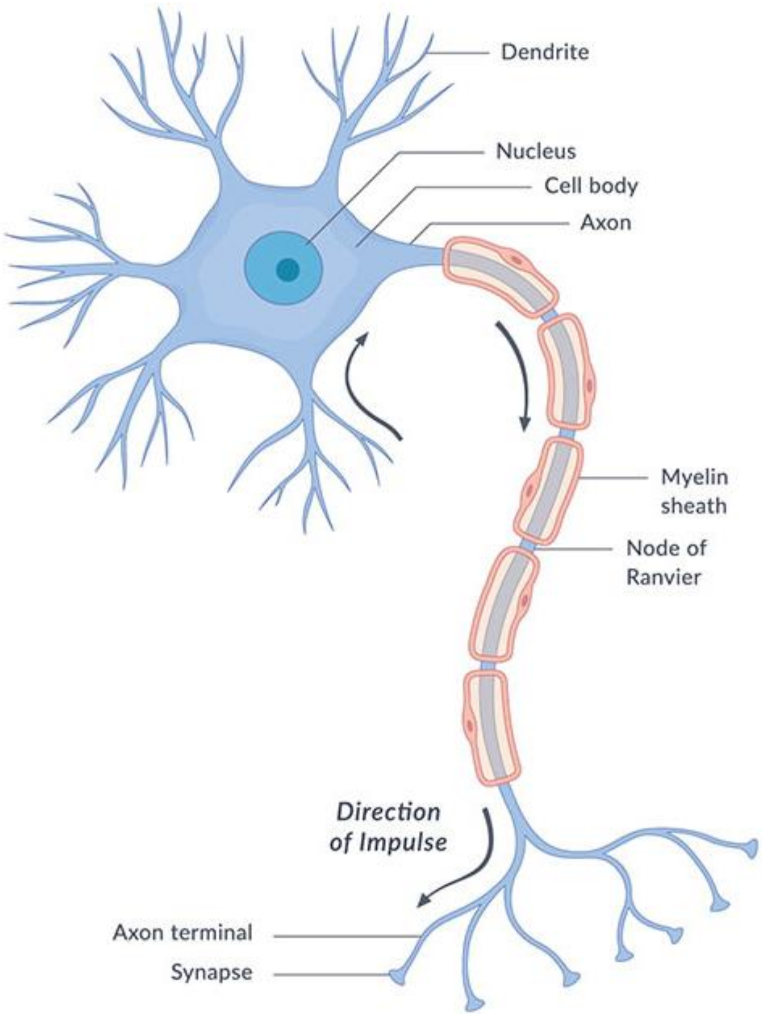
Neuroscience 101

Parts of a Neuron

- Soma (cell body)
  - nucleus
- Dendrites
- Axon
- Myelin Sheath
- Axon Terminals



Glial Cell Types

Astrocytes

- ~50% of all brain cells
- Regulate NT concentrations
- Promote new synapse formation
- Nourish neurons
- Regulate chemical content of extracellular space

Ependymal Cells

- Cerebrospinal fluid
- Brain metabolism
- Waste clearance

Microglia

- Immune support
- Brain development
- Injury repair
- Able to clear debris

Oligodendrocytes

- Produce myelin for multiple segments and up to 30 axons

Schwann Cells

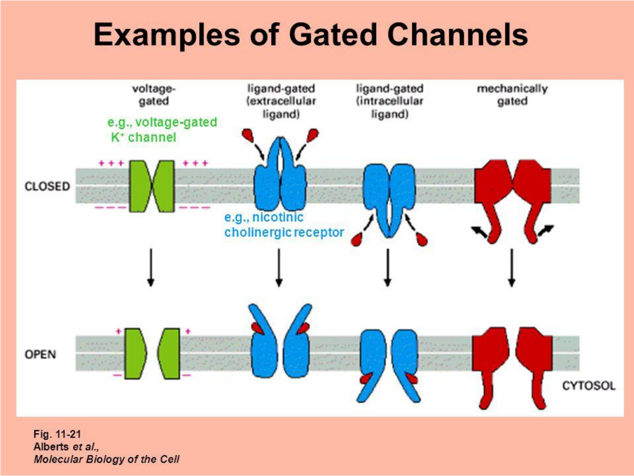
- Produce a myelin sheath for a single segment of a single axon

Satellite Cells

- Supply nutrients to surrounding neurons
- Provide protective cushioning

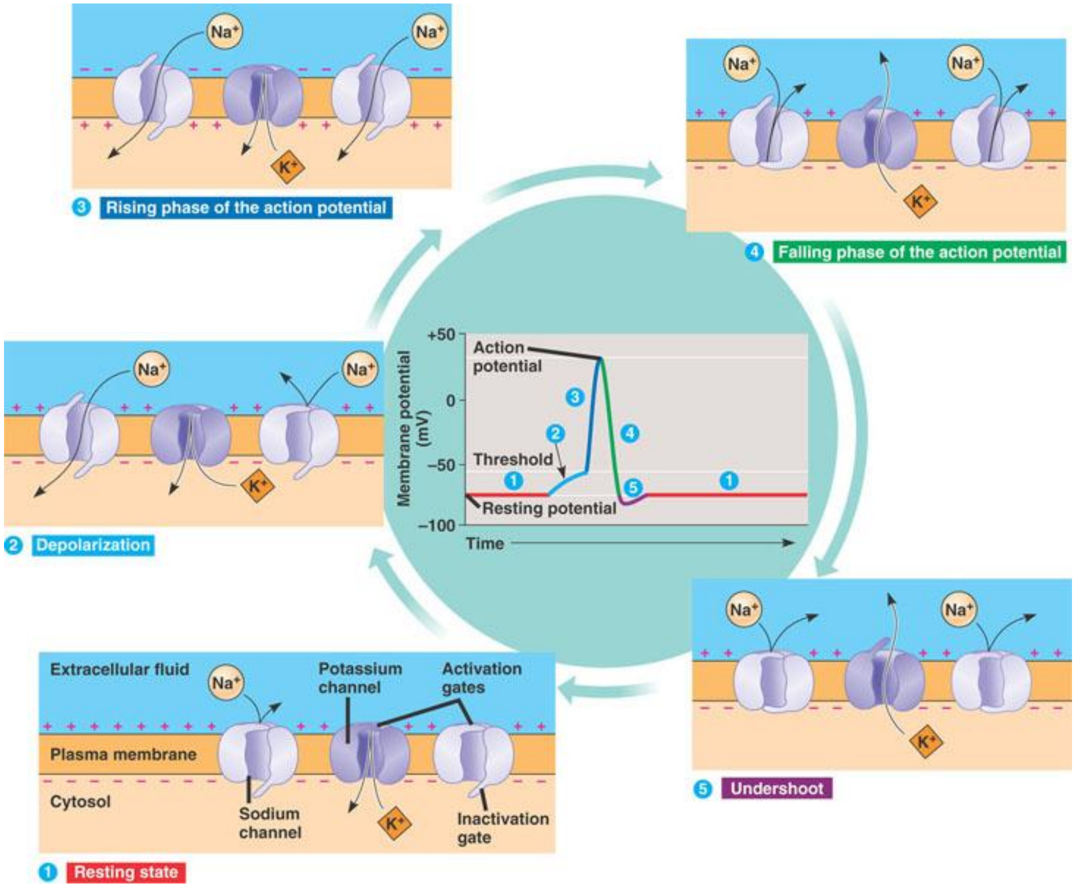
Types of Channels

- Mechanically gated: activated in response to mechanical stimuli
  - Example: pressure, stretch, vibration, sound, touch)
- Ligand gated: activated due to a ligand (chemical) binding to the channel
- Voltage gated: activated by changes in the electrical membrane potential near the channel



Action Potential

- At first the neuron is at rest
- Voltage-gated sodium channels (VGSCs) open and allow sodium ions to enter the cell. This leads to depolarization of the cell.
- After depolarization, repolarization/hyperpolarization occurs. In this step of the process, the VGSCs close and Voltage-gated potassium channels (VGPCs) open. This allows potassium ions to exit the cell, since there is so much positive charge that has entered the cell.
- Once there is a balance of charge across the membrane, the neuron will return to its resting potential.



Graded Potentials

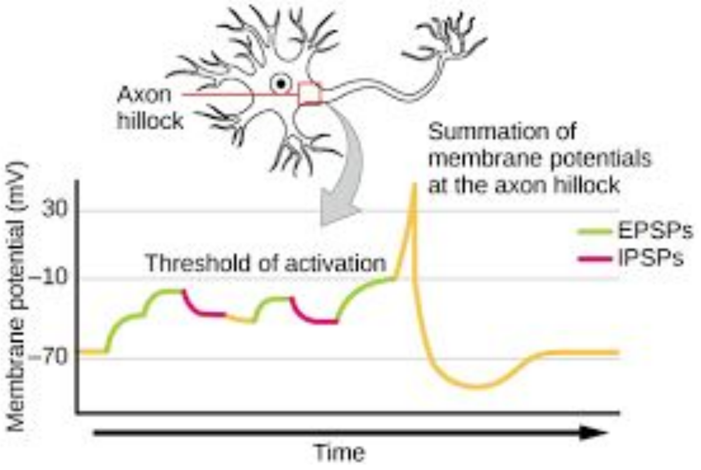
- Graded potentials vary in size; they are proportional to the size of the stimulus
- Graded potentials cause the membrane potential to change
- They do not always lead to an action potential due to the stimulus not reaching threshold

Excitatory Postsynaptic Potentials (EPSP)

- Sodium ion influx
- Gets closer to threshold/easier to excite the neuron

Inhibitory Postsynaptic Potentials (IPSP)

- Chloride ion influx
- Gets further from threshold/harder to excite neuron



DNA & RNA Background

- DNA is compacted at many different levels
  - Methylation causes nucleosomes to pack tightly together
  - Acetylation results in loose packing of nucleosomes
- Euchromatin: uncoiled chromatin and transcriptionally active
- Heterochromatin: condensed chromatin, which contains inactive genes

- Messenger RNA (mRNA): copied from DNA and used in protein synthesis
- Transfer RNA (tRNA): transports amino acids to mRNA during protein synthesis
- Ribosomal RNA (rRNA): used in protein synthesizing machinery

Central Dogma: DNA → RNA → Proteins

- To allow replication and gene expression, chromatin must:
  - Relax compact structure
  - Expose regions of DNA to regulatory proteins
  - Have a reversal mechanism for inactivity
- Overview of Protein Synthesis and transport pathway:
  - DNA transcription
  - mRNA processing
  - mRNA binding to free ribosome
  - Protein translation
  - Protein translocation to the ER
  - Transport to the Golgi complex
  - Exocytosis
- Transcription creates messenger RNA (mRNA) via: Initiation, Elongation, and Termination
- Translation creates proteins via: Initiation, Elongation, and Termination

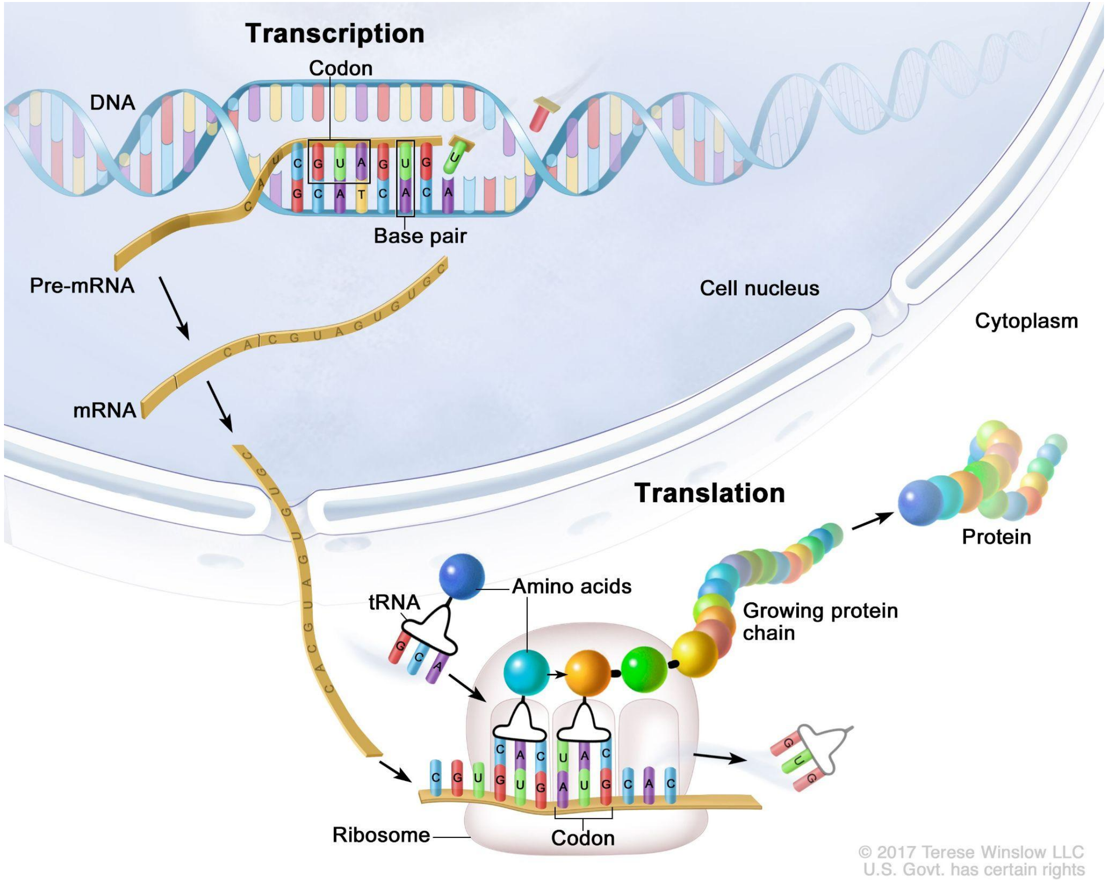
Transcription and Translation

- Initiation: After general transcription factors bind, RNA polymerase binds to DNA in promoter regions, which is a sequence of bases that RNA poly recognizes
- Elongation: RNA poly builds mRNA from reading the bases from the DNA template strand
- Termination: mRNA is released

- After termination in transcription, the mRNA leaves the nucleus and binds to a free ribosome in the cytoplasm
- Initiation: the large and small subunits of a ribosome, mRNA, and tRNA carrying the first amino acid come together to form the initiation complex
- Elongation: mRNA reads 3 nucleotides at a time and adds the correct amino acid to the growing polypeptide chain
- Termination: a stop codon enters the ribosome and causes a separation between the polypeptide chain and the tRNA. From this, the new protein is released

Overview and Next Steps

- Newly created proteins are imperative for extracellular signaling
- Surface receptors on other cells receive these proteins, which sets off a signalling cascade throughout the receiving cell
- When this signal is amplified, it is possible that it can lead to gene regulation because these proteins can directly activate or suppress gene transcription in the nucleus



Neurotransmitters:

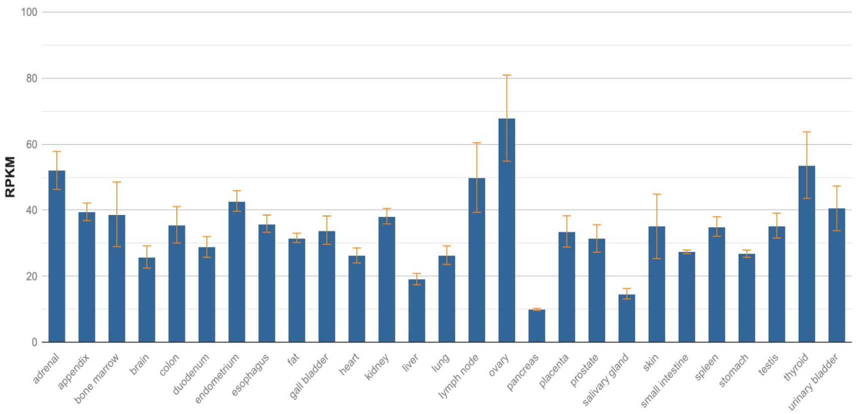
chemicals that are released from the synapse of a neuron after an action potential diffuses across the synaptic cleft

- GABA: primary inhibitory NT in the CNS
- Glutamate: most abundant excitatory NT in the CNS, involved in memory
- Acetylcholine: an excitatory NT involved in muscle contraction, learn, and memory
- Serotonin: an excitatory NT involved in mood and sleep

Genes

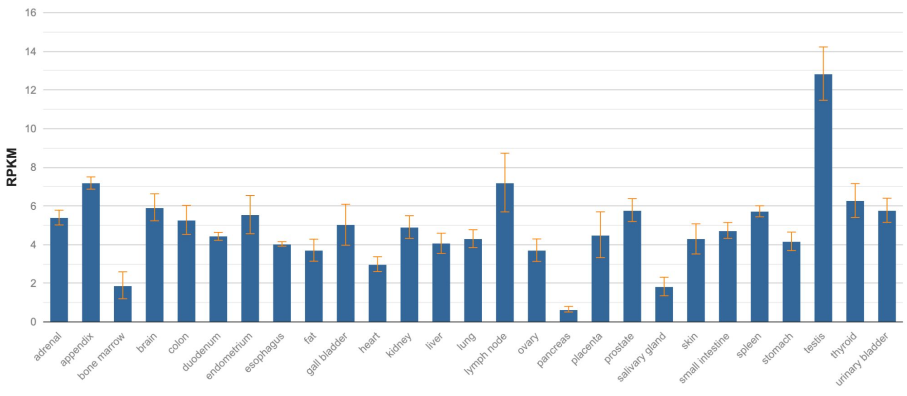
elf3m

- Encodes a protein that is part of the transcription factor that is required for synthesis of proteins in eukaryotes
- Humans



cstf3

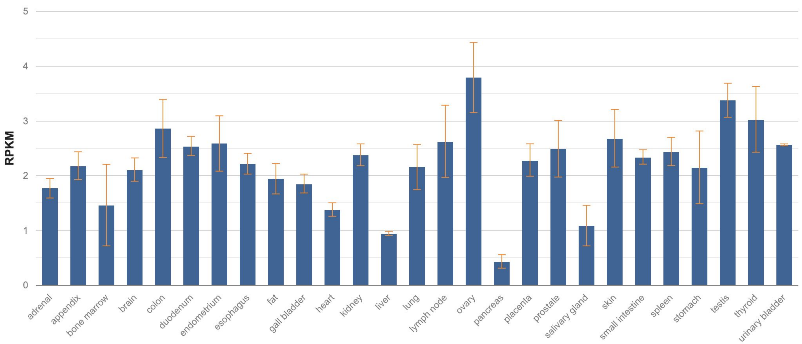
- Encodes one factor of the cleavage stimulation factor complex
- Involved in cleavage of pre-mRNA
- Humans



Genes cont.

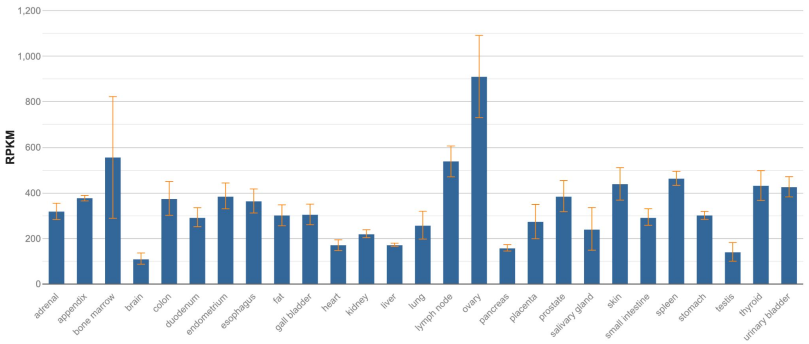
gpatch1

- Enables RNA binding activity
- Involved in mRNA splicing
- Humans



rpl12

- Encodes a protein that is a part of the large subunit
- Belongs to the L11P family of ribosomal proteins
- Humans



Extra Information

- “In addition to these local effects, calcium influx into the postsynaptic neuron can alter cellular function by activating new gene transcription. Calcium influx activates a number of signaling pathways that converge on transcription factors within the nucleus, which in turn control the expression of a large number of neuronal activity-regulated genes.”
- NMDAR: glutamate-gated ion channel that is blocked by a magnesium ion at a negative membrane potential. To remove the magnesium ion, depolarization needs to occur.
    - “ionotropic glutamate receptors that regulate gene expression and synaptic plasticity by mediating glutamate-and depolarization-dependent calcium influx”
- “Cell-type classification has been transformed by single-cell transcriptomics, which reveals the entire repertoire of expressed genes (the transcriptome) in each of thousands or millions of single cells isolated from a brain region of interest.”
- “In a cell as complex as a neuron, these gene regulatory mechanisms are widely used to facilitate proper development and function of the nervous system and allow the nervous system to adapt to changes in the environment.”
- “It is thought that remodeling of chromatin influences gene expression by affecting access of transcription-regulatory factors to DNA.”