Lecture-1

The cerebrum has 4 lobes-Frontal(controls cognitive tasks and voluntary movements), Parietal(touch sensation, generates an awareness of where our body is in space), Temporal(memory, hearing and language processing) and Occipital(handles vision). Input to brain is received from sensory organs and output from brain to other organs travel through brains stem. The cerebellum has more neurons than in the rest of the brain, it's just they're smaller in size and densely packed. We've some common naming convention in standard neuroscience literature as follows: Consider a 3D co-ordinate system across brain, x-axis, y-axis and z-axis in the direction of ear to ear, nose to back of head, neck to top of head respectively. Sagittal, coronal and Horizontal(also called axial) cross sections are created when brain is cut by a z-y, z-x and x-y plane respectively. Along z-axis direction, top part of brain is referred as "superior/dorsal", bottom of brain as "inferior/ventral". Along x-axis direction, we categorize as left and right hemispheres. "Medial" means towards the centre of brain and "lateral" means on or close to surface. Now, "ipsilateral" would refer to something on the same hemisphere and "contralateral" to something on the other hemisphere. Along y-axis direction, "rostral" or "anterior" means towards the nose, "candal" or "posterior" means towards the back of head. We can combine multiple of these naming descriptions to refer to a certain region of the brain. E.g., dorsolateral frontal lobe would refer to top of front of head in either of hemispheres. Another e.g. medial rostral temporal lobe would mean near to brain's centre and closer to nose than the back in the temporal lobe.

Lecture-2

A neuron primary consists of cell body, axon and dentrites. The brain structure comprises of two prime regions-the gray matter(cell body and dendrites comprise this) and white matter(axons). Gray matter referred as cortex, hence the gray matter in cerebrum is called cerebral cortex or neocortex, cerebellar cortex in cerebellum, allo cortex in hippocampus and olfactory bulbs. These cortex differ in their structure and number of layers. On the surface, the brain has grooves and ridges called sulcus and gyrus respectively. Signals have to travel long way through axons, so to prevent these signals from not dying out the axon is covered with a whitish material(also responsible for whitishness of white matter) called myelin which performs insulation. Broca and Wernicke area located in left hemisphere are important for language, former for speech production and later for speech comprehension. So, in patients with Broca's area damaged(Broca's aphasia) they'll find it difficult to speak fluently or name objects, but they can easily understand what someone else is speaking or conveying. But surprisingly these patients can sing some well known songs, because these songs evoke a series of motor commands to sing the song and aren't related to language production of brain. The left and right hemispheres are connected through a large no of axons packed in a C shaped structure called Corpus Callosum. Corpus callosotomy is a surgery to remove corpus callosum and the resulting patients are called split brain patients. These patients find it difficult to name an object in the left visual field but not in right visual field. This is because most of our senses are perceived in opposite brain hemispheres. So the left visual field will send input signals of the object to right hemisphere but since the corpus callosum is not present, these signals can't travel to the left hemisphere where it could comprehend the object and produce speech to name it. But for the input received in right visual field, would go to left hemisphere and would easily comprehend the object and name it.

Lecture-3

Near the nose, we've olfactory bulbs in the brain, which detects all different kinds of molecules giving us a sense of smell. It is said that our neurons don't regenerate or divide to produce new neurons after birth but now certain brain regions have been discovered to generate new neurons after birth, this process is called postnatal neurogenesis and the olfactory bulb is one of the few area which perform this. Rats and mice have larger olfactory bulbs than us because our primary sense is vision and we add other sensory inputs on top of it but for rats, their smell is their primary input. Behind the Olfactory bulbs we have optic chiasm which is the region where the optic nerves coming from the eyes cross and the later part of optic nerve after this crossing is called optic tract. Moving further along y-axis direction away from nose, we've brain stem. This is one of the most crucial region responsible for motor control ,sensation, consciousness and sleep for a person. A person may survive a gun shot or other parts of the brain damaged but without brain stem can't survive. Initial part of brain stem called pons(left and right), above the pons is midbrain, below is medulla oblangata. A human brain has 12 cranial nerves-Olfactory(smell), optic nerve(vision information), oculomotor(controls eye muscles), trochlear(controls lateral eye movements), trigeminal(inputs from face, outputs to jaw control), abducens(eye movements with relation to sagittal plane), facial nerve(controls facial expressions, gets ⅔ of tongue input), vestibulocochlear(our inner ears don't just sense sound, they sense acceleration/rotation in semi-circular canals, this sense is important for movement/balance called vestibular sense), glossopharyngeal(takes remaining ⅓ of tongue input, also sends output to stylopharyngeus allowing us to swallow), vagus nerve(gets taste input from epiglottis, also controls breathing, vocalisation), accessory(controls neck movements), hypoglossal(swallowing, vocalisation) they pass input information from sensory organs to brain and carry the motor signals from brain to muscles. The cerebellum is more wrinkled than cerebrum(or telencephalon) hence can accommodate more gray matter or cortex inside it, hence the former has 70 billion neurons packed while the later has only 15. The fact is intelligence is not just correlated to large brain volume, but to the presence of more wrinkled surface or large surface capable of accommodating more gray matter. Hence intelligence is a complex correlation function of amount of wrinkling and brain volume. Cerebellum performs motor coordination, this explains why larger neurons are required, since motor functions are extremely complex and require inputs from multiple senses to understand a motion, hence large neurons coordination help us to perform complex actions of our body very easily. People with damaged cerebellum have very rigid and shaky movements. This disorder is callled cerebellar ataxia. Cerebellum also performs neurogenesis throughout life.

Lecture-4

Cerebrum comprises three sub-regions- cerebral cortex(gray matter), basal ganglia and the limbic system(where we'll find hippocampus in the temporal lobe). Hippocampus is significant for declarative memory which is information that can be accessed consciously, e.g. memories of events happened during our life or episodic memory. Non-declarative memory or implicit memory are happening subconsciously or on autopilot mode, e.g. whenever we touch hot objects, we always feel pain, not in our conscious control to stop it, hence it's a non-declarative memory. Patients whose hippocampus are destroyed remember all declarative memory before the damage but can't form new ones. This is because the declarative memory is stored throughout the brain and hippocampus only helps for making those information long term memory(lasting for longer time) and itself doesn't store all the memories. Dentate gyrus of hippocampus also exhibits neurogenesis. A six layer area around hippocampus is where input comes in, and output goes to cerebral cortex through fornix. Amygdala is located adjacent to hippocampus consisting of a cluster of neurons called nucleus. It is responsible for primitive emotions and not complex emotions like disappointments or nervousness which are believed to happen in prefrontal cortex. While experiencing fear or pain, it is the amygdala that affects respiration and heart rate and induces fight or flight response. Information that is crucial to remember for future, are send by amygdala to hippocampus to store them in long term memory so that they assist in future encounters of the same situation, e.g. we remember moments of sadness, fear, danger in great detail but not simple routines like eating, enjoying something etc. because the former are crucial for future. The basal ganglia is one of the primitive organs of brain(primitive because it's also one of the organs earliest evolved in animals). It performs a lot of automated functions and damage to it can cause motionless like in Parkinson's disease. It performs important role in motor learning, forming habits etc. Sensory information except olfaction(smell) passes through thalamus before entering different brain regions. Hence the thalamus would regulate the sensory information, e.g., it'll shut down sensory inputs when a person goes to sleep. Note that the olfaction is still active while a person sleeps, hence any information received for smell during sleep will be consolidated or stored in long term memory.

Lecture-5

The sole purpose of the occipital lobe is to process visual input. Data from the eye after preprocessing at the retina reaches optic chiasm where the data from the left visual field goes to right hemisphere and from the right visual field goes to left hemisphere. Note, that the right half of each eye comprises the left visual field and the left half of each eye comprises the right visual field. Thereafter the signal travels through optic tract to lateral geniculate nucleus(LGN) of thalamus then to optic radiation, as the axons from LGN starts radiating outwards projecting onto primary visual cortex(V1, it performs edge detection, first stage in decoding seeing mechanism) in occipital lobe. After receiving input from both eyes, V1 projects on V2 then V2 projects onto V3. As signals move from V1, to V2 then V3 then to higher layers more and more complex visual decoding happens such as geometrical shapes detection, complex patterns, object recognition etc. After V3, data takes two path dorsal and ventral. Dorsal stream or "where" stream projects to V5(MT or Medial Temporal Visual Area) where visual motions in the environment are detected such as locating spatial location of objects around, their motions etc. Ventral stream or "what" stream projects to V4(infra temporal cortex or IT) it performs object detection or what the object is. MT and IT are in temporal lobe. Damage to ventral stream renders a person unable to identify objects such as a person may not be able to tell you if it is a comb but he can show it that it's used to comb the hair. Damage to dorsal stream renders a person unable to perceive motion, e.g. if we pour water into an empty glass, the person will see it as empty initially then suddenly filled at a different level, half full and then full, not perceiving the motion of water pouring. Besides vision, the temporal lobe also performs language, memory, audition, emotions, olfaction etc. Lesion to the hippocampus renders the inability to form long term memory. Let's look at the audition now. Sound is first perceived in cochlea in the ear. In cochlea there are neurons called hair cells so called by having hair like tendrils called stereocilia on one end of them which is present in a liquid called perilymph. Sound waves travel in a mechanical medium like perilymph where they'll move stereocilia, which will open calcium potassium pumps to release ions into the cell which in turn causes these hair cells to release neurotransmitters into afferent auditory nerve and then the data passes to medial geniculate nucleus then to primary auditory cortex or a1(in temporal lobe). The difference in the way sound perceived in our different ears help us decide the direction of the sound, e.g. if noise coming from left, left ear perceives it before than right ear and this time difference called "Interaural Time Difference", the noise will also be lounder to the left ear then to the right because of crossing through brain and surroundings, this loudness difference is called "Interaural Level Difference", the brain can detect both of these and tells us that sound coming from left. Bats and owls are even better at sound localisation and they use it to detect the location and distance of their prey.

Lecture-6

The dorsal stream of the vision mechanism discussed above also leads to the parietal lobe. Parietal lobe performs some very complex functions like it takes inputs from multiple senses and connects them e.g., determining our spatial location with relation to our objects around us, like what's there in our surroundings, what's moving, what's happening, where we are in space, etc. The location of the parietal lobe(center of neocortex) is such that it can receive inputs from all kinds of senses or lobes, like it's near to the audition section, visual section and other signals of importance that travel into its adjacent lobes. Parietal lobe contains somatosensory strip/cortex which manages touch sensation, it's neurons are localised in functions, that means a particular neuron or small group of localised neurons will handle touch sensation of a particular region of body, this is also the reason why we know the location of touch on our body. With this, we can create a somatosensory map, which is just naming the neurons or their localised groups with the name of the body part whose touch sensation they handle. It we map the somatosensory strip to complete body with body parts occupying larger portions of strip appear larger in size than rest of them, then that model is called a "Homunculus". Individuals with stroke or damage to one half of the parietal lobe experience "Hemispatial Neglect" in which a patient completely ignores one side of their visual field. Left Hemispatial Neglect is more common, since in this case, the right hemispheres' parietal lobe is damaged, and the left hemisphere is already so much overloaded with computations such as for language that it can't take any of right hemisphere work hence it can't be healed easily. While for Right Hemispatial Neglect, the left hemisphere parietal lobe is damaged, now the right hemisphere can accommodate some of the functions performed by the damaged lobe of left hemisphere, hence this will heal in this case. Patients with hemispatial neglect will never be able to perceive one side of their visual field, e.g., a person wanting to draw a house may draw only one side of it. Note that the visual system is still infact, meaning the signals are still travelling to occipital lobe but when passed on to parietal lobe, no meaningful conclusions are drawn hence no information is perceived from one side, and person perceives only one side of it.