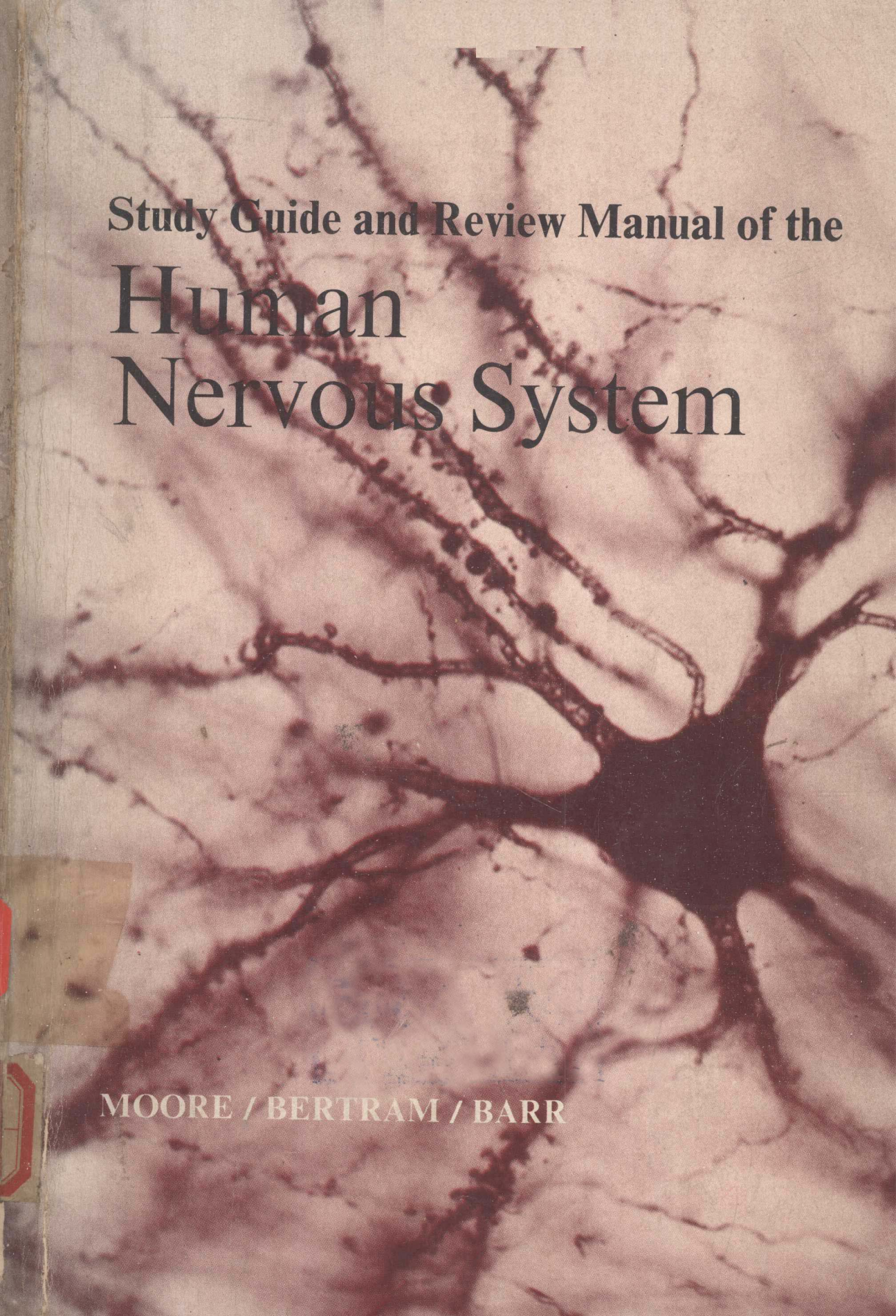

Study Guide and Review Manual of the

Human Nervous System

MOORE / BERTRAM / BARR

Study Guide and Review Manual of the Human Nervous System

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PREFACE

Because of the general acceptance of the senior author's Study Guides in Human Embryology and Human Anatomy, the Saunders Company asked us to prepare a similar learning aid for the Human Nervous System. This book is intended for those studying the nervous system for the first time, but it will surely be helpful to residents and others revising their knowledge of this complex system.

Although the questions and explanations are primarily anatomical, functional aspects are referred to and examples of clinical conditions are given. Because of the curtailment of time available for studying neuroanatomy, there has been a trend to teach only those aspects that are useful in clinical practice. Students naturally wish to know how much of this subject their teachers expect them to know.

Because of the extremely complex nature of the central nervous system, most students find neuroanatomy difficult. The objectives listed at the beginning of each chapter in this Study Guide define what students should be able to do in neuroanatomy before they begin their clinical studies. The objectives are based on the view that it is neither necessary nor desirable to expect students to master more than the essentials of the vast amount of knowledge on the nervous system that exists. By restricting the amount of formal instruction to basic neuroanatomy and by formulating instructional objectives, students are afforded the opportunity of acquiring much of this knowledge for themselves from lectures, dissections, museum specimens, atlases, audiovisual aids, and by interaction with basic science and clinical teachers.

In establishing the objectives, we have attempted to "bridge the gap" between neuroanatomy and gross anatomy of the nervous system. For this reason, consideration of cranial nerves is not restricted to those portions of them that lie within the cranial cavity.

Because multiple-choice examinations are being commonly used in medical and dental schools, and are formidable even to the best prepared, commonly used types of these questions have been developed around each region of the nervous system. Many questions have been developed to exemplify the clinical applications of neuroanatomy. Questions related to clinical problems requiring neuroanatomical knowledge for their solution are used frequently. All questions are intended for those wishing to test the state of their knowledge and to improve their skills with multiple-choice examinations.

Because we have attempted to establish what aspects of neuroanatomy are important for every medical student to know, we should appreciate receiving constructive criticism of the instructional objectives and questions. We want the questions and answers to be free of ambiguity and representative not only of the important aspects of neuroanatomy but also of high standards of education.

We should like to thank Mr. Brian Decker, Medical Editor of the

W.B. Saunders Company, for asking us to prepare this Study Guide and Review Manual, and for his helpful advice during its preparation. Mr. Walter Bailey, President of W. B. Saunders Company of Canada, has also been most encouraging and supportive. We are grateful to Mr. David Miller, Vice President-Publisher, Harper & Row, Publishers, Inc., for permitting us to use many illustrations from Dr. Barr's book, The Human Nervous System.

We also thank the many colleagues who have read the objectives and questions and made valuable suggestions for improving them. The authors are particularly pleased to acknowledge the editorial assistance of Mrs. E.J. (B.B.) Akesson, Assistant Professor of Anatomy, University of Toronto, who also critically read the manuscript. The secretarial assistance of Miss Pat Bryan, Mrs. Callie Cesarini, Miss Jill Parsons, and Mrs. Marion Moore is acknowledged with sincere thanks. Marion warrants special mention because she did all the final typing and preparation of the manuscript for photo-offset printing. Mrs. L. Eljas and Mr. H. Loth helped with the preparation and arrangement of the illustrations. Their help is much appreciated.

Toronto and London, Canada

The Authors

USER'S GUIDE

THIS GUIDE is designed to help you study, and later review, the HUMAN NERVOUS SYSTEM by providing learning objectives and various types of multiple-choice question based on these objectives.

The questions are not intended as a substitute for careful study, but they should enable you to detect your areas of weakness and afford you the opportunity of correcting these defects in your knowledge. Although answers to the questions are explained and notes are given, you should consult your textbook freely for further information. Through discussion of areas of weakness with your colleagues and instructors, you can test your ability to do the things listed as objectives at the beginning of each chapter.

TO USE this Study Guide most effectively, we suggest that you:

1. *Read the objectives listed at the beginning of the region or system you plan to study.*

2. *Carefully read the appropriate chapter(s) in your textbook and atlas and review your dissections, keeping these objectives in mind.*

3. *Attempt to answer the multiple-choice questions. The knowledge required to answer the questions indicates how much you are expected to know in order to fulfill the objectives. The test questions are similar to those used in various board and school multiple-choice examinations, and are designed to be answered at the rate of about one per minute.*

   As you complete each set of questions, check your answers. If any of your answers are wrong, read the notes and explanations and study the appropriate material and illustrations in your textbook and atlas, before proceeding to the next set of questions.

4. *If you get 80 per cent or more of the questions correct on the first trial, or during a subsequent review, you have performed very well and should have no difficulty answering similar questions based on these objectives.*

5. *When you have completed the study of a region or a system, e.g., the brain stem or the motor system, attempt the review examination at the end of the book. If the level of your performance is not superior, determine where your knowledge is defective and review this material before attempting the examination at a later date.*

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PART ONE REGIONAL ANATOMY

PART TWO THE SYSTEMS

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REFERENCE BOOKS

Barr, M.L.: The Human Nervous System: An Anatomical Viewpoint. 2nd ed., Hagerstown, Harper & Row Publishers, Inc., 1974.

Carpenter, M.B.: Core Text of Neuroanatomy. 2nd ed., Baltimore, Williams & Wilkins Co., 1978.

Moore, K.L.: The Developing Human. Clinically Oriented Embryology. 2nd ed., Philadelphia, W.B. Saunders Co., 1977.

PART ONE

REGIONAL ANATOMY

1. EARLY DEVELOPMENT OF THE NERVOUS SYSTEM

OBJECTIVES

BE ABLE TO:

* Discuss the origin of the nervous system from the neural plate, using simple diagrams to illustrate the neural groove, the neural folds, the neural tube, and the neural crest.

* Give an illustrated account of how the mature brain develops from the embryonic brain vesicles.

* Explain the embryological basis of anencephaly and spina bifida with myeloschisis.

TRUE AND FALSE STATEMENTS

DIRECTIONS: Indicate whether the following statements are true or false by underlining the T or the F at the end of each statement.

1. The nervous system has its origin in the neural plate which appears around the middle of the third week of development. T or F

2. In addition to the central nervous system, much of the peripheral nervous system is also derived from ectoderm on the dorsal surface of the embryo. T or F

3. All interstitial or neuroglial cells are derivatives of the outer ectodermal layer of the embryo. T or F

4. The neural tube begins to form at the end of the third week by a midline invagination of the neuroectoderm. T or F

5. Growth and differentiation of the neural tube are greatest in the caudal portion. T or F

6. The cerebrum is derived from the enlarged rostral end of the neural tube. T or F

7. By the end of the fourth week of its development, the brain consists of five brain vesicles. T or F

8. The myelencephalon is the most caudal of the brain vesicles. T or F

INDICATE WHETHER STATEMENTS ARE TRUE OR FALSE

9. The metencephalon develops into the medulla. T or F

10. The brain stem is derived from the rhombencephalon or hindbrain. T or F

11. The telencephalon gives rise to the cerebrum of the mature brain. T or F

12. The lumen of the telencephalon is largely converted into a lateral ventricle in each cerebral hemisphere. T or F

---------- ANSWERS, NOTES AND EXPLANATIONS ----------

1. T The nervous system develops from a thickened area of embryonic ectoderm called the neural plate. It appears during developmental stage 8 (about 18 days).

2. T Much of the peripheral nervous system is derived from the neural crest which forms from ectoderm as the neural plate becomes infolded to form the neural tube. The neural tube subsequently separates from the surface ectoderm and lies deep to it. At first the neural crest lies between the surface ectoderm and the neural tube, but it soon develops into two parts which migrate to the dorsolateral regions of the neural tube. Here they give rise to the sensory ganglia or dorsal root ganglia of the spinal and cranial nerves. Other neural crest cells give rise to autonomic ganglia.

3. F All neuroglial or supporting cells differentiate from neuroepithelial cells of the neural tube, a derivative of the ectoderm of the embryo, except microglial cells (microglia) which originate from the mesoderm surrounding the neural tube. The glioblasts (spongioblasts), formed by neuroepithelial cells after the production of neuroblasts (primordia of nerve cells) has ceased, give rise to astrocytes, oligodendrocytes, and ependymal cells.

4. T The first evidence of development of the central nervous system appears by the middle of the third week as the neural plate. Soon neural folds appear and fuse to form a neural tube. This fusion begins at the end of the third week in the region of the fourth pair of somites and proceeds in cranial and caudal directions.

5. F Growth and differentiation of the neural tube are greatest in the cranial portion. In the flexed embryo, the term rostral is used to describe the extreme cranial or cephalic end of the brain which becomes curved ventrally as it develops into the cerebrum.

6. T The neural folds in the enlarged rostral end of the developing brain fuse to form a primary brain vesicle known as the prosencephalon or forebrain. Subsequently it divides into two secondary brain vesicles: the telencephalon and the diencephalon. These vesicles give rise to the cerebrum, comprising the cerebral hemispheres and the diencephalon.

7. F Initially there are three primary brain vesicles: the prosencephalon (forebrain), the mesencephalon (midbrain), and the rhombencephalon (hindbrain). The prosencephalon and the rhombencephalon each divide into two secondary brain vesicles during the fifth week, so that there are five brain vesicles: the telencephalon, diencephalon, mesencephalon, metencephalon, and myelencephalon.

8. T The myelencephalon is the most caudal of the five secondary brain vesicles. Its walls give rise to the medulla and its cavity forms the inferior part of the fourth ventricle.

9. F The walls of the metencephalon give rise to the pons and the cerebellum and its cavity forms the superior part of the fourth ventricle.

10. F The brain stem, consisting of the midbrain, pons, and medulla, develops from the mesencephalon (midbrain) and the rhombencephalon (hindbrain).

11. F The telencephalon gives rise to the cerebral hemispheres, a large part of the cerebrum, but the remaining parts of the cerebrum, the thalamus, epithalamus, hypothalamus, and subthalamus, are derived from the diencephalon.

12. T Most of the cavity of the telencephalon becomes the lateral ventricles of the cerebral hemispheres. A small portion of its cavity forms part of the third ventricle. Most of the slit-like cavity of the third ventricle forms from the cavity of the diencephalon.

FIVE-CHOICE COMPLETION QUESTIONS

DIRECTIONS: Each of the following questions or incomplete statements is followed by five suggested answers or completions. SELECT THE ONE BEST ANSWER in each case and then underline the appropriate letter at the lower right of each question.

1. THE ROSTRAL AND CAUDAL NEUROPORES NORMALLY CLOSE DURING THE _____ WEEK OF EMBRYONIC DEVELOPMENT.
   A. Third
   B. Fourth
   C. Fifth
   D. Sixth
   E. Seventh

   A B C D E

2. WHICH STATEMENT ABOUT THE MESENCEPHALIC FLEXURE IS CORRECT?
   A. It is a pronounced ventral bend in the developing midbrain region
   B. It separates the mesencephalon from the diencephalon
   C. It indicates the region where the neural tube bends in a dorsal direction
   D. It separates the midbrain from the metencephalon
   E. It causes the roof of the rhombencephalon to become very thin

   A B C D E

3. THE PONS AND CEREBELLUM ARE DERIVED FROM THE:
   A. Myelencephalon
   B. Metencephalon
   C. Mesencephalon
   D. Diencephalon
   E. Telencephalon

   A B C D E

4. GROWTH AND DIFFERENTIATION OF THE NEURAL TUBE ARE GREATEST IN THE _____ PORTION.
   A. Middle
   B. Caudal
   C. Cervical
   D. Rhombencephalic
   E. Rostral

   A B C D E

SELECT THE ONE BEST ANSWER

5. WHICH OF THE FOLLOWING IS THE NAME OF BOTH A PRIMARY AND A SECONDARY BRAIN VESICLE?
   A. Myelencephalon
   B. Metencephalon
   C. Mesencephalon
   D. Diencephalon
   E. Telencephalon

   A B C D E

6. WHICH OF THE FOLLOWING IS NOT DERIVED FROM THE DIENCEPHALON?
   A. Thalamus
   B. Epithalamus
   C. Corpus striatum
   D. Neurohypophysis
   E. Hypothalamus

   A B C D E

7. WHICH OF THE FOLLOWING MAJOR REGIONS OF THE CENTRAL NERVOUS SYSTEM IS THE LEAST DIFFERENTIATED COMPONENT OF THE NEUROAXIS?
   A. Myelencephalon
   B. Spinal cord
   C. Metencephalon
   D. Mesencephalon
   E. Diencephalon

   A B C D E

8. WHICH REGION OF THE EMBRYONIC BRAIN UNDERGOES THE GREATEST DEVELOPMENT IN FORMING THE MATURE HUMAN BRAIN?
   A. Myelencephalon
   B. Metencephalon
   C. Mesencephalon
   D. Diencephalon
   E. Telencephalon

   A B C D E

9. WHICH OF THE FOLLOWING STRUCTURES IS NOT DERIVED FROM THE TELENCEPHALON?
   A. Cerebral hemisphere
   B. Corpus striatum
   C. Medullary center
   D. Neocortex
   E. Thalamus

   A B C D E

10. ANENCEPHALY, A CONDITION EXHIBITING MARKEDLY DEFECTIVE BRAIN DEVELOPMENT AND ABSENCE OF THE BONES OF THE CRANIAL VAULT, RESULTS PRIMARILY FROM FAILURE OF THE:
    A. Bones of the cranial vault to develop
    B. Rostral part of the neural tube to close
    C. Prosencephalon to divide into two secondary brain vesicles
    D. Neural folds to form in the rostral region of the embryo
    E. Mesencephalic flexure to form in the midbrain region

    A B C D E

---------- ANSWERS, NOTES AND EXPLANATIONS ----------

1. B Fusion of the neural folds begins in the midregion of the embryo at the beginning of the fourth week and proceeds in cranial and caudal directions. The neural folds at the open ends of the neural tube, the rostral and caudal neuropores, fuse around the middle of the fourth week. The rostral neuropore closes about two days before the caudal neuropore. Failure of these neuropores to close results in serious neural tube defects: anencephaly (absence of most derivatives of the forebrain) and spina bifida with myeloschisis (cleft in the vertebrae and spinal cord).

2. A The mesencephalic (cephalic) flexure is a ventral bend that occurs in the midbrain or mesencephalic region as the brain grows rapidly during the fourth week. A similar bend, the cervical flexure, occurs at the junction of the myelencephalon and the developing spinal cord.

3. B The pons and cerebellum develop from the walls of the metencephalon, the fourth secondary brain vesicle. The cavity of the metencephalon becomes the superior part of the fourth ventricle.

4. E Growth and differentiation are greatest in the rostral (noseward) portion of the neural tube, from which the large and complex brain develops. Most of the neural tube becomes the spinal cord.

5. C The mesencephalon, one of the three primary brain vesicles, does not divide during the fifth week and so it is also one of the five secondary brain vesicles. The mesencephalon of the mature brain is usually called the midbrain.

6. C The diencephalon of the mature brain, consisting of the thalamus, epithalamus, hypothalamus, and subthalamus, is derived from the diencephalon of the embryonic brain. The diencephalon forms the central core of the cerebrum. The corpus striatum, a large mass of gray matter, forms within the telencephalon or cerebral hemisphere.

7. B The spinal cord is the least differentiated component of the neuroaxis (central nervous system); that is, it is the least modified portion of the embryonic neural tube. The primitive segmental arrangement of the spinal cord is reflected in the series of paired spinal nerves, each of which is attached to the cord by a dorsal sensory root and a ventral motor root.

8. E The telencephalon, represented by the massive cerebral hemispheres, undergoes the most differentiation during development of the mature brain. Most of the cortex of the cerebral hemispheres is neocortex which provides areas for all modalities of sensation (exclusive of smell) and special motor areas.

9. E The thalamus is a derivative of the diencephalon; however, both the diencephalon and telencephalon are derivatives of the primary brain vesicle, known as the prosencephalon or forebrain.

10. B Anencephaly results when the most rostral part of the neural tube fails to close around the twenty-fourth day of development. This leads to failure of the cerebrum and cranial vault to form. The incidence of anencephaly is about 1:1000 births. As the exposed brain and membranes (meninges) are highly susceptible to infection, these infants rarely live for very long.

MULTI-COMPLETION QUESTIONS

DIRECTIONS: In each of the following questions or incomplete statements, **ONE OR MORE** of the completions given is correct. At the lower right of each question underline A if 1, 2, and 3 are correct; B if 1 and 3 are correct; C if 2 and 4 are correct; D if only 4 is correct; and E if all are correct.

1. WHICH OF THE FOLLOWING STATEMENTS IS (ARE) CORRECT?
   1. The brain and spinal cord have their origin in the neural tube
   2. The nerve cells of the central nervous system are derivatives of the outer ectodermal layer of the embryo
   3. Growth and differentiation are greatest in the rostral portion of the neural tube
   4. The three primary vesicles appear toward the end of the third week of development

A B C D E

A	B	C	D	E
1,2,3	1,3	2,4	only 4	all correct

2. THE WALLS OF THE PROSENCEPHALON GIVE RISE TO THE:
   1. Thalamus
   2. Cerebral hemispheres
   3. Hypothalamus
   4. Corpus striatum

   A B C D E

3. THE CAVITIES OF THE BRAIN VESICLES GIVE RISE TO THE:
   1. Lateral ventricles
   2. Cerebral aqueduct
   3. Third ventricle
   4. Central canal of the spinal cord

   A B C D E

4. WHICH OF THE FOLLOWING EMBRYOLOGICAL NAMES OF BRAIN VESICLES IS (ARE) COMMONLY USED TO DESCRIBE PARTS OF THE MATURE CENTRAL NERVOUS SYSTEM?
   1. Prosencephalon
   2. Diencephalon
   3. Metencephalon
   4. Mesencephalon

   A B C D E

5. WHICH OF THE FOLLOWING PARTS OF THE BRAIN IS (ARE) NOT A DERIVATIVE OF THE TELENCEPHALON?
   1. Thalamus
   2. Corpus striatum
   3. Cerebellum
   4. Olfactory bulb

   A B C D E

6. THE CEREBRUM IS DERIVED FROM THE:
   1. Diencephalon
   2. Mesencephalon
   3. Telencephalon
   4. Metencephalon

   A B C D E

7. WHICH OF THE FOLLOWING SECONDARY BRAIN VESICLES CONTRIBUTE(S) TO THE FORMATION OF THE BRAIN STEM?
   1. Myelencephalon
   2. Metencephalon
   3. Mesencephalon
   4. Diencephalon

   A B C D E

8. THE CAVITY OF THE RHOMBENCEPHALON (HINDBRAIN) IS CONVERTED INTO THE:
   1. Lateral ventricles
   2. Cerebral aqueduct
   3. Third ventricle
   4. Fourth ventricle

   A B C D E

9. WHICH OF THE FOLLOWING CONGENITAL MALFORMATIONS RESULT(S) FROM NEURAL TUBE DEFECTS?
   1. Spina bifida occulta
   2. Anencephaly
   3. Microcephaly
   4. Myeloschisis

   A B C D E

10. THE DIENCEPHALON OF THE EMBRYONIC BRAIN IS REPRESENTED IN THE MATURE BRAIN BY THE:
    1. Thalamus
    2. Epithalamus
    3. Hypothalamus
    4. Subthalamus

    A B C D E

---------- ANSWERS, NOTES AND EXPLANATIONS ----------

1. A 1,2, and 3 are correct. The brain and spinal cord develop from a thickened area of embryonic ectoderm, the neural plate. The lateral edges of this plate soon become elevated to form neural folds which begin to fuse around the end of the third week, forming the neural tube. By the end of the fourth week, three primary brain vesicles are present: the prosencephalon (forebrain), the mesencephalon (midbrain), and the rhombencephalon (hindbrain).

2. E All are correct. The prosencephalon (forebrain) divides into two secondary brain vesicles, the diencephalon and telencephalon. The diencephalon develops into the thalamus, epithalamus, hypothalamus, and subthalamus. The telencephalon gives rise to the cerebral hemispheres, consisting of the olfactory system, corpus striatum, cortex, and medullary center.

3. A 1,2, and 3 are correct. The cavities of the brain vesicles give rise to the lateral ventricles, the third ventricle, the cerebral aqueduct, the fourth ventricle, and the central canal of the medulla oblongata. The central canal of the spinal cord, like the ventricles of the brain, is derived from the lumen of the neural tube but is not derived from the cavity of any of the brain vesicles.

4. C 2 and 4 are correct. The embryological terms diencephalon and mesencephalon are retained to designate parts of the mature brain. The diencephalon forms the central core of the cerebrum. The mesencephalon undergoes less change than any other part of the brain, except the caudal part of the hindbrain. In the mature brain, the mesencephalon is most often called the midbrain.

5. B 1 and 3 are correct. The thalamus is a derivative of the diencephalon, not of the telencephalon, and the cerebellum is derived from the metencephalon. The telencephalon gives rise to the cerebral hemispheres, consisting of the olfactory system, corpus striatum, cortex and medullary center.

6. B 1 and 3 are correct. The cerebrum comprises all derivatives of the prosencephalon or forebrain vesicle. Thus, it is derived from the diencephalon and the telencephalon, the secondary brain vesicles derived from the prosencephalon.

7. A 1,2, and 3 are correct. The brain stem consists of: a) the medulla, a derivative of the myelencephalon; b) the pons, derived from the metencephalon; and c) the midbrain, a derivative of the mesencephalon. Although each of these three regions has special features, they have certain fiber tracts in common, and each region includes nuclei of cranial nerves.

8. D Only 4 is correct. The cavity of the rhombencephalon or hindbrain vesicle is converted into the fourth ventricle, bounded by the medulla, pons, and cerebellum. The central canal of the closed portion of the medulla is also derived from the cavity of the hindbrain vesicle.

9. C 2 and 4 are correct. Failure of the rostral neuropore to close results in anencephaly, a common abnormality (about 1:1000), characterized by absence of prosencephalic (forebrain) derivatives. Failure of the caudal neuropore to close results in a severe form of spina bifida, usually in