Lecture One - *Monday 1st March*

Brain

- Average Human brain weighs about 1300-1400 grams
- Only takes up 2% of total body weight
- But it uses ~20% of energy demands of the body

The brain is the organ of **interpretation** and **prediction**

The brain is continually taking in sensory data, energy from the outside world, converting it into a form that you can make sense of, integrating that information with previous experiences and then making predictions about what might happen next. Brain has evolved to predict what might happen in the future, and enhance our chances of survival because of predicting upcoming events.

Interpretation:

Smell
Outside our own bodies, there is no such thing as smell and it's the way we interpret and response it. e.g. bad smelling meat is a warning system for our bodies, to be like don't eat this meat.

Colour
Colour also doesn't exist outside our nervous system, all there is, is light energy at different frequencies. Our nervous system interprets them as reds and blue etc. Dependent on the frequency of light that is bouncing off surfaces.

Animals and aliens could come and interpret colours and smells differently, it just depends on the make up of their nervous system.

Interpretation:

Pareidolia - seeing faces in inanimate objects. This happens cause faces are so important for humans and provide an enormous amount of social information about what is going to happen next.

Your brain is continually making predictions about:
- *what is gong to happen next?*
- *What, of the current information available to me, is most likely to be most useful?*

past experience (memory) is most useful in guiding these processes

On-going Theme of Psyc
- All our thoughts, experiences and actions are the direct reflections of the activity of the brain
- The brain is a physical system operating according to physical laws
- The mind a product of brain activity

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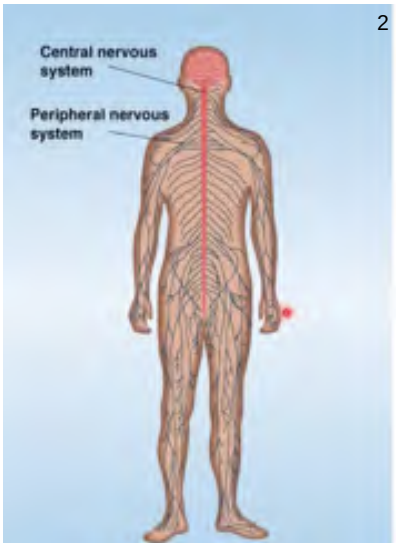
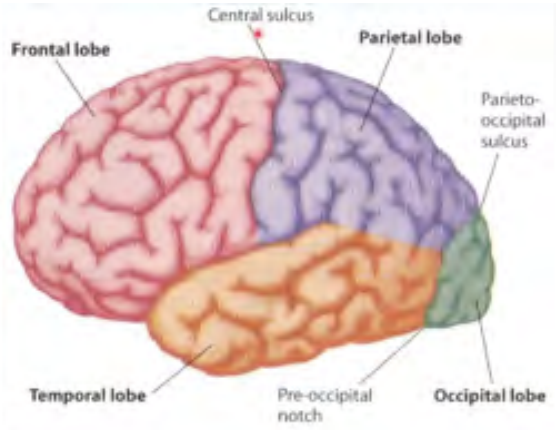
Nervous Systems
Nervous system involves the brain, the spinal cord and all the nerves that are carrying information out to muscles so that we can move, breathe and make decisions

Nervous system can be divided into two parts - Central Nervous system (brain and spinal cord) and Peripheral Nervous system (carrying information to muscles or collecting information and carrying it to the central nervous system)



The four lobes of the human cerebral cortex

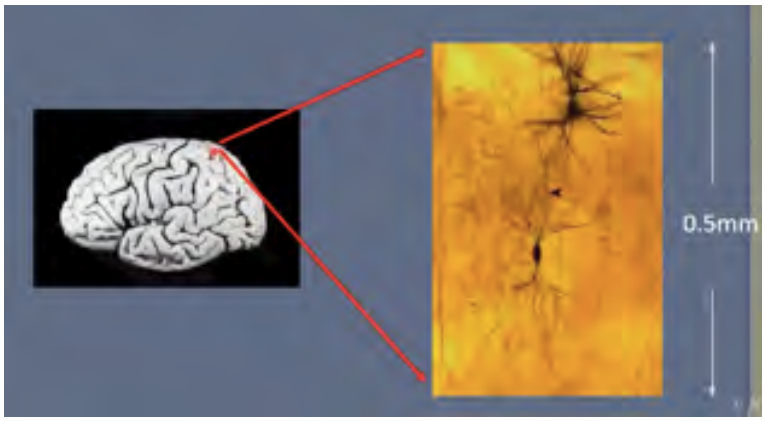
- **Frontal Lobe -** decision making
- **Parietal Lobe -** move through space, make movements relative to our bodies
- **Occipital Lobe -** visual system processing
- **Temporal Lobe** - memory



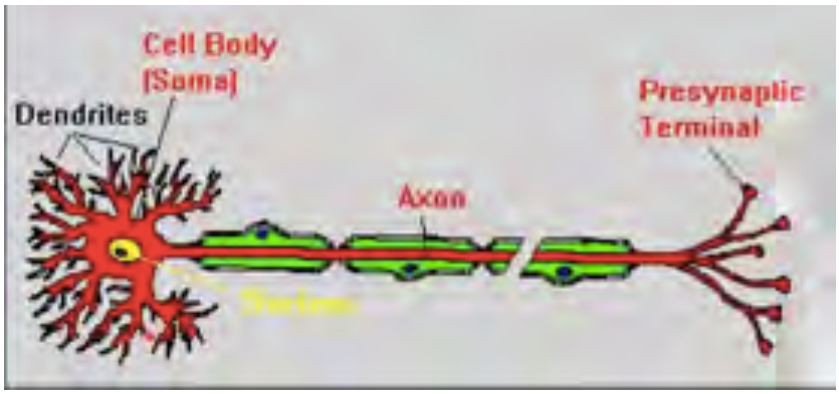
What are the brain's processing units?
- Neurons (specialised nerve cells)
  - Neurons allow you to see, hear, move, have experiences, to smell, to have emotions etc

Approx. 85,000,000,000 (85 billion) in the average human brain - each makes between 100-10,000 connections with others

So not only a massive number of processing units in the brain but also each of those processing units are able to communicate with each other. Those connections allow you to behave in different ways etc



The main components of a neuron



Axons can vary in length because it can project information from different parts fo the body - can be up to a metre in the peripheral nervous system.

Information flow

The key to information processing in the nervous system is the simple fact that:
The inside of a neuron is negatively charged compared to the outside

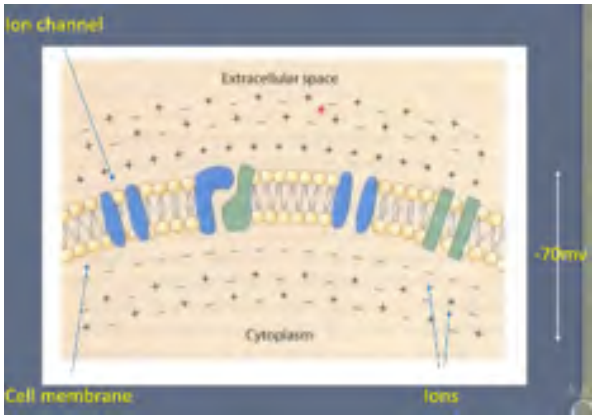
Resting Membrane Potential (RMP) - around -70mV

Information is transmitted within the cell by transient alterations in the membrane potential
- Those alterations are the opening and closing of ion channels

Dendrites ——————————————————————> axon

Input ——————————————————————> output

Membrane:



Outside the cell - **Extra-Cellular Space**
Inside the cell - **Cytoplasm**

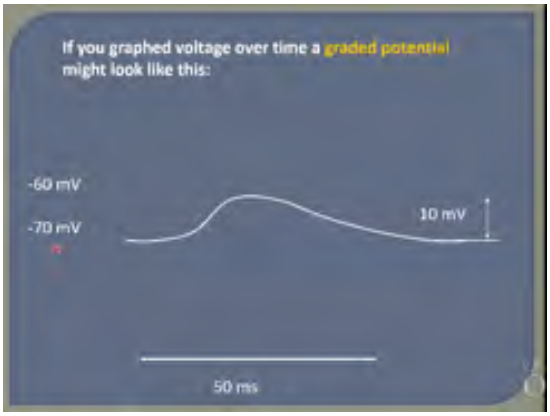
Negative charges sitting inside the membrane
Positive chargers sitting just outside

The difference between those charges are about -70mV

When the channels start to open the difference in the voltage changes, depending on whether positive or negative ions travel - if positive ions travel through to the Extra-Cellular Space, the voltage will become more positive

Within dendrites this 'pulse' can vary in size i.e. it is a <u>graded potential</u> (when ions move through the channels) - *magnitude of the single coming in changes the pulse*

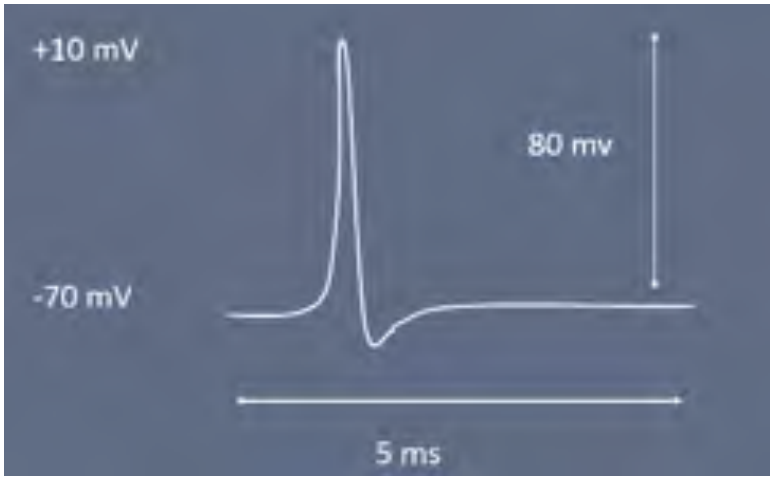
Pulse of activity can be generated at the presynaptic terminal by either another cell sending a message to it or that cell is communicating directly with the outside world.



Integration of information can occur in the dendrite by the ***spatial (the summing of two inputs in different places) or temporal (first one and then second one at one place) summation*** *of graded potentials*

Within the axons this 'pulse' is all or none *(an action potential)* depending upon whether it reaches a threshold level of intensity at the initial segment (or axon hillock). That is called an all or none potential, or commonly known as an action potential (AP)

If you graphed voltage over time an **action potential** might look like this

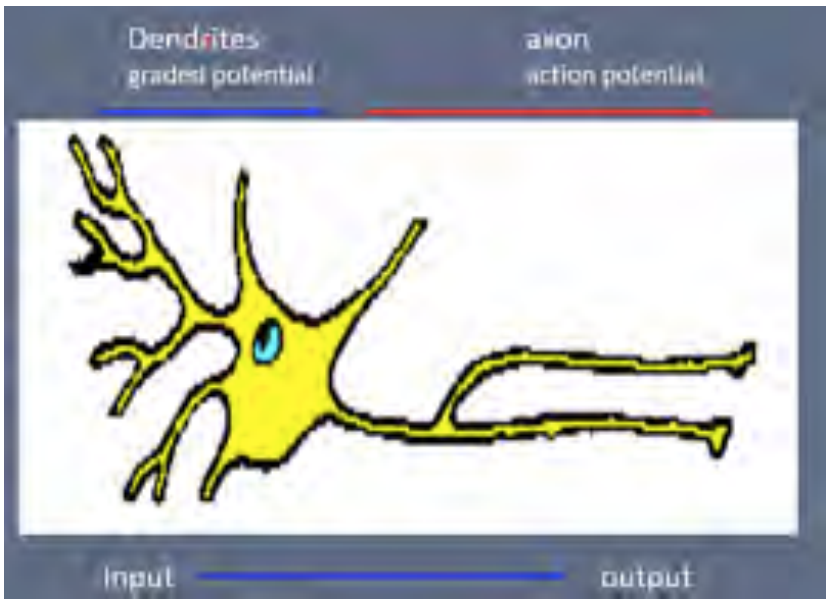


Input at the dendrites, which produces graded potentials which travels down at the axon hillock, where there is a threshold for the generation of an action potential. The graded potential has to be sufficiently large for there to be the generation of an action potential. Action potential can travel long distances.

Porcupine Fish release a toxin in the spikes causes the action potential to be disrupted.

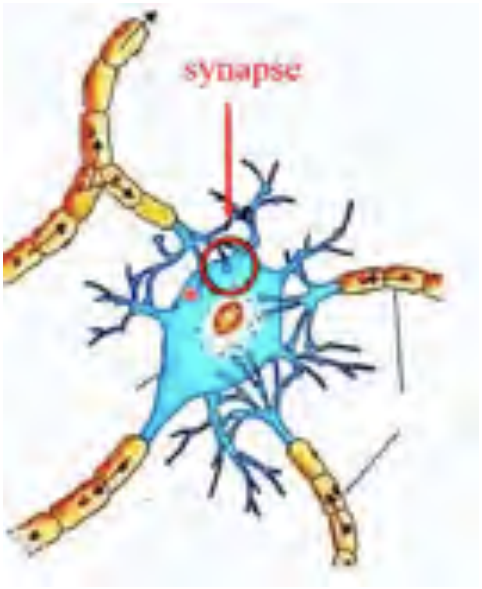
Puffer Fish has a toxin called **Tetrodotoxin (TTX)**
10,000 times deadlier than cyanide
Approx. 200 cases of poisoning per year - from Fugu (50% fatal)
- you can eat this fish but if not filleted properly can be fatal
Blocks ion flow through channels that generate action potentials
Become paralysed, so can't breathe

Summary: Information is transmitted within the cell by transient alterations in the membrane potential



Lecture Two - Wednesday 3rd March

Neurons, Neurotransmitters, Drugs and Mental function

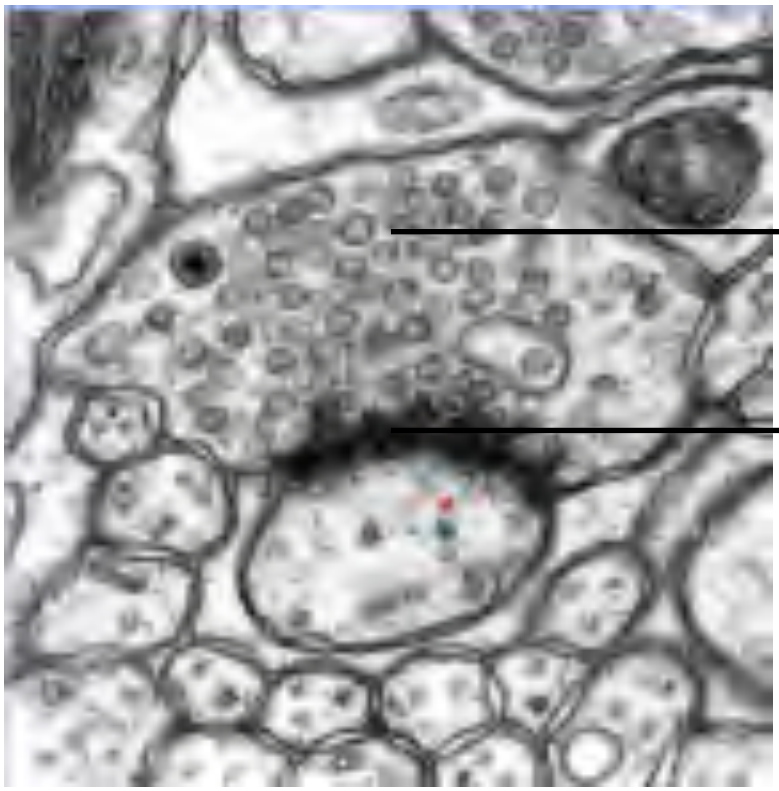


Synapse - where the cell junction is and information is passed

Synapses - The special junctions that neurons communicate with each other across.

When an action potential arrives at an axon terminal a special chemical called **neurotransmitter** is released at the synoptic cleft

Receptors at the postsynaptic neuron reopens to the neurotransmitter and generate a **graded potential**

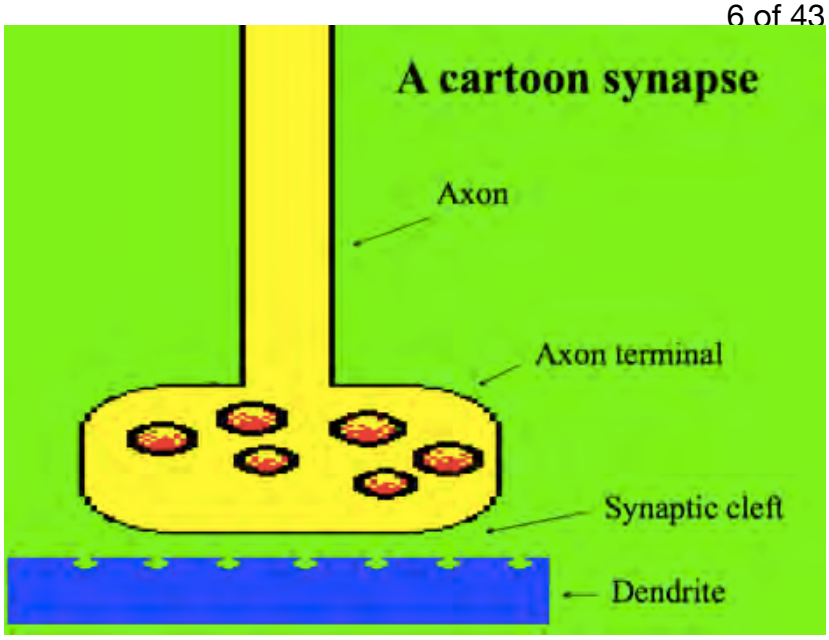


Vesicles - the structures that hold the neurotransmitter

Neurotransmitter synthesised and then stored i vesicles

dark area - synapse

1. AP travels down an **axon**
2. It causes the vesicles to move out towards the **synaptic cleft** to merge with the **membrane** of the cell
3. This releases the molecules of **neurotransmitter** which then binds with these **receptors**
4. A **gradual potential** is produced
5. The **neurotransmitter** doesn't sit round in the **cleft**, after a period of time, it will flow out of it and and be taken back up into the **axon terminal** and it will be remanufactured into more **neurotransmitters**.



Neurotransmission at synapses

Drugs can have an effect by altering the way that the neurotransmitter:

- synthesis
- storage
- release
- binding
- re-uptake

Agonists

- Drugs that bind to a receptor of a cell and trigger a response by the cell are.
- Often mimics the action of a natural occurring substance.
- **An indirect agonist** enhances the release or action of an endogenous neurotransmitter.

Antagonists

- Drugs that block or suppress agonist-mediated responses

There are a number of different neurotransmitters in the brain:

e.g. **acetylcholine** - activate muscles, neuromuscular junctions release acetylcholine, also important for memory
dopamine
noradrenaline - levels of activation, nervous system being activated
glutamate - thinking, rapid thought processes and responding
serotonin - regulating mood

e.g. At the cholinergic synapse (a synapse that uses neurotransmitter (acetylcholine):

agonists (active/increase responses):
- Nicotine
- Black widow spider venom

antagonists:
- Scopolamine - *(cross brain blood barrier and decrease the transmission of the central synapses that use acetylcholine, helps with sea sickness, it suppresses the vestibular signals so that you feel less nauseous)*
- Botulinum toxin - *surpasses your ability to control your muscles and you have paralysis, you become relaxed*

The effects of changes in neurotransmission I:
Parkinson's disease

- disorder of movement
- affects approx. 1% of the population
- develops as you get older
- tremor
- muscular rigidity
- slowness of movement (bradykinesia)
- postural instability
- involuntary shifts of posture (dystonia and dyskinesia - drug side effects)
- shuffling, wide-based gait with forward leaning posture
- leading to festination (start moving faster and faster)

DBS (Deep brain stimulation) - Two probes are dropped deep in the brain and hooked up via a wire in the neck through to a pace maker in the chest. This provides a steady stream of electricity to the brain per second.

The effects of changes in neurotransmission II:
Schizophrenia

affects approx. 1% of the population

Positive symptoms (new psychological experiences outside normal range)
- delusions - e.g. thinking you're someone famous or aliens are communicating with you
- hallucinations e.g. auditory hallucinations (voices speaking to you)
- disorganised thinking

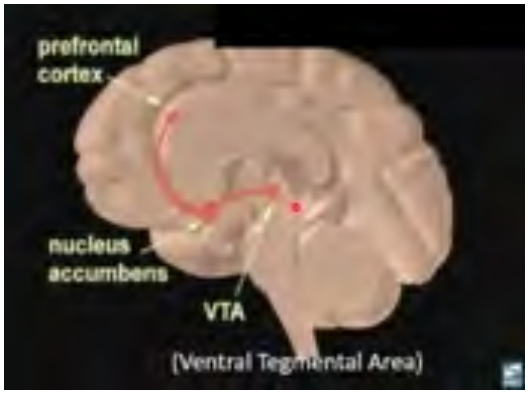
Negative symptoms (loss of normal function
- blunted affect (reduction in emotional response in situations)
- poverty of speech and thought
- apathy (no longer care about yourself or what other people think of you)

Cognitive symptoms (changes in cognitive function)
- poor working memory
- disruption in executive function and attention (difficulty in planning on what you do with the day)

Both Parkinson's disease and Schizophrenia seem like two very different diseases but are linked together by a neurotransmitter

- Dopamine antagonists have anti-schizophrenic effects
- These drugs produce Parkinson symptoms
- PD is associated with degeneration of the *substantia nigra* a midbrain nucleus with output neurons that release dopamine
- PD can be treated with dopamine agonist e.g. L-Dopa and Bromocriptine
- Dopamine agonist (Amphetamine, cocaine and L-Dopa) trigger schizophrenic episodes in normal individuals

PD is treated by boosting dopamine, Schizophrenia is treated by drugs that suppress dopamine



The actions of some psychoactive drugs at the synapse:
Coffee - adenosine antagonist, when levels of adenosine are high in your brain you will feel sleepy, caffeine is getting into your nervous system and suppressing the transmission at those synapses that use adenosine and then you more alert
Marijuana - THC receptor agonist
LSD - suppresses serotonergic neutrons
Prozac - serotonin reuptake inhibitors (SSRI) - mood is enhanced because the serotonin is sitting in the synapse for longer
Ecstacy - (MDMA) serotonine agonist (+na. +dop.)
Cocaine - dopamine agonist

Lecture Three - Friday 5th March

Simple Neural Circuits and Memory

Dopamine is of interest not only because of its involvement in Parkinsons's disease and schizophrenia but also because of its connection to many drugs of abuse.

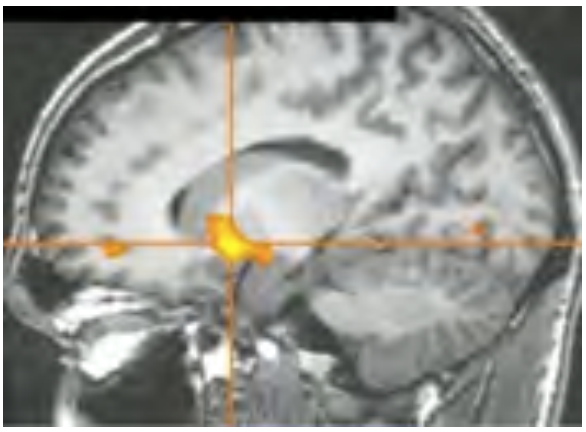
Intracranial Self-Stimulation (ICSS)

- Intracranial self-stimulation (ICSS) appears to produce a pleasurable effect in animals (including humans)
- ICSS activates dopaminergic pathways including the nucleus accumbens and VTA
- An animal in an operant chamber. A lever on the wall that is connected to an electrical stimulator, when the lever is presses the stimulator produces a few brief pulses of electrical activity, which is capable of activating neurons which causes them to produce APs.
- First time the animal pressed the lever, they received stimulation and very soon afterwards they would go back to the lever and within a short time they would be pressing the lever over and over again until they fell over exhausted.
    - Electrode is turning on dopamine neurons in particular areas and when those dopamine areas are activated, the animal experiences a very pleasurable situation so is quite happy to sit there and keep pressing the lever.
    - It was the same sort of feeling as drinking or eating after being hungry/thirsty but the only difference is that they didn't become full instead fell over from exhaustion.

The animal is prepared to get heavily shocked to experience the pleasure of the lever. But an animal who was thirsty would not be prepared to run across to get a shock.

Other tests include: A maze being in a T structure, the mouse runs up and at one end of the T, there is the lever and on the other side there is a female on heat, but the mouse would always prefer to go for the lever. Or water if the mouse was thirsty, it wouldn't go for water.

Around 50% of the neurons in the VTA are dopaminergic. The VTA projects to a number of regions including the nucleus accumbent and prefrontal cortex.



The human reward system (e.g. VTA and uncles accumbent) is activated by a wide range of reinforcers including food, sex, money, drugs of abuse, beauty and humour.

The initial studies on humans and animals with the ICSS, was not popular for a period of time because of the ethics of it, and now the DBS has become more popular because of Parkinson's. Recent pre-clinical and clinical trials suggest that Deep Brain Stimulation in areas including the nucleus accumbent may be effective in moderating treatment-resistant depression.

Neurons are the basic functional units of the nervous system

Q -How is complex behaviour produced?
A - The nervous system relies on the operation of networks of neurons to produce complex behaviour

The simplest behaviour-production network is the reflex.

The reflex

A simple automatic response to a stimulus

- stereotypes
- subconscious
- unlearned

e.g.
- eyeblink
- swallowing
- pull dilation/constriction
- piloerection
- photic sneeze (10% population)

Background Information:

There are several million neurons concerned with the generation of movement but all of the commands to muscles are communicated through approx. 400,000

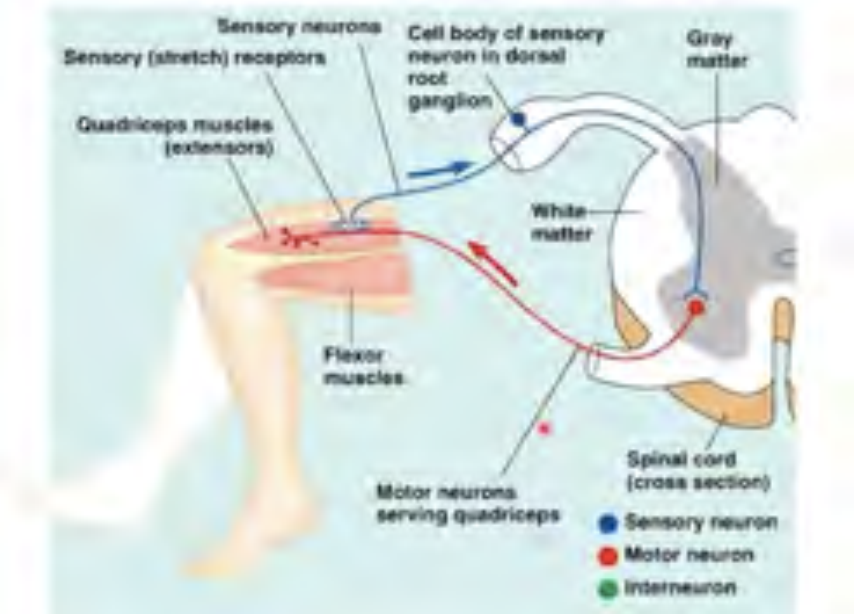
alpha motor neurons - the neuron that takes the messages from the nervous system and communicates it to the muscles.

Muscles are composed of muscle fibres and can produce force by contracting and they will contract when a signal goes through the alpha motor neuron.

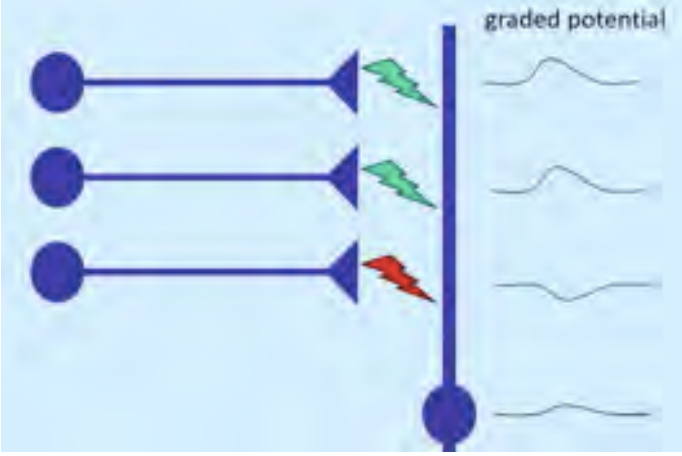
Monosynaptic Stretch reflex - operates in a number of joints

When the muscle contracts, then the knee will extend, doctors will check this reflex by tapping on your knee

Quad muscle, axon terminals for the alpha motor neuron



Synaptic excitation and inhibition

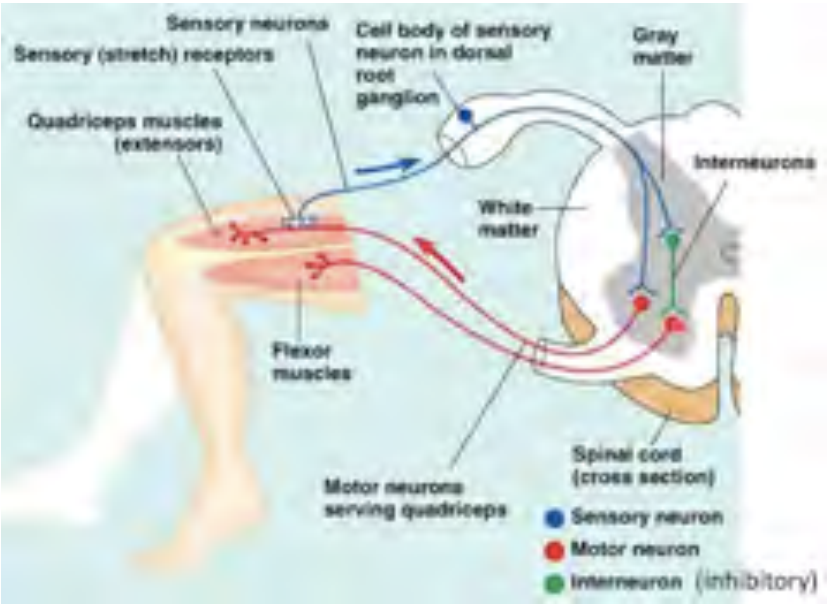


Transmission of information:

- excitation (green) - makes it more likely that this cell is going to fire

- inhibition (red) -makes it less likely that this cell is going to fire

Polysynaptic Reflex



Every time you send a signal for one muscle of contract you also send a signal to the opposite muscle to relax

A few other reflexes of note:

- Grasping
- Suckling
- Vestibulo-Ocular Reflex (VOR) - modifiable
  - Stable gaze and allows your eyes to move in a different direction to your head

Inhibited by maturing brain, but may be *disinhibited*

- If person is in a car crash and the doctors test those reflexes and they grasp etc it will be an indication that some sort of damage has occurred and disinhibition of the reflex.