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[1] Regarding the three regions of the insect brain, the most anterior is the

a. Protocerebrum*
b. deutocerebrum
c. tritocerebrum
d. varies according to the particular insect

[2] The nervous system of animals is patterned by mechanisms that are different from those that pattern the rest of the body

a. true
b. false*

[3] The insect brain contains approximately _____ neuroblasts.

a. 100*
b. 20
c. No
d. 300

[4] In the vertebrate brain, which vesicle gives rise to the paired cerebral hemispheres?

a. Prosencephalon*
b. Mesencephalon
c. Metencephalon
d. Myelencephalon

[5] The gnathal segments of the insect CNS are located

a. Between the abdominal and thoracic segments
b. Between the tritocerebrum and the abdominal segments
c. Between the protocerebrum and the thoracic segments
d. Between the tritocerebrum and the thoracic segments*

[6] In the vertebrate brain, which vesicle gives rise to the cerebellum?

a. Prosencephalon
b. Mesencephalon
c. Metencephalon*
d. Myelencephalon

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[7] In *drosophila* the anterior-posterior axis is established by

a. The distribution of the RNA-binding transcription factor called *bicoid* and the protein *nanos* localized in the anterior and posterior poles of the embryo, respectively
b. The distribution of a gene that codes for an RNA-binding protein called *nanos* localized in the anterior pole of the embryo and a transcription factor called *bicoid* localized in the posterior pole of the embryo
c. The distribution of a gene that codes for an RNA-binding protein called *nanos* localized in the posterior pole of the embryo and a transcription factor called *bicoid* localized in the anteror pole of the embryo*
d. The distribution of the RNA-binding transcription factor called *bicoid* and the protein *nanos* localized in the posterior and anterior poles of the embryo, respectively

[8] The *drosophila* oocyte exhibits two gradients of mRNA for the maternal-effect genes, one at each pole; these gradients regulate the expression of gap genes.

a. True*
b. False

[9] Mutations in *Hox* genes in the fly may cause

a. Each segment of the animal to be uniquely morphologically different
b. A segment of the animal to be morphologically repeated*

[10] *Homeobox* genes in *Drosophila* are arranged in _____ clusters, in linear arrays on the chromosomes, in the order of their expression along the anterior-posterior axis.

a. Two*
b. Eight
c. Three
d. A variable number of

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[11] *Hox* genes are important in

a. The development of positional identity in animals*
b. Establishing the correct number of segments in the anterior-posterior axis
c. Arthropods but not vertebrates
d. Establishing cytoplasmic polarity (the maternal effect)

[12] *Hox* gene clusters in *Drosophila* and *mouse*

a. Have similar spatial organization and similar order along the chromosomes*
b. Have different spatial organization but similar order along the chromosomes
c. Have similar spatial organization but different order along the chromosomes
d. Are unrelated in terms of spatial organization and order along the chromosomes

[13] Because *Homeobox* genes are highly conserved among the phyla, there are approximately the same number in *mouse* as in *Drosophil* (and humans).

a. True
b. False*

[14] In both flies and mice, the position of a particular *Hox* gene on the chromosome is correlated with its expression along the anterior-posterior axis.

a. True*
b. False

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[15] The *Hox a13, b13, c13* and *d13* genes in the mouse are expressed in

a. The posterior end of the animal at the 5' end of the chromosome*
b. The anterior end of the animal at the 3' end of the chromosome
c. The posterior end of the animal at the 3' end of the chromosome
d. The anterior end of the animal at the 5' end of the chromosome

[16] Repeated morphological subdivisions of the hindbrain in vertebrates are known as

a. Telomeres
b. Rhombomeres*
c. *Hox* gene clusters
d. Flexures

[17] In the vertebrate hindbrain, a unique set of motor neurons, controlling different muscles of the head, arises from each

a. Telomere
b. Rhombomere*
c. *Hox* gene cluster
d. Flexure

[18] How do segments in the vertebrate hindbrain become different from one another?

a. Each rhombomere has a unique paralogous group of *Hox* genes
b. The expression of paralogous groups of *Hox* genes coincides with rhombomeric boundaries*
c. Members of paralogous groups 1-4 of *Hox* genes are expressed in a non-overlapping pattern
d. The pattern of expression of paralogous groups of *Hox* genes varies in different vertebrates

[19] Which is correct?

a. Overlapping patterns of *Hox* gene expression in vertebrates results in less dramatic phenotypic mutants if a single *Hox* gene is lost
b. Loss of two or more *Hox* genes in vertebrates results in more severe phenotypic deficits similar to those seen in arthropods
c. Both of these statements are true*
d. Neither of these statements is true

[20] As an example of the remarkable conservation of *Hox* gene functioning across phyla, it appears that, in both arthropods and vertebrates, the developmental cascade –gap, pair-rule and segment polarity genes—parcels the embryo into smaller and smaller regions, each of which has a unique *Homeobox* expression pattern that uses very similar upstream mechanisms.

a. True
b. False*

[21] The anterior-to-posterior order of the segmentation of motor neurons of the cranial nerves in the vertebrate hindbrain is:

a. Glossophyaryngeal, abducens, facial, trigeminal
b. Trigeminal, facial, abducens, glossopharyngeal*
c. Glossopharyngeal, trigeminal, abducens, facial
d. Facial, abducens, glossopharyngeal, trigeminal

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[22] In the normal vertebrate embryo, the retinoic acid gradient is

a. About 10 times higher in the posterior than the anterior region*
b. About 10 times higher in the anterior region than the posterior
c. At a low level in all regions otherwise defects in *Hox* gene expression in the anterior segments will occur
d. At a high level in all regions otherwise defects in *Hox* gene expression in the anterior segments will occur

[23] Identifying the source of the retinoic acid gradient in the embryo, demonstrates that

a. Non-neural tissue in the developing embryo plays a critical role in development of the nervous system*
b. Normal development of the nervous system does not rely upon interactions with non-neural tissues
c. Retinoic acid plays a minor role in the expression of *Hox* genes
d. Retinoic acid response elements in *Hoxa1* and *Hoxb1* are neither necessary nor sufficient for anterior-posterior rhombomere-specific expression patterns.

[24] Enzymes that synthesize retinoic acid are found in the mesoderm.

a. True*
b. False

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[25] Nieuwkoop's activator-transformer hypothesis is best described

a. The first neural inducer causes mesodermal cells to develop posterior characteristics; the second neural inducer, anterior ones
b. The first neural inducer causes ectodermal cells to develop anterior characteristics; the second neural inducer, posterior ones*
c. Both neural inducers differentiate ectodermal cells into anterior and posterior characteristics, unless the ectodermal cells are placed in the caudal neural plate
d. Both neural inducers differentiate mesodermal cells into anterior and posterior characteristics, if the mesodermal cells are placed in the caudal neural plate

[26] Co-inhibition of *Wnt* and BMP signals leads to

a. Induction of anterior neural structures*
b. Induction of posterior neural structures
c. Induction of trunk neural tissue
d. Induction of head but not brain structures

[27] Synergy between the BMP antagonist *noggin* and the *Wnt* antagonist *Dkk1* is demonstrated by

a. Noting the normal head and brain development of mice with the loss of a single allele of both genes
b. Noting the abnormal head and brain development of mice with a loss of a single allele of both genes*
c. Noting the normal head and brain development of mice lacking *Dkk1* alone
d. The Cerberus protein does not inhibit either the *Wnt* or the *Dkkt* pathways

[28] The FGF class of molecules have been proposed as a 'transformer' because

a. FGFs induce anterior gene expression in animal caps that have undergone experimental neural induction using a BMP antagonist
b. FGFs induce posterior gene expression in animal caps that have undergone experimental neural induction using a BMP antagonist*
c. FGFs do not act in a concentration-dependent manner like retinoic acid
d. Reducing concentrations of FGF in chick embryos induces posterior members of the *Hox* cluster to be expressed

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[29] Frog embryos injected with anti-*dkk1* (anti-15) antibody

a. Develop a second head
b. Develop abnormalities of the trunk and tail
c. Develop microcephaly and/or cyclopia*
d. Develop normally

[30] The signals that "anteriorize" or "posteriorize" the embryo follow the rule that differences among cells are created by changing the pattern of gene expression via specific transcription factors.

a. True*
b. False

[31] Anencephaly, a failure of developing brain regions rostral to rhombomere 3, may be caused by

a. A deletion of *Gbx2* gene
b. A deletion of *Otx2* gene*
c. Too much *FrzB* protein
d. Too much *Cerberus* factor

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[32] Cross repression of transcription factors is a widely used mechanism for

a. Generation of distinct boundaries between expression domains in the embryo*
b. Establishing the anterior-posterior gradient of retinoic acid
c. Establishing repeated morphological subdivisions of the hindbrain
d. Induction of gene expression in the embryo

[33] The molecular basis for the hypothesis that specific regions of the neural tube are organizing centers for patterning adjacent regions of the neural tube, was established through studies of the _____.

a. Midbrain/hindbrain border*
b. Metencephalon
c. Mesencephalon
d. Hindbrain/spinal cord border

[34] If a small piece of quail metencephalon is transplated into the forebrain of a similarly developed chick embryo

a. The cerebellum fails to develop
b. The cerebellum develops but the superior and inferior colliculi fail to develop
c. The cerebellum fails to develop but a new superior and inferior colliculi develop
d. The cerebellum develops and a new superior and inferior colliculi also develop*

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[35] The important signaling molecules *Wnt1* and *En1* are localized to the mes-met boundary; in knockout mice they have been shown to be critical for the normal development of

a. Cerebellum and midbrain*
b. Forebrain
c. Medulla
d. All of these structures

[36] One of the major signals of "organizer" activity in the developing nervous system is *Fgf8*; among other roles it sets up and maintains the

a. Initial distinction between the anterior and posterior divisions of the embryonic nervous system
b. Division between dorsal and ventral thalamus
c. Organization of the anterior pole of the neural tube
d. The mes-met boundary*

[37] According to the current model of how the mes-met signaling center arises, the last stage is:

a. *Fgf8* is expressed at the point of cross-inhibition of *Otx2* and *Gbx2*
b. The interaction of *Otx2* and *Gbx2* maintains *Fgf8* expression
c. *Fgf8* induces *En1*in the cells that express both *Irx1* and *Otx2*
d. *Fgf8* regulates growth of progenitor cells in the mes-met region*

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[38] Evidence from research on the mes-met boundary suggests that localized organizing centers are a derivative, not a basic mechanism of brain patterning.

a. True
b. False*

[39] Crucial elements for producing a “fate map”, a description of the ultimate fate of various embryonic cells are

a. Vital dyes
b. Cell injections
c. Transplant studies
d. All of these are critical elements*

[40] Fate-mapping studies have demonstrated that the fate of cells in the embryonic nervous system is always fixed and cannot be changed.

a. True
b. False*

[41] Interspecific transplant studies are successful when two species are similar enough at an early embryonic stage that transplanted cells will integrate with host cells so well that the transplanted cells lose their identity.

a. True
b. False*

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[42] Even though the basic pattern of forebrain organization is common to all vertebrates, the pattern has been elaborated upon in order to generate the diversity of brain organization actually found in extant species.

a. True*
b. False

[43] The prosomeric model of forebrain development proposes that there are both longitudinal as well as transverse patterns of gene expression that subdivide the neural tube into sections of different regional identities.

a. True*
b. False

[44] According to the prosomeric model of development, there are _____ prosomeres in the vertebrate forebrain, numbered from caudal to rostral.

a. Six*
b. Four
c. Three
d. Varies according to the species

[45] The current evidence strongly suggests that several different classes of transcriptional factors play a role in specifying the positional identity of cells in any one particular brain region.

a. True*
b. False

[46] The nine *Pax* genes are all expressed in the developing nervous system, playing a key role in specifying regional differences in the vertebrate forebrain.

a. True
b. False*

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[47] Humans with mutations in an allele of *Pax6* exhibit

a. Aniridia*
b. An ectopic eye
c. Failure of eye development
d. Cyclopia

[48] *Pax6* is an example of a single gene controlling the development of an entire sensory organ, in this case, the eye.

a. True
b. False*

[49] The onset of expression of which transcription factors in the anterior region of the neural plate signal the determination of the cells in this region to an eye fate.

a. *Pax6/eyeless*
b. *Eya/eyes absent*
c. *Six3/sine oculus*
d. All of these transcription factors*

[50] Which part of the early neural tube develops first?

a. Floorplate*
b. Roofplate
c. Floorplate and roofplate develop at the same time
d. Floorplate and roofplate develop at different times according to the species

[51] What provides early evidence that the neural tube is differentiating along the dorsal-ventral axis?

a. The floorplate, roofplate and sulcus limitans*
b. The mes-met boundary and the regional expression of transcriptor factors
c. The rhombomeric and prosomeric organization of the forebrain
d. All of these

[52] The distinct dorso-ventral polarity of the neural tube is dependent on

a. The presence of the notochord*
b. The floorplate and roofplate flattening
c. The rhombomere segments
d. All of these

[53] In mammals, a polarity signal (secreted protein) is released from the mesoderm which is necessary and sufficient to induce dorso-ventral polarity in the neural tube; the responsible gene is called

a. *Sonic hedgehog**
b. *Pax6*
c. *Hedgehog*
d. Either *Pax7, Olig2* or *Nkx2.2*

[54] *Shh* acts as a morphogen in the neural tube like _____ does for the patterning of rhombomeres.

a. Retinoic acid*
b. *Pax6*
c. *Fgf8*
d. *Otx2* and *Gbx2*

[55] A particularly striking mutant phenotype arising from disruption of *Shh* in the ventral forebrain during embryogenesis is

a. Cyclopia*
b. Failure of limb development
c. Defects in the mandible and maxillae
d. All of these

[56] In experimental removal of the notochord, prior to closure of the neural tube, defects in ventral neural tube differentiation include

a. Lack of motor neurons*
b. Lack of sensory neurons
c. Too many motor neurons
d. Ectopic motor neurons

[57] The neural crest may be considered

a. An indicator of dorsal neural tube differentiation*
b. An indicator of ventral neural tube differentiation
c. An indicator that dorso-ventral polarity has been disrupted
d. An ectopic collection of cells indicating failure of neural tube closure

[58] For the neural tube to differentiate properly, must the notochord be touching it?

a. Yes
b. No*

[59] Smooth muscle cells derive from the cells of the neural crest.

a. True*
b. False

[60] The ectoderm provides the molecular signals to promote _____ differentiation in the lateral regions of the spinal cord.

a. Dorsal*
b. Ventral
c. Medial
d. anterior

[61] BMPs and *Wnt*s, expressed at the margin of the neural plate, induce the development of the _____ at the boundary of the neural plate and the _____.

a. Neural crest; ectoderm*
b. Neural tube; mesoderm
c. Neural crest; mesoderm
d. Neural tube; ectoderm

[62] In the fly embryo, the transcription factors *msh, ind, vnd,* uniquely specify the position of neuroblasts along a Cartesian grid; these genes are expressed according to a gradient of the morphogen _____ whose homolog in vertebrates is _____

a. *Dpp; BMP**
b. *Wnts; Dpp*
c. *BMP; Dpp*
d. *Wnts; BMP*

[63] The mammalian cerebral cortex is derived from the

a. Dorsocaudal telencephalic vesicle
b. Dorsocaudal rhombocephalic vesicle
c. Ventrorostral telencephalic vesicle
d. Ventrorostral rhombocephalic vesicle

[64] The differentiated regions (specializations) of the cerebral cortex arise later in development as a consequence of connections with other brain regions and experience.

a. True
b. False*

[65] Two important transcription factors that play a role in the specification of regional identities in cortex are _____ and _____, expressed in opposing gradients across the cortical surace

a. *Pax6 Emx2**
b. *Pax6 Shh*
c. *Shh Emx2*
d. *BMP Shh*

[66] Increasting the amount of *Fgf8* in the anterior pole of the telencephalic vesicle causes a downregulation of *Emx2* with the result that cortical regions such as motor cortex are shifted in a _____ direction.

a. Caudal*
b. Rostral
c. Medial
d. Lateral