Primordial Germ Cells

- Produce gametes (egg and sperm)
- How are primorial germ cells determined?
  - Cytoplasmic determinants in egg
    - Proteins and mRNA are localized in region called the germ plasm
    - Nematodes, flies, frogs
  - Interactions between neighboring cells
    - Salamander, mammals

Nematodes

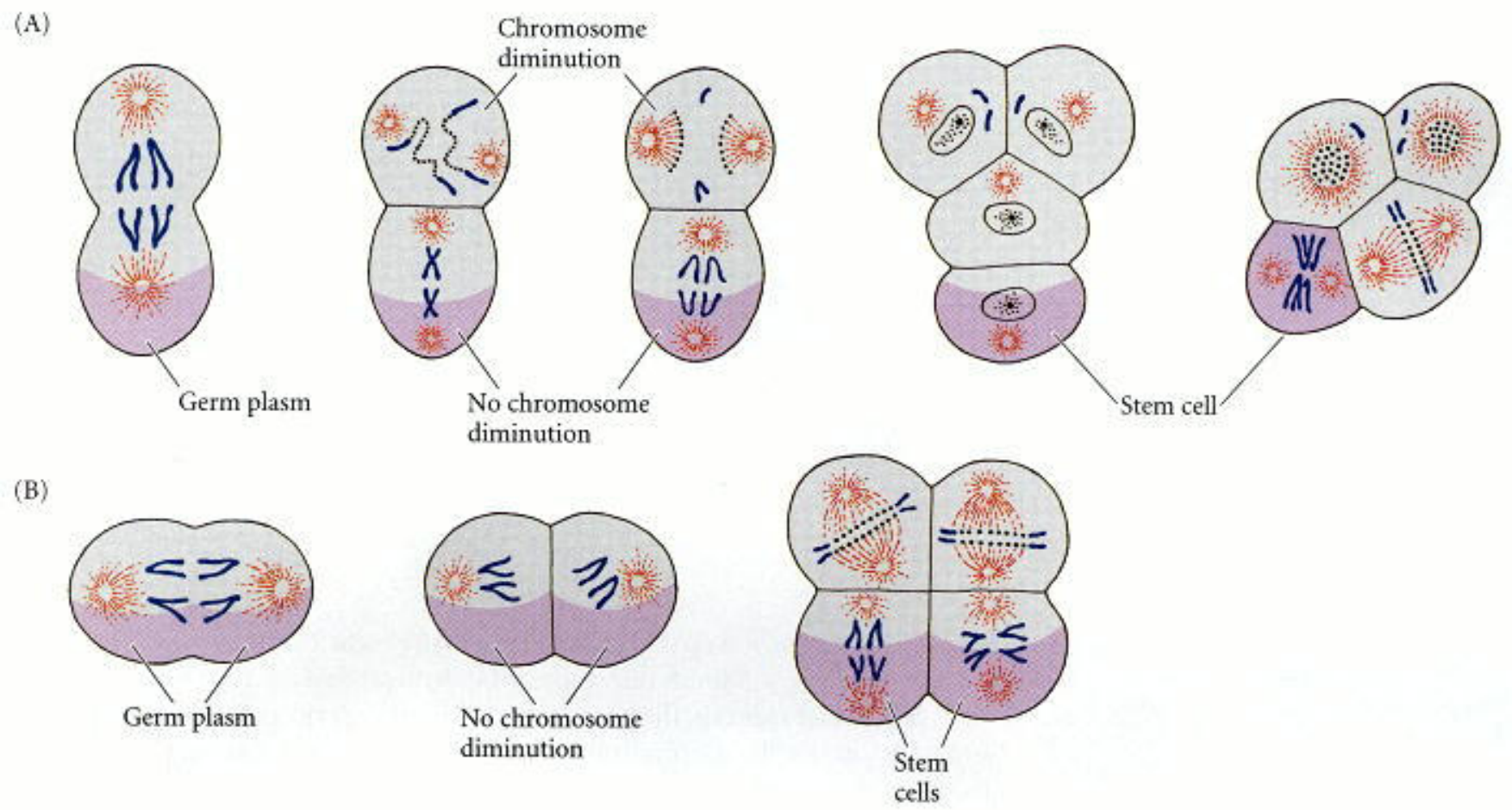
Parascaris

C. elegans

Nematode germ cells

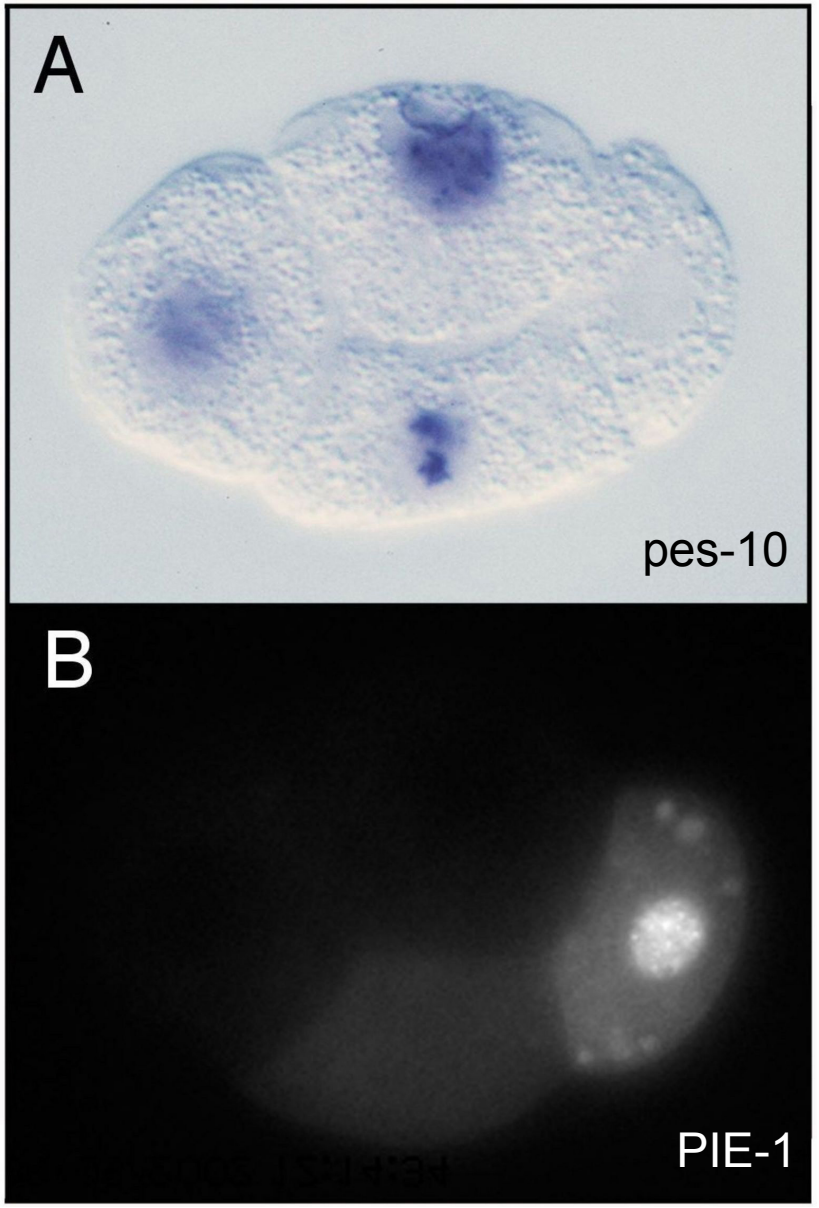
- Animal pole
  - No yolk
  - Produces most cells
- Vegetal pole
  - Yolk
- Equatorial cleavage plane
- Chromosome diminution
  - DNA fragments and only part of the DNA is present in somatic cells

Boveri's experiments on *Parascaris*

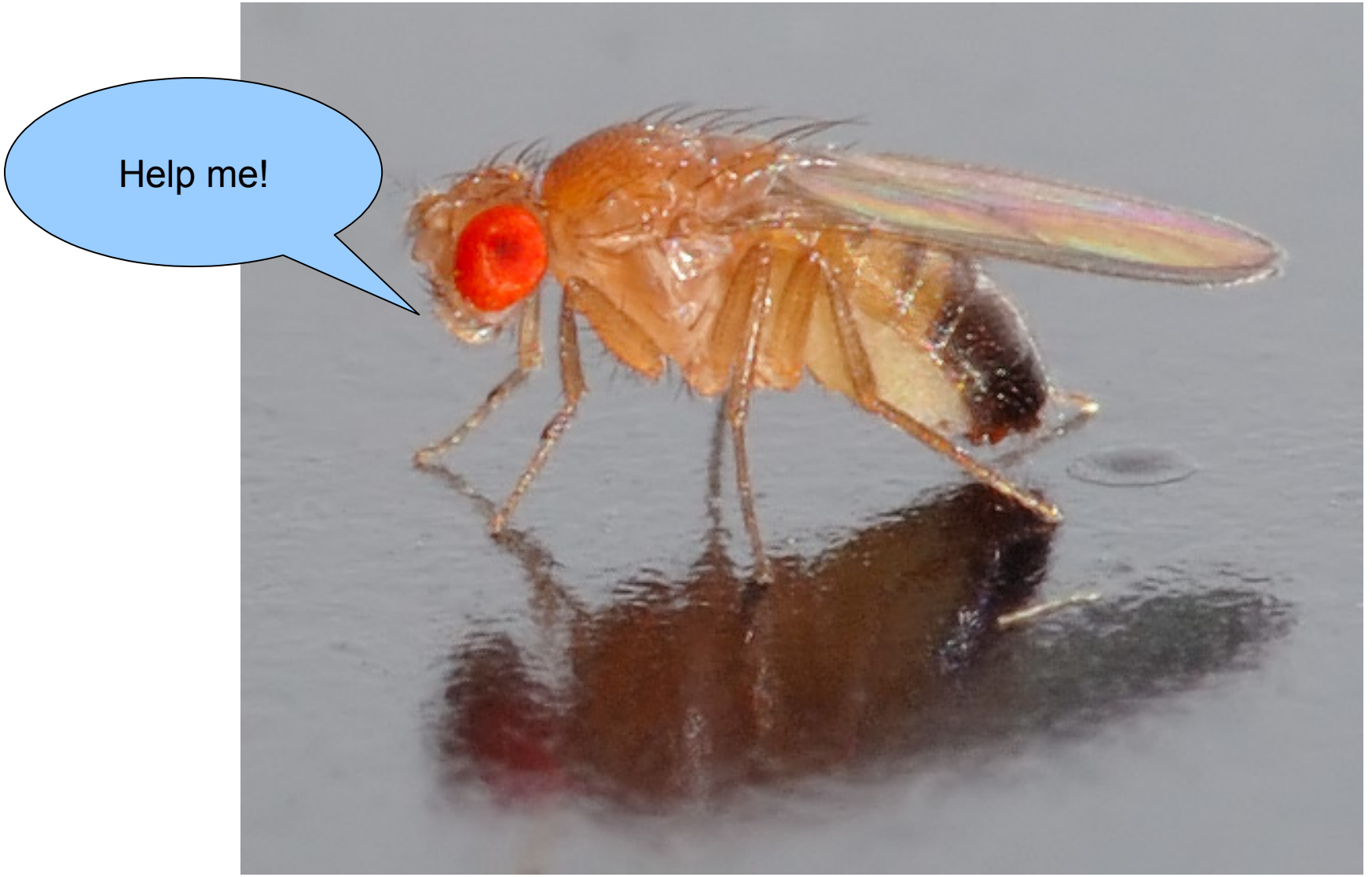


C. elegans

- P-granules migrate to P4 blastomere
  - Alters transcription
- PIE-1 protein activated
  - Blocks most gene transcription

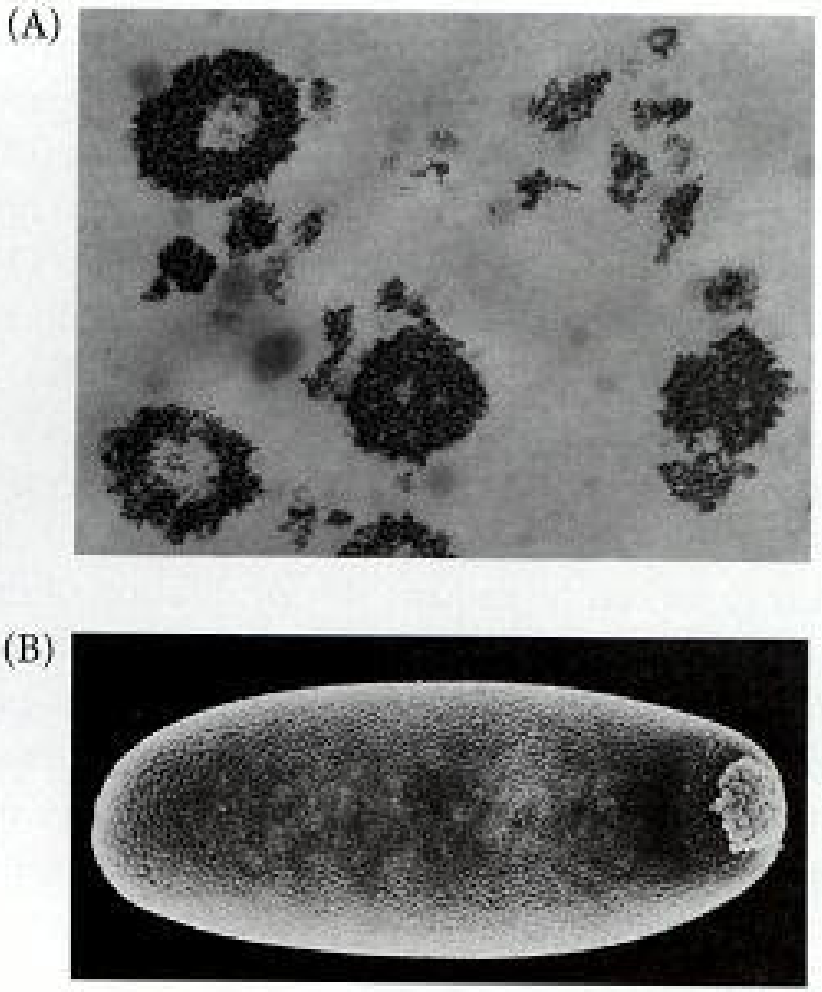


Drosophila melanogaster

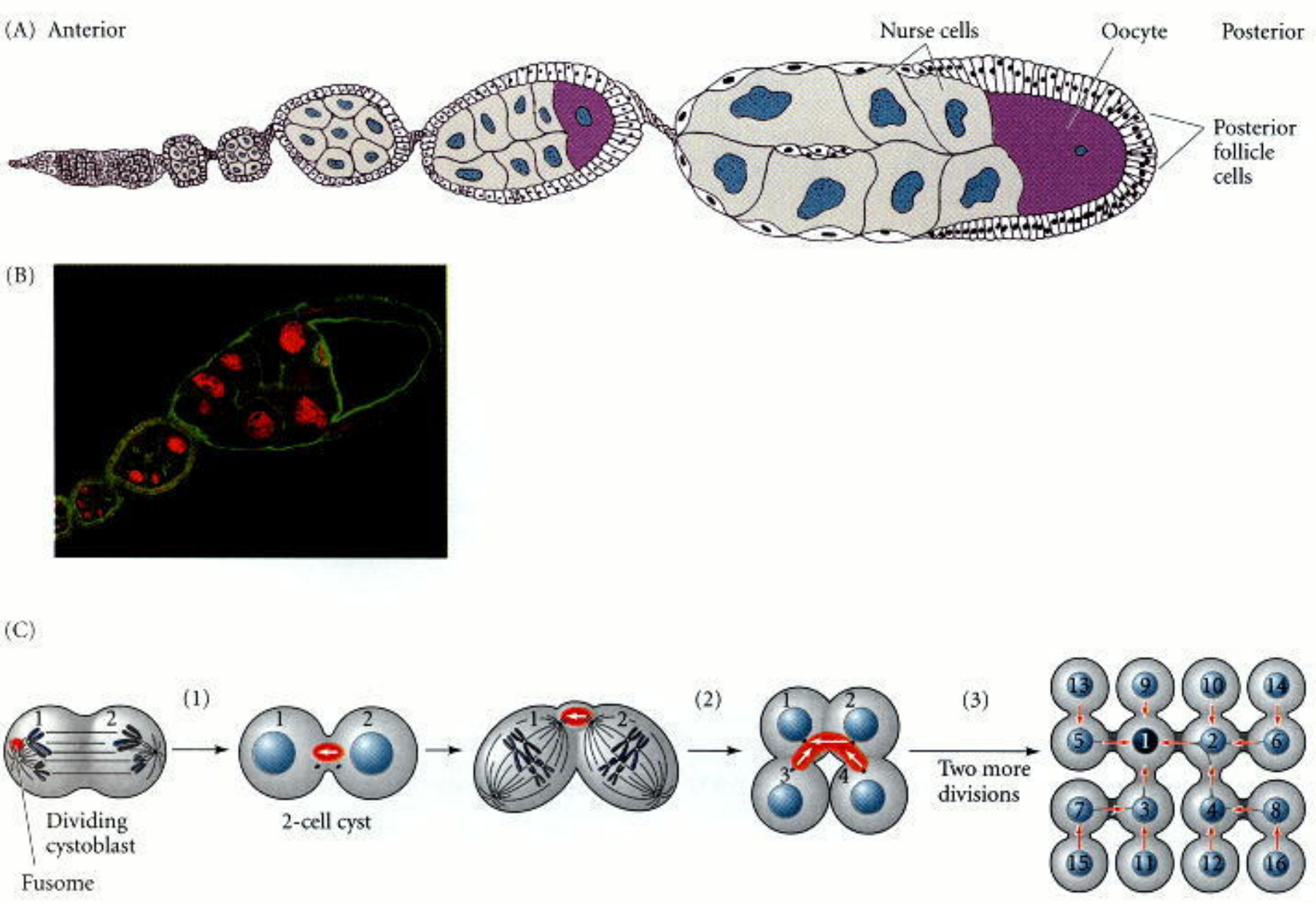


Germ cell determination in *Drosophila*

- Pole granules (A) form at posterior pole
- Pole cells (B) migrate to posterior of developing embryo (ninth division)



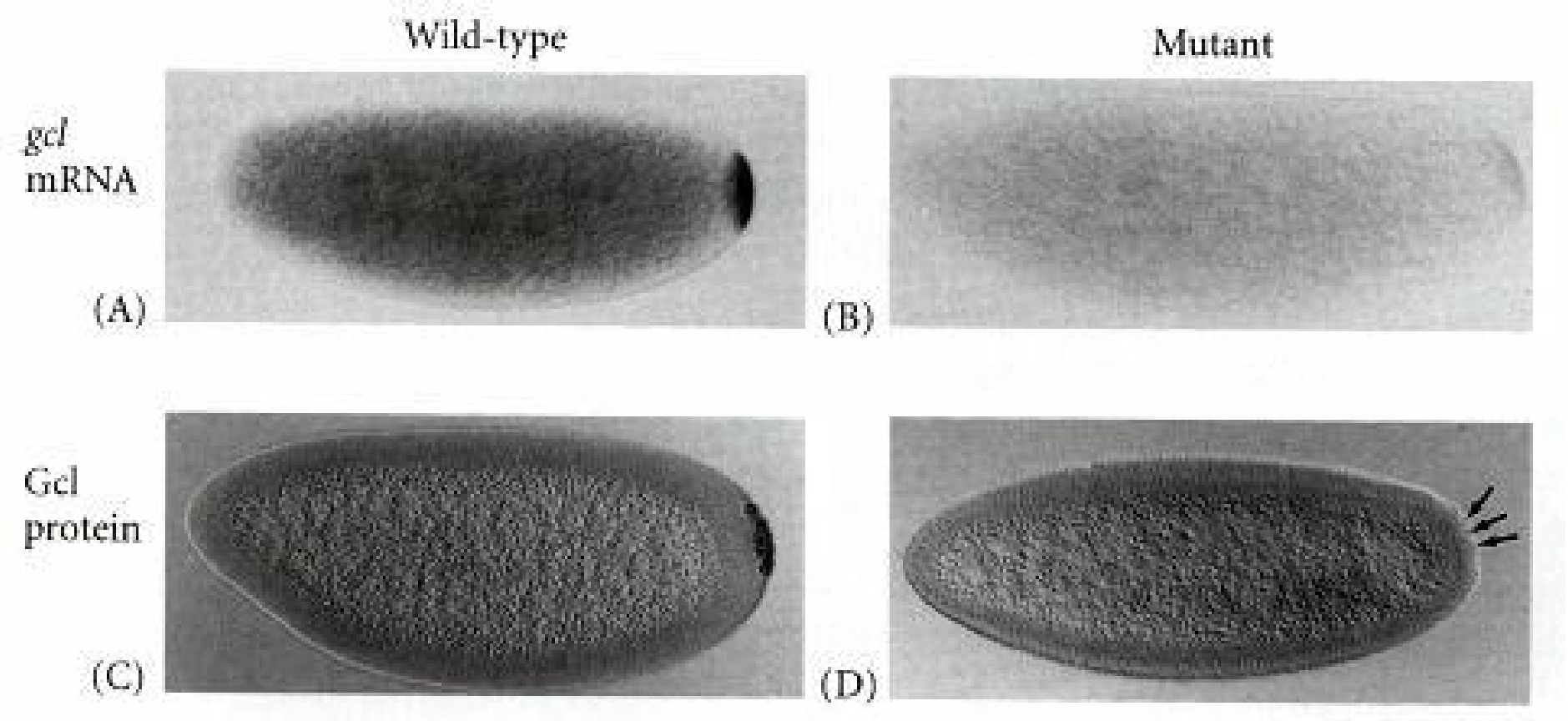
Cystocyte development in *Drosophila*



Genes involved in pole cell formation in *Drosophila*

- Germ cell-less
- Polar granule component
- Posterior group
  - Oscar
  - Nanos
  - Vasa
  - Piwi and Augergine

Localization of the germ cell-less gene in *Drosophila*



Germ cell-less (gcl))

- mRNA produced by nurse cells and deposited into egg
- mRNA transported to posterior pole of egg (pole plasm)
- Transcribed into protein early in development
- gcl protein enters nuclei and alters gene transcription
- Necessary for pole cell production
- Human homologues necessary for spermatogenesis

Polar granule component (Pgc)

- Non-coding RNA
- Inhibits transcription by blocking RNA polymerase II phosphorylation
- When mutated pole cells develop into somatic cells

Oskar

- Involved in localizing factors (proteins and mRNA) necessary for pole cell formation to the posterior end of developing egg
- Expressing abnormal expression of Oskar causes production of extra pole cells

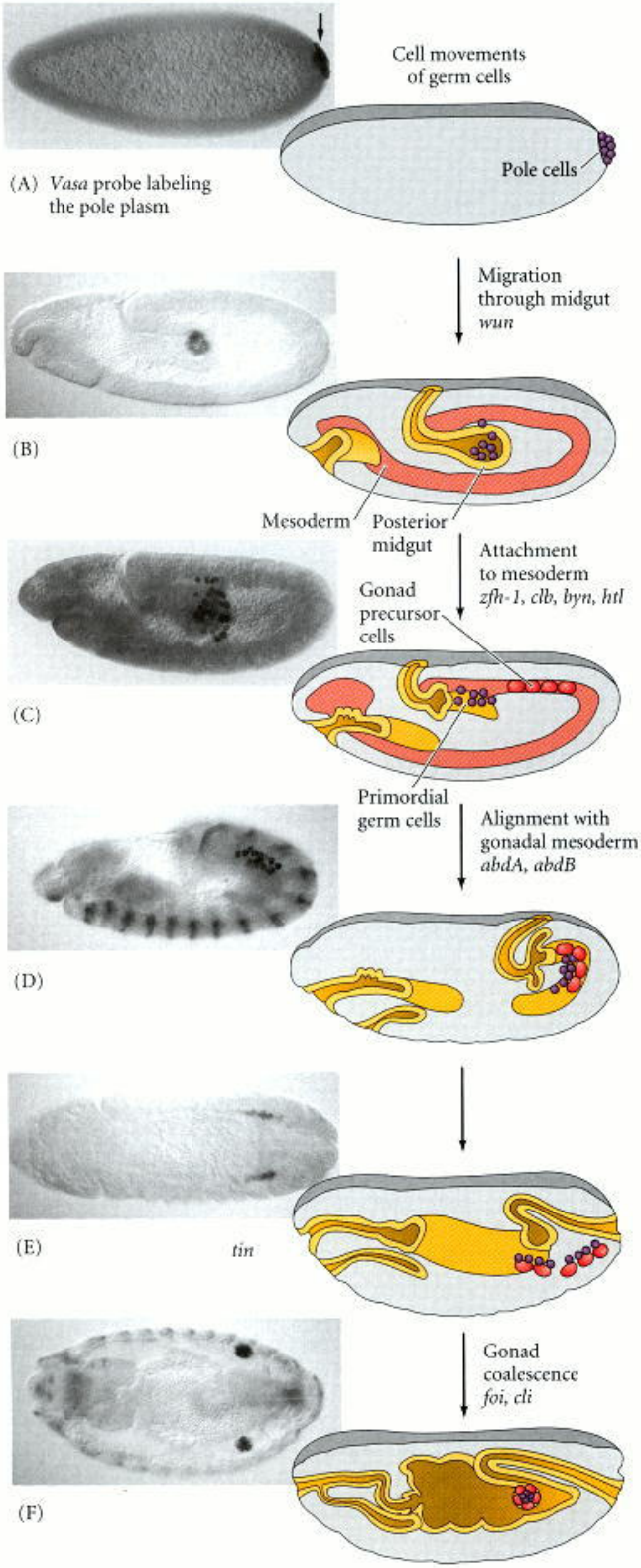
Nanos

- Prevents development of somatic cells
- Blocks translation
- Localized by oskar

Vasa, Piwi, Aubergine

- Vasa – initiates germ cell differentiation and meiosis
  - RNA binding protein
- Piwi, Aubergine – necessary for germ cells to develop into stem cells in gonad
  - Repress transcription

Germ cell migration in *Drosophila*



Germ Cell Determination in Vertebrates

- Frogs
- Zebrafish
- Mammals

Frogs

- Vegetal region contains *Drosophila* pole plasm homologue
  - For example: *Xcat2* homologue of *Nanos*
  - Germ plasm granules are present in unfertilized egg
    - Tethered to yolk
    - After fertilization microtubules position germ plasm granules in vegetal pole

Zebrafish

- Germ plasm polar granules containing *Drosophila* pole plasm homologue
  - For example: *Nanos* and *Vasa*
- Maternally supplied
- Associated with cleavage furrow
- At 1000 cell stage only four cells have germ plasm
  - 4 clusters of primordial germ cells form

Mammals

- Eggs do not contain germ plasm
- Induction causes germ cell production

Testis and Associated Structures

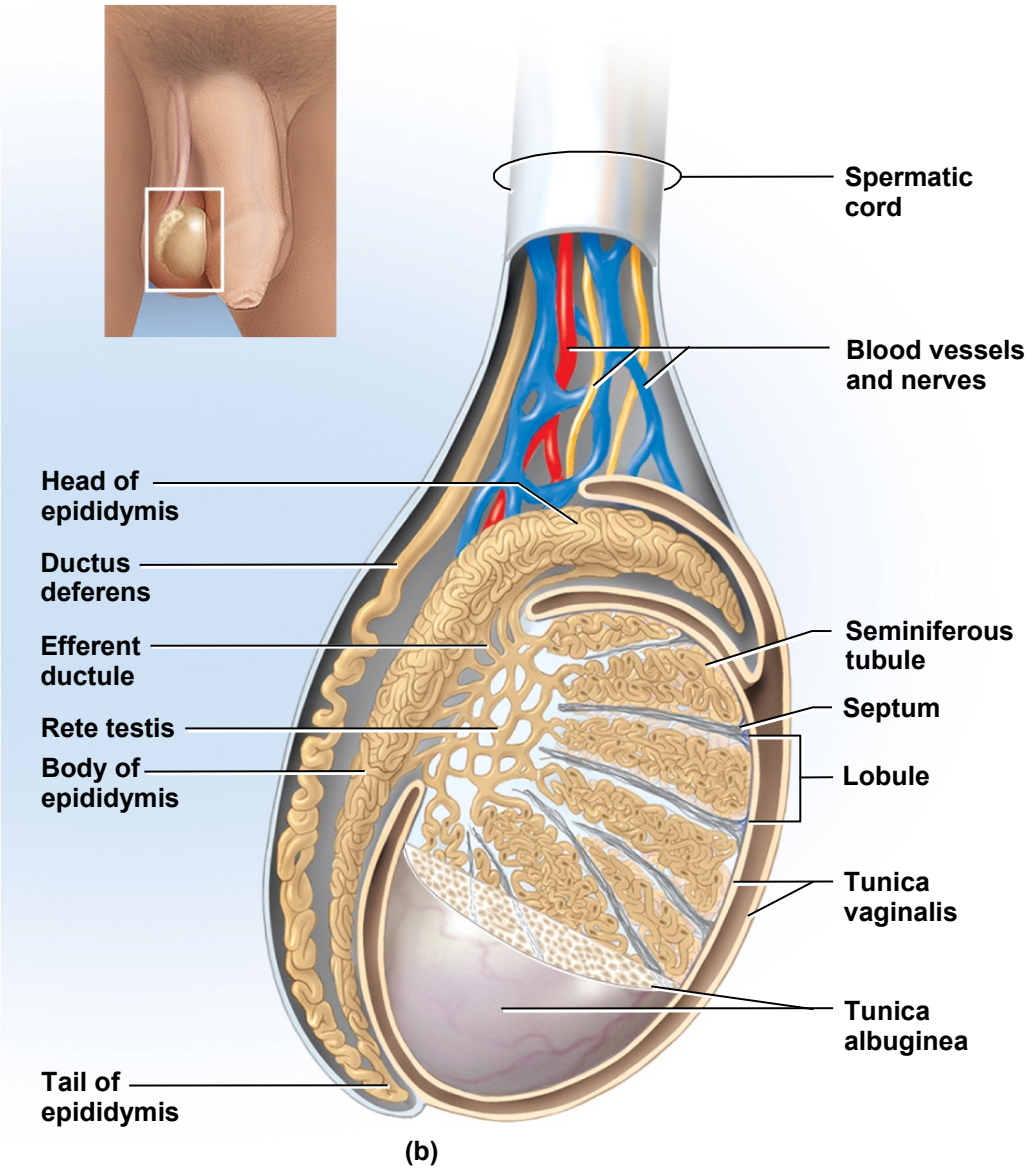


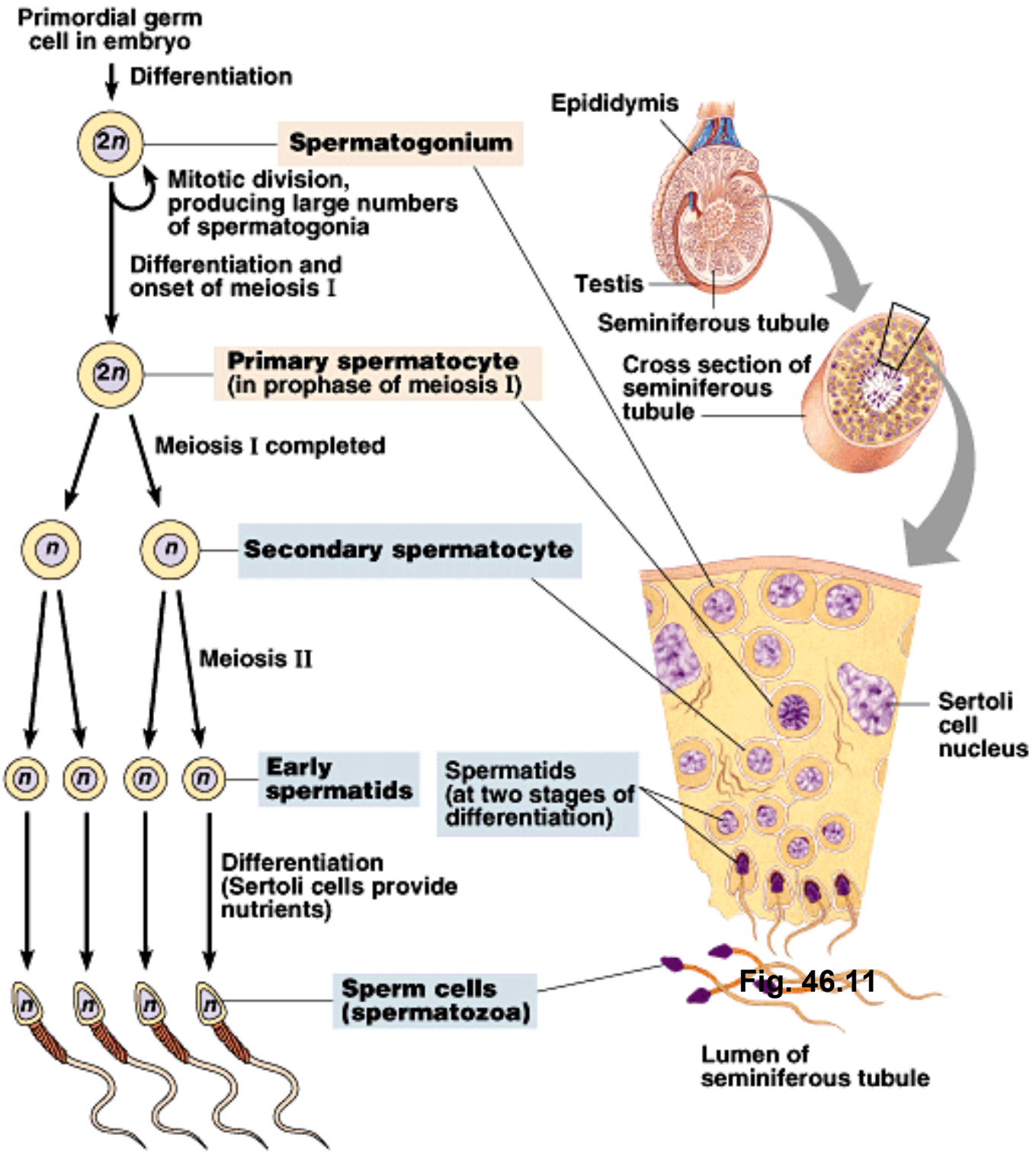
Figure 27.9b

Endocrine Control

As hypothalamus matures it produces **gonadotropin-releasing hormone (GnRH)**

- GnRH stimulates anterior pituitary cells (**gonadotropes**) to secrete:
  - **follicle stimulating hormone (FSH)**
    - stimulates Sertoli **cells** to secrete **androgen-binding protein** that binds testosterone keeping it in the seminiferous tubule lumen to stimulate spermatogenesis and raising sperm count
  - **luteinizing hormone (LH)**
    - stimulates **interstitial cells** to produce **testosterone**

Primordial germ cell PGC



Spermatogenesis

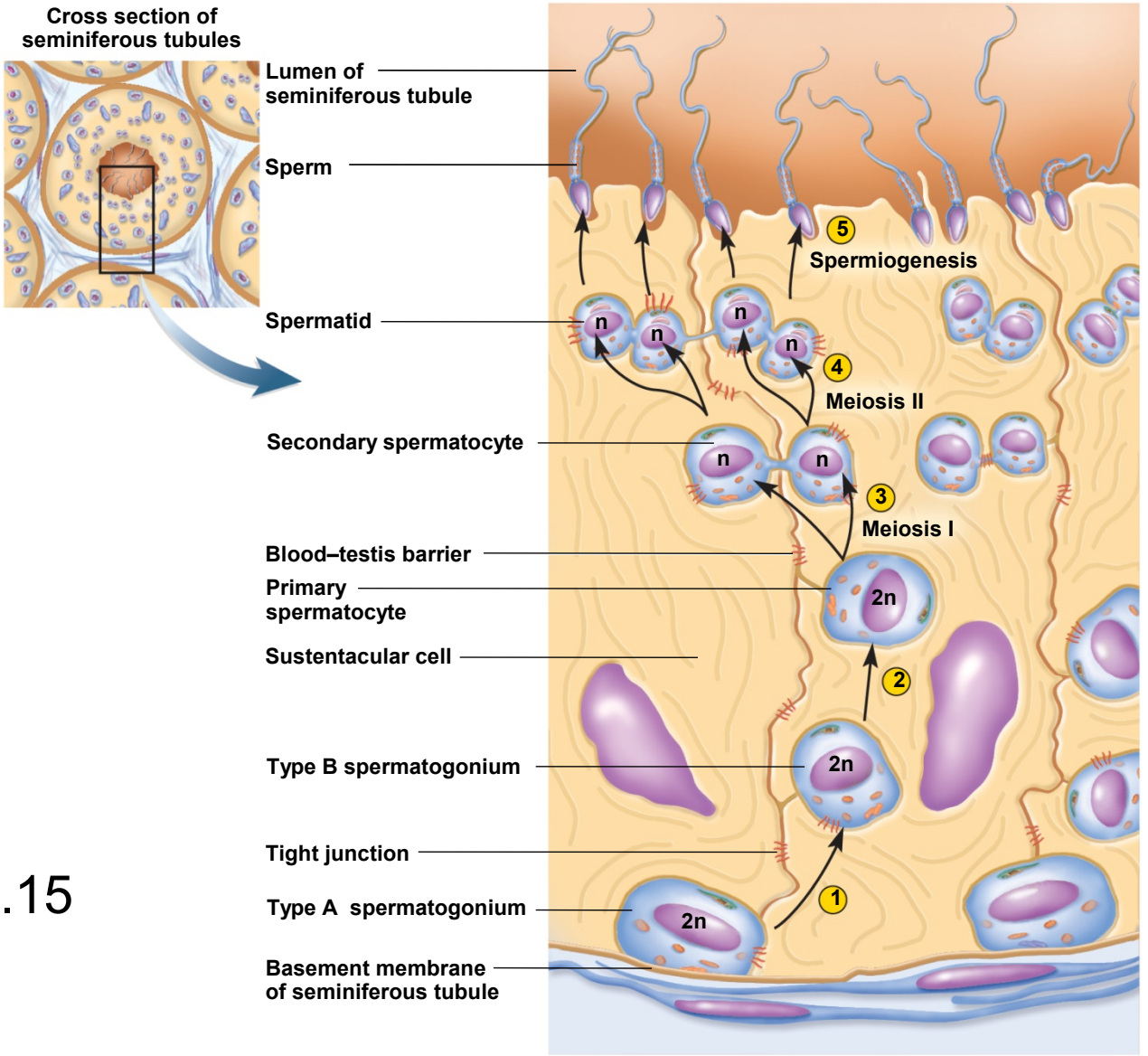


Figure 27.15

Histology of Testis

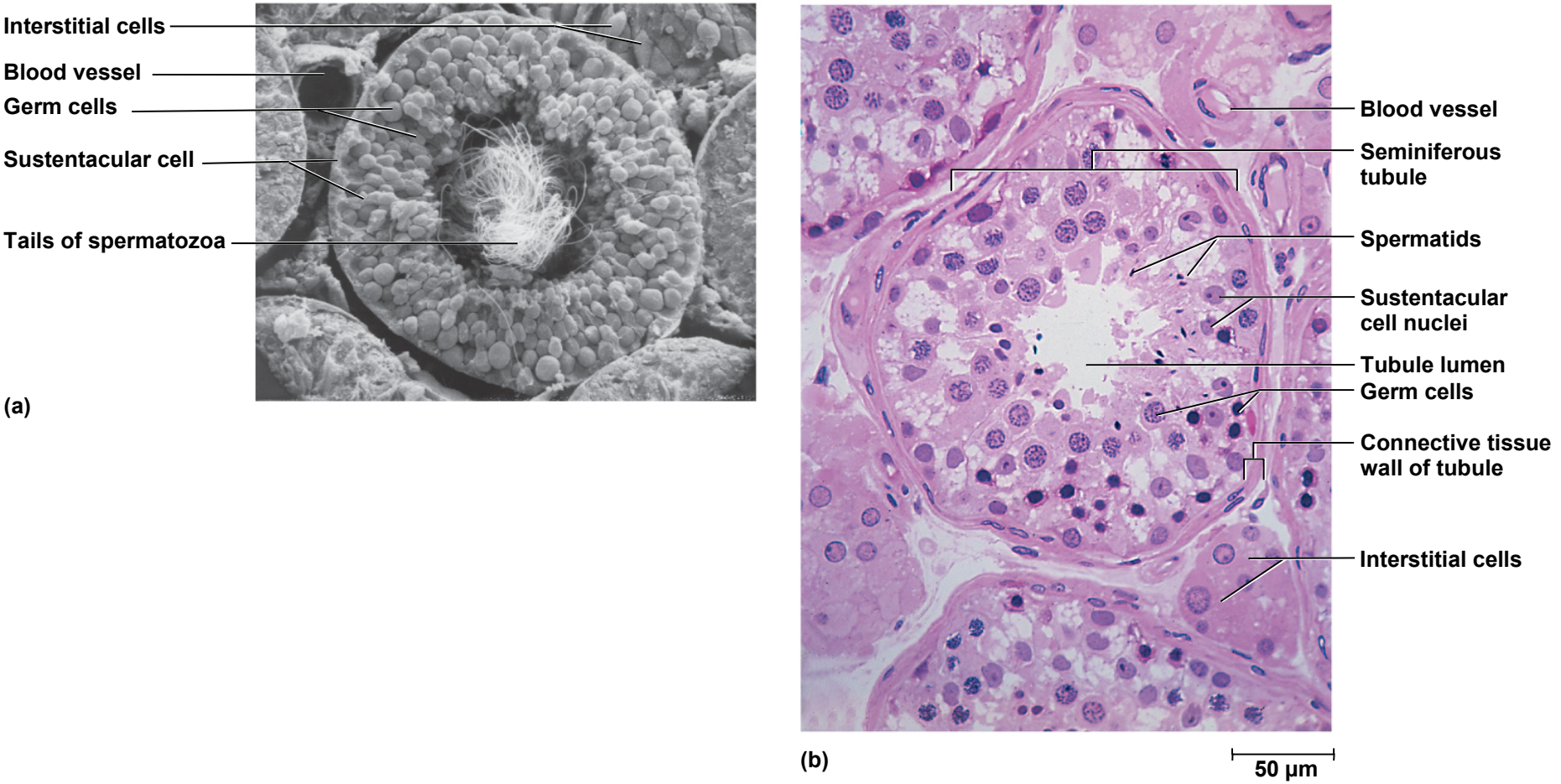


Figure 27.10 a-b

Spermatozoon

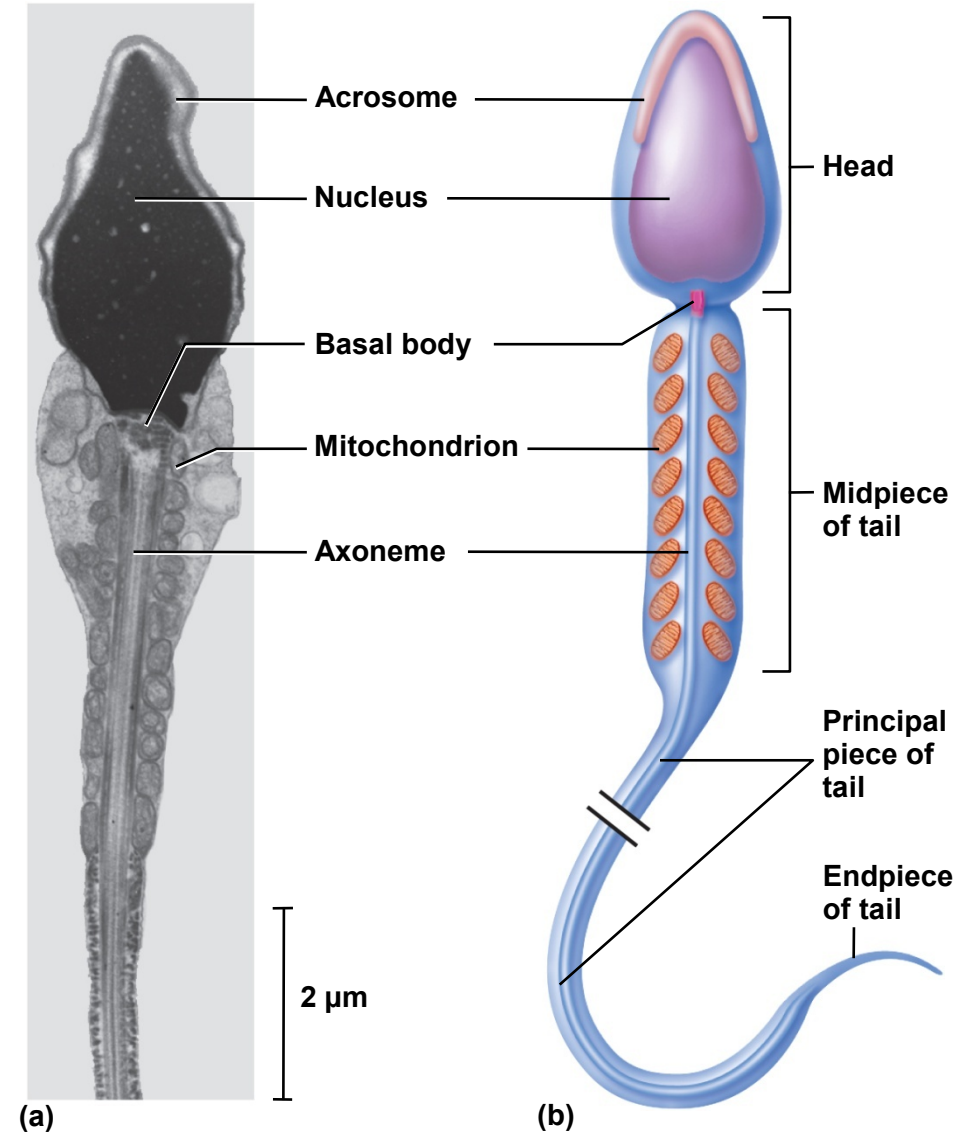
Sperm structure:

Haploid nucleus.

Tipped with an **acrosome**.

Contains enzymes that help the sperm penetrate to the egg.

A large number of mitochondria provide ATP to power the flagellum



a: Visuals Unlimited

Uterus

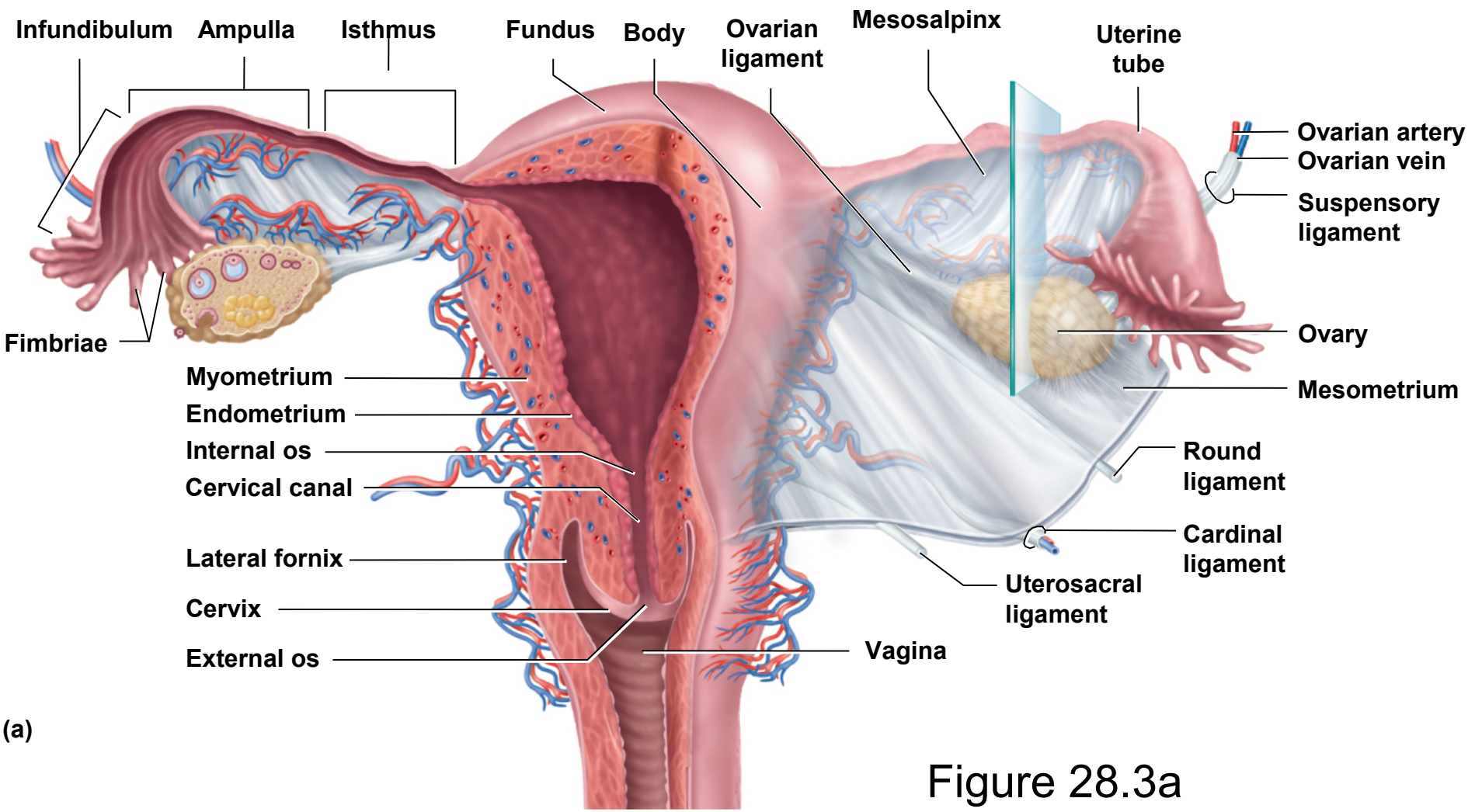


Figure 28.3a

Anatomy of Ovary

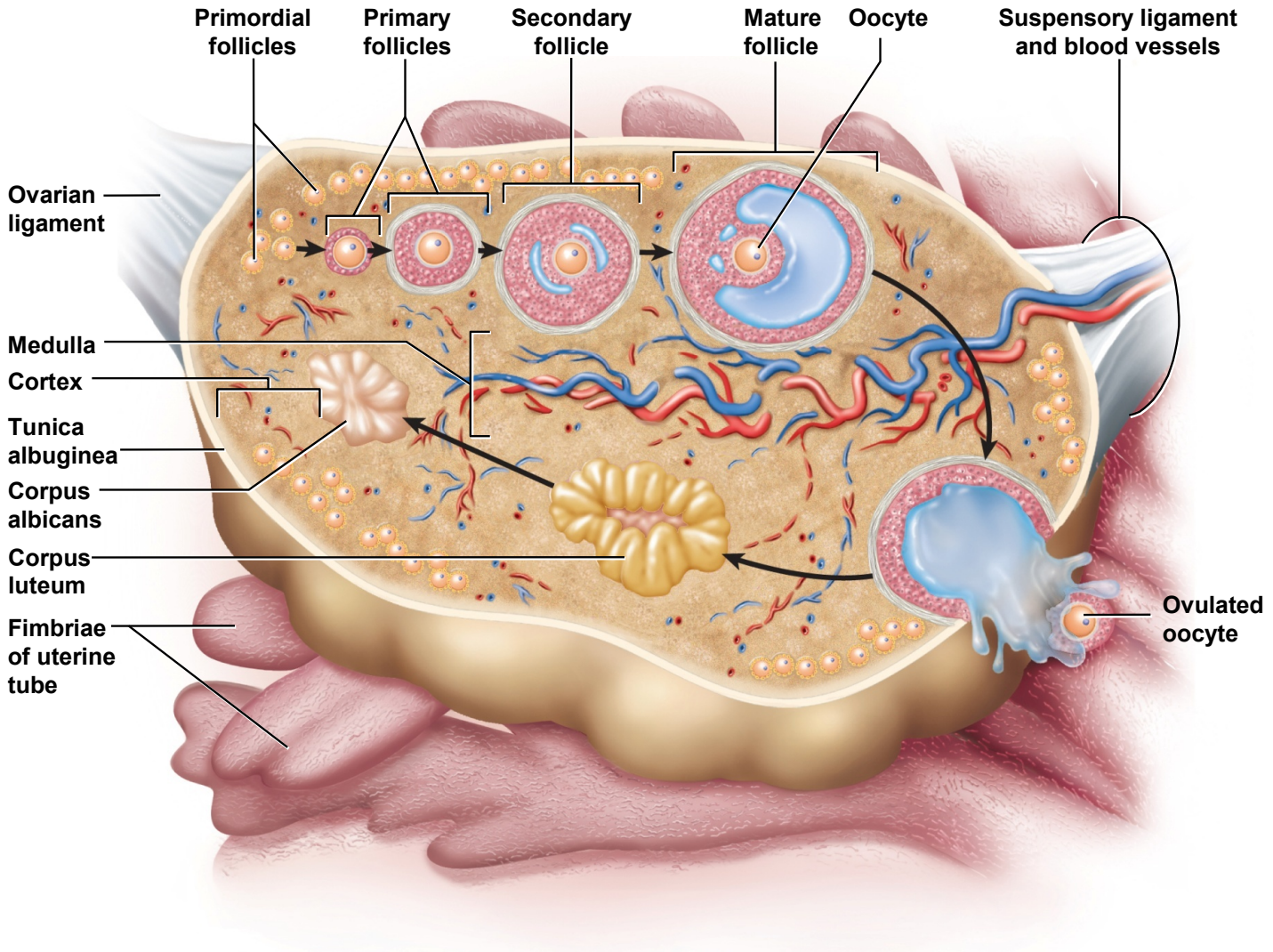


Figure 28.2

Oogenesis and Follicle Development

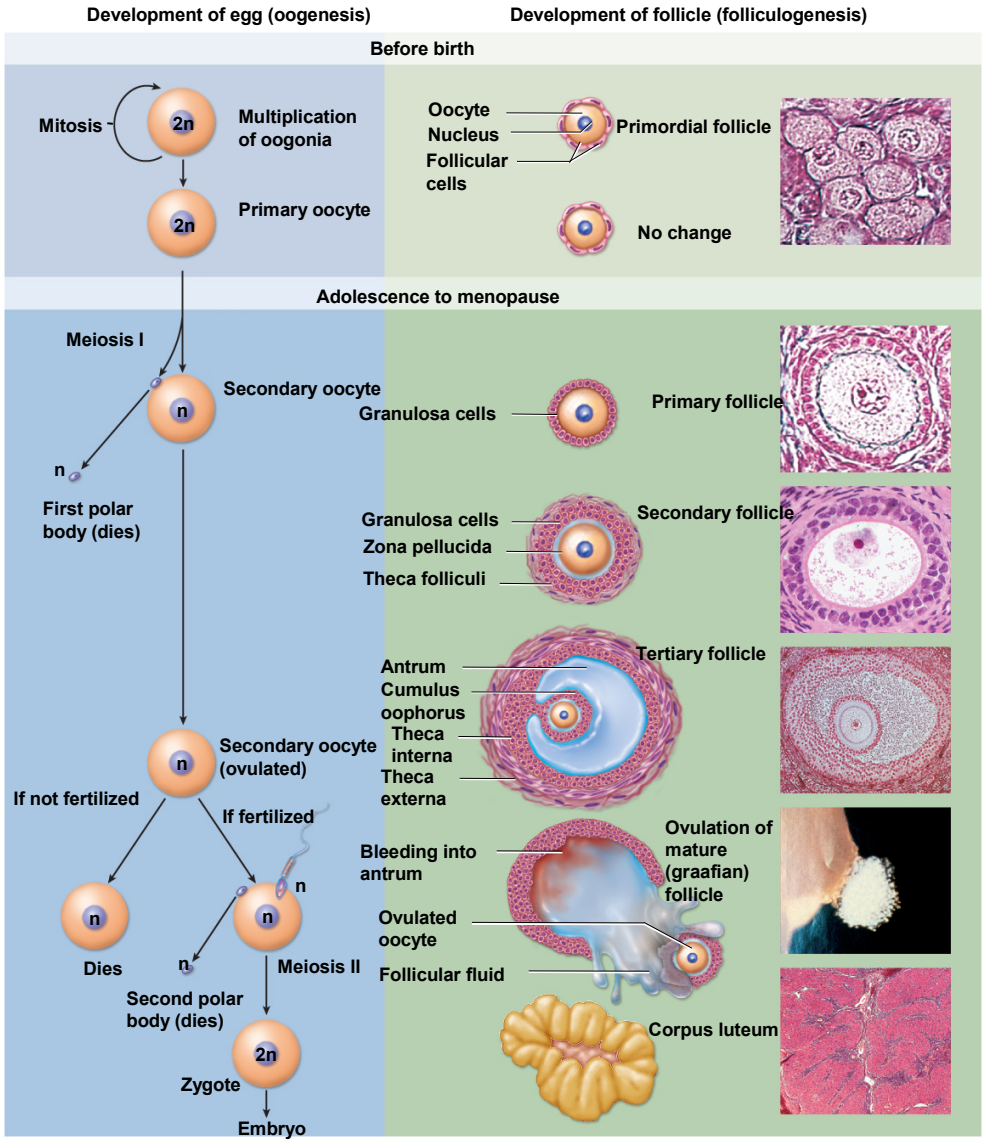


Figure 28.11

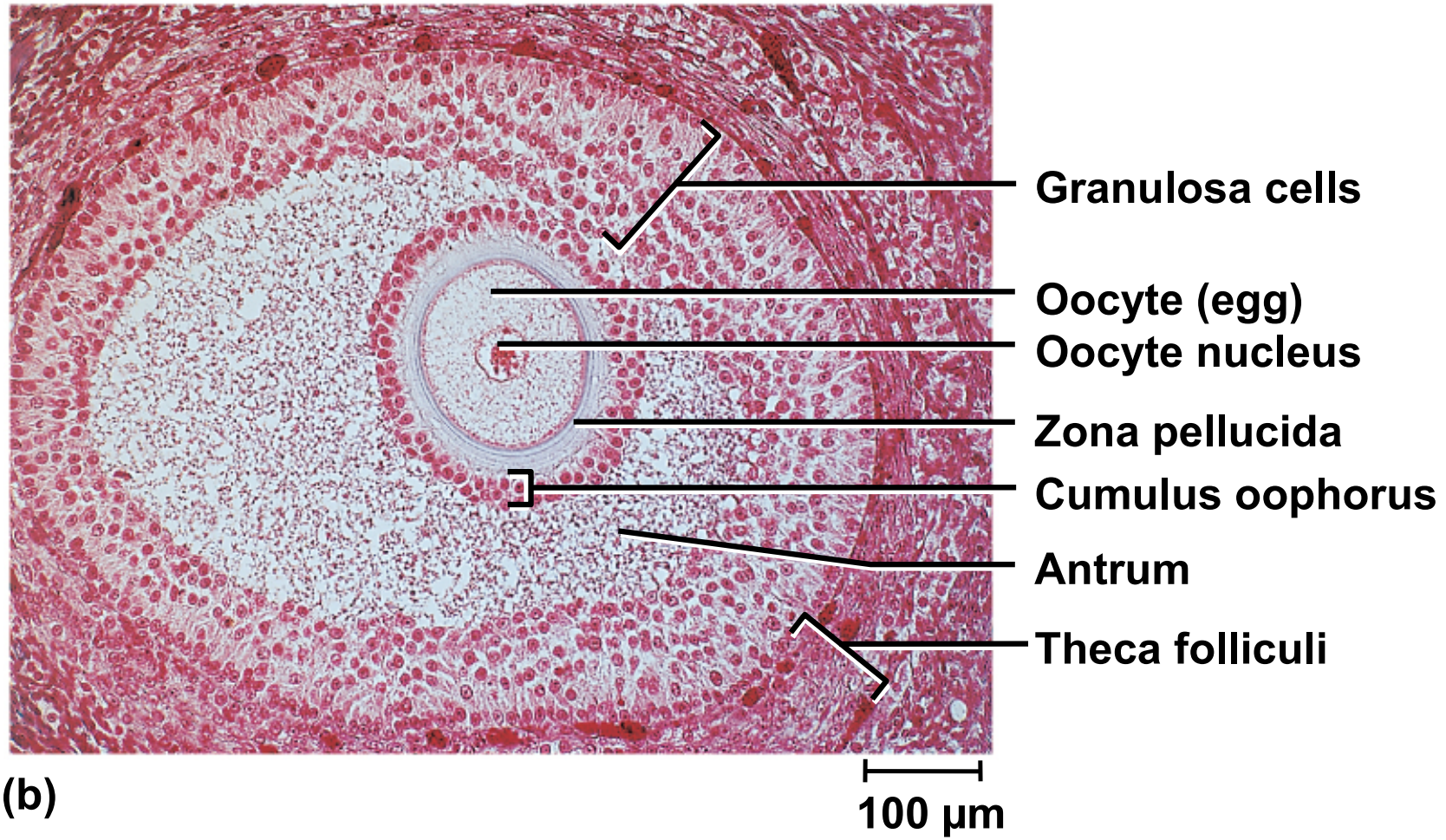
Folliculogenesis

- folliculogenesis – the development of the follicles around the egg than undergoes oogenesis
  - **primordial follicles**
    - consists of a primary oocyte in early meiosis
    - surrounded by a single layer of squamous **follicular cells**
    - most wait 13 to 50 years before they develop further
    - adult ovary has 90% to 95% primordial follicles
  - **primary follicles**
    - have larger oocytes and follicular cells that still form a single layer
  - **secondary follicles**
    - still larger oocytes and follicular cells now stratified (**granulosa cells**)
    - **zona pellucida** – layer of glycoprotein gel secreted by granulosa cells around the oocyte
    - **theca folliculi** – connective tissue around the granulosa cells condenses to form a fibrous husk

Folliculogenesis

- **tertiary follicles**
  - granulosa cells begin secreting follicular fluid
  - fluid-filled cavity, the **antrum**
  - **cumulus oophorus** – a mound of granulosa cells on one side of the antrum that covers the oocyte and secures it to the follicular wall
- **mature (graafian) follicles**
  - normally only one follicle from each month's cohort becomes a mature follicle destined to ovulate
  - remainder degenerate

Histology of Ovarian Follicles



Manfred Kage/Peter Arnold, Inc

Figure 28.12b

Endoscopic View of Ovulation

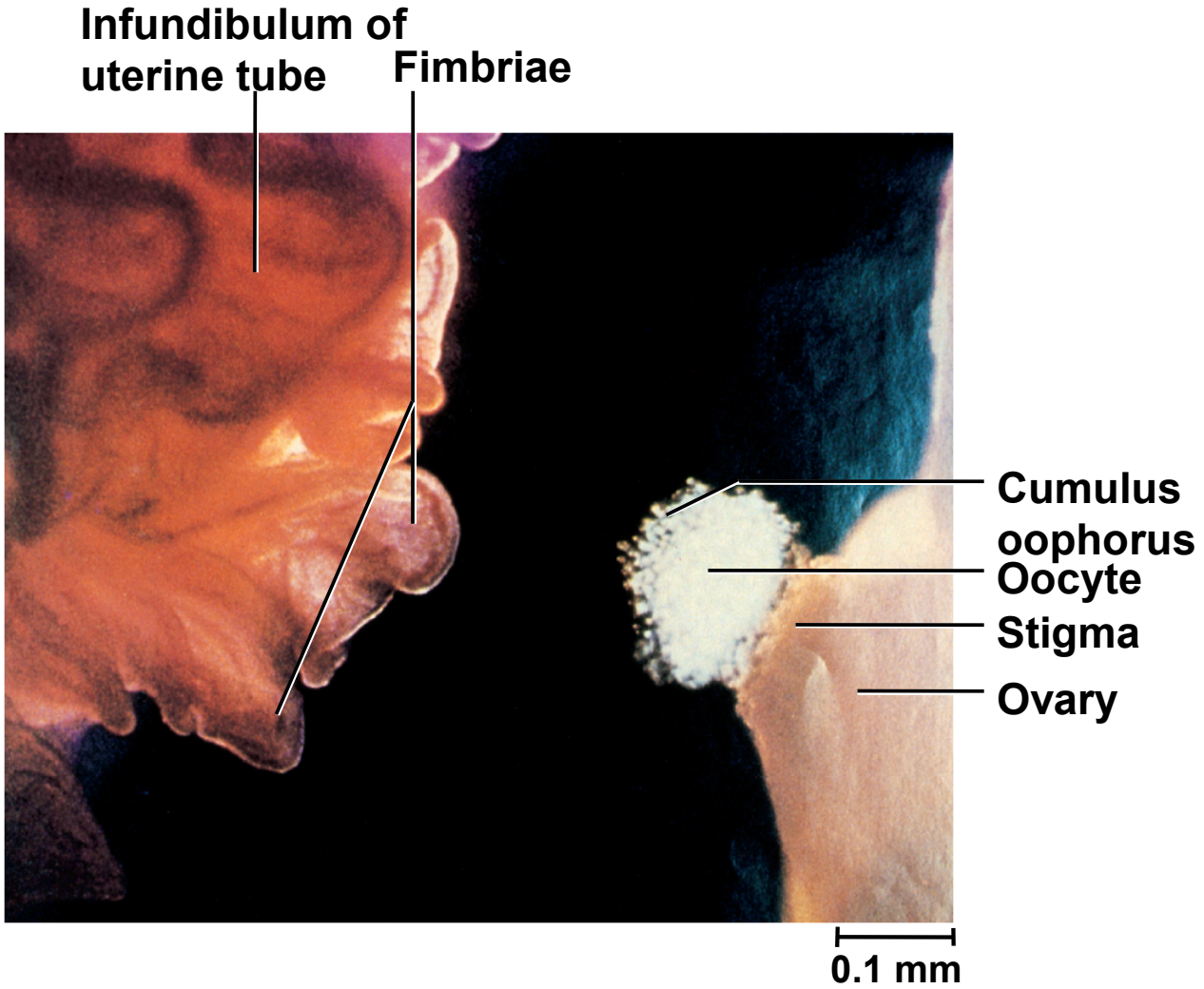


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Figure 28.15

Pituitary-Ovarian Axis

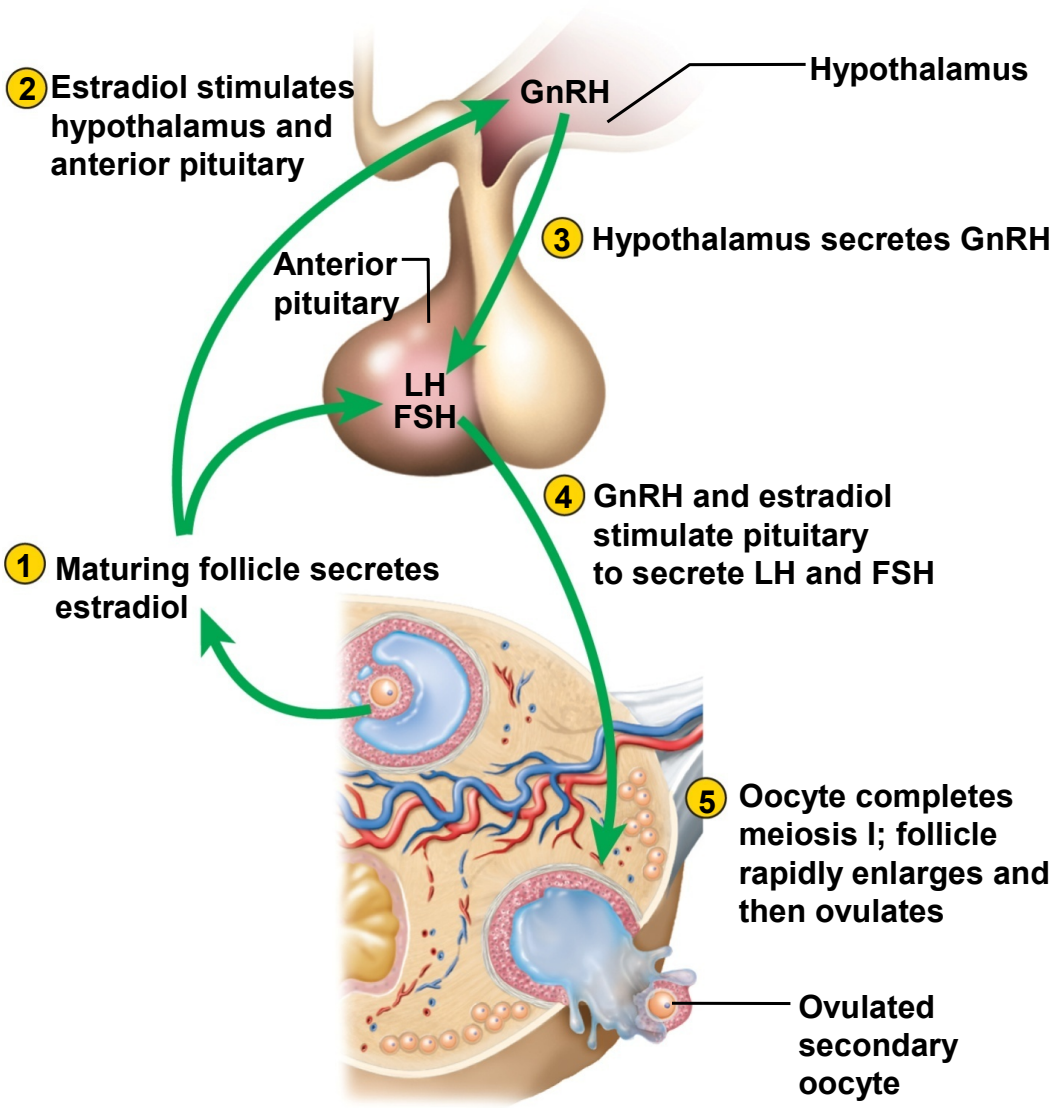
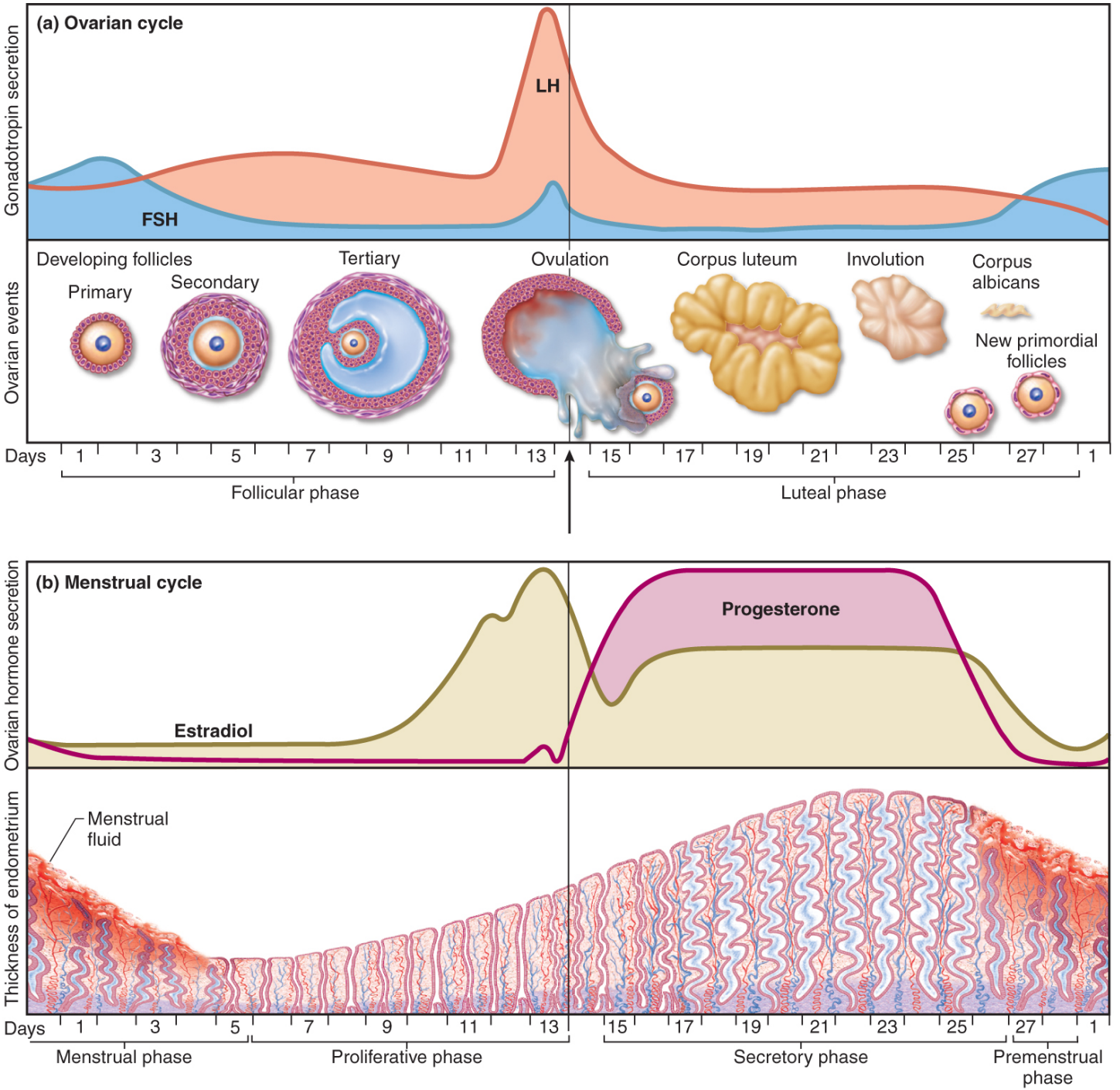


Figure 28.13



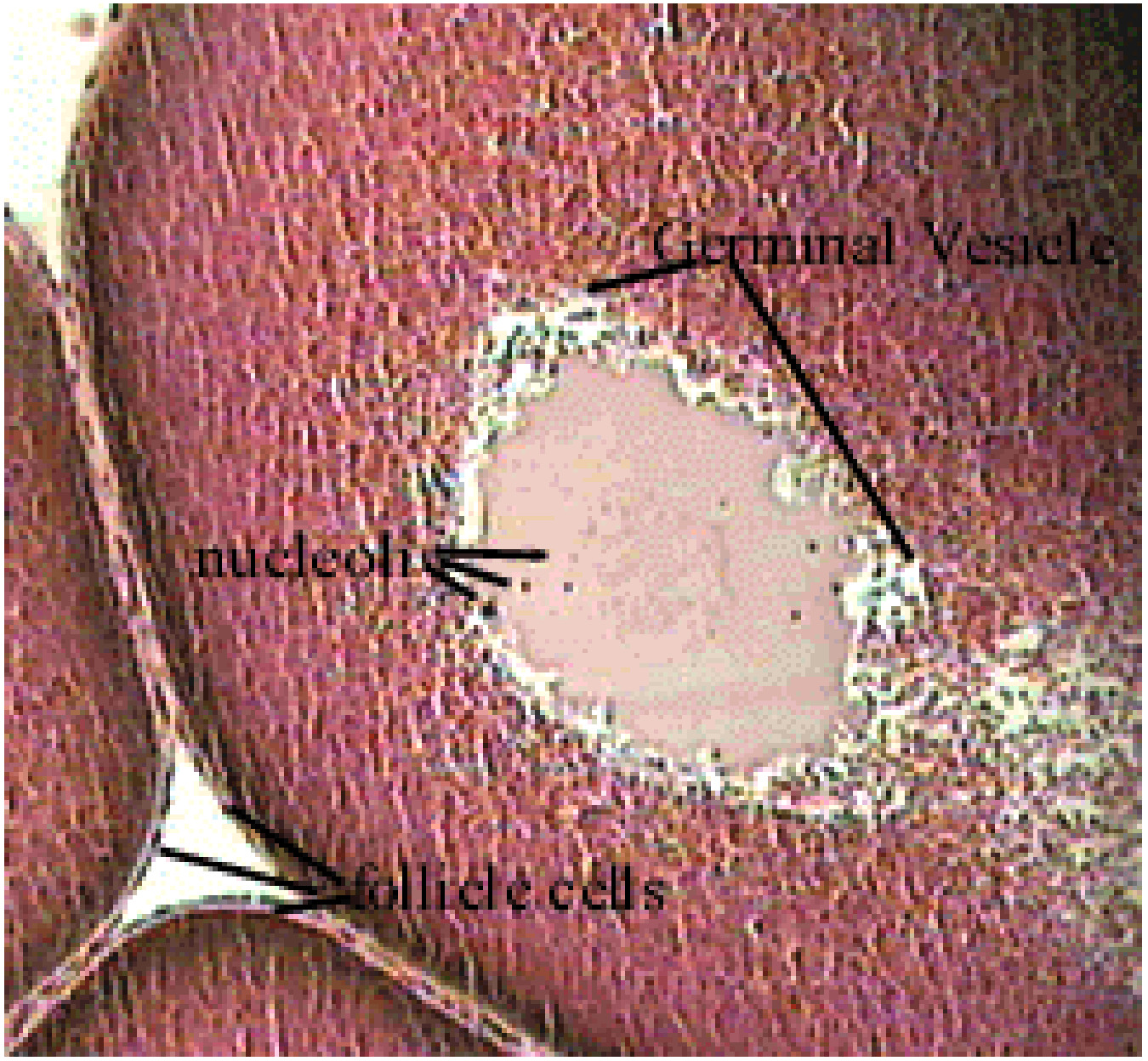
Growth of Primary Oocyte

Increase in Gene Expression
- Lampbrush Chromosomes
  - Increased number of Nucleoli
- gene amplification

Increased number of Organelles

Yolk Production
- Egg Types
  - Isolecithal – mammals, echinoderms
  - Mesolecithal – amphibians
  - Telolecithal – birds, fish, reptiles
  - Centrolecithal – arthropods

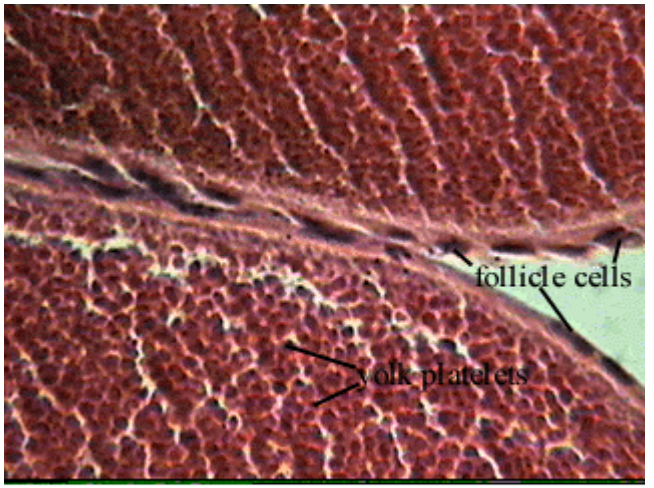
Isolecithal



Frog Ovary 100x

Egg Envelopes

I. Produced within the ovary
Vitelline Membrane sea urchin, frog, bird
Zona pellucida mammal



Frog Ovary 400x

II. Produced outside of the ovary
jelly
albumin & shell membranes