Lecture 4

Histology of Nervous Tissue

- Two principal cell types
  1. Neurons—excitable cells that transmit electrical signals

Histology of Nervous Tissue

2. Neuroglia (glial cells)—supporting cells:
   - Astrocytes (CNS)
   - Microglia (CNS)
   - Ependymal cells (CNS)
   - Oligodendrocytes (CNS)
   - Satellite cells (PNS)
   - Schwann cells (PNS)

Astrocytes

- Most abundant, versatile, and highly branched glial cells
- Cling to neurons, synaptic endings, and capillaries
- Support and brace neurons

Astrocytes

- Help determine capillary permeability
- Guide migration of young neurons
- Control the chemical environment
- Participate in information processing in the brain

Microglia

- Small, ovoid cells with thorny processes
- Migrate toward injured neurons
- Phagocytize microorganisms and neuronal debris

Ependymal Cells

- Range in shape from squamous to columnar
- May be ciliated
  - Line the central cavities of the brain and spinal column
  - Separate the CNS interstitial fluid from the cerebrospinal fluid in the cavities

Oligodendrocytes

- Branched cells
- Processes wrap CNS nerve fibers, forming insulating myelin sheaths

Satellite Cells and Schwann Cells
- Satellite cells
  - Surround neuron cell bodies in the PNS
- Schwann cells (neurolemmocytes)
  - Surround peripheral nerve fibers and form myelin sheaths
  - Vital to regeneration of damaged peripheral nerve fibers

Neurons (Nerve Cells)
- Special characteristics:
  - Long-lived ($\rightarrow$ 100 years or more)
  - Amitotic—with few exceptions
  - High metabolic rate—depends on continuous supply of oxygen and glucose
  - Plasma membrane functions in:
    - Electrical signaling
    - Cell-to-cell interactions during development

Cell Body (Perikaryon or Soma)
- Biosynthetic center of a neuron
- Spherical nucleus with nucleolus
- Well-developed Golgi apparatus
- Rough ER called Nissl bodies (chromatophilic substance)

Cell Body (Perikaryon or Soma)
- Network of neurofibrils (neurofilaments)
- Axon hillock—cone-shaped area from which axon arises
- Clusters of cell bodies are called nuclei in the CNS, ganglia in the PNS

Processes
- Dendrites and axons
- Bundles of processes are called
  - Tracts in the CNS
  - Nerves in the PNS

Dendrites
- Short, tapering, and diffusely branched

- Receptive (input) region of a neuron
- Convey electrical signals toward the cell body as graded potentials

The Axon
- One axon per cell arising from the axon hillock
- Long axons (nerve fibers)
- Occasional branches (axon collaterals)

The Axon
- Numerous terminal branches (telodendria)
- Knoblike axon terminals (synaptic knobs or boutons)
  - Secretory region of neuron
  - Release neurotransmitters to excite or inhibit other cells

Axons: Function
- Conducting region of a neuron
- Generates and transmits nerve impulses (action potentials) away from the cell body

Axons: Function
- Molecules and organelles are moved along axons by motor molecules in two directions:
  - Anterograde—toward axonal terminal
    - Examples: mitochondria, membrane components, enzymes
  - Retrograde—toward the cell body
    - Examples: organelles to be degraded, signal molecules, viruses, and bacterial toxins

Myelin Sheath
- Segmented protein-lipoid sheath around most long or large-diameter axons
- It functions to:
  - Protect and electrically insulate the axon
  - Increase speed of nerve impulse transmission

Myelin Sheaths in the PNS
- Schwann cells wraps many times around the axon
  - Myelin sheath—concentric layers of Schwann cell membrane
- Neurilemma—peripheral bulge of Schwann cell cytoplasm

Myelin Sheaths in the PNS

- Nodes of Ranvier
  - Myelin sheath gaps between adjacent Schwann cells
  - Sites where axon collaterals can emerge

Unmyelinated Axons

- Thin nerve fibers are unmyelinated
- One Schwann cell may incompletely enclose 15 or more unmyelinated axons

Myelin Sheaths in the CNS

- Formed by processes of oligodendrocytes, not the whole cells
- Nodes of Ranvier are present
- No neurilemma
- Thinnest fibers are unmyelinated

From Egg to Zygote

- For fertilization to occur, coitus must occur no more than
  - Two days before ovulation
  - 24 hours after ovulation
- Fertilization: when the sperm's chromosomes combine with those of a secondary oocyte to form a fertilized egg (zygote)

Accomplishing Fertilization

- Ejaculated sperm
  - Leak out of the vagina immediately after deposition
  - Are destroyed by the acidic vaginal environment
  - Fail to make it through the cervix
  - Are dispersed in the uterine cavity or destroyed by phagocytes
  - Few (100 to a few thousand) reach the uterine tubes

Accomplishing Fertilization

- Sperm must become motile
- Sperm must be capacitated before they can penetrate the oocyte
  - Secretions of the female tract weaken acrosome membrane

Capacitation

- This involves the enhancement of the sperm's motility

- The cell membrane must become fragile so that the hydrolytic enzymes in their acrosomes can be released
- As sperm swim through the cervical mucus, uterus, and uterine tubes, secretions of the female tract cause some of the membrane proteins to be removed
- Also the cholesterol that keeps the membranes stable is depleted
- This mechanism prevents the spilling of acrosomal enzymes prematurely.

Acrosomal Reaction and Sperm Penetration

- Sperm must breach oocyte coverings
  - Corona radiata and zona pellucida
- Sperm binds to the zona pellucida and undergoes the acrosomal reaction
  - Enzymes are released to digest holes in the zona pellucida
  - Hundreds of acrosomes release their enzymes to digest the zona pellucida

Acrosomal Reaction and Sperm Penetration

- Sperm head approaches the oocyte
- An acrosomal process forms and binds to receptors
- Oocyte and sperm membranes fuse
- Only one sperm is allowed to penetrate the oocyte (monospermy)

Completion of Meiosis II and Fertilization

- As sperm nucleus moves toward the oocyte nucleus it swells to form the male pronucleus
- The Ca^{2+} surge triggers completion of meiosis II $\rightarrow$ ovum + second polar body
- Ovum nucleus swells to become a female pronucleus
- Membranes of the two pronuclei rupture and the chromosomes combine

Embryonic Development

- Cleavage
  - Mitotic divisions of zygote
  - First cleavage at 36 hours $\rightarrow$ two daughter cells (blastomeres)

  - At 72 hours → morula (16 or more cells)
- At day 3 or 4, the embryo of ~100 cells (blastocyst) has reached the uterus

Embryonic Development
- Blastocyst: fluid-filled hollow sphere
- Trophoblast cells
  - Display factors that are immunosuppressive
  - Participate in placenta formation
- Inner cell mass
  - Becomes the embryonic disc (→ embryo and three of the embryonic membranes)

Implantation
- Blastocyst floats for 2–3 days
- Implantation begins 6–7 days after ovulation
  - Trophoblast adheres to a site with the proper receptors and chemical signals
  - Inflammatory-like response occurs in the endometrium

Implantation
- Trophoblasts proliferate and form two distinct layers
  1. Cytotrophoblast (cellular trophoblast): inner layer of cells
  2. Syncytiotrophoblast: cells in the outer layer lose their plasma membranes, invade and digest the endometrium

Implantation
- The implanted blastocyst is covered over by endometrial cells
- Implantation is completed by the twelfth day after ovulation