MCB 61 – Study Tables

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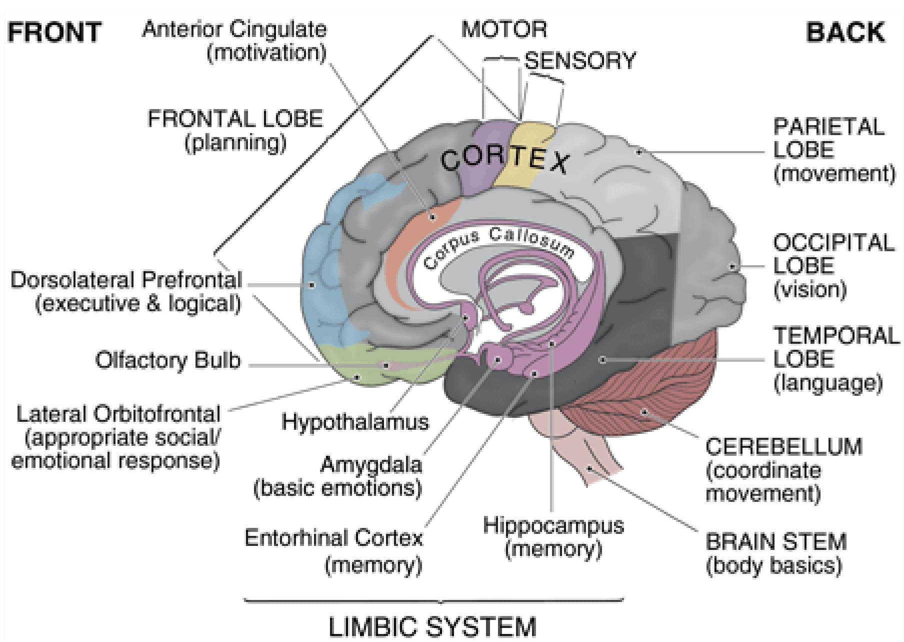

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LECTURE

Lec 1 – Hominids and a *Space Odyssey*	
2001: A Space Odyssey	A film by Stanely Kubrick that depicts the trials of man vs. machine. The movie has an opening nod to the development of murder as a social interaction between hominids.
Stanley Kubrick, Arthur C. Clarke	Stanley Kubrick – director of *2001: A Space Odyssey* Arthur C. Clarke – writer of the original *2001: A Space Odyssey* and co-writer for the adapted screenplay. He had three laws referred to as Clarke's Three Laws: 1) When a scientist states something is possible, he is right. If impossible, he is probably wrong 2) The only way to find the limits of possibility is to attempt to venture past it *3) Advanced technology is indistinguishable from magic*
Hominids	Human-like animals, including modern humans and "recent" ancestors (appx 5 mya)
Genus *Australopithecus*	The genus preceding *Homo*. Evolved around 4 mil years ago, extinct by 2 mil years.
Genus *Homo*	The current genus of humans. The only extant species is *Homo sapiens*.
Homo Neanderthalensis	A parallel evolutionary branch of *Homo*. Lived 300,000-30,000 years ago
Chauvet Cave Paintings, France	Discovered in 1994, the caves had drawings depicting animals and some anthropologic behaviors. Believed to date around 15,000-30,000 years ago, it is thought that ancient humans traveled down these caves by torchlight and drew art, using the atmosphere of the cave as a mystical (and possibly hallucinogenic) experience.
Stonehenge, England	Built around 4,500 years ago, this site was believed to be an ancient observatory or some other astronomical structure. Importance of rituals in the lives of the ancients?
Evolution of Brain/Skull Size	Common trend of skull size increase among newer species of humans. Determined by fossil examination. More than just increased body size. - Ardi – 350cc - Austra – 500cc - H. Habilis – 700cc - H. Erectus – 1000cc - H. Neanderthalensis – 1400cc - H. Sapiens – 1400cc
Violence, killing of conspecifics	Evolved trait, however tendencies of love and trust are generally higher than violence. Estimates of 150,000,000 people died in the 20^{th} century (and 175,000 in the US during 21^{st} century) as a result of violence. Great proponents of peace include John Lennon and MLK. Compassion and kindness are "perhaps the strongest and most natural of our behavioral tendencies."
Does HAL have a mind?	HAL is a computer that is self-aware and has blatant tendencies toward self-preservation. Mind – a collection of mental experiences. Mental Experiences – subjective (first-person, internal) experiences including thoughts, feelings, perceptions (visual, auditory, olfactory, gustatory, olfactory, tactile). Consciousness – capacity to be aware When it comes down to it, the answer to this question is irreducibly subjective because what defines consciousness and mental experience is subjective.

Lec 2 – The Brain and the Mind	
Mind, Consciousness	See ***Does HAL have a mind?***
Mind-body problem	How exactly are our minds and mental experiences connected to our physical body? Neurologists liken there to be a connection with the brain and the mind, but is the mind a product of the brain?
Physicalism, physical materialism	Everything about reality as described by the laws of physics
Nervous System Complexity across Species	Sponges – no nervous system Hydra – Nerve net network of neurons Jellyfish – simple nervous system Nematode – Complex behavior, simple neurons (302), considered good candidate for developmental research Flatworms – Nerve clusters, more complex system Insects – sophisticated brains and behaviors Vertebrates – spinal cord and brains that look similar among all vertebrates
Cerebrum, Cerebellum, Brain Stem	Cerebrum – often called the cerebral cortex – the sheet of brain tissue matter that forms the folds. Controls all voluntary actions along with the cerebellum. Cerebellum – the "ridgy" thing at the base of the cerebrum that is responsible for some motor control, timing, and some cognitive functions like attention. Brain Stem – the cluster of neural cells and tissue that connect the brain with spinal cord and neurons that are threaded throughout the body.
Cerebral Cortex, Sulci, Gyri	Cerebral Cortex – the cerebrum that is highly folded up. Sulci – The grooves of the folds of the cerebral cortex. Gyri – The bumps of the folds of the cerebral cortex.
Corpus Callosum	The 200,000,000 neurons that connect the brain hemispheres. It assists the communication between the right and left hemispheres
Cerebral Lobes, Brain Hemispheres	The brain is divided into four lobes: the frontal (main signals), temporal (auditory), parietal (special sense and navigation), and occipital (vision) lobes. The central sulcus separates the frontal and parietal lobes. The longitudinal fissure divides the left and right cerebral hemispheres.
Lec 3 – Studying the Brain and Chemistry	
Gray Matter, White Matter, Ventricles	Gray matter – neural cell bodies (Soma) White matter – nerve fibers (Axon + Myelin) Ventricles – cavities filled with cerebral spinal fluid (protection and spinal connection)
Andreas Vesalius	He was responsible for meticulously dissecting the human body to understand the location of nerve fibers. Artists helped draw his dissections and discoveries
Meninges: Dura, Arachnoid, Pia	Meninges refers to the protective tissue that covers the outside of the brain, including: Dura – a skin-like sheet of tissue, the most external of the meninges tissues Arachnoid – layer of tissue just under the dura and more delicate. It includes a spiderweb-like complex with the pia mater where the CSF resides Pia – delicate layer on top of the brain.

Meningitis	An inflammation of the meninges that could be fatal or lead to irreversible brain damage.
Cerebrospinal Fluid (CSF)	Fluid that rests in the subarachnoid space that serves to cushion the brain in the skull.
William James	One of the first psychologists who wrote *Principles of Psychology* in 1890. It brought to life the connection between the brain and consciousness.
René Descartes	Wrote the *Trestise of Man* (published posthumously in 1662) that contemplated the question of "who are we?" "What do we think we are or do?" He questioned the nature of the nervous system and what makes consciousness a reality. In the book was a drawing of a person reacting to a fire suggesting a connection between the feeling in the hand and the head.
Luigi Galvani	He was the first person to connect electricity with movement in animals ("animal electricity") with shocking a frog leg
Camilio Golgi, Golgi Stain	Golgi researching psychosis in mental patients by studying the brain. Came up with a chemical to stain neurons with a microscope – the black reaction (Golgi Stain). $AgNO_3 + K_2CrO_4 \rightarrow$ *Ag_2CrO_4* only stains 1% - 2% of neurons Illustrated neurons, thought they were all continuous.
Santiago Ramón y Cajal	Worked to illustrate neurons in the body. Believed they were segmented in parts
Nerve Cell, Neuron	Nerve cells are the basic units of inter-organ communication. There are approximately 10^{11} nerve cells in the human body.
Glial Cell, Glia	Glial cells are a class of cells that make up part of the brain. There are about 5-10x more glial cells than there are neurons (about 10^{12} glial cells).
Dimitri Mendeleev	The man who created the periodic table of elements. He also used the table to accurately predict the existence of undiscovered elements.
Elemental Composition of the Human Body	The human body is comprised of about 96% Oxygen, Carbon, Hydrogen, and Nitrogen. The rest is composed of Calcium, Phosphorus, Potassium, Sulfur, Sodium, Chlorine, and other trace elements. Oxygen is the most abundant atom in the human body (65%). Hydrogen is the most abundant in the body by atom count. Carbon would be the most abundant element in terms of dry weight.
Ions: Cations, Anions	Cations are ions with a positive charge (less electrons) anions are ions with a negative charge (more electrons). Ions are charged atoms
Molecules, covalent bonds	Molecules are collections of atoms bonded by covalent bonds (generally nonmetal elements)
Organinc Molecules, Hydrocarbons	Molecules synthesized by living things; they generally are composed of hydrocarbon skeletons and primarily involve C, H, O, N, S, P.
Lec 4 – Microbiology Foundations	
Polymers, Plastics, Resin Identification Code	Plastics are categorized with the Resin Identification Code: 1-7 for plastics. It was designed to look like the recycle sign. Plastics are essentially a hydrocarbon polymer that varies in complexity between the plastics. *1) PETE – polyethylene terephthalate* (recyclable) 2) *HDPE – high-density polyethylene* (recyclable) 3) V – polyvinyl chloride 4) LDPE – low-density polyethylene 5) PP – propylene 6) PS – polystyrene 7) Other
Polarity	The nature of molecules to have a positive and/or negative side(s) to their form. Polar molecules can form bonds of varying intensities with attractive forces.
Hydrogen Bonds	Hydrogen bonds are attractive bonds weaker than ionic bonds, but stronger than London Dispersion Forces. They are formed by the contact of molecules with an O-H, N-H, or F-H bond. Polarity describes the effects.

Hydrophobic/lipophilic; Hydrophilic/lipophobic	Hydrophobic/lipophilic substances are nonpolar and more likely to dissolve in nonpolar substances like oil. Hydrophilic/lipophobic substances are polar.
Biological Macromolecules	Polysaccharides, Polypeptides, lipids, and Nucleic Acids make up the biological macromolecules.
Lipids/fats, Phospholipids, Lipid Bilayer Membrane	Formed from a glycerol and three fatty acids (or two fatty acids and one phosphoric acid group in phospholipids), these macromolecules serve as energy storage (lipids), hormones (steroids), and substituents of the lipid bilayer (phospholipids). The bilayer forms with the nonpolar tails pointed toward the center and the polar heads (phosphoric acid group) pointed toward the outside of the membrane.
Amino Acids, Polypeptides, Proteins	Amino acids have an amine group, a carboxylic acid group and a functional group. They form polymers—linked by peptide bonds—that form proteins when they reach a length of about 30 or more.
Levels of Description for Protein Structure: Primary, Secondary, Tertiary	A protein's primary structure is its basic amino acid sequence. A protein's secondary structure is the way the primary structure folds together. The tertiary structure is the protein's overall 3D shape.
Alpha Helix	A single helix that forms between amino acids (linkages every 4 amino acid) it forms part of the secondary structure of a protein along with the pleated sheet. The alpha helix was discovered by Linus Pauling.
Carbohydrates, Sugar	Carbohydrates are polysaccharides: polymers of sugar molecules that serve as energy storage in the body and ID tags for proteins.
Nucleic Acids: deoxyribonucleic acid (DNA), ribonucleic acid (RNA)	A polymer of nucleotides (units of sugar attached to a phosphate group and a purine or pyrimidine base). They form DNA and RNA in the cell which are used for cellular blueprints and genetic code messengers respectively. They form a double helix molecule as DNA. Largest molecules in our body.
Lec 5 – The History of DNA and Molecular Biology	
Gene	A packet of information in the form of a DNA sequence that encodes information for specific phenotypes and proteins in the human body. Fundamental unit of inheritance.
Charles Darwin	The author of *Origin of the Species*, which summed up the principle of natural selection and proclaimed all life on earth came from a common ancestor.
Gregor Mendel	Catholic monk who came up with the principle that traits are passed on in an orderly way (pea plant experiments and phenotypes). He had no relationship with Darwin.
Wendell Stanley	He was responsible for crystallizing the first virus (tobacco mosaic) for structural and hereditary study. His research led to the isolation of a nucleoprotein that displayed activities of the TMV. The person who Stanley Hall is named after.
Niels Bohr	Gave a "Light and Life" lecture (1932) – don't get depressed about troubles with observation, sometimes these obstacles will shed light on new facets of science. Questions what is "molecular level."
Max Delbruck	Astronomer, then quantum mechanics, then molecular biology. In 1935 he wrote a paper "On the Nature of Gene Mutation and Gene Structure" which, in chapter 3, described genes as hard molecules. Worked with Salvador Luria on bacteriophage genetic studies.
Ewin Schrodinger	A scientist inspired by Delbruck's paper, wrote *What is Life?* in 1944 which addressed molecules and biology. He proposed that a "new lens of physics" will be discovered (i.e. another field of science which will turn out to be Molecular Biology).
Oswald Avery	He studied the transformation in bacteria over generations. He discovered that DNA was the genetic material passed down each generation, but approached it in

	a way that did not mirror the status quo. Also, his experiments were more complex.
Hershey-Chase Experiement	The widely-accepted experiment in 1952 that proved that DNA was the genetic material in organisms, and not proteins. It involved a blender, radioactive S and P (proteins and nucleic acids respectively), E. coli, and a bacteriophage (T2). It occurred 8 years after the Avery experiment.
Francis Crick	A researcher that worked on discovering the structure of DNA under Sir Lawrence Bragg. He co-published "Molecular Structure of Nucleic Acids" with James Watson in 1953.
James Watson	A researcher who worked on the discovery of DNA structure with Francis Crick while under an internship with Max Perutz. He co-published "Molecular Structure of Nucleic Acids" with Francis Crick. Won the Nobel Prize for Physiology/Medicine in 1962 with Crick and Wilkins.
Rosalind Franklin	A researcher studying the structure of DNA using x-ray crystallography. Her photographs were instrumental in aiding Watson and Crick in discovering the structure of DNA.
DNA structure and function	DNA is a double helix that has genetic material encoded in its codons (nucleotide triplets) that correspond to a different amino acid. DNA is the genetic material behind the inheritance of traits.
Nucleotide codons, genetic code	Nucleotide codons are triplets of nucleotides that correspond to a different amino acid. The genetic code is the combination of codons that encode for full proteins and phenotypes.
Gene transcription	Gene transcription occurs when mRNA molecules are polymerized on the temporarily unzipped DNA of a cell.
Translation	Translation occurs when mRNA is read (by codon) by ribosomes to polymerize amino acids into proteins.
Lec 6 – Membranes, Ions, and Polarization	
Linus Pauling	Discovered the alpha helix by folding paper. Won the Nobel Prize in Chemistry (1954) and Peace (1962). Proposed the triple helical structure of DNA with nucleotides on the outside.
California Loyalty Oath	The oath required by all state employees in California that required the uncompromising loyalty of the employees to the state and country (i.e. "I am not a Communist"). Edward Tolman famously rejected the oath and brought it to the supreme court.
Diffusion	The movement of matter to evenly fill a space (i.e. movement down a concentration gradient).
Ion Channels	Intrinsic proteins that facilitate the diffusion of ions across a phospholipid bilayer membrane and down their concentration gradient (a type of passive transport).
Ion pumps	Intrinsic proteins that facilitate the movement of ions across a phospholipid bilayer membrane against their concentration gradient. This movement requires ATP and is a type of active transport.
ATP	The "energy packets" of cells. They are essentially adenosine nucleotides with three phosphate groups. The breaking of a phosphate-phosphate bond and subsequent formation of a phosphate-molecule bond drives many endergonic reactions in the cell.
Energy consumption by the human brain	25% of the basal metabolic rate of the body, which equals about 360 kilocalories per day. 60% of that rate goes to run Na/K pumps.
Major ions for neural function: Na^+, K^+, Cl^-, Ca^{++}	Ions dissolved in the aqueous medium of the body that pass the membrane at different times and concentrations to aid in the production of an action potential. They pass through the membrane via ion channels and ion pumps.

Ion concentration differences inside the cell and outside cell	The concentration of Na^+, Cl^-, and Ca^{++} are greater outside of the cell whereas the concentration of K^+ is greater inside the cell.
Membrane and resting potential	The unequal distribution of the ions inside and outside of the nerve cell membrane leads to the resting potential/membrane potential of -70 mV inside of the cell.
Hyperpolarization, depolarization	Hyperpolarization – the switch to a more negative voltage potential. Depoloarizaion – the switch to a more positive voltage potential.
Lec 7 – Action Potentials and Neurotransmittance	
Alan Hodgkin, Andrew Huxley	Scientists who published in *Nature*. Contributed to the WWII effort before working again and predicted the presence of voltage-gated ion channels in nerve cells. They also directly measured the voltage changes across a nerve cell membrane.
Squid Axon	The focus of Hodgkin and Huxley's research that were sufficiently large in diameter (0.5 mm) so that a voltmeter could be inserted. The properties of squid axons aided in Hodgkin and Huxley's research and ultimately the theory they proposed with what was happening when a neural signal travels along an axon.
Action Potential	A momentary spike in the voltage of a cell. The action potential in a nerve cell resembles a jump in +60 mV, a subsequent drop of -70 mV, and a depolarization to -70 mV.
Voltage-gated ion channels: Na^+, K^+, Ca^{++}	Voltage-gated ion channels are ion channels that open up at a certain voltages to allow ions to pass across the membrane down their concentration gradient. Sodium channels are activated around a voltage of -55 mV, and potassium channels are activated around a voltage of +30 mV.
Firing threshold	The minimum voltage before an ion channel may open up and allow ions to pass through the membrane.
Refractory period	The period of time in which ion channels must wait before a stimulus can open the channels after they are used. This prevents reverse propagation of a nerve signal.
Action potential propogation along axon	Once an action potential is started, voltage gated sodium channels open at some location at an axon. The Na^+ ions rapidly drift from where they flow in and make nearby areas in the axon more positive. This leads to the activation of voltage-gated sodium ion channels that are not in their refractory periods (i.e. a forward motion).
Axon hillock	The first place where an action potential will occur. The part of the axon that is closest to the soma. The further away from this a synapse is, the weaker the signal.
Myelin	A type of glial cell that is composed of primarily plasma membrane (75%). It is formed when oligodendrocytes or Schwann cells wrap their cell bodies around the axon. This act of wrapping around the axon spaces out the clusters of gated channels allowing a faster propagation of an axon signal. Unmyelinated axons have a protein density of 100 per μm^2 and a speed of several mph, whereas myelinated axons have a protein density of 10,000 per μm^2 and a speed of 200 mph. Insects don't have myelin.
Oligodendrocytes, Schwann Cells	Oligodendrocytes – myelin on the nerve cells in the brain. The nucleus exists extant of the wrappings, allowing it to extend over many axons. Schwann Cells – myelin on the nerve cells in the peripheral nervous system. The nucleus exists inside of the wrapping parts.
Nodes of Ranvier	The points at which different myelin cell wrappings touch on an axon.
Saltatory conduction	The propagation of a charge from one node of Ranvier to another.
Multiple sclerosis	An inflammatory disease brought about by the unmyelination of axons.

Electrical synapse: Gap Junction, Connexins, Connexons	An electrical synapse is effectively a gap junction between one nerve cell and another. Gap junctions are transport proteins that connect two cells. The proteins in an electrical synapse are 2 connexons forming a channel, which are formed from 6 connexins each. The gap between cells is about 3.5 nm. The size of the pores are 1-2 nm, generally larger than ion channels to allow varieties of ions to pass through quickly. In short, electrical synapses are responsible for the communication of ion concentration or membrane potential changes from one cell to another.
Chemical Synapse	Complex synapses that provide for kinds of regulation, including changes in signal strength, feedback, and varied effects on different target cells. The gap between neurons (the synaptic cleft) is about 30 nm long.
Neurotransmitter	A molecule passed from a presynaptic neuron via exocytosis that binds to a receptor protein in a postsynaptic neuron to elicit a change or propagate a signal.
Neurotransmitter Receptor	An intrinsic receptor protein in the membrane of the postsynaptic neuron that binds to a neurotransmitter molecule and elicits a change or a propagation of a signal. Sometimes there are receptors imbedded in the presynaptic membrane, allowing for possibilities of feedback. There are ionotropic receptors (similar to voltage-gated channels but the firing mechanism is due to a neurotransmitter) and metabotropic receptors (see **metabotropic receptors, GPCR**).
Reuptake transporter	Intrinsic transporter proteins in the membrane of the presynaptic neuron that reabsorb neurotransmitters via vesicles (for reuse and prevention of extreme signal propagation).
Dendritic Spines	Small protrusions from the dendrite that receives input from a single synapse of an axon and help transmit signals to the soma.
Otto Loewi	A researcher who demonstrated the concept of chemical neurotransmission in 1920 with frog hearts. Through the stimulation of the vagus nerve in one heart, its beating slowed; a fluid transfer to another jar with another heart led to the slowing of the second heart.
Vagus nerve, vagusstoff	A nerve that is part of the autonomic nervous system (parasympathetic) and is responsible for controlling heart rate. *Vagusstoff* was the name given by Otto Loewi to the chemical (neurotransmitter) that was responsible for the change in the system.
Acetylcholine	The neurotransmitter responsible for the parasympathetic portion of the autonomic nervous system. This was the *vagusstoff* that Otto Loewi observed.
Glutamate	The most abundant neurotransmitter in the human brain. Glutamate is the ionized form of the amino acid glutamic acid, which is one of the 20 amino acids that encode for organic proteins. In the aqueous solutions of the brain, the ionized form dominates.
GABA	The major inhibitory neurotransmitter in the brain: gamma-amino-butyric acid. A large number of GABA receptors are ionotropic receptors.
Glutamic acid Decarboxylase	The enzyme responsible for the transformation of glutamic acid into GABA.
Lec 8 – Neurotransmitter Mechanisms	
Ionotropic receptors	Receptor proteins that act like voltage-gated ion channels, with the exception of a neurotransmitter as the firing mechanism.
EPSP	Excitatory post-synaptic potentials occur when a membrane potential depolarization is observed in the post-synaptic membrane after a neurotransmitter binds to a receptor proten.
IPSP	Inhibitory post-synaptic potentials occur when a membrane potential hyperpolarization is observed in the post-synaptic membrane after a neurotransmitter binds to a receptor protein.

Spatial and temporal summation of neuronal input	Action potentials are initiated through the summation of EPSPs and IPSPs. EPSPs or IPSPs, when fired off in a close temporal spacing/simultaneous stimuli lead to constructive interference. When the voltage potential reaches -50 mV, the action potential begins
Metabotropic receptors, GPCRs **Metabotropic receptors, GPCRs (cont)**	G-protein coupled receptors are complex receptor systems that involve the following in succession: 1) receptor protein 2) G-protein 3) Effector Enzyme 4) Second Messengers (cAMP) 5) Protein Kinase 6) Substrate Protein The benefits of metabotropic receptors include versatility and signal amplification. Cellular effects include enzyme activation, channel properties, gene transcription, etc.
GPCR signaling: receptor, G-protein, effector enzyme, intracellular messenger, protein kinase	1) Receptor receives a signal via a neurotransmitter which facilitates a change in shape on the intracellular side. 2) That allows the G-protein to bind to it and release a GDP (guanosine diphosphate) while subsequently binding to a GTP (guanosine triphosphate). 3) The G-protein breaks apart and can attach to other molecules—including effector enzymes and protein kinases—to bring about a change that may be facilitated by intracellular messengers (cAMP, cGMP, IP_3, DAG). 4) Protein kinase may phosphorylate ion channel proteins or other molecules including transcription factors.
Autonomic nervous system: sympathetic, parasympathetic	The autonomic nervous system is part of the peripheral nervous system (PNS) that regulates various body organs and internal functions including heart rate, blood pressure, respiration, and digestion. It is split into two parts – the parasympathetic and the sympathetic nervous system. The parasympathetic nervous system regulates the calming effects on the body (relaxes the body), whereas the sympathetic nervous system regulates the excitatory effects on the body (prepares the body for emergencies).
Neurotransmitters (NT): norepinephrine, acetylcholine	Norepinephrine is the neurotransmitter for the sympathetic nervous system and acetylcholine is the neurotransmitter for the parasympathetic nervous system.
Sympathomimetic, parasympatholytic	Something that is sympathomimetic replicates the sympathetic system and enhances it. Parasympathomimetic molecules do the same for the parasympathetic system. They are agonists. Something that is sympatholytic interferes with the sympathetic system and reduces it. Parasympatholytic molecules do the same for the parasympathetic system. They are antagonists.
Acetylcholine	The neurotransmitter for the parasympathetic system. It is found in the brain and neuromuscular junction. The nuclei for the acetylcholinergic system include the basal forebrain nuclei and the midbrain nuclei.
Nicotinic and muscarinic AChRs	Nicotinic acetylcholine receptors are ionotropic sodium channels whereas muscarinic acetylcholine receptors are metabotropic receptors.
Acetylcholine esterase enzyme	An enzyme that breaks down acetylcholine. One of the fastest enzymes.

Neuromuscular junction (NMJ)	A junction that connects the nervous system to muscle fibers, in which acetylcholine is released from a neuron that binds to nicotinic acetylcholine receptors in the muscle membranes to stimulate movement.
Serotonin, raphe nuclei	100,000 neurons are part of the serotonin circuitry, with several clusters of serotonergic neurons existing in the brain stem called Raphé nuclei. Serotonin is found in blood (1940s) with effects on constriction and dilation of blood vessels. Serotonin was later found to exist within the brain. Serotonin ultimately comes from the amino acid tryptophan (in 2 steps).
Dopamine, ventral tegmentum, substantia nigra	Dopamine comes from 3 transformations of phenylalanine and is the precursor to norepinephrine (noradrenaline) and epinephrine (adrenaline). The nuclei in the system of dopaminergic cells include the ventral tegmentum and the substantia nigra (smaller).
Norepinephrine, locus coeruleus	The norepinephrine-producing region of the brain stem is the locus coeruleus.
Biosynthesis of monoamine neurotransmitters	The synthesis of monoamine neurotransmitters (including dopamine, serotonin, norepinephrine, epinephrine, and histamine) stems from the stepwise reactions of amino acids which are catalyzed by enzymes.
Peptide neurotransmitters	Short chains of amino acids linked by peptide bonds that act as neurotransmitters.
Lec 9 – Seizures and Toxins	
Electroencephalography (EEG)	The recording of electrical activity along the scalp over a period of time. It also measures the fluctuations of voltage throughout the neurons in the brain.
seizure	The result of too much excitation in neuronal connections and not enough inhibition that leads to an explosive chain reaction of excitation in the body. Often leads to memory loss, loss of consciousness, and muscle spasms.
Idiopathic seizure, causes of seizures	Idiopathic seizures are seizures of unknown causes. Several factors may cause seizures, including physical trauma, infection, fever, tumor, emotional stress, sleep deprivation, and certain drugs/withdrawal.
Epilepsy	A condition of chronic and recurrent seizures. Nearly 1% of the US population has epilepsy. Diagnosis usually comes after a trigger event.
Antiseizure medications	Medications for seizures include barbiturates (phenobarbital) and benzodiazepines (diazepam = Valium, acute seizure treatment; clonazepam = Klonopin, long-term seizure treatment). In severe cases, surgical procedures are carried out to excise small portions of the brain that are seizure-inducing foci. 30% of people with epilepsy find that their seizures are not controlled by medication.
Electrocorticography (ECoG)	The practice of placing electrodes directly on the brain to measure the electrical activity of the brain and neurons.
Pharmacology	The study of how drugs interact with the body
Paracelsus	The 16th century Swiss physician/alchemist who claimed that “everything is a poison. The difference between medicine and a poison is the dose.”
Tetradotoxin (TTX)	A toxin that comes from many poisonous animals including puffer fish, salamanders, and blue-ringed octopi. The toxin interferes with the voltage-gated sodium channels, leading to muscle weakness/paralysis, respiratory paralysis, and numbness. Due to its polarity, it does not pass the blood-brain barrier. It does not stop the heartbeat.
Blood-brain Barrier	The blood vessels in the CNS are so constricted that only nonpolar substances may pass through to other tissues of the CNS.
TTX resistance	Some organisms are TTX resistant due to a change of a single amino acid in the primary structure of the sodium ion channel. This dramatically reduces its ability to bind to the channel.

Saxitoxin, PSP	A toxin found in dinoflagellates (red tides) and other protists that leads to paralytic shellfish poisoning (PSP). The effects are similar to TTX poisoning, and like TTX, saxitoxin does not pass the blood-brain barrier.
Lec 10 – Toxins and Drugs	
Cocaine, local anesthesia	Local anesthetics produce a numbing sensation in a localized area, as opposed to general anesthesia which numbs the entire body. Cocaine is a local anesthetic, as it numbs locally. Other local anesthetics include lidocine (Xylocaine), procaine (Novacain).
Batrachotoxins	A toxin that prevents the closure of voltage-gated sodium channels. It doesn't kill the animal, but slows the animal. Unlike STX and TTX, it doesn't jam the channel, but prevents it from closing. It is found in the skin of many tropical frogs in the Amazon.
Ciguatoxins	Toxins end up in fish (produced by dinoflagellates) and produce a lowering of the threshold voltage for the opening of the channel.
Psychoactice drugs: top 5	1) Caffeine 2) Alcohol 3) Nicotine (tobacco) 4) Arecoline (areca/betel palm nut) 5) Cannabinoids (cannabis/marijuana)
Caffeine	Isolated from coffee in 1820. Caffeine is a stimulant that leads to increased alertness/wakefulness, increased blood pressure and heart rate, increased kidney output, and increased metabolic rate.
Adenosine as NT	Adenosine works as a neurotransmitter to inhibit function: caffeine is an antagonist. Caffeine is made from adenine.
Tobacco, nicotine	Nicotine is an agonist at nicotine acetylcholine receptors. It leads to stimulation and relaxation. It is thought to be a chemical synthesized for protection.
Alcohol, ethyl alcohol	A type of sedative-hypnotic drug that is ingested. Least poisonous alcohol to the human body. Enhances the inhibitory effect of GABA.
Sedative-hypnotic drugs	Drugs that produce sedative or relaxing effects in low doses and hypnotic or sleep-inducing effects in high doses.
Barbiturates, benzodiazepines	Barbiturates are a pharmaceutical sedative-hypnotic drug that was first introduced into medicine in the early 20th century. They treat anxiety and insomnia and were among the first synthetic drugs. Chemicals include secobarbital, amobarbital, pentobarbital, and thiopental. Benzodiazepines were also introduced by the same company as barbiturates and have similar effects. Both are sedative-hypnotic drugs.
GABA receptor	GABA receptors are ionotropic receptors that increase inhibition in the CNS by increasing the flow of chloride ions into neuron, giving rise to the sedative-hypnotic effects.
Therapeutic index	The ratio of the lethal dose in organisms to the effective/therapeutic dose in organisms. The closer the number is to 1, the less threshold that exists for an effective dose versus a toxic one.
Lec 11 – Psychoactive Drugs	
***Erythroxylum coca*, cocaine**	Origins in *Erythroxylum coca*. Its most potent effect is to react with reuptake transporters and block them in dopamine and norepinephrine systems.
Effects of cocaine: at synapses, CNS and autonomic	The ultimate effect of cocaine is the magnified effect of the dopamine and norepinephrine transmitters. Effects include increased wakefulness, stamina, focused attention, positive mood and euphoria. It is a sympathomimetic, leads to cardiovascular damage.

Psychosis	The loss of contact with reality that includes delusions (false beliefs about what is taking place) and hallucinations (seeing or hearing things that aren't there).
Amphetamine and related molecules: effects at synapses	Related to cocaine, these molecules make reuptake transporters leaky so there is excessive nerve stimulation at dopamine or norepinephrine systems. The effects on the body are the same as cocaine.
Opium, opium poppy (*Papaver somniferum*), morphine, opioids	Most concentrated way to get opium out is through opium poppy seed pod sap. Opium was used for cough suppression, treatment of diarrhea, and analgesia (pain relief). Morphine was discovered by Friedrich Serturner. Opioids are molecules that have the same effects as opium in the nervous system (not necessarily a similar shape). Semi-synthetic opioids include etorphine, hydropmorphone, and oxycodone.
Endorphins, opiod receptors	Endorphines are the endogenous (natural in the body) opioids. They bind to opiod receptors (metabotropic receptors) to produce similar effects. Endorphis are polypeptide chain neurotransmitter.
LSD	Psychoactive properties were discovered by Albert Hofmann in 1943. Lysergic acid diethylamide is one of the most potent psychoactive drugs, needing only a few micrograms to have a great effect on the body.
Albert Hofmann	The man who discovered LSD. His discovery of LSD was a groundbreaking discovery of how chemical signaling could be closely associated with the workings of the brain and how one's mental experience is determined by the chemical interactions within the brain.
Maria Sabina	She introduced ethnobotanic practices with psychoactive drugs into the mainstream. She was a shaman who used psilocybe mushrooms to improve her experience.
Psilocyvin, DMT, mesacaline, peyote cactus	All psychoactive drugs that are used by tribal peoples in their practices for medicinal effects (DMT – Amazon) and hallucinations (Psilocybin, peyote – shaman).
Lec 12 – Psychoactive Drugs pt. II and Gap Junctions	
Shaman	See **Shaman** in CH 1
Schedule One controlled substance	A drug that is completely illegal in the United States due to its high potential for abuse, no medical use, and a lack of accepted safety for use of the drug.
Cannabis	A plant categorized in the schedule one group. There are about 60 cannabinoids present in the one cannabis plant. They affect the GPCR cannabinoid receptors
THC	One of about 60 chemically related molecules found in the Cannabis plant that has been identified as a major psychoactive chemical constituent of cannabis (identified in 1964). It is a very hydrophobic and easily crosses the blood-brain barrier. The receptor for THC is a cannabinoid receptor that appears to be the most abundant of all GPCR receptors.
Endocannabinoids, anandamide	Agonists of the cannabinoid receptor including anadamide and 2-arachidonylglycerol (2AG).
Retrograde signaling	Changing the strength of the synapses as a signal passes backwards into a presynaptic neuron. Takes place at trillions of synapses. Endocannabinoid retrograde signaling is believed to be involved in the dynamic tuning of the strength of synapses.
Gap junctions/electrical synapses	Gap junctions are connections between neurons that allow for chemical communication though channel proteins called connexons (shared cytoplasm). Electrical synapses involve neurotransmitter-protien receptor communication allowing for various action potential or GPCR reactions to commence.
Connexon (channel, made up of several proteins)	Connexons are channels made up of several connexin proteins; when 2 connexons are put together, they form a gap junction. There are 2 forms of connexins: homomeric (all the same connexins) and heteromeric (mixture of connexins).

	Channels that have all the same connexin types are homotypic and channels with a mixture of connexins are heterotypic.
Connexin (individual proteins)	Connexins form the building blocks of gap junctions. There are 12 per gap junction. Connexins are named for their molecular weight: Cx36 = connexin, 36 dalton weight.
Electrical synapse vs. chemical synapse – speed and directionality issues	Electrical synapses are slower and unidirectional whereas chemical synapses are faster and bidirectional
Lec 13 – Epilepsy and Neurogenesis	
seizure	Convulsions, memory loss, and/or loss of consciousness brought about by the cascade of uninhibited excitation of unusually large amounts in neural synapses. Characterized by hyperexcitability and hypersynchrony.
EEG	A noninvasive method of functional brain imaging where electrodes are put on the head of a subject and real-time imaging is shown of brain activity. The spatial resolution = many cm, the temporal resolution = milliseconds.
Traumatic brain injury (TBI)	Traumatic Brain Injuries generally involve the breakdown of the blood-brain barrier and is the leading cause of death in young adults. Traumatic brain injuries lead to the loss of astrocytes because of that blood-brain barrier breakage, leading to other issues.
albumin	Albumin is a protein complex in the human blood serum that is not supposed to be in the brain, but can control some brain centers. It can bind to TGF-βR2 receptors on neural cells, which express GFAP that starts alert/repair system, opening up the blood/brain barrier.
Astrocytes at synapses	Astrocytes are glial cells that help from the blood-brain barrier, and are responsible for repair after traumatic brain injuries. After a TBI, astrocytes are lost, leading to a loss of K^+ immuno-rectifying channels and a neutralization of the K^+ potential.
Hyperexcitation and hypersynchrony	Hyperexcitation and hypersynchrony are expressed as a result of astrocyte loss (due to TBI). The TBI causes action potential freezing, waiting for a trigger. This trigger can easily be agitated by glutamate buildup at the synapse due to the lack of reuptake transporters.
Human genome: size, % transcribed, % translated	The human genome is 23 chromosomes/2C, and 3 billion base pairs long Greater than 75% of the DNA is transcribed to RNA Less than 5% of the genome encodes for protein
Stem cells	Stem cells are progenitor cells to more specialized cells and can mutate based on signals and gene activation. They form from the embryo, hence the common prefix embryonic stem cells.
Neural tube	Forms after the embryonic disk, this forms into the entire CNS including the spinal cord.
Cell differentiation	The process of a cell changing from one cells to another, governed by transcription factors and proteins. Cell differentiation is responsible for the formation of different tissues.
Transcription factors	Protein complexes composed of one or more proteins that work in tandem with RNA polymerase to transcribe certain genes.
Neurotrophins, nerve growth factor (NGF)	Neurotrophins are nerve growth factors that are important for cell growth and survival. NGF (nerve growth factor) was the first neurotrophin to be discovered. In general, neurotrophins are responsible for for cell growth, differentiation, migration, and synaptogenesis in neurons.
Neural progenitor cells	Embryonic stem cells that give rise to the nervous system through a process of neurogenesis and gliogenesis.

Overproduction of cells followed by apoptosis	Some areas of the human body during embryonic development see instances of cells that exist in areas in which they don't belong. They are useful for development, but not after. Generally these cells undergo programmed cell death (apoptosis) via proteolytic caspases. Large numbers of neurons are eliminated if not promoted by the nerve growth factors; in some regions of the brain, 50% of the neurons can die from apoptosis.
Growth cone	The growth cone is the region on the tip of an axon that possess mechanisms of sensitivity, motility, and guidance. These were hypothesized by Rámon y Cajal after examining microscopic images of growing neurons in chicken embryos.
Lec 14 – Chemo-Affinity and Neuroplasticity	
Cytoskeleton	Microtubules, microfilaments, intermediate filaments. They help form the structure and motility of the cell. Microtubules are composed of tubulin and microfilaments are composed of actin.
Microtubule, microfilament, actin, tubulin	Microtubules are long polymers of tubulin dimers. They form the skeleton of the cell and form "railways" for the movement of chromosomes and organelles. Microfilaments are formed from actin polymers and aid in cellular contraction, (neural) growth, and cytokinesis.
Roger Sperry	Through experiments, he discovered the difference between the right and the left brain. Through an optic nerve of frog experiment, Sperry hypothesized through 3 cases (cut optic nerve-normal; cut optic muscles and rotate 180 degrees-skewed; both-skewed) the chemo-affinity hypothesis.
Chemo-affinity hypothesis	The hypothesis from Roger Sperry that neurons use specific chemical signals to guide their wiring during development and neural regeneration.
Neurotrophins, nerve growth factors: contact vs. soluble	Neurotrophins are the chemicals that guide the wiring of neurons as described by the chemo-affinity hypothesis. Contact – proteins on one cell that bind to receptors on another cell. The growing neuron grows in (or away from) the direction of the contact. Examples include Ephrin, Netrin, Neuropilin, Plexin, Semaphorin, Slit, and Robo Soluble – NGF, glia-derived nerotrophic factor (GDNF), and NT3 are examples of proteins that promote the growth and survival of a neuron without specific cell-cell contact.
Pruning	Over the development of a brain in an organism, synapses that are used become stabilized and strengthened, while those that aren't used are eliminated (pruned).
Neuroplasticity	The capacity of neural circuitry to alter its properties: synapses and numbers.
Lec 15 – Lesions and Structural Imaging	
Embryonic and adult neurogenesis	Embryonic neurogenesis is the formation of neurons from embryonic stem cells. Adult neurogenesis and myelination reaches its minimum past the age of 20. Glial cell formation, synapse strengthening and pruning, myelination, and sprouting of dendritic spires all continue at robust rates during childhood (5 wk – 5 mo).
Hippocampal dentate gyrus , subventricular zone	Both are sites for adult neurogenesis, with the hippocampal dentate gyrus forming new neurons and rewiring and the subventricular zone existing as a site for neural stem cells.
Regeneration in the olfactory system	GBC (globos basal cells) and HBC (horizontal basal cells) are stem cells that replace neurons in the olfactory gland. GBC are responsible for regeneration, while HBC is responsible for regeneration and GBC formation.
Brain damage and brain-mind connection	Damage to the brain can affect actions, thoughts, feelings, and perceptions about the world and one's identity.
Lesion: stroke, tumor, traumatic injury, disease	An injury to the brain that includes stroke, tumor, physical trauma, and brain diseases.

Phineas Gage	A foreman who had a rod busted through his head (nonfatal). He lived but his behavior drastically changed for the irritable.
Static/structural brain imaging	Static/structural brain imaging allows for the visualization of the structure of the brain. Methods include posthumous dissection, surgery, x-ray photography, and Computed Axial Tomography (CAT/CT).
x-ray imaging	William Röntgen discovered x-rays in 1895. Since, they have been used for static brain imaging, where finer tuning of x-rays allows for tissue discrimination in photographs. It is invasive and implemented in CAT scans to produce 3D structures. 3D x-ray pictures help improve the ability to determine the location of a lesion.
Computed axial tomography (CAT, CT)	An invasive brain imaging method where x-ray axial photographs are taken to create a 3D structure of an observed area, allowing for better treatment and identification of the lesion and its location.
Magnetic resonance imaging (MRI)	A noninvasive brain imaging method where the spin property of hydrogen atoms is used to create a 3D reconstruction of the brain. It does this using magnets.
Nuclear Spin, NMR	Nuclear spin is a property of atoms that involves the spin of its nucleus and alignment top or bottom. NMR readings are measurements of spin that allow for the identification of molecules based on the spin properties of their component atoms.
Lec 16 – Dynamic Imaging	
Invasive vs non-invasive imaging	Invasive imaging involves the use of methods that involve direct contact with the brain or harmful processes to the body. Non-invasive imaging is not harmful to the body and does not involve cutting into the body.
Dynamic brain imaging	Imaging the brain in action; this generally involves recording the processes of the brain while a subject undergoes tasks. Dynamic brain imaging helps researchers understand the functional aspect of the brain.
Wilder Penfield	Wilder Penfield was the pioneer of brain mapping using electrical stimulation and recording. He was the first to implement the use of electrocortocography (ECoG). He utilized ECoG to treat epileptic patients and study feelings and their relationship with the brain.
EEG and ECoG	Electroencephalography (EEG) – a noninvasive method of recording the processes of the brain with good temporal resolution, but poor spatial resolution. EEG results are more easily contaminated by non-cerebral activities. Electrocorticography (ECoG) – an invasive method of recording the processes of the brain with good spatial and temporal resolution. Two types include epidural ECoG (above the dura mater) and subdural ECoG (below the dura mater). Both are forms of dynamic brain imaging. Moving action potentials create electromagnetic fields that pass through surrounding tissues.
Hans Berger	This German scientist pioneered the use of human EEG in 1920s. He was inspired by the potential long-distance sibling communication he experienced. He gave EEG its name.
Epileptogenic tissue	Neural tissues that serve as the nexuses for epileptic activity in the brain.
Temporal and spatial resolution	These refer to the resolution of dynamic brain imaging apparent in localizing and timing brain activity: EEG – temporal: miliseconds, spatial: many cm MEG – temporal: miliseconds, spatial: mm PET – temporal: seconds to minutes, spatial: cm fMRI – temporal: seconds, spatial: mm
Prosopagnosia	Prosopagnosia is a condition of face-blindedness: the inability to distinguish and recognize faces, even while looking at them sometimes.

Magnetoencephalography (MEG)	A type of dynamic brain imaging in which magnets cancel out background magnetic noise and measure the 1 picotesla strength electrical signals put out by the brain. SQUID tech (superconduction quantum interference device) assists in magnetic cancellation.
Magnetic field strength: Gauss, Tesla	Magnetic fields can be measured in terms of gauss and tesla: 1 Tesla = 10,000 Gauss Earth's Magnetic field = 0.5 gauss Refrigerator door = 50 gauss Ambient magnetic noise (power cables, etc.) = 0.1 microtesla/0.01 gauss
fMRI, hemoglobin, BOLD signal	fMRI stands for functional magnetic resonance imaging. It uses the same machine as an MRI, but analyzes the brain's functional properties. After taking a control image (no stimulus), it takes series of images of the brain, looking at the hydrogen atoms in water molecules in the vicinity of hemoglobin (higher concentration = more hemoglobin = more brain activity). Hemoglobin produces a different magnetic perturbation effect on its local environment when oxygenated, making it easier to determine locations of increased neural activity. BOLD signal (blood-oxygen level dependence) is the measure of increased flow of blood into more active regions of the brain.
Lec 17 – PET and Heavy Elements	
Positron emission tomography (PET)	A type of functional/dynamic brain imaging that involves measuring the energy emissions from positron/electron matter cancellation.
Stable vs unstable atomic isotopes	Stable isotopes exist without any form of nuclear decay. Unstable atomic isotopes undergo nuclear decay in which it loses electrons or nuclear particles.
Radioactivity/radioactive decay	Radioactive objects are radioactive because the atoms that compose the object are decaying subatomic particles. Radioactive atoms decay at a rate measured by their half-life. A half-life is equivalent to how long it takes for half of the radioactive atoms in a mass to decay. Radioactive decay comes in 2 forms: alpha decay (^{4}He decay), beta-minus decay (electron decay) and beta-plus decay (positron decay).
Positron emission, annilation, gamma photons	Positron emission is a form of beta decay in which an isotope loses a beta-plus particle (positron) and a nuclear proton is converted into a neutron. Annilation occurs when a matter particle (electron) collides with an anti-matter particle (positron) with the result being the mass cancellation of both particles and a conversion of that mass into energy (gamma photons). The gamma photons radiate opposite and in various directions of each other allowing for accurate triangulation of radiation origin points.
PET isotopes: fluorine, oxygen, carbon	The primary radioactive isotopes used include ^{11}C, ^{15}O, and ^{18}F. The isotopes have half-lives of 20, 2, and 110 minutes respectively. They are generally inserted into biological molecules like water (^{15}O) and glucose (^{18}F), where they are tracked in movement or in accumulation. ^{11}C is used to track the location of neurotransmitter receptors in the brain (e.g. dopamine)
Image subtraction	Happens in fMRI. One can take an image taken of brain activity and subtract a control picture (representative of basic activity) from it to find areas of function for a specific action/feeling.
Ernest Lawrence	Faculty member at UC Berkeley who discovered the ability to make radioactive isotopes through a cyclotron. His work led to the discovery of many heavy elements and the Manhattan project.
Cyclotron	A particle accelerator that allows for the smashing of atoms together to create heavier elements/isotopes.
Trans-uranium elements	Elements that exist past Uranium on the periodic table that were discovered using the cyclotron: • Neptunium

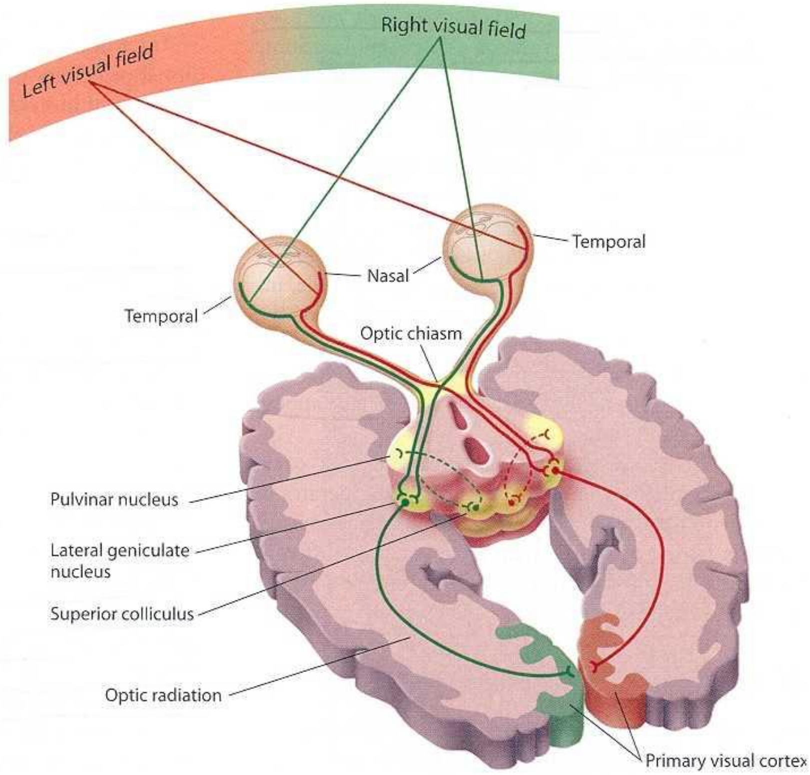
	• Plutonium • Americium • Curium • Berkelium – 1400 year lifetime • Californium • Einsteinium • Francium • Nobelium • Lawrencium • Mendelevium • Ruthefordium • Seaborgium • Livermorium – 60 ms lifetime
Lec 18 – Olfaction	
Sensation, perception	Sensory perception constitutes the collection of information (sensation) via sensory organs and the analysis/interpretation of the nervous system (perception).
Bacterial chemotaxis	Bacteria can detect and respond to physical stimuli in their environment. Chemoreceptor proteins respond to particular chemicals and detect attractants. There is a bias toward attractants by tumbling (flagellate movement) less in that direction
***E. coli* random walk/swim: runs and tumbles**	*E. coli* moves in a way that it swims straight and tumbles about for a moment when its flagella changes direction; after a while, it goes to swimming again. It moves with directional bias due to physical stimuli by tumbling less in that direction. Its movement is described as a random walk.
Olfaction	The ability to smell: detect airborne stimuli that may elicit an emotional and/or sensational response. Humans have the capacity to discern 10,000 different odors.
Olfactory receptor cells	Olfactory receptor cells are modified neurons with dendrites that branch into the nasal epithelia and are coated with cilia (GPCRs) (surface area). They also have axons that connect with the olfactory nerve.
Olfactory stem cells	Stem cells that exist to replace malfunctioning or dead olfactory receptor cells.
Cilia	Extensions of the cytoplasm, membrane and microtubules that allow for increased surface area for more receptor proteins.
Olfactory receptor proteins	Proteins embedded in the membrane of the olfactory receptor cells that bind to certain molecule shapes and send a signal via GPCR reactions to the rest of the cell. There are 350 different kinds of olfactory receptors in humans.
Pseudogene	A gene in the genome that encodes for a nasal receptor protein, but is not used for the organism.
Essential oil	Aromatic odors: the “flavor” component of plants. Sometimes referred to as the most distinctive/powerful molecule in the smell.
Aromas; mixtures of molecules vs single molecules	Aromas are formed generally from the mixture of molecules activating different olfactory receptor proteins at varying intensities. This is how we can distinguish between 10,000 different kinds of odors with 350 cells.
Spices as aromatics	Spices were very popular during the Age of Exploration, primarily because of their smell.
Sulfur, thiols	Molecules with these elements/groups tend to be very stinky, and is a major component of skunk spray.
Anosmia: specific and general	Anosmia is the loss of scent. Specific anosmia refers to the loss of sensitivity to a specific type of smell. General anosmia is the complete loss of smell.

Olfactory bulb	The olfactory bulb receives the axons from olfactory receptor cells and is located above and adjacent to the nasal cavity. The synapses formed are between the receptor cells and the mitral cells of the olfactory bulb.
Connections to limbic system and cortex	The mitral cells of the olfactory bulb send axons into other forebrain regions including the pyriform cortex, the thalamus, and orbitofrontal cortex. Connections with the hippocampus and hypothalamus are also present.
Pheromones, vomeronasal organ	Pheromones are the olfactory chemical used for interspecies communication. It is used for sex, attraction, and social status. The vomeronasal organ is responsible for pheromone detection.
Lec 19 – Gustation	
Taste bud	A cluster of taste receptor cells located on the tongue, upper palate, and cheeks. Each taste bud contains about 100 taste receptor cells. Taste receptor cells contain microvilli structures embedded with receptor proteins. There are also stem cells that exist to replace/form new taste buds.
Stem cells and gustatory cell replacement	Stem cells within a taste bud are not primordial stem cells that can differentiate into any cell, but cells that have flexibility in differentiating into various types of taste receptor cells with different taste receptor proteins. Stem cells replace taste receptor cells every two weeks.
Receptor cell types: salt, bitter, sweet, sour, umami	Taste receptor cells can be broken down into 5 generic types: ***Salt***: stimulated by the Na^+ in NaCl flowing in through taste receptor cell channels, initiating an action potential. ***Sour***: similar mechanism as salt, but with H^+ from acidic substances. ***Bitter***: reaction of molecules with GPCRs on one of 30 taste receptor proteins. Various different molecules can be perceived as bitter, potentially for defense (toxins=bitter). Among things that are bitter are plant alkaloids including caffeine and cocaine. ***Sweet***: reaction of molecules with GPCRs on one of 2 taste receptor proteins. Synthetic molecules are created to replace the taste of glucose/sucrose with fewer molecules – less calories. Synthetic molecules include aspartame (180x sweet, most common), saccharin (1st, 500x sweet), Sucralose (600x sweet), and Neotame (10,000x sweet). ***Umami***: savory flavor, ruled by glutamate receptors (GPCR) and glutamate/MSG reactions. Recently discovered by Japanese scientists (Kikunae Ikeda - 1909) and accepted by the western world. Glutamate = amino acid, detection helps with detecting proteins.
Taste receptor proteins: ion channels and GPCR	See above for specific details. Different taste receptor cells use ion channels and GPCR reactions to determine taste.
Gustatory neural pathways	Cranial nerve fibers carrying taste sensory information > lower brainstem > divide in 2 pathways: Pathway 1 > thalamus > insula (primary gustatory cortex) > somatosensory cortex (parietal lobe). Related to the perceptual qualities of different tastes. Pathway 2 > hypothalamus & amygdala. Related to emotional associations.
Capsicum annum	The chili plant native to South America that is an example of spicy hotness in taste.
Capsaicin	The molecule that is found to be associated with hotness in foods. Proteins in the mouth and on the skin have been found to operate as receptors for capsaicin (TRPV1 receptors). The activation of the receptor via capsaicin molecules and temperature activate Ca^{++} ion channels. In terms of perception, the chili hot and fire hot are the same. Piperine (black pepper) is an agonist at TRPV1
Menthol	The molecule that is found to be associated with coolness in foods. Proteins in the mouth and on the skin have been found to operate as receptors for menthol

	(TRPM8 receptors). They operate similarly to capsaicin receptors, in being activated by menthol and temperature (37 °C).
Isothiocynates	The molecule found to be associated with pungency in foods (wasabi, horseradish, etc.). The perceptions are stimulated by receptor proteins (TRPA1 receptors) that affect calcium ion channels. They are found around the body. Also activated by heat.
TRP channels	TRP channels are found all over the body and mouth where they are associated with spicy, pungent hotness and coolness. Within the skin, they are responsible for these feelings and for feelings of pain. The feelings associated with TRP channels are not considered tastes because they operate and channel through the nervous system in different ways.
Flavor	A combination of smell, taste, pungency, and texture, and its perception. The 3 taste like perceptions (hot, cool, and pungent), the 5 tastes, and the 350 olfactory receptor proteins allow for a ton of unique taste combinations.
Lec 20 – Hearing (pt. I)	
Sound: physical and perceptual properties	Sound can be defined by its physical property, in that sound exists when a variation in air pressure created by sound energy propagating through compressions and rarefactions is created by an action. Sound can also be defined by its perceptual property that a sound exists when it is detected by something.
Human hearing range (frequency)	The hearing range of a human rests between 100 Hz and 20,000 Hz.
Speed of sound	The speed of sound is 1100 fps or 335 m/s or 750 mph
Timbre	A property of a waveform that describes the complexity of the vibration. They can be described using amplitude versus frequency graphs and Fourier analysis. Generally characterized by the overtones.
Joseph Fourier and Fourier analysis	Joseph Fourier was a French mathematician who described how any complex waveform can be described as the sum of component, simple sinusoidal waves. Fourier analysis is that practice of decomposing a wave into component forms.
Perception of one's own voice	The perception of one's own voice is different from others' perception of it because one's ears pick up bodily vibrations from the skull's conduction of it. That added component changes our perception of our own voice.
Cochlea, basilar membrane, Fourier analysis	The Cochlea is the spiral bone structure that houses the basilar membrane in fluid (named after Greek/Latin for spiral shell). The basilar membrane is a specialized membrane that vibrates at different frequencies, with higher frequencies vibrating closer to the ossicles and oval window. Hair cells line the basilar membrane, and through this unique form of vibration, the basilar membrane already does its own form of Fourier analysis.
Hair cells (inner and outer)	Hair cells contain hairs/cilia attached to one end with hairs attached to others through tiny molecular cables. Disturbing the hairs activate the K^+ channels, leading to depolarization and the opening of Ca^{++} channels, triggering the release of a neurotransmitter into the synaptic cleft with the cranial nerve number eight. Inner hair cells compose most of the hair cells that send signals to the spiral ganglion and the cochlear nucleus. There are about 3500 of these cells per cochlea. Outer hair cells, numbering 12000 cells per cochlea make fewer connections to the spiral ganglion and have much more input to the brainstem. Outer hair cells may be limitedly associated with adjusting basilar membrane sensitivity.
Prestin	The outer hair cells contain this protein molecule. Elongates and contracts as a function of membrane-potential changes. This pushes against basilar membrane, changing sensitivity and stiffness.
Auditory nerve	The nerve that connects the cochlea to the brain.

Auditory neural pathways into brain	Hair cell > post synaptic dentrite of 8^{th} cranial nerve > spiral ganglion > medulla > cochlear nucleus > superior olive > lateral lemniscus > inferior colliculus > medial geniculate nucleus (MGN) > primary auditor cortex A1 (in cerebral cortex)
Primary auditory cortex, A1	Instrumental for auditory analysis. Spatial mapping of basilar membrane has been preserved, with neurons in A1 responding to the signal stimulus similarly. This is referred to a tonotopic representation.
Directional sound perception in humans and other animals	Easier to determine with lower frequencies. There are two mechanisms with which this can work accurately: through Interaural time differences and Interaural level differences – analyzing the minute differences between time and volume between the the two ears in regards to a source of sound.
Hearing loss: infection, genetic, noise-induced	Hearing loss can be brought on through infection (permanent damage due to toxins and/or bacteria invading the ear), genetics (the presence of ion channels or lack of structures in hair cells of the cochlea that lead to malfunctioning ears), and noise exposure (noise too loud and constant exposure to moderately loud sounds leading to excitotoxic over-stimulation). Only a few thousand hair cells need to die for deaf effects.
Lec 21 – Hearing (pt. II) and Vision (pt. I)	
Vestibular system	3D orientation allowing for spatial awareness as we walk, move, and turn in comparison to gravity and acceleration. Allows for the maintenance of balance.
Semicircular system	There are 3 orthogonal, semicircular canals that are attached to the cochlea in the inner ear that are attached to two bulbous structures called the utricle and saccule. They all form a fluid filled structure and the basis of the vestibular system. The 3 canals form an x, y, and z system with each 90^o from each other.
Semicircular canals	The three semicircular canals are the horizontal canal, superior canal, and posterior canal
Utricle, saccule	The utricle and saccule contain hair receptor cells that detect the movement of fluid in the semicircular canals. Changes in movement create different changes in flow within the canals and allow for 3D spatial orientation.
Otolith	Microscopic calcium carbonate stones that are suspended in the fluid above the hair cells. They add an increased inertial component to the vestibular system allowing for better balance.
Pitch, fundamental frequency, overtones, timbre	Pitch is how we distinguish frequency. A chord contains multiple frequencies, with the fundamental frequency being the primary/base pitch (generally louder) and the overtones being the additional frequencies that contribute to the unique sound, or timbre of the sound wave.
Tonotopic organization	The organization of simple sinusoidal waves in that compose a sound through Fourier analysis via instruments or the basilar membrane.
Acoustic shadow	An area where sound waves fail to propagate due to the physical/topographic disruption of the waves in space.
Electromagnetic spectrum	The spectrum of wavelengths of electromagnetic energy: Wavelength: low → high Gamma ray > X-Ray > UV ray > Visible light > IR > Radio Wave Energy: high → low
Visible light	Electromagnetic radiation that falls between 380 nm and 740 nm of wavelength. This light we can detect with our eyes.
Retina	The section of the eye consisting of a layer of photosensitive cells and layers of interconnected nerve cells. There are also crosses of blood vessels and a region called the macula/fovea.
Macula/fovea	The 'pit' in the retina that contains the highest density of cones and the lowest density of rods.

Blind spot	Each eye has a blind spot due to the lack of photosensitive cells in an area dominated by the optic nerve. The brain compensates for these blind spots with predictions and sights from the other eye.
Photoreceptor cells: rods, cones	There are two types of photoreceptor cells: rods and cones. Rods are characterized by a rod shape and rhodopsin (496). These cells pick up dimmer light and lack the ability to detect color. Cones come in three types utilizing cone-opsin: cone 419 (S opsin), cone 531 (M opsin), and cone 559 (L opsin). These cones are responsible for the detection of color. S opsin – violet & blue, M opsin – green and yellow, L opsin – orange and red. M and L opsin codes are found on the X – chromosome.
Lec 22 – Vision (pt. II)	
Retinal achomatopsia	Characterized by the complete loss of cones in a eyes: 100,000,000 rods, no cones. Extreme sensitivity to light characterized.
Photoreceptor cells: inner and outer segments	The outer segment is characterized by membranous disks with the photoreceptor proteins (10^8 opsins); the outer segment shape is what gives the rods and cones their names. Inner segments contain the usual cell organelles and funtions.
Rhodopsin, cone opsins	The photosensitive proteins (about 350 AA long) that contain retinal, a molecule that—under light—shape shifts, starting a GPCR event. Rhodopsin are grayscale, light sensitive and cones are color, less light sensitive.
Retinal, retinol (vitamin A), beta-carotene	Retinal is a molecule that can be synthesized from vitamin A and beta carotene. It shape shifts under stimulus from light photons, triggering GPCR events in photoreceptive cells.
Isomerization (cis to trans)	The change of a molecule around a double bond between a *cis*- (the molecule parts face each other) and *trans*- (the molecule parts are opposite each other). It usually requires some input of energy.
GCPR intracellular cascade	Light stimulates the opsin which activates a G-Protein, activating cGMP (phosphodiesterase enzyme). This leads to decreased GMP and the closure of Na^+ channels. This leads to a membrane potential change, and an increase in neurotransmitter release and an enormous amplification across neural cells.
Retina: bipolar cells ganglion cells	Ganglion cells are where the axons come together to form the optic nerve. The bipolar cells contain the amacrine and horizontal cells and serve as the bridge to the ganglion cells. Inner eye > ganglion cells > bipolar cells > photoreceptive cells
Retina: horizontal cells, amacrine cells	Amacrine cells help regulate the bipolar cells and are responsible for 70% of the input to the ganglion cells. Horizontal cells also aid in the input from the photoreceptor cells, but they also aid in the adjustment of the eyes in seeing well in dim and bright light.
Receptive field	Because of light-focusing protperties of the eye, photoreceptor cells will only respond to stimuli originating from specific regions of visual space. The receptive field property assists in tracking where the stimuli originated from.

Map: world to retina to cortex	
LGN, visual cortex (V1 etc)	The Lateral geniculate nucleus (LGN) has two parts: one on each hemisphere of the brain. Visual information from the left side goes to the right side of the brain and vice-versa. The LGN then has axons that connect with the primary visual cortex (V1, V2, V3, etc.)
Scotoma, hemianopia	Scotoma is the existence of a blind spot due to a lesion in the V1 area of the primary visual cortex. Hemianopia is the complete loss of sight due to a similar lesion.
Cortical achromatopsia	Cortical achromatopsia is the impaired or complete loss of color vision due to a lesion in the V4 region of the primary visual cortex.
Motion blindness	Motion blindness occurs when there is a lesion in the V5 region of the primary visual cortex
Prosopagnosia	Face-blindedness: the inability to distinguish and remember faces.
Blindsight	The ability to guess (correctly) about visual stimuli in a blind region of perception, possibly due to the actions in the superior colliculus. Literally sight in spite of blindness.
Superior colliculus	The superior collicus exists in the midbrain and receives about 10% of the visual information from the eye. Information sent to the superior colliculus eventually makes its way to the primary visual cortex and is responsible for unaware responses to visual stimuli and blindsight.

READER

CH 1	
Shaman	People who cultivate connection with their inner recesses and the other worlds in order to facilitate healing and divination.
Hallucination	Perceptual experience in the absence of external stimulus, brought on by hallucinogens.
2001: A Space Odyssey	See Lecture Table
Hominid	See Lecture Table
Hominid evolution	Ardipithecus ramidus – 4.4 mya Australopithecus afarensis – 3-4 mya Australopithecus africanus – 1.5-3 mya Australopithecus robustus – 1-2 mya Homo habilis – 1.5-2 mya Homo erectus – 0.5-1.5 mya Homo neanderthalensis – 30,000-300,000 y Homo sapiens – 200,000-now y
Genus *Australopithecus*	See Lecture Table
Genus *Homo*	See Lecture Table
Hominid brain size	See Lecture Table
Mind	See Lecture Table
Consciousness	See Lecture Table
What it means "to be" somebody or something	To be aware of your own mental experiences or sense of self. In other words to have a mind or consciousness by the preceding definitions.
Mind-body problem	See Lecture Table
CH 2	
William James	See Lecture Table
Neurons, glia	See Lecture Table
Evolution of nervous system in animals	See Lecture Table
Basic structure of vertebrate brain	Consists of a forebrain (cerebrum), midbrain (optic tectum), hindbrain (medulla and cerebellum), and spinal cord.
Gyrus (gyri), sulcus (sulci)	See Lecture Table
Cerebral cortex	See Lecture Table
Cerebral lobes: frontal parietal, temporal, occipital	See Lecture Table
Cerebral landmarks: longitudinal fissure, central sulcus, lateral fissure	The longitudinal fissure separates the hemispheres of the brain. The central sulcus separates the frontal lobe from the parietal lobe. The lateral fissure separates the temporal lobe from the frontal and parietal lobes.
Andreas Vesalius	See Lecture Table
Meninges: dura, arachnoid, pie	See Lecture Table
Cerebrospinal fluid (CSF)	See Lecture Table
René Descartes	See Lecture Table
Luigi Galvani	See Lecture Table
Nerve cell (neuron), axon, dendrite	Dendrites are extensions that lead to the neuron cell body (the soma) and the axon is the myelin-coated extension that connects to the soma through the axon hillock and terminates at the axon terminus.
Camillo Golgi	See Lecture Table
Santiago Ramón y Cajal	See Lecture Table
Golgi Stain	See Lecture Table

CH 3	
Chemistry, alchemy	Chemistry is the science of matter and its transformations. Alchemy was the progenitor to chemistry. Alchemy comes from *al kamia* - the Arabic for Egypt (black-earth land)
Dimitri Mendeleev	See Lecture Table
Periodic table of elements	The table of elements developed by Dimitri Mendeleev in which elements are organized by their chemical properties including atomic number, category, and atomic weight.
Elements of living organisms	Living organisms are primarily composed of C, H, O, N, Ca, P, S, Na, K, Cl
Ion, cation, anion	See Lecture Table
Molecule	See Lecture Table
Covalent chemical bond	A chemical bond in which atoms share electrons with each other. Most nonmetal molecules are bonded with covalent bonds.
Organic molecule	See Lecture Table
Symbolic language of molecular structure	The molecules are drawn in such a way that the carbon-hydrogen bonds are non-existent and carbon is replaced by a joint.
Hydrocarbon	See Lecture Table
Petroleum	Petroleum is the mixture of basic hydrocarbons (only C and H) of various sizes and is used in modern fuels (fossil fuel).
Polarity	See Lecture Table
Hydrogen bond	See Lecture Table
Hydrophilic, hydrophobic, lipophilic lipophobic	See Lecture Table
Fats/lipids	See Lecture Table
Phospholipid bilayer membrane	See Lecture Table
Amino acids	See Lecture Table
Proteins peptide bonds	See Lecture Table
Protein structural levels: primary, secondary, tertiary	See Lecture Table
Carbohydrate, sugar	See Lecture Table
Nucleic acid, DNA, RNA	See Lecture Table
CH 4	
Gene	See Lecture Table
Charles Darwin	See Lecture Table
Gregor Mendel	See Lecture Table
Neils Bohr	See Lecture Table
Max Delbruck	See Lecture Table
Erwin Schrodinger	See Lecture Table
Oswald Avery	See Lecture Table
Hershey-Chase Experiment	See Lecture Table
Francis Crick, James Watson	See Lecture Table
Double Helical Structure of DNA	See Lecture Table
Triplet Nucleotide codon	See Lecture Table
Genetic code	See Lecture Table
Transcription	See Lecture Table
Translation	See Lecture Table

CH 5	
Diffusion	See Lecture Table
Phospholipid bilayer and ion permeability	See Lecture Table
Na/K pump	See Lecture Table
ATP	See Lecture Table
Energy consumption by body and brain	The basal energy consumption of the body is about 1440 kcal per day or 1 kcal per min
Intracellular/extracellular ion concentration differences in neurons	See Lecture Table
Membrane potential and resting potential	See Lecture Table
Hyperpolarization and depolarization	See Lecture Table
Ion-channel proteins	See Lecture Table
Alan Hodgkin and Andrew Huxley	See Lecture Table
Squid axon	See Lecture Table
Action potential	See Lecture Table
Voltage-gated ion channels	See Lecture Table
Refractory period of the action potential	See Lecture Table
Propagation of the action potential	See Lecture Table
Myelin	See Lecture Table
Oligodendrocytes and Schwann Cells	See Lecture Table
Nodes of Ranvier	See Lecture Table
Salutatory conduction	See Lecture Table
CH 6	
Electrical synapse	See Lecture Table
Chemical synapse	See Lecture Table
Chemical synapse in action	When an action potential reaches the end of a synapse, the depolarization activates voltage-gated calcium channel to facilitate the diffusion of calcium ions into the cell. The calcium binds to proteins in the SNARE complex (protiens in vesicle membranes that are posed to attach to the neural membrane and fuse) which facilitate exocytosis of neurotransmitters in storage vesicles.
Storage vesicles, synaptic cleft	Storage vesicles are the media in which the neurotransmitters are stored within a neuron. When exocytosis happens, the neurotransmitters are released into the synaptic cleft.
Reuptake transpoters	See Lecture Table
Otto Loewi	See Lecture Table
Acetylcholine	See Lecture Table
Ionotropic receptors	See Lecture Table
Depolarization, EPSPs	See Lecture Table
Hyperpolarization, IPSPs	See Lecture Table
Glutamate (glutamic acid), GABA	See Lecture Table

Spatial and temporal summation of neuronal input	See Lecture Table
Metabotropic receptors, GPCRs	See Lecture Table
Spatial and temporal summation of neuronal input	See Lecture Table
Metabotropic receptors, GPCRs	See Lecture Table
GPCR signaling: receptor, G-Protein, effector enzyme, intracellular messenger, protein kinase	See Lecture Table
CH 7	
Central nervous system (CNS): brain, spinal cord	The part of the nervous system that contains the brain and the spinal cord.
Peripheral nervous system (PNS): sensory, neuromuscular, autonomic, enteric	The Peripheral Nervous System has multiple components. It encompasses the sensory systems and their connection with the brain. Also included are the connections between the CNS and muscle fibers. The autonomic nervous system is also a part of the PNS. The last part is the enteric nervous system which is an elaborate network of neurons in the gastrointestinal system.
Autonomic: sympathetic and parasympathetic	See Lecture Table
Autonomic neurotransmitters: norepinephrine, acetylcholine	See Lecture Table See Lecture Table
Agonist, antagonist	Agonists increase the effects, whereas antagonists decrease the effects
Sympathomimetic, sympatholytic, parasympathomimetic, parasympatholytic	See Lecture Table
Acetylcholine, basal forebrain nuclei, midbrain nuclei	See Lecture Table
Serotonin, raphe nuclei	See Lecture Table
Dopamine, substantia nigra, ventral tegmentum	See Lecture Table
Norepinephrine, locus coeruleus	See Lecture Table
Biosynthesis of monoamine neurotransmitters	See Lecture Table
Peptide neurotransmitters	See Lecture Table
Seizure, idiopathic seizure	See Lecture Table
Epilepsy	See Lecture Table
Surgical procedures for seizure disorders	See Lecture Table
Anti-seizure medications	See Lecture Table
CH 8	
Pharmako, pharmacology	See Lecture Table

Medicine, poison	The only difference between a medicine (positive effects on the body) and a poison (negative effects on the body) is the dose.
Paracelsus	See Lecture Table
Tedtrodotoxin (TTX)	See Lecture Table
Blood-brain barrier	See Lecture Table
TTX resistance	See Lecture Table
Saxitoxin (STX)	See Lecture Table
Paralytic shellfish poisoning (PSP)	See Lecture Table
Batrachotoxin (BTX)	See Lecture Table
Cocaine, local anesthesia	See Lecture Table
Psychoactice drug, psychopharmacology	Psychoactive drugs are drugs that have a profound effect on the mind or psyche.
Most widely used psychoactive drugs (Top 5)	See Lecture Table
Route of administration, route of entry	The route of administration depends on the drug. Caffeine is ingested along with alcohol and arecoline. Cannabis is inhaled along with nicotine.
CH 9	
caffeine	See Lecture Table
Caffeine containing plants	Plants that contain caffeine include coffee, tea, cacao, yerba mate, guanana, and kola.
Adenosine	See Lecture Table
Nicotine, tobacco	See Lecture Table
Alcohol, ethyl alcohol	See Lecture Table
Sedative-hypnotic drugs	See Lecture Table
Barbituates, benzodiazepines	See Lecture Table
General anesthetics	See Lecture Table
Opium, opium poppy (*Papaver somniferum*)	See Lecture Table
Morphine, opiods	See Lecture Table
Endorphins	See Lecture Table
Coca (*Erythroxylum coca*)	See Lecture Table
Cocaine	See Lecture Table
Effects of cocaine: at synapse, CNS and autonomic	See Lecture Table
Psychosis	See Lecture Table
Amphetamine and related molecules	See Lecture Table
Psychedelics/hallucinogens	See Lecture Table
Albert Hofman	See Lecture Table
Psilocybin, DMT, mescaline	See Lecture Table
Cannabis, cannabinoids	See Lecture Table
Retrograde signaling	See Lecture Table
CH 10	
Human genome	See Lecture Table

Transcription factor	See Lecture Table
Embryonic stem cell	See Lecture Table
Neural progenitor cell	See Lecture Table
Neurogenesis	The creation of new neural cells from neural progenitor cells
Gliogenesis	The creation of new glial cells from neural progenitor cells
Neural tube	See Lecture Table
Growth cone	See Lecture Table
Cytoskeleton: microfilaments, microtubules	See Lecture Table
Roger Sperry	See Lecture Table
Chemo-affinity hypothesis	See Lecture Table
Nerve growth factors, neurotrophins	See Lecture Table
Nerve guidance	Nerve guidance is governed by neurotrophins with varying methods on how the systems of guidance work; these differences are due to the different properties of the neurotrophins, generally divided into soluble and contact neurotrophins.
Synaptogenesis	The formation of new neuron connecitons
Synaptic pruning	See Lecture Table - Pruning
Neuroplasticity: pre-synaptic and post-synaptic mechanisms	Neuroplasticity is the change in the wiring of neurons in an organism that can be divided into pre-synaptic and post-synaptic mechanisms. Pre-synaptic – receptors on the axon terminus responding to the released neurotransmitter, leading to an effect (glutamatergic synapse: glutamate + pre-syn glutamate receptors → open Na^+ and Ca^{++} channels, strengthening synapse). Retrograde signals can also contribute. Post-synaptic – influence gene transcription to produce large numbers of neurotransmitter receptors are produced and inserted into post-synaptic membrane.
CH 11	
Brain lesions and their causes	Stroke – disturbance of blood flow to a region of the brain sufficient to lose a loss of function Tumor – issues with transcription factors, signaling molecules/molecular checkpoints, DNA mutation affecting division regulation. Physical trauma – MTBI or TBI, closed or penetrating (the brain) head injuries. Other – neuronal death
Static or structural brain imaging	See Lecture Table
x-ray photography	Photographs taken using x-rays that rely upon the varied permeability of x-rays of various tissues and biological structures.
Wilem Röntgen	The discoverer of x-rays, he won the first Nobel Prize in Physics in 1895
Computed axial tomography (CAT, CT)	See Lecture Table
Nuclear magnetic resonance (NMR)	See Lecture Table
Magnetic field strength, tesla, gauss	See Lecture Table

Magnetic resonance imaging (MRI)	See Lecture Table
Dynamic or functional brain imaging	See Lecture Table
Hans Berger & EEG	See Lecture Table
Wilder Penfield & surgical electrodes	See Lecture Table
MEG	See Lecture Table
PET	See Lecture Table
PET radioactive isotopes: 18-F, 15-O, ll-C	See Lecture Table
Cyclotron	See Lecture Table
Ernest Lawrence	See Lecture Table
Trans-uranium elements	See Lecture Table
fMRI	See Lecture Table
Hemoglobin	See Lecture Table
BOLD signal	See Lecture Table
Spatial and temporal resolution of brain imaging methodologies	See Lecture Table
CH 12	
Sensory perception (sensation + perception)	See Lecture Table
Chemotaxis	See Lecture Table
***E. coli* motility: runs and tumbles**	See Lecture Table
Phototaxis, phototropism	The process of moving toward light.
Naïve realism	What we perceive is identical to what exists in nature.
Five canonical senses in humans	Auditory (hearing), Visual (sight), Gustatory (taste), Olfactory (smell), Somatosensory (touch)
Vestibular and proprioceptions	The ability to detect the 3D orientation of one's body and parts including relationships with gravity and acceleration. It utilizes the vestibular system in the inner ear and information related to muscle tension and joint movement.
Visible light, electromagnetic spectrum	See Lecture Table
Karl von Frish	Scientist who discovered that honeybees have color vision. Bees also used polarized light to orient themselves.
Ultraviolet sensing in honeybees	Honeybees have additional capacities to see UV light allowing them to see patterns in flowers that attract them.
Infrared sensing in pit viper	Pit vipers have pit organs which can sense IR light in a similar way to eyes. It allows sight in dark.
Polarization of light	Polarization of light is the vibration of the electromagnetic field aligned in specific planes.
Auditory perception (in humans + animals)	Human auditory perception—see Hearing. Animals have different frequency ranges than humans, some higher (bats, dolphins, insects, whales)
Frequency, hertz (Hz)	How many cycles in a wave happen per second.
Echolocation	The use of emitting high-frequency sound and analyzing their rebound patterns to determine the physical orientation of the organism. Sight with sounds.

Electric field detection	Some animals can detect electrical fields with ampullae of Lorenzini, especially from sharks and platupuses
Magnetic field detection	Many animals—fish, birds, turtles—can detect the earth's magnetic field for migration and orientation.
CH 13	
Anatomy of the human eye	Cornea – the outer layer of cells covering the iris. Iris – the pigmented muscle that adjusts the diameter of the pupil Pupil – the hole below the cornea that light goes through Fovea – the pit in the retina with a high concentration of cone cells Blind Spot – the retinal region internal to the optic nerve Blood vessels – the vessels that brings blood to the eye, enclosed by optic nerve Optic nerve – the nerve that connects the eyes to the brain Retina – the eye tissue containing the photosensitive cells and neurons Sclera –the dorsal outer covering of the eye
Macula, fovea	See Lecture Table
Blind spot	See Lecture Table
Retina, photoreceptors, rods, cones	See Lecture Table
Rhodopsin and cone-opsin photoreceptor proteins	See Lecture Table
Light absorption spectra (sensitivity spectra) of photoreceptor proteins	See Lecture Table
Spatial distribution of photoreceptors in the retina	See Lecture Table
Trichromatic and tetrachromatic color vision	Humans generally have trichromatic vision, as characterized by the S, M, and L cone-opsins. There are two types of L cone-opsins though, so some women who get both L-cone opsins in their X-chromosomes have tetrachromatic color vision.
Anomalous color vision	The decrease in ability to distinguish colors—in other words, color blindness.
Color blindness: red-green and blue-yellow	Red-green colorblindness (inability to distinguish between red and green) results from a defect/absence of an L or M cone-opsin. They are sex-linked, so they affect 2% of males and 0.1% of females. Blue-yellow colorblindness (inability to distinguish between blue and yellow) results from a defect/absence of S cone-opsin gene/protein. It is rarer (0.01%) because it is not sex-linked.
Retinal achromatopsia	See Lecture Table
Photoreceptor cell structure, inner and outer segment	See Lecture Table
Retinal, vitamin A, beta-carotene	See Lecture Table
GPCR amplification and photoreception	See Lecture Table
Major cell layers in the retina: photoreceptor, bipolar, ganglion	See Lecture Table
Amacrine and horizontal cells	See Lecture Table
Vertebrate vs. invertebrate eye structure	Vertebrates have the eye typical of our specific study (see anatomy of human eye). Invertebrates (like octopi) have eyes they acquired via convergent

	evolution. The eye has its cellular order (photoreceptor cells, bipolar cells, ganglion cells) reversed in comparison to vertebrate eyes.
LGN	See Lecture Table
Contralateral connectivity	The phenomena where information from the left side of the world gets analyzed in the right side of the brain and vice-versa.
Visual cortical maps	Regions of the primary visual cortex (V1, V2, V3, etc.) have a map of visual space. This means that receptive fields of adjacent photoreceptor cells respond to regions of visual space nearby. This leads to the preservation of the topographical relationships of images throughout the visual nerve system.
Receptive field of cell	See Lecture Table
V1 lesion, scotoma	A lesion in the V1 section of the brain leads to scotoma or anopia.
V4 lesion, cortical achromatopsia	A lesion in the V4 section of the brain leads to colorblindness.
V5 lesion, motion blindess	A lesion in the V5 section of the brain leads to motion blindness.
Infero-temoporal cortex (IT) and complex visual features	The visual cortical region in the inferior and medial temporal lobe found in monkeys and humans that respond selectively to images and faces. Lesions in this area impair the ability to recognize objects and faces.
Prosopagnosia	See Lecture Table
CH 14	
Sound: physical and perceptual properties	See Lecture Table
Loudness, pitch, timbre	Loudness = amplitude, pitch = frequency, timbre = complex wave summations with amplitude and frequency components.
Speed of sound	See Lecture Table
Joseph Fourier analysis	See Lecture Table
Tympanic membrane, ossicles	The tympanic membrane is the ear drum. The vibrations of the membrane provoke movement in the ossicles (hammer, anvil, and stirrup) that create vibrations on the oval membrane, and consequently, the basilar membrane.
Cochlea, basilar membrane	See Lecture Table
Auditory nerve	See Lecture Table
Perception of one's own voice	See Lecture Table
Auditory neural pathways into brain	See Lecture Table
Primary auditory cortex, A1	See Lecture Table
Hearing loss: infection, genetic, noise-induced	See Lecture Table
Decibel scale	Named after Alexander Graham Bell, it describes a logarithmic scale to categorize sounds of varying loudness. 25 dB – quiet room 50 dB – human speech 80 dB – noisy restaurant 100 dB – jackhammer 120 dB – concert
Hearing aids: acoustic amplifier, cochlear implant	Hearing aids (acoustic amplifiers) generally assist in hearing by amplifying the sounds around, making it louder for the few remaining functional hair cells to pick up. Cochlear implants can restore some hearing functions to completely deaf people, but is nowhere near the same caliber as normal hearing.
Vestibular system	See Lecture Table

Semicircular canals, utricle, saccule	See Lecture Table
Otoliths	See Lecture Table
CH 15	
Volatile molecules and aroma	Volatile molecules are molecules that exist in a gaseous form readily in nature, or at least have a partial pressure that requires some molecules to exist in vapor form. These molecules that exist in the air can be picked up by olfactory receptor cells through inhalation through the nose. Aromas can consist of a mixture of molecules that interact with various amounts of different protein receptors.
Olfactory epithelium	The external layer of cells lining the nasal cavity that is responsible for catching and detecting aromatic molecules.
Olfactory receptor cells and stem cells	See Lecture Table
Olfactory receptor proteins	See Lecture Table
Numbers of olfactory receptor proteins in humans, mammals, fish	Humans have 350 (low mammalian range) different types of olfactory receptor proteins. Fish have about 100; mice (high mammalian range) have about 1300.
Essential oil	Originally designated the oily concentration of volatile aromatic molecules from plants. Oils are generally hydrophobic, prepared by distillation and heating.
Small molecular changes and possible effects on smell	Small changes in molecular structures can affect the way that molecule is perceived by an organism, due to it possibly binding to a different receptor protein in the nasal epithelium.
Thiols	See Lecture Table
Anosmia	See Lecture Table
Olfactory bulb	See Lecture Table
Olfactory neural pathways	Molecule > olfactory receptor proteins (nasal epithelium) > olfactory receptor cell axons > mitral cells in olfactory bulb > axons to forebrain > pyriform cortex > thalamus > orbitofrontal cortex (hippocampus and hypothalamus)
Pheromone	See Lecture Table
CH 16	
Taste buds	See Lecture Table
Taste cell replacement	See Lecture Table
Five canonical tastes	See Lecture Table
Ions and ion-channel proteins involved in taste perception	H^+, Na^+, and Ca^{++} and their respective channels are used in taste receptors, with Na^+ related to the salty taste, H^+ related to a sour taste, and Ca^{++} related to the pungent, cool, and spicy/hot perceptions.
GPCRs and taste perception	See Lecture Table
Sugar and synthetic sweeteners	Sugar–sucrose–is responsible for the tastes of sweetness. Evolutionarily, that taste designated good/healthy foods. Now, it is put into every food, so "diet" options exist: aspartame, saccharin, neotame, stevioside (a plant extract), and sucralose. Many of the synthetic sweeteners were created via the "principle of limited sloppiness" i.e. on accident.
Umami	See Lecture Table
Gustatory neural pathways into brain	See Lecture Table
Capsaicin, chili, hotness	See Lecture Table
TRP receptors	See Lecture Table
Menthol, coolness	See Lecture Table

Isothiocynates	See Lecture Table
flavor	See Lecture Table
CH 17	
Somatosensory Receptors	Receptor proteins within the nerve fiber membrane of nerves near the skin that respond to various physical stimuli. Generally responsive to touch, poking, and temperature.
Dorsal-root ganglion	Cell bodies for the nerve fibers that enervate the skin. It rests between the dendrite containing somatosensory receptors and the axon that leads to the central nervous system.
Receptive Fields	Defined by the region of skin where a physical stimulus would elicit activity in a specified neuron. Spatial information with regards to touch is maintained along the neural pathway.
Primary Somatosensory Cortex (S1)	The part of the brain that analyzes touch information, it contains a "map" of one's body. It receives signals from the contralateral side of the body. A lesion would produce a loss of sensation (similar to visual scotoma) in the corresponding area of the body the lesion hit in the brain.
Wilder Penfield	Canadian neurosurgeon who aided in the discovery of somatosensory body maps. He electrically stimulated different regions of the cerebral cortex and observed patient sensations.
Somatosensory Body Map	A map of what regions of the somatosensory cortex correspond to what regions of the body. Created by Wilder Penfield, it shows that most parts of the body maintain similar orientation in their representation in S1. The more representation a body part has in S1 (i.e. amount of neurons) the more sensitive they are.
Neglect Syndromes	Touch sensation is working, but is ignored or not recognized unless attention is brought to it. It can be caused by a lesion in the secondary somatosensory cortex (S2, S3, S4, S5…)
Somatosensory Agnosia	Lesions in the secondary somatosensory cortex which cause touch sensations that feel weird and confusing.
Mouse Whisker Barrels	Collections of neurons in the brain (grouped together like a barrel) that receive information from a single whisker. Mice use whiskers for increased perception of the environment. If one whisker is destroyed, the corresponding barrels help make adjacent whiskers more sensitive (an effect of neuroplasticity)
Phantom Limbs	Analogous process to mice losing whiskers. When a human loses an arm, the region of the brain that codes for the neurons that were removed rewire to new areas on the body. Thus, the part of the brain stays in use, but the analogous body part is no longer there: a phantom sensation is produced.
Neroplasticity: Synaptic Mechanisms	Neurons in the brain that analyzed a now missing part of the body rewire to adjacent areas of the cortex allowing for the sensation of the missing part to exist alongside a sensation of a body part that the new neurons associated with.
Primary Motor Cortex (M1)	The region of the brain immediately anterior to the central sulcus, it sends out signals that lead to neuromuscular junctions and triggers the contraction of muscle fibers. There is a contralateral connection between M1 and the body (right controls left and vice versa). Lesions in M1 can lead to paralysis.
Motor Body Map	The map that is contained within M1 that allows for successful signal propagation to the appropriate body parts. Signal mapping is maintained within the neurons.
Apraxis	A disorder to organization of body movements due to a lesion in the premotor areas of the brain.
Mirror Neurons	Neurons that are active during both movement and observation of a movement. Invoked as a contributor to the neuronal basis of empathic connections between persons.

Anosognosia	Lesions in the posterior frontal and anterior parietal lobes of the right cerebral hemisphere (only) lead to not only weirdness and paralysis, it also leads to a denial of anything wrong.
CH 18	
Hemispheric Asymmetry	In spite of the symmetrical look of the brain (macroscopically) the underlying processes and neuronal connections are different on both sides (microscopically).
Face Perception, Prosopagnosia	Posterior temporal lobe responsible for perception of human faces, and some aspects of face perception are lateralized, and each side of a face looks slightly different. Prosopagnosia is an abnormality in which faces cannot be recognized.
Aphasias	The general clinical condition of some kind of language impairment.
Broca's Aphasia, Production Aphasia	Paul Broca found an association between lesions in the left frontal lobe and a person's inability to speak. Broca's Aphasia describes a condition in which a person has trouble with producing spoken and written language. Forms from a lesion win Broca's area
Wernicke's Aphasia, Comprehension Aphasia	An aphasia described by Carl Wernicke in which there is a problem with the comprehension of spoken and written language. Forms from a lesion in Wernicke's area.
Wada Test	A presurgical test created by Juhn Wada, it involved injecting a sedative-hypnotic barbiturate into the right or left carotid artery and asking the patient to count. Patients who were injected in the left side stopped counting for the most part, confirming the left side of the brain as the dominant side for language. *Type: Left:Right:Both* Right Handed: 97:3:0 Left Handed: 70:15:15
Corpus Callosum, Callosotomy	The severing of the corpus callosum (the bridge between brain hemispheres) due to its negative contribution during seizure attacks.
Roger Sperry, split-brain patients	Sperry worked with splitting the corpus callosum in epileptic patients. After the surgery, Sperry would perform an experiment stimulating both sides of the cortex differently and comparing results.
Lateralization of cortical function	The differentiation of certain functions/superiorities of one cortex hemisphere over another. Left: superior in language, numeric reasoning, visual detail/ Right: nonverbal communication, music
Synesthesia	Stimuli of one sense eliciting a sensation in another sense. It may have a significant genetic component (Nabokovs). It may be simulated with psychoactive drugs.
Albert Einstein's brain differences	It had an expanded area of tissues in the parietal lobes near the junction with temporal lobes (spatial perception). This may be the cause of his great understanding of the physical universe in regards to space and time.