

**First Session**

**Introduction**

- No two brains are the same
- 9.2-13.8 billion by end of century
  - even with this increase in population, every brain is different
- Approx. 90 bn. people have ever lived
- Brain is not the size of two clenched fists – bigger than you'd assume
  
- People wake up during open brain surgery sometimes
- Have to stimulate area around brain tumour to see how much they can afford to lose
  - As no two brains are the same people may have more or less room for error
  - Don't need to give anaesthetic to brains there are no loose nerve endings
  - Can produce religious and quasi-religious experiences through stimulation during brain surgery
  - Angular gyrus – can make you feel like you're floating above body on table (when poked during surgery)
- Not all brain cells are neurons
- Neurons change every day so your brain today is not the same as your brain was yesterday
- Brain is not a static organ like a kidney – they change in response to your environment
- Memories alter the structure of our brain
- Genome makes the brain how it is when you're born, but your environment creates memories and situations that alter and shape our behaviour and brains
- I.e. car crash damage to frontal lobe = changes in behaviour – sometimes permanently
- Food that you eat will affect how your brain works
- In psych departments, research – trying to change function by altering diet

**Structure**

- Cerebral cortex
  - Outer 2-6mm of the brain
  - Decision making, reasoning, thinking, expressing emotions, motor, personality, semantic memory, working memory
  - Plethora of psychological functions that this outer region is engaged in
  - Other animals don't have the same level of function
- Oversimplification of function – i.e. there is no "memory centre"
- Cerebellum
  - At back of brain
  - Balance, fine motor movements

- Basal ganglia
  - Drives habitual behaviour
- Brain stem
  - Top of brain stem – areas involved in sleep
- Hippocampus
  - Gateway to memory
  - In cases of hippocampus – there are major effects on memory
  - **Clive Wearing**
  - *Herpes simplex* virus got into his brain – into his hippocampus
  - He could no longer form memories after the point of damage – his long term memory was unharmed – could remember he'd gone to university as an organ player and knows he's married to his wife
  - He writes in diaries every thirty seconds that he's "waking up for the first time"
  - He's frustrated because he knows something is wrong but he doesn't know what – has been told about his brain damage but forgets
- Amygdala
  - Ability to recognise emotion in other people's faces
  - Neurodevelopmental disorder – autism – affected by the amygdala
  - Autism – children like sameness
    - Can go into the room of an autistic child and move something, they may probably notice
  - 5 mothers with autistic children (4/5 boys)
    - one mother demonstrated her son's inability to make eye contact by putting him on her lap and gently turned his face around to face hers – he looked everywhere but at her
  - Speaking of boy with Asperger's – unable to deal with optician as the idea of someone looking into his eye made him incredibly uncomfortable
  - Microsoft and Google – changing their interview process
    - No longer judging applicants if they don't make eye contact – they are aware that a lot of their employees are autistic/have Asperger's
    - Used to be a running joke that an Oxford dept. was entirely autistic

### Cannabis

- Cerebral cortex, hippocampus, amygdala, corpus callosum are most affected by cannabis
- Our age group are the most vulnerable to the effects of cannabis
- Cannabis in 60s/70s/80s was nowhere near as powerful
- Nowadays – it can be almost 20x stronger
- 7 y/o in Birmingham who smokes skunk
  - if smoking weed at 7 – heroin by 18 (more likely)
- start using at 15 – using for three years – significant alteration to brain structure
- Filbey (2016) – those who began using marijuana at the age of 16 or younger showed brain variations that indicate arrested brain development in the prefrontal cortex

- Can lower ability to make decisions – lead to incapacity to control expression of behaviour, and make logical decisions
- Active ingredient in cannabis (THC) will bind to receptors in brain and cause changes over time
- If you have (or have close relatives with) schizophrenia, anxiety, bipolar, depression, would recommend staying away from cannabis as it especially affects those groups
  - History of mental illness
- Those who started using marijuana after age 16 showed the opposite effect and demonstrated signs of accelerated brain aging

#### So, what is the difference between the ages of those brains to cause that difference?

- Brain becomes myelinated – greater degree of control over emotional expression
- Brain itself isn't changing that much but you become more able to control it

#### Final notes on cannabis

- + Anti-emetic – makes you feel less sick
- + Can be used with cancer patients
- - Can be the kick starter for schizophrenia
- - Nowadays 64% of schizophrenics use cannabis – people may self-medicate with cannabis “it takes the edge off”

#### Nerve Cells and Neuroplasticity

- Neuron – difference between other cells – has the axon
- Action potential along axon – messages can travel faster along a myelinated axon than along a non-myelinated axon
- Measure electrical waves of brain processing using EEG
  - Wakefulness – relaxed state
  - Stage 1 sleep – theta waves (4-7 Hz)
  - Stage 2 sleep – sleep spindle (11-15 Hz)
  - Stage 3 sleep – slow wave sleep (0.5-2.0 Hz)
- Synapses are “spring cleaned” at night – if you don't get enough sleep then amyloid (a protein) isn't cleared out from the brain – amyloid is associated with Alzheimer's

#### Synapse

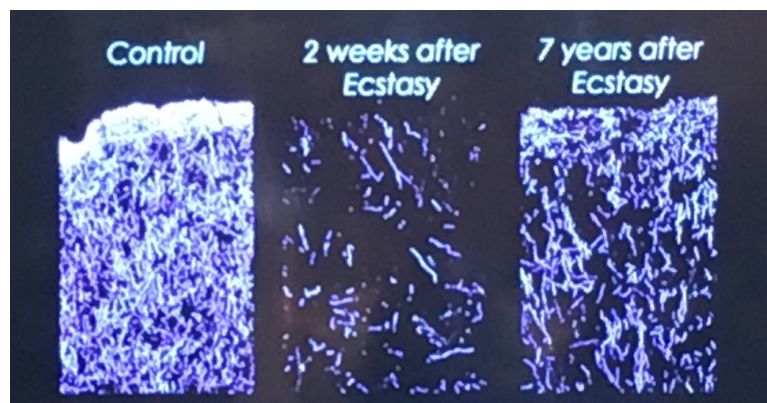
- Around 100 neurotransmitters – different chemically and associated with different psychological functions
  - Serotonin – sleep and others, but also drinking
  - Dopamine – emotion, thinking, movement
- Be lucky if we have an Alzheimer's treatment in the next 10 years, probs more likely 20
- Only the active zone releases neuro transmitters
  - Like a rain shower, sprinkling of neurotransmitters – about 10 locations dotted across active one
  - About 100ms must pass before an individual site can be used again: neurons often fire at 50-100s

- **Marmite**
  - A teaspoon of marmite every day for a month, compared to a teaspoon of peanut butter was associated with a 30% reduction in the brain's response to visual stimuli measured by EEG.
  - This may be due to the levels of vitamin B12 which in turn increase the levels of GABA – which is inhibitory
- **Neuroplasticity**
  - Neurogenesis – continuous generation of new neurons in certain brain regions
  - Neuroplasticity can result from
    - Traumatic events – 9/11 – 10,000 new Yorkers were diagnosed with PTSD, 6,000 being treated still today
      - people had to decide whether they jumped or burned to death
      - 200 people were jumpers
      - emergency workers witnessed the explosions of jumpers – as when you hit the ground there is nothing left of you
      - these witnesses and survivors hear “the sound of the jumpers”
      - such difficulty treating PTSD as it creates a physical change in brain
    - Exercise – after even 20 minutes - release of BDNF into brain
      - 2 hours of exercise a week – breaking a sweat – 9% decrease in cancer mortality
    - stress
    - social interaction
    - meditation
    - emotions
    - learning
    - paying attention
    - diet
    - new experiences
  - NASA recruiting neurosciences and psychologists to work out what will happen to brains of astronauts who are going to mars – effect of radiation
  - Planet similar to earth – 8 lightyears away
    - What would happen to brain on the way?
    - Astronaut selection – need to be socially and psychologically stable – don't want them to get into arguments in space shuttle/space station
  - When travelling through space would the exact things that you were selected for change in space due to brain changes
  - Brain changes function and shape in space as seen by fMRIs

## Drugs

### Ecstasy

- Rave drug developed in the 1990s
- “love drug”
- mdma, mdea
- rarely will get straight mdma – if you try to buy some “ecstasy” will be made up of ketamine and other drugs
- serotonin present in cerebral cortex neurons
  - animal researchers very rarely *want* to do harm to animals, due to ethical reasons and also that if an animal is in pain it can be a confounding variable
- Sections taken from the neocortex of monkeys that were given ecstasy twice a day for four days (control monkeys were given saline)



- Ecstasy punctures hole in blood/bone barrier – makes things that normally can't get into the brain are then able to get into the brain
- Makes membranes permeable throughout whole body not just in brain – as the drug diffuses into the blood stream

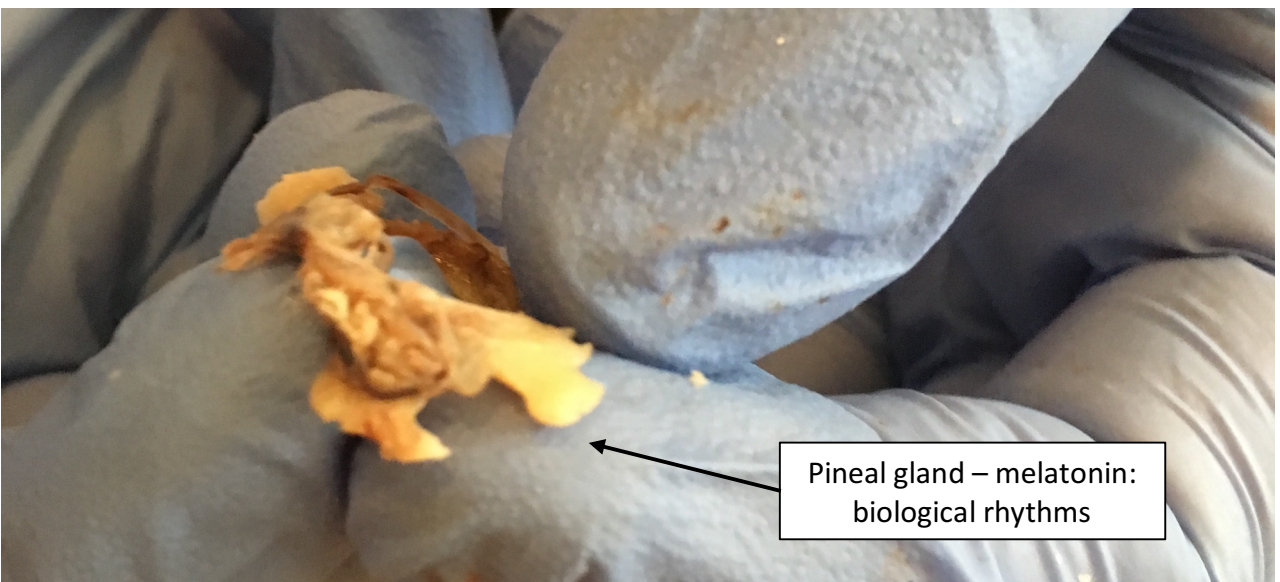
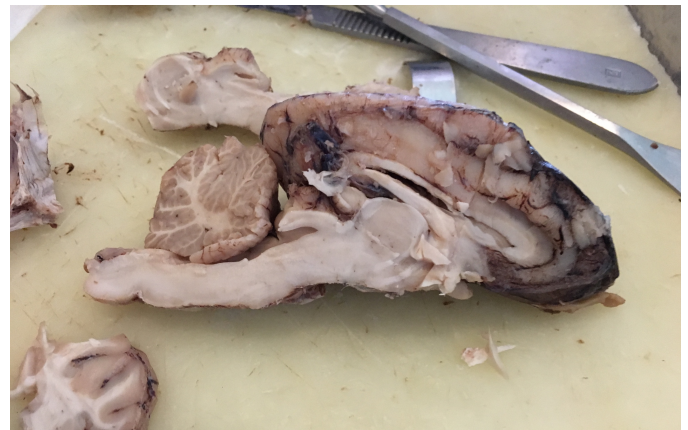
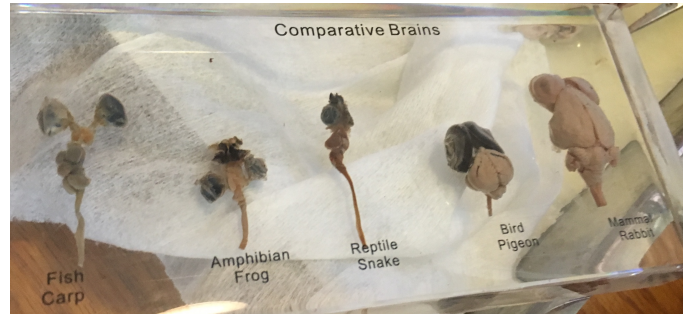
## EPIGENETICS

### Chromatin

- If chromatin is open – we can see DNA through histones
- If it is closed – the DNA is trapped inside – can't get to the gene to be used – either by the body or by biologists
- Inside chromatin can be GR gene – helps body to get over periods of stress
- Rats that are licked by mother rats grow up to be healthy, functioning rats; those that weren't grew up to be anxious rats that couldn't deal with stress
- By stroking baby on cheek, back, arms, legs – can make the baby more able to cope with post birth stress
- Post WWII – changes passed on from mother to child in CR1 gene –linked to stress response. If traumatised before even pregnant – can be passed on to your child increasing risk of mental illness due to the stress
- 14 generations in animals – passed down
- Women who weren't pregnant but were traumatised by 9/11 – had a higher level of children with mental illness

- Women in *Denmark*, who watched news and read about 9/11 while pregnant had babies that were born 50 ounces lighter – due to release of cortisol; a stress drug, causes a decrease in appetite and also takes fat away from the foetus and to the mother – “double whammy”

## Dissection



## POST LUNCH

### Frontal Lobe

- Broca's area (left) – language
- Higher thinking
- Decision making
- Personality

### Temporal Lobe

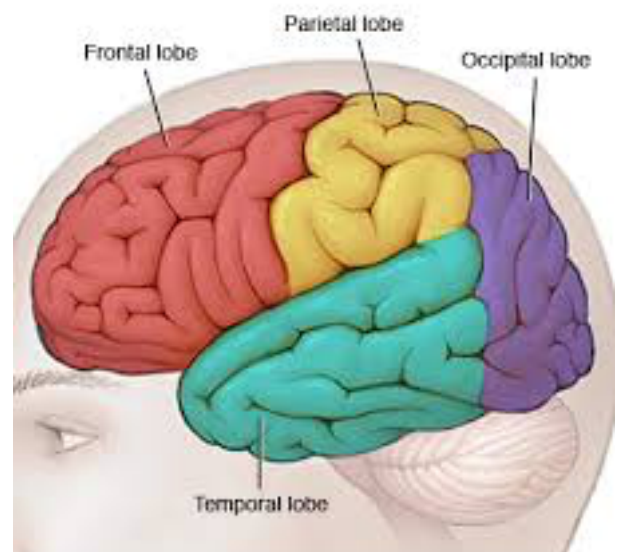
- Object recognition

### Parietal Lobe

- Image processing

### Occipital Lobe

- Visual processing
- Once an image is produced the information is then sent forward to the parietal and temporal lobes



### Auditory Agnosia – agnosia (without memory of)

- May hear a fire engine and not understand that it is the sound of an emergency vehicle

### Different types of agnosia

- Facial recognition – may be looking at a photo of themselves or of their child (for example) and may just describe their features but not actually recognise the face

### Frontal Lobe

- How we initiate activity in response to environment
- Judgements we make about what occurs in our daily activities
- Control of emotional responses
- Control of expressive language
- Memory for habits and motor activities

### Areas involved in Language

- Broca's area + Wernicke's area
- Broca – first person to discover that cancer cells can spread in the body
- Broca – discovered the area through the post mortem of a man who could only say one word "tonk" (?)
- Broca's Aphasia – words are stammered out and really struggle to get the words out – however the words are often accurate
- Wernicke's Aphasia – they produce fluid speech but the words make no sense – can create new words

- A type of Aphasia that causes people to only be able to say words that they understand – for example, if you ask them to repeat the word “blange” they wouldn’t be able to repeat it due to its lack of meaning. However, if they asked them to repeat the word “cigarette”, they would be able to repeat it without issue as they understand the meaning

#### Are male and female brains wired differently?

- Females – greater degree of interhemispheric connections
- Males – greater connectivity between front and back, but lesser interhemispheric connectivity
- The press interpreted this to mean that this was the reason for “women being better at multitasking” and “men being better at map reading”
- So important not to stray from your results and apply this to things that aren’t actually applicable
- Differences between sexes’ brains aren’t that visible before or during puberty
- “there are less differences than some would like, and more differences than some would believe” – speaking on sex differences
- does being more in touch with your feminine side mean that you have a more female brain?
- Emerging science of transgender brains – MtF transgender people show different brain wiring to FtM transgender people

#### We can now scan foetal brains as well as adult brains

- Prenatal prognoses of babies’ wiring scans – “from the current brain scan of your child, there is a 46% chance of your child developing schizophrenia in its later adolescence”
  - Is this a good idea? – due to the current schema of schizophrenia

#### The brain organoid

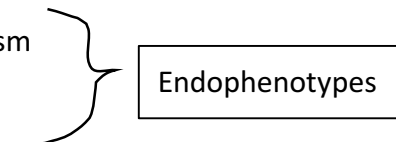
- Once you start the process of a brain developing – it begins to go off on its own
- If we are creating these brains are we creating consciousness?
- What is consciousness? Are animals conscious?
  - Scientists would believe that worms aren’t conscious
- Scientist has looked at amoebas with high speed camera – can put a food source down and they rush towards it – move the food source away at the last second, they seem to pause, discuss, regroup and continue back to the new position of the food source
- Just because animals can’t communicate thoughts – doesn’t mean that they don’t have thoughts



- This research for consciousness isn't to do with the need to understand animals – it's so we can understand more about humans
  - Whether or not / at what point foetus' have consciousness
  - Coma patients – do they have consciousness – EEGs show not having any brain activity but coma patients can be asked to imagine playing a shot in tennis if they are in pain, and imagine walking around in their home if they're not – and brain scans can show electrical activity showing these areas being activated
  - Death

Is there a criminal brain?

- Predisposition vs. environment
  - Often the two must come together – environment affects people differently so maybe this suggests that the predisposition could have a larger impact on this
- Depends on the definition of crime
- There is no genetics of crime
  - But there is a genetic of alcoholism
  - Genetics of addiction
  - Genetics of risk taking



Examples of Brain Regions Associated with Pro-Social Behaviour

Brain Region	Pro-Social Behaviour
Anterior cingulate cortex	Empathy
Orbital PFC	Regret
Ventromedial PFC	Ethical/moral decisions
Ventrolateral PFC	Inhibition of behaviour
Dorsolateral PFC	Reasoning

Herbert Weinstein – murder or manslaughter?

- American law holds people criminally accountable unless they act under duress (i.e. with a gun pointed to their head) or if they suffer from a defect in rationality (i.e. not being able to tell right from wrong)
- 65-year-old man (Herbert Weinstein) – strangled his wife to death then threw her body out of their 12<sup>th</sup> floor apartment window, to make it look like suicide
- His lawyer suggested that he shouldn't be held accountable for his actions because of a "mental defect" – this was a cyst in his arachnoid membrane that was revealed through a brain scan
- The prosecution didn't think the evidence of the cyst should be admitted in court. The judge said that the defence could tell the jury that they had identified a cyst with brain scans, but not that these cysts were associated with violence. The prosecution however was concerned that even showing images of Weinstein's brain could've caused the jury to change their decision.
- On the morning of jury selection (11 days later) the prosecution agreed to let Weinstein plead guilty in exchange for a reduced sentence for manslaughter, rather than murder.

### Donta Page – his death sentence was changed to a life sentence

- Donta Page (black man) brutally raped and murdered a woman
  - Was taken for brain scans and was found to not have a fully functional brain
- His childhood
  - His mother repeatedly beat his head against a wall – often went to hospital
  - His father beat him after returning home drunk
  - His mother strangled him with an electrical cord until he couldn't breathe – while he was passing out she would loosen it, he would gasp for air, and she would tighten it again
  - His mother decided that she didn't want to look after him anymore so left him at his grandparents – where he was raped (aged 10)
- He was left with no feelings of empathy due to his prefrontal brain damage from childhood – also lack of morality

### Michael – paedophilia

- Was a teacher who was perfectly normal – until his behaviour started changing and was found to be abusing his wife and daughter as well as taking child pornography to school
- He was prosecuted with the abuse of his daughter and the pornography was uncovered
  - He was asked to choose between going to prison or going on a treatment program
  - He chose the treatment program – knowing what happens to paedophiles and sexual offenders in prison – often killed or at least brutally abused
  - He didn't last two weeks in the course as he began to proposition one of the female leaders there
  - He was then to be taken to prison and was in a holding cell when he complained of a headache and looked ill – so was taken to the hospital where he urinated in his trousers during his examination and showed no concern

### **LACK OF JUDGEMENT – I.E. URINATING, SELF-DEFECATION = ISSUE WITH PREFRONTAL CORTEX**

- They then conducted a brain scan and found a tumour in the frontal cortex behind his eye the size of an orange, was removed and was then back to normal, returned home (controversially) to his wife and daughter
- Until 8 months later, his wife found a folder of recently downloaded child pornography on his laptop – she checked due to his relapse into odd behaviour
- He returned to hospital and they found that the tumour had begun to regrow
- Was then removed again and he has since (as far as we know) remained his usual, non-paedophilic self
- Did Michael's tumour lead to his paedophilia? Does this suggest that all paedophiles have some sort of orbitofrontal dysfunction in the brain?
- Could it be that Michael was born as a potential paedophile, but with a working frontal lobe he could moralise that this was the wrong thing to do? But when the orbitofrontal lesion developed and impacted on the orbitofrontal circuits – his capacity for behaviour control was taken away? Leaving the previously dormant paedophilic behaviour able to take control?

- Difficult to answer any of these questions due to difficulty in understanding criminal behaviour – biological and environmental factors leading up to these behaviours
- There isn't a *criminal brain* but there are case studies showing brain damage leading to free will being taken from individuals, which lead people to commit criminal acts
- Research done at University of Exeter – over 60% of all violent offenders have some degree of brain damage
- It's so difficult to generalise because no two brains are the same – so the role of the court is to take each case and treat it as an individual issue
- Research suggests that our brains complete an action before our conscious is aware of us doing that action – almost as if the subconscious says to the conscious “here you go, have the illusion of free will”
  - However, this lack of free will will never stand in court because the whole foundation of the justice system is the idea of us having free will – thus we can be held responsible for our actions

## Neurobionics

- (2012)
- Electrodes over the surface of the scalp
  - Words like “deep” “jazz” etc. – then measured the brains response to these words, measure brain activity as you hear those words
  - They then ask the ppt. to think the word – when you think of the words you get a very similar pattern of brain activity as when you hear it
    - Thus, researchers can tell what word you were thinking of based on your brain activity
  - Rig this up to a computer that can recognise patterns in brain activity and then it can say the word that the brain activity matches with
    - You think of the word “deep” and the computer says the word “deep”
- More recent research (2017)
  - It also works with sentences
    - “The witness shouted during the trial”
    - “The student thought of the brain”
    - Produce different brain activity when thought of
    - Thus, researchers can see which sentence you were thinking of
- Beginning to enter an era of mind reading
  - Possible applications (good/bad)
  
- Mental control of robotic limbs
  - Returns movement to paraplegics
- By thinking about it people can pick things up
  - Can now implant wiring into limbs to replicate electrical impulses from brain reaching muscles
- The aim is to get people who have lost limbs or feeling to be able to function fully again
  - Example of man who is paralysed below the bottom of his back – no use of legs, with bionic legs he could be able to walk again without assistance, thinks about using his legs and can move them
- Last year, it was demonstrated that through EEG activity, it is possible to switch on genes
  - Could in theory use our own thoughts to switch on our genetic material
  - Could have incredible implications for treatment of illnesses – as in future could possibly switch on parts of our immune system in order to prevent or treat certain illnesses

## Schizophrenia & The Shattered Mind

### Intro to Mental Health

- “If you talk to God, you are praying; if God talks to you, you have schizophrenia”
  - Thomas Szasz (1973)
- Schizophrenogenic mother – can reinforce possibility for schizophrenia
- DSM-5 (American but used for research in UK) – ICD is most generally used in UK
- Frotters – people who receive pleasure from rubbing up against someone – something that was a real problem during the Olympics and is a problem on the tube – comes under the subset of paraphilia

### Schizophrenia

- Positive symptoms are most common in the early morning
- Hallucinations (auditory) often start off as positive comments
  - E.g. the boy who thought his dead mother was talking to him “I’m sorry I was taken away from you – I’ll be with you from now on”
- Progresses to be more negative
  - E.g. the boy then hearing his mother telling him “you’re no son of mine” “you’re a disgrace” until finally just repeating “kill yourself” – echolalia
- **Watched clip of “Sectioned” – video of a man called Richard**
  - Stops talking mouth still moves – due to speaking to the voices or voices telling him not to say it out loud
  - Hyper-motorisations – micro-movements – additional movements that weren’t necessary
  - Auditory hallucinations – hearing voices, telling him to commit suicide on New Year’s Day
  - Delusions – he believes it’s the gods that are talking to him
  - Slurring speech – and slight speech disorganisation
- Glutamate and dopamine
  - Drugs that try and target glutamate in recent years aren’t working
  - Only drug that’s been given a license to be used to treat schizophrenia is “cariprazine” – a dopamine drug
- There is no single gene causing the condition – 1,200 genes that have been linked with schizophrenia in recent years
  - COMT gene potentially not working
  - Multiple levels of gene problem
- Environmental factors
  - Inner city area
  - Exposure to drugs
- There are patients that won’t respond to any treatment – these patients will have schizophrenia for the rest of their lives
  - “strips you of humanity, just as you’re entering adult life” – as it often comes about at the end of adolescence