

**PREPARING FOR CERTIFYING EXAMINATION OF THE AMERICAN  
COLLEGE OF THERIOGENOLOGISTS**

**Updated January 9, 2015**

The field of theriogenology is broad, encompassing many disciplines and involving several domestic species. The Certifying Examination will include fields of specialty beyond the recent experience of most theriogenologists. Material in the examination will include the reproductive processes of food-producing animals (cattle, goats, sheep and swine), companion animals (cats, dogs, horses, camelids) and, to a limited extent, exotic and laboratory animals and birds. It is recommended that the candidate attain a broad general base of knowledge in Theriogenology as it applies to anatomy, embryology, physiology, pathology, microbiology, biotechnology, endocrinology, and clinical medicine and surgery. The theriogenologist who is a specialist in a basic science must be aware of applied theriogenology and the clinician or practitioner should review the basic aspects of theriogenology. Also refer to the General Information Guide (GIG) for more information.

**STUDY TIPS FROM CANDIDATES WHO HAVE PREVIOUSLY TAKEN THE ACT CERTIFYING EXAM**

The following information was obtained from the Post-examination Survey that was given to all candidates immediately after completion of the 2005 ACT Certifying Examination. It represents the compiled responses of the candidates who successfully passed the examination and became Diplomates. This information does not necessarily reflect the views of the ACT or ACT Certifying Examination Committee. Posting of this information should not be viewed as an endorsement.

**Top 5 ways to study:**

1. Read textbooks early on, taking notes as you read. Divide the notes into sections by species or general topic (i.e. anatomy, endocrinology, physiology, etc.) As the exam draws nearer, review the notes, do not try to go back and re-read the texts.
2. Use flash cards for subjects that are conducive – i.e. abortion, maternal recognition of pregnancy, etc.
3. Use tables for comparative topics between species – i.e. pregnancy characteristics, spermatogenesis, etc.
4. Discuss concepts, topics and diseases in study groups, graduate classes, with professors and mentors, and on the ACT candidate list-serve.
5. Go to other colleges or practices to work with species or in areas that you are unfamiliar or do not have access to at your institution or practice, to gain hands-on experience and obtain good mentoring from persons with expertise in that particular field.

**How to Better Utilize your Mentor:**

1. Make a comprehensive study plan and stick to it. Don't expect to have time off work just before the exam to study (cram). There is no way to "play the system" to pass the ACT certifying examination.
2. Have multiple mentors and schedule regular meetings to update your progress. Candidates are strongly encouraged to undertake broad-based preparation.
3. Adequacy of preparation is dependent on the dedication of candidates to their preparation, the mentors available to them, and to the candidate's desire and ability to seek out education experiences outside their species of interest. Don't expect your mentor to take the initiative for your learning.

## **EXAM FORMAT**

The certifying examination contains three different types of questions: multiple-choice, essay, and practical questions. For the multiple choice questions, candidates are expected to select the correct answer amongst five possible alternatives. Candidates are expected to express themselves fully in responding to the essay questions to demonstrate that they are specialists in Theriogenology. This include explaining simple, more general concepts as well as more specific, technical aspects. The practical examination consists of a series of projected images, each accompanied by written questions that require only short answers.

## **MULTIPLE-CHOICE SAMPLE QUESTIONS**

**Question: Development of equine allantochorionic microcotyledons occurs in all of the following areas EXCEPT:**

- a. the gravid uterine horn.
- b. the nongravid uterine horn.
- c. the uterine body.
- d. the nongravid uterine horn and uterine body.
- e. the area overlying the endometrial cups.

**Answer:** e

### **References:**

- Asbury AC, LeBlanc MM. The placenta. In: McKinnon AO, Voss JL, eds. Equine reproduction. Philadelphia: Lea & Febiger, 1993;509-516.
- Bucca S, Fogarty U, Collins A, Small V. Assessment of fetoplacental well-being in the mare from mid-gestation to term: transrectal and transabdominal ultrasonographic features. Theriogenology. 2005;64:542-557.

**Question: Which of the following has NOT been attributed to ingestion of zearalenone?**

- a. Reduced litter size in gilts.
- b. Preputial enlargement in boars.
- c. Irregular interestrus intervals in sows.
- d. Agalactia in gilts.
- e. Increased incidence of stillbirths in sows.

**Answer:** a

### **References:**

- Oswailer GD. Mycotoxins. In: Straw BE, D'Allaire S, Mengeling WL, Taylor DJ, eds. Diseases of swine. 8th ed. Ames, Iowa: Iowa State University Press, 1999;731-755.
- Long GG, Diekman MA. Effect of purified zearalenone on early gestation in gilts. J Anim Sci 1984;59:1662-1670.

## **ESSAY SAMPLE QUESTIONS**

**Question: Using the following headings, discuss the cloning of Dolly the sheep.**

### Preparation of the cloned nuclear material (3 pts):

The nucleus from a cell culture line of mammary gland was transferred into an enucleated oocyte (cytoplast). The culture cell line was passed between 3 and 6 times before being used as nuclear donors. The donor cells were fully differentiated. Recipient oocytes were flushed from the oviducts when arrested in metaphase II (MII). The DNA replication stage of the donor cell nucleus and the cytoplasmic stage of the recipient ooplasm were in synchrony. The recipient cytoplasts arrested at MII have high maturation promoting factor (MPF) activity. Since nuclei transferred into this environment undergo membrane breakdown and chromosome condensation it is important that transferred nuclei be diploid to continue their development. Donor cells were made quiescent by reduction of the serum concentration in culture media from 10% to 0.5% for 5 days, which caused cells to exit the growth cycle and arrest in the G0 phase of the cell cycle, in a diploid state.

### Transfer of nuclear material (2 pts):

Recipient oocytes were then transferred to calcium free media containing Cytochalasin B and a DNA specific fluorochrome; a glass pipette was used to remove the first polar body and the metaphase plate located under it. The Cytochalasin B allowed removal of the metaphase plate by disrupting myofilaments which increases cell membrane elasticity and allows membrane enclosed cytoplasm containing the metaphase plate to be drawn into the pipette and removed. Removal was confirmed by examining the (enucleated oocyte) under UV light (the fluorochrome stained DNA will be clearly visible if the metaphase plate was not removed). The donor cell was then aspirated into the enucleation pipette and introduced into the oocyte through the previously created hole in the zona pellucida. This cell sat within the zona but outside the oocyte plasma membrane.

### Activation of the transferred nuclear material (2 pts):

The oocyte cytoplasm required activation into parthenogenetic development - this mimics the activation of fertilization where repeated transient increases in intracellular calcium occur. Electrical pulse application causes analogous changes in calcium concentration. A series of electrical pulses was used to activate the oocyte and fuse the cells (oocyte and donor). An initial DC pulse was used to activate the oocyte cytoplasm then an AC pulse aligned the cells so that the fusion series was applied at 90 degrees to the plane of contact between the cells.

### Transfer to a recipient animal (1 pt):

These reconstructed embryos were then cultured in vivo in the ligated oviduct of a recipient ewe till day 7 when they were reexamined and morula and blastocyst stages were transferred to synchronized recipients for development to term.

### Implications for future genomic development (2 pt):

The real implications of the work involve the continuity of the genome during development. The results indicate that the genome of somatic cells does not undergo irreversible modification during the growth, development and differentiation of tissues. Wilmut et al., were able to reset the clock for the genome of these cells and reactivate the entire genome of a differentiated cell so that the information within was able to develop a complete animal.

**References:**

- Campbell KHS, McWhir WA, Ritchie WA, Wilmut I. Sheep cloned by nuclear transfer from a cultured cell line. *Nature* 1996;380:64-66.
- Wilmut I, Schnieke AE, McWhir J, Kind AJ, Campbell KHS. Viable offspring derived from fetal and adult mammalian cells. *Nature* 1997;385:810-813.
- Paterson L, DeSousa P, Ritchie W, King T, Wilmut I. Application of reproductive biotechnology in animals: implications and potentials. *Applications of reproductive cloning. Anim Reprod Sci* 2005;793:137-143.

**Question: Using the following headings, describe the differences between the breeding soundness examination of the bull and the stallion. Assume semen collection in the bull is performed by electroejaculation and semen collection in the stallion is performed by collection with an artificial vagina.**

Evaluation of libido and copulatory ability (2 pt):

Semen collection by electroejaculation in bulls does not allow the evaluation of libido and copulatory ability. Alterations in the shape of the erect penis may occur during electroejaculation but should not be considered significant. Copulatory ability needs to be assessed with a teaser cow/heifer if there is a concern about the ability of the bull to breed normally. In contrast, libido and copulatory ability are readily evaluated during semen collection with artificial vagina in stallions. Stallion age, experience, familiarity with the environment, and time of the year are some factors that need to be considered when making judgments about libido and copulatory behavior.

Testicular measurements (2 pt):

In bulls, scrotal circumference is highly correlated with testicular volume and is the only measurement evaluated. Scrotal circumference is obtained with a flexible tape at the position of the largest circumference while both testes are pushed down into the scrotum by applying gentle pressure at the scrotal neck. Scrotal circumference measurement is compared to suggested minimum values according to the bull's age. Due to differences in the anatomy of the scrotum and testes, scrotal circumference is not evaluated in stallions. In contrast, the total scrotal width including both testes is measured using calipers in stallions. The measurement is the distance between the left and right greatest curvature of the scrotum obtained while gently pushing the testes down into the scrotum. Total scrotal width less than 8 cm is reason for concern. In addition length, width, and height might be obtained for each testis using calipers or ultrasound. Formulas have been described for calculating testicular volume based of these measurements in stallions.

Evaluation of semen volume, and sperm concentration, motility, and morphology (3 pt):

Semen from bulls is usually collected into graduated tubes and volume is read directly from the tube. Sperm concentration is simply categorized according to visual inspection of the semen sample (e.g. watery, milky, and grainy or fair, good, and very good). Since electroejaculation can greatly affect semen volume and sperm concentration, the actual sperm concentration and total sperm number in the ejaculate are not determined in bulls. In contrast, determining the total sperm number in the ejaculate is paramount for the evaluation of stallions. The first step for the evaluation of semen from stallions is the removal of the gel fraction by filtration. Gel-free semen volume is determined using graduated tubes/cups or by weight. Sperm concentration is determined using manual (haemocytometer) or automatic methods (densimeter, Nucleocounter) and total sperm number in the ejaculate is calculated by multiplying sperm concentration by semen volume.

Sperm motility and morphology are evaluated using similar methods in bulls and stallions. Sperm motility can be evaluated subjectively under 200-400 X magnification using a microscope equipped with phase-contrast or DIC. The evaluator attempts to determine the proportion of the sperm population that is progressively motile after evaluating several fields under the microscope. Alternatively, sperm motility can be evaluated using automated, objective computer-assisted sperm analysis (CASA). Sperm morphology is evaluated under 1000X magnification using fixed samples and wet-mount preparation with phase-contrast or DIC, or using stained slides (e.g. eosin-nigrosin) and bright-field microscopy. A minimum of 100 sperm are examined and classified when determining sperm morphology. Although the techniques used for determining sperm motility and morphology in bulls and stallions are similar, there are differences in how these parameters are used for assessing breeding soundness in these two species. In bulls, there are minimum guidelines for each sperm motility and morphology, whereas in stallions these results are used for the calculation of total number of motile and morphologically normal sperm in the ejaculate.

#### Breeding soundness classification categories and criteria (3 pt)

Bulls can be classified as satisfactory or unsatisfactory prospective breeders. In order to be classified as a satisfactory potential breeder a bull must be free of physical abnormalities that would affect fertility, scrotal circumference must be at or above the minimum for the age, sperm motility should be greater than 30%, and the proportion of normal sperm should be greater than 70%. Unsatisfactory bulls are those that fail to meet the criteria for satisfactory in one or more categories. In addition, a category called "classification deferred" is used for bulls that cannot be rated as satisfactory but are likely to improve with time and/or therapy.

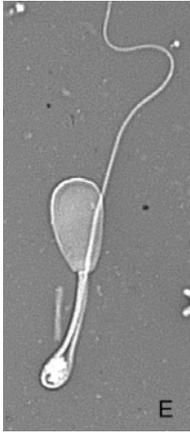
Stallions can be classified as satisfactory, questionable, or unsatisfactory prospective breeders. Satisfactory stallions must be free of physical abnormalities that would affect fertility, have two scrotal testes and epididymides of normal size, shape and consistency, have good libido, have semen and urethral bacterial culture results that are not consistent with infection of the genital tract and are negative for sexually-transmitted bacteria, and produce a minimum of 1 billion motile, morphologically normal sperm in each of two ejaculates collected at least one hour apart. These guidelines were designed for stallions breeding 40 mares by natural service or 120 mares by artificial breeding. The veterinarian must consider the number of mares in the stallion book and the nature of the problem(s) in order to classify stallions that fail to meet the criteria for satisfactory in one or more categories.

#### **References:**

- Barth AD. Evaluation of potential soundness of the bull. In: Youngquist RS, Threlfall WR, editors. Current Therapy in Large Animal Theriogenology. Saunders Elsevier, 2007; pp. 228-40.
- Hopkins FM, Spitzer JC. The new Society for Theriogenology breeding soundness evaluation system. Vet Clin North Am Food Anim Pract 1997;13:295-304.
- Kenney R, Hurtgen J, Pierson R, Witherspoon D, Simns J. Society for Theriogenology manual for clinical fertility evaluation of the stallion. Society for Theriogenology 1983.
- Love CC. Stallion semen evaluation and interpretation. In: Proceedings of the SFT Annual Conf. 2002;93-101.

## PRACTICAL SAMPLE QUESTIONS

**Question:** This is an image of a defective bovine sperm. Identify the abnormality, describe where in the reproductive tract it develops, and list its cause(s).



**Answer:** Distal midpiece reflex, develops in the epididymis, and is caused by increased testicular temperature or stress.

**Reference:** Barth AD, Oko RJ (1989) Abnormal Morphology of Bovine Spermatozoa. Iowa State University Press, Ames.

**Question:** This is an image of aborted swine fetuses. Describe the condition affecting most fetuses and the most probable infectious etiological agent(s).



**Answer:** mummification, most likely cause by porcine parvovirus or PRRS virus.

**Reference:** Christianson WT (1992) Stillbirth, mummies, abortions, and early embryonic death. Veterinary Clinics of North America – Food Animal Practice 8:623-639.

## **SUGGESTED STUDY MATERIAL (updated January 2015)**

The following list has been reviewed by members of the Examination Committee. Listed references are considered to contain relevant contributions to the field of Theriogenology and may be helpful in the candidate's preparation for completion of the Certifying Examination. Candidates should not expect themselves to read all the material on the list and are encouraged to consult with a mentor about their personal study plan, tailoring their personal reading list and study strategy to meet their own strengths and weaknesses. The following reading list is not intended to be *an exclusive or required* reading list, but rather as a *guide* to help candidates to locate information.

### **General reproductive embryology, anatomy, and physiology**

- Benirschke K (2011) Comparative Placentation. International Veterinary Information Service: [www.ivis.org](http://www.ivis.org)
- Chenoweth P, Lorton S (2014) Animal Andrology Theories and Applications. [www.cabi.org](http://www.cabi.org)
- Hafez ES (2000) Reproduction in Farm Animals. Wiley-Blackwell.
- Heide Schatten H, Constantinescu GM (2007) Comparative Reproductive Biology. Wiley-Blackwell.
- Roberts SJ (1986) Veterinary Obstetrics and Genital Diseases. Edwards Bros., Ann Arbor MI.
- Senger PL (2012, 3<sup>rd</sup> ed.) Pathways to Pregnancy and Parturition. Current Conceptions Inc., Seattle.

### **Bovine reproduction**

- Barth AD, Oko RJ (1989) Abnormal Morphology of Bovine Spermatozoa. Iowa State University Press, Ames
- Hopper R (2014) Bovine Reproduction. Wiley-Blackwell.
- Morrow DA (1986) Current Therapy in Theriogenology. Saunders.
- Noakes DE, Parkinson TJ, England GC (2009). Veterinary Reproduction & Obstetrics. Saunders.
- Veterinary Clinics of North America – Food Animal Practice: (1) Bovine theriogenology, vol 21, 2005; (2) Bull infertility, vol 13, 1997; (3) Diagnosis of abortion, vol 10, 1994; (4) Female bovine infertility, vol 9, 1993.
- Youngquist RS, Threlfall W (2006) Current Therapy in Large Animal Theriogenology. Saunders, Philadelphia.
- Bovine Theriogenology Images: [www.vet.k-state.edu/media/images/therio](http://www.vet.k-state.edu/media/images/therio)
- Dairy Cattle Reproduction: [www.uwex.edu/ces/dairyrepro](http://www.uwex.edu/ces/dairyrepro)
- Manual of the International Embryo Transfer Society.
- Proceedings from Annual Conferences of the American Association of Bovine Practitioners.

### **Equine reproduction**

- Ball BA (2004) Recent Advances in Equine Reproduction. International Veterinary Information Service: [www.ivis.org](http://www.ivis.org)
- Brinsko SP, Blanchard TL, Varner DD, Schumacher J, Love CC (2010). Manual of Equine Reproduction. C.V. Mosby.
- Dascanio J, McCue P (2014) Equine Reproductive Procedures. Wiley-Blackwell.
- Derek C. Knottenbelt DC, Pascoe RR, Leblanc M, Lopate C (2003) Equine Stud Farm Medicine & Surgery. Saunders.
- Ginther OJ (1995) Ultrasonic Imaging and Animal Reproduction: Horses. Equiservices Publishing, Cross Plains.
- Ginther OJ (1992). Reproductive Biology in the Mare. Equiservices Publishing, Cross Plains.

- McKinnon AO, Squires EL, Vaala WE, Varner DD (2010) Equine Reproduction. Wiley Blackwell.
- Samper J, Pycock P, McKinnon AO (2007) Current Therapy in Equine Reproduction. Saunders.
- Youngquist RS, Threlfall W (2006) Current Therapy in Large Animal Theriogenology. Saunders, Philadelphia.
- Veterinary Clinics of North America – Equine Practice: (1) Advances in reproduction, vol 22, 2006; (2) Diagnostic techniques and assisted reproductive technology, vol 12, 1996; (3) Stallion management, vol 8, 1992.
- Proceedings from Annual Conferences of the American Association of Equine Practitioners.
- Proceedings from the International Symposium on Equine Reproduction.

### **Small animal reproduction**

- Concannon PW, England G, Verstegen III J, Linde-Forsberg C (2006) Recent Advances in Small Animal Reproduction. International Veterinary Information Service: [www.ivis.org](http://www.ivis.org)
- England G, von Heimendahl A. (2010, 2<sup>nd</sup> ed.) Manual of Small Animal Reproduction and Neonatology, British Small Animal Veterinary Association, Cheltenham, England ([www.bsava.com](http://www.bsava.com)).
- Feldman EC and Nelson RW. (1996) Canine and Feline Endocrinology and Reproduction, WB Saunders Co., Philadelphia.
- Johnston SD, Root Kustritz MV and Olson PN. (2001) Canine and Feline Theriogenology, WB Saunders Co., Philadelphia.
- Lopate C (2012) Management of Pregnancy and Neonatal Dogs, Cats and Exotics Pets. Wiley-Blackwell.
- Peterson M, Kutzler M (2010). Small Animal Pediatrics: The First 12 Months of Life. Saunders-Elsevier.
- Veterinary Clinics of North America – Small Animal Practice: Clinical theriogenology, vol 31, 2001.
- 7th Quadrennial International Symposium on Canine and Feline Reproduction, 2012 - Whistler, BC, Canada: <http://www.ivis.org/proceedings/iscfr/2012/toc.asp>
- Small Animal Reproduction Notes: [www.tc.umn.edu/~rootk001/Class\\_notes\\_Root\\_Kustritz.htm](http://www.tc.umn.edu/~rootk001/Class_notes_Root_Kustritz.htm)

### **Porcine reproduction**

- Morrow DA (1986) Current Therapy in Theriogenology. Saunders.
- Straw BE, Zimmerman JJ, D'Allaire S, Taylor DJ (2006) Diseases of Swine. Wiley-Blackwell.
- Veterinary Clinics of North America – Food Animal Practice: Swine reproduction, vol 8, 1992.
- Youngquist RS, Threlfall W (2006) Current Therapy in Large Animal Theriogenology. Saunders, Philadelphia.
- Proceedings from Annual Conferences of the American Association of Swine Practitioners.

### **Small ruminants and camelid reproduction**

- Cebra C, Anderson D, Tibary A, Van Saun R, Johnson L. (2013) Llama and Alpaca Care: Medicine, Surgery, Reproduction, Nutrition, and Herd Health. Elsevier.
- Fowler ME (2010) Medicine and Surgery of Camelids, Wiley-Blackwell.
- Pugh DG, AN Baird (2011, 2<sup>nd</sup> ed) Sheep and Goat Medicine. Elsevier-Saunders.
- Veterinary Clinics of North America – Food Animal Practice: Update on llama medicine, vol 10, 1994.
- Youngquist RS, Threlfall W (2006) Current Therapy in Large Animal Theriogenology. Saunders, Philadelphia.
- Maryland Small Ruminant Page: [www.sheepandgoat.com/repro.html](http://www.sheepandgoat.com/repro.html)

## **Exotics/laboratory/avian reproduction**

- Youngquist RS, Threlfall W (2006) Current Therapy in Large Animal Theriogenology. Saunders, Philadelphia.
- Morrow DA (1986) Current Therapy in Theriogenology. Saunders.
- Etches RJ (1995) Reproduction in Poultry. CAB International.
- Veterinary Clinics of North America – Food Animal Practice: Ratites 14, 1998.

## **Reproductive pathology**

- McEntee K (1990) Reproductive Pathology of Domestic Mammals. Academic Press, San Diego.
- Jubb KVF, Kennedy PC and Palmer N (1993) Pathology of Domestic Animals. Academic Press, New York.
- Buergelt C (1997) Color Atlas of Reproductive Pathology of Domestic Animals. Mosby, St. Louis.
- Ladds PW, Wu F, Chang W, Shyu J (1997) Color Atlas of Veterinary Reproductive Pathology. Iowa State Press.
- Linklater KA and Smith MC (1993) Color Atlas of Diseases and Disorders of the Sheep and Goat. Mosby, Aylesbury.
- Necropsy Show and Tell: [w3.vet.cornell.edu/nst](http://w3.vet.cornell.edu/nst)
- Veterinary Reproductive Pathology: [www.uoguelph.ca/~rfoster/reproath/repro.htm](http://www.uoguelph.ca/~rfoster/reproath/repro.htm)

## **Reproductive surgery**

- Walker DF and Vaughan JT (1980) Bovine and Equine Urogenital Surgery, Lea and Febiger.
- Wolf DF, Moll HD (1998) Large Animal Urogenital Surgery. Williams & Wilkins.

## **Multiple topics on multiple species**

- ACT Board Preparation list-serve: contact Charles Franz ([Charles@Franzmgmt.com](mailto:Charles@Franzmgmt.com)) to have you name included in the list
- Comparative Theriogenology: [www.vetmed.lsu.edu/eiltslotus/theriogenology-5361](http://www.vetmed.lsu.edu/eiltslotus/theriogenology-5361)
- Proceedings from Annual Conferences of the Society for Theriogenology.
- Proceedings from the International Congress on Animal Reproduction.
- Proceedings from Annual Conferences of the International Embryo Transfer Society.
- The Drost project: [www.drostproject.org](http://www.drostproject.org)

## **Journals**

- Animal Reproduction Science
- Biology of Reproduction
- Clinical Theriogenology
- Journal of Andrology
- Journal of Animal Science
- Journal of Dairy Science
- Reproduction
- Reproduction in Domestic Animals
- Theriogenology

## **STUDY GUIDE FOR EXAMINATION PREPARATION**

*Disclaimer - This study guide is not composed of "old" examination questions but was created by a former member of the certifying exam committee. Questions in this study guide are not necessarily in the format required for questions submitted with the Examination Application. This guide does not attempt to cover all aspects of theriogenology that may be questioned in a given examination.*

### **Normal female reproductive anatomy and physiology**

1) Fill in the chart describing estrus:

	AVERAGE LENGTH OF ESTROUS CYCLE	LENGTH OF STANDING HEAT	TIME OF OVULATION COMPARED TO STANDING HEAT
Cow			
Mare			
Ewe			
Doe (goat)			
Bitch			
Queen			
Sow			
Llama			

2) Stages of the bovine estrous cycle: List them and for each list what is the dominant structure on the ovary, what is the primary hormone released, and what are the physical and behavioral changes exhibited. What is different about the cat?

3) Name five species that are induced ovulators.

4) What is the length of the estrous cycle in large primates (e.g. gorillas)?

5) What effect does progesterone have on LH and FSH secretion? What effect does estradiol have?

6) What is the correlation between peak concentrations of estrogen in serum and heat behavior in the cow? In the bitch?

7) What is the significance of a skyhook vulva in pigs?

8) What initiates luteal regression at the end of diestrus?

9) What is unique about the female reproductive tract in rabbits?

10) Name five species that cycle seasonally, describe daylength for the time of year when they cycle and describe ways to manipulate the cycle so as to allow out-of-season breeding.

11) In the llama, in which uterine horn does pregnancy occur? Which ovary is functional? In the chicken, which uterine horn and ovary are active?

12) Fill in the chart describing onset of puberty:

	AGE AT ONSET OF PUBERTY (MOS)
Cow	
Mare	
Ewe	
Doe (goat)	
Doe (rabbit)	
Sow	
Bitch	
Queen	
Llama	
Hamster	

13) Describe factors that affect puberty onset in the above species.

**Normal male reproductive anatomy and physiology**

1) Fill in the chart describing time of puberty onset.

	AGE AT ONSET OF PUBERTY (MOS)
Bull	
Stallion	
Ram	
Buck	
Boar	
Dog	
Tom	

2) Describe some factors that affect puberty onset in these species.

3) What are the accessory sex glands of the:

- Bull
- Stallion
- Boar
- Dog
- Ram
- Buck
- Tom

4) Fill in the following chart about semen quality:

	TOTAL # OF SPERM PER EJACULATE	SEASONAL?
Bull		
Stallion		
Ram		
Buck		
Boar		
Dog		
Cat		

4) List the number of days in the spermatogenic cycle and the total duration of spermatogenesis for the following species:

- Bull
- Stallion
- Boar
- Ram
- Dog

5) What is the most common cause of testicular hypoplasia in bucks?

What is the most common cause of epididymitis in rams?

6) What are the hormones secreted by the interstitial cells and Sertoli cells of the testes?

What are the functions of these hormones?

7) What is ABP? From where is it secreted? What is its function?

8) Describe measurement of testosterone in serum.

9) What are spermiogenesis, spermatocytogenesis and spermatogenesis?

10) Describe the interior architecture of the testis. What is the basal compartment? What forms the adluminal compartment and what is its significance?

11) Describe formation of spermatozoa from a spermatogonium with names of cell types and chromosome numbers (n vs 2n).

12) What are cellular associations?

### **Bovine theriogenology topics**

1) Describe fremitus of the uterine artery as an aid in pregnancy diagnosis.

2) For each, list causative organism, route of transmission and testing / sample collection:

- Bovine brucellosis
- Bovine campylobacteriosis
- Bovine venereal trichomoniasis
- Leptospirosis
- IBR
- BVD

3) Name four things correlated with scrotal circumference.

4) What is desired calving interval? How many estrous cycles after calving do you have to achieve pregnancy? What is the primary sign of estrus? What are secondary signs? Describe three heat detection aids.

5) Describe estrus synchronization with prostaglandin and with progesterone in cattle.

6) Describe pregnancy termination in cattle with prostaglandin alone and with prostaglandin plus dexamethasone.

7) Discuss hydroamnion and hydriallantois.

8) Retained fetal membranes: List the definition, causes and treatment options.

9) Discuss causes of post-partum anestrus in cattle.

10) Discuss hormonal induction of lactation.

### **Equine theriogenology topics**

1) Discuss pros and cons of pasture mating, hand breeding, and artificial insemination in horses.

2) Discuss photoperiod manipulation of the equine estrous cycle.

3) Discuss twinning in mares.

4) Why are different drugs used at different stages of pregnancy to terminate pregnancy in mares?

5) Describe five infectious and five non-infectious causes of abortion in mares.

6) Describe endometrial biopsy categories and what they mean.

7) Discuss neonatal isoerythrolysis.

- 8) What is CEM? Discuss its clinical signs and treatment.
- 9) List maternal and fetal causes of dystocia in mares.
- 10) What are the significance and treatment of retained fetal membranes in mares?

### **Cytogenetics**

- 1) Describe the structure of DNA. How does RNA differ from DNA?
- 2) How does DNA become a protein?
- 3) Define diploid and haploid cells.
- 4) What are the differences between mitosis and meiosis?
- 5) Define the following terms:
  - Aneuploid
  - Monosomic
  - Trisomic
- 6) Define the diagram the following:
  - Deletion
  - Translocation - What is a Robertsonian translocation and what is its significance?
  - Inversion
- 7) Differentiate chimeras and mosaics.
- 8) Describe three inherited morphologic defects of spermatozoa in cattle.
- 9) Describe heritable XX sex reversal, as described in American Cocker Spaniels.
- 10) Define true hermaphrodites, and male and female pseudohermaphrodites.

### **Fertilization**

- 1) What is the difference between a primary and a secondary oocyte? Which species ovulate which types?
- 2) Could spermatozoa aspirated from the testes fertilize ova? Why or why not?
- 3) Describe attachment of spermatozoa to the zona pellucida.
- 4) What is the function of the acrosome?
- 5) How is polyspermy prevented?
- 6) Describe fusion of the nuclear material from the female and male gametes.
- 7) Define zygote, morula, blastocyst and hatched blastocyst.
- 8) What is parthenogenesis?
- 9) What are monozygotic, dizygotic and conjoined twins?

10) Fill out the following chart:

SPECIES	DAY OF IMPLANTATION
Bovine	
Equine	
Porcine	
Ovine	
Canine	
Human	

### **Pregnancy wastage**

- 1) What is the definition of early embryonic death? What differentiates early embryonic death from abortion?
- 2) At what stage of embryonic development is loss most likely to occur in cattle? In horses?
- 3) List five non-infectious causes of early embryonic death in swine?
- 4) Can you use time of return to service as an indicator of litter size in swine? Why or why not?
- 5) Describe ways to differentiate a maternal cause of early embryonic death from a fetal cause in a litter-bearing species.
- 6) Discuss the Rhesus antigen during pregnancy in women and how it may be a cause of embryonic death.
- 7) List five infectious causes of early embryonic death and the species in which the disease occurs.
- 8) How common is early embryonic death in women? Is thermal stress a cause of pregnancy loss in women as it is in swine?

### **Female infertility**

- 1) Define primary anestrus and secondary anestrus.
- 2) Describe non-pathologic causes of anestrus - what is the physiologic mechanism behind lactational anestrus? Seasonal anestrus?
- 3) List pathologic causes of anestrus.
- 4) What are causes of ovulatory failure?
- 5) What are causes of fertilization failure?
- 6) What is the most common cause of infertility in bitches?
- 7) What are repeat breeders?

## **Estrus synchronization**

- 1) Cattle - Describe two estrus synchronization programs using prostaglandin F2alpha.
- 2) Cattle - Describe estrus synchronization using progesterone.
- 3) Small ruminants - Describe estrus synchronization using progesterone.
- 4) Horses - Describe estrus synchronization using prostaglandin F2alpha.
- 5) Horses - Describe estrus synchronization using progesterone.
- 6) Llamas - Is estrus synchronization practiced in llamas? Why or why not? What protocols are commonly used?
- 7) Small animals - Is estrus synchronization practiced in dogs or cats? Why or why not? What protocols are commonly used?
- 8) What is the "dormitory effect"?

## **Urogenital surgery**

Be familiar with the following procedures:

- 1) Caslick's vulvar suture technique
- 2) Cesarean section
- 3) Penile amputation
- 4) Ovariectomy
- 5) Surgical insemination
- 6) Surgical techniques in embryo transfer
- 7) Episioplasty
- 8) Castration
- 9) Ovariohysterectomy
- 10) Marsupialization / drain placement for prostatic disease
- 11) Minchev's method for vaginal prolapse in cattle
- 12) Buhner's vulvar suture technique
- 13) Surgical repair techniques for urine pooling in mares

## **Small ruminant theriogenology topics**

- 1) What is the "buck effect"?
- 2) How is artificial lighting used to manipulate estrus in small ruminants?
- 3) What is the clinical manifestation of perivulvar ectopic mammary tissue in goats?
- 4) Define "cloudburst".

- 5) What is the link between polledness and intersex in goats?
- 6) Describe habitual abortion in Angora goats.
- 7) Are sheep-goat hybrids viable and fertile?
- 8) Describe two techniques used to increase ovulation rate in sheep?
- 9) For each, list the pathogen, route of exposure, clinical presentation, diagnosis and treatment:
  - Campylobacteriosis
  - Chlamydiosis
  - Toxoplasmosis
  - Q fever
  - Border disease
- 10) Discuss pros and cons of artificial insemination in sheep.
- 11) What are common causes of epididymitis in young rams?
- 12) What is "pizzle rot"?

### **Reproductive anomalies**

Describe the following:

- 1) Schistosomus reflexus
- 2) Amorphus globosus
- 3) Cyclopia
- 4) "Bulldog" calves (chondrodysplasia)
- 5) Perosomus elumbis
- 6) Perosomus horridus
- 7) Fetal anasarca
- 8) Arthrogryposis
- 9) Hydrocephalus
- 10) Freemartinism
- 11) Male and female pseudohermaphrodites
- 12) True hermaphrodite
- 13) Lateral hermaphrodite

## Reproductive management technologies

1) For the following, define it and describe how this measure can be used to define problems or improve performance in a herd:

- Calving interval
- Calving to conception interval
- Average days in milk

2) List and discuss three measures of heat detection efficiency.

3) List and discuss three measures of insemination success.

4) Fill in the following table:

STATISTIC	TARGET	PT AT WHICH TO TAKE ACTION
Calving interval		
Calving to conception interval		
Estimated % heat detection		
Days in milk at first service		
Services per conception		
First service conception rate		

5) Can gonadotropin releasing hormone (GnRH) be used to alter interval from calving to first estrus and, if so, how?

## Reproductive pharmacology

1) Describe clearance and excretion of steroid hormones.

2) List two reasons why oral treatment of cattle with chloramphenicol is not recommended.

3) Why is it not recommended to use bacteriostatic and bacteriocidal drugs in combination?

For each drug or drug class, identify bacteriostatic versus bacteriocidal:

	BACTERIOSTATIC?	BACTERIOCIDAL?
Tetracycline		
Cephalosporins		
Penicillins		
Chloramphenicol		
Sulfonamides		
Aminoglycosides		

- 4) Why are tetracyclines preferred over penicillins for treatment of mycoplasma infections?
- 5) Are antibiotics absorbed into the systemic circulation after intrauterine infusion?
- 6) How might intrauterine infusion of antibiotics alter the estrous cycle?
- 7) Does uptake and distribution of antibiotics vary with stage of the estrous cycle in cows? Mares?
- 8) Why is oxytocin's effect on myometrial contractility greater post-partum?
- 9) What are the side-effects of progestogen therapy in cats?
- 10) List and describe five clinical uses of gonadotropin releasing hormone (GnRH):

### **Nutrition**

- 1) What is the nutritional basis of the negative correlation between high milk production and poor fertility?
- 2) Is body condition associated with fertility in young and mature bulls?
- 3) Discuss pregnancy toxemia in small ruminants? Does it occur in other species?
- 4) Define "flushing".
- 5) Describe use of nutrition as a way to decrease twin conceptuses in mares.
- 6) What is the reproductive effect of decreased dietary taurine in cats?
- 7) What is "nursing sickness" in ferrets?

### **Small animal theriogenology topics**

- 1) Describe use of measurement of serum progesterone for breeding management in dogs.
- 2) Describe three ways to induce ovulation in cats.
- 3) Describe the pathogenesis, clinical signs, diagnosis and treatment of feline ovarian remnant syndrome.
- 4) Compare mammary neoplasia in dogs and cats.

5) For each, give the common signalment, clinical signs, appearance on ultrasound, characteristics of tissue aspirates examined microscopically, and preferred treatment:

- Benign prostatic hypertrophy / hyperplasia (BPH)
- Prostatitis
- Prostatic neoplasia

6) How does conception rate vary with type of semen used for artificial insemination in dogs (fresh semen versus chilled versus frozen)?

7) For each, describe the mode of action, treatment regimen, efficacy and side-effects, when used for pregnancy termination in dogs:

- Estradiol cypionate
- Prostaglandin F2alpha
- Mifepristone
- Bromocriptine
- Epostane
- Dexamethasone
- Cabergoline

8) Compare the pros and cons of progestogens and androgens for estrus suppression in dogs. In cats?

9) Describe the pathogenesis of canine pyometra?

10) Describe normal testicular descent and pathogenesis of cryptorchidism. Is cryptorchidism hereditary in dogs?

11) For canine vaginal prolapse, what are the pathogenesis, clinical presentation and recommended treatment?

12) Describe five tests used for diagnosis of canine brucellosis, including a general idea of their sensitivity and specificity.

## **Abortion**

1) Describe the pathogenesis of *Toxoplasma gondii* as an abortifacient agent in cats and other species.

2) List five plants that cause abortion, in any species.

3) What are the clinical signs and the recommended vaccine schedule for equine herpesvirus 1?

4) List five toxins that cause abortion, in any species.

5) For *Brucella abortus*, describe clinical presentation, diagnosis, treatment and control measures.

6) What is the most common infectious cause of abortion in goats?

7) Discuss hypoluteoidism in dogs.

8) Describe the pathogenesis of erysipelas as an abortifacient in pigs.

9) For each, describe clinical presentation, diagnosis, treatment and control measures:

- IBR
- BVD
- Blue tongue
- Foothill abortion
- Trichomoniasis
- Aspergillosis

10) Name five non-infectious causes of abortion, in any species (and don't give me your five plants or toxins).

### **Reproductive toxicology**

- 1) What are phytoestrogens and what are the effects of these compounds on sheep?
- 2) What are the clinical manifestations of fescue toxicosis in mares?
- 3) List five drugs that alter spermatogenesis and describe their mode of action.
- 4) What is the pathogenesis of carbon monoxide (CO) induced abortion in sows?

### **Avian theriogenology topics**

- 1) What are the parts of the oviduct of the chicken and what is the function of each part?
- 2) Describe clinical signs, diagnosis and treatment of egg binding in caged birds. Is oxytocin a useful treatment?
- 3 Describe sexing of caged birds.
- 4) Differentiate male anatomy of poultry from that of domestic mammals.
- 5) What are post-ovulatory follicles in chickens and what is their function?
- 6) What are the effects of estrogen in chickens?
- 7) What is the connection between molting and egg laying in chickens?

### **Pregnancy diagnosis and maternal recognition of pregnancy**

- 1) For the following species, what substance is considered to be the factor that stops release of prostaglandin, lysis of the CL and loss of the pregnancy?
  - Sheep
  - Pigs
  - Cattle
  - Horse

2) Complete the following table concerning pregnancy diagnosis in the dog:

TEST	DAYS OF PREGNANCY WHEN FIRST ACCURATE	OVERALL ACCURACY / LITTER SIZE / VIABILITY
Abdominal palpation		
Abdominal ultrasound (B mode)		
Abdominal radiographs		
Progesterone assay		
Relaxin assay		

3) Describe what you feel on rectal palpation of the cow and mare at the following months of gestation:

	MARE	COW
2 MONTHS		
5 MONTHS		

4) When is the earliest number of days after mating that the embryonic vesicle is visible by B mode ultrasonography in the:

- Mare (transrectal)
- Cow (transrectal)
- Ewe and doe (transabdominal)
- Sow (transabdominal)

5) Describe how measurement of progesterone in milk or serum can be used for pregnancy diagnosis in dairy cattle.

6) Discuss the apparent conundrum of pregnancy - why doesn't the dam expel the antigenically foreign fetus?

### Embryology and teratology

1) For each type of placentation, describe the placenta and tell in which species it occurs.

Maternal attachment:

- Diffuse (microcotyledonary)
- Cotyledonary
- Zonary

- Discoidal

Layers of attachment:

- Epitheliochorial
- Syndesmochorial
- Endotheliochorial
- Hemochorial

Loss at parturition:

- Deciduate (conjoined)
- Adeciduate (apposed)

2) Define the following terms:

- Blastocyst
- Trophoblast
- Inner cell mass
- Implantation
- Yolk sac
- Amnion
- Allantois

3) For each tissue type, state whether it arises from ectoderm, mesoderm, or endoderm:

- Glandular tissue
- Muscle
- Lining of GI tract
- Hair
- Heart and blood vessels
- Liver
- Nervous system
- Connective tissue

4) What is the indifferent gonad?

5) What are the unique aspects of fetal circulation?

6) Describe the following congenital defects:

- Hydrocephalus
- Arnold-Chiari malformation in cattle
- Combined immunodeficiency in Arab horses
- Porcine stress syndrome

- Deafness in dogs

7) Teratogens - List five for each category:

- Nutritional deficiencies
- Endocrine factors
- Drugs
- Plants
- Viruses

8) What structures arise from the:

- Paramesonephric ducts
- Urogenital sinus (female)
- Genital fold
- Mesonephric ducts
- Urogenital sinus (male)
- Genital tubercle

### **Parturition**

1) What is waxing?

2) Describe how fetal stress is hypothesized to precipitate the onset of parturition.

3) What is Ferguson's reflex?

4) Describe uterine contractions in the pig during parturition.

5) Discuss induction of parturition with:

- Dexamethasone in cattle
- Prostaglandins in small ruminants
- Oxytocin in mares
- Prostaglandins in pigs

6) Describe change in position of the foal during parturition.

7) Describe normal fetal presentation in small animals.

### **Dystocia and obstetrics**

1) Define the following terms:

- Presentation
- Position
- Posture

- 2) List eight maternal and eight fetal factors causative of dystocia.
- 3) Describe resolution of a dystocia in a heifer carrying a large, live bull calf with the head back.
- 4) Describe resolution of a dystocia in a cow carrying a “dog-sitting” calf.
- 5) Describe the use of a de-torsion rod.
- 6) Describe performance of epidural anesthesia in a mare during dystocia.
- 7) List some advantages and disadvantages of fetotomy.
- 8) Is a right or left flank approach preferred for standing C-sections in cattle?
- 9) What is en-bloc ovariohysterectomy and how is it used to treat dystocia in small animals?
- 10) Discuss appropriate use of oxytocin in bitches for dystocia.

**Swine theriogenology topics**

- 1) List five factors affecting onset of puberty in gilts.
- 2) Discuss use of prostaglandin to short-cycle sows.
- 3) Describe rectal palpation, ultrasound (A mode, Doppler and B mode), vaginal biopsy and measurement of plasma estrone sulfate for pregnancy diagnosis in pigs.
- 4) What are some signs of impending parturition in pigs?
- 5) Fill in the following table:

DISEASE	ORGAN-ISM	SIGNS	DIAGNOSIS	THERAPY	CONTROL
Parvovirus					
Leptospirosis					
Brucellosis					
Pseudorabies					
Erysipelas					

- 6) What does the acronym PRRS stand for? Describe clinical signs, transmission, diagnosis and control of PRRS.
- 7) What does the acronym SMEDI stand for, and what are the SMEDI viruses in swine?

8) Fill in the following table:

	TARGET
Litters / sow / year	
Pigs / sow / year	
Stillbirths (%)	
Number of live pigs / litter	
Weaning to service interval (days)	
Abortions (%)	
Number of pigs weaned / litter	
Number pigs marketed / sow / year	

### Artificial insemination

1) Fill out the following table:

	TYPE OF SEMEN COLLECTION ROUTINELY USED FOR AI	NUMBER OF SPERMATOZOA IN ONE INSEMINATION DOSE
Dog		
Boar		
Stallion		
Bull		
Ram		
Tom cat		

- 2) Describe semen collection in stallions.
- 3) What are the primary functions of semen extender?
- 4) Describe freezing of semen in straws.
- 5) Why do many spermatozoa die during the freezing and thawing process?
- 6) Describe insemination of cows.
- 7) What is unique about AI in pigs?
- 8) Describe three methods for intrauterine insemination in dogs.

9) In dogs, what are conception rates with natural service, AI with fresh semen, AI with chilled semen, and AI with frozen semen?

**Embryo transfer**

- 1) Define embryo transfer.
- 2) List five advantages of embryo transfer.
- 3) Outline two superovulation regimens for use in cattle.
- 4) Describe one surgical and one non-surgical embryo collection technique.
- 5) Describe one surgical and one non-surgical embryo transfer technique into the recipient.
- 6) Hypothesize why superovulation generally is not successful in the mare and bitch.
- 7) For embryo transfer in swine, describe number and placement of surgically implanted embryos.
- 8) Fill in the following table:

	TRANSMISSIBLE IN OR ON EMBRYO?
Bovine leukosis virus	
Blue tongue	
IBR	
BVD	
<u>Brucella abortus</u>	
<u>Mycobacterium tuberculosis</u>	
Porcine parvovirus	
Pseudorabies	

- 9) Can disease transmission be controlled by washing and/or freezing embryos?
- 10) Embryo transfer has been performed successfully in domestic cats. What are the advantages of this research?

**In vitro fertilization, nuclear transfer, transgenesis**

- 1) Define in vitro fertilization (IVF).
- 2) Are newly ejaculated spermatozoa capable of fertilization? If not, describe what measures can be taken to make them capable of fertilization.
- 3) What are transgenic animals and what is their purpose?
- 4) What is cloning?

5) What was unique about Dolly, the sheep cloned in Scotland?

**Physiology of gestation**

- 1) Describe serum concentrations of progesterone, estrogen, relaxin, and prolactin during pregnancy in the bitch.
- 2) Define superfecundation and superfetation.
- 3) Describe the hormonal control of mammary development and lactation.
- 4) What is placental lactogen?
- 5) What are the effects of progesterone during pregnancy?
- 6) Describe the corpora lutea of pregnancy in the mare.
- 7) Describe changes in hematocrit during pregnancy in bitches.
- 8) Which of the following species are dependent on the CL throughout pregnancy?

	DEPENDENT ON CL THROUGHOUT?
Horse	
Cow	
Dog	
Sheep	
Pig	
Cat	

- 9) What is hCG and from where is it produced?
- 10) Describe the cause and uses of the pre-parturient drop in rectal temperature in bitches.

**Exotic and laboratory animal theriogenology topics**

- 1) Describe hyperestrogenism in ferrets.
- 2) Describe estrus and follicular dynamics in llamas.
- 3) What is “dribble” ejaculation and in what species is it known to occur?
- 4) What are male and female ferrets called? Male and female rabbits?
- 5) Please complete the following table:

	AGE - FEMALE PUBERTY	ESTRUS CYCLE LENGTH	GESTATION LENGTH	LITTER SIZE	PUBERTY AGE - MALE
Rabbit					
Mouse					
Hamster					
Rat					
Gerbil					
Guinea pig					

6) Name two species of laboratory animals that may exhibit prolonged gestation if nursing a litter concurrently.

7) Why must guinea pigs be bred before 7 months of age?

8) In many exotic animals, steroid concentrations in feces are measured to assess the estrous cycle and to diagnose pregnancy. What are some disadvantages of this technique? What fecal steroids are measured for pregnancy diagnosis?

9) What is embryonic diapause? Name three species in which it occurs.

10) Differentiate milk of marine mammals from that of land mammals.

11) For the ostrich, please list:

- Side of female reproductive tract that is active
- Age at sexual maturity
- Seasonality
- External signs of breeding readiness in male
- Hatchery protocol