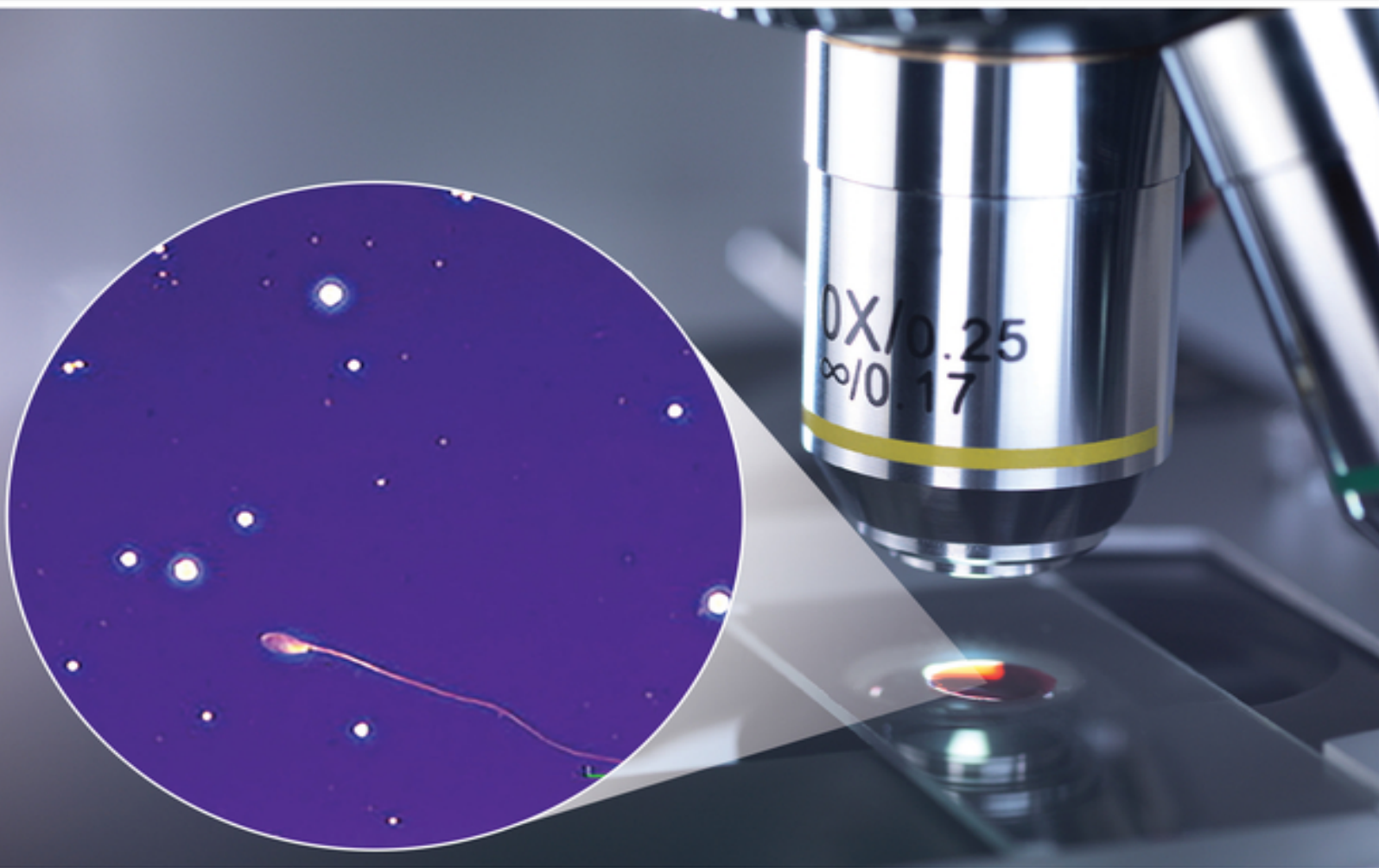


# Sperm Morphology of Domestic Animals

Jennifer Koziol and Chance Armstrong



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# Table of Contents

[Cover](#)

[Title Page](#)

[Copyright Page](#)

[Dedication Page](#)

[Preface](#)

[About the Companion Website](#)

[Introduction](#)

[I.1 Spermatogenesis](#)

[I.2 Length of Spermatogenesis in Domestic Species](#)

[I.3 Maturation of Spermatozoa in the Epididymis](#)

[I.4 Staining Techniques and Evaluation of Morphology](#)

[I.5 Vital Staining](#)

[I.6 Preparation of Semen Smears or Coverslip Slides](#)

[I.7 Differential Counting of Sperm Morphology](#)

[Section I: Head Abnormalities](#)

[1 Pyriform and Tapered Heads](#)

[2 Nuclear Vacuolation, Including the Diadem Defect](#)

[3 Macrocephalic and Microcephalic Sperm](#)

[4 Rolled Head-Nuclear Crest-Giant Head Syndrome](#)

[5 Abnormal DNA Condensation](#)

[6 Acrosome Abnormalities](#)

[7 Normal Detached Heads and Free Abnormal Heads](#)

8 Decapitated Sperm Defect

Section II: Midpiece Abnormalities

9 Proximal Cytoplasmic Droplet

10 Pseudodroplet

11 Mitochondrial Sheath Defects

12 Corkscrew Sperm Defect

13 Dag Defect

14 Distal Midpiece Reflex

15 Bowed Midpieces

16 Distal Droplets

17 Abaxial Midpieces

Section III: Tail (Principal Piece) Abnormalities

18 Tail Stump Defect

19 Coiled Principal Pieces

20 Double Forms and Accessory Tails

21 Bent Principal Pieces

22 Short Tail Defect

Section IV: Aberrations of Stains and Other Cells in the Ejaculate

23 Aberrations Due to Staining

24 Aberrations Due to Cold Shock

25 Round Cells in the Ejaculate

26 Teratoids

27 Medusa "Cells"

28 Aberrations of Semen Quality

28.1 Oligospermia/Azoospermia

28.2 Hemospermia

28.3 Urospermia

## [28.4 Antisperm Antibodies](#)

[References](#)

[Index](#)

[End User License Agreement](#)

## List of Tables

Introduction

[Table I.1 Mean time of sperm epididymal passage in domestic](#)

## List of Illustrations

Introduction

[Figure I.1 Morphologically normal sperm from a bull \(eosin-nigrosin, 1000×\)....](#)

[Figure I.2 Morphologically normal sperm from a bull \(phase contrast wet moun...](#)

[Figure I.3 Morphologically normal sperm from a buck \(eosin-nigrosin, 1000×\)....](#)

[Figure I.4 Morphologically normal sperm from a stallion \(eosin-nigrosin, 100...](#)

[Figure I.5 Partially stained sperm with a pink posterior and a white anterio...](#)

[Figure I.6 Poorly prepared slide with too many sperm per field, which impede...](#)

[Figure I.7 A small line of stain is placed along the slide followed by a sma...](#)

[Figure I.8 Using a second slide, one can start in the stain backing up to pi...](#)

[Figure I.9 Slides should neither be too dark or too light, and when viewed u...](#)

## Chapter 1

[Figure 1.1 Pyriform head in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 1.2 Pyriform head in a bull as indicated by arrow \(eosin-nigrosin, 10...](#)

[Figure 1.3 Pyriform head in a bull as indicated by arrow \(eosin-nigrosin, 10...](#)

[Figure 1.4 Detached pyriform head in a bull indicated by arrow \(eosin-nigros...](#)

[Figure 1.5 Pyriform head in bull as indicated by arrow \(eosin-nigrosin, 1000...](#)

[Figure 1.6 Pyriform head in a bull as indicated by arrow \(eosin-nigrosin, 10...](#)

[Figure 1.7 Pyriform head in bull as indicated by arrow also note the proxima...](#)

[Figure 1.8 Pyriform head in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 1.9 Pyriform head in a ram \(eosin-nigrosin, 1000×\).](#)

[Figure 1.10 Pyriform head in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 1.11 Pyriform head defect in a bull as indicated by arrow compared to...](#)

[Figure 1.12 Pyriform-shaped head in a bull with proximal droplet \(phase cont...](#)

## Chapter 2

Figure 2.1 Nuclear vacuoles as indicated with arrow also note the proximal d...

Figure 2.2 Small vacuoles in head of sperm as indicated with arrow (eosin-ni...

Figure 2.3 Vacuole in the head of sperm from a bull (eosin-nigrosin, 1000×)....

Figure 2.4 Nuclear vacuoles in a bull also note the proximal droplet (eosin-...

Figure 2.5 Large nuclear vacuole in a bull (eosin-nigrosin, 1000×).

Figure 2.6 Multiple small nuclear vacuoles in the head of a sperm from a bul...

Figure 2.7 Multiple small nuclear vacuoles in the head of a sperm from a bul...

Figure 2.8 Large confluent nuclear vacuole from a bull (eosin-nigrosin, 1000...

Figure 2.9 Multiple small nuclear vacuoles in a buck (eosin-nigrosin, 1000×)...

Figure 2.10 Large confluent nuclear vacuoles in the head of sperm from a bul...

Figure 2.11 Diadem defects in a bull (phase contrast wet mount, 1000×).

Figure 2.12 Diadem defect in a bull (phase contrast wet mount, 1000×).

Figure 2.13 Diadem defect in a bull (phase contrast wet mount, 1000×).

Figure 2.14 Large vacuole in the head (arrow). Also note the pseudodroplet (...

Figure 2.15 Multiple vacuole in the head of the sperm. Also note the mitocho...

[Figure 2.16 Multiple diadem defects indicated by arrow \(eosin-nigrosin, bull...](#)

### Chapter 3

[Figure 3.1 Macrocephalic sperm head in a bull indicated by arrow next to a n...](#)

[Figure 3.2 Macrocephalic head with proximal droplet in a bull \(eosin-nigrosi...](#)

[Figure 3.3 Microcephalic heads in a bull as indicated by arrows \(phase contr...](#)

[Figure 3.4 Microcephalic head in a bull \(eosin-nigrosin, 1000×\).](#)

### Chapter 4

[Figure 4.1 Rolled head \(arrow\): Rolled heads are often noted with the roll a...](#)

[Figure 4.2 Rolled head in a bull indicated by arrow also note the teratoid i...](#)

### Chapter 5

[Figure 5.1 Abnormal chromatin condensation in a bull as shown by arrows \(Feu...](#)

### Chapter 6

[Figure 6.1 Acrosome abnormalities. Variation in appearance of knobbed acroso...](#)

[Figure 6.2 Indented acrosome defect with arrowing pointing toward indentatio...](#)

[Figure 6.3 Knobbed acrosome defect as noted by arrow, arrowhead points towar...](#)

[Figure 6.4 Knobbed acrosome as noted by arrow \(eosin-nigrosin, bull, 1000×\)....](#)

[Figure 6.5 Indented acrosome as noted by arrow \(eosin-nigrosin, bull, 1000×\)...](#)

[Figure 6.6 Indented acrosome as noted by arrow, arrow heads indicates proxim...](#)

[Figure 6.7 Knobbed acrosome defect in a ram as indicated by arrows \(eosin-ni...](#)

[Figure 6.8 Knobbed acrosome defect in a buck as indicated by arrow \(eosin-ni...](#)

[Figure 6.9 Knobbed acrosome defect in a buck as indicated by arrow \(eosin-ni...](#)

[Figure 6.10 Knobbed acrosome defect in a bull in the indented form \(eosin-ni...](#)

[Figure 6.11 Knobbed acrosome defect in a stallion \(eosin-nigrosin, 1000×\).](#)

[Figure 6.12 Knobbed acrosome defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 6.13 Knobbed acrosome defect in a bull \(eosin-nigrosin, 1000×\).](#)

## Chapter 7

[Figure 7.1 Abnormal detached head in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 7.2 Abnormal detached head in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 7.3 Detaching head in a buck \(eosin-nigrosin, 1000×\).](#)

[Figure 7.4 Detached abnormal head with corresponding tail in a bull \(eosin-n...](#)

## Chapter 9



[Figure 9.1 Proximal cytoplasmic droplets in a bull - spherical cytoplasmic d...](#)

[Figure 9.2 Proximal cytoplasmic droplet in a ram as noted by arrow \(eosin-ni...](#)

[Figure 9.3 Proximal cytoplasmic droplet in a buck as noted by arrow \(eosin-n...](#)

[Figure 9.4 Proximal cytoplasmic droplet in a bull \(eosin-, 1000×\).](#)

[Figure 9.5 Sperm with proximal cytoplasmic droplets in a dog suffering from ...](#)

[Figure 9.6 Proximal cytoplasmic droplets in a dog as indicated by arrows \(eo...](#)

[Figure 9.7 Proximal cytoplasmic droplet in a stallion \(eosin-nigrosin, 1000×...](#)

[Figure 9.8 Proximal cytoplasmic droplet in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 9.9 Proximal cytoplasmic droplet in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 9.10 Proximal cytoplasmic droplet in a bull \(phase contrast wet mount...](#)

[Figure 9.11 Proximal cytoplasmic droplet in a bull as noted by arrow also py...](#)

[Figure 9.12 Proximal cytoplasmic droplet in a bull \(eosin-nigrosin, 1000×\)....](#)

## Chapter 10

[Figure 10.1 Pseudodroplet is characterized by local thickening somewhere alo...](#)

## Chapter 11

[Figure 11.1 Abnormal midpiece that culminates in a terminally coiled tail \(e...](#)

[Figure 11.2 Abnormal midpiece in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 11.3 Broken midpiece in a bull with breaks indicated by arrows \(eosin...](#)

[Figure 11.4 Broken midpiece at the site of attachment in a bull \(eosin-nigro...](#)

[Figure 11.5 Abnormal midpieces in a bull \(phase contrast wet mount, 1000×\). ...](#)

[Figure 11.6 Abnormal midpiece in a ram, note the roughened mitochondrial she...](#)

[Figure 11.7 Abnormal midpiece with mitochondrial sheath defect in a ram \(eos...](#)

[Figure 11.8 Mitochondrial sheath defects as indicated by arrows in a ram \(eo...](#)

[Figure 11.9 Mitochondrial sheath defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 11.10 Mitochondrial sheath defect in a bull \(eosin-nigrosin, 1000×\)....](#)

[Figure 11.11 Mitochondrial sheath defect in a buck \(eosin-nigrosin, 1000×\)....](#)

## Chapter 12

[Figure 12.1 Corkscrew sperm in a bull as indicated by arrow \(eosin-nigrosin,...](#)

[Figure 12.2 Corkscrew sperm defect in a ram \(eosin-nigrosin, 1000×\).](#)

[Figure 12.3 Corkscrew defect in buck \(eosin-nigrosin, 1000×\).](#)

[Figure 12.4 Corkscrew defect in bull \(eosin-nigrosin, 1000×\).](#)

## Chapter 13

[Figure 13.1 Dag defect as indicated by arrow with distal midpiece reflex bel...](#)

[Figure 13.2 Dag defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 13.3 Dag defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 13.4 Dag defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 13.5 Dag defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 13.6 Dag defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 13.7 Dag defect in a bull \(phase contrast, 1000×\).](#)

## Chapter 14

[Figure 14.1 Distal midpiece reflex \(DMR\) in a stallion. Note proximal drople...](#)

[Figure 14.2 DMR in a bull. Note midpiece reflexed around a droplet, which is...](#)

[Figure 14.3 DMR in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 14.4 Multiple DMR defects in a bull suffering from environmental stre...](#)

[Figure 14.5 DMR in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 14.6 DMR in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 14.7 DMR in a bull, note the trapped droplet \(phase contrast wet moun...](#)

[Figure 14.8 DMR in a bull \(phase contrast wet mount, 1000×\).](#)

[Figure 14.9 DMR in a bull \(eosin-nigrosin, 1000×\).](#)

## Chapter 15

[Figure 15.1 Bowed midpiece \(eosin-nigrosin, 1000×\).](#)

## Chapter 16

[Figure 16.1 Distal droplet in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 16.2 Distal droplet in a ram \(eosin-nigrosin, 1000×\).](#)

[Figure 16.3 Distal droplet in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 16.4 Distal droplet in a bull \(phase contrast wet mount, 1000×\).](#)

## Chapter 17

[Figure 17.1 Abaxial implantation \(arrow\) \(eosin-nigrosin, bull, 1000×\).](#)

[Figure 17.2 Abaxial implantation in a stallion \(eosin-nigrosin, 1000×\).](#)

## Chapter 18

[Figure 18.1 Tail stump defect with stumps obscured by cytoplasmic droplets \(...\)](#)

[Figure 18.2 Tail stump defect in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 18.3 Tail stump defect in a bull, also note pyriform shape and diadem...](#)

[Figure 18.4 Tail stump defect in a bull \(eosin-nigrosin, 1000×\).](#)

## Chapter 19

[Figure 19.1 Coiled principal piece in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 19.2 Coiled principal piece in a bull \(arrow\) sperm also has a proxim...](#)

[Figure 19.3 Coiled principal piece in a ram \(eosin-nigrosin, 1000×\).](#)

[Figure 19.4 Coiled principal piece in a bull \(arrows\) \(eosin-nigrosin, 1000×...](#)

[Figure 19.5 Coiled principal piece in a bull \(arrow\) \(phase contrast wet mou...](#)

## Chapter 20

[Figure 20.1 Double midpiece in a buck \(eosin-nigrosin, 1000×\).](#)

[Figure 20.2 Double midpieces in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 20.3 Double heads and midpiece that culminate into a single principal...](#)

[Figure 20.4 Double midpiece that terminate into a coiled tail \(eosin-nigrosi...](#)

[Figure 20.5 Double midpieces in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 20.6 Double midpiece in a bull indicated by arrow \(eosin-nigrosin, 10...](#)

[Figure 20.7 Accessory tail indicated by arrow in a bull \(eosin-nigrosin, 100...](#)

## Chapter 21

[Figure 21.1 Bent principal piece in a bull - note the lack of cytoplasmic dr...](#)

[Figure 21.2 Bent principal piece in a bull as indicated by arrowhead compare...](#)

[Figure 21.3 Bent principal piece in a bull \(eosin-nigrosin, 1000×\).](#)

[Figure 21.4 Bent principal pieces in a bull \(eosin-nigrosin, 1000×\).](#)

## Chapter 22

[Figure 22.1 Short tail defect in a bull characterized by missing principal p...](#)

[Figure 22.2 Short tail defect in a bull \(eosin-nigrosin, 1000×\).](#)

## Chapter 23

[Figure 23.1 When multiple sperm with bent principal pieces and no retained d...](#)

[Figure 23.2 Cytoplasmic droplets are shed during ejaculation and can be note...](#)

[Figure 23.3 Eosin-nigrosin stain often contains small particles of undissolv...](#)

[Figure 23.4 Cracking of stain due to prolonged drying. Drying can be hastene...](#)

## Chapter 25

[Figure 25.1 Round cells can be noted during evaluation of sperm motility. St...](#)

[Figure 25.2 Round cells within an ejaculate \(wet mount, bull, 400×\).](#)

[Figure 25.3 Round cells can sometimes be noted on evaluation of sperm morpho...](#)

[Figure 25.4 Diff-Quik<sup>®</sup>-stained slide to allow for differentiation of wh...](#)

[Figure 25.5 Diff-Quik<sup>®</sup>-stained slide from a bull with vesiculitis. Arro...](#)

## Chapter 26

[Figure 26.1 Teratoid cell as noted by arrow \(eosin-nigrosin, bull, 1000×\).](#)

[Figure 26.2 Teratoid cell as noted by arrow \(eosin-nigrosin, bull 1000×\).](#)

[Figure 26.3 Teratoid cell \(eosin-nigrosin, bull, 1000×\).](#)

[Figure 26.4 Teratoid cell \(phase contrast, bull, 1000×\).](#)

## Chapter 27

[Figure 27.1 Medussa “cell” \(arrow\) \(eosin-nigrosin, bull, 1000×\).](#)

## Chapter 28

[Figure 28.1 Brown-tinged semen from a bull diagnosed with chronic vesiculiti...](#)

[Figure 28.2 Semen sample with yellow pigment due to high riboflavin concentr...](#)

# Sperm Morphology of Domestic Animals

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*For RLC and DFW who taught us to never be satisfied and  
complacent with the status quo*

## Preface

*Sperm Morphology of Domestic Animals* has been written to further the understanding of morphologic assessment in the dog, stallion, bull, buck, and ram. This text is directed toward veterinary students and practitioners. Morphologic evaluation of sperm is a confusing part of the fertility examination. Ample images and figures have been added to provide real-time support during semen evaluation. The authors sincerely hope the added imagery will help provide clarity to a complex and often confusing portion of fertility assessment. Morphologic evaluation of sperm is an ever-evolving area of theriogenology, and this text has been written with the latest information from the current literature.

The authors would like to thank their mentors and other leaders in the field of theriogenology that inspire excellence in all that they set out to accomplish. This text would not have been possible without the generous support from Wiley.

## About the Companion Website

This book is accompanied by a companion website:

[www.wiley.com/go/koziol/sperm](http://www.wiley.com/go/koziol/sperm)



The website includes:

- Teaching PowerPoints

## Introduction

Sperm evaluation provides a noninvasive method to evaluate testicular and epididymal function, providing information similar to that gained by a testicular biopsy. An abnormal spermiogram with supporting evidence from the history and physical exam can give insights into reasons for abnormal testicular function, and consequently allow formation of a prognosis for recovery or potential treatment. When an abnormal spermiogram is found, the types and number of abnormalities combined with history regarding environment, nutrition, and health status can be used to compile a reason for spermiogram disturbances noted. The veterinarian can then use that information to make a diagnosis and prognosis for recovery.

An awareness of the mechanism of sperm transport in the female reproductive tract aids in understanding the relationship between sperm quality and fertility and consequently the level of defects that can be tolerated and still maintain reasonable pregnancy rates. The cervix, uterus, and uterotubal junction all reduce the number of abnormal sperm that can reach the site of fertilization. The cervix filters sperm with tail defects, while severely deformed heads are filtered at the level of the cervix, uterus, and uterine tubes. However, the filter system is not perfect and some sperm abnormalities may still reach the oocyte and induce fertilization [[1](#), [2](#)].

Three main criteria should be taken into account when evaluating abnormal sperm morphology: (i) abnormalities of the nucleus that allow ovum penetration and zona reaction but not fertilization or embryonic development *cannot* be tolerated at levels >15–20% without subsequent decrease in pregnancy rate; (ii) abnormalities of the

acrosome and sperm tail do not interfere with the ability of normal sperm to fertilize ova and therefore can be tolerated at levels up to 25%; (iii) at least 70–75% of spermatozoa should be normal [3]. The types and percentages of defects should be taken into consideration in both natural and artificial mating systems.

## **I.1 Spermatogenesis**

A thorough understanding of normal and abnormal spermatogenesis facilitates understanding and interpretation of a spermiogram (description of sperm morphology noted during evaluation) ([Figures I.1–I.4](#)). The testis is largely composed of seminiferous tubules and interstitial tissue. The latter is located between the seminiferous tubules and consists primarily of Leydig cells, which produce and secrete steroid hormones, as well as vascular and lymph vessels that supply the testicular parenchyma. Seminiferous tubules arise from primary sex cords and contain germinal cells, as well as Sertoli cells, which support and nurture production of sperm. Sertoli cells form tight junctions, creating the most important portion of the blood–testis barrier [4]. Spermatogenesis occurs primarily in the tubulus contortus section of the seminiferous tubules. These tubules are surrounded by contractile peritubular cells that promote flow out of the tubulus contortus into the rectus (straight portion) of the seminiferous tubule. Both ends of each tubule are connected with the rete testis.



**Figure I.1** Morphologically normal sperm from a bull (eosin-nigrosin, 1000 $\times$ ).

Spermatogenesis can be divided into three phases. The first phase, proliferation, consists of six mitotic divisions of spermatogonia, increasing the number of A-spermatogonia then B-spermatogonia. An important part of this phase is stem cell renewal. Loss of intercellular bridges allow some spermatogonia to revert to stem cells. B-spermatogonia then undergo several mitotic divisions, with the last division resulting in primary spermatocytes. The meiotic phase begins with diploid primary spermatocytes. During meiosis I, genetic diversity is ensured by DNA replication and crossing over during production of secondary spermatocytes, and as a result, from a genetic perspective, no two sperm are identical. The last phase, known as the



differentiation phase or spermiogenesis, is differentiation of a spherical undifferentiated spermatid into a fully differentiated sperm with a head, a flagellum which includes the midpiece, and the principal piece. The length of spermiogenesis differs between species. An example is that it takes the last 18 days for the spermiogenesis stage of spermatogenesis to be completed in the bull.

Correct clinical interpretation of spermiograms also requires understanding of the specific timing of spermatogenesis in the species being evaluated. An understanding of the cycle of the seminiferous epithelium aids in this mission. The cycle of seminiferous epithelium is the progression through a complete series of stages at one location along a seminiferous tubule. On cross-sectional evaluation of the seminiferous tubule, four to five concentric layers of germ cells are present with each layer representing a generation. Each cross-section along the length of the seminiferous tubule will have a distinct appearance. Each cross section with its four to five generations of germ cells represents a stage of the seminiferous epithelium cycle. For example, a cross section in stage 1 will have a base layer of A-spermatogonium followed by primary spermatocytes, and another layer of primary spermatocytes, followed by a layer of immature spermatids. A stage 8 cross section will begin with a layer of A-spermatogonium, followed by B-spermatogonium, primary spermatocytes, immature spermatids, and mature spermatids that are ready to be released into the lumen. Along the length of any given seminiferous tubule, there are many zones or cross sections in different stages with only a few zones at an appropriate stage to release mature spermatid into the lumen of the seminiferous tubule, which will then travel through the rete testis to be transported to the head of the epididymis. These different zones allow for the creation of a spermatogenic wave or constant release of

sperm along the length of each tubule. With zones in multiple stages along the length of the tubule, there is a constant flow of spermiation, which allows for a constant flow of sperm to the epididymis.



**Figure I.2** Morphologically normal sperm from a bull (phase contrast wet mount, 1000×).