Production of Fertile Sperm

- hormonal regulation of the testis
- mitotic division of spermatogonia
- meiotic divisions of spermatocytes
- morphologic transformation of spermatids into spermatozoa

Hormonal Regulation of the Testis

Pulses are important!
Spermatogenesis

Sertoli Cell

Every 13.5 Days sperm are released from this point

Every 13.5 Days a new group of cells initiate the cycle

Typical Sequence of Spermatogenesis

Many Sperm are Produced

Potential Sperm Produced

1
2
4
8
16
32
64

Spermiation
Rete Testis
Spermogenesis
Spermatogenesis
Meiosis
Mitosis
Mitotic Divisions

- species dependent
  - between 2 and 6 divisions (4 to 64 potential daughter cells produced)
- classifications vary among species and investigators
  - A₁, A₂, A₃, A₄, B₁, B₂, P
  - A₁, A₂, B₁, P
  - A₁, A₀, A₁, A₂, I, B, P
- cytoplasmic bridges form between daughter cells

Degenerating Spermatogonia (Apoptosis, as high as 75%)

Germ Cells / Sertoli Cell

<table>
<thead>
<tr>
<th>Species</th>
<th>Primary Spermatocytes</th>
<th>Round Spermatids</th>
<th>Max. Potential Spermatids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equine</td>
<td>3.0 ± 0.2</td>
<td>10.9 ± 0.9</td>
<td>64</td>
</tr>
<tr>
<td>Bovine</td>
<td>1.2 ± 0.1</td>
<td>5.2 ± 0.6</td>
<td>64</td>
</tr>
<tr>
<td>Human</td>
<td>1.3 ± 0.1</td>
<td>4.2 ± 0.2</td>
<td>16</td>
</tr>
</tbody>
</table>

Apoptosis of Germ Cells

- Season
- Disease
- Trauma or heat
- Hormone levels
- Normal part of spermatogenesis

Stem Cell Renewal

- To keep spermatogenesis going indefinitely
- Replenish testis in case of injury, trauma, or high heat

Spermatogonial Renewal in the Rat and Bull

FSH
Spermatogonial Renewal in the Primate

Spermiogenesis

Golgi Phase
Development of Acrosome Migration of Centrioles

Cap Phase

Acrosomal Phase

Acrosome Development Continues Flagellum Elongates
Maturation Phase
- Manchette disappears
- Mitochondria migrate
- Dense fibers form

Spermiation

Temporal Relationships of Spermatogenesis

Spermatogenesis

Multiple Generations of Germ Cells

57 days
Stallion
Stages

- Specific cellular associations within a small segment of a seminiferous tubule
- Stages are not the same length in time
Cycle

- progression through sequence of all stages
- 4.5 cycles to form spermatozoa
  - some species variation

Bull Spermatogenesis - Cycles

Duration of Spermatogenesis

<table>
<thead>
<tr>
<th></th>
<th>Bull</th>
<th>Ram</th>
<th>Boar</th>
<th>Stallion</th>
<th>Man</th>
</tr>
</thead>
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<tr>
<td>cycle (days)</td>
<td>13.5</td>
<td>10.4</td>
<td>8.3</td>
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<td>16</td>
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<tr>
<td>Spermatogenesis</td>
<td>61</td>
<td>47</td>
<td>39</td>
<td>57</td>
<td>75</td>
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</table>

Coordination of Stages
Form Waves

- some portion of seminiferous tubule is always releasing sperm

Compartmentalization of Spermatogenesis and the Blood Testis Barrier
Seminiferous Tubule and Interstitial Tissue

Interstitial Tissue

Vascular System Provides
- Nutrients
- Oxygen
- Growth Factors
- Hormones

Cycles and Stages

Compartmentalization
- Basal
  - mitosis
  - spermatogonia (A, I, B)
  - primary spermatocytes
- Adluminal
  - meiosis
  - primary spermatocytes
  - secondary spermatocytes
  - spermatids
  - spermiogenesis
- Lumen
  - spermiation
**Blood Testis Barrier**
- Sertoli cells and associated tight junctions
- first appears at puberty
- induced by FSH
- after puberty can be maintained by FSH and/or testosterone
- essential for meiosis !!!!!

**Tight Junction Role in Meiosis**
- Sertoli cells can manipulate environment around 1° spermatocyte
  - Enters meiosis
  - Completes meiosis
- Destruction of TJ causes impairment of meiosis
  - Heat, heavy metals, pesticides, lack of FSH or Testosterone

---

**Capacity for Sperm Production**

<table>
<thead>
<tr>
<th>Species</th>
<th>Testis Weight (gm)</th>
<th>Sperm/gm (X 10^6)</th>
<th>DSP (X 10^9)</th>
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<tr>
<td>Dairy Bull</td>
<td>650</td>
<td>18</td>
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<tr>
<td>Man</td>
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<td>4</td>
<td>.045 - .2</td>
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Variation in Sperm Production

- Testis Size
- Efficiency of spermatogenesis
  - mitotic division
  - degeneration of germ cells
- Length of spermatogenesis

Apoptosis of Germ Cells

- Season
- Disease
- Trauma or heat
- Hormone levels
- Normal part of spermatogenesis

Over Population of Spermatogonia

Animation of Spermatogenesis

View the Animation of Spermatogenesis Using the Link at the Bottom of the Screen

The objective is to see how the process of spermatogenesis takes place over time and involves both stages and cycles.

- In the animation, the timing of events is correct but we have taken liberties in moving groups of cells from side to side to make room for development of other cells.
- The animation begins with primordial germ cell migration into the primary sex chord and replication of gonocytes to form stem cell A-Type spermatogonia.