

BIO380HF—HUMAN DEVELOPMENT
University of Toronto Mississauga
Second Midterm Test—October 12, 2011
Professor Danton H. O'Day
Test Length: 50min; 100 Marks Total

Answer all questions giving the best or most appropriate answer in each case. No aids allowed.

KEY

A. MULTIPLE CHOICE—Underline the best answer (2 mark each; 30 marks total)

1. Human male germ cells arise in the:
 - a. placenta prior to gastrulation
 - b. epiblast prior to gastrulation
 - c. neurogenital ridges prior to gastrulation
 - d. testicles prior to gastrulation
 - e. none of the above

2. The routes the germ cells follow is lined with:
 - a. fibronectin
 - b. extracellular matrix
 - c. laminin
 - d. extracellular proteins
 - e. all of the above

3. Which of the following statements about Turner syndrome is true?
 - a. It is due to the lack of an X or Y chromosome
 - b. It leads to a female phenotype
 - c. It occurs in 1 in 2500 females
 - d. It leads to cognitive defects
 - e. All of the above are true

4. The secondary follicle
 - a. is surrounded by several layers of follicle cells
 - b. contains some follicular fluid
 - c. contains a secondary oocyte
 - d. all of the above
 - e. a and b are correct

5. The tertiary follicle
 - a. is surrounded by a single layer of follicle cells
 - b. contains no follicular fluid
 - c. contains a tertiary oocyte
 - d. contains a secondary oocyte
 - e. contains a primary oocyte

6. Which of the following are not part of the mature male genitalia

- a. Urethra
- b. Bartholomew's gland
- c. Vasa efferentia
- d. Cowper's gland
- e. Bulbourethral gland

7. Which of the following statements about the human ejaculate are not true:

- a. It contains as many as 250×10^7 sperm
- b. It has a volume of 20mL
- c. A count of 5 million sperm/mL is sufficient for male fertility
- d. Semen has a pH of 8.7
- e. All of the above
- f. All of the above except b

8. Which of the following statements about alkaline phosphatase is not true?

- a. It removes phosphate groups from molecules
- b. It works at a pH above 7.0
- c. It is a marker for primordial germ cells
- d. It is a marker for both primordial germ cells and semen
- e. It is an enzyme

9. Which of the following statements about acid phosphatase is not true?

- a. It removes phosphate groups from molecules
- b. It works at a pH below 7.0
- c. It is a marker for primordial germ cells
- d. It is a marker for semen
- e. It is an enzyme

10. Which of the following statements about integrin is true?

- a. It is found in the extracellular matrix
- b. It binds to fibronectin
- c. It is a marker of primordial germ cells
- d. It lines the pathways primordial germ cells follow
- e. It is an enzyme

11. Which of the following statements about the primary oocyte is not true?

- a. It is locked in diplotene
- b. It has started meiosis I
- c. It has not started meiosis I
- d. It has not started meiosis II
- e. It has not released a polar body

12. Which of the following statements about meiotic non-disjunction is true?

- a. It is considered to be a result of the "maternal age effect"
- b. It is not related to the "paternal age effect"
- c. It can be due to non-disjunction during mitosis
- d. It does not involve the spindle apparatus
- e. All of the above are correct

Name: _____ KEY _____ Student Number: _____

13. Mutants in the human DAZ gene lead to:

- a. the absence of gonads
- b. the absence of genital ridges
- c. the absence of sperm
- d. all of the above
- e. none of the above

14. Which of the following statements about annulate lamellae is not true?

- a. It is adjacent to the germinal vesicle of the developing egg
- b. It is found in the cytoplasm of the developing egg
- c. It likely contributes to the forming pronuclei
- d. It is derived from the developing pronuclei
- e. It consists of parallel stacks of nuclear envelope-like membranes

15. Which of the following statements about the axoneme is not true?

- a. It has a central doublet of microtubules
- b. It is surrounded by a cell membrane
- c. It is able to undergo microtubular sliding
- d. It possesses dynein which converts cAMP into ATP
- e. It is surrounded by dense fibres

Part B. SHORT ANSWER. Answer in point form or sentences. Where appropriate, your answer must be clearly written, organized and progress in a logical sequence. Diagrams can be used.

1. Using clearly written sentences, list the steps used in the two different approaches that are used to generate transgenic mice. (15 marks)

See figure 3.10 in “Creating Transgenic Mice” Online self-study

3. Using well written, organized sentences. Define and clarify the importance of the following. (5 marks each; 15 Marks total)

a. Block to Polyspermy:

- Polyspermy is the penetration of the egg by more than one sperm
- Polyspermy leads to abnormal development because the chromosomal # is altered
- Normally the low number of sperm cells in the fallopian tubes in mammals reduces chances of polyspermy
- Special blocks to polyspermy exist:
Fast Block: electrical change in egg membrane;
Slow Block: modification of zona pellucida

b. Calcium Regulation of Acrosome Exocytosis:

Calcium plays a part in the exocytosis of the acrosome during fertilization as evidenced by the following and other results. When calcium ionophores (chemicals that cause channels to form in membranes allowing calcium to flow through) are added to sperm they induce the acrosome reaction. The increased calcium levels that drive the acrosome reaction come from various sources as shown in the following diagram. Binding of ZP3 to the ZP3 receptor in the sperm membrane activates G protein signaling that in turn activates phospholipase C ultimately causing intracellular levels of calcium to increase. TRPC calcium ion channels and T-type calcium channels in the sperm cell membrane allow calcium to influx from outside the cell. Together the increase calcium levels drive the membrane fusion events of the acrosome reaction.

c. Zona Pellucida

Protein coat surrounding the egg

Species-specific barrier to sperm binding and penetration; keeps sperm of foreign species out

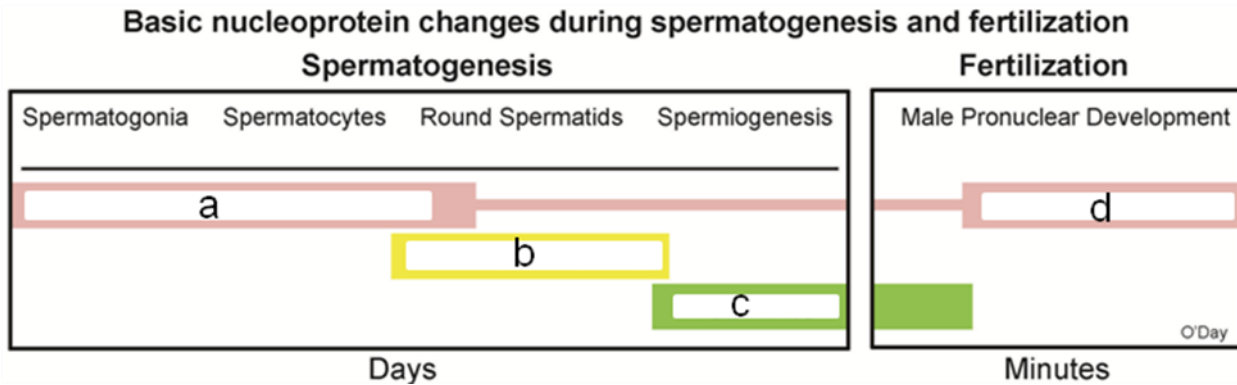
Not 100% effective; some cross-species fertilization can occur (e.g., horse & donkey = mule; some species of monkeys can cross fertilize); Remove the ZP and other species sperm can fertilize and egg (e.g., Hamster Test for Male Fertility; human sperm can fertilize the zona-less hamster egg)

The Zona Pellucida is made up of three major glycoproteins:

- ZP3 mediates Sperm-Specific Egg Binding
- ZP2 mediates subsequent sperm binding

ZP1 cross-links ZP2 and ZP3 as protein meshwork; not essential for fertilization but is important for structural integrity of zona pellucida; mice that lack ZP1 produce embryos that hatch prematurely causing developmental problems

4. Using the following diagram answer the questions that follow. (20 Marks)



i. Name the nucleoproteins indicated by the following numbers noted in the above diagram:

(2 marks each a-d)

a: ___paternal histones_____

b: ___transitional histones_____

c: ___protamines_____

d: ___maternal histones_____

ii. What distinguishes a basic nucleoproteins from b?

histones: 100+ amino acids in size; lysine rich; H1-H5 variants (3 marks)

transition proteins: TP1 ~50aa, lys, arg, his-rich; TP2 ~100aa; ser, pro, cys-rich (3 marks)

iii. What distinguishes a basic nucleoproteins from c?

Protamines are smaller, ~50aa; P1 arg, cys-rich; P2 his-rich (2 marks)

iv. What is the difference in chromosome structure in cells expressing a basic nucleoproteins from those expressing c basic nucleoproteins?

histones organize nucleosomes (beads on a string); protamines don't and therefore allow tighter packing of DNA (2marks)

v. What role do these changes play in spermiogenesis?

-nuclear condensation and shaping; streamlining cell and protecting DNA (2 marks)

5. Compare and contrast oogenesis with spermatogenesis using point form to fill in the following table. (20 marks)

A. Similarities

- Both start from primordial germ cells that migrate to gonadal ridges
- Both increase numbers of gonidia by mitosis
- Both convert gonidia to haploid gametes by meiosis
- Both involve growth and differentiation

B. Differences

Oogenesis

- Events randomly distributed through ovary
- Egg stages surrounded by follicle cells
- Produces a large, round immobile ovum
- Each primary oocyte yields one egg and 2-3 polar bodies
- Large amount of growth in size
- Differentiation occurs before meiosis
- Special egg organelles (e.g. annulate lamellae)
- Cell membrane specialized for sperm binding

Spermatogenesis

- Events organized from wall to lumen of seminiferous tubules
- Occurs in association with Sertoli cells
- Produces a streamlined, motile spermatozoan
- Each primary spermatocyte produces 4 sperm
- Comparatively small amount of growth
- Differentiation occurs after meiosis
- Special sperm organelles (e.g., acrosome, flagellum)
- Cell membrane specialized for egg binding