What Are Gametes?

- Gametes
  - mature form of cells set aside which will undergo meiosis and contribute a haploid chromosomal complement at fertilization to reconstitute the diploid
- Egg or oocyte
  - large, storage
- Sperm
  - small, motility

Gametogenesis

- Formation of gametes
  - primordial germ cell
  - proliferation
  - become oo- or spermato- gonia
  - undergo meiosis
  - become gametes
- Mutations here really matter

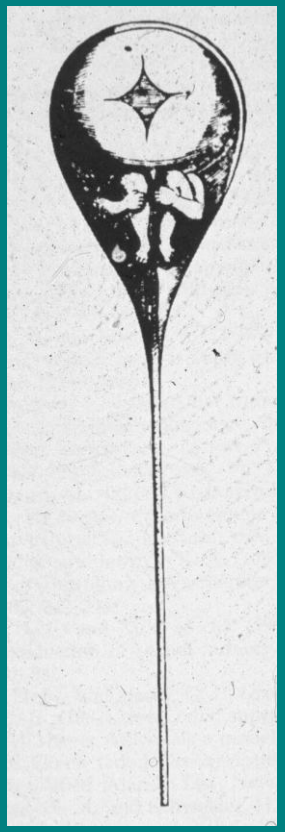
Stages of Gametogenesis

- Nomenclature
  - gonium -> 1º -cytes -> 2º -cytes -> -tids
- Progression
  - 1 premeiotic S-phase (DNA synthesis)
  - 2 meiotic cell divisions
  - all 4 spermatids = in size
  - 1 large oocyte + 2 or 3 small polar bodies

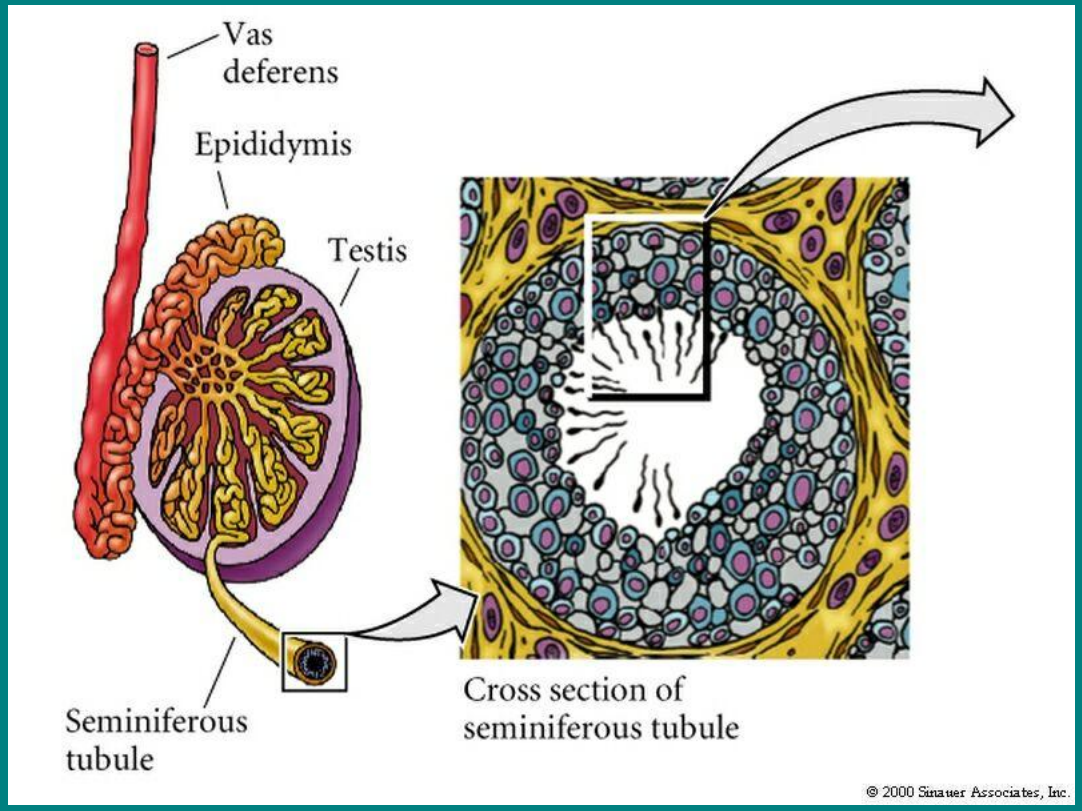
When do Gametes Differentiate?

- Time of differentiation
  - for males from haploid spermatid → mature spermatozoa
  - for females during primary oocyte prophase I
    - vitellogenesis
    - recombination
    - growth

How to Make a Sperm



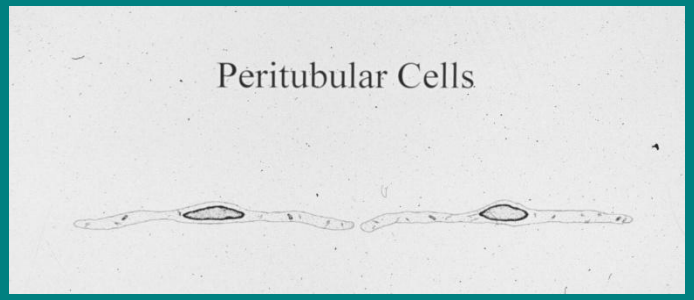
Structure of a Mammalian Testis

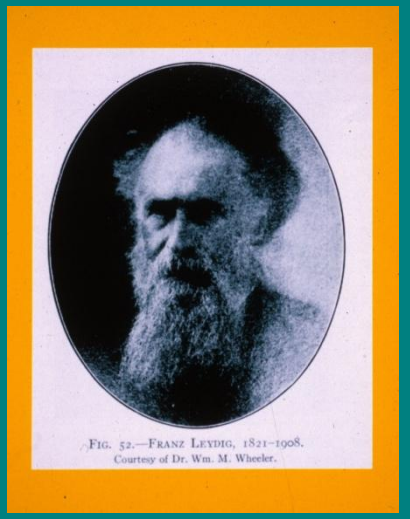


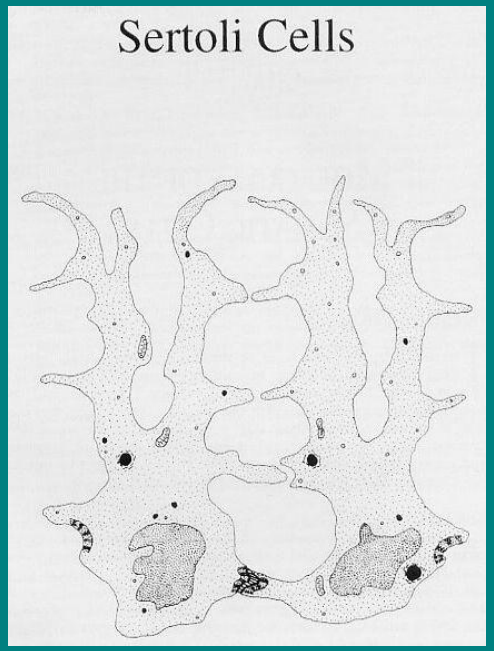
What Cell Lineages Contribute to the Testis?

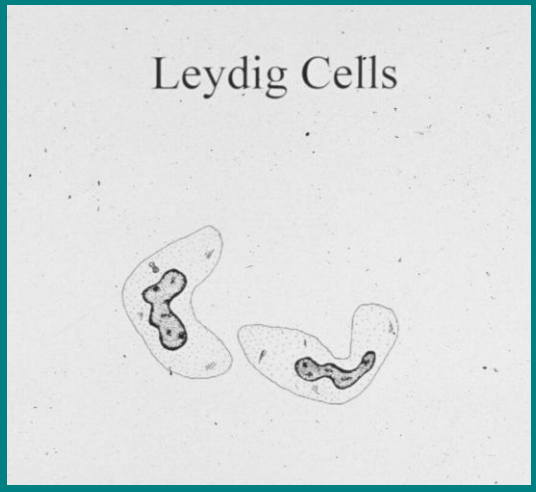
- Somatic cells
  - Leydig
  - peritubular
  - Sertoli
- Germ cells

Somatic Testicular Cells

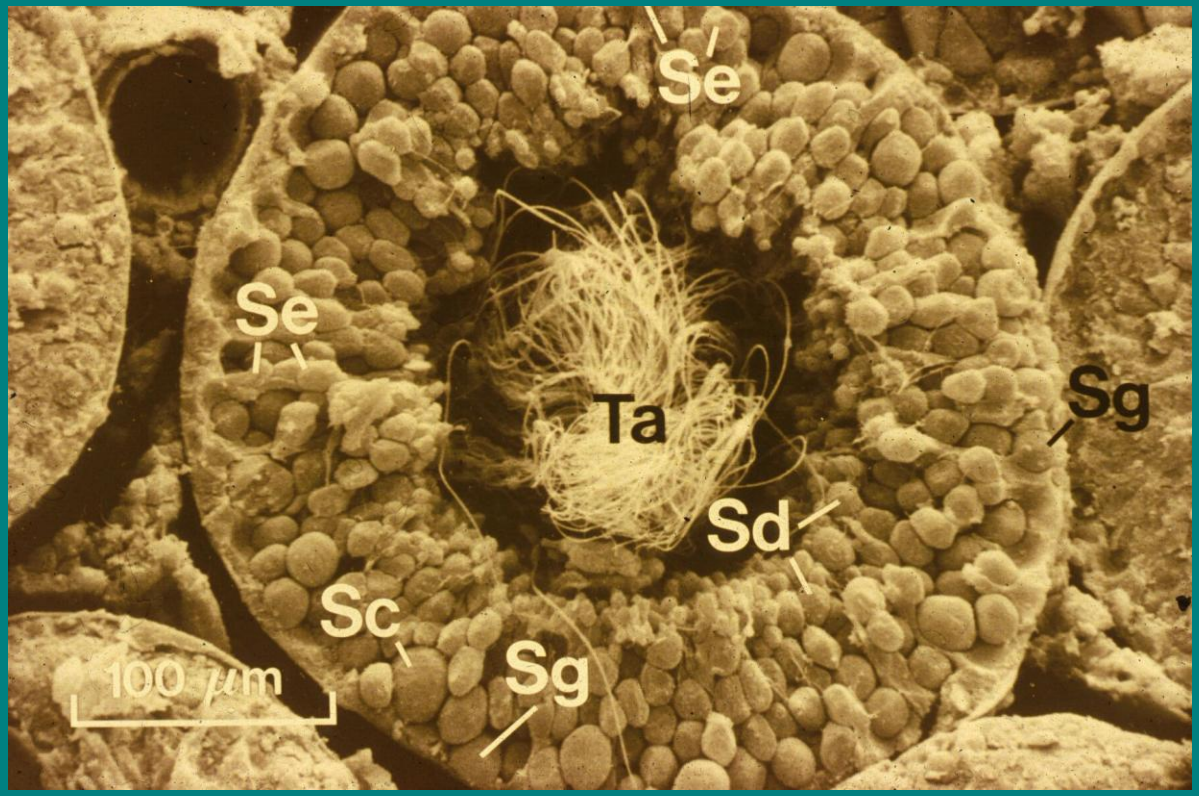




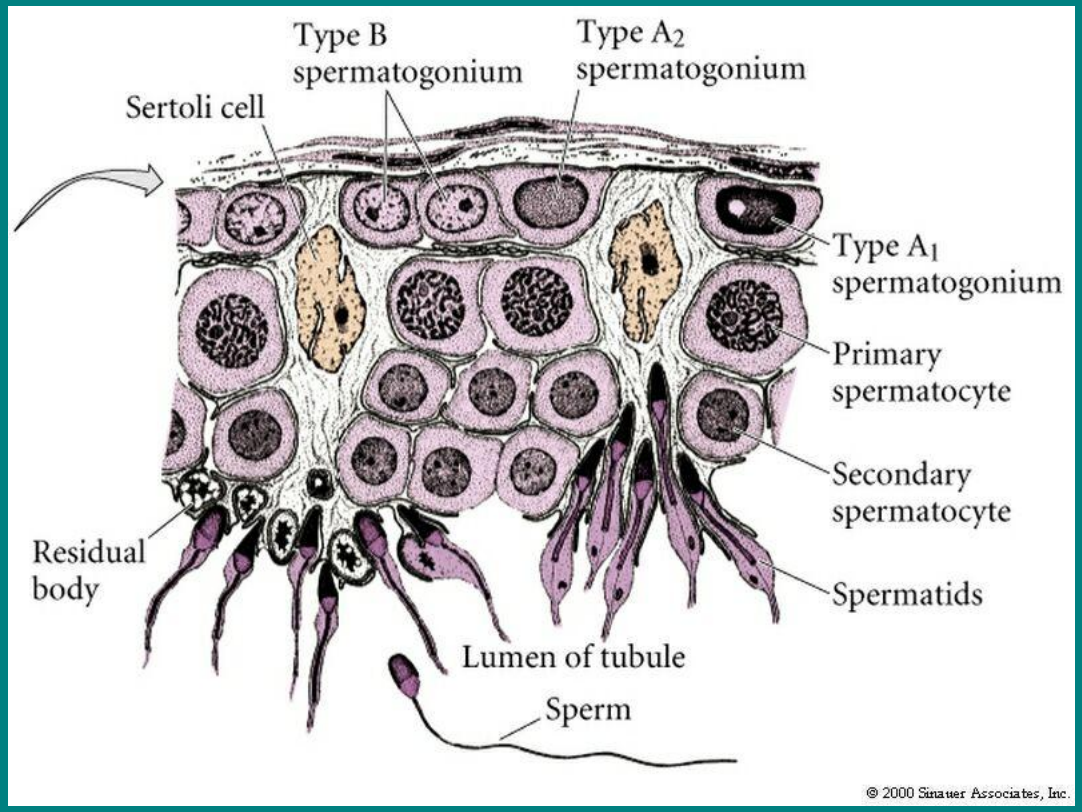




SEM of Tubule



Cross Section of Tubule



What Are Stem Cells?

- Stem cells
  - divide to produce 1 cell the same and one different from mother cell
  - thus produces unlimited supply of cells while retaining a copy in reserve of stem cell
  - there are also embryonic and adult stem cells of various potentials
  - in testis, the stem cell population is found among the spermatogonia

What Controls Stem Cells?

- Spermatogonial stem cells
  - mutations W (white-spotting) and Sl (steel) produce defects in pigment, blood and sterility
  - affect stem cell signaling
  - W = c-kit gene encoding growth factor receptor
    - transmembrane protein
  - Sl = KL encoding kit ligand
    - both on cell surface and secreted

How Do We Know W or Sl Are Important?: Mutants in Kit

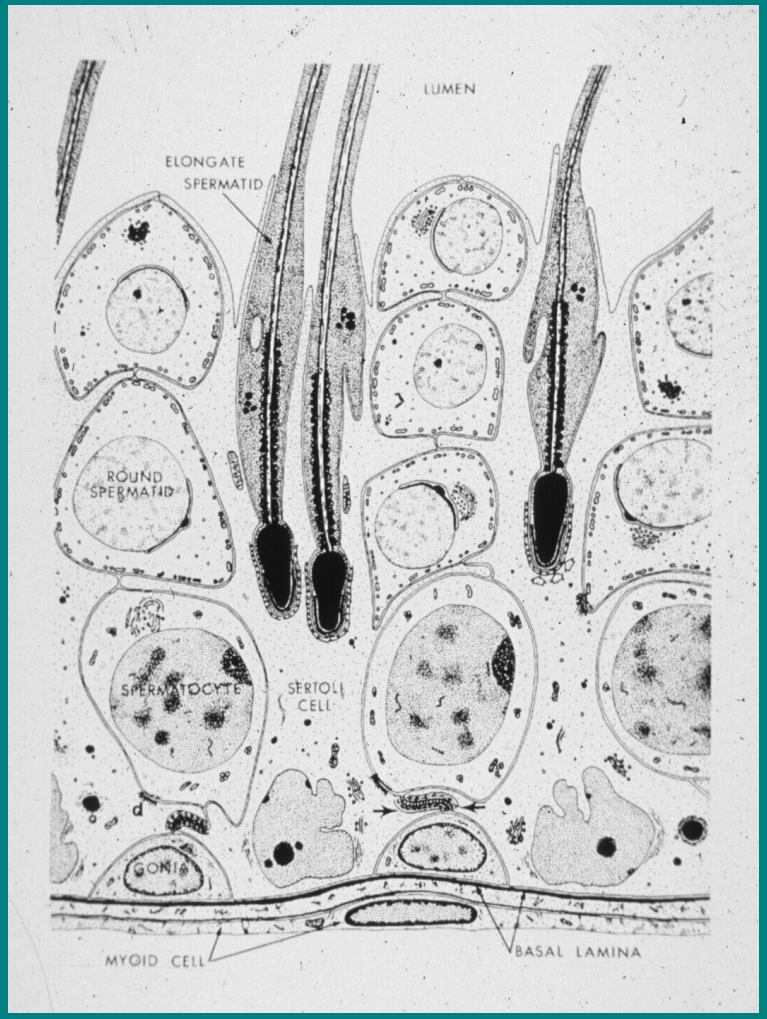
How Do We Know? Experiment

- KL signaling
  - c-*kit* expressed in 1^{o} germ cells and spermatogonia
  - KL expressed in Sertoli and other cells interacting with germ cells
  - experiment: inject antibody to c-kit into peritoneum
    - blocks binding of KL to c-kit and inhibits proliferation

Are All Testis Cells Subject to Same Signals?

- Blood testis barrier
  - Sertoli cells make tight separation between the basal and adlumenal (near the lumen) compartments
  - spermatogonia are in the basal compartment but the others are in the microenvironment of the adluminal compartment controlled by the Sertoli cells

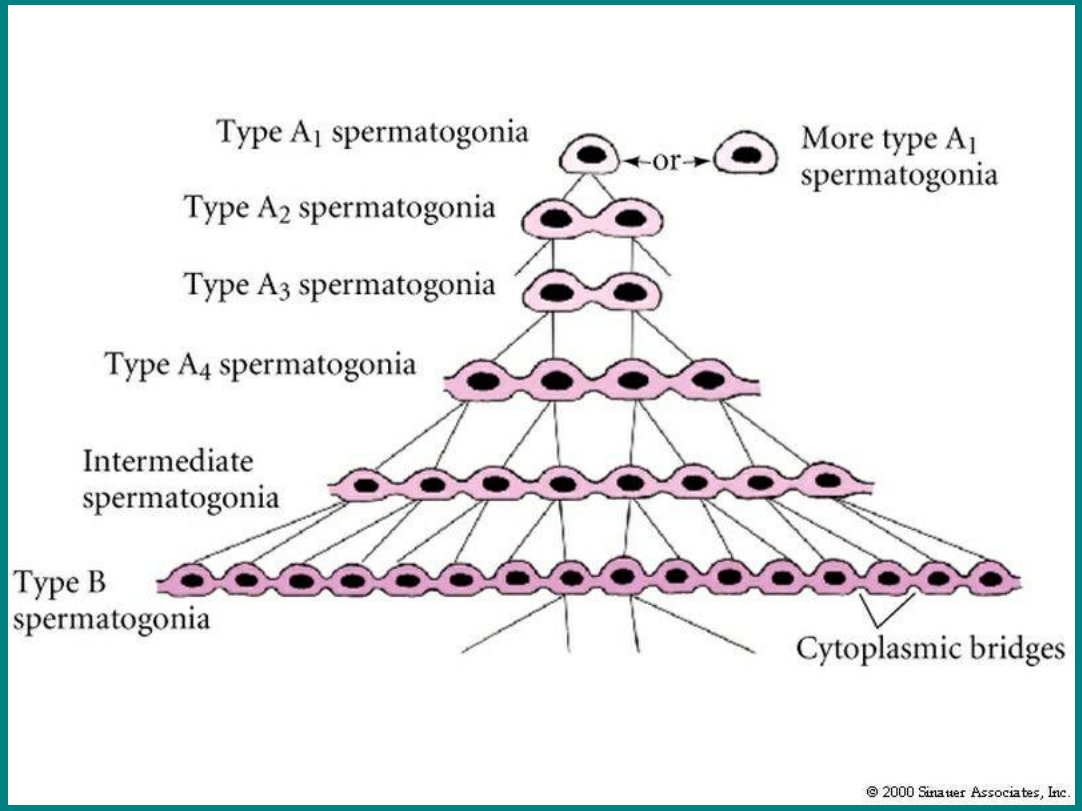
Cross Section of Tubule



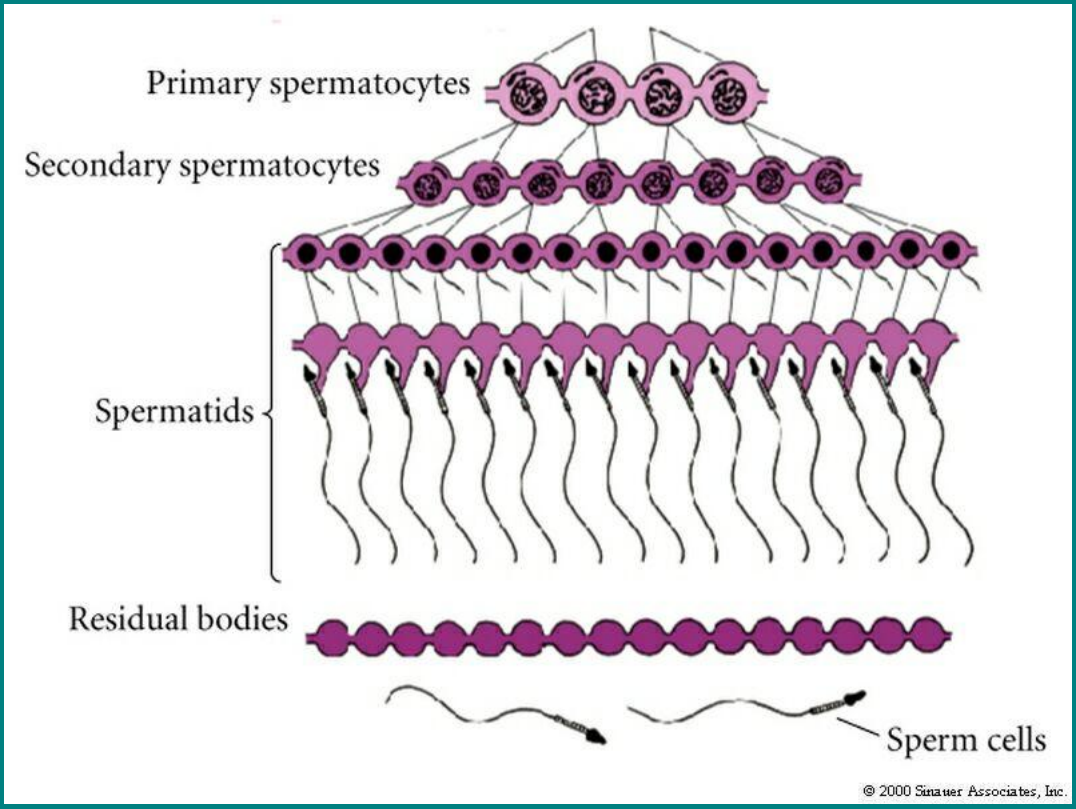
Are Cells Only Controlled by External Signals?

- Male germ cells often form nests connected by cytoplasmic bridges by incomplete cell division
- May contribute to synchrony of development in the differentiation phase (spermiogenesis)
- It takes 65 days from spermatogonia to spermatozoa in humans

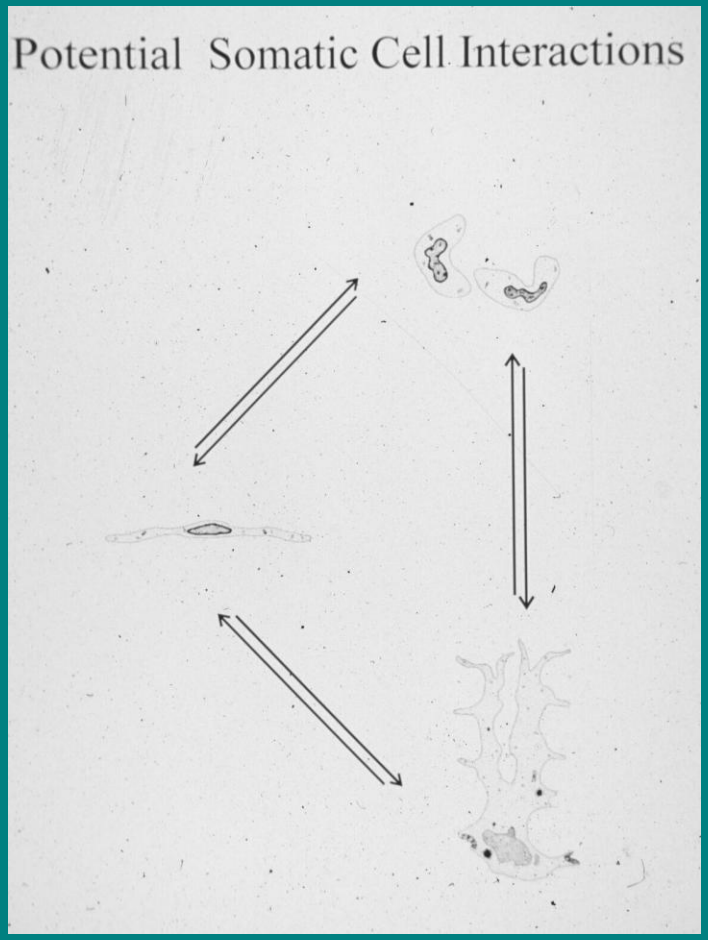
Spermatogonial Syncitium



Syncitia in Spermiogenesis



Do Testicular Somatic Cells Communicate?



Leydig

Peritubular

Sertoli

Do Pituitary and Testis Communicate?

- Communication axes
  - brain ⟷ testis
    - brain: luteinizing and follicle stimulating hormones (LH, FSH)
    - testis: inhibin, activin, follistatin
  - somatic ⟷ somatic
    - peritubular → PModS → Sertoli
    - Leydig → testosterone → Sertoli and peritubular
    - Sertoli → stimulatory and inhibitory factors ⟶ Leydig

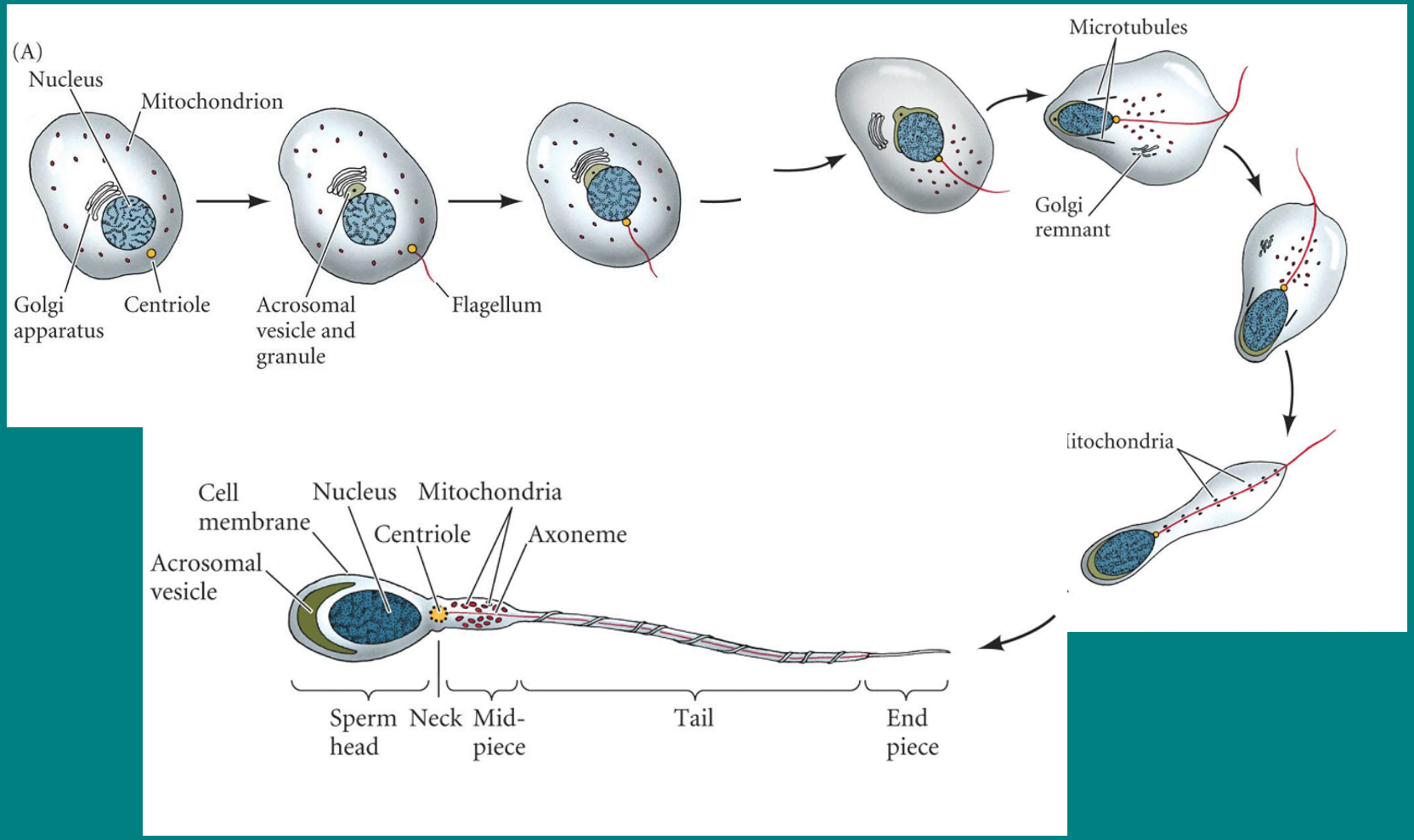
Do Somatic and Germ Line Communicate in Testis?

- Communication axes (cont.)
  - somatic ⟷ germ line
    - germ line: basic fibroblast growth factor, nerve growth factor
    - somatic: testosterone, various growth factors

How is Cell Differentiation Accomplished to Make Sperm?

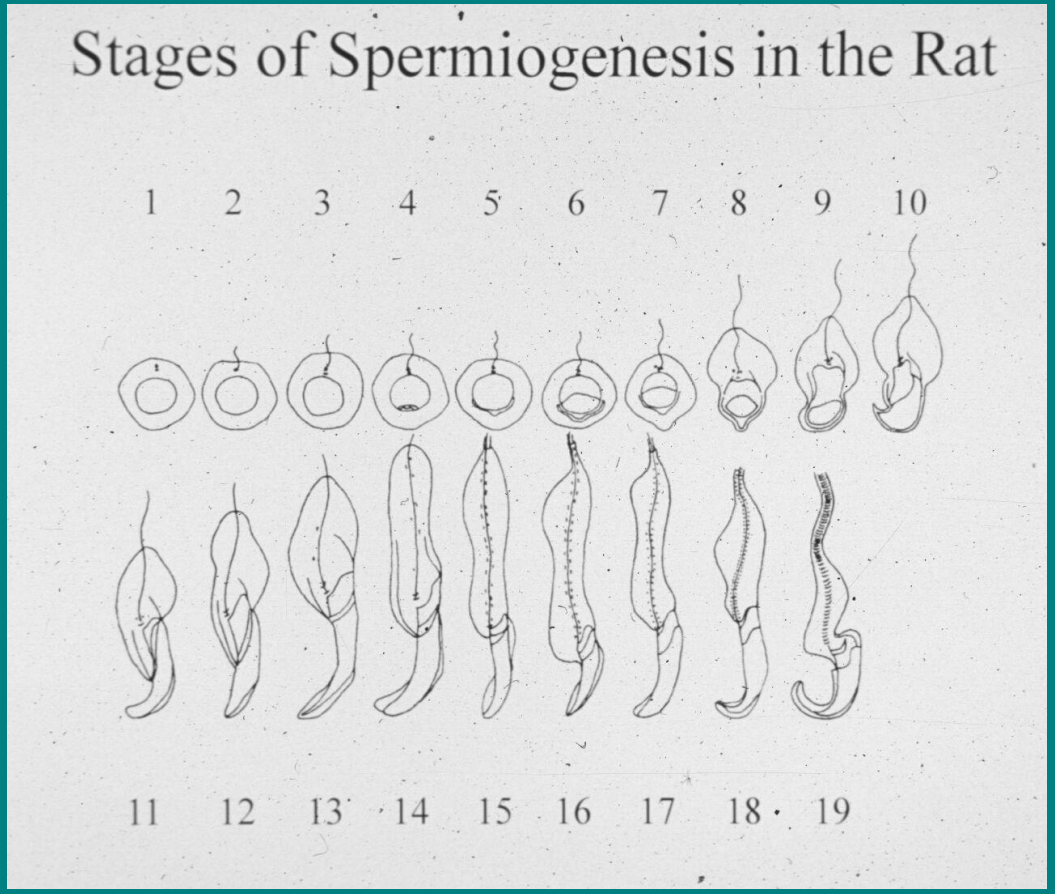
- Major alterations to make mature sperm cell
  - Golgi → acrosomal vesicle
  - nucleus → compacted and new DNA binding proteins
  - centrosomes associate with head
  - mitochondria fused or collected in midpiece
  - flagellum
  - shedding of excess cytoplasm

Morphogenesis of Spermatids

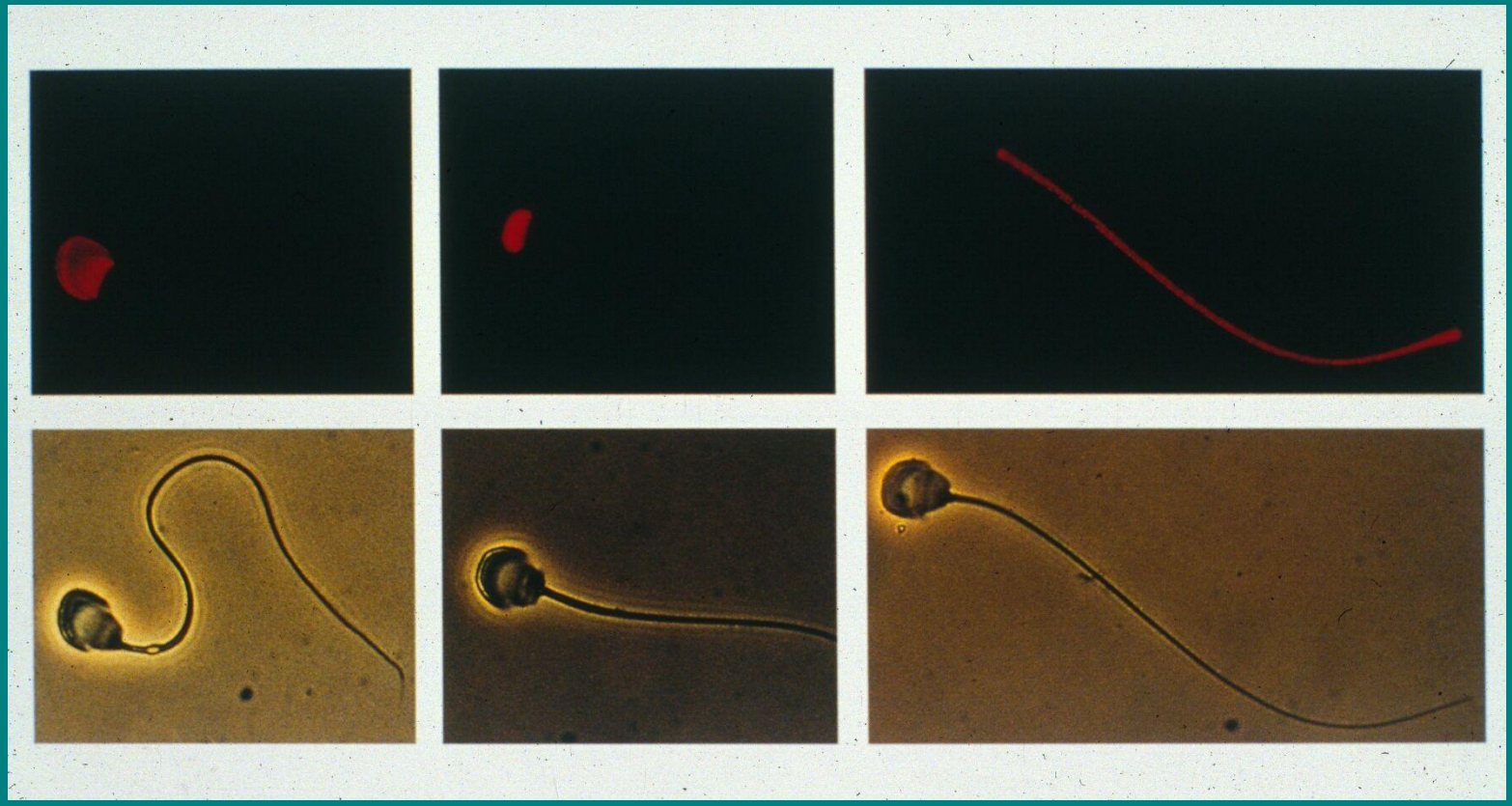


Is Spermiogenesis Progressive?

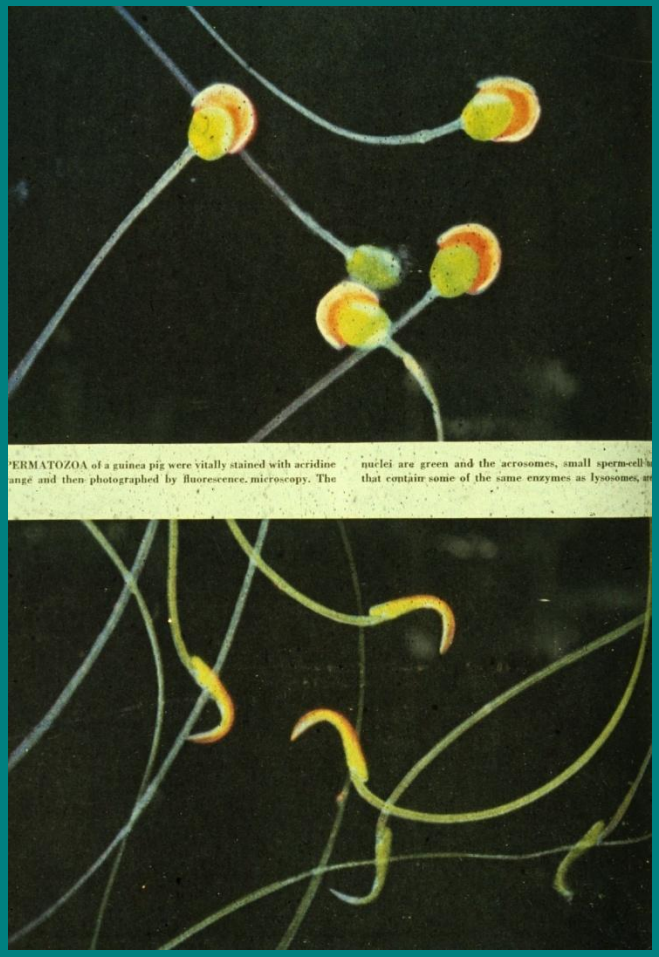
All spermatids
All haploid



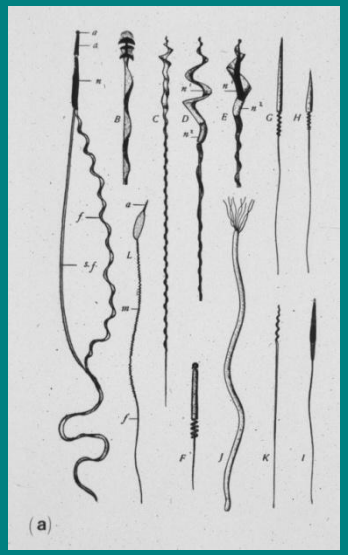
Are There Functional Differences in Mature Sperm Surface?

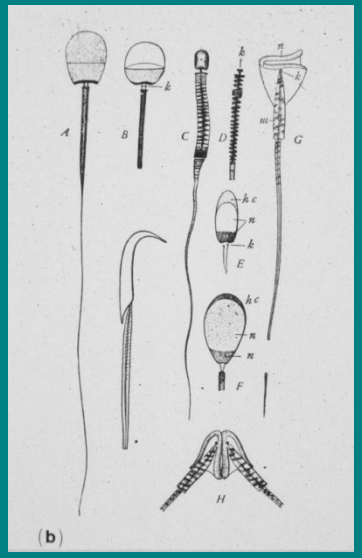


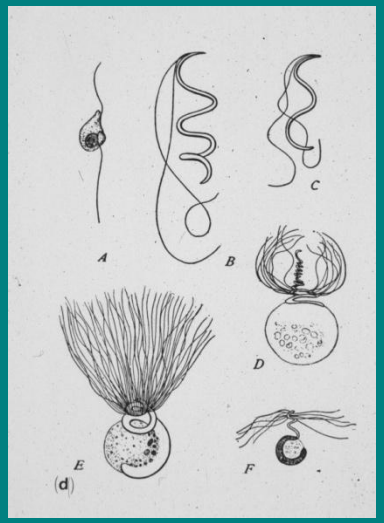
Internal Specialization of the Head: Nucleus and Acrosome

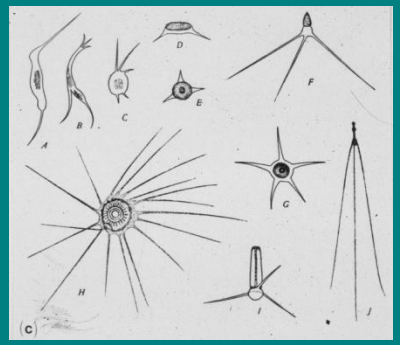


Is There Great Diversity in Mature Sperm Morphology?









E.B. Wilson, 1898

To Be a Good Sperm, It's Not Enough to Be Beautiful and Run Fast

Sperm are differentiated for many tasks: e.g. swimming, egg recognition, penetration of egg coats, fusion, delivery of genome

Is There Biochemical Diversity Among Animals?

- DNA packaging proteins
  - highly conserved histones in somatic cells
    - basic DNA binding nucleosome forming proteins
  - in spermatozoa
    - wide array of different types
- Hypothesis
    - no replication, transcription, metaphase chromosomes in spermiogenesis
    - removes all evolutionary constraints associated with these processes
    - proteins free to diverge