidence that the hippocampus is involved in the associative process.

Learning outside the Hippocampus

Findings suggest strongly that the cerebellum is involved in the forming of the association for easier tasks. We must not forget, however, that the cerebellum is also involved in sensory processes and motor movements (including the control of eye movement). So we must ask ourselves if lesions in the cerebellum might impair learning not because they impair the associative process but because they interfere with the animal's ability to hear the tone or blink eyes- that is, they interfere with the sensory and motor processes required performing the conditioned response.

According to Thompson, this possibility on the basis of studies in which lesions in only one lobe of the cerebellum (the cerebellum is bilaterally lobed) have been shown to disrupt learning in only one eye. If, for example, he places a lesion in the dendate nucleus in the left lobe of the cerebellum, the rabbit is unable to learn a conditioned response with left eye but is able to do so with the right eye. Thompson's contention is that if a lesion were affecting the animal's ability to hear the tone, it will disrupt learning in both eyes.

The Synaptic basis of Learning

The possibility that the synapse may hold the key to learning was originally proposed by Donald Hebb (1949) who suggests that learning does not create new pathways but rather alters the sensitive pathways. According to Hebb's synaptic theory, learning is the realisation of a potential. What learning does is to affect synaptic conduction in a way that makes use of particular pathways and makes particular responses more probable. Various synaptic changes have been suggested as the source of this facilitation. Hebb, for example, contended that the pre-synaptic terminals actually grow or swell as a result of stimulation during learning.

Hebb's contention is appealing. After all, a smaller gap would call for release of less neurotransmitter to stimulate adjacent neurons, would it

not? The problem is that there is no evidence that stimulating the central nervous system does indeed produce a growth or swelling of the pre synaptic fibers, certainly not with the speed necessary to account for learning. On the other hand, there is evidence to suggest long term effects of environmental stimulation on the growth and the overall size of the nervous system, particularly the cortex.

Learning in the Pre- Synapse

What Kandel has done is to trace the change in synaptic activity- the change in other word, in the post synaptic excitatory potential- to a change in the ability of pre-synaptic endings to release a neurotransmitter. Kandel has found that during habituation, the ability of the pre synaptic endings to release a neurotransmitter decreases. During sensitisation, on the other hand, the ability to release a neurotransmitter increases.

By investigating this neurotransmitter activity more extensively, Kandel has found that the amount of neurotransmitter released by the pre-synapse is determined largely by the concentration of calcium into the pre-synaptic terminals. According to Kandel, the repeated stimulation that occurs during habituation inhibits the opening of the calcium channels, while the noxious stimulus during sensation facilitates the opening. This is the physiological basis of learning in its simplest form.

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Study Session Summary

Summary

From the foregoing, it is evident that learning as a behavioral change meets two criteria: it results from experience and it endures over time. It was also established that information is learned in two ways; first by classical conditioning, which consists of pairing two different stimuli so that when the first stimuli appears, we may predict the appearance of the other. Learning could also come via instrumental conditioning, which consists of delivering reinforcement for a particular response so that the likelihood of the response is enhanced, or in the case of negative reinforcement, decreased. Though not all learning can be reduced to these two, but some of the dramatic breakthroughs in regard of the physiological basis of learning have come from studies based on these learning paradigms.

It was discovered that learning is accompanied by the formation of an association, some changes in the nervous system. The brain particularly the cortex especially in higher animals is indispensable as the part of the nervous systems that is responsible for learning (Horridge, 1962).

Assessment

Assignment

1. Discuss two theories of learning.
2. Describe the relevance of the brain to learning.

Study Session 10

Physiological Psychology of Emotion

Introduction

In this Study, we will examine the meaning and classification of emotion. We will also discuss theories that are related to emotion and the physiology of emotion.

Learning Outcomes

When you have studied this session, you should be able to:

10.1 describe emotion.

10.2 classify emotion.

10.3 discuss theories of emotion.

10.4 explain the physiology of emotion.

10.1 Meaning of Emotion

An emotion is emotion is a mental and physiological state associated with a variety of feelings, thoughts and behaviour. It is a prime determinant of the sense of subjective well being and appears to play a control role in many human activities. Carison and Halfield (1992) also define emotion as a positive or negative state of arousal in reaction to a perceived or remembered event or object.

Many researchers distinguish feeling and emotion, where feeling is referred to the subjective experience of the emotion. Some believe that emotions can occur unconsciously, and hence that emotion is a more general phenomenon than its subjective feeling. Feelings also may more narrowly refer to the experience of bodily changes.

There is a distinction, which focuses on the difference between the emotion and the cause of the emotion. For example do we say that thoughts about a loved one cause the emotion of love or that these thoughts are part of the emotion? One way to resolve this issue is to see whether the emotion can occur independently of these thoughts. Thus, thoughts about a particular person or situation could not be part of the emotion of love, since one can experience the same emotion about many other things. Yet could one experience love without some thought or other of a loved person or object? If not, then we stipulate that thoughts of a loved object are part of the emotion. Some theorists argue that at

least some emotions can be caused without any thoughts or indeed 'cognitive activity' at all.

Therefore a related distinction is between the emotions and the results of the emotion, principally behavior and emotional expression. People often behave in certain ways as a direct result of their emotional state, such as crying, fighting or fleeing. Yet again, if one can have the emotion without the corresponding behavior then we may consider the behaviour not to be essential to the emotion.

10.2 Classification of Emotion

1) The circumplex model (Russel, 1979), which places emotions along bi-polar dimensions of valence and arousal.
2) Foundational or Non-foundational- Another popular option is to divide emotions into basic complex categories, where some emotions are considered foundational to the existence of others (Ekman 1999). In this respect complex emotions may be regarded as development upon basic emotions. Such development may occur due to cultural conditioning or association.
3) Another important means of distinguishing emotions concerns their occurrence in time. Some emotions occur over a period of a second (e.g., surprise) where others can last years (e.g.,love). The latter could be regarded as a long term tendency to have an emotion regarding a certain object rather than an emotion proper (though this is disputed). A distinction is then made between emotion episodes and emotional dispositions. Dispositions are also comparable to character traits, where someone may be said to be generally disposed to experience certain emotions, though about different objects. For example an irritable person is generally disposed to feel irritation more easily or quickly than others.
4) Classification related to affective states (e.g., Klaus Scherer, 2005), place emotions within a more general category of affective states. Where affective states can also include emotion related phenomena such as pleasure and pain, motivational states like hunger or curiosity, moods, dispositions and traits.

10.3 Theories Related to Emotion

The first cluster is namely somatic theory of pain. It holds that bodily responses rather than judgments are essential to emotions. The first modern version of such theories comes from William James in the 1880s.

10.3.1 The James-Lange Theory

The theorists argue that emotional experience is largely due to the experience of bodily changes. These changes might be viscera, postural or facially expressive. Danish psychologist Carl Lange also proposed a similar theory at around the same time and thus the resulting position is known as the James –Lange theory. It states that a changed situation lead

to a changed bodily state. James says 'the perception of bodily changes as they occur is known as emotion'. James further claims that ' we feel sorry because we cry' angry because we strike, afraid because we tremble, and not that we cry, strike or tremble, because we are sorry, angry or fearful, as the case may be (Mind, 1884). Finally, the theory conversely, asserts that first we react to a situation (running away and crying happen before the emotion, and then we interpret our actions into an emotional response.

10.3.2 The Perceptional Theory

This is a new Jamesian theory. Its argument is that bodily responses are central to emotions, yet they emphasise the meaningfulness of emotion or the idea that emotions are about some thing, as is recognized by cognitive theories. The new claim of this theory is that conceptually-based cognition is unnecessary for such meaning. Rather the bodily changes themselves perceive the meaningful content of a/the emotion as a result of being casually triggered by a certain situation. In this respect, emotions are held to be analogous to faculties such as vision or touch, which provide information about the relation between the subject and the world in various ways (Prinz, 2004).

10.3.3 Cognitive theory of Emotion

It states that cognitive activity in the form of judgments, evaluations or thought are necessary in order for emotion to occur. This is necessary to capture the fact that emotions are about something or have internationality, which such cognitive activity may be conscious or unconscious and may or may not take the form of conceptual processing (Lazarus, 1991).

10.3.4 The Canon-Bard theory

Walter Cannon argued against the dominance of the James-Lange theory regarding the physiological aspects of emotions of bodily changes in pain, hunger, fear and rage. Where James argued that emotional behaviour often precedes or defines the emotion, Cannon and Bard argued that the emotion arises first and then stimulates typical behavior.

10.3.5 The Two-Factor Theory

It has a link with the cognitive theory; here is the Singer-Schachter theory. This is based on experiments purportedly showing that subjects can have different emotional reactions despite being placed into the same physiological state with an injection of adrenaline. Subjects were observed to express either anger or amusement depending on whether another person in the situation displayed that emotion.

10.3.6 Gate Pain Theory

According to Gate theory, spinal cord areas that receive message from pain receptor also receive input from other skin receptor and axon descending from the brain. These other inputs sometime close the gate for pain message (Melack and Walls, 1965).

10.4 The Physiology of Emotion

Emotions comprise of three related components: behavior, physiology and cognitive, but most emotion theorists tend to concentrate on one component or another. The major concern is one the physiology of emotion. Emotion is a brain function involving (generally) the more primitive brain areas. It directs connection between these areas; and the eyes may allow emotional processing to bypass the influence of high cognitive processes.

It is traditionally believed that areas of the brain associated with emotional expression are generally more ancient and primitive than areas associated with higher cognitive processes such as reasoning. Other research demonstrates direct neurobiological connections between the emotional centers of the brain and part of the eye (the retina) or ear that allows emotional activation without the influence of higher cognitive processes (LeDoux and Hirst, 1996; Ohman, Flykt and Lundguist, 2000; Zajonc, 1984; 1998). In other words, you may experience various emotions quickly and directly without necessarily thinking about them or being aware of why you feel the way you do.

The Physiology of Pain and Emotion

The skin receives any type of external stimulation through the spinal cord and relays it to the Thalamus which sends the message to the somatosensory cortex for interpretation, because it is responsible for sensory aspect of pain while a redirection will produce the emotional aspect in the Hypothalamus and the Amygdala structures.

Brain Areas Associated with Emotion

Traditionally, the limbic system, the forebrain area bordering the brain stem has been regarded as critical for emotion and many other brain areas are important too. For example, temporary inactivation (by a magnet) of the medial frontal cortex impairs people's ability to identify angry expressions without impairing their identification of happy expression (Harmer, Thilo Rothwell & Goodwin, 2001). Also, the emotional experience we call disgust mainly activates the insular cortex or insula (Phillipe et al; 1997). That location is interesting because the insular cortex is the primary taste cortex.

The limbic system is a set of brain structures comprising the hippocampus and amygdala. They support a variety of functions including emotion, behavior and long term memory. Also the limbic system is closely associated with olfactory structures. The limbic system includes many structures in the cerebral cortex and sub-cortex of the brain, which are the following:

Amygdala: It is the little almond shaped structure, deep inside the antero-region of the temporal lobe. It connects with the hippocampus, septal nuclei, the prefrontal area and the medial dorsal nucleus, inferior to the thalamus. This connection makes it possible for the amygdala to play its important role on the mediation and control of major affective activities like friendship, love and affection, on the expression of mood and mainly on fear, rage and aggression. The amygdala, being the center for

identification of danger is fundamental for self-preservation. When triggered, it gives rise to fear and anxiety, which lead the animal into a stage of alertness, getting ready to flight or fight.

Hippocampus: It is particularly involved with memory phenomena, especially with the formation of long-term memory (the one that sometimes lasts forever). When both hippocampi (right and left) are destroyed nothing can be retained in the memory. The subjects quickly forget any recently received message. The intact hippocampus allows one to compare the conditions of a present threat with similar past experience thus enabling it to choose the best option in order to guarantee its own survival.

Thalamus: It is concerned with stimulation of the medial dorsal and anterior reactivity. However, the importance of these nuclei on the regulation of emotional behaviour, is not due to the thalamus itself, but to the connections of these nuclei with other limbic system structure.

Hypothalamus: This structure has ample connections with other presencephalic areas and the mesencephalus. Lesions of the hypothalamus nuclei interfere with several vegetative functions and some of the so-called motivated behaviors, like thermal regulations, sexuality, combativeness, hunger and thirst. It is believed that it plays a role in emotion specially its lateral parts seem to be involved with pleasure and rage, while the median part is like to be involved with aversion, displeasure and a tendency to uncontrollable and loud laughing. However, in general terms, the hypothalamus has more to do with the expression of symptomatic manifestations of emotions than with the genesis of the affective states when the physical symptoms of emotion appear, the threat they pose returns via hypothalamus to the limbic centers and hence to the pre-frontal nuclei increasing anxiety.

Cingulate Gyrus: It is located in the medial side of the brain between the cingulated sulcus and the corpus callosum (principal fibers bundle connecting the two cerebral hemispheres). It is known that the frontal part coordinates smells and sight with pleasant memories of previous emotion. This region also participates in the emotional reaction to pain and in the regulation of aggressive behaviour.

Finally, it is important to stress that all these structures interconnect intensively and none of them is the sole responsible for any specific emotional state. However, some contribute more than others to this or that kind of emotion.

10.5 Treatment of Emotional Disorders

In recent years we have heard a great deal about the severe and long-lasting emotional disorders that can occur after a variety of traumatic events. Perhaps the most impressive traumatic event is war. But emotional disorders also occur after physical assault (particularly, rape), car accidents, natural catastrophes, or the sudden death of a loved one.

The emotional disorder that follows a trauma is known as post-traumatic stress disorder (PTSD). DSM-IV describes the setting event for PTSD as exposure to a traumatic event during which one feels fear, helplessness or

horror. Afterward, victim re-experience the event through memories and nightmares. When memories occur very suddenly and the victims find themselves reliving the event, they are having a flash back.

10.5.1 Drugs Treatment (Post-traumatic Stress Disorder)

The preliminary drug is selected serotonergic reuptake inhibitor (SSRI), (e.g., Prozac, Paxil), which are also effective for treating anxiety disorders in general.

10.5.2 Psychological Treatment (Post–traumatic Stress Disorder)

Most clinicians agree that victims of PTSD should face the original trauma in order to develop effective coping procedures and thus overcome the debilitating effects of the disorders (Barlow and Lehman, 1996).

In psychoanalytic therapy, reliving emotion trauma to relieve emotional suffering is called catharsis. The trick, of course, is in arranging the re-exposure so it will be therapeutic rather than traumatic once again. It may include the use of imaginary exposure, in which the content of the trauma and the emotions associated with it are worked through systematically. The complication however, is that trauma victims often repress their memories of the event. Generally, re-exposure to the trauma is best carried out very gradually.

Tip

Emotions can be pre-programmed genetically or learned. They are manifested in various ways, including facial expressions, tones of voice, and actions furthermore. They can be caused either by stimuli impinging on us from outside or by things that happen within our body.

Emotion and motivations are very closely linked. Often, it is difficult to distinguish between them. In general, for motives the stimulus is un-observed whereas for emotions it often is apparent. Motive is desire to attain something, while emotion are feeling that does not link to attainment.

Study Session Summary

Summary

In this Study Session, you learnt the following:

- An emotion is a mental and physiological state associated with a variety of feelings, thoughts and behaviour. It can be classified based on the circumplex model (Russel, 1979)- which places emotions along bi-polar dimensions of valence and arousal, the foundational or non-foundational, their occurrence in time, and relativity to affective states.
- Some of the theories related to emotion include the James-Lange theory, the perceptional theory, the cognitive theory of emotion, the Canon-Bard theory, the Two- Factor Theory, and the Gate Pain Theory

- Concerning the physiology of emotion, emotions comprise of three related components: behavior, physiology and cognitive. Concerning the physiology of pain and emotion, the skin receives any type of external stimulation through the spinal cord and relays it to the Thalamus which sends the message to the somatosensory cortex for interpretation, because it is responsible for sensory aspect of pain while a redirection will produce the emotional aspect in the Hypothalamus and the Amygdala structures. The brain areas associated with emotion include the limbic system comprising of the hippocampus and amygdala.Similarly, the thalamus, hypothalamus, and cingulate gyrus, which are all interconnected are involved in the expression of emotions.
- The emotional disorder that follows a trauma is known as post-traumatic stress disorder (PTSD). DSM-IV describes the setting event for PTSD as exposure to a traumatic event during which one feels fear, helplessness or horror. Drug treatment of PTSD include the use of selective serotonergic reuptake inhibitor (SSRI), (e.g. Prozac, Paxil), which are also effective for treating anxiety disorders in general. Psychological treatment of PTSD include the use of psychoanalytic therapy, precisely by reliving emotion trauma to relieve emotional suffering is called catharsis.

Assessment

Assignment

1. Discuss three theories of emotion with practical applications.
2. Classify emotions into six different categories, mentioning the relevance of each.
3. Explain the role of the brain in the expression of emotions in human beings.
4. Identify six areas of the brain, mentioning their importance in maintaining emotion.
5. Mention the major approaches to the treatment of emotional disorders, highlighting any related physiological pathway in the process.

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Study Session 11

Cerebrovascular Accident

Introduction

In this Study Session, we will examine how lack of oxygen can lead to the sudden death of a portion of the brain cells – stroke.

Learning Outcomes

When you have studied this session, you should be able to:

11.1 identify factors affecting progression or extent of stroke.

11.2 describe cerebral blood flow.

11.3 explain the mechanisms of neuronal injury, Ischemic Penumbra (IP), neuronal death, ischemic stroke, thrombosis, embolism, and global–ischemic stroke .

11.4 highlight the role of clinical psychologists in stroke teams.

11.5 describe psychological intervention in stroke management.

11.1 What is Stroke?

A stroke is the sudden death of a portion of the brain cells due to a lack of oxygen. A stroke occurs when blood flow to the brain is damage resulting in abnormal function of brain. It causes by blockage or rupture of an artery to the brain. A stroke is caused by the interruption of the blood supply to the brain, usually because a blood vessel bursts or is blocked by a clot. This cuts off the supply of oxygen and nutrients, causing damage to the brain tissue. The most common symptom of a stroke is sudden weakness or numbness of the face, arm or leg, most often on one side of the body. Other symptoms include: confusion, difficulty speaking or understanding speech; difficulty seeing with one or both eyes; difficulty walking, dizziness, loss of balance or coordination; severe headache with no known cause; fainting or unconsciousness. The effects of a stroke depend on which part of the brain is injured and how severely it is affected. A very severe stroke can cause sudden death.

The two major mechanisms causing brain damage in stroke are; ischemia and hemorrhage. In ischemic stroke, which represents about 80% of all strokes, decreased or absent circulating blood deprives neurons of necessary substrates. The effects of ischemia are fairly rapid because the brain does not store glucose, the chief energy substrate and is incapable of anaerobic metabolism (Jones, Morawetz, Crowell, et al., 1981). Non-traumatic intracerebral hemorrhage represents approximately 10% to 15%

of all strokes. Intracerebral hemorrhage originates from deep penetrating vessels and causes injury to brain tissue by disrupting connecting pathways and causing localised pressure injury. In either case, destructive biochemical substances released from a variety of sources play an important role in tissue destruction.

Focal Ischemic Injury

A thrombus or an embolus can occlude a cerebral artery and cause ischemia in the affected vascular territory. It is often not possible to distinguish between a lesion caused by a thrombus and one caused by an embolus. Thrombosis of a vessel can result in artery-to-artery embolism. Mechanisms of neuronal injury at the cellular level are governed by hypoxia or anoxia from any cause that is reviewed below.

At a gross tissue level, the vascular compromise leading to acute stroke is a dynamic process that evolves over time. The progression and the extent of ischemic injury is influenced by many factors (Wass and Lanier, 1996; Bruno, Biller, Adams Jr, et al., 1999).

Cerebral Blood Flow

Normal cerebral blood flow (CBF) is approximately 50-to 60 ml/100g/ Min and varies in different parts of the brain. In response to ischemia, the cerebral autoregulatory mechanisms compensate for a reduction in CBF by local vasodilatation, opening the collaterals, and increasing the extraction of oxygen and glucose from the blood. However, when the CBF is reduced to below 20 ml/100g/min, an electrical silence ensues and synaptic activity is greatly diminished in an attempt to preserve energy stores. CBF of less than 10ml/100g/min results in irreversible neuronal injury (Jones, Morawetz, Crowell et al., 1981;. Pulsinelli, 1995; Hakim, 1998).

Mechanisms of neuronal injury

Formation of microscopic thrombi responsible for impairment of microcirculation in the cerebral arterioles and capillaries is a complex phenomenon. Formation of a micro thrombus is triggered by ischemia-induced activation of destructive vasoactive enzymes that are released by endothelium, leucocytes, platelets and other neuronal cells. Mechanical “plugging” by leucocytes, erythrocytes, platlets fibrin ensues (Garcia, Liu, Yoshida et al. (1994). At a molecular level, the development of hypoxic- ischemic neuronal injury is greatly influenced by “overreaction” of certain neurotransmitters, primarily glutamate and aspartate. This process called “excitotoxicity” is triggered by depletion of cellular energy stores. Glutamate, which is normally stored inside the synaptic terminals, is cleared from the extracellular space by an energy dependent process. The greatly increased concentration of glutamate (and aspartate) in the extracellular space in a depleted energy state results in the opening of calcium channels associated with N-methy1-D-asapartate (NMDA) and alpha-amino-3-hydroxy-5-methyl-4-isoxanole propionate (AMPA) receptors. Persistent membrane depolarisation causes influx of calcium, sodium, and chloride ions and efflux of potassium ions (Becker, 1998; DeGraba, 1998).

Intracellular calcium is responsible for activation of a series of destructive enzymes such as proteases, lipases, and endonucleases that allow release of cytokines and other mediators, resulting in the loss of cellular integrity (DeGraba, 1998).

Inflammatory response to tissue injury is initiated by the rapid production of many different inflammatory mediators, tumor necrosis factor being one of the key agents. Leukocyte recruitment to the ischemic areas occurs as early as thirty minutes after ischemia and reperfusion. In addition to contributing to mechanical obstruction of microcirculation, the leucocytes also activate vasoactive substances such as oxygen free radicals, arachidonic acid metabolites (cytokines), and nitric acid. The cellular effects of these mediators include vasodilatation, vasoconstriction, increased permeability, increased platelets aggregation, increased leukocyte adherence to the endothelial wall, and immunoregulation.

Endothelial cells are one of the first cell types to respond to hypoxia. This response occurs at morphological, biochemical and immunological levels, causing a variety of physiological and pharmacological effects. Morphologically, endothelial cells swell and form“microvilli” at the luminal surface of the cell. This results in a reduction in the luminal patency of the capillary vessel. Mechanical plugging by erythrocytes, leukocytes, and platelets ensues. At a biochemical level, endothelial cells mediate the effects of vasoactive agents such as endothelin peptides, eicosanoids, and smooth muscle relaxant (probably nitric acid), which in part modulate the vascular tone of the microcirculation. Activation of endothelial adhesion molecules promotes leukocyte adherence to the endothelial wall, a key process in the initiation of the inflammatory process (DeGraba, 1998).

Ischemic Penumbra (IP)

Within an hour of hypoxic- ischemic insult, there is a core of infarction surrounded by an oligemic zone called the ischemic penumbra (IP) where autoregulation is ineffective. The critical time period during which this volume of brain tissue is at risk is referred to as the “window of opportunity” since the neurological deficits created by ischemia can be partly or completely reversed by reperfusing the ischemic yet viable brain tissue within a critical time period (2 to 4 hours?) (Adams and Shaw, 1994).

IP is characterised by some preservation of energy metabolism because the CBF in this area is 25% to 50% of normal. Cellular integrity and function are preserved in this area of limited ischemia for variable periods of time. The pathophysiology of IP is closely linked to generation of spontaneous waves of depolarization (SWD). SWD can originate from multiple foci; some from the ischemic core and others form ischemic foci within the peri-infarct zone (penumbra). Sustained increases of synaptic glutamate and extracellular potassium ions are closely associated with the development of SWD. Glutamate receptor antagonists that block transmembrane calcium flux and prevent intracellular calcium accumulation are known to suppress SWD. Hypoxic or rapid depolarisations eventually supervene just before irreversible neuronal death (Back, Dietrich, and Watson, 1996).

Neuronal Death

The two processes by which injured neurons are known to die are coagulation necrosis and apoptosis. *Coagulation necrosis (CN)* refers to a process in which individual cells die among living neighbor cells without eliciting an inflammatory response. This type of cell death is attributed to the effects of physical, chemical, or osmotic damage to the plasma membrane. This is in contrast to liquefaction necrosis, which occurs when cells die, leaving behind a space filled by "inflammatory response" or pus.

In CN, the cell initially swells then shrinks and undergoes pyknosis – a term used to describe marked nuclear chromatin condensation. This process evolves over 6 to 12 hours. By 24 hours extensive chromatolysis occurs resulting in pan-necrosis. Astrocytes swell and fragment, myelin sheaths degenerate. Irreversible cellular injury as demonstrated by eosinophilic cytoplasm and shrunken nuclei are seen between 8 to 12 hours after arterial occlusion (91). The morphology of dying cells in coagulation necrosis is different than that of cell death due to apoptosis (Heros, 1994).

The term apoptosis is derived from the study of plant life wherein deciduous trees shed their leaves in the fall. This is also called "programmed cell death", because the leaves are programmed to die in response to seasonal conditions. Similarly, cerebral neurons are "programmed" to die under certain conditions, such as ischemia. During apoptosis, nuclear damage occurs first. The integrity of the plasma and the mitochondrial membrane is maintained until late in the process. Ischemia activates latent "suicide" proteins in the nuclei, which starts an autolytic process resulting in cell death. This autolytic process is mediated by DNA cleavage (Choi, 1996).

Apoptotic mechanisms begin within 1 hour after ischemic injury whereas CN begins by 6 hours after arterial occlusion. This observation has an important bearing on future directions of research. The manner by which apoptosis evolves is a focus of much research, because, hypothetically, neuronal death can be prevented by modifying the process of DNA cleavage that seems to be responsible for apoptosis.

Ischemic Stroke

The three main mechanisms causing ischemic strokes are: (a) thrombosis, (2) embolism and (3) global ischemia (hypotensive) stroke. All ischemic strokes do not neatly fall into these categories and the list of entities responsible for unusual stroke syndromes is very long. However, strokes caused by vasospasm (migraine, following SAH, hypertensive encephalopathy) and some form of "arteritis" stand out among the more infrequent causes of stroke.

Thrombosis

Atherosclerosis is the most common pathological feature of vascular obstruction resulting in thrombotic stroke (Challa, 1999). Atherosclerotic plaques can undergo pathological changes such as ulcerations,

thrombosis, calcifications, and intra-plaque hemorrhage. The susceptibility of the plaque to disrupt, fracture or disrupt or ulcerate depends on the structure of the plaque, and its composition and consistency. Disruption of endothelium that can occur in the setting of any of these pathological changes initiates a complicated process that activates many destructive vasoactive enzymes. Platelet adherence and aggregation to the vascular wall follow, forming small nidi of platelets and fibrin. Leucocytes that are present at the site within 1 hour of the ictus mediate an inflammatory response (Challa, 1999).

In addition to atherosclerosis, other pathological conditions that cause thrombotic occlusion of a vessel include clot formation due to hypercoagulable state, fibromuscular dysplasia, arteritis (Giant cell and Takayasu), and dissection of a vessel wall.

In contrast to the occlusion of large atherosclerotic vessels, lacunar infarcts occur as a result of occlusion of deep penetrating arteries that are 100 to 400 mm in diameter and originate for the cerebral arteries. The putamen and pallidum, followed by pons, thalamus, caudate nucleus, and internal capsule are the most frequently affected sites. The size of a lacunar infarct is only about 20 mm in diameter. The incidence of lacunar infarcts is 10% to 30% of all strokes depending on race and preexisting hypertension and diabetes mellitus. The small arteriole, most frequently as a result of chronic hypertension lengthens, becomes tortuous and develops subintimal dissections and micro-aneurysms rendering the arteriole susceptible to occlusion from micro-thrombi. Fibrin deposition resulting in lipohyalinosis is considered to be the underlying pathological mechanism (Yu, McNeil, O Malley, Davis, and Donnan, 1995).

Embolism

Embolic stroke (ES) can result from embolisation of an artery in the central circulation from a variety of sources. Besides clot, fibrin, and pieces of atheromatous plaque, materials known to embolize into the central circulation include fat, air, tumor or metastasis, bacterial clumps, and foreign bodies. Superficial branches of cerebral and cerebellar arteries are the most frequent targets of emboli. Most emboli lodge in the middle cerebral artery distribution because 80% of the blood carried by the large neck arteries flow through the middle cerebral arteries (Garcia, Ho, & Pantoni, 1998).

The two most common sources of emboli are: the left sided cardiac chambers and large arteries, (e.g., “artery to artery” emboli that result from detachment of a thrombus from the internal carotid artery at the site of an ulcerated plaque).

The neurological outcome from an ES depends not only on the occluded vascular territory but also on the ability of the embolus to cause vasospasm by acting as a vascular irritant. The vasospasm can occur in the vascular segment where the embolus lodges or can involve the entire arterial tree. Vasospasm tends to occur in younger patients, probably because the vessels are more pliable and less atherosclerotic.

Many embolic strokes become “hemorrhagic” causing hemorrhagic infarction (HI). Hemorrhagic infarct (used here synonymously with

hemorrhagic transformation of an ischemic infarct) is an ischemic infarct in which bleeding develops within the necrotizing cerebral tissue. The pathogenesis of hemorrhagic transformation of a pale infarct is a complex phenomenon.

The two common explanations that are advanced to explain the pathogenesis of HI in embolic strokes are: (1) Hemorrhagic transformation occurs because ischemic tissue is often reperfused when the embolus lyses spontaneously and blood flow is restored to a previously ischemic area. An initial vascular obstruction is likely to occur at a bifurcation of a major vessel. The occlusion may obstruct one or both of the branches, producing ischemia of the distal tissue. Blood vessels as well as brain tissue are rendered fragile and injured. When the occluding embolus either lyses spontaneously or breaks apart and migrates distally, CBF is restored to the "injured or ischemic" microcirculation. This can result in a hemorrhagic or "red infarct" in what had previously been a bloodless field. The areas that continue to be poorly perfused are referred to as "pale" or "anemic infarcts." (2) Hemorrhagic transformation is also known to occur with persistent occlusion of the parent artery proximally, indicating that hemorrhagic transformation is not always associated with migration of embolic material. HI on the periphery of infarcts in presence of persistent arterial occlusion is caused by reperfusion from leptomeningeal vessels that provide collateral circulation. In patients with ES, it is not unusual to see HI side-by-side with ischemic infarction.

The three main factors associated with "red infarcts" or hemorrhagic infarctions include the size of the infarct, richness of collateral circulation, and the use of anticoagulants and interventional therapy with thrombolytic agents. Large cerebral infarctions are associated with a higher incidence of hemorrhagic transformation. Hypertension is not considered to be an independent risk factor for hemorrhagic transformation of an ischemic infarct (Hart, and Easton, 1986).

Global – Ischemic or Hypotensive Stroke

Profound reduction in systemic blood pressure due to any reason is responsible for "hypotensive stroke." Some neurons are more susceptible to ischemia than others. These include the pyramidal cell layer of the hippocampus and the Purkinje cell layer of the cerebellar cortex. Cerebral gray matter is also particularly vulnerable. Abundance of glutamate in these neurons renders them more susceptible to global ischemia.

Global ischemia causes the greatest damage to areas between the territories of the major cerebral and cerebellar arteries known as the "boundary zone" or "watershed area." The parietal-temporal-occipital triangle at the junction of the anterior, middle, and posterior cerebral arteries is most commonly affected. Watershed infarction in this area causes a clinical syndrome consisting of paralysis and sensory loss predominantly involving the arm; the face is not affected and speech is spared. Watershed infarcts make up approximately 10% of all ischemic strokes and almost 40% of these occur in patients with carotid stenosis or occlusion (Garcia and Anderson, 1997).

11.2 Factors Affecting Progression or Extent of Stroke

Rate of onset and duration: the brain better tolerates an ischemic event of short duration or one with slow onset.

Collateral circulation: the impact of ischemic injury is greatly influenced by the state of collateral circulation in the affected area of the brain. A good collateral circulation is associated with a better outcome.

Health of systemic circulation: Constant cerebral perfusion pressure depends on adequate systemic blood pressure. Systemic hypotension from any reason can result in global cerebral ischemia.

Hematological factors: a hypercoagulable state increases the progression and extent of microscopic thrombi, exacerbating vascular occlusion.

Temperature: elevated body temperature is associated with greater cerebral ischemic injury.

Glucose metabolism: hyper- hypoglycemia can adversely influence the size of an infarct.

11.3 Role of Clinical Psychologists in Stroke Teams

- Direct Patient Contact: This includes, assessment, formulation and management of psychological disorders post-stroke including depression, anxiety, self-esteem issues and adjustment difficulties. It is also necessary to do an assessment, formulation, management and cognitive rehabilitation of post-stroke impairment as well as assessment and management of behavioural problems post-stroke
- Indirect Patient Contact.: This includes an assessment of carer strain on patients post-stroke, working with carers as co-therapist, consultation and advice to therapists / external care providers
- Teaching/training and research

Psychological Intervention

Often, cognitive behavioural therapy (CBT) is advised, because CBT is collaborative i.e., based on shared formulation of problems, goal driven, problem focused i.e. what strategies can be put in place to alter maintaining factors? CBT is also relatively brief.

Focus of psychological therapy for mood disorders after stroke

1) Behavioural components e.g., anxiety management, graded exposure, behavioural activation etc.
2) Cognitive components e.g., normalisation, challenging negative thoughts, cognitive restructuring, etc.

Acknowledgement:

Opinions of Sid Shah, in his publication on "Pathophysiology of Stroke" formed the background of this write-up.

Study Session Summary

Summary

In this Study Session, we discussed how portion of the brain may suddenly die due to lack of oxygen. The two major mechanisms causing brain damage in stroke are; ischemia and hemorrhage. Our discussion also covers the folwing:

- Factors affecting progression or extent of stroke include: Rate of onset and duration, collateral circulation, Health of systemic circulation, Hematological factors, Temperature, Glucose metabolism
- The normal cerebral blood flow (CBF) is approximately 50-to 60 ml/100g/ Min and varies in different parts of the brain.
- Concerning the mechanisms of neuronal injury, formation of microscopic thrombi responsible for impairment of microcirculation in the cerebral arterioles and capillaries is a complex phenomenon. Formation of a micro thrombus is triggered by ischemia-induced activation of destructive vasoactive enzymes that are released by endothelium, leucocytes, platelets and other neuronal cells.
- Concerning ischemic penumbra (IP), within an hour of hypoxic-ischemic insult, there is a core of infarction surrounded by an oligemic zone called the ischemic penumbra (IP) where autoregulation is ineffective.
- For neuronal death, the two processes by which injured neurons are known to die are coagulation necrosis and apoptosis.
- Concerning ischemic stroke, the three main mechanisms causing ischemic strokes are: (a) thrombosis, (b) embolism, and (c) global ischemia (hypotensive) stroke.
- Atherosclerosis is the most common pathological feature of vascular obstruction resulting in thrombotic stroke.
- Embolic stroke (ES) can result from embolisation of an artery in the central circulation from a variety of sources. Besides clot, fibrin, and pieces of atheromatous plaque, materials known to embolize into the central circulation include fat, air, tumor or metastasis, bacterial clumps, and foreign bodies.
- Profound reduction in systemic blood pressure is responsible for "hypotensive stroke." Some neurons are more susceptible to ischemia than others. These include the pyramidal cell layer of the hippocampus and the Purkinje cell layer of the cerebellar cortex. Cerebral gray matter is also particularly vulnerable. Abundance of glutamate in these neurons renders them more susceptible to global ischemia.
- Role of clinical psychologists in stroke teams include: direct patient contact, indirect patient contact, as well as teaching/training and research. Often, cognitive behavioural therapy (CBT) is advised, because CBT is collaborative i.e. based on shared formulation of

problems, goal driven, problem focused i.e. what strategies can be put in place to alter maintaining factors? CBT is also relatively brief.

Assessment

Assignment

1. Mention five (5) factors affecting progression or extent of stroke.
2. Describe cerebral blood flow.
3. Explain the mechanisms of neuronal injury.
4. Describe the role of clinical psychologists in Stroke Teams.

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Study Session 12

Schizophrenia

Introduction

In this Study Session, we will discuss a rear illness, schizophrenia. We will also describe the biology and effects of this illness. Finally, we will examine drug therapy for this illness.

Learning Outcomes

When you have studied this session, you should be able to:

12.1 describe the symptoms of schizophrenia.

12.2 identify at least four types of schizophrenia.

12.3 explain the biology of schizophrenia.

12.4 highlight the effects of schizophrenia on the brain.

12.5 describe drug therapy for schizophrenia.

12.1 What is Schizophrenia?

Schizophrenia is a severe mental illness that affects one to two percent of people worldwide. The disorder can develop as early as the age of five, though it is very rare at such an early age. Most men become ill between the ages of 16 and 25 whereas most women become ill between the ages of 25 and 30. Even though there are differences in the age of development between the sexes, men and women are equally at risk for schizophrenia. There is of yet no definitive answer as to what causes the disorder. It is believed to be a combination of factors including genetic make-up, pre-natal viruses, and early brain damage which cause neurotransmitter problems in the brain.

Schizophrenia is a psychiatric disorder characterised by periods of psychosis. It is “psychiatric” because it affects the brain in a physiologic manner. The psychosis is when an individual seems to experience things that are not real or loses touch with reality. These experiences may be in combination with the real world or totally independent of the real world.

12.1.1 Symptoms of Schizophrenia

A variety of symptoms characterise schizophrenia which include positive and negative symptoms.

Positive Symptoms

Delusion

Delusions are false beliefs that appear obviously untrue to other people. For example, a person with schizophrenia may believe that he is the President of Nigeria when he is not. People with schizophrenia may have delusions that others, such as the police or the SSS, are plotting against them or spying on them. They may believe that aliens are controlling their thoughts or that their own thoughts are being broadcast to the world so that other people can hear them.

People with schizophrenia may also experience hallucinations (false sensory perceptions). People with hallucinations see, hear, smell, feel, or taste things that are not really there. Auditory hallucinations, such as hearing voices when no one else is around, are especially common in schizophrenia. These hallucinations may include two or more voices conversing with each other, voices that continually comment on the person's life or voices that command the person to do something.

Bizarre behaviour

People with schizophrenia often behave bizarrely. They may talk to themselves, walk backward, laugh suddenly without explanation, make funny faces, or masturbate in public. In rare cases, they maintain a rigid, bizarre pose for hours on end. Alternately, they may engage in constant random or repetitive movements.

Disorganised thinking and speech

People with schizophrenia sometimes talk in incoherent or nonsensical ways, which suggests confused or disorganised thinking. In conversation they may jump from topic to topic or string together loosely associated phrases. They may combine words and phrases in meaningless ways or make up new words. In addition, they may show *poverty of speech*, in which they talk less and more slowly than other people, fail to answer questions or reply only briefly, or suddenly stop talking in the middle of speech.

Negative Symptoms

Social Withdrawal

Another common characteristic of schizophrenia is social withdrawal. People with schizophrenia may avoid others or act as though others do not exist.

Affective flattening

Reduction in the range and intensity of emotional expression, including facial expression, voice tone, eye contact and body language.

Alogia (poverty of speech)

Lessening of speech fluency and productivity, thought to reflect slowing or blocked thoughts; often manifested as short, empty replies to questions.

Avolition

The reduction, difficulty or inability to initiate and persist in goal-directed behavior. Often mistaken for apparent disinterest, examples of avolition are: no longer interested in going out with friends, no longer interested in activities that the person used to show enthusiasm, no longer interested in anything, sitting in the house for hours or days doing nothing.

Cognitive symptoms

Disorganised thinking, slow thinking, Difficulty understanding, Poor concentration, Poor memory, Difficulty expressing thoughts, Difficulty integrating thoughts, feelings, behaviors

12.2 Types of Schizophrenia

- **Paranoid:** Persons are very suspicious of others and often have grand schemes of persecution at the root of their behaviour. During this phase they may have hallucinations and frequent delusions
- **Hebephrenic:** also known as disorganised schizophrenia; characterized by emotionless, incongruous, or silly behavior, intellectual deterioration, frequently beginning insidiously during adolescence. May be verbally incoherent and may have moods and emotions that are not appropriate to the situation. Hallucinations not usually present.
- **Catatonic:** Person is extremely withdrawn, negative and isolated. May have marked psychomotor disturbances.
- **Residual:** Lacks motivation and interest in day-to-day living. Person is not usually having delusions, hallucinations or disorganized speechs
- **Schizoaffective:** There will be symptoms of schizophrenia as well as mood disorder (depression, bipolar, mixed mania).
- **Undifferentiated:** Conditions meeting the general diagnostic criteria for schizophrenia but not conforming to any of the previous types. Exhibits more than one of the previous types without a clear dominance of one.

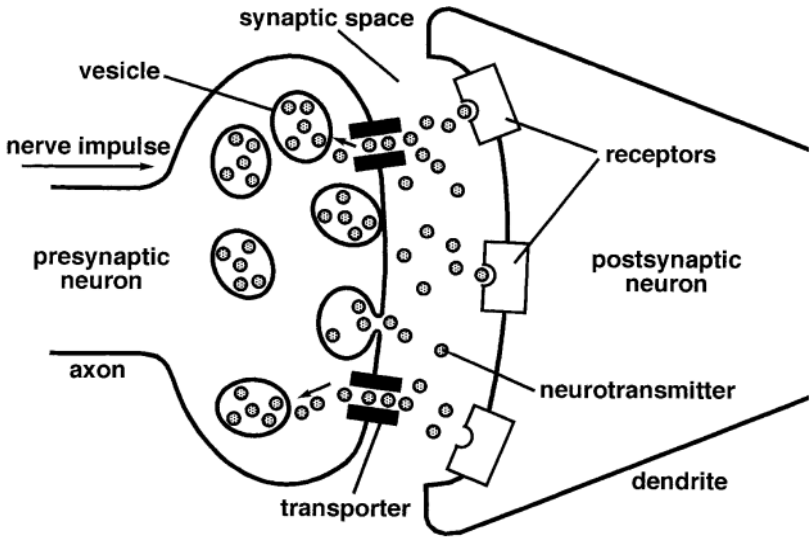
12.3 Biology of Schizophrenia

Our thoughts, feelings, and actions are all transmitted in the Central Nervous System as electrochemical impulses. These impulses reach the ends of presynaptic neurons. Neurotransmitter chemicals are released that cross the synaptic cleft and bind to specific receptor sites onto postsynaptic neurons. The binding action triggers electrical changes. These changes either inhibit or continue the conduction of that impulse. Alterations or decrease of neurotransmitters at postsynaptic receptors is associated with the many different forms of neuropathologic conditions.

Major categories of neurotransmitters are cholinergic, monoamines, and neuropeptides. Each type of neurotransmitter is associated with the

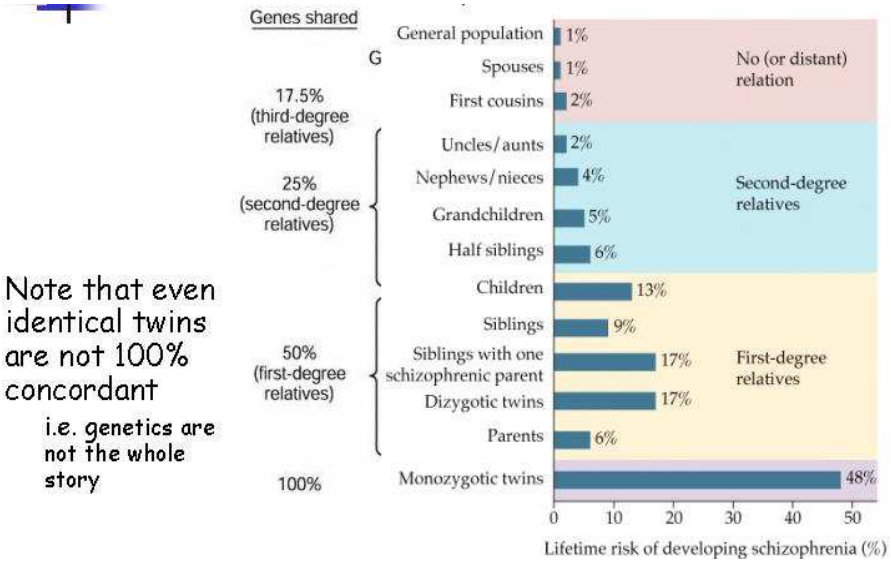
conduction of impulses in different areas of the Central Nervous System. For instance, serotonin is a monoamine transmitter that innervates receptors in the Pons, medulla, thalamus, and limbic system. A decrease in serotonin levels is connected with clinical depression. Another example is the amino acid inhibitory transmitter, a type of GABA. GABA innervates receptors in the hypothalamus, cortex, cerebellum, basil ganglia, and hippocampus. Decrease in GABA availability is associated with anxiety disorders and Schizophrenia.

Fig 12.1



12.3.1 Strong genetic component to Schizophrenia

Fig 12.2 Strong genetic component to schizophrenia



Family studies: the above table presents a summary of the risk for schizophrenia in various relatives of schizophrenic index cases. Quite clearly, relatives of schizophrenic patients are at increased risk, and the risk increases as the genetic relationship between proband and relative becomes closer. More recent information confirms what is shown in table and also indicates that risk for schizophrenia is particularly high in the

families of female and early onset probands (Sham, 1994). The data gathered by the family method thus support the notion that a predisposition for schizophrenia can be transmitted genetically. Yet relatives of a schizophrenic proband share not only genes but also common experiences. The behaviour of a schizophrenic parent could be very disturbing to a developing child. The influence of the environment cannot be discounted as a rival explanation for the higher morbidity risks.

Twins studies: Concordance rate for MZ and DZ twins are also given in the table. Concordance for identical twins (48%) although greater than that of fraternal twins (17%) is less than 100%. This study is important; if genetic transmission alone accounted for schizophrenia and one twin was schizophrenic, the other twin would also be schizophrenic because MZ twins are genetically identical. Consistent with a genetic interpretation of these data, concordance among MZ twins does increase when the proband is severely ill.

Adoption studies: the study of children of schizophrenic mothers who were reared from early infancy by nonschizophrenic adoptive parents has provided more conclusive information on the role of genes in schizophrenia by eliminating the possible effects of a deviant environment. In a study carried out in Denmark under Kety's direction (Kety et al, 1975, 1994). The starting point for the investigation was a culling of the records of children who had been adopted at a young age. All adoptees that had later been admitted to a psychiatric facility and diagnosed as schizophrenic were selected as the index cases. For the remaining cases, the investigators chose a control group of people who had no psychiatric history and who were matched to the index group on such variables as sex and age. Both the adoptive and the biological parents and the siblings and half-siblings of the two groups where identified, and a search was made to determine who among them had a psychiatric history. As might be expected if genetic factors figure in schizophrenia, the biological relatives of the index cases were diagnosed as schizophrenic more often than were member of the general population; the adoptive relatives were not.

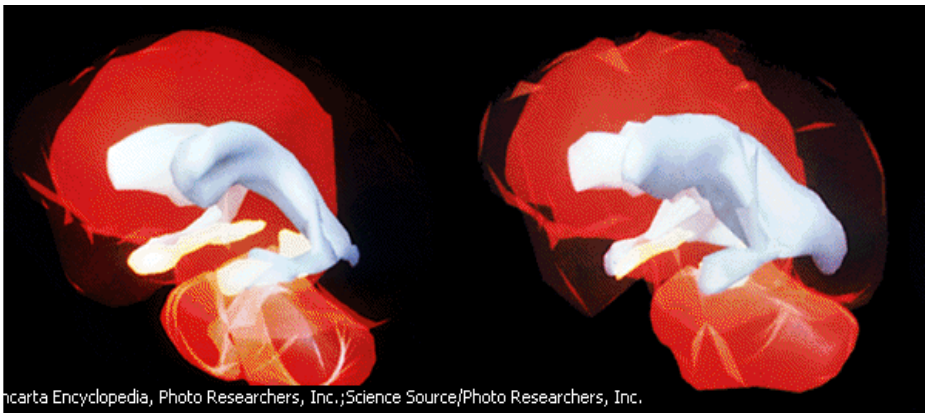
12.4 Effects of Schizophrenia on the Brain

New tests and machines enable researchers to study the structure of schizophrenic brains using Magnetic Resonance Imagery (MRI), Positron emission tomography (PET), Functional Magnetic resonance imaging (fMRI), and single-photon emission computerized tomography (SPECT). The different lobes of affected brains were examined and compared to those of normal brains, showing several abnormalities. These abnormalities include:

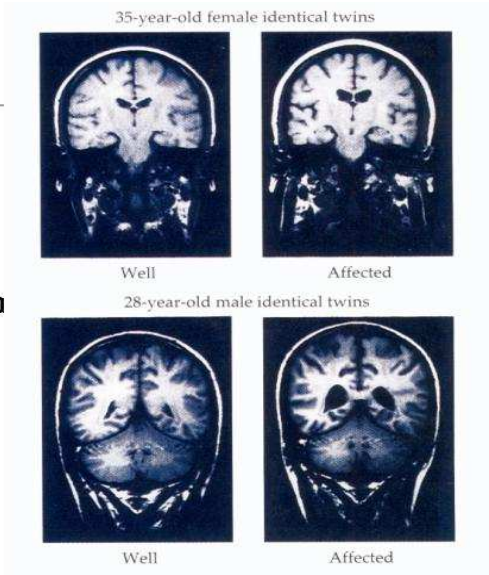
1) Ventricular abnormalities: The most common finding was the enlargement of the lateral ventricles, which are the fluid-filled sacs that surround the brain. Studies of patients with schizophrenia have consistently revealed and enlargement of cerebral ventricles, especially the lateral ventricles.
2) Ventricular enlargement is not related to length of illness or to duration of hospitalization. Weinberger, (1980) found that the degree

of ventricular enlargement predicts the patient's response to antipsychotic drugs. Patients with more enlarged ventricles show poorer response to these drugs.

Fig 12.3

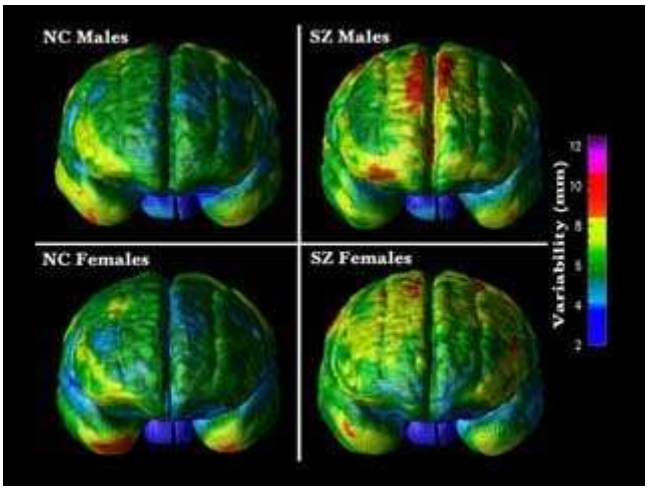


- MRI images of monozygotic twins discordant for schizophrenia
  - Ventricles are enlarged in schizophrenia



a. Tests showed that blood flow was lower in frontal regions in afflicted people when compared to non-afflicted people. This condition has become known as **hypofrontality**. The hypofrontality hypothesis suggests that lower activity in the frontal lobes may produce some of the negative symptoms found in schizophrenia, such as mood disorders and social withdrawal (Andereasen et al., 1992). Measures of blood cerebral flow and glucose metabolism indicate that people with schizophrenia show lower levels of frontal lobe activity than healthy controls during difficult cognitive task (Weinberger, 1994). Difference in frontal lobe activity can be used to distinguish between an identical twin with schizophrenia and the healthy member of the pair (Berman, Torrey, Daniel, and Weinberger, 1992). One possible reason for the reduced activity may be a smaller number of synaptic connections in this area. Glantz and Lewis (2000) found that neurons in the prefrontal cortex showed fewer dendritic spines in patients with schizophrenia.

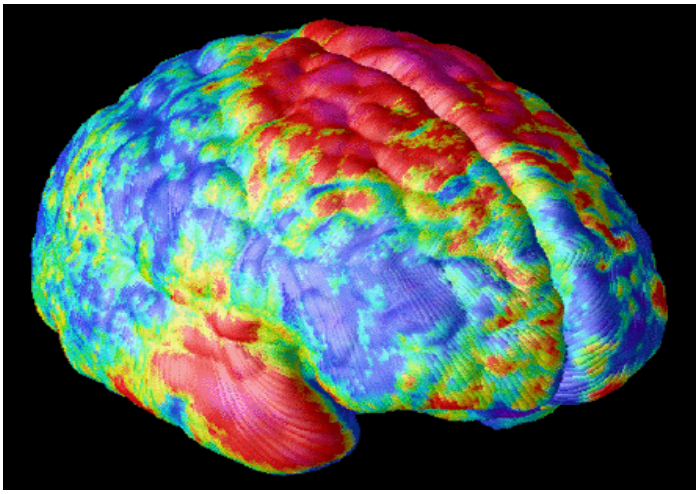
Fig 12.4



b. There is, however, a great deal of evidence that shows that the temporal lobe structures in schizophrenic patients are smaller. Some studies have found the hippocampus and amygdala to be reduced in volume. Also, components of the limbic system, which is involved in the control of mood and emotion, and regions of the Superior Temporal Gyrus (STG), which is a large contributor in language function, have been notably smaller. The Heschl's Gyrus (which contains the primary auditory cortex), and the Planum Temporale are diminished. The severity of symptoms such as auditory hallucinations has been found to be dependent upon the sizes of these language areas.

The map in Fig. 12.5 reveals the 3-dimensional profile of gray matter loss in the brains of teenagers with early-onset schizophrenia, with a region of greatest loss in the temporal and frontal brain regions that control memory, hearing, motor functions, and attention.

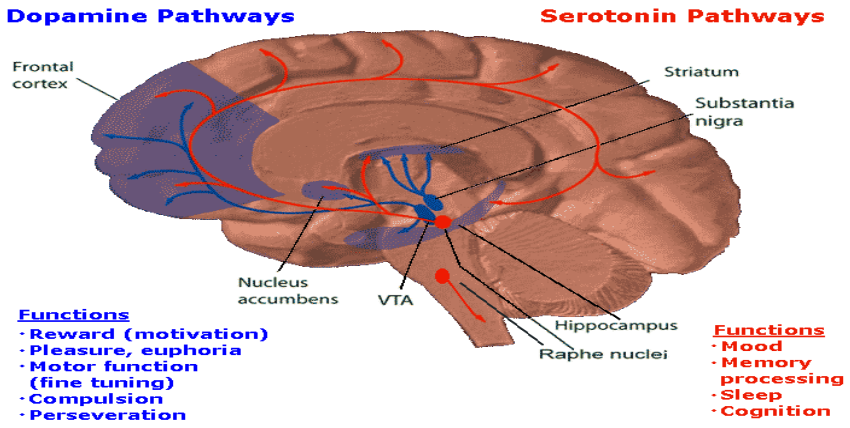
Fig 12.5 Mapping brain tissue in adolescent schizophrenic



Another area of the brain that has been found to be severely affected is the prefrontal cortex. The prefrontal cortex is associated with memory, which would explain the disordered thought processes found in schizophrenics. Test done on humans and animals in which the prefrontal

cortex has been damaged showed similar cognitive problems as those seen in schizophrenic patients. The prefrontal cortex has one of the highest concentrations of nerve fibers with the neurotransmitter dopamine and scientists have learned that the relatively new antipsychotic drug, which increases the amount of dopamine released in the prefrontal cortex, often improves cognitive symptoms. They also found that the prefrontal cortex contains a high concentration of dopamine receptors that interact with glutamate receptors to enable neurons to form memories. This means that dopamine receptors may be especially important for reducing cognitive symptoms.

Fig 12.6



The Psychotogens hypothesis

Several proposals have suggested that schizophrenia develops from faulty metabolic processes in the brain that produce abnormal substances that generate psychotic behaviour. Such hypothetical substances called psychotogens might be similar in some ways to hallucinogenic agents. The chemical structure of some manufactured hallucinogens resembles that of some neurotransmitters. Metabolic faults in particular pathways might cause the brain to convert an innocuous molecule into a behaviorally maladaptive substance capable of producing schizophrenic symptoms.

The Glutamate Hypothesis

A disturbance in glutamate system might provide the large-scale effects that would for the wide range of positive symptoms in schizophrenia. Glutamate and dopamine systems often interact in the brain. Increasing or decreasing glutamate should result in similar behavioural outcomes. If psychotic symptoms are associated with dopamine sensitivity, they might also be related to reductions in glutamate activity. The drug PCP (Phencyclidine) provides a useful model for this account process (Jentsch and Roth, 1999; Moghaddam and Adams, 1998). PCP is capable of producing schizophrenia like symptoms, including auditory hallucinations. PCP not only stimulates dopamine release but also blocks the NMDA glutamate receptor. Psychosis due to PCP use responds' favorable to treatment with dopamine antagonists (Jentsch et al, 1997).

The dopamine hypothesis

Many clinical and basic experimental findings have suggested that abnormally high levels of dopamine receptor stimulation form the basis of schizophrenia. Dopamine is a synaptic transmitter in the brain with the role of positive reinforcement. Various clues suggesting that dopamine plays a role in schizophrenia came from observations of:

a. *Amphetamine psychosis:* The similarity of amphetamine psychosis to schizophrenia is supported by the findings that amphetamine exacerbates symptoms of schizophrenia. Neurochemically, amphetamine promotes the release of catecholamine, particularly dopamine, and prolongs the action of the released transmitter by blocking reuptake. Rapid relief from amphetamine psychosis is provided by injection of the dopamine antagonist example Chlorpromazine.

b. *The effects of antipsychotic drugs:* the introduction of Chlorpromazine drastically reduced the population of patients in psychiatric hospitals in the United States in early 1950s. This drug was discovered by Henri Laborit in the 1940s for muscle relaxation in surgery. The French surgeon found out that Chlorpromazine not only achieves this effect, but also reduces worry and preoperative tension. Later on, Laborit collaborated with psychiatrists in trying this substance on psychiatric patients; they found remarkable antipsychotic effects. Chlorpromazine was then introduced on a large scale in psychiatric hospitals around the world, with a profound impact. The Chlorpromazine and other related substances (**phenothiazines**) act in the brain by blocking (antagonizing) postsynaptic receptor sites for dopamine, specifically D_2 type. This observation was subsequently extended to other antipsychotic drug classes, such as **butyrophenones** including haloperidol.

c. *Parkinson's disease*: another tail leading to the dopamine hypothesis of schizophrenia is the study of Parkinson's disease. Parkinson's disease is caused by the degeneration of nerve cells located in the brainstem (in the substantia nigra). These cells contain dopamine, and administering the substance L-dopa (levodopa), a precursor for the synthesis of dopamine, increases the amount of released dopamine, which thus provides some relief of Parkinson's symptoms. Two observations of patients with Parkinson's connect this disease with schizophrenia and the dopamine hypothesis. First, some patients given L-dopa to relieve Parkinsonian symptoms become psychotic. Second, some patients with schizophrenia receiving chlorpromazine develop Parkinsonian symptoms. In fact, treatment with traditional antipsychotic drugs can result in permanent movement disorders.

1. The hippocampus and amygdale have been found to be smaller than normal in some individuals with schizophrenia (Lawrie, Whalley, Job, and Johnstone, 2003; Schulze et al., 2003). In addition to being smaller than normal, the hippocampus shows an unusual disorganisation in some cases of schizophrenia. The cells of the hippocampus are normally lined up rather neatly in rows. In the hippocampus of some patients with schizophrenia, the cells are in relative disarray, given the importance of the hippocampus in memory and cognition, this lack of organization may account for some of the deficits in reasoning and thought found in schizophrenia. The disorganisation of the hippocampus suggests problems in prenatal cell migration and may reflect the role of viral infection in schizophrenia.

2. Furthermore, patients with schizophrenia who have enlarged ventricles show a marked reduction in levels of dopamine β-hydroxylase, an enzyme that catalyzes the conversion of dopamine into norepinephrine.

Evidence against the Dopamine hypothesis

Criticisms of the dopamine model of Schizophrenia began to emerge in 1980s (Alpert and Friedhoff, 1980 cited in Breedlove, 2002).

1. Clinical observations revealed that some patients with schizophrenia show no changes when treated with drugs that affect dopamine.
2. Further experiments, conducted as new methods were developed (particularly the ability to use PET scanning to examine drug action in the brain of living patients) challenged the view that the amount of dopamine blocking was correlated with clinical benefit. These studies showed that some patients had over 90% of their D_2 receptors blocked by anti-psychotic drugs, but showed little reduction in their psychoses. This primarily occurs in patients who have had the psychosis for ten to thirty years. At least 90-95% of first-episode patients, however, responds to antipsychotics at low doses and does so with D_2 occupancy of 60-70%.
3. Furthermore, although dopamine-inhibiting medications modify dopamine levels within minutes, the associated improvement in patient symptoms is usually not visible for at least several days, suggesting that dopamine may be indirectly responsible for the illness.
4. Similarly, a new generation of anti-psychotic drugs (called the **atypical antipsychotics**) were found to be just as effective as older typical antipsychotic drugs in controlling psychosis, particularly the negative symptoms, despite the fact that they have lower affinity for dopamine receptors than for various other neurotransmitter receptors. More recent work, however, has shown that atypical antipsychotic drugs such as clozapine and quetiapine bind and unbind rapidly and repeatedly to the dopamine D_2 receptor.

12.5 Drug Therapy for Schizophrenia

Although there is no cure for schizophrenia, effective treatment exists that can improve the long-term course of the illness. With many years of treatment and rehabilitation, significant numbers of people with schizophrenia experience partial or full remission of their symptoms.

12.5.1 Treatment of Schizophrenia

Treatment of schizophrenia usually involves a combination of medication, rehabilitation, and treatment of other problems the person may have. Antipsychotic drugs (also called neuroleptics) are the most frequently used medications for treatment of schizophrenia.

Antipsychotic medications, developed in the mid-1950s, can dramatically improve the quality of life for people with schizophrenia. The drugs reduce or eliminate psychotic symptoms such as hallucinations and delusions. Antipsychotic drugs help reduce symptoms in 80 to 90 percent of people with schizophrenia.

The medications can also help prevent these symptoms from returning. Common antipsychotic drugs include risperidone (Risperdal), olanzapine (Zyprexa), clozapine (Clozaril), quetiapine (Seroquel), haloperidol (Haldol), thioridazine (Mellaril), chlorpromazine (Thorazine), fluphenazine (Prolixin), and trifluoperazine (Stelazine). People with schizophrenia usually must take medication for the rest of their lives to control psychotic symptoms. Antipsychotic medications appear to be less effective at treating other symptoms of schizophrenia, such as social withdrawal and apathy.

12.5.2 Side Effects of Antipsychotic Drugs

Minor side effects include weight gain, dry mouth, blurred vision, restlessness, constipation, dizziness, and drowsiness. Other side effects are more serious and debilitating. These may include muscle spasms or cramps, tremors, and tardive dyskinesia, an irreversible condition marked by uncontrollable movements of the lips, mouth, and tongue. Newer drugs, such as clozapine, olanzapine, risperidone, and quetiapine, tend to produce fewer of these side effects. However, clozapine can cause agranulocytosis, a significant reduction in white blood cells necessary to fight infections. This condition can be fatal if not detected early enough. For this reason, people taking clozapine must have weekly tests to monitor their blood.

Study Session Summary

Summary

In this Study Session, we examined Schizophrenia, a psychiatric disorder characterised by periods of psychosis. The psychosis is when an individual seems to experience things that are not real or loses touch with reality.

- Positive symptoms of schizophrenia include delusion, bizarre behaviour, disorganised thinking and speech, etc.
  Delusions are false beliefs that appear obviously untrue to other people.
- Negative symptoms include social withdrawal, affective flattening, alogia (poverty of speech), avolition, etc.
- Cognitive symptoms include disorganised thinking, slow thinking, difficulty understanding, poor concentration, poor memory, difficulty in expressing thoughts, difficulty integrating thoughts, feelings, and behaviours
- Types of Schizophrenia include paranoid, hebephrenic, catatonic, residual, schizoaffective, and undifferentiated
- Although there is no cure for schizophrenia, effective treatment exists that can improve the long-term course of the illness. Common antipsychotic drugs include risperidone (Risperdal), olanzapine (Zyprexa), clozapine (Clozaril), quetiapine (Seroquel), haloperidol (Haldol), thioridazine (Mellaril), chlorpromazine (Thorazine), fluphenazine (Prolixin), and trifluoperazine (Stelazine).

Assessment

Assignment

1. Identify five symptoms of schizophrenia
2. Mention 4 types of schizophrenia
3. Explain the biological basis of schizophrenia disorder
4. Describe the effects of schizophrenia on the brain
5. Highlight the types of drugs used in the management of schizophrenia

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Study Session 13

Biology of Depression

Introduction

Depression is an illness that involves the body, mood, and thoughts, that affects the way a person eats and sleeps, the way one feels about oneself, and the way one thinks about things.

Learning Outcomes

When you have studied this session, you should be able to:

13.1 mention 4 types of depression

13.2 identify 6 symptoms of depression

13.3 discuss possible structural/anatomical changes in the brain of a depressed person.

13.4 describe drug treatment of depression.

13.1 Depression and Its Causes

A depressive disorder is not the same as a passing blue mood. It is not a sign of personal weakness or a condition that can be wished away. People with a depressive disease cannot merely "pull themselves together" and get better. Without treatment, symptoms can last for weeks, months, or years. Appropriate treatment, however, can help most people with depression.

There is not just one cause of depression. It is a complex disease that can occur as a result of a multitude of different factors, including biology, emotional and environmental influences. For some, depression occurs due to a loss of a loved one, a change in one's life, or after being diagnosed with a serious medical disease. For others, depression just happened, possibly due to a family history of the disorder.

13.2 Types of Depression

There are several different types of depression, including:

1) Major depressive disorder
2) Dysthymia (mild chronic depression)
3) Seasonal affective disorder
4) Psychotic depression

13.3 Symptoms of Depression

Symptoms of depression include:

- Poor appetite or weight loss or increased appetite and weight gain
- Difficulty in sleeping (insomnia or sleeping longer (hypersomnia))
- Loss of energy or tiredness to the point where it is impossible to make simple everyday decisions.
- An observable slowing down or agitation, agitated depression shown by wringing of hands, pacing about the room / complaining.
- A markedly diminished loss of interest or pleasure in activities that were once enjoyed.
- Feelings of self reproach or excessive / inappropriate guilt over real or imagined events.
- Complaints or evidence of diminished ability to think or concentrate.
- Suicidal thoughts without a specific plan or a suicide attempt with a specific plan to complete the suicidal behaviour.

Not everyone who is depressed has all these symptoms, but everyone who is depressed has at least some of them, co-existing, on most days.

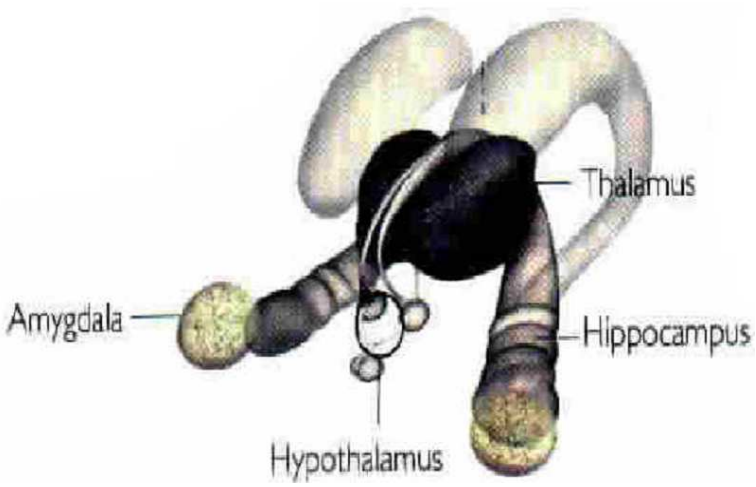
13.4 Biology of Depression

There is absolute proof that people suffering from depression have changes in their brains compared to people who do not suffer from depression.

1. The hippocampus, a small part of the brain that is vital to the storage of memories, is 9%-13% smaller in women with a history of depression than in those who've never been depressed. A smaller hippocampus has fewer serotonin receptors. Serotonin is a neurotransmitter -- a chemical messenger that allows communication between nerves in the brain and the body.

What scientists don't yet know is why the hippocampus is smaller. Investigators have found that cortisol (a stress hormone that is important to the normal function of the hippocampus) is produced in excess in depressed people. They believe that cortisol has a toxic or poisonous effect on the hippocampus. Cortisol is one of several glucocorticoids released by the adrenal glands in response to activity in the so-called hypothalamic-pituitary-adrenal (HPA) axis; because cortisol levels increase in response to stress, there may be a link between stressful life events and the development of depression. Abnormalities in glucocorticoid metabolism may be tested directly using the dexamethasone suppression test (DST). It’s also possible that depressed people are simply born with a smaller hippocampus and are therefore inclined to suffer from depression.

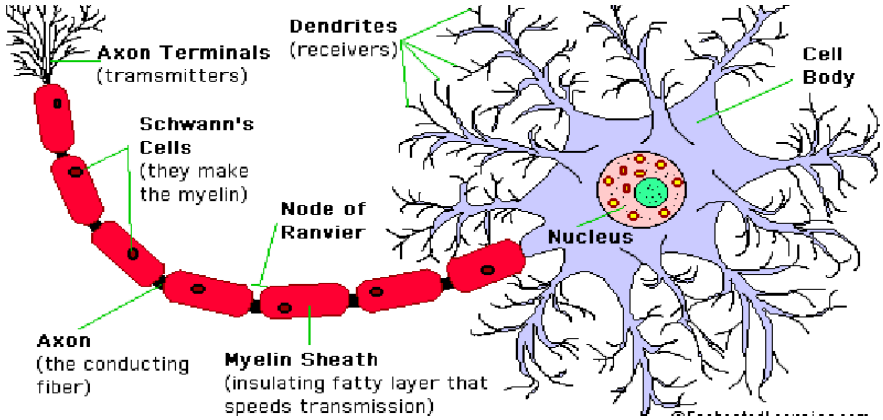
Fig 13.1 Limbic system showing amygdale, thalamus, hippocampus and hypothalamus



You may have heard that depression is the result of a simple imbalance of brain chemicals. Although brain chemicals are certainly part of the cause, this explanation is too simplistic.

The brain uses a number of chemicals as messengers to communicate with other parts of itself and with the nervous system. These chemical messengers, called neurotransmitters, are released and received by the brain's many nerve cells, which are also called neurons. Neurons are constantly communicating with each other by way of exchanging neurotransmitters. This communication system is essential to all of the brain's functions.

Fig 13.2 A picture of what a neuron in the brain looks like.



A tiny space called a synapse connects neurons to one another. In a simple scenario, one neuron (the sender) sends a neurotransmitter message across the synapse and the next neuron (the receiver) receives that message by way of a receptor embedded on its surface. Receptors are tiny molecules that function like a lock on a door. Receptors have chemical channels with particular shapes, which perfectly match the shape of neurotransmitter molecules that are sent across the synapse. When a "matching" neurotransmitter and receptor come into contact with each other, the neurotransmitter fits itself into the receptor molecule's channel. As a result, the receptor becomes activated or opened, just like when a key enters a lock and turns to open it. When there are no

neurotransmitter molecules around to unlock the receptors, the receptors remain in a closed or inactive state.

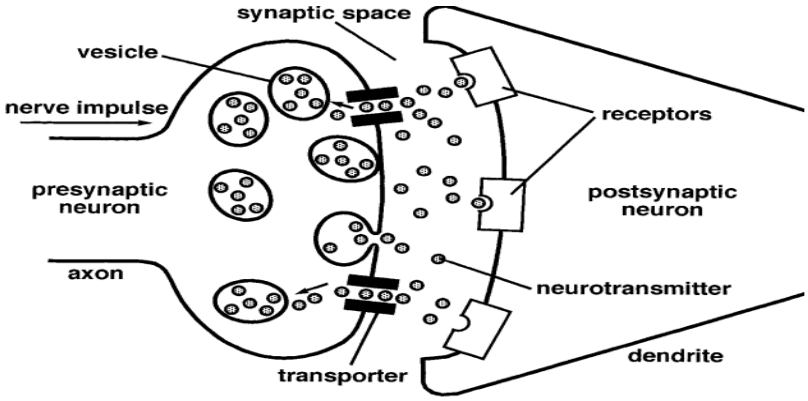


Fig 3.2 A synaptic transmission

In music, it is not just the notes that make up a melody; it is also the spaces or rests between the notes that make each note stand out and be distinct. It's exactly the same with regard to neurotransmitters and synapses. There needs to be some quiet time between neurotransmitter messages for those messages to have any meaning. It is important that receptors be allowed to reset and deactivate between messages so that they can become ready to receive the next burst of neurotransmitters. In order to achieve this "resetting", the receptors relax and release their captured neurotransmitters back into the synapse where about 90% of them get taken up again (in a process called reuptake) by the original sending neuron. The neurotransmitters are then repackaged and reused the next time a message needs to be sent across the synapse. Even though this seems like a complicated set of steps, this entire information transmission cycle occurs in the brain within in a matter of seconds. Any problem that interrupts the smooth functioning of this chain of chemical events can negatively impact both the brain and nervous system.

The brain deactivates the neurotransmitter substance once it has passed on its message in one of two ways:

1) Either an enzyme (monoamine oxidase) is produced which breaks down the chemical messenger or
2) The neurotransmitter is reabsorbed into the preexisting neuron a process called reuptake.

Several specific neurotransmitters, including one called serotonin, are responsible for regulating moods, as well as appetite, sleep and stress response functions. Lowered mood happens when the brain can’t access enough of the right combinations of these neurotransmitters.

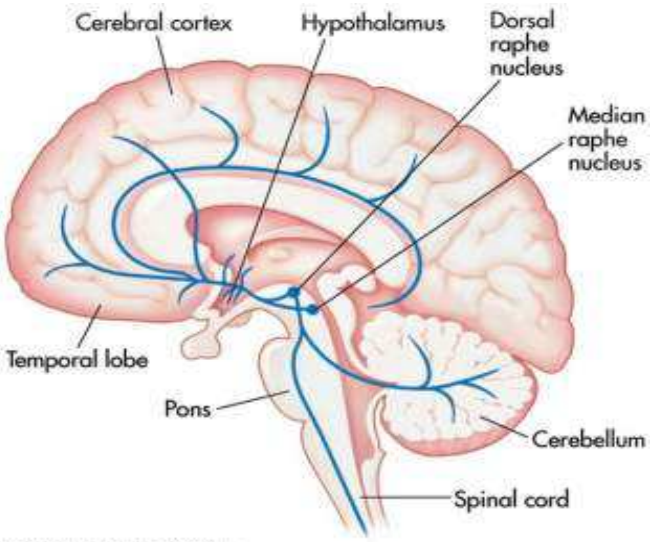


Fig 13.3 Serotonin pathways in the Brain

Several things might potentially go wrong with this process and lead to a serotonin deficit. Just to enumerate a few possibilities:

i. Not enough serotonin is produced,
ii. There are not enough receptor sites to receive serotonin,
iii. Serotonin is being taken back up too quickly before it can reach receptor sites,
iv. Chemical precursors to serotonin (molecules that serotonin is manufactured from) may be in short supply.
v. As you can see, if there is a breakdown anywhere along the path, neurotransmitter supplies may not be adequate for your brain's needs. Inadequate supplies lead to the symptoms that we know as depression.

Teuting carried out a study in 1981 to measure the amount of serotonin and noradrenaline in urine samples of depressed and non-depressed participants. He found empirical support for the biology of depression where depressed participants had lower levels of these two neurotransmitters in their urine, compared to control participants. Further biological evidence concerning the cause of depression comes from many twin studies of monozygotic (MZ) and di-zygotic (DZ) twins. Price (1986) wanted to provide evidence for a genetic cause of bipolar depression. He examined sets of MZ twins and DZ twins. As the identical twins shared 100% of their genes, it was expected that they would have very similar psychological functioning. This was called the concordance rate. There should have been a lower concordance rate for DZ twins as they share only 50% of their genes. In his sample of 97 pairs of MZ twins, raised by the same family he found a concordance rate of 68%. The concordance rate for DZ twins (119 pairs) was only 23 % for bipolar disorder in DZ twins. This shows that biology and not other social factors like being raised with an identical sibling, is a major contributor in bipolar depression.

13.5 Biological Treatment of Depression

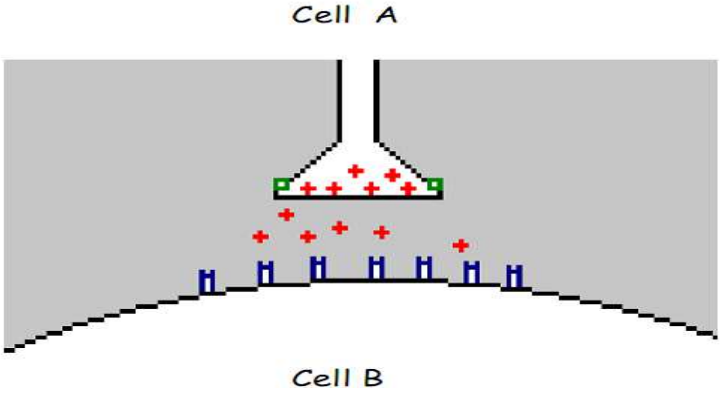
Drug Therapy

The first anti-depressants, developed in the 1950s, are the tricyclic anti-depressants (TCA) and the monoamine oxidase (MAO) inhibitors. TCAs block the reuptake of three neurotransmitters: serotonin, norepinephrine, and dopamine. TCAs include the drugs amitriptyline, doxepin, imipramine, nortriptyline, and desipramine. Although TCAs are as effective as the anti-depressants developed later, they have more unpleasant side effects.

MAO inhibitors decrease the rate at which neurotransmitters are broken down by the body so they are more available to interact with nerve cells, or neurons. MAO inhibitors currently available in the United States include phenelzine and tranylcypromine.

A third group of anti-depressants, known as selective serotonin reuptake inhibitors (SSRIs), became available in 1987. SSRIs block the reuptake of the neurotransmitter serotonin, thereby prolonging its activity. There are currently a number of SSRIs available for use in the United States, including fluoxetine, sertraline, paroxetine, and citalopram. Of this group, the best known is fluoxetine, commonly known by its brand name, Prozac. Sertraline is sold as Zoloft, paroxetine as Paxil, and citalopram as Celexa. Although all SSRIs work the same way, they have different side effects. Newer groups of anti-depressants regulate the levels of serotonin and an additional neurotransmitter. The best-known serotonin and norepinephrine reuptake inhibitor (SNRI) is venlafaxine. Bupropion, sold as Wellbutrin, is a serotonin and dopamine reuptake inhibitor (SDRI). Tetracyclic anti-depressants prevent the neurotransmitters serotonin and norephinephrine from binding to nearby nerve cells. Mirtazapine, sold as Remeron, is a tetracyclic antidepressant.

Fig 13.4

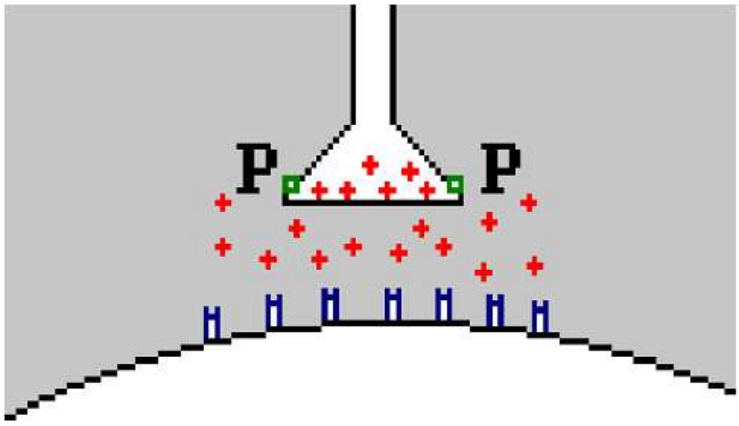


This is a picture of the synapse between two neurons. As you can see Cell A has released neurotransmitters to communicate to Cell B (red). Cell B has receptors that are specific to these neurotransmitters. (Blue) These receptors will only respond to the specific neurotransmitter that fits its receptor. On Cell A you can see green areas which represent how the left over neurotransmitter in the synapse is taken back up into Cell A to be recycled and used again.

How Anti-depressants Affect this Communication Process

We know that anti-depressants increase the amount of neurotransmitter available in the synapse, but how does it do this? There are two ways that anti-depressants do this. The first is by decreasing the amount of neurotransmitter being broken down by enzymes in the synapse that "eat up" the extra- neurotransmitters. The second way neurotransmitters are decreased is by decreasing the amount of neurotransmitter taken back up into Cell A. These medications are known as the Selective Serotonin Reuptake Inhibitors (SSRI's).

Fig 13.4



In this picture the "P" stands for Prozac. In a patient who was taking Prozac you would see that the reuptake channels for the serotonin neurotransmitter were blocked, ultimately leaving more serotonin available in the synapse. (Red) This is true of the other SSRI's like Zoloft, Paxil, Celexa and Lexapro.

How effective are antidepressants?

Researchers agree that when depression is severe, medication can be helpful—even life–saving. However, research shows that antidepressants fall short for many people. A major government study released in 2006 showed that fewer than 50 percent of people become symptom-free on antidepressants, even after trying two different medications. Furthermore, many who do respond to medication slip back into major depression within a short while, despite sticking with drug treatment.

Other studies show that the benefits of depression medication have been exaggerated, with some researchers concluding that, when it comes to mild to moderate depression, anti-depressants are only slightly more effective than placebos.

Side Effects of Anti-Depressant Medication

Side effects are common in all anti-depressants. For many people, the side effects are serious enough to make them stop taking the medication.

Side effects of SSRIs (selective serotonin reuptake inhibitors)

The SSRIs act on a chemical in the brain called serotonin. Serotonin helps regulate mood, but it also plays a role in digestion, pain, sleep, mental clarity, and other bodily functions. As a result, the SSRI antidepressants cause a wide range of side effects. Common side effects

include sexual problems, drowsiness, sleep difficulties, and nausea. While some side effects go away after the first few weeks of drug treatment, others persist and may even get worse.
In adults over the age of 65, SSRIs pose an additional concern. Studies show that SSRI medications may increase the risk for falls, fractures, and bone loss in older adults. The SSRIs can also cause serious withdrawal symptoms if you stop taking them abruptly. These symptoms include: nausea, insomnia, anxiety, restlessness, decreased sex drive, dizziness, weight gain or loss, tremors, sweating, sleepiness, fatigue, dry mouth, diarrhea, constipation, and headaches.

Side effects of atypical anti-depressants
There are a variety of newer depression drugs, called atypical antidepressants, which target other neurotransmitters either alone or in addition to serotonin. Some of the brain chemicals they affect include norepinephrine and dopamine. The side effects vary according to the specific drug. However, many of the atypical anti-depressants can cause nausea, fatigue, weight gain, sleepiness, nervousness, dry mouth, and blurred vision. The atypical anti-depressants include: Bupropion (Wellbutrin), Venlafaxine (Effexor), Mirtazapine (Remeron), and Duloxetine (Cymbalta).

Study Session Summary

Summary

In this Study Session, we observed that depression is an illness that involves the body, mood, and thoughts that affect the way a person eats and sleeps, the way one feels about oneself, and the way one thinks about things. Depression can occur as a result of biological, emotional and environmental influences. We also noted the following:

- Types of depression include: major depressive disorder, dysthymia (mild chronic depression), seasonal affective disorder, and psychotic depression
- Symptoms of depression could include: poor appetite or weight loss or increased appetite and weight gain, difficulty in sleeping (insomnia or sleeping longer (hypersomnia), loss of energy or tiredness to the point where it is impossible to make simple everyday decisions. an observable slowing down or agitation, a markedly diminished loss of interest or pleasure in activities that were once enjoyed; feelings of self reproach or excessive / inappropriate guilt over real or imagined events, complaints or evidence of diminished ability to think or concentrate, and suicidal thoughts
- There is absolute proof that people suffering from depression have changes in their brains compared to people who do not suffer from depression. For example, the hippocampus is smaller in women with a history of depression, their hippocampus have fewer serotonin receptors.
- Drugs used in the treatment of depression include tricyclic antidepressants (TCA), monoamine oxidase (MAO) inhibitors, and selective serotonin reuptake inhibitors (SSRIs).

Assessment

Assignment

1. Mention 4 types of depression.
2. Identify 6 symptoms of depression.
3. Discuss possible structural/anatomical changes in the brain of a depressed person.
4. Highlight possible neurotransmitter disorders in the brain of a depressed person
5. Describe psychological methods of managing depression.

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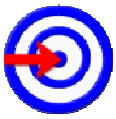
Study Session 14

Human Sexual Motivation

Introduction

Human sexual motivation is an unusual motivation. In lower animals we speak about sexual motivation as a "drive." That is, we state that some internal, innate force pushes the animal to engage in reproductive behaviour. Humans don't simply give in to an internal push towards sexual behaviour. Instead, human motivation to engage in sexual behaviour is due to a complex relationship among several factors. You will therefore explore human motivation in this Study Session.



Learning Outcomes

When you have studied this session, you should be able to:

14.1 describe human sexual motivation.

14.2 highlight at least four factors in human sexual motivation.

14.3 analyse human sexual motivation.

14.1 The Concept of Human Sexual Motivation

Most theorists refer to motivation as an inferred need, desire or impulse which initiates directs and sustains behavior (e.g., Coon, 1997; Wood and Wood, 1996). One group of psychologists calls motivation a factor which explains the relations between stimuli and behavior (Bernstein, Clarke-Stewart, Roy, and Wickens, 1997). By combining these two definitions and applying them to human sexual behavior we could say that sexual motivation is an inferred, internal state influenced by several factors which determines engagement in sexual activity.

14.2 Factors in Human Sexual Motivation

It is common to try to organise various psychological topics by placing the factors involved into environmental and physiological categories. For example, you would place hormones, a known component of sexual motivation, into the physiological category. But where would you place something like desire for physical pleasure, a frequently cited element in sexual motivation (Abramson and Pinkerton, 1995; Cofer, 1972; Hatfield and Rapson, 1993)? Physical pleasure has both a physiological

component (the physical sensations associated with touch) and a subjective psychological component. Where does something subjective like pleasure fit in our breakdown into physiological and environmental components? Pleasure is an emotion (Cofer, 1972), which, according to the Schacter-Singer theory, is a subjective feeling based upon physiological arousal and interpretations of the stimuli that are linked to the arousal (Cornelius, 1996). Thus emotions are both physiologically and cognitively-based.

14.3 Analysis of Human Sexual Motivation

Physiological Correlates - An analysis of human sexual motivation couldn't proceed without first discussing physiological factors, in particular, hormones. The influence of hormones in sexual behaviour is well-supported by research. Both men and women produce estrogens, progestins and androgens, though women produce far more estrogens and progestin and men more androgens (Hokanson, 1969; Leger, 1992). In lower species, hormone levels are almost directly correlated with sexual behavior, however, as one moves up the phylogenetic scale, other elements become involved (Fisher, 1993; Hokanson, 1969). In humans, hormones are also related to sexual desire, but are not the entire story.

In males, a minimum level of testosterone is necessary to maintain normal sexual motivation in males (Leger, 1992). If males' testosterone levels fall below the threshold, sexual motivation is greatly reduced. However, once the threshold level is reached, it no longer predicts sexual behavior/activity. Women's studies also show correlations between hormones and sexual desire (Leger, 1992; Sherwin and Gelfan, 1987; Sherwin, Gelfan, and Brender, 1985), however, the results are inconsistent (Leger, 1992). Since neither increases nor decreases in hormones in either males or females are perfectly correlated with sexual desire, it stands to reason that there must be other factors involved. As Hokanson (1969) concludes, hormones serve the primary purpose of readying the individual for action, but other factors determine whether the individual actually engages in sexual activity.

Another physiological factor in sexual motivation may well be odor and sense of smell. Of all the elements researched, odor and sense of smell have received the least attention, probably because, as Kohl and Francoeur (1995) state, their influence on sexual behavior is difficult to ascertain. However, body odor (i.e. airborne hormones) definitely influences our behaviorus. In their review of numerous studies such as synchronization of menstrual cycles of women who live together, and the influence of hormone-scented masks on individuals' ratings of others, Kohl and Francoeur (1995) state that odor must be involved in our sexual behaviours also. Odors may influence sexual behavior.

Sexual Orientation - Our desire to engage in sexual behavior with someone is also influenced by sexual orientation. Sexual orientation refers to the direction of an individual's sexual attraction (Wood, et al., 1996). Most individuals are heterosexual (Laumann, 1994; Wellings, et al., 1994) which means they are primarily attracted to the opposite sex.

Homosexuals are individuals who are attracted to the same sex and bisexuals are attracted to both sexes.

Why are individuals attracted to one sex rather than another? LeVay (1995) believes that most researchers of the topic agree it is a combination of multiple factors including genetic makeup, hormones and social experiences. He further believes that newer studies (e.g., Bailey and Pillard, 1991; Bailey, Pillard, Neale, and Agyei, 1993) indicate that genes are perhaps more influential than the other factors. Studies indicate that the percentage of individuals who call themselves homosexual is quite small, ranging from about .5% to 2.8% (Laumann, 1994; Wellings, et al., 1994). This estimate is significantly lower than the rates given in the problematic Kinsey Reports (1948; 1953).

In his review of several studies on the prevalence of homosexuality, LeVay (1995) states that it is best to keep an open mind towards reviewing new evidence since changing attitudes and beliefs appear to be linked to self-stated homosexuality. What he was referring to was the indication that individuals are more likely to express their gay behavior within their own culture as that culture becomes more accepting of homosexuality. Thus it is apparent that culture influences the expression of one's sexual orientation which in turn influences sexual motivation.

Pleasure - As mentioned earlier, pursuit of erotic pleasure is a primary reason to engage in sexual behavior (Abramson et al., 1995; Hatfield et al., 1993). Kinsey and colleagues (1953) found that children between the ages of 2 and 5 years of age spontaneously touch their genitals. At this age, one could not argue that this sexual behavior is learned or designed to contribute to reproduction. Abramson and Pinkerton (1995) point out that the pleasure of sexual behavior is physiologically and psychologically-based and that the sex organs do not exist merely to guarantee reproductive behavior. As an example, they cite the female orgasm, uncommon during vaginal penetration, but very common by more direct means of clitoral stimulation. In other words, sexual pleasure does not occur merely to ensure procreation. We engage in sexual behavior because it is enjoyable. However, as will be reviewed later, what is considered pleasurable may well be influenced by one's interpretation of the stimuli.

Cognitions - How a stimulus is interpreted influences how individuals respond to that stimulus. Zellman and Goodchild (1983) surveyed 400 teenagers and found that the behaviours girls felt conveyed romantic interest were the same actions boys considered invitations to sex. Since societies create very different gender roles for men and women, differences in interpretation of the same data are bound to occur (Wade, et al., 1996). Wade's comments indicate that culture influences sexual behaviors, not only through performance of behaviors that are considered appropriate, but also through interpretation of those behaviours.

Cognitions and arousal - Based upon the results of surveys such as the Kinsey studies (1948; 1953), men have been considered to be more sexually responsive than women. Early studies comparing men and women's subjective responses to erotic films supported that theory. However, when studies were conducted comparing male and female

physiological responses to male-produced, male-intended erotic films, researchers found that men and women actually experienced the same physiological arousal (Laan, Everaerd, Van Bellen, and Hanewald; 1994). When participants were asked to express their feelings about the stimuli, men reported sexual arousal and positive affect, yet women reported disgust and lack of arousal. In other words, both men and women experienced the same physiological arousal but different subjective arousal. When women viewed an erotic film produced by women for women, the female participants showed the same physiologic arousal as they did to male-produced films, but reported significantly greater sexual arousal, interest and positive affect. As interpreted by the researchers, the difference was due to how women interpreted the content of the films. Essentially, this study indicated that interpretation of the stimuli is of great importance in subjective feelings of sexual arousal. Cognitions affect sexual arousal in another fashion. According to Kalat (1996), inhibition of arousal can occur in individuals who believe that sex is shameful. These individuals experience sexual arousal, but have difficulties achieving sexual orgasm because of their thoughts.

Palace and Gorzalka (1992) study sexually functional and dysfunctional women and found that cognitions and physiological arousal were simultaneously important in sexual arousal. They hypothesized that cognitions and physiological arousal comprise a feedback loop to determine overall sexual arousal. These many studies indicate that the thoughts individuals have regarding various stimuli impact individuals sexual motivation through influencing their arousal or their interpretations of behavior.

Attraction - Numerous elements have been identified as playing a role in attraction. For example, attraction is a function of proximity (how frequently you cross paths with someone), familiarity and similarity (e.g., in looks, or attitudes) (Kalat, 1996). This has been supported both with studies of attraction to friends and to romantic partners.

Playing hard-to-get also contributes to human's attraction to one another (Hatfield, Walster, Piliavin and Schmidt, 1988). Apparently individuals make attributions about potential significant others based upon how quickly that person returns a show of interest. Those who are easily attained are less attractive than those who are more difficult to attain due to the traits the relationship-seeker attributes to her. For example, relationship seekers fear that easy-to-get women might display inappropriate behaviors in public. However, a hard-to-get woman who indicates interest in the relationship-seeker has positive traits attributed to her such as warmth and friendliness.

Another overwhelmingly important element in attraction is physical attractiveness. As stated previously, research between attitudes and behaviors are not always consistent. Research on what individuals find attractive in potential dates provides further evidence for this inconsistency in human sexual behavior. Although subjects stated that physical attractiveness was one of the least important elements in their attraction to someone else, in actual experiments using blind dates, the only factor which predicted whether subjects desired a second date with the same person was the attractiveness of the blind date (Walster, Aronson, Abrahams, and Rottman, 1966). This was true for both male

and female participants of the study. In a study on physical attractiveness and relationship length, the factor which best predicted whether couples would remain together nine months after they began dating was the similarity in their physical attractiveness (White, 1980). This "matching" phenomenon in which people tend to select mates that match them in terms of physical attractiveness, has been replicated and expanded upon with consistent results (Feingold, 1988). It might seem that we learn to appreciate beauty from the culture that we are born into, yet studies of pre-school children indicate that they too, prefer attractive classmates and also make attributions based on classmates' physical characteristics (Dion and Berscheid, 1971).
Attraction to others is yet another element of sexual motivation that has its roots in both nature and nurture -- it is obviously innate to seek out attractive others, yet we still lean towards mates who are more similar to us, an apparent influence of culture and learning in addition to an inherited predisposition.

Learning - Learning is, of course, highly influential in sexual motivation. We copy the behaviors of those we respect and admire. We learn to repeat behaviors that are rewarded (and sexual behavior is rewarding for most) and we learn to discontinue behaviors that have negative outcomes. Conditioning is believed to influence sexual motivation. Certain stimuli may increase sexual arousal. For example, one might become sexually aroused by candlelight due to the learned association with sexual pre-encounters such as a romantic, candlelight dinner. It has also been proposed that conditioning accounts for sexually dysfunctional behaviours and sexual deviance (O'Donohue and Plaud, 1994). For example, a pedophile (person sexually aroused by children) might have been accidentally sexually aroused in the presence of a child. Principles of conditioning indicate he would seek this same combination of factors in the future in order to achieve the same pleasurable circumstances again. Fear of rejection, a learned component, is indeed the reason most often given by single men for not engaging in sex.
Matching theory (Carli, Ganley, and Pierce-Otay, 1991), which states that individuals within couples are frequently very similar in attractiveness ratings, is easily understood using the principles of conditioning. For example, an average-looking man who is rebuffed whenever he approaches beautiful females should reduce his attempts to interact with beautiful women. Similarly, he should rebuff less-attractive women if he could interact with more attractive women. Who he ultimately couples with should be very similar in looks due to the conditioning of each person's partner-choosing behaviors.
Conditioning as a theory to explain sexual deviance and dysfunction is not without its critics. O'Donohue and Plaud (1994) examined several studies which used behavioural and aversion therapy to change sexual behaviors. Due to methodological problems in the studies they examined, they believe that conditioning plays a much smaller role in sexual motivation than previously believed. Thus conditioning may play some role in the sexual motivation, but how much of a role it plays is not clear.

Culture - As mentioned throughout this essay, culture determines what behaviors are gender appropriate, what behaviors may or may not be

performed in public, and what behaviors are considered sexually arousing. Yet culture and learning are inextricably tied together. An individual could not acquire his or her culture's norms without learning taking place. Conversely, there is very little one could learn which is not influenced by culture. For example, when we model the behaviors of individuals from our own society, we are copying behaviours that are more than likely already societally-influenced. If we view behaviors performed by individuals from another culture, we do so through lenses already colored by our society's influence. Hence any learning we might acquire from a culturally-different person is mediated by our own culture first.

Attitudes and Culture - Attitudes are defined as relatively stable evaluations of a person, object, and situation or issue (Wood et al., 1996). Studies have shown that behaviors normally considered proper in one culture, may be improper or unarousing in another. In other words, attitudes towards sexual behaviors are culturally learned. For example, some cultures find kissing repulsive (Tiefer, 1995) while other cultures insist on same-gender sex as a rite of passage into adulthood (Herdt, 1984).

It is still noted, even in some surveys in the United States (e.g., Laumann et al., 1994), that men and women have different attitudes toward sexual behaviors. For example, men are more interested in a variety of sexual behaviors, such as group sex, than are women. These divergences are undoubtedly, as mentioned earlier, a function of the gender roles each society impresses upon its members. A comparison of Swedish and American college students sought to examine if indeed the difference in men's and women's attitudes could be definitively tied to culture, rather than inherent gender differences (Weinberg, Lottes, Shaver, 1995). Specifically, it was believed that men and women in Sweden would have more convergent and relaxed attitudes toward sexual behaviors than the American participants. Sweden is generally known to have more relaxed sexual standards. It is believed that this is due, in part, to several years of mandatory sex education and the relatively equal power that women have in society. The study indeed showed that Swedish men and women had very similar attitudes towards sexual behaviours. Americans, as expected, had very different attitudes about what constituted appropriate sexual behaviors. We should remember it was cautioned earlier against drawing causal conclusions from a descriptive study such as this; however the information further indicates that culture is associated with differences in sexual attitudes.

The influence of learning on sexual motivation is quite profound. Attraction, cognitions, and sexual orientation, variables mentioned previously are also influenced by learning. Thus a key component which determines the level of our sexual motivation is learning.

Study Session Summary

Summary

In this Study Session, you learnt that sexual motivation is influenced by complex relationships among numerous factors including hormones, cognitions, learning and culture. Because these variables are also associated with one another, in addition to sexual motivation, it is difficult to place them in discrete categories. Finally, the inability to clearly isolate the many variables involved in human sexual motivation ensures that this topic will continue to fascinate researchers for a very long time.

Assessment

Assignment

1. Identify factors in Human Sexual Motivation.
2. Discuss physiological correlates.
3. Describe sexual orientations, giving three examples to illustrate these.
4. Highlight the role of pleasure, cognitions, attraction, learning, and culture in human sexual motivation.

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