Adult Basic Education

Science

Biology 3101A

Maintaining Dynamic Equilibrium II

Curriculum Guide

Prerequisites: Biology 2101A
Biology 2101C

Credit Value: 1

Biology Concentration

Biology 1101
Biology 2101A
Biology 2101B
Biology 2101C
Biology 3101A
Biology 3101B
Biology 3101C

Table of Contents

To the Instructor

I. Introduction to Biology 3101A

Biology 3101A is the first of three courses (the others are Biology 3101B and Biology 3101C) that are equivalent to Biology 3201 in the current high school system.

Biology 2101A, *The Cell*, and Biology 2101C, *Maintaining Dynamic Equilibrium I*, are **pre-requisites** for this course. However, before deciding to leave out any courses in the Biology concentration, you should ensure that you are aware of what courses students need to complete in order to meet the entrance requirements for the receiving post-secondary institution that they plan to attend.

Biology 3101A will identify and introduce the role of the nervous (electrochemical) and endocrine (chemical) systems in the body. Cells, tissues, organ systems and ultimately organisms must maintain a biological balance despite changing external conditions. Homeostasis is the state of internal balance so critical to existence. It represents a dynamic equilibrium, displaying constant interactions and checks and balances both within organisms and between organisms and their environment. There are a variety of systems within living things responsible for the maintenance of this delicate balance.

II. Curriculum Guides

Each new ABE Science course has a Curriculum Guide for the instructor and a Study Guide for the student. The Curriculum Guide includes the specific curriculum outcomes for the course. Suggestions for teaching, learning, and assessment are provided to support student achievement of the outcomes. Each course is divided into units. Each unit comprises a **two-page layout of four columns** as illustrated in the figure below. In some cases the four-column spread continues to the next two-page layout.

To the Instructor

Curriculum Guide Organization:
The Two-Page, Four-Column Spread

Unit Number - Unit Title		Unit Number - Unit Title	
Outcomes Specific curriculum outcomes for the unit.	**Notes for Teaching and Learning** Suggested activities, elaboration of outcomes, and background information.	**Suggestions for Assessment** Suggestions for assessing students' achievement of outcomes.	**Resources** Authorized and recommended resources that address outcomes.

III. Study Guides

The Study Guide provides the student with the name of the text(s) required for the course and specifies the sections and pages that the student will need to refer to in order to complete the required work for the course. It guides the student through the course by assigning relevant reading and providing questions and/or assigning questions from the text or some other resource. Sometimes it also provides important points for students to note. (See the *To the Student* section of the Study Guide for a more detailed explanation of the use of the Study Guides.) The Study Guides are designed to give students some degree of independence in their work. Instructors should note, however, that there is much material in the Curriculum Guides in the *Notes for Teaching and Learning* and *Suggestions for Assessment* columns that is not included in the Study Guide and instructors will need to review this information and decide how to include it.

IV. Resources

Essential Resources

Text: Biology; Bullard, Chetty, et al; McGraw-Hill Ryerson, 2003.

McGraw-Hill Ryerson, Biology, Teacher's Resource.

Recommended Resources

McGraw-Hill Ryerson, Biology, Teacher's Resource CD-ROM.

McGraw-Hill Ryerson, Biology 11/12 #D Science Animations.

McGraw-Hill Ryerson, Biology 11/12 Computerized Assessment Banks.

Department of Education web site:
www.gov.nl.ca/edu/science_ref/main.htm

Other Resources

Textbook web site:
http://www.mcgrawhill.ca/school/booksites/biology/

Center for Distance Learning and Innovation: http://www.cdli.ca/

V. Recommended Evaluation

Written Notes	10%
Labs/Assignments	20%
Test(s)	20%
Final Exam *(entire course)*	50%
	100%

The overall pass mark for the course is 50%.

Maintaining Dynamic Equilibrium II

Unit 1 - Nervous System: Structures

Outcomes

1.1 Analyze the nervous system and explain its structure and dynamics.

1.1.1 Explain the basic structure and function of the central nervous system. Include:
(i) brain
(ii) spinal cord

1.1.2 Explain how the nervous system is protected. Include:
(i) skull
(ii) meninges
(iii) cerebrospinal fluid

1.1.3 Explain the basic structure and function of the brain. Include:
(i) cerebrum
(ii) cerebellum
(iii) medulla oblongata
(iv) thalamus
(v) hypothalamus
(vi) midbrain
(vii) pons
(viii) corpus callosum

1.1.4 Describe the basic functions of a peripheral nervous system. Include:
(i) autonomic
- sympathetic
- parasympathetic

(ii) somatic

Notes for Teaching and Learning

Students should be given the opportunity to observe the principal features of the central nervous system, using models, dissected mammalian brains or computer simulations, and to identify and label major physical structures and their functions from drawings or photos of that organ.

Students should understand that the basic function of the cerebrum is to sort and interpret all the information from our senses. It is the part of the brain that makes humans different from animals because it is the centre of human consciousness. Students should also understand that the cerebrum can be divided into two hemispheres (left and right) or into four lobes (frontal, parietal, temporal, occipital). For this course it is not necessary for students to know the function of each hemisphere or lobe individually.

Students may have difficulty understanding the divisions and overall functioning of the nervous system. They should study the chart in Appendix A, "Organization of the Nervous System".

Unit 1 - Nervous System: Structures

Suggestions for Assessment

Presentation

- When teaching to a group, instructors could invite a physician or public health specialist to give a presentation on some aspect of the nervous system. Students should research and prepare questions related to the topic. With the instructor, students should review and revise questions. The questions selected should be asked during the presentation. Following the presentation students should prepare a brief summary of the answers given.

Laboratory Activities

- Students could identify regions of preserved sheep brain.

Pencil and Paper

- Students should complete relevant Section Review and Chapter Review questions.
- Students should start to develop a glossary of terms that they discover and will use in this unit. The glossary can be added to as students progress through the unit.
- Students can prepare a chart to visually contrast the sympathetic and parasympathetic components of the autonomic nervous system on various parts of the body (e.g., heart, digestive tract, blood vessels, bladder, bronchi, eye).
- Students could prepare a chart to show the organization of the human nervous system.
- Students should label the diagram of the human brain. Instructors should make sure that students are able to label the diagram correctly without referring to the text or any other resource.

Resources

McGraw-Hill Ryerson Biology, pages 392-401.

McGraw-Hill Ryerson Biology, Teacher's Resource.

McGraw-Hill Ryerson Biology, Teacher's Resource CD-ROM.

Biology 11/12 Computerized Assessment Banks.

Diagram, "The Human Brain", Appendix A.

www.gov.nl.ca/edu/science_ref/main.htm

http://www.mcgrawhill.ca/school/booksites/biology/

Unit 2 - Nervous System: Neurons

Outcomes	Notes for Teaching and Learning
2.1 Explain how the nervous system helps to maintain homeostasis.	The nervous system is responsible for receiving information from internal and external stimuli and the quick response to that information. Students have explored the concept of homeostasis in Biology 2101C. This concept can be reviewed with students and related to the nervous system.
2.1.1 Identify requirements necessary for a nervous response to occur. Include: (i) sensory receptors (skin, eye, ear) (ii) impulse transmission (neurons) (iii) interpretation and analysis of impulses (brain, spinal cord) (iv) effectors (muscle, gland)	Students should review the concepts of dynamic equilibrium, negative feedback loop, sensory receptors, integrators and effectors.
2.1.2 Define neuron, nerve and reflex arc.	Students can observe microscopically the structure of neurons and neuromuscular junctions on prepared microscope slides within the laboratory. Instructors should note that the axon terminal is not specifically named in the textbook. The axon terminal is described as the bulb-like ends of the axon. Other terms for this structure may include end brushes or terminal endings.
2.1.3 Describe the structure of the typical neuron and explain the function of each part. Include: (i) dendrite (ii) cell body (iii) axon	Students should complete Investigation 12.A: "The Nervous System and Reflex Responses". "Exploring Further" section could be made optional.
2.2 Perform an experiment to investigate and collect data on the nervous system (reflexes).	

Unit 2 - Nervous System: Neurons

Suggestions for Assessment

Laboratory Activities

- Students could perform the available laboratory activities provided to illustrate some aspects of the nervous system. These may include microscopic examination of components of the nervous system, dissection of specimens, or observation of models in order to observe the structure of the nervous system.

  They may also include activities to investigate reflex times, observation of the behaviour in response to stimuli of specimens like Planaria or the effect of the stimulant caffeine on Daphnia. Assessment would depend on the nature and depth of the activities selected.

- Students must complete Investigation 12.A, "The Nervous System and Reflex Responses".

Paper and Pencil

- Students should label the diagram of a neuron. Instructors should make sure that students are able to label the diagram correctly without referring to the text or any other resource.

- Students should complete relevant Section Review and Chapter Review questions.

- Students should add to the glossary of terms.

Resources

MGH Biology, pp. 392, 395 402-404.

Core Lab:
Investigation 12.A, "The Nervous System and Reflex Responses", pp. 396-397.

Diagram, "A Neuron", Appendix A.

Unit 3 - Nervous System: Disrupting Homeostasis

Outcomes	Notes for Teaching and Learning
3.1 Describe disorders linked to the nervous system and their effect on homeostasis of the system and the organism as a whole. Include: (i) Multiple Sclerosis (ii) Alzheimer's Disease (iii) Parkinson's Disease (iv) Meningitis	Specific pathologies of the nervous system could be researched along with the capability of technology to diagnose, treat or cure the problem. The research might include an investigation of the physiological basis and causes of neurological diseases and discuss the effectiveness and the ethics of new innovative treatments (e.g., transplant of fetal brain tissue into patients as a treatment for Parkinson's). Students may be interested in other conditions related to nervous function, such as polio, stroke, Bell's palsy, ALS, Tourette's Syndrome, epilepsy or mental disorders related to chemical imbalances. The research provides a good opportunity for linkage with the Language Arts program.
3.2 Analyze why and how technologies related to the treatment of nervous system disorders were developed. and improved over time. Include: (i) MRI (ii) EEG (iii) CAT Scan	Students should investigate how these technologies influence our ability to explore the human brain. It is important that students know something about disorders of the nervous system and something about the technologies available to help diagnose disorders and that they learn more about the functioning of the human brain. Students must complete 2 assignments to cover outcomes 3.1 and 3.2. These assignments are required but the content should not be tested.

Suggestions for Assessment

Presentation

- When teaching to a group, students could be introduced to individuals knowledgeable in nervous system pathologies by using community resources such as physicians, organizations (Alzheimer Society, Parkinson Foundation, Heart and Stroke Foundation, Canadian Mental Health Association, Multiple Sclerosis Society), sufferers of, or caregivers of those who possess these disorders. They could also be introduced to a radiologist/x-ray technician to give a presentation on MRI, CAT, scan of EEG.

- Students should complete relevant Section Review and Chapter Review questions.

- Students should add to the glossary of terms.

Assignment

- Students must complete Assignment 1, *"Nervous System Disorders".*

- **NOTE:**
  The assignment should be marked and the marks used as part of the evaluation for the course. The content covered in the assignments should not be tested.

Resources

MGH Biology, pp. 398-399.

MGH Biology, pp. 404-408.

Assignment 1, "Nervous System Disorders" Appendix A.

Unit 3 - Nervous System: Disrupting Homeostasis

Outcomes

3.3 Describe how the use of prescription and non-prescription drugs can have a role in maintaining or disrupting homeostasis. Include:

(i) anaesthetics

(ii) prescription drugs (OxyContinTM, ValiumTM, RitalinTM)

(iii) illegal drugs (marijuana, ecstasy, cocaine)

(iv) legalized drugs (alcohol, nicotine, caffeine)

Notes for Teaching and Learning

Outcome 3.3 is covered by completing the assignment, "*Drugs and Homeostasis"*. It can be found in Appendix B.

Students may analyze evidence concerning the influence of anaesthetics, drugs and chemicals, natural and synthetic, on the functioning of the nervous and endocrine systems and their relationship to addiction theory (e.g., nicotine, oxycontin, morphine, LSD). Students may compare the relative physiological and societal impacts of chemical and drug use on adult development as compared to fetal development

Students can discuss/debate the merits of using drugs for treatments of nervous disorders against the long-term side effects.

Students can discuss/debate the legalization of certain drugs such as marijuana for medicinal purposes.

Further investigation of the topics covered by the assignment provides a good opportunity for connections with Language Arts courses.

Unit 3 - Nervous System: Disrupting Homeostasis

Suggestions for Assessment

Performance

- In conjunction with the Language Arts program, students could participate in a debate as a means of exploring the use of drugs for the treatment of nervous disorders or regarding the legalization of drugs.

Presentation

- Students could be introduced to individuals knowledgeable in the influence of the use of prescription and non-prescription, legal and illegal drugs on the maintenance of homeostasis within the human system by using community resources such as physicians, pharmacists and available organizations. Students should research and prepare questions related to the topic. With the instructor, students should review and revise questions. The questions selected should be asked during the presentation. Following the presentation students should prepare a brief summary of the answers given.

Assignment

- Students must complete Assignment 2, "*Drugs and Homeostasis"*.

- **NOTE:**
  The assignment should be marked and the marks used as part of the evaluation for the course. The content covered in the assignments should not be tested.

Resources

MGH Biology, p. 408.

Assignment 2, "Drugs and Homeostasis", Appendix B.

Unit 4 - Nervous System: Sense Organs

Outcomes

4.1 Explain how the eye as a sense organ helps maintain homeostasis.

4.1.1 Describe the general structure and function of the eye. Include:
(i) lens
(ii) iris
(iii) retina
(iv) cornea
(v) choroid layer
(vi) fovea centralis
(vii) rods
(viii) cones
(ix) pupil
(x) blind spot
(xi) optic nerve
(xii) aqueous humour
(xiii) vitreous humour

4.1.2 Trace the path of light through the eye and explain how the amount of light entering the eye is regulated.

Notes for Teaching and Learning

The investigation of sense organs serves as a cross-curricular link with the waves/sound/light sections of physics.

Students should observe the principal features of the mammalian eye, using models, dissected structures or computer simulations, and identify and label major visible structures and their functions from drawings or photos of those organs. They should be able to label diagrams of the human eye.

For an elaboration on the blind spot see Minilab on page 413 and Figure 12.21 on page 412.

Unit 4 - Nervous System: Sense Organs

Suggestions for Assessment

Laboratory Activities

- Following the procedure outlined, students could dissect the sheep eye provided and identify the parts. They could complete a table that relates the structure of the parts of the eye with their function.

- Students could do Investigation 12.B, "The Effect of Light on Pupil Size".

Paper and Pencil

- Students should label the diagram of the human eye. Instructors should make sure that students are able to label the diagram correctly without referring to the text or any other resource.

Resources

MGH Biology, pp. 409-413.

Diagram, "The Human Eye", Appendix A.

Unit 4 - Nervous System: Sense Organs

Outcomes	Notes for Teaching and Learning
4.2 Explain how the ear as a sense organ helps maintain homeostasis.	Students should observe the principal features of the mammalian ear, using models, dissected structures or computer simulations, and identify and label major visible structures and their functions from drawings or photos of those organs. They should be able to label diagrams of the human ear.
4.2.1 Describe the general structure and function of the ear. Include: (i) pinna (ii) tympanic membrane (iii) ossicles (i.e., malleus, incus, stapes) (iv) eustachian tube (v) semi-circular canals (vi) cochlea (vii) auditory nerve	Students should know that the ossicles are also known as the hammer, anvil and stirrup respectively.
4.3 Trace the pathway of sound through the ear.	When the pathway is traced through the ear, the structures should be limited to only those discussed above. Students should recognize the importance of hair cells in transmission of sound through the cochlea to the auditory nerve.

Unit 4 - Nervous System: Sense Organs

Suggestions for Assessment

Paper and Pencil

- Students could construct a flow chart that shows the path of sound energy through the auditory system.
- Students should complete relevant Section Review and Chapter Review questions.
- Students should label the diagram of the human ear. Instructors should make sure that students are able to label the diagram correctly without referring to the text or any other resource.

Testing

- This is the end of the section of the course covering the nervous system. Instructors may choose to give a test to cover units 1 - 4. The mark for this test could be used as part of the evaluation for the course. Testing should include some of the diagrams that students have studied.

Resources

MGH Biology, pp. 414-416.

Diagram, "The Human Ear", Appendix A.

Biology 11/12 Computerized Assessment Banks.

Unit 5 - Endocrine System: Maintaining Homeostasis

Outcomes

5.1 Explain how the endocrine system helps maintain homeostasis.

5.1.1 Understand the general concept of a hormone and target cell or organ.

5.1.2 Compare how non-steroid and steroid hormones cause changes in target cells. Include:
(i) solubility in cell membrane
(ii) location of receptors
(iii) end result

5.1.3 Identify the location and function of principal endocrine glands in the human organism. Include:
(i) pituitary
(ii) hypothalamus
(iii) pineal
(iv) thyroid
(v) parathyroid
(vi) adrenal
(vii) pancreas (Islets of Langerhans)
(viii) thymus
(ix) ovaries
(x) testes

Notes for Teaching and Learning

The endocrine system of animals releases chemical hormones into the blood to be circulated. These help maintain homeostasis by causing or preventing change in specific organs or tissues of the body. The endocrine system is slower in producing an effect than the nervous system; however, it is a more sustained effect. It is important for students to realize that the nervous system and endocrine system work together in a coordinated fashion.

Instructors could review the basic biochemical structure of carbohydrates, proteins and lipids/steroids. Students should examine diagrams that illustrate the location of receptors for non-steroid hormones compared to steroid hormones. They should recognize the importance of the solubility of steroid hormones in the cell membrane and the critical nature of the shape of non-steroid hormones. Additional hormones may also be of interest to students (antidiuretic hormone, cortisol, aldosterone).

Students should understand that the non-steroid hormones cause chain reactions in the target cells while steroid hormones stimulate genes to produce a protein.

Students should be provided with the opportunity to observe the principal features of the endocrine system, utilizing models, dissection or computer simulations and to identify and label those structures through the use of drawings or photographs.

It is not necessary that students know the function of all hormones associated with every gland. Students should know the general function of each gland. Specific hormones will be dealt with in later outcomes.

Ovaries and testes have a dual function. For this reason they are dealt with in more detail in Biology 3101B.

Suggestions for Assessment

Pencil and Paper

- Students should complete relevant Section Review and Chapter Review questions.
- Students should start to develop a glossary of terms that they discover and will use as they study the endocrine system. The glossary can be added to as students progress through the unit.
- Answer key for question 5.3 in the Study Guide:

	Steroid	Non-steroid
Fat soluble?	Yes	No
Location of receptors	Inside the nucleus.	Plasma membrane.
Action	Binds to DNA and leads to activation of certain genes and protein synthesis.	Triggers a chain of chemical reactions. [An enzyme converts ATP to cAMP(the second messenger), which activates an enzyme cascade.]

Resources

MGH Biology, pp. 420-441.

MGH Biology, pp. 486-487.

MGH Biology, pp. 490-493.

Diagram, "Location of Endocrine Glands", Appendix A.

Unit 5 - Endocrine System: Maintaining Homeostasis

Outcomes

5.2 Identify and describe the structure and function of important biochemical compounds, including non-steroid and steroid hormones.

5.2.1 Identify the following hormones, their source gland, and explain their general effect on the human organism:

(i) ADH - Anti-diuretic hormone

(ii) thyroxine

(iii) adrenaline

(iv) somatotropin (HGH–human growth hormone)

(v) insulin

(vi) glucagon

Notes for Teaching and Learning

The study of hormones and their effects provides a good opportunity for research and debate. Instructors may be able to have students do this in conjunction with the Language Arts program. Students can discuss the social, ethical and health issues associated with hormone therapy for the treatment of humans (e.g., growth hormones, steroid use in sports, hormone use to slow the effects of aging or to minimize jet lag). This may lead to questions such as "Should physicians provide HGH as a treatment for individuals who have normal levels of human growth hormone, yet are genetically shorter than average, simply to increase their height?" Students may investigate the hormonal connection with biorhythms and seasonal affective disorder (SAD). Students may investigate the abuse among athletes of steroid hormones as they attempt to build body tissue quickly and increase their athletic ability and the long-term side effects that result.

Blackline Master, “Regulation of Blood Glucose”, can be used to help students understand the effects of insulin and glucagon as antagonistic hormones.

Unit 5 - Endocrine System: Maintaining Homeostasis

Suggestions for Assessment

Pencil and Paper

- Students could select a hormone and investigate the effects of its hypersecretion and hyposecretion in the body. They should prepare a visual display to illustrate this. Hormones may include HGH, aldosterone, cortisol, thyroxine, insulin, or glucagon. This provides another opportunity for linkage with Language Arts.

- Students should complete relevant Section Review and Chapter Review questions.

Resources

MGH Biology, pp. 428-446.

Blackline Master, "Regulation of Blood Glucose".

Unit 6 - Endocrine System: Feedback Mechanisms

Outcomes

6.1 Analyze homeostatic phenomena to identify the feedback mechanisms involved.

6.1.1 Describe representative positive and negative feedback loops. Include:
(i) hypothalamus-pituitary complex as a negative feedback control
(ii) oxytocin as positive feedback control

6.1.2 Describe the regulation of blood sugar by controlled release of insulin and glucagon.

6.2 Describe disorders and treatments linked to the secretions of the endocrine system and their effect on the homeostasis of the system and the organism as a whole. Include:
(i) pituitary dwarfism
(ii) gigantism
(iii) hyperthyroidism
(iv) hypothyroidism
(v) diabetes mellitus

6.3 Analyze examples of Canadian contributions to science and technology.

6.3.1 Investigate the role played by Frederick Banting and Charles Best in the discovery of insulin.

Notes for Teaching and Learning

Within the discussion of the hypothalamus-pituitary complex, RF (releasing factor), pituitary hormones and target tissues (e.g., TSH on thyroid) should be included. Oxytocin should be used to illustrate a positive feedback loop in a human system. When the "water breaks" pressure is exerted on the cervix, an increase in uterine contractions occurs. In turn more oxytocin is released which, then increases the contractions. This cycle would continue until the Expulsion Stage is finished. This will be covered further in Biology 3101B.

Instructors could contact the Canadian Diabetes Association or do an Internet search to obtain sample data concerning blood and/or urine composition. Data can be analyzed and interpreted in order to infer the role of hormones in homeostasis. Students could perform an experiment to investigate the presence of sugar in simulated urine samples, and compare the results with other urinalysis data. Using a table, students may compare the conditions of juvenile diabetes and adult-onset diabetes. Headings may include age of onset, cause, severity, method of treatment. Students could research and present modern approaches to the detection, treatment and control of diabetes, e.g., the onset of diabetes in relation to diet and exercise and culture (some populations).

Students may hypothesize the effect on organisms of the oversecretion (hypersecretion) or undersecretion (hyposecretion) of hormones.

Outcomes 6.2 and 6.3 are covered by completion of Assignment 3 (in Appendix B).

Unit 6 - Endocrine System: Feedback Mechanisms

Suggestions for Assessment

Pencil and Paper

- Students could analyze and interpret the data provided on blood or urine composition. They should use it to determine the role of hormones in homeostasis.
- Students could prepare a short report on the role played by Canadian researchers Frederick Banting and Charles Best in the discovery of insulin. Assessment should be based on quality of work submitted. (Language Arts link.)
- Students should add to the glossary of terms for this section.
- Students should do relevant Section Review and Chapter Review questions.

Assignment

- Students must complete Assignment 3, "*Endocrine System Disorders"*.
- **NOTE:**
  The assignment should be marked and the marks used as part of the evaluation for the course. The content covered in the assignments should not be tested.

Resources

MGH Biology, pp. 302-303, 424, 427, 429 - 432, 435 - 439..

Assignment 3, "*Endocrine System Disorders"*, *Appendix B.*

Outcomes

Optional Lab

6.4 Perform an experiment to investigate and collect data on the endocrine system.

6.4.1 Test solutions to determine if they contain high levels of glucose.

Notes for Teaching and Learning

This lab can only be done if proper lab facilities are available. It would only be appropriate when teaching to a group. Instructors may replace this particular lab with another of their choice.

The outcome 6.4 is addressed by completing *Identifying Diabetes Mellitus*, p.436-437. Instructors should note that the Lab requires the preparation of four solutions of glucose for the students to test. An easy method to prepare a class set of stock solutions is to prepare the most concentrated solution first and then prepare the others by diluting it with water. The following table (procedure) will produce enough for a class of thirty students.

Solution	%	Solute		Solvent
A	1.7	8.5g of $C_6 H_{12} O_6$		500.0 ml H_2O
B	1.3	50.0 ml of Soln A	Add to	15.0 ml H_2O
C	0.85	50.0 ml of Soln A		50.0 ml H_2O
D	0.3	50.0 ml of Soln A		230.0 ml H_2O

In order to see changes in the solutions during lab time, it will be necessary to increase the temperature of the water bath significantly higher than what is indicated in the text. You may wish to boil the water. Fresh Benedicts Solution will give the best results. It could be useful for students to observe the rate of color change in solutions during heating as an indication of the differences between concentrations.

Unit 6 - Endocrine System: Feedback Mechanisms

Suggestions for Assessment

Laboratory

- Students could perform the Laboratory Activity, "*Identifying Diabetes Mellitus*". Students should submit the Post-Lab and Conclude and Apply questions for evaluation.

Testing

- Students should be given a final examination which covers the entire course. If a test was given earlier on the nervous system emphasis should be on the endocrine system. Students should be required to label a diagram of the endocrine system on this exam.

Resources

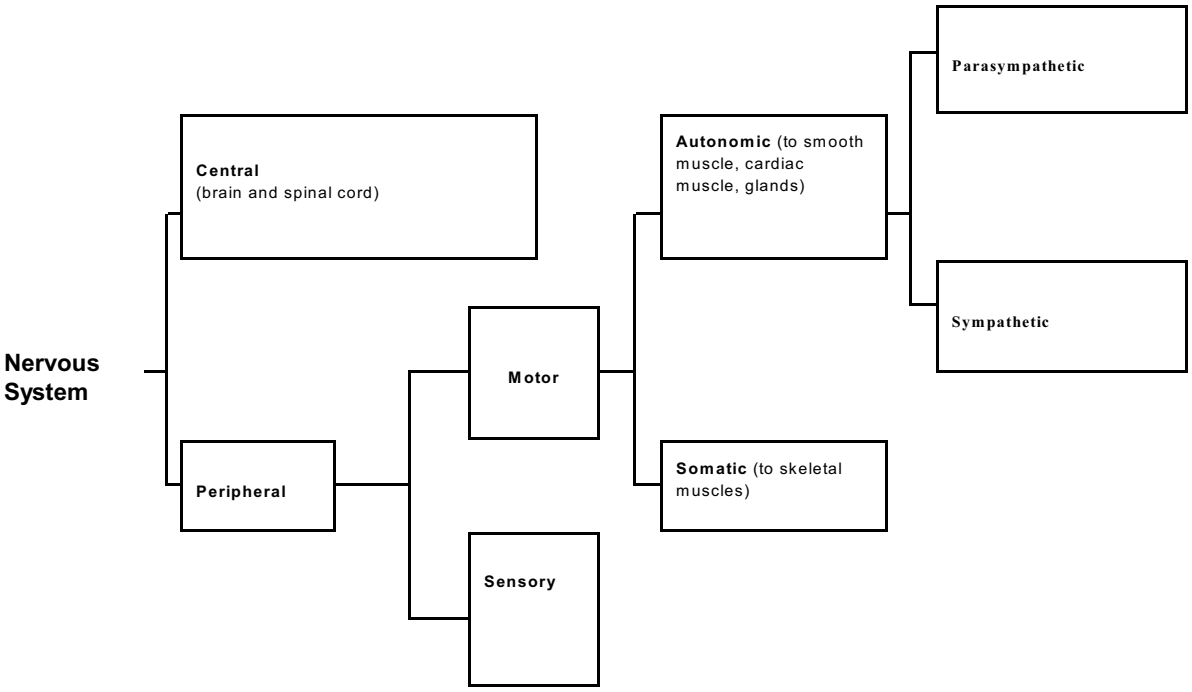
Lab: *Identifying Diabetes Mellitus*, p.436-437.

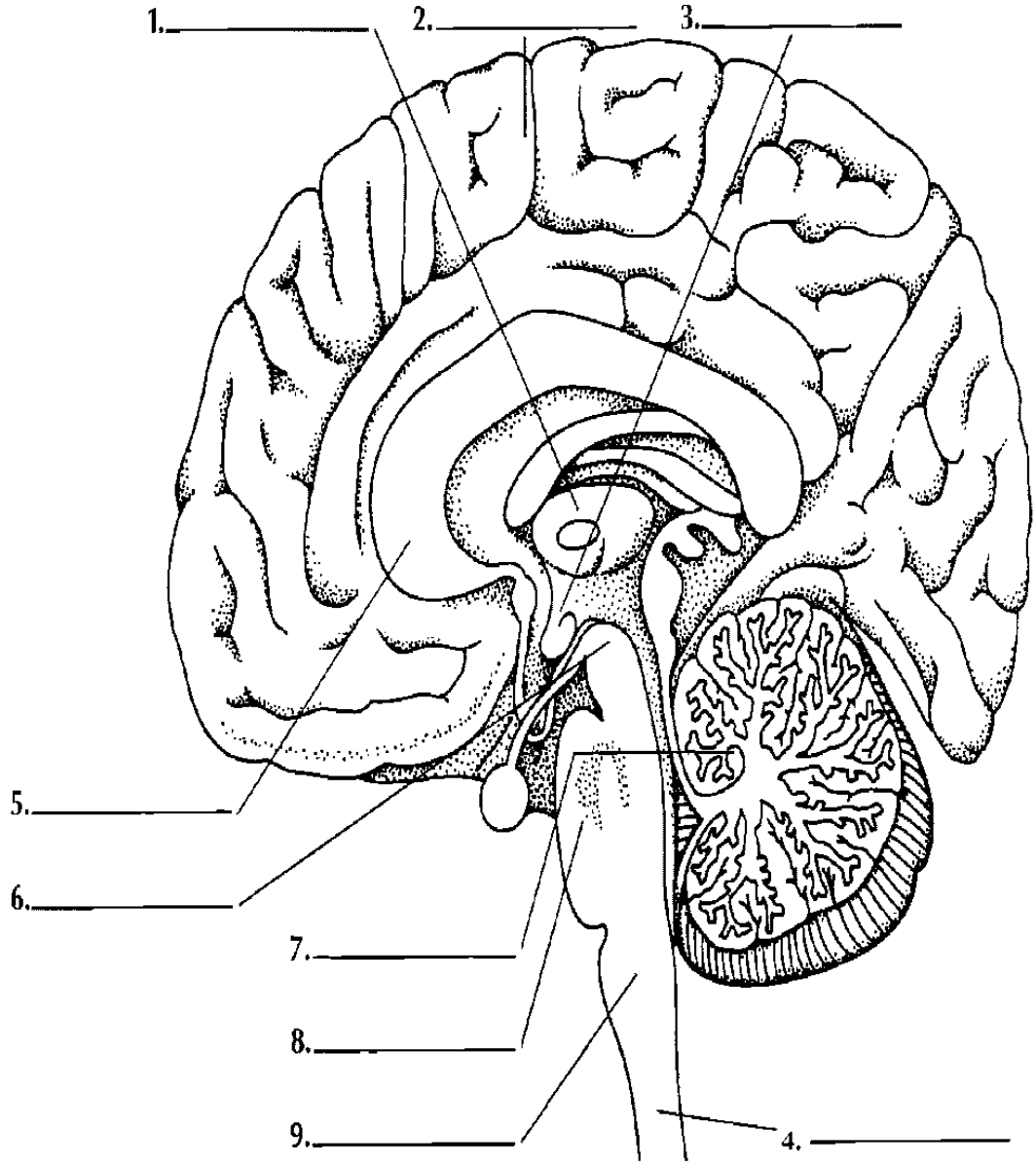
Biology 11/12 Computerized Assessment Banks.

Appendix A

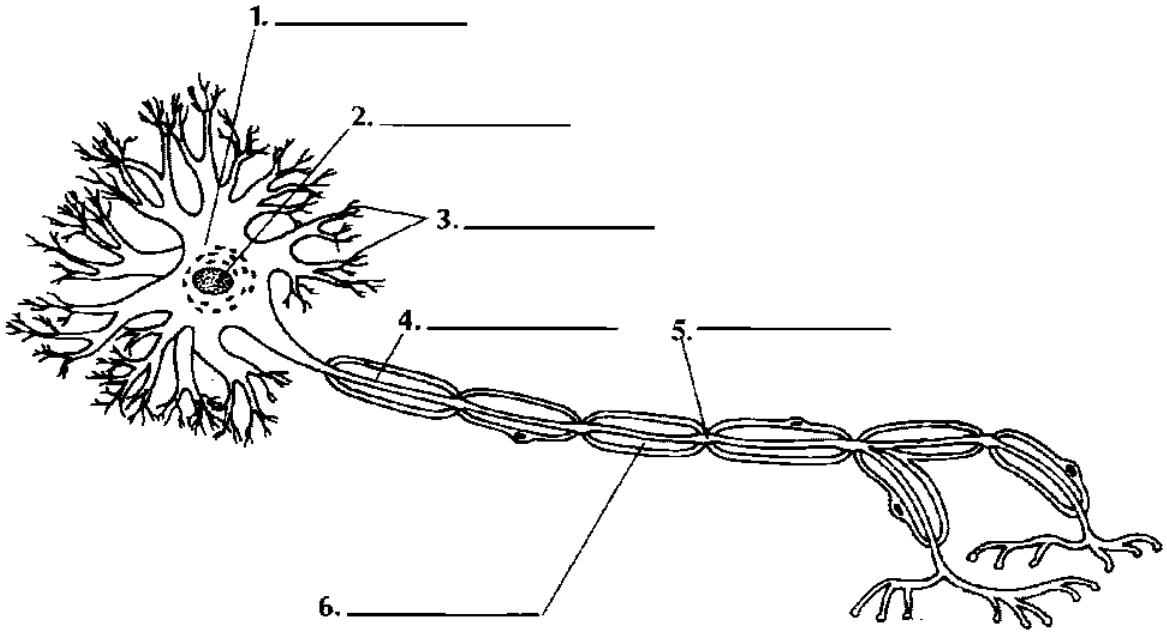
Diagrams

Figure 1 - Chart of the Nervous System

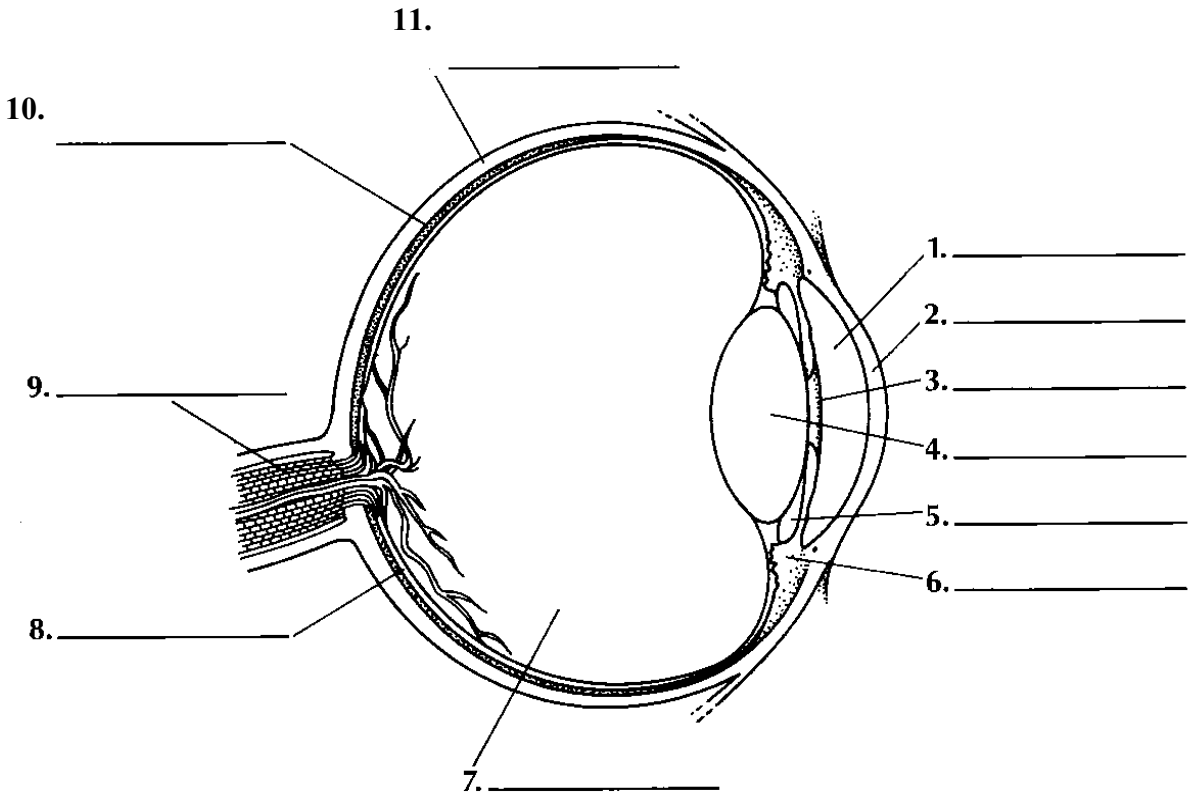




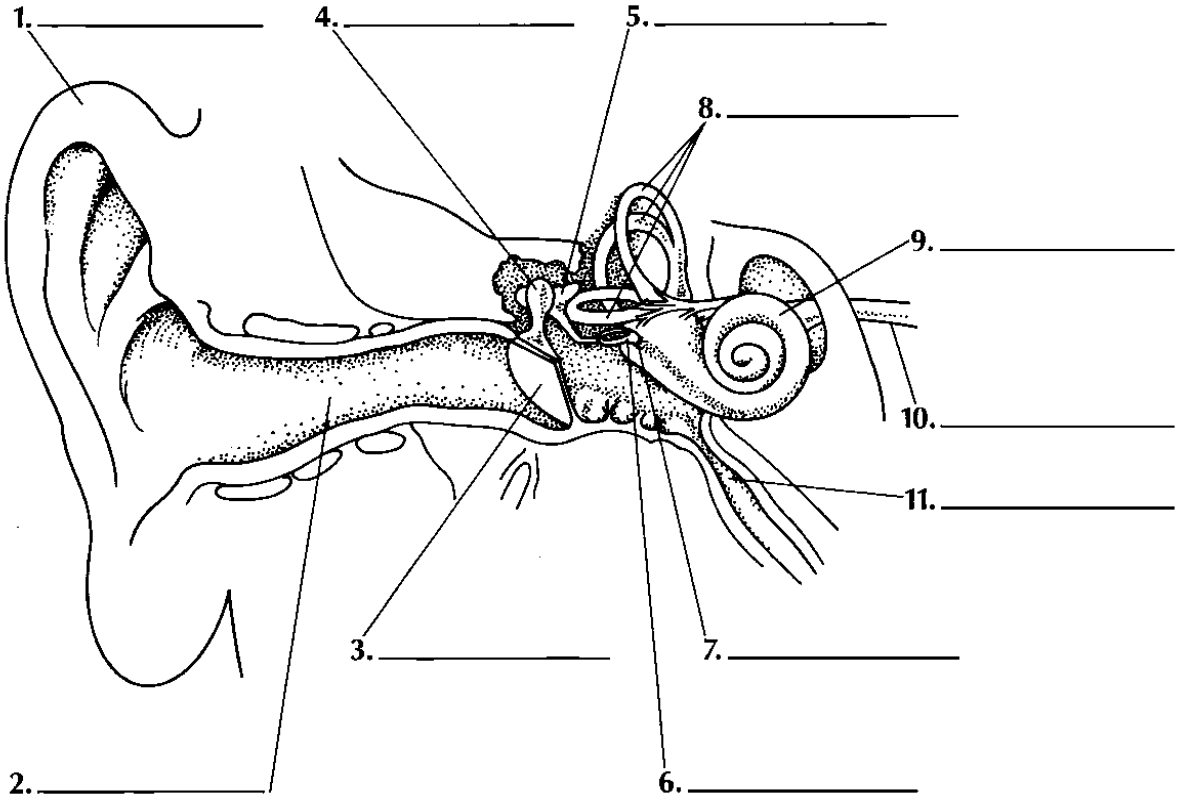
Structure of the Brain



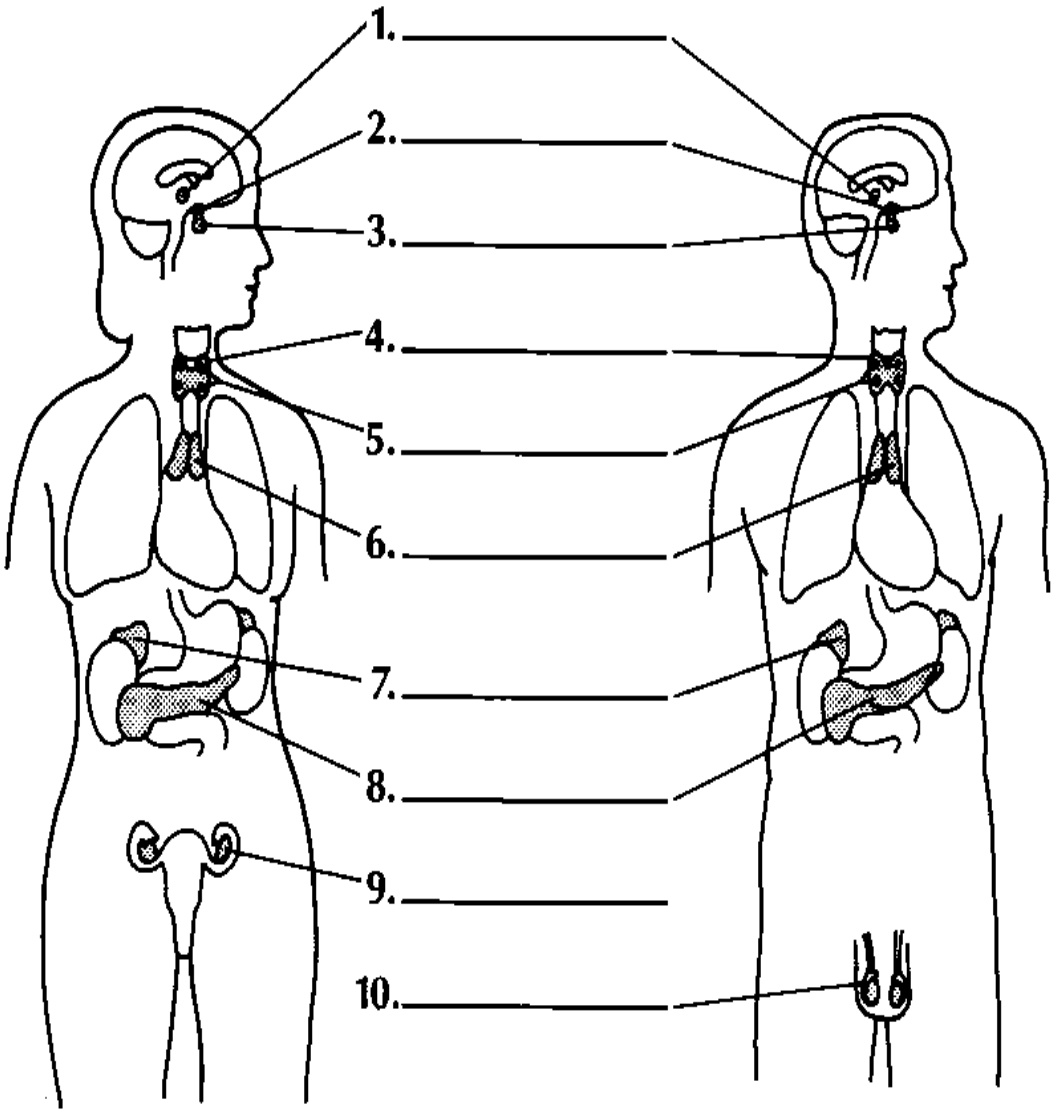
Structure of a Neuron



Structure of the Eye

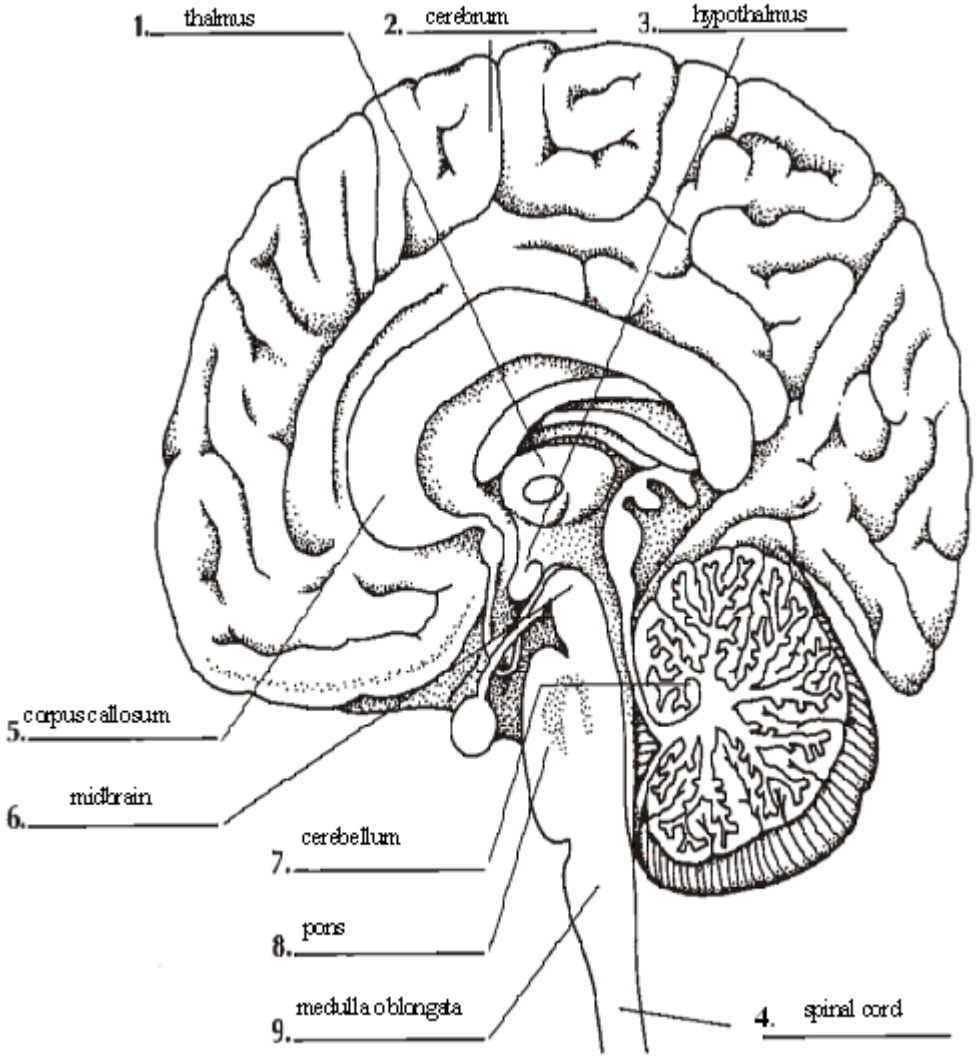


Structure of the Ear

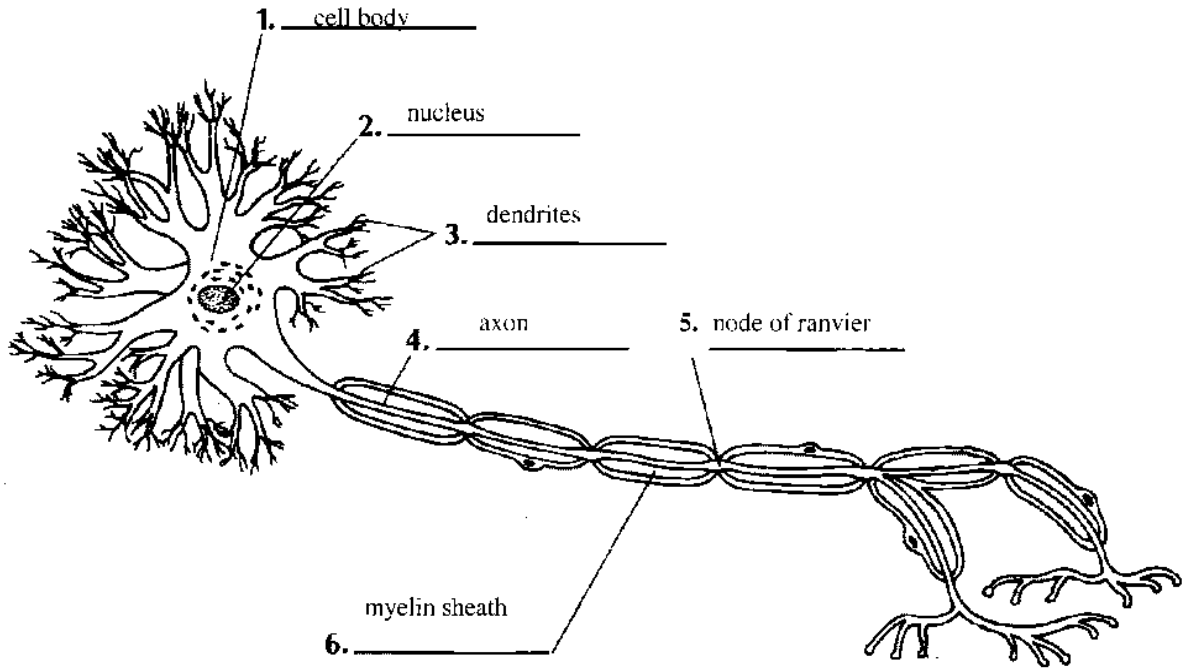


Glands of the Human Endocrine System

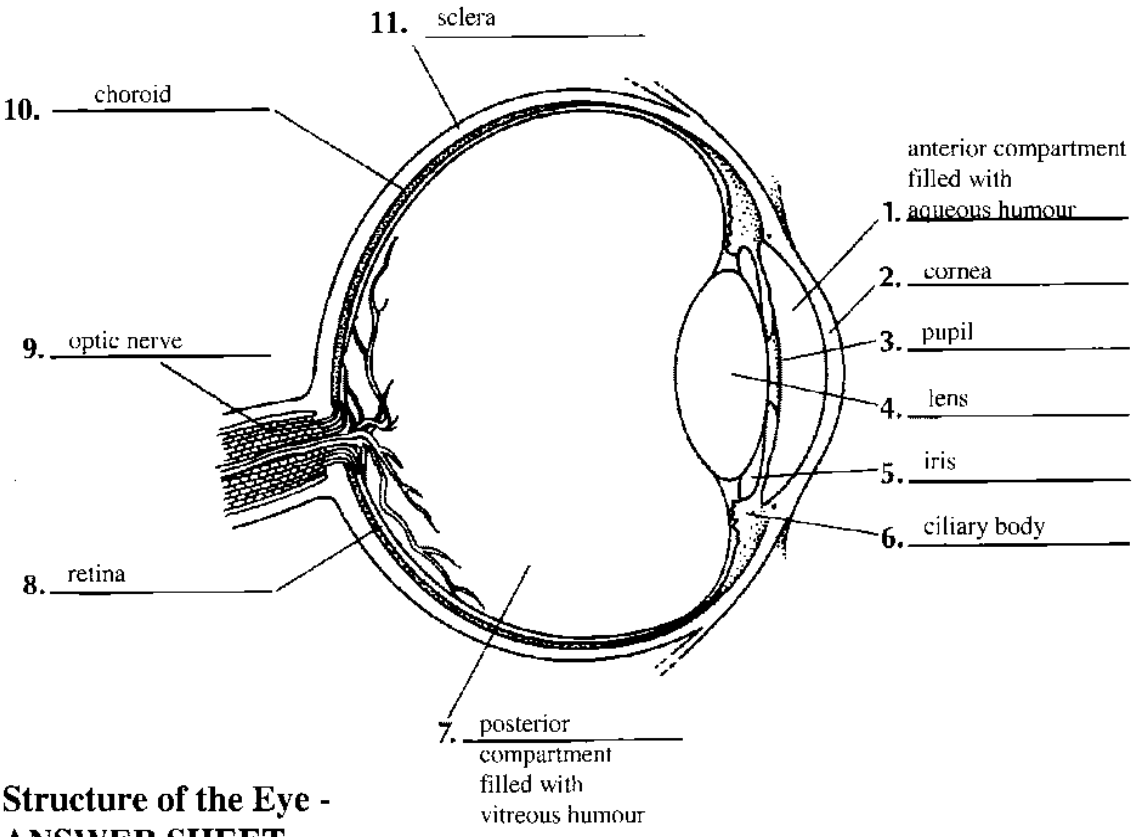
ANSWER SHEETS



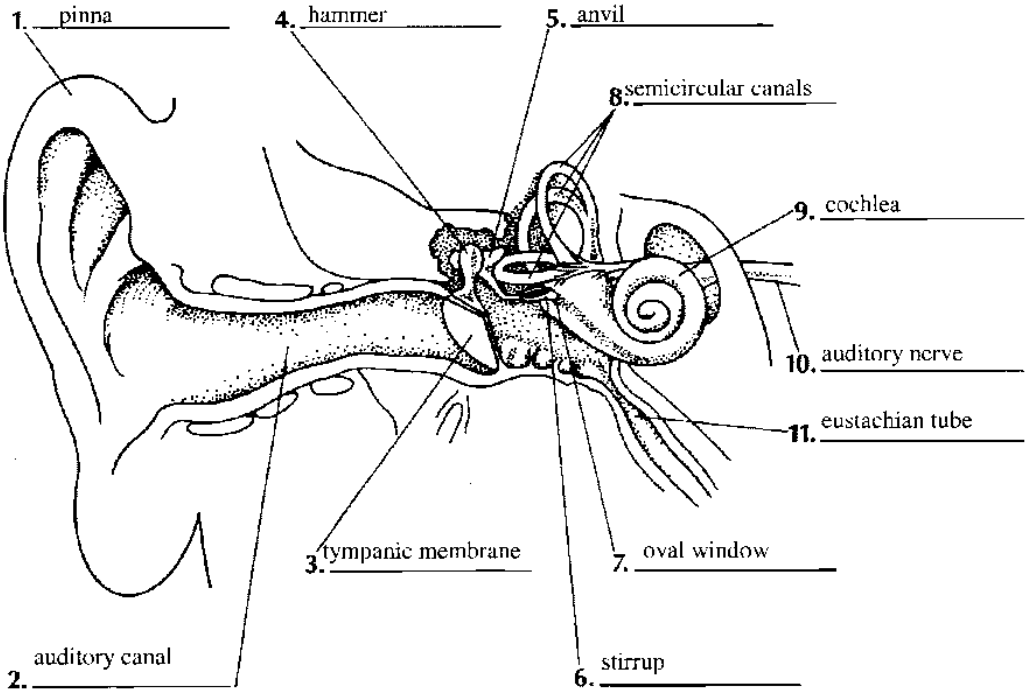
Structure of the Brain - ANSWER SHEET



Structure of a Neuron - ANSWER SHEET



Structure of the Eye - ANSWER SHEET



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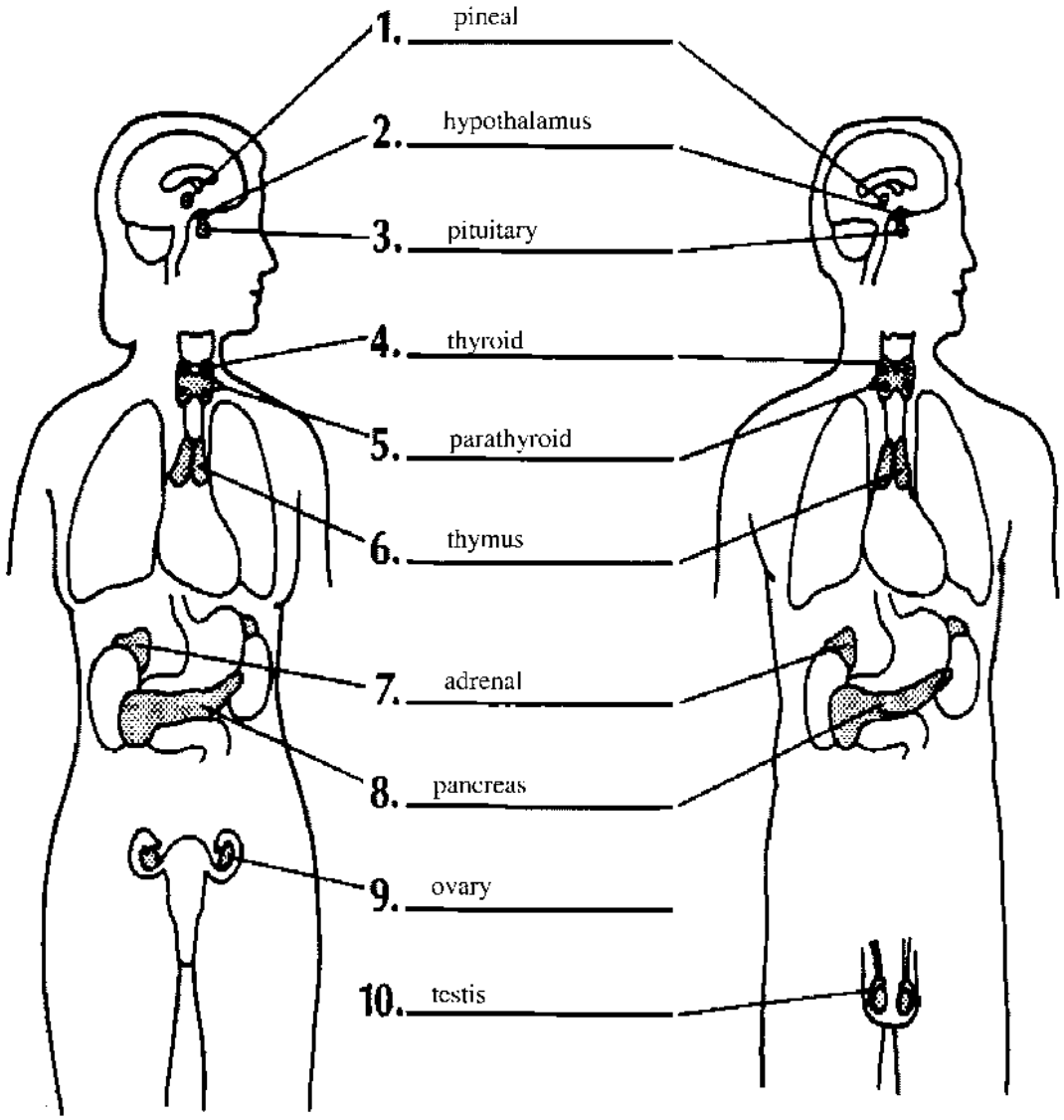

Glands of the Human Endocrine System - ANSWER SHEET

Appendix B

Assignment 1

Nervous System Disorders

1. For each of the following disorders;

   Multiple Sclerosis, Alzheimer's Disease, Parkinson's Disease, Meningitis:

   (a) Explain how it affects the nervous system

   (b) Give the cause (if known)

   (c) Describe the symptoms

   (d) Describe treatment(s)

2. Explain how EEG, MRI and CAT scan are used to help understand brain function.

Assignment 2

Drugs and Homeostasis

Outcomes:

1. Analyze the effects of drugs on homeostasis.

2. Describe disorders linked to the nervous system and their effect on the homeostasis of the system and the organism as a whole. (317-4)

3. Describe how the use of prescription and nonprescription drugs can have a role in maintaining or disrupting homeostasis. (317-7)

Introduction

Drugs have been considered invaluable to society as an instrument in the treatment of disease. Insulin is a hormone used to control diabetes. Chemotherapy uses drugs to destroy cancer cells. The use of painkillers such as Tylenol and antibiotics are prevalent in society. Prozac is a well-known drug used in the treatment of depression. Drugs have also been considered a danger to society because of their inappropriate use and addictive nature. Many high profile actors have admitted to drug and alcohol abuse such as Ben Affleck, Winona Rider and Robert Downey Jr. and have sought rehabilitation for their addictions. This module will examine the medical use of drugs in the treatment of disease, as well as their abuse in society. It will also examine the long-term affects of drugs on the health of the human body.

Neurotransmitters and the Nervous Response

Many drugs affect neurotransmitters. Neurotransmitters are chemicals secreted by neurons which stimulate motor neurons or neurons of the central nervous system. Some neurotransmitters are excitory and include acetylcholine, norepinephrine (noradrenaline), serotonin and dopamine. Other neurotransmitters are associated with relaxation such as dopamine and serotonin. Many neurotransmitters can have multiple functions.

The drugs abused in society are typically stimulants or depressants thought to block or enhance certain neurotransmitters. Diseases of the nervous system are often associated with the improper functioning of a neurotransmitter or improper functioning of the enzyme used to break them down once they have been released and attached to the receptor site of the postsynaptic neuron. Drugs can be developed to mimic the effects of the affected neurotransmitter or enzyme to treat these diseases.

Drugs in the Treatment of Disease

As just outlined, imbalances in neurotransmitters can contribute to certain diseases. Several well known examples are Parkinson's disease and Huntington's disease. Parkinson's disease is believed to be caused by a dopamine deficiency due to the gradual death of the neurons that produce dopamine. A dopamine deficiency

can result in tremors and rigidity in the limbs since messages can not be sent between areas of the brain controlling body movement.

Huntington's disease is believed to be caused by a malfunctioning of an inhibitory neurotransmitter. Huntington's is a genetic disorder characterized by jerky movements and loss of mental and emotional abilities due to the destruction of neurons in certain areas of the brain.

Potential treatment is aimed at replacing the damaged neurons in both of these cases through the experimental use of stem cell transplants. At present, other treatments involve targeting the defective neurotransmitters such as increasing dopamine levels in Parkinson's patients.

More and more research has shown that mental illness is also a result of imbalances of neurotransmitters. Mental illnesses were once considered to have no biological basis but rather be due to factors in an individual's environment such as experiencing stress or forms of mental and physical abuse. At one time, sufferers of mental illness were deemed as "weak-minded" and lacking the skills to cope with life.

As science has progressed, genetic connections were made with individuals in the same family suffering from mental illness. This lead to the exploration of a biological basis for mental disorders and resulted in a greater understanding by society regarding the causes of mental illness. Mental illness is now discussed more openly in society and is appreciated as a medical condition.

Debate still continues regarding the issue of nature versus nurture in the onset of mental illness but all must agree that the biological basis of mental disorders exists. The effective treatment of mental disorders with drugs also adds support to the biological basis of these disorders. This next section will explore the biological basis of certain mental illnesses and the use of drugs in their treatment.

Clinical Depression

Clinical depression is the most frequently encountered mental illness. Clinical depression is now considered a physical condition in which there is a fault in the brain chemistry. It may afflict up to 5% of the population. Symptoms of depression include a distinct change in mood accompanied by an extreme feeling of hopelessness. Other symptoms include: loss of appetite, weight loss, headaches, sleeplessness, loss of energy, tiredness, and anxiety. Suicide is common in about 15% of depressed patients.

Serotonin, dopamine, and noradrenaline are neurotransmitters linked to clinical depression. Those suffering from depression either secrete too little of a particular neurotransmitter or too much of the neurotransmitter which is broken down by enzymes (monoamine oxidases) when it is reabsorbed into nerve endings.

Three major classes of drugs are used in the treatment of depression. They are monoamine oxidase inhibitors (MAOI's) , selective serotonin re-uptake inhibitors (SSRI's), and tricyclic compounds.
Drug treatment is difficult because some drugs may have no effect and the patient may spend a period of time searching for the proper drug and dosage that may help to

alleviate the depression. It also takes several weeks for the drugs to take effect, if they are to work. In this time period, the patient could go into remission or the condition may worsen. The result can be unrelated to the drug. These factors may make the treatment with drugs difficult and the process of finding a successful drug very lengthy. It is unknown why the effect of drugs taken such a length of time or why some drug treatments are successful and others are not. More research into the causes of depression is needed in order to obtain more successful treatment.

Tricyclic inhibitors appear to slow the re-uptake of serotonin and noradrenaline.

MAOI's are believed to inhibit monoamine oxidase (MAO). MAO is an enzyme that is believed to break down serotonin and noradrenaline. It has been shown that enhancement of these neurotransmitter systems leads to the elevation of mood. A danger of MAOI's and tricyclic compounds is the increased risk of heart failure. MAO inhibitors can not be taken with certain foods such as cheese, avocado, and wine because this interaction will raise blood pressure that can cause heart failure and death. Usually, doctors will avoid prescribing MAOI's for these reasons. These drugs can also be lethal at relatively low dosages, which is a concern for suicidal patients.

Serotonin re-uptake inhibitors are the most widely prescribed antidepressant. It appears to have fewer dangerous side-effects. A well known example is Prozac. It functions by blocking serotonin uptake and therefore increase the levels of serotonin at the synapse. Side-effects include nausea, headache, insomnia and anxiety.

Bipolar Disorder

Bipolar disorder is also known as manic depression. It affects about 5 in 1000 people. It is characterized by severe mood swings ranging from mania to depression, with normal periods in between. During a manic phase, individuals may think that they are invincible, behave recklessly or believe in delusions such as ones of fame. During the depressive phase, the individual loses interest in his/her usual activities, may sleep excessively or suffer from insomnia. They may also be at risk of suicide during the depressive stage.

At one time, sufferers from manic depression were unable to function in life normally. Fortunately, manic depression can now be treated with both medication and psychotherapy. The most common medication is lithium carbonate. It functions by maintaining the chemical balances in the brain to prevent mood swings. Lithium appears to work in the treatment of both mania and depression. This is because it is believed that the depressive phase is a result of the preceding manic phase. If the manic phase can be controlled, then the depressive phase can be controlled indirectly. Other drugs may be used to treat the symptoms of depression.

Unfortunately, the long term use of lithium can affect the kidney and thyroid gland since lithium interferes with water and salt balance. There must be regular check ups to ensure that the lithium levels do not rise to a toxic level. Other side-effects of lithium treatment include: diarrhea, nausea, hand tremor, blurred vision, confusion, and swelling in the legs and feet. The side effects of this medication are why some manic depressives are reluctant to continue use of lithium. Researchers and drug companies

are working to find better medications with less side-effects. In the meantime, patients are left with the dilemma of taking a medication that provides the benefit of treating their mental disorder but can also create grave concerns over some of its very serious side-effects.

The causes of manic depression are still uncertain. There appears to be a genetic link and episodes can also be triggered by stress. Chemical changes are also being studied. Manic behaviour is believed to be due to a high level of noradrenergic activity. This activity continues until the neurotransmitter systems are depleted. It is believed that lithium may prevent mania by preventing noradrenaline depletion.

Schizophrenia

A greater understanding in society of schizophrenia as a mental illness was created by the award winning movie, A Beautiful Mind. The movie focusses on the life of John Forbes Nash Jr. and his struggle to cope with his mental illness. Nash was a mathematical genius who later received a Nobel Prize in Economics. Actor, Russell Crowe, plays Nash and portrays the symptoms of the disorder, as well as Nash's struggle. The primary symptoms of schizophrenia include disturbance of thought patterns, disturbance of affective reactions and autism or withdrawal. Secondary symptoms include hallucinations, delusions and paranoia. These symptoms all represent a loss of contact with reality. This disorder appears at a rate of 1 to 2 percent in the population.

There is a biological basis that predisposes individuals to the development of schizophrenia. A form of dopamine dysfunction, such as excessive dopamine activity, is believed to cause schizophrenia. Schizophrenic patients seem to have an excess number of dopamine receptors.

Chlorpromazine and related drugs have been used in the treatment of schizophrenia and function in blocking the dopamine receptors. Unfortunately, the side effects are similar to Parkinson's disease. Other side-effects include abnormal body and facial movements and extreme pacing. If this occurs, either the dosage is adjusted or a new medication is prescribed. Other side-effects include dry mouth, constipation, blurred vision and low blood pressure. Unfortunately, patients with schizophrenia are faced with a similar dilemma as those with bipolar disorder. They must rely on a drug to treat their disorder and enable normal functioning in life, but it has difficult side-effects.

Commonly Abused Drugs

Alcohol

Alcohol is probably the most commonly abused drug in society. Of all abused drugs, it is presently the only one considered legal upon reaching of age. It has been a large part of our culture for many years and is often associated with social functions and celebrations. However, alcohol use definitely has its dark side. It is known to alter personalities and cause people to behave in a manner outside their normal personalities. A night of abusing alcohol can lead to embarrassment and regret once the effects have worn off. Poor judgment while drinking alcohol can lead to making deadly decisions such as drunk driving. Also, people have abused alcohol to the extent they vomit in their sleep and choke to death. Groups such as MADD (Mothers Against Drunk Driving)

are advocating for the responsible use of alcohol.

Alcohol is usually considered to be a depressant but can act as a stimulant in small doses. Alcohol affects the nervous system by increasing the inhibitory neurotransmitter GABA (Gamma Amici Biotypic Acid). It also modifies the effects of another excitory neurotransmitter called glutamate. A blood alcohol content of 0.10 can induce blurred vision, slurred speech, poor muscle coordination, and lack of rational judgment. A blood alcohol content of 0.40 to 0.50 g/100 ml will induce coma and a level of 0.60 will result in death. If a Newfoundland and Labrador driver is found to have a Blood Alcohol Concentrate (BAC) of 0.05 g/100 ml, he/she receives a fine and a 24 hours suspension of the licence. If the driver is found to have a BAC of 0.08 g/100 ml or greater criminal charges will be laid. Alcohol abuse can lead to short-term memory loss and blackouts. It can irritate the gastrointestinal tract and increase hydrochloric acid production. Its long-term use can also cause disorders such as cirrhosis of the liver and heart disease. Alcoholism is considered to be a genetic and environmental disease that can lead to death. Alcoholism is associated with addictive personalities and may be a secondary result of depression. Severe alcoholics often appear jaundiced due to cirrhosis of the liver. Their immune systems are impaired and they are more prone to disease. There are organizations such as Alcoholics Anonymous that enable sufferers of alcoholism and their families to cope with this disease.

Marijuana

A Canadian Senate committee has proposal the legalization of marijuana for non-medical use, citing that it is less harmful than alcohol. They believe that marijuana should be governed by the same laws as alcohol. They believe legalization would allow for better regulation and taxation of the drug. Many argue that prohibition of drugs such as marijuana supports organized crime. It would also save money in law enforcement. This means that it could potentially be sold in corner stores. Others raise concerns about addiction and health concerns. There is also concern that it may be the "gateway" to abuse of more dangerous drugs. It is believed that if marijuana is legalized, more teens will abuse the drugs because access would be easier. As a result of this, the Supreme Court of Canada has drafted legislation that would decriminalize marijuana usage. Individuals possessing a small amount of the drug would be fined much like a speeding ticket. It is quite possible that within the lifetime of this module marijuana will be decriminalized.

Marijuana is derived from the Indian hemp plant Cannabis sativa. The active compound in marijuana, tetrahydrocannabinol (THC), works by binding to CB1 receptors found on presynaptic membranes in the brain. These receptors function in blunting pain. THC also causes the release of the neurotransmitter dopamine which elevates mood and controls muscle movements. These biochemical pathways can explain how the drug affects its users and how it may also be used for medicinal purposes.

In low concentrations, THC causes euphoria. It has the ability of enabling the user to block out pain, frustration or confusion. There are also some serious health concerns regarding the use of marijuana. In high concentrations it can cause hallucinations, anxiety, depression, and psychotic

symptoms. Smoking marijuana can cause lung cancer, sinusitis, and bronchitis. It increases the level of carbon monoxide in the blood which, in turn, reduces the amount of oxygen reaching the heart. Repeated use tends to lead to the inability to deal with everyday challenges. Long term use can result in: impaired speech, memory loss, difficulty in understanding complex ideas, insomnia, impaired visual perception, and infertility. Marijuana use has also been linked to reducing immunity towards disease.

Marijuana has been demonstrated to have some positive effects in the treatment of disease. It has been used to treat medical conditions such as nausea in chemotherapy patients and to stimulate appetite in AIDS patients. It may also offer relief from pain and reduce spasticity due to multiple sclerosis. It has been shown to help sufferers of severe arthritis. It can be used as an anti-epileptic and anti-depressant. It is believed to be far less addictive than many prescribed painkillers. Furthermore, it is believed that marijuana could be manufactured in other forms so that it does not have to be smoked and harm the lungs.

Regulations are now in place that permit sufferers from terminal illnesses and chronic conditions to grow and smoke their own marijuana. They may also designate someone to grow it for them. At present, the Canadian Medical Society opposes marijuana use for medicinal purposes because of the lack of clinical research. Debate continues among the medical community about prescribing the use of marijuana. The legal system, however, supports the use of marijuana for medicinal purposes since denying an individual treatment that they believe helps their medical problem would be infringing on their human rights.

Cocaine

Cocaine is derived from the plant Erthoxylon coca and can be inhaled, smoked or injected. It results in a feeling of euphoria followed by depression. Cocaine acts by first stimulating the release of norepinephrine and dopamine and, in higher doses, the release of serotonin. Cocaine then interferes with the re-uptake of these neurotransmitters and these neurotransmitters build up in the synapse. Prolonged use will cause the body to produce less dopamine and the user will need more cocaine. Side effects include mental impairment, convulsions, hallucinations, stroke, heart attack and death.

Heroin

Heroin is a highly addictive derivative of morphine and comes from the opium poppy, Papaver somniferum. Heroin is normally injected but can also be snorted or smoked. It operates by binding to opioid receptors in the brain in which natural chemical endorphins are involved in the relief of pain. Heroin mimics the action of endorphins. After initial exposure users experience a surge of euphoria “rush” followed by a drowsy trance-like slate. Prolonged use can cause less endorphin production. Side-effects include: depressed respiration, impaired coordination, and decreased tolerance to pain, long term effects can include: collapsed veins, infections of heart valves and liver disease. Death can result from overdose.

Rohypnol

Rohypnol is a drug associated with rave parties and comes from the benzodiazepine

family. It is considered to be the "date rape" drug and has become infamous for its use in committing sexual assault. It is often given to unsuspecting victims by dissolving it in a beverage while they are unaware. It is similar to ValiumTM but has ten times its strength. In combination with alcohol, it can be deadly. Rohypnol is highly addictive and induces severe withdrawal symptoms. Its use can cause deep sedation, respiratory distress, blackouts for up 24 hours, and amnesia.

Ecstasy

Ecstasy is known as Methylene Dioxy Meth Amphetamine (MDMA) and has street names such as X, Rolls, E, Adam, Beans and Buddies. It is one of the designer drugs associated with rave parties. When Ecstasy first became popular, it was believed to be a "safe" drug with no side-effects. It was soon discovered, like many drugs, to have deadly consequences with its abuse.

The initial use of ecstasy results in:increased heart rate, increased blood pressure, dilation of pupils and bronchi, brain stimulation, increased motor activity, tightening of jaw muscles, grinding of jaws, overheating, sweating, heat stroke, and dehydration. Complications can result in renal failure, depression, liver failure, cardiovascular collapse and respiratory failure to name a few. The long-term use of ecstasy can result in irreparable brain damage. Its use is known to damage the brain cells that produce serotonin. In fact, long after ecstasy use, the nerve fibres in the brain that were destroyed have grown back abnormally or not at all.

OxyContin

OxyContin is a trade name for the drug oxycodone hydrochloride. It was developed in 1996 as a slow release pain reliever for people who suffer from severe or chronic pain. Because of its chemical similarity to codeine, methadone and morphine, this semisynthetic opiate works by acting as a central nervous system depressant causing a range of effects from analgesia to respiratory depression.

At the street level, OxyContin is often referred to as Oxy's, OC's or Hillbilly Heroin. Most abusers of this drug avoid the slow release properties by chewing, snorting or injecting the medication to get an instant and intense "high". Since its introduction, OxyContin abuse has caused a dramatic rise in the incidence of overdose, emergency room treatment and death.

The short term effects of this drug are constipation, nausea, vomiting, lack of interest, dizziness, sweating and weakness. However, the long term effects are primarily addiction. OxyContin abuse is no different from heroin, cocaine or alcohol abuse. The addict's change their lifestyle to allow more and more drug use.

Designer Drugs

Designer drugs are associated with underground high school and college parties called raves. They are called designer drugs because they are created by altering the molecular structure of existing drugs to enhance their effects. They are prepared by underground chemists known as "cookers". "Cookers" are untrained and unlicensed chemists that work in poorly constructed laboratories. Of course, these conditions offer little quality control and makes abuse of these drugs even more dangerous.

Designer drugs are derived from three different types of drugs. These drugs are

known as PCP, fentanyl, and amphetamine/methamphetamine. The street drugs created from these drugs are known as XTC, Ecstasy, Adam, Eve, Lover's Speed, GHB, Special K, Fantasy and Nature's Quaalude. Fentanyl derivatives are known to be up to 1000 times more potent than heroin. In general, designer drugs can create a wide range of physical problems such as: hypertension, uncontrolled tremors, total paralysis, seizures, permanent brain damage, and death.

Prescription Drugs

In recent years, concern has arisen over the abuse of prescription drugs. Some prescription drugs are easily addictive and patients can experience difficulty with withdrawal along with dangerous side effects. Some adolescents are becoming frequent abusers of prescription drugs due to the effects of euphoria that can be produced by these drugs. Crimes of breaking and entering pharmacies for the purpose of stealing prescription drugs are on the rise. There are three main prescription drugs that are most commonly abused: Opioids, CNS depressants and stimulants.

Opioids

Opioids are typically used to treat pain. These medications fall into a class of narcotics and include oxycontin, morphine, codeine and DemerolTM. Opioids function by attaching to specific proteins called opioid receptors. These receptors are found in the brain, spinal cord and gastrointestinal tract. When opioids attach to the opioid receptors they are able to block the transmission of pain messages to the brain. Opioids can produce a feeling of euphoria by affecting regions of the brain that enable us to perceive pleasure. However, they can result in physical dependence and addiction. Tolerance of opioids can result in the need to take higher doses to achieve the same effect. Withdrawal will cause: restlessness, muscle and bone pain, insomnia, diarrhea, vomiting, cold flashes, goose bumps, and involuntary leg movements. A large dose can lead to respiratory depression resulting in death.

CNS Depressants

CNS depressants are often used to treat anxiety and sleep disorders by slowing normal brain function. Common CNS depressants include barbiturates and ValiumTM. Most CNS depressants act on the brain by affecting the neurotransmitter gammaaminobutryic acid (GABA). The function of GABA in the human body is to decrease brain activity. Therefore, increased doses will create the drowsy effect required to treat anxiety and sleep disorders. Individuals can build a tolerance to CNS depressants over time and require larger doses. Withdrawals can cause the opposite effects of the drug. The mind can race out of control, possibly resulting in seizures and other problems.

Stimulants

Stimulants are used to treat narcolepsy, obesity, depression, and attention-deficit hyperactivity disorder (ADHD). These drugs enhance brain activity and result in increased alertness, energy, elevated blood pressure, increased heart rate and respiration. Examples of stimulants include RitalinTM and DexandrineTM. The chemical structure of stimulants is similar to the chemical structure of the neurotransmitters norepinephrine and dopamine. Stimulants work by increasing the amount of these

neurotransmitters to the brain. An increase in dopamine results in an increase in blood pressure, increase in heart rate, constriction of blood vessels, increase in blood glucose and it opens the pathways of the respiratory system. Stimulants do not result in physical dependence or withdrawal. However, they can be used compulsively and high doses repeatedly can lead to feelings of hostility and paranoia. High doses can cause body temperatures to rise to a dangerously high level. They can also create an irregular heartbeat leading to the risk of cardiovascular failure. There is also the potential of lethal seizures.

Conclusion

Drugs can play a role in both maintaining and disrupting homeostasis. When problems in the neurotransmitter balance occur, such as in the case of mental illness, drugs can play a role in restoring the balance. However, further study into the effects of different neurotransmitters is essential to achieve a better understanding of diseases caused by neurotransmitter imbalance. This can lead to better drug treatments that have less serious side-effects. Drug abuse can also disrupt homeostasis. Understanding the effects of drug abuse on neural pathways and the overall health of an individual can aid in the education of individuals considering drug abuse. It can also aid in the treatment of those suffering from addiction. Understanding the seriousness of drug abuse on long-term health may make one think twice about engaging in the legal and illegal use of drugs.

Questions

Understanding Concepts

1. For each mental illness, (clinical depression, bipolar disorder and schizophrenia) list the neurotransmitters involved, the nature of the imbalance of the neurotranmitter, the drugs used in their treatment, and side-effects of each of these drugs. This may be done in the form of a chart.

2. For each street drug, (alcohol, marijuana, cocaine, heroin, RohypnolTM, ecstasy and OxyContin®) list the effects on neural pathways, the short-term effects of the drug and the long-term effects of the drug.

3. What are the dangers of using designer drugs?

4. For each of the prescription drugs, (opioids, CNS depressants and stimulants) list the effects on neural pathways, the short-term effects of the drug and the long-term effects of the drug.

Extensions

1. Debate the pros and cons of the use of marijuana in the treatment of chronic pain.

2. Debate the merits of whether or not to use drugs for treatments of nervous diseases such as mental illness disorders despite the side effects of these drugs.
3. Debate the merits of legalizing marijuana. Research the present legislation regarding the legalization of marijuana.

4. Using the knowledge that you have gained about the causes of mental

illness, respond to the following statement: "Mental illness is a figment of one's imagination and one can choose whether or not to control his/her thoughts."

5. Choose a drug of interest to research. Report your findings in the form of a magazine article.

6. Write a letter to an imaginary friend whom you know is abusing drugs. In this letter, use what you know about the dangers of drug use to persuade them quit and seek help.

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Assignment 3

Endocrine System Disorders

1. For each of the disorders listed below, give its cause and a brief description of its effects on the person who has it:

   (i) pituitary dwarfism

   (ii) gigantism

   (iii) hyperthyroidism

   (iv) hypothyroidism

   (v) diabetes mellitus

2. (a) Name the 2 Canadian scientists who are recognized for the discovery of insulin.

   (b) What disease is insulin used to treat?