Chapter 3
The Biological Basis of Behaviour

PSYC 1001

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Did you ever wonder ...

- Can new powerful brain technologies allow us to control our environment?
- How are messages sent from one part of the brain to another?
- Why did the Rain Man develop such amazing intellectual capacities?
- Can new cells implanted in a damaged brain help it to recover functioning?

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... Today we'll be talking about the fascinating world of the brain and how it is related to behaviour.

Today's Learning Objectives

1. How the nervous system supports communication: hardware, transmission of information
2. Organization of PNS, CNS
3. How do we "look" inside the brain to see what's going on: techniques
4. Parts of the brain and behaviour / functioning
5. Heredity
6. Evolution: adaptation

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More specifically, we'll answer these types of questions and more by looking at …
[go through objectives] ….

1. Communication in the Nervous System

- Learning objectives
  - Structure of the neuron: → The basic hardware of communication in the nervous system
  - Action potential → How nervous impulses work within a neuron
  - Synapse →How one nerve communicates to another through the synapse
  - Neurotransmitters → Chemicals in the brain, roles with respect to behaviour

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[Go through learning objectives] …

How does communication in the nervous system work. This is really important because when we engage in a behaviour or in thinking, different parts of the brain are recruited and synchronized to make our experience possible.

For example, when you are remembering a day at the beach, your brain is actually reactivating those parts of the brain that were active when the event took place… your visual cortex captured the ocean waves, the sun shining, your kids surfing, people sun-bathing … your auditory cortex captured the screams of kids, the sound of waves and peeping of those pesky sea gulls going for your sandwich. … at that moment your hearing and sight recruit your motor system so you can dodge that bird which in turn quickly recruits your speech production system, Broca's area, which emits a few 4-letter words. All this happens really fast, at a dizziying pace … but it happens as one continuous flow of experience because different parts of the brain communicate with each other in a very efficient fashion.

So how does the brain communicate. Well let's start with the hardware.

The Nervous System's Hardware

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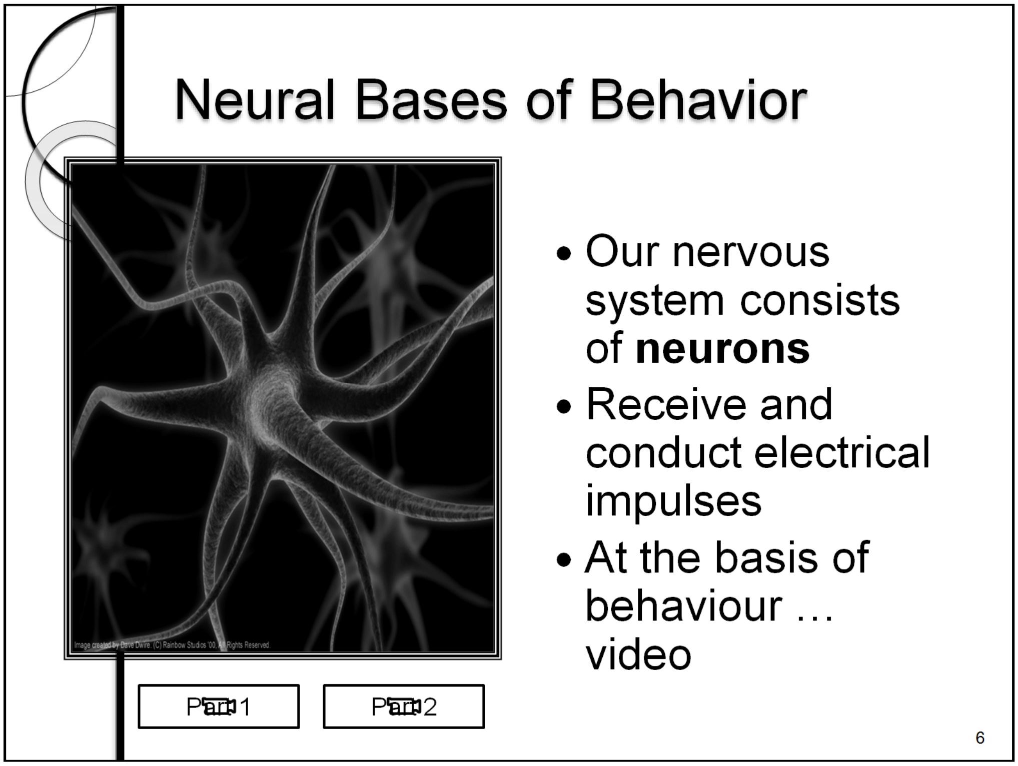
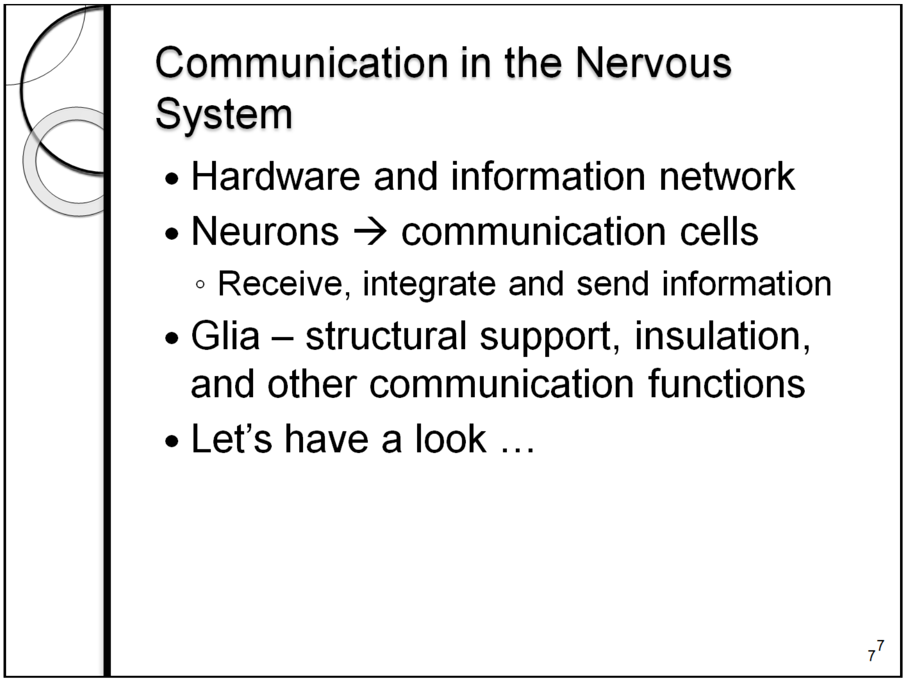


The **hardware** of the nervous system is made up of cells called **neurons**. There are many kinds but basically, these are **specialized** cells that function on the basis of **electrical impulses** which they **receive** from other neurons and, in turn, **conduct** to other neurons down the line. Without neurons there would be no behaviour, no thinking, no memories

Let's have a look at a video on what are called **mirror neurons It i**llustrates the importance of neurons but also touches on all aspects of what we will cover tonight. Listen for things like techniques for **measuring** brain activity, **organization** of the brain, **brain chemicals** and **evolution**.



Behaviour depends on the rapid processing and travel of information through the nervous system. So the nervous system is really a communication network.

CLICK

As an analogy, think of what happens in the background when you are speaking on the phone or using the internet. Your **voice** and the **clicks** on your computer are **translated** into **signals** that carry **information**. These signals are sent at **really high speed** along lines through **complex computer systems** that process the signals and make sure that they are **sent along the right path** to the right destination.

In terms of the nervous system, **stimulation** from the world around us impinge on our **senses** and are then translated into **nerve impulses** that carry useful information to the right parts of the **brain** for **interpretation**. But unlike telecommunications, the nervous system is made up of different types of **living cells**. The most basic are called **neurons** and **glia**.

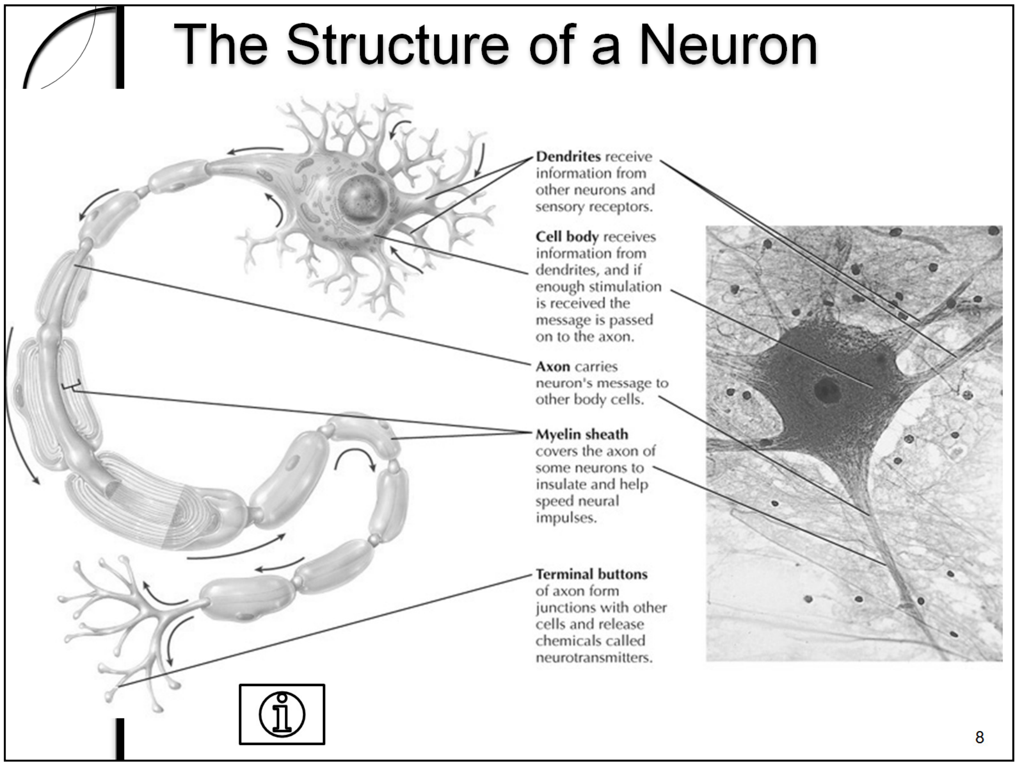
CLICK

At a high-level, n**eurons** are directly responsible for the communication signals in the nervous system. They receive, integrate, and transmit information..

CLICK

Glia are cells that provide structure and insulation for neurons…neural "glue?. But they may have other functions.

Let's have a look ...



Here's the basic physiology of the neuron

Neurons

(Use picture to describe parts and transmission of neural impulse)

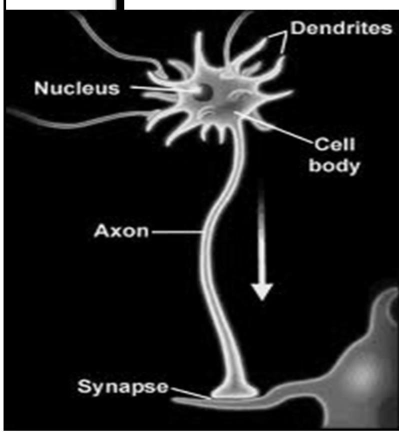
Glial

Limits cross-talk between neurons. Helps ensures that information is communicated where it is mean to.

Myelin sheaths, made up of gial cells, also speed up transmission. When the glia deteriote (e.g. Alzheinmers's, Parkinson's), people lose physical control over their body and begin to lose cognitive functionign. So glia cells play a key role in communication.

Although glial cells are involved in communication, most of that work falls on neurons.

The Neural Impulse: Sending Information



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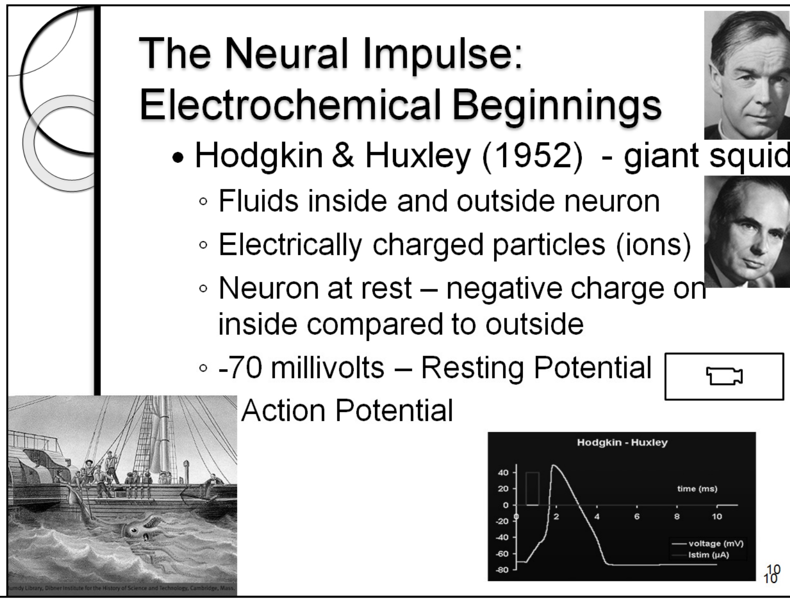
Ok, so we just covered the hardware of the nervous system i.e. neurons are necessary for communication to occur, but what about how information is itself transmitted. That's what we'll talk about next ...



Hodgkin and Huxley in the 1950's discovered the mechanics of neural transmission. They were interested in finding out what happens when a neuron is stimulated and how exactly does neural transmission work. Given how small animal neurons are in general, ... **CLICK ...** these researchers opted to study the giant squid…which has axons that are about 100 times larger than human axons. This allowed them to more easily measure changes in voltage.

They learned that the neural impulse is a complex mechanism made up of an **electric** step followed by a **chemical** step.

Hodgkin and Huxley found that the electrical step involves **fluids inside and outside** the neuron that contain electrically charged particles called **ions**.

They also found that when a neuron is "at rest" the inside has more negative ions than the outside (-70 millivots). The stable negative charge of a neuron when it is inactive is what is called its **resting potential*.*** *... **CLICK** **...***When sufficiently stimulated though it fires with a spike in electrical charge. This is called an **"Action Potential".**

This shift in the electrical charge travels along the axon from the dendrites to the terminal buttons and is essentially an explosion of electrical activity. Either an action potential occurs, or it doesn't. We say that an action potential is an all-or-nothing event.

SIMULATION

The Neural Impulse: The Action Potential

- Absolute Refractory period
  - After an action potential, the neuron has some downtime for 1 or 2 ms called
- Relative Refractory period
  - Gradual return to resting potential
  - More stimulation needed

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Right after the action potential the neuron has some downtime for 1 to 2 ms. This is known as **the Absolute Refractory period**. During this time, a neuron is unable to fire.

This is followed by the relative refractory period during which the cell slowly goes back to its resting potential of -70 mvolts. The neuron can fire during this period but requires more stimulation than when it's in its resting state

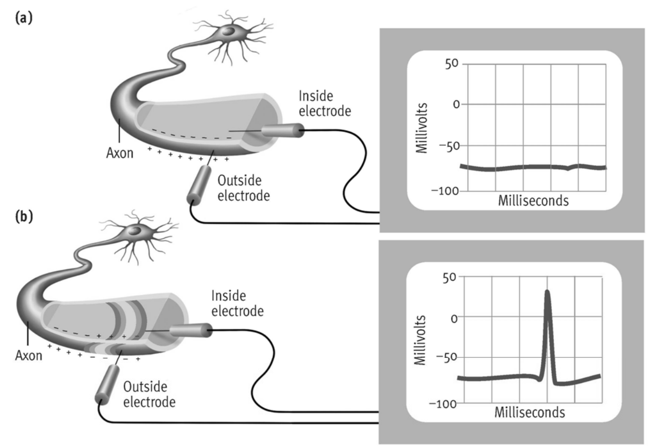

Figure 3.2

The neural impulse. The electrochemical properties of the neuron allow it to transmit signals. The electric charge of a neuron can be measured with a pair of electrodes connected to an oscilloscope, as Hodgkin and Huxley showed with a squid axon. Because of its exceptionally thick axons, the squid has frequently been used by scientists studying the neural impulse. (a) At rest, the neuron's voltage hovers around −70 millivolts. (b) When a neuron is stimulated, a brief jump occurs in the neuron's voltage, resulting in a spike on the oscilloscope recording of the neuron's electrical activity. This change in voltage, called an *action potential*, travels along the axon like a spark travelling along a trail of gunpowder.

See & Hear 12

Although action potentials are all-or-nothing, neurons do in fact reflect the intensity of a stimulus. The **more intense** the stimulus the **more often** the neuron fires. The **weaker** the stimulus the **fewer** time it will fire.

Neurons also differ in how fast impulses travel down the axon. Speed of transmission is faster for axons with smaller diameters than those with larger diameters. Action potential travel at speeds up to 100 meters per second.

Let's check it out … see link "Hear some action potentials" at bottom of page

The Synapse: Where the neurons meet

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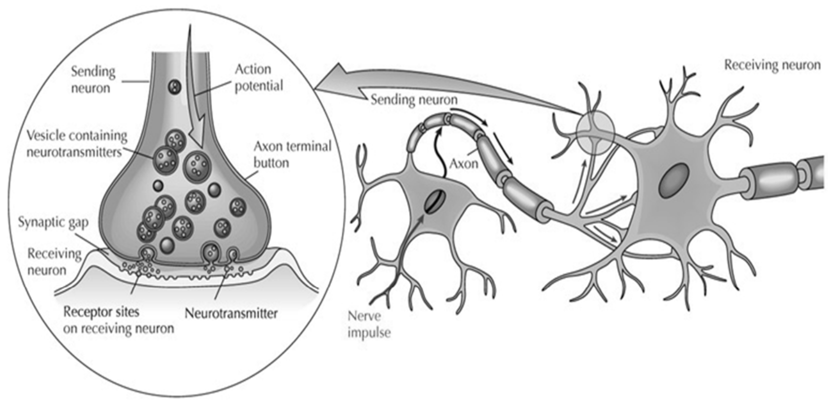
Remember that information transmission through neurons is an electro-chemical event. We just talked about the actional potential which is the electical part of neuronal communicaiton. This is what initiates communication. The next part is the chemical component which takes place where the neurons physically meet.

The Synapse



- Between neurons, communication occurs through transmission of neural information across a synapse by neurotransmitters (chemicals released by neurons that alter activity in other neurons).

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We hear a lot about what are called neurotransmitters. You’ve likely heard of serotonin in the context of mood and eating behaviour, and possibly GABA which serves in some cases to dampen and help focus brain activity. Here’s a video that provides an example

Video

So when we talk about that second key step in communication between neurons, we’re referring to NTs ... Although there are other types of brain chemicals as well..

The Synapse: Chemicals as Signal Couriers

- Synaptic cleft / gap
- Presynaptic neuron
  - Synaptic vesicles
  - Neurotransmitters
- Postsynaptic neuron
  - Receptor sites

Recap whole process

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Neurons don’t actually touch at a synapse, instead they are separated by a microscopic gap between the terminal button of one neuron and the cell membrane of another neuron - the synaptic cleft or synapse.

Electrical signals can’t jump this gap. Instead, the neuron that is sending the message (the presynaptic neuron) releases neurotransmitters into the synaptic cleft (gap). This occurs when the action potential gets to the terminal button and causes the synaptic vesicles (storage sacs for the neurotransmitter) to fuse with the membrane at the end of the axon and spill its contents into the synaptic cleft.

The neurotransmitters diffuse across the space where they find open receptor sites on the postsynaptic neuron. These sites recognize and respond to some neurotransmitters, but not to others.

Video – recap whole process

as a recap of whole process from stimulation of dendrites, occurence of an action potential and communication from the pre-synaptic neuron to the post synaptic neuron through the synaptic gap

When a Neurotransmitter Binds: The Postsynaptic Potential

- Voltage change at receptor site – postsynaptic potential (PSP)
  - Not all-or-none
  - Changes the probability of the postsynaptic neuron firing
- Positive voltage shift – excitatory PSP
- Negative voltage shift – inhibitory PSP

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When a neurotransmitter from the pre-synaptic neuron crosses the synapse, it finds a receptor site on the postsynaptic neuron, binds to it and causes a voltage change. So now we're back to talking about the first phase of communication in the nervous system i.e. Electrical events, but this time in the postsynaptic neuron, the one receiving stimulation. What this will give you is an understanding of how an electrical charge is built-up to eventually lead to the occurence of an action potential.

... Ok so we're back at the receptor site on the post-synaptic membrane where a neurotransmitter from the pre-synaptic neuron has just binded. This voltage change is not an all-or-none. It just changed the voltage of the cell a bit, and by doing so it changes the probability that the post-synaptic neuron will fire. This is called a **postsynaptic potential.** More NTs will bind to individual receptor sites, each changing the overall voltage of the cell a bit.

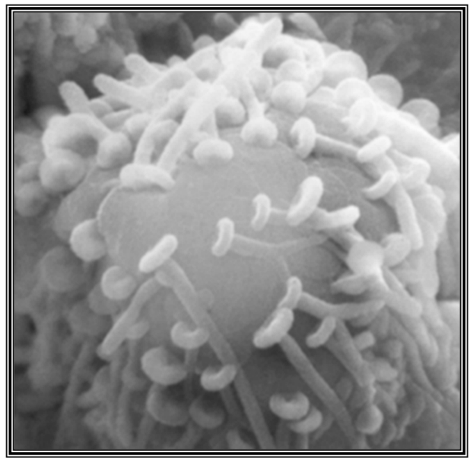
The postsynaptic potential can be **excitatory** or **inhibitory**. It's important to understand these two basic types of stimulation.

An **excitatory** post-synaptic potential (EPSP) makes the neuron more likely to fire by **decreasing the negativity** of the inside of the neuron with respect to the outside.

An **inhibitory** postsynaptic potential (IPSP) **increases the negativity** of the inside of the neuron with respect to the outside, making it less likely to fire.

The Synapse:
Chemicals as Signal Couriers

- Note how the **axon terminals** of sending neurons almost completely cover the **cell body** of the receiving neuron.



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It’s interesting to note how different reality is from the sanitized picture I’ve given you of one axon communicating with one neuron. Note how the **axon terminals** of sending neurons in this picture almost completely cover the **cell body** of the receiving neuron.

Signals: From Postsynaptic Potentials to Neural Networks

- One neuron, signals from thousands of other neurons
- Requires integration of signals
  - PSPs add up, balance out
  - Balance between IPSPs and EPSPs
- Neural networks
  - Patterns of neural activity
  - Interconnected neurons that fire together or sequentially

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So really, one neuron may receive signals from thousands of other neurons, across thousands of different synapses. But it won’t fire until the overall charge of the cell body reaches a threshold. So each neuron must integrate the many signals arriving at the same time before it “decides” to fire.

EPSPs are summed up together …enough can cause the cell’s voltage to reach the threshold at which the action potential will begin.

But if the neuron is receiving both EPSPs and IPSPs, as is often the case, they may balance out and the neuron remains at rest.

So, the state of the neuron at any point is a weighted balance.

Thought occurs through the firing of millions of neurons in unison. Our perceptions, thoughts, and actions depend on patterns of neural activity in interconnected neurons that fire together or sequentially – **neural networks**.

- Synaptic connections
  - Elimination and creation
  - Synaptic pruning

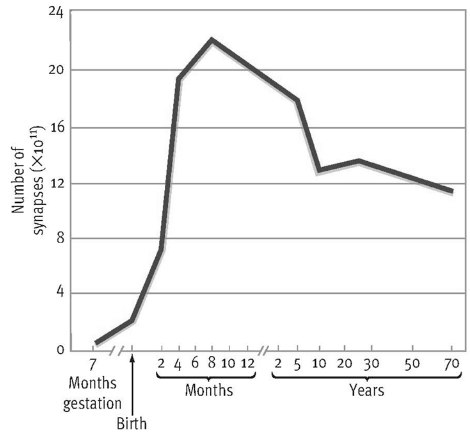


Figure 3.5

Synaptic pruning. This graph summarizes data on the estimated number of synapses in the human visual cortex as a function of age (Huttenlocher, 1994). As you can see, the number of synapses in this area of the brain peaks around age one and then mostly declines over the course of the life span. This decline reflects the process of *synaptic pruning,* which involves the gradual elimination of less active synapses.

Source: Data based on Huttenlocher, P. R. (1994). Synaptogenesis in human cerebral cortex. In G. Dawson & K. W. Fischer (Eds.), *Human behavior and the developing brain.* New York: Guilford Press. Graphic adapted from Kolb, B., & Whishaw, I. Q. (2001). *An introduction to brain and behavior.* New York: Worth Publishers.

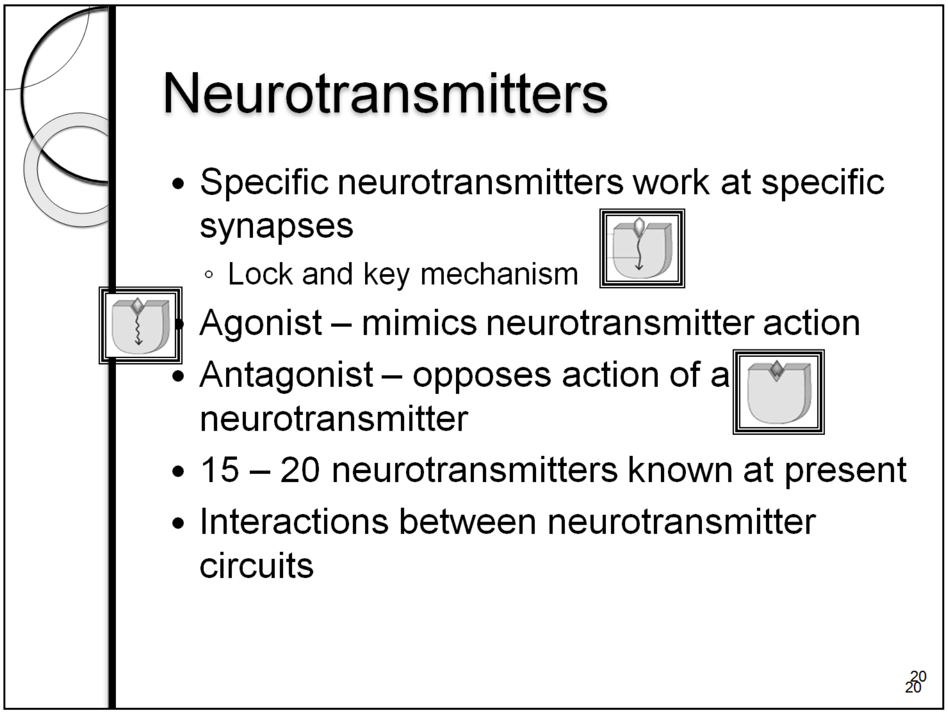
Pruning in babies

The links in these networks are constantly changing, with synaptic pruning or the elimination of old or unused synapses playing a larger role than the creation of new synapses in the sculpting of neural networks. For example, the number of synapses in the human visual cortex begins to decline around 6 to 8 months of age.

This concept of **synaptic pruning** is very important because it seems to be related to learning. Donald Hebb a researcher from McGill university is famous for what has become known as the **Hebbian Learning Rule** i.e. the synapses between neurons that communicate with each tend to undergo changes by promoting more efficient communication. This is thought to reflect the occurrence of learning. This is often called the Hebb Synapse.

VIDEO on pruning in kids

But now what about these chemicals that mediate the transmission of information from one neuron to another. Let’s have a look at how they work and describe the most common ones



Click ... So NTs deliver their messages by crossing the synapse and by binding to a receptor site on the post-synaptic dendrites…in a **lock and key type manner**. Not just any receptor site will do …there must be a perfect fit between the shape of the NT and the shape of the receptor site.

Click ... Some drugs mimic neurotransmitters, fitting into receptor sites so perfectly that the site is fooled and a PSP is set up…these chemicals are called **agonists**. E.g. Some antidepressants mimic serotonin and so increase mood by making up for the lack of serotonin in the brain

Click ... Other chemicals oppose the action of a NT…they bind to the receptor site but don't really fit well enough to "fool" the site…they just block it. The chemicals are called **Antagonists.** These are used when there is too much of a good thing e.g. aloperidol is an antagonist used in the treatment of schizophrenia. It acts by blocking receptors for the NT dopamine to control delusions and hallucinations. DA yperactivity has been linked to delusions and hallucinations.

Click

Right now, we know of about 15-20 substances that qualify as NTs…5 are commonly researched.

Click

While research has outlined many interesting connections between neurotransmitters and behaviour, most aspects of behaviour are probably regulated by the interaction of many neurotransmitters

Table 3.1

Common Neurotransmitters and Some of Their Functions

Neurotransmitter	Functions and Characteristics
Acetylcholine (ACh)	Activates motor neurons controlling skeletal muscles Contributes to the regulation of attention, arousal, and memory Some ACh receptors stimulated by nicotine
Dopamine (DA)	Contributes to control of voluntary movement, pleasurable emotions Decreased levels associated with Parkinson's disease Overactivity at DA synapses associated with schizophrenia Cocaine and amphetamines elevate activity at DA synapses
Norepinephrine (NE)	Contributes to modulation of mood and arousal Cocaine and amphetamines elevate activity at NE synapses
Serotonin	Involved in regulation of sleep and wakefulness, eating, aggression Abnormal levels may contribute to depression and obsessive-compulsive disorder Prozac and similar antidepressant drugs affect serotonin circuits
GABA	Serves as widely distributed inhibitory transmitter Valium and similar antianxiety drugs work at GABA synapses
Endorphins	Resemble opiate drugs in structure and effects Contribute to pain relief and perhaps to some pleasurable emotions

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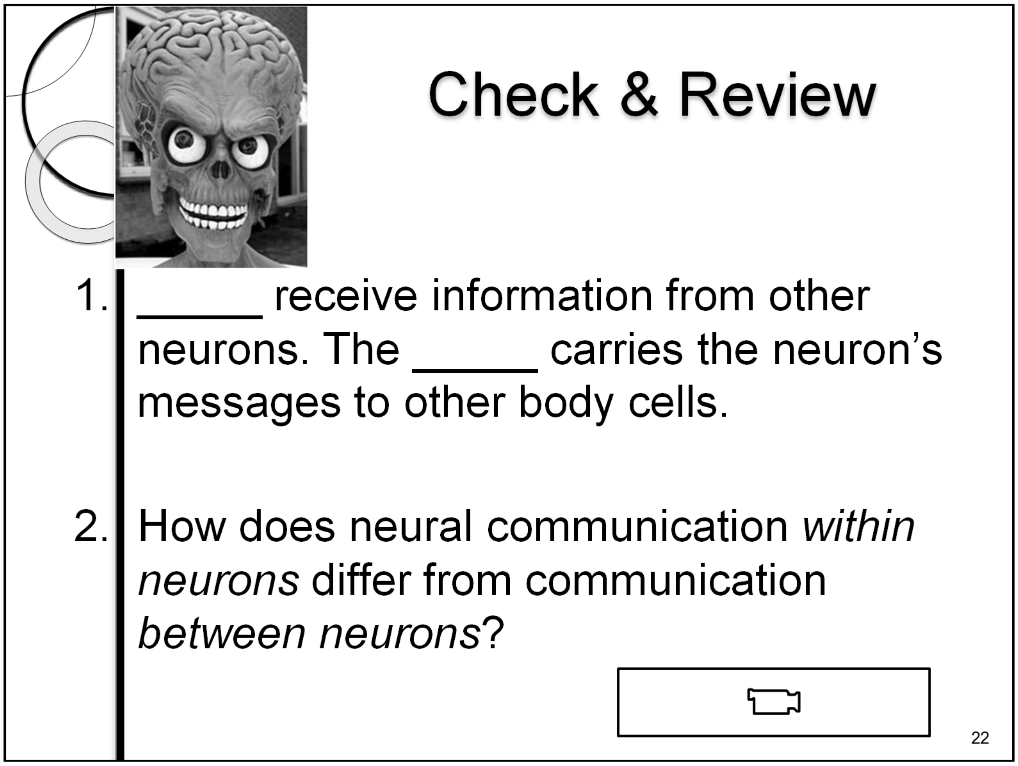

Dendrites

Axon

Within: Electric, involves ions

Between: chemical ... Neurotransmitters

VIDEO: Ok so now we're going to transition into the nervous system, its structure and behaviour. The following video provides a good summary of the role of synaptic transmition, some hints of specific brain structures ,and how these are related to behaviour

2. Organization of the nervous system

- Learning objectives
  - Two basic systems → peripheral, central

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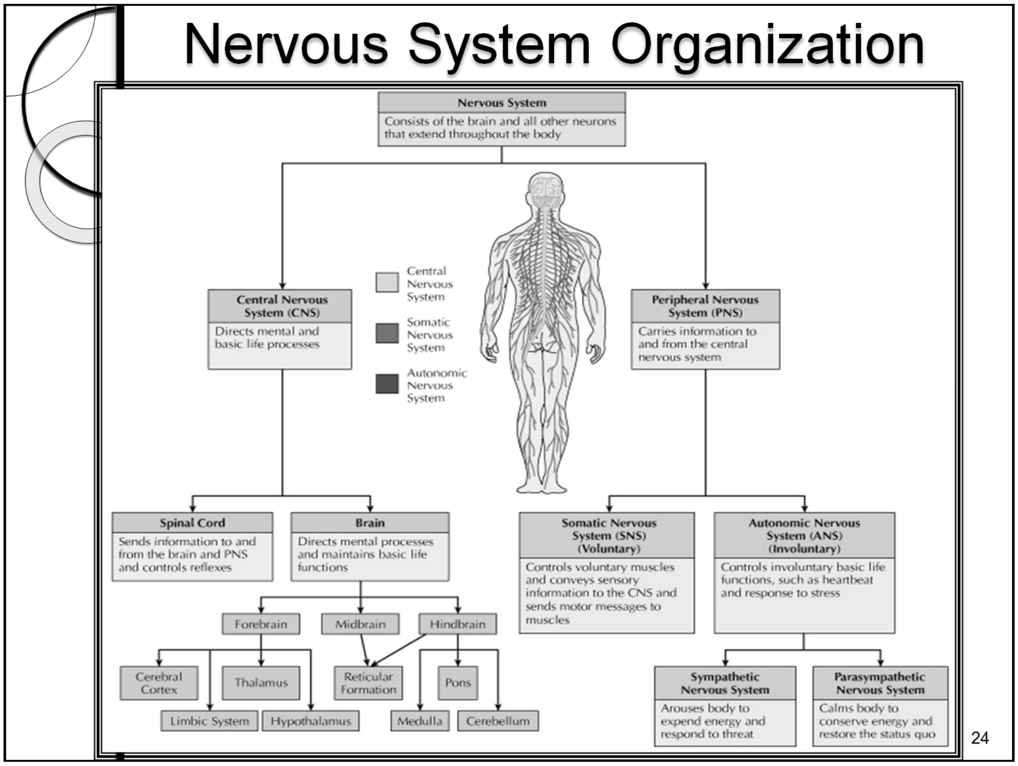
We've seen how communication works within and between neurons through electro-chemical events. Now let's turn to the overall organization of the nervous system i.e.

the peripheral nervous system and the central nervous system



The nervous system has two main divisions, central and peripheral.

The **central nervous system** consists of the brain and spinal cord, while **the peripheral nervous system** consists of nerves that lie outside the brain and spinal cord.

In the peripheral nervous system, **afferent** nerve fibres send information toward the CNS, while **efferent** nerve fibres send information away from the CNS. E.g. If you touch a hot element on a stove, afferent nerves carry the message of danger to the spinal column that interprets it and automatically sends back a command through the efferent nerves to the hand to move.

There are two divisions of the peripheral nervous system, the **somatic**, or voluntary portion, and the **autonomic**, or involuntary portion.

The **autonomic** portion of the peripheral nervous system governs involuntary, visceral functions…such as heart and breathing rate, blood pressure, etc. When a person is autonomically aroused, these speed up. This speeding up is controlled by the **sympathetic** division of the autonomic nervous system which mobilizes the body's resources for emergencies and creates the fight-or-flight response.

The **parasympathetic** division, in contrast, activates processes that conserve bodily resources…slowing heart rate, reducing blood pressure, etc.

3. Studying the Brain: Research Methods

- Electroencephalography (EEG)
- Damage studies/lesioning
- Electrical stimulation (ESB)
- Transcranial Magnetic Stimulation
- Brain imaging:
  - computerized tomography (CAT)
  - positron emission tomography (PET)
  - magnetic resonance imaging (MRI)

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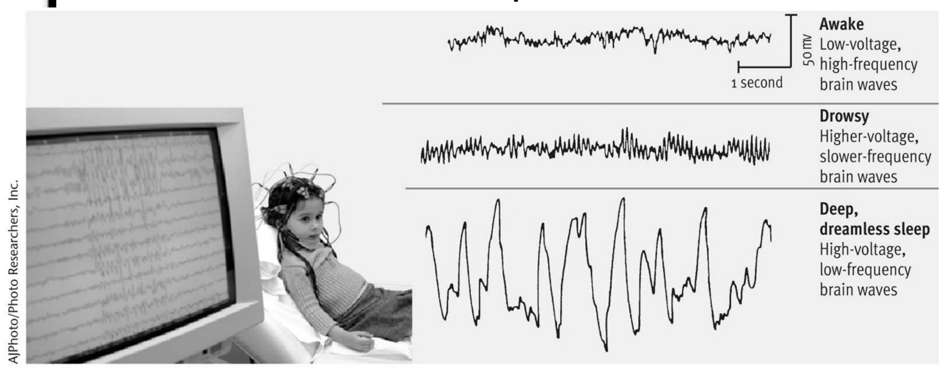
Before we get into the details of the structure of the brain and its relation to behaviour, it's worth taking a moment to describe several of the more common techniques used to research the brain.

These include:

Electroencephalography (EEG), Damage studies/lesioning, Electrical stimulation (ESB), and different forms of brain imaging e.g. computerized tomography, positron emission tomography, magnetic resonance imaging

3. Studying the Brain: Research Methods

- Electroencephalography (EEG)
- Monitoring electrical activity of the brain
- Mental state - sleep



Electroencephalography (EEG) – monitoring electrical activity of the brain

Monitoring **electrodes** are placed on the head. The pick-up the electrical activity of the brain, called brain waves. Each electrode picks up the combined activity of the neurons around it, so the EEG doesn’t distinguish between the activity of neurons at different layers. It’s range depth-wise is limited.

Different brain **waves** are associated with different **states** of mental activity, and often used in the diagnosis of various mental disorders. EEGs have also been commonly used to study the phase of sleep

3. Studying the Brain: Research Methods

- Damage studies/lesioning
- Destroy a part of the brain to see impact on behaviour
- Animal research

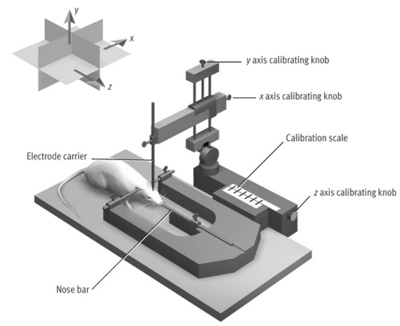


Figure 3.11
An anesthetized rat in a stereotaxic instrument. This rat is undergoing brain surgery. After consulting a detailed map of the rat brain, researchers use the control knobs on the apparatus to position an electrode along the three axes (x, y, and z) shown in the upper-left corner. This precise positioning allows researchers to implant the electrode in an exact location in the rat's brain.

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An invasive methodology involves lesioning parts of the brain in animals to see what behaviours are affected. Similarly, in humans brain damage resulting from accidents provide insight into the brain-behaviour relationship. A lot has been learned about the brain using these methods, however there one key limitation. The change in behaviour may not be due to the what is assumed to be the damaged structure. It may instead be due to damage to the nerve fibers that actually connect distant brain structures.

Also because of the violent nature of most head trauma in humans (e.g. car accidents), it's impossible to account for all areas of the brain that have been impacted. As a result, the observed change in behaviour may not be due solely to what has been identified as the damaged brain areas.

3. Studying the Brain: Research Methods

- Electrical stimulation of the brain (ESB)
  - Sending a weak electric stimulus into the brain → impact on behaviour
  - Mostly animal research
  - Humans during brain surgery
    - Wilder Penfield e.g. epilepsy
    - http://www.youtube.com/watch?v=FqCEMyKp8OA

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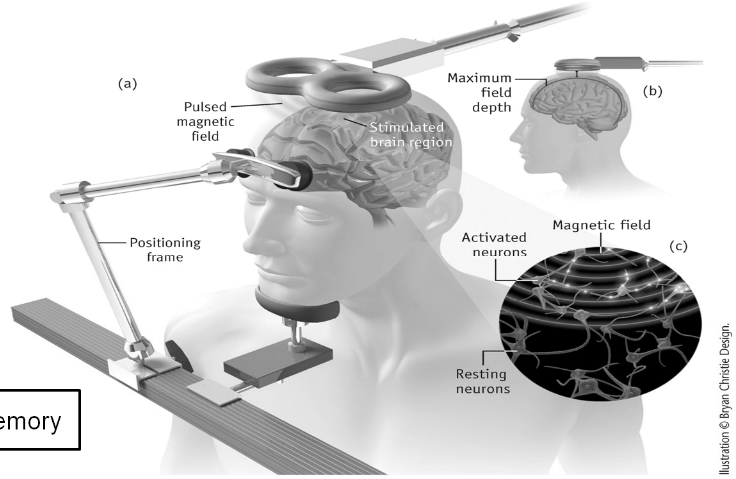
...Wilder ... This involves the application of a weak electrical stimulation to different parts of the brain to see their role in behaviour. Wilder Penfield, a pioneer in the research and treatment of epilepsy used this technique to figure out the origin of seizures in various patients in order to be able to treat them. He knew he had found the locus when the patient reported the sensation of what is called the Aura.

VIDEO

Transcranial Magnetic Stimulation



Improving memory

Figure 3.12

Transcranial magnetic stimulation (TMS). In TMS, (a) magnetic pulses are delivered to a localized area of the brain from a magnet mounted on a small paddle. (b) The magnetic field penetrates to a depth of only 2 centimetres. This technique can be used to either increase or decrease the excitability of the affected neurons. (c) The inset at the bottom right depicts neurons near the surface of the brain being temporarily activated by TMS.

Adapted from Bremner, J. D. (2005). *Brain imaging handbook*. New York: W. W. Norton, p. 34. Adapted by permission.

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Another technique involves placing a magnetic coil above a person's head which then emites a magnetic pulse that penetrates up to 2 cm into the brain.

This pulse is used to temporarily activate or deactivate specific sections of the brain. So if you have people doing, for example, specific cognitive tasks and performance is affected, then you've learned something about which brain structures are involved. So this is a type of temporary virtual brain lesioning technique that has been very useful in uncovering brain function in humans.

3. Studying the Brain: Research Methods

- Brain imaging:
  - computerized tomography (CAT)
  - positron emission tomography (PET)
    - For locating neurotransmitter activity
  - magnetic resonance imaging (MRI)

PET (6 mins)

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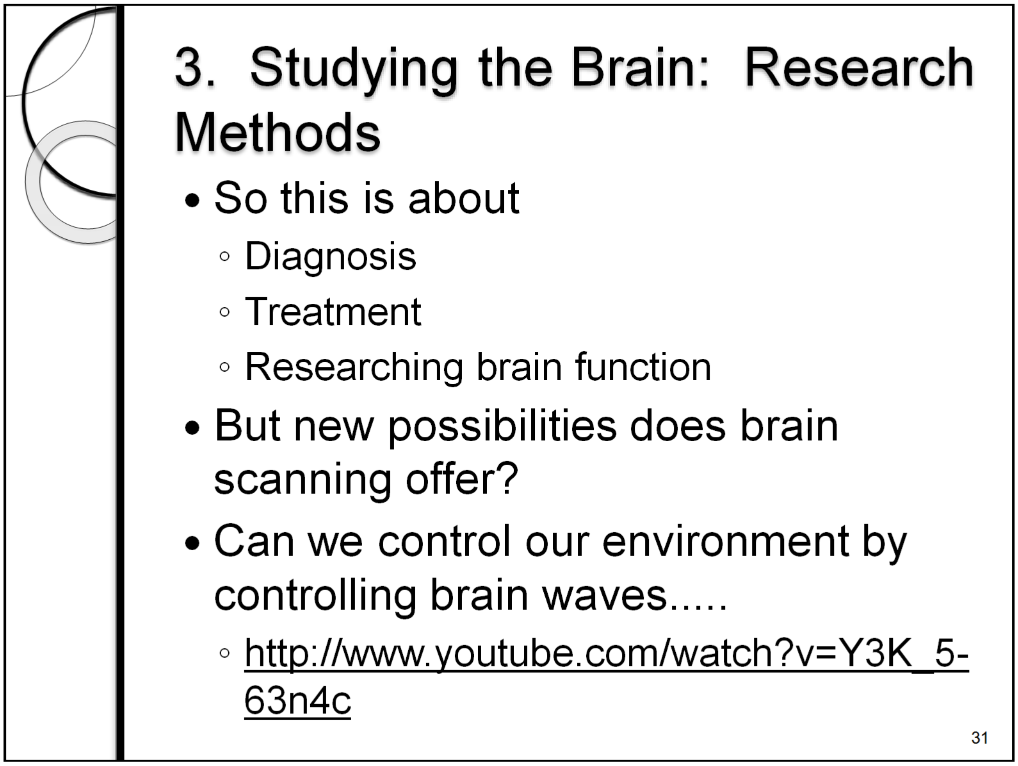
Several brain imaging techniques including:

- **CT scan: computerized tomography** – computer **enhanced X-ray** used to examine brain structure, typically to reveal extent of structural damage to the brain
- **PET scan: positron emission tomography** – where **radioactively tagged** chemicals serve as markers of blood flow or metabolic activity in the brain that are monitored **by X-ray**. This is the technique most often used to examine **neurotransmitter activity**
- **magnetic resonance imaging (MRI)** – uses magnetic fields, radio waves to examine brain activity, the resulting information is presented as a 3-D image with high resolution. More accurate than CT and PET scans

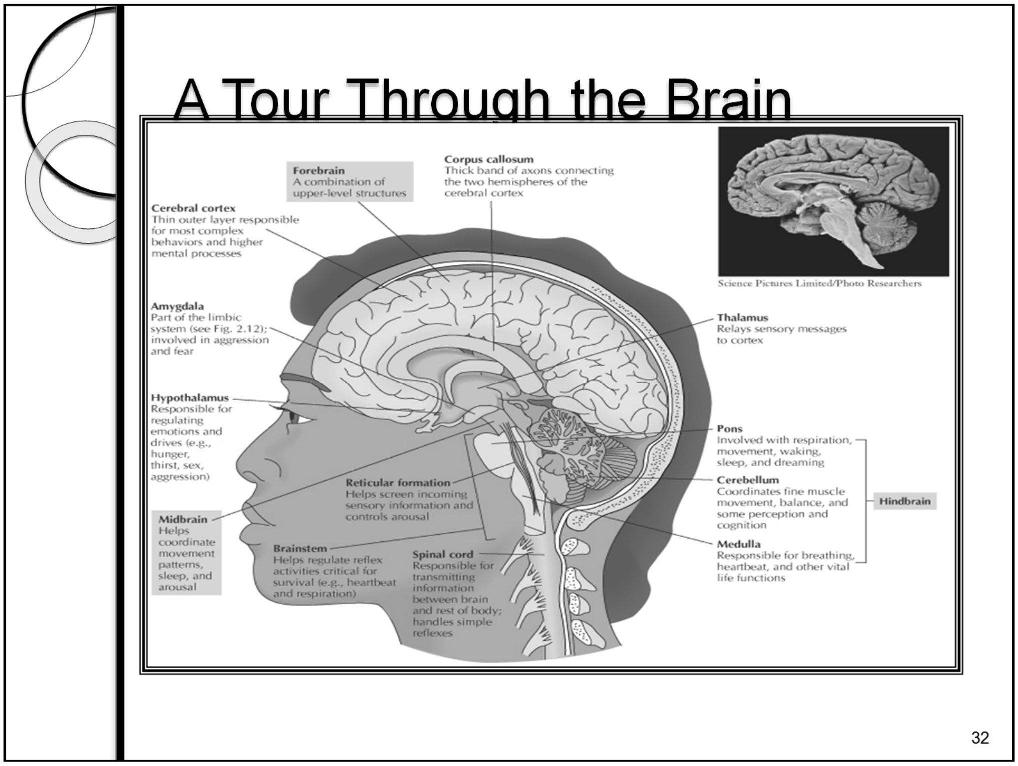
•**SKIP VIDEO**



So research methodologies provide a means of diagnosing brain-based disorders, identifying treatments, but also researching brain function.

Looking beyond that, what future opportunities do these imaging techniques provide? Will there be a time when we can control our environment by controlling our brain waves. Let’s have a look at an example of what may be coming down the pipe ...

VIDEO

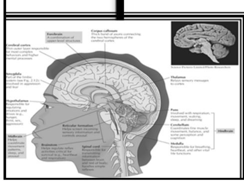


Having looked at techniques for investigating the brain, let’s look at some of the key discoveries that have increased our understanding of the relationship between brain structure and behaviour.

The brain can be thought of as being divided into three main areas: the hindbrain, the midbrain and the forebrain

A Tour Through The Brain: Hindbrain

- Three key structures of the hindbrain:
  - **Medulla**: essential automatic bodily functions
  - **Pons**: respiration, movement, waking, sleeping, and dreaming
  - **Cerebellum**: coordination of fine muscular movements, balance, and some aspects of perception, cognition, and language



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The hindbrain is located at the lower end of the brain, where the spinal cord joins the brainstem and is made of three structures.

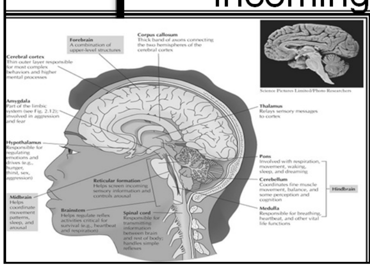
• The **medulla** is in charge of circulation, breathing, muscle tone, and the regulating of reflexes…

• the **pons** is important in sleep and arousal, respiration, movement

• the **cerebellum** is critical in the coordination of movement and equilibrium.

A Tour Through The Brain: Midbrain

- **Midbrain**: collection of brain structures in the middle of the brain; coordinates movement patterns, sleep, and arousal
- **Reticular Formation**: runs through the hindbrain and the midbrain; screens incoming information and controls arousal



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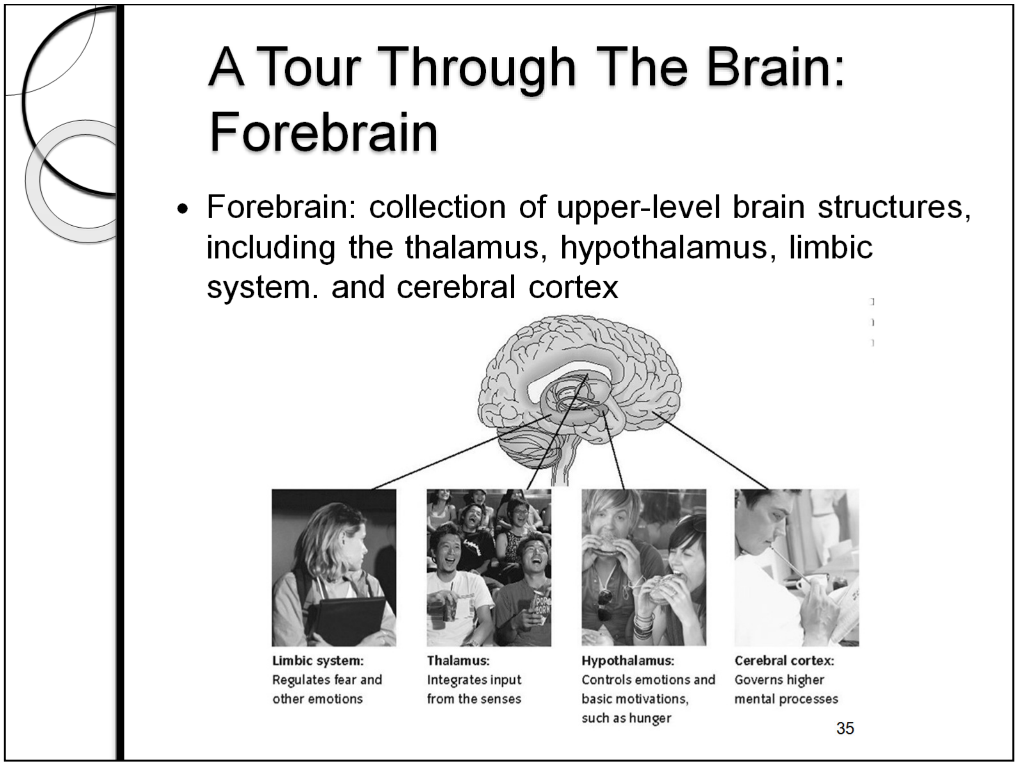
The **midbrain** lies just above the hindbrain and is involved in sensory functions such as locating where things are in space. It also contains structures which are important for voluntary movement through the action of dopamine neurotransmitters. **Parkinson's** disease is due to degeneration of the substantia nigra, a structure in the midbrain where dopamine plays a key role on voluntary motor control

The **reticular activating system** is found in both the hind and midbrain, and is important in **sleep** and **arousal**, as well as **breathing** and **pain perception.**



The **forebrain** is the largest and most complex region of the brain. In fact, the human forebrain is the largest of all animals accounting for over ¼ of the cerebral cortex. It includes

• the **limbic** system – which is a loosely connected network of structures involved in emotion, motivation, memory, and other aspects of behaviour…

• the **thalamus** – the way station for all incoming sensory information before it is passed on to appropriate higher brain regions…

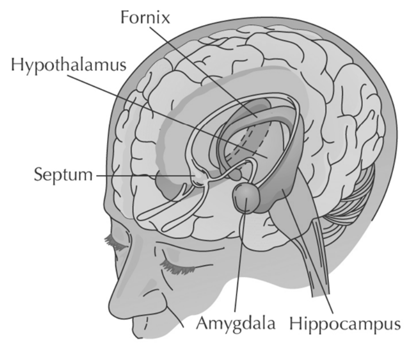
•T he **hypothalamus** – which is the regulator of basic biological needs such as hunger, thirst, sex drive, and temperature regulation…

• and finally, the **cerebrum** which is the largest and most complex portion of the human brain…and has a convoluted outer layer called the cerebral cortex…the **cerebrum** is **responsible** for complex mental activities such as learning, remembering, thinking, and consciousness.

•Let's look at each of these structures in a bit more detail ...

Forebrain: Limbic System

- Limbic System: interconnected group of forebrain structures involved with emotions, drive reduction, and memory
  - Amygdala
  - Hypothalamus
  - Hippocampus



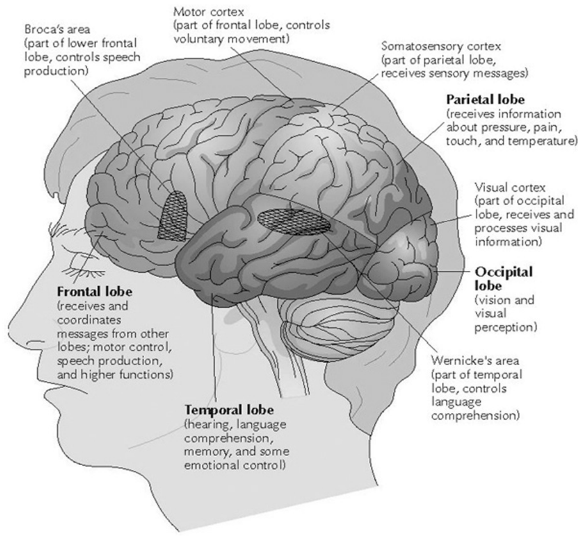
The Limbic System is an interconnected network of structures involved in emotion, drive and memory

Amygdala: seat of processing of both positive and negative emotions e.g plearsure, pain and fear. In the 1950's, **Olds** demonstrated its role by implanting electrodes into the amygdala of rats brains and hooking them up to an electric stimulator. When the rats pressed on a lever a mild electric stimulation was sent to the amygdala. Very quickly, rats kept coming back for more, pressing the lever thousands of times per hour suggesting that stimulation to this area of the brain results in **pleasure**. In terms of negative emotions, the amygdala has been implicated in the development of fear e.g. of thunder and lightening

Hypothalamus: regulates biological needs – its a key link between the brain and the endocrine system in the rest of the boidy e.g. key in eating behaviour (centres for hunger and satiety

Hippocampus plays a central role in memory. For example, it is known that this structure is the first to be severely affected in Alzheimer's. However, it now known to play only one part in a complex memory system. It would appear that each area of the brain is dedicated to different types of sensory processing also has its own memory area e.g. Vision, hearing and touch would have their own memory components. The hippocampus is key in ensuring that integration occurs

Forebrain
Lobes of the Cerebral Cortex



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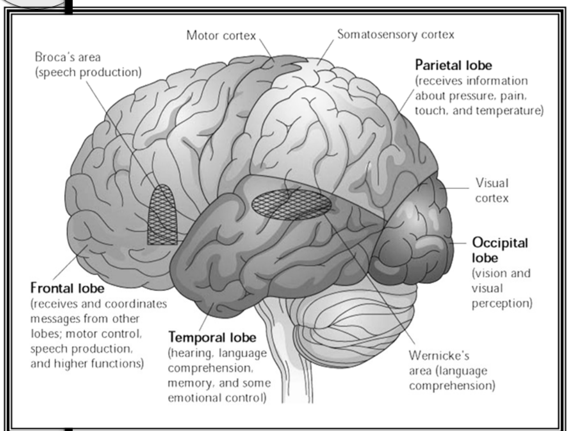
The cerebral cortex is divided into four broad sections called lobes ... Go over picture

Forebrain: Lobes of the Cerebral Cortex



- **Occipital Lobes:** located at the back of the brain; responsible for vision and visual perception

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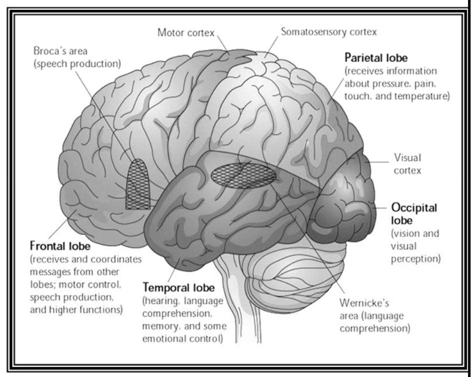
Forebrain: Lobes of the Cerebral Cortex

- **Parietal Lobes:** located at the top of the brain directly behind the frontal lobes; responsible for interpreting bodily sensations
- **Temporal Lobes:** located on each side of the brain above the ears; responsible for hearing, language comprehension, memory, and some emotional control



Temporal lobe - Wernicke's aphasia http://www.youtube.com/watch?v=IRB-UR3-QB8

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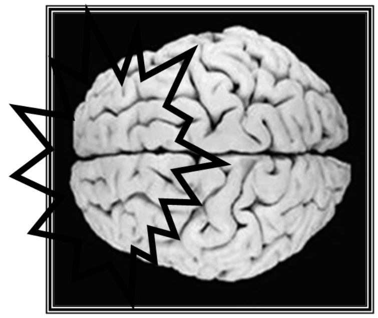
Parietal Lobes located at the top of the brain directly behind the frontal lobes are responsible for interpreting bodily sensations

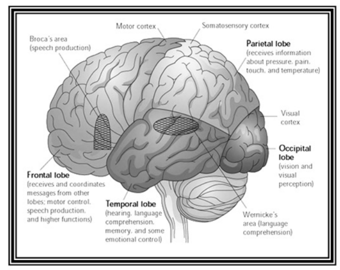
The temporal lobes are located on each side of the brain above the ears, and are responsible for hearing, language comprehension, memory, and some emotional control

Note **Wernicke's** area. People with **damage** to Wernicke's area are able to perceive language. They can speak, they just **can't understand what people are saying**. So they typically make things up. Listen to this video of an interview with a patient with Wernicke's aphasia. Note that his responses are completely understandfable but he is unable to respond to her questions because he doesn't really understand her.

Forebrain: Lobes of the Cerebral Cortex

- **Frontal Lobes:** receive and coordinate messages from other lobes; responsible for motor control, speech production (Broca's area), and higher functions, such as thinking, personality, emotion, and memory
- Broca's aphasia
  - http://www.youtube.com/watch?v=2bgm6zzGsUQ





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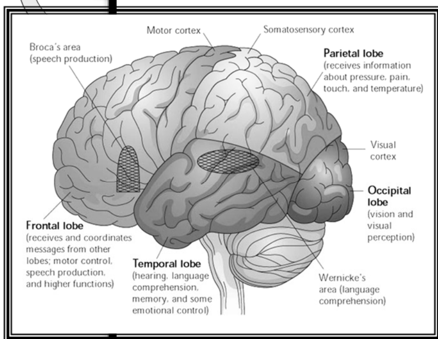
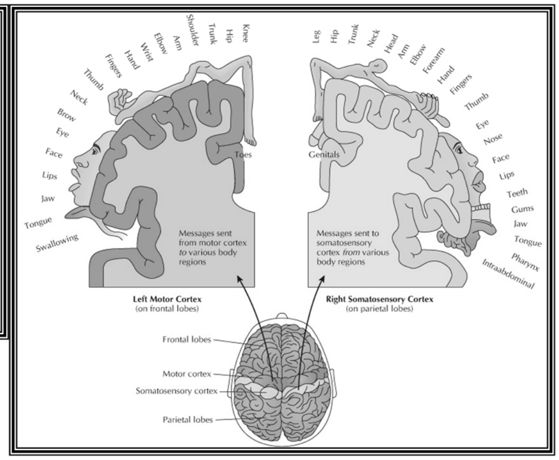
The Frontal Lobes receive and coordinate messages from other lobes and are responsible for motor control, speech production (Broca's area), and higher functions, such as thinking, personality, emotion, and memory

In contrast to Wernicke's aphasia that affects language perception from the temporal lobe (as seen in the last video), **Broca's aphasia** affects the ability to **produce language** due to damage to the Broca's area in the frontal lobe. In this video, note that the patient understands everything that the interviewer asks him, but has severe impairment in his ability to respond.

A Tour Through The Brain:Motor Cortex and Somatosensory Cortex





Burnt toast http://www.youtube.com/watch?v=dTs7UOVOWTc

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Go through pictures...

VIDEO

Check & Review

1. What are the three key structures of the hindbrain?

2. The _____ includes the thalamus, hypothalamus, limbic system, and cerebrum.

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After questions...

Hindbrain: medulla, cerebellum, pons

Forebrain

Plasticity of the Brain

- Neuroplasticity: brain's lifelong ability to reorganize and change its structure and function
- Neurogenesis: division and differentiation of nonneuronal cells to produce neurons
- Stem Cells: precursor (immature) cells that give birth to new specialized cells

We used to believe that the brain remained relatively unchanged after childhood. Development was something that occurred early on and then stopped only to quickly deteriorate with age. We now know that that is not the case.

This is recognized in terms like "**neuroplasticity**" which results from recent research showing that the brain is continually changing as a result of various development stages and experiences. For example, we know that individuals who specialize in certain activities tend to have corresponding brain areas that are **enlarged** or more **active** compared to the norm. E.g. That part of the somatosensory cortex that receives input from fingers has been shown to be enlarged in musicians.

It was also previously thought that the formation of new neurons through **neurogenesis** did not take place in adults. It appears that following damage to the brain e.g. head injuries, the brain is busily trying to repair damage by creating new neurons

Finally, a controversial topic is that of **stem cell** production. These precursors to neurons are being used to create specialized cells for repairing damaged brain tissue. These may provide promising treatment for previously untreatable disorders. The controversy comes from the attempt to harvest stem cells from eggs fertilized in vitro

5. Cerebral Laterarility

- Left brain / Right Brain
- Intact brain → hemispheric specialization

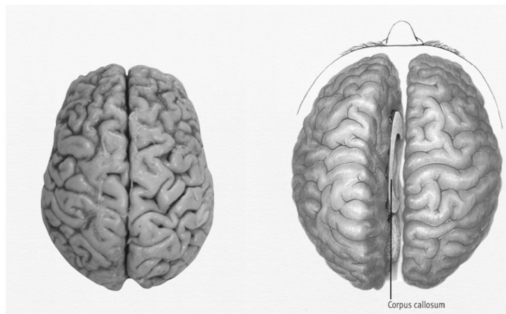

Figure 3.18

The cerebral hemispheres and the corpus callosum. (Left) As this photo shows, the longitudinal fissure running down the middle of the brain (viewed from above) separates the left and right halves of the cerebral cortex. (Right) In this drawing, the cerebral hemispheres have been "pulled apart" to reveal the corpus callosum. This band of fibres is the communication bridge between the right and left halves of the human brain.

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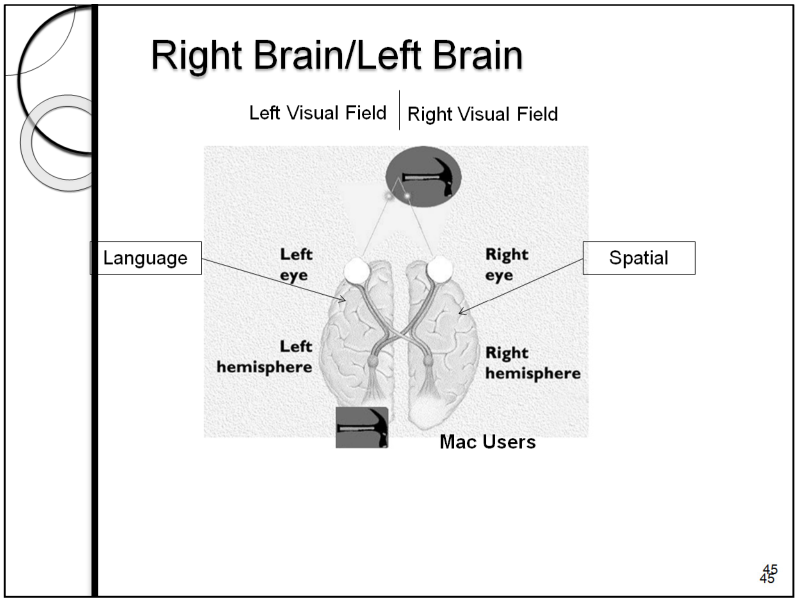
We talked about the specialization of different parts of the brain. This is also true of what is called brain laterality.

The cerebrum is also divided into two specialized hemispheres that are connected by the corpus callosum. The corpus callosum is a thick band of fibres (axons) that transmits information between the hemispheres.

A fascinating aspect of the brain is that each hemisphere has to some extent specialization of function. For example, the left hemisphere controls the right side of the body and the right hemisphere controls the left side of the body.

Vision is a bit more complex and provides a special window for understanding how different functions interact. Let's have a look at how visual perception works between hemispheres ...



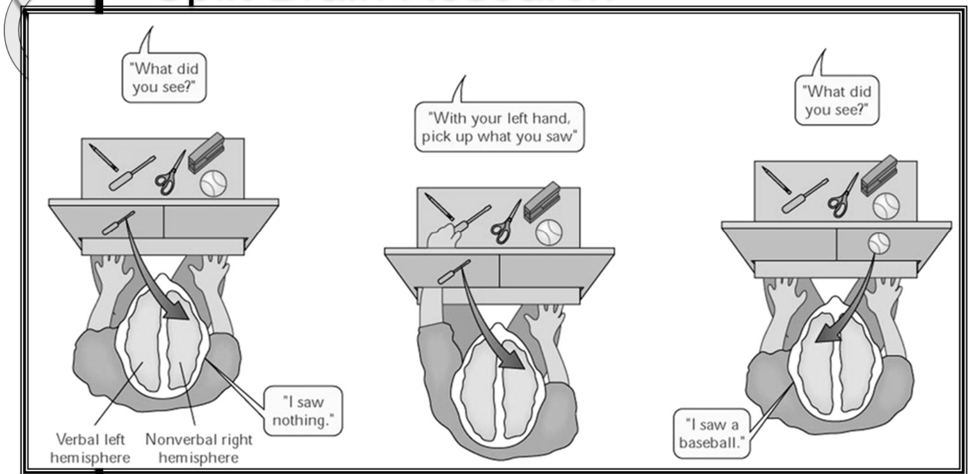
Here we can see the two hemispheres. Among other things the LH specializes in language and the RH in spatial abilities.

Vision starts with the left and right visual fields. This is a way of dividing reality around us. If you take the midpoint between your eyes then everything you see the left is the left visual field and everything to the right is the right visual field. The left side of each eye picks up what is in the right visual field. So in this example, the hammer, which is in the right V.F. Is captured by the left side of eacheye. The hammer's image that falls on the left eye travels directly to the left occipital lobe. The hammer's image that falls on the right eye travels to the left occipital lobe but by crossing between hemispheres through the corpus callosum. Objects present in the LVF are represented in the right visual cortex.

Turns out that the two hemispheres help each other out by communicating through the corpus callosum. In this example, the hammer located in the right visual field is visually processed by the left hemisphere. If you were asked if you see anything, you would respond yes and name the hammer because your language centre is also in the left hemisphere. If the hammer were in the left visual fields, its image would be processed by the right visual cortex. However, in order to respond verbally to the presence of the hammer, the right hemisphere would have to recruit the language capabilities of the left hemisphere through the corpus callosum.

Now imagine what would happen if the corpus callosum were cut . What would happen to our experience of the richness of reality?

Right Brain / Left Brain: Split-Brain Research



Kim Peak – The real rain man

- http://www.youtube.com/watch?v=NJjAbs-3kc8&feature=related
- http://www.youtube.com/watch?v=Auufbu_ZdDI&feature=related

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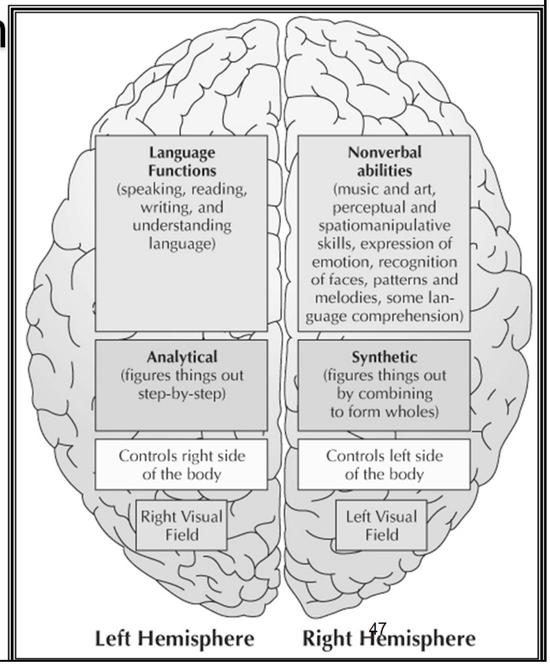
Severing the corpus callosum, as is done in patients with uncontrollable epilepsy, has provided very useful information on the role and functions of the left and right hemispheres. Let’s examine that using this example of a typical paradigm for investigating the impact.

When presented with a screwdriver in the left visual field, the right hemisphere processes that information, however, the patient is unable to verbally acknowledge the presence of the object. This occurs because the severed corpus callosum prevents the right occipital lobe from recruiting the language capabilities of the LH. However, when given a spatial task to pick up what he saw, the person is able to perform the task because the right hemisphere, the same hemisphere that processed the image, also houses spatial functioning. Note that this finding is reinforced in the picture on the right. When asked if they saw a baseball presented in the right visual field, the person is able to respond because the image is located in the same hemisphere as the language centre in the left hemisphere.

VIDEO – Not in class

Right Brain/Left Brain: Lateralization

- The left and right hemispheres of your brain each specialize in particular operations.



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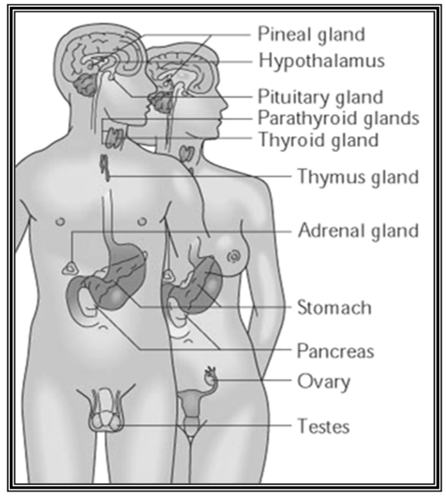
L.H. Specializes in language and analytical functions e.g. Figuring things out step-by-step. The R.H. Specializes in non-verbal abilities like music and art, spatial manipulation, expression of emotions, facial recognition, etc. It also has a synthetic function e.g. Putting pieces together into a whole .. Doing crossword puzzles

6. Communication through the endocrine system

- **Endocrine System:** collection of glands that manufacture and secrete hormones into the bloodstream



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A key part of behaviour is the system of hormones and glands that permeates the body and serves as both an obedient servent to the brain and as a feedback mechanism to let it know what's going on.

The hypothalamus in the brain's limbic system mediates communication between the brain the endocrine system. How does the endocrine system work ...

Communication through the endocrine system

- Hormones – chemical messengers in the bloodstream
  - Pulsatile release by endocrine glands
  - Negative feedback system
- Endocrine glands
  - Pituitary – "master gland," growth hormone
  - Thyroid - metabolic rate
  - Adrenal - salt and carbohydrate metabolism
  - Pancreas - sugar metabolism
  - Gonads - sex hormones

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Hormones are chemical messengers in the bloodstream that are secreted by the endocrine glands in a pulse-like manner – that is, several times per day in brief bursts or pulses. The levels of many hormones increase to a certain level, then signals are sent to the **hypothalamus** or other endocrine glands to stop secretion of that hormone – creating a **negative feedback system.**

These glands include: the (1) **pituitary** – the **master gland** that secretes substances influencing the operation of all the other glands; as well as growth hormone; (2) the **thyroid gland** – which controls metabolic rate; (3) the adrenal glands – which control salt and carbohydrate metabolism; (4) the pancreas – which secretes insulin to control sugar metabolism; and the (5) gonads – which secrete sex hormones involved in the development of secondary sex characteristics and reproduction.

Communication through the endocrine system

- Little research on behaviour
- Testosterone
  - Aggression
  - Cognitive functioning, but biase

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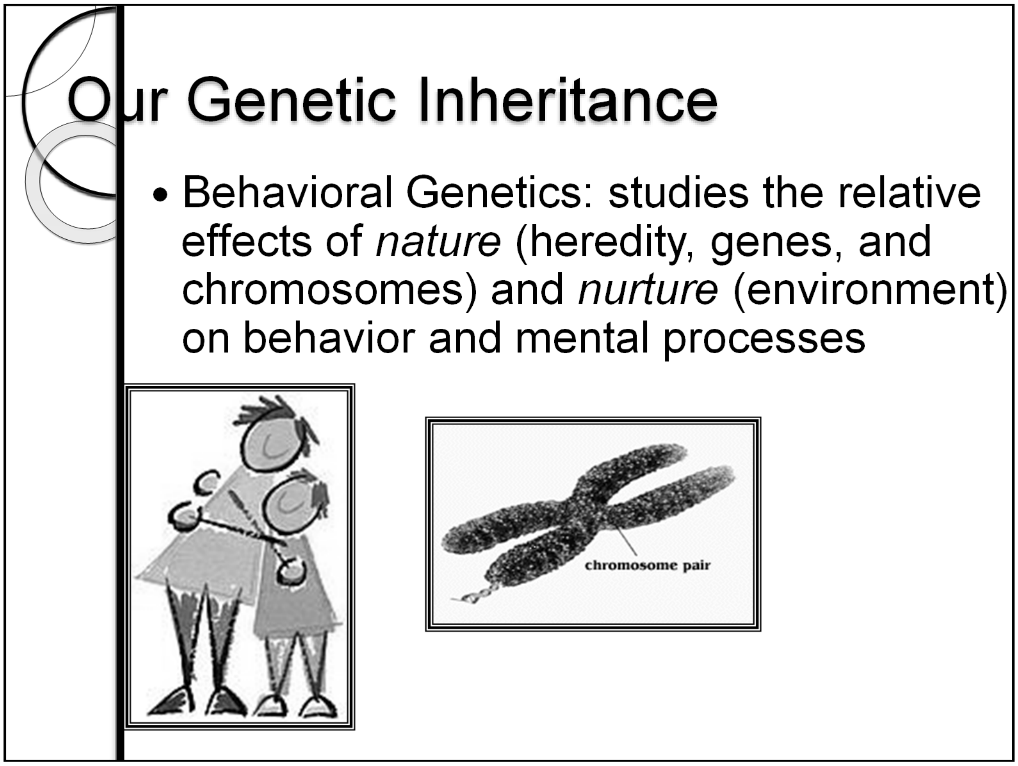
Current research is focused on determining the relationship between the levels of various hormones and behaviour although very little is known from that perspective. Most research on hormones focuses on their physiological roles.

The most widely researched in psychology is testosterone. E.g. High testosterone levels in males tend to be related to high levels of aggression. That relationship also exists in women but to a much lesser extent. Remember thought that research does not show that testosterone causes aggression. This is purely correlation research.

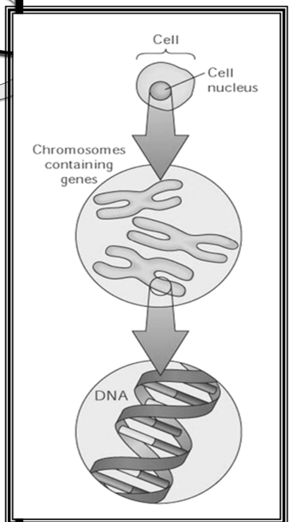
Some research also shows that higher levels of testosterone tend to be associated with measures of memory, information processing speed and spatial ability, but data are biased because they are based on samples of males.



Questions about how much of behaviour is biologically based and how much is environmentally based are very old ones in psychology. Since the 1970's, however, research methodologies have been developed in the field of behavioural genetics that shed new light on the age-old nature vs. nurture question.

There is some basic terminology of course ...

Our Genetic Inheritance: Genes & DNA



- The nucleus of every cell contains genes, which carry the code for hereditary transmission. These genes are arranged along chromosomes (strands of paired DNA).

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Genes and Behaviour: The Interdisciplinary Field of Behavioural Genetics

- Behavioural genetics = the study of the influence of genetic factors on behavioural traits
- Basic terminology:
- Chromosomes – strands of DNA carrying genetic information
  - Human cells contain 46 chromosomes in pairs (sex-cells – 23 single)
  - Each chromosome – thousands of genes, also in pairs
- Dominant, recessive
- Homozygous, heterozygous
- Genotype/Phenotype and Polygenic Inheritance

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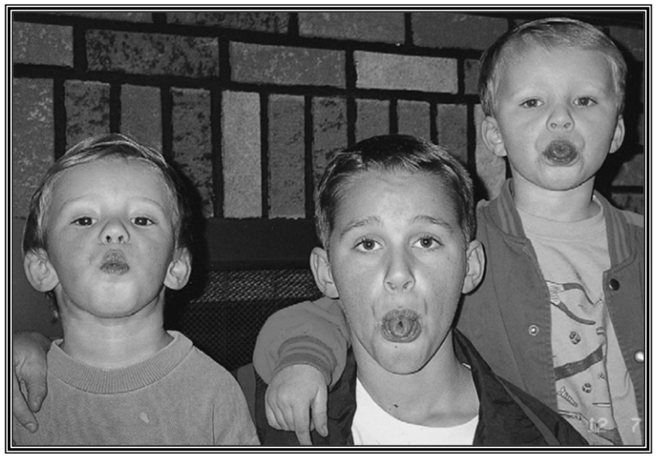
Chromosomes are strands of Deoxyribonucleic Acid (DNA) carrying genetic information…each human cell contains 23 pairs, with the exception of sex cells which have 23 single chromosomes…not yet paired.

Each chromosome contains thousands of **genes**, which also occur in pairs…sometimes a member of a pair has a louder voice, always expressing itself and masking the other, different, member of the pair…this is a **dominant** gene. A **recessive** gene is one that is masked when the paired genes are different.

When a person has two genes in a specific pair that are the same, the person is **homozygous** for that trait…if the genes are different, **heterozygous**

Genotype refers to a person's genetic makeup, while **phenotype** refers to the ways in which a person's genotype is manifested in observable characteristics. You can have different genotypes which yield the same phenotype (i.e. one person might have 2 genes for detached earlobes (**dominant**) while another has one for attached and one for detached…both, outwardly, look the same in the earlobe department)…most human traits are not so simple with regard to genetic transmission…they are **polygenic**, or influenced by more than one pair of genes.

Our Genetic Inheritance: Genes & DNA



- *Tongue-curling* is one of the few traits that depends on a specific dominant gene.

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There are only a few behaviours that are control by a single gene. Tongue curling is an example

Method for investigating heredity

55

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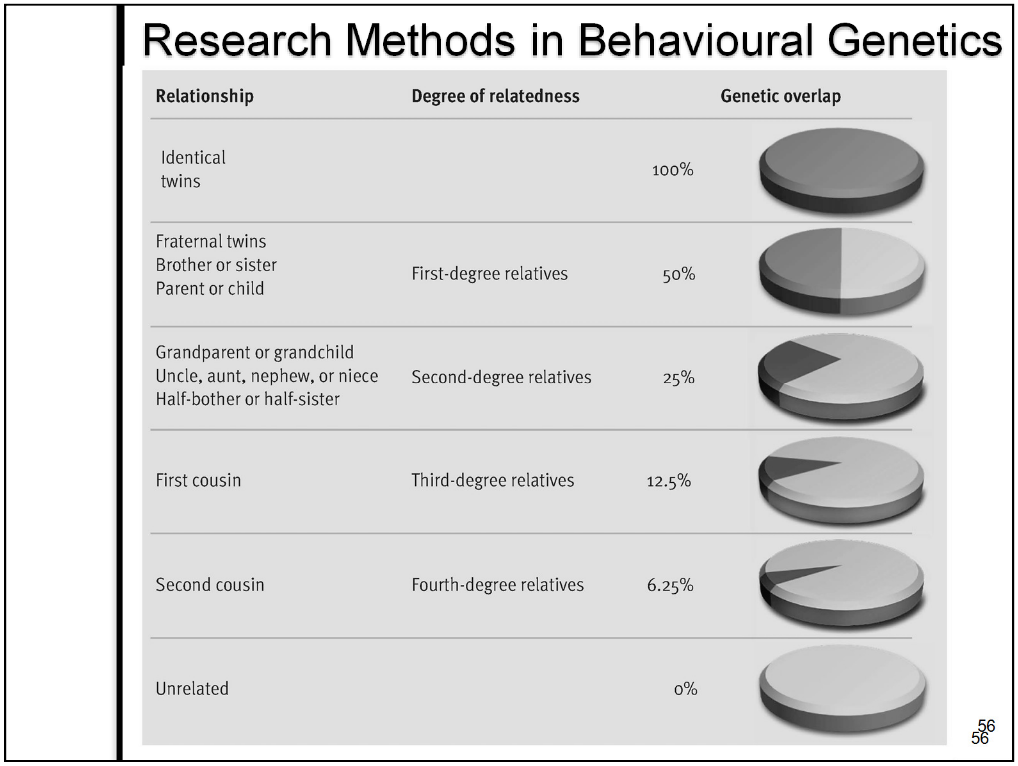

Research Methods in Behavioural Genetics

Relationship	Degree of relatedness	Genetic overlap
Identical twins		100%
Fraternal twins Brother or sister Parent or child	First-degree relatives	50%
Grandparent or grandchild Uncle, aunt, nephew, or niece Half-bother or half-sister	Second-degree relatives	25%
First cousin	Third-degree relatives	12.5%
Second cousin	Fourth-degree relatives	6.25%
Unrelated		0%

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Research methods in behavioural genetics rely on the notion of degree of relatedness and genetic overlap. The greater the degree of genetic overlap then the more likely that two individuals will share traits.

Go through slide

Research Methods in Behavioural Genetics

- Family studies – does it run in the family?
- Twin studies – compare resemblance of identical (monozygotic) and fraternal (dizygotic) twins on a trait
- Adoption studies – examine resemblance between adopted children and their biological and adoptive parents

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So what are the methods.

Family studies simply assess hereditary influence by examining blood relatives to see how much they resemble one another on a specific trait…determine whether it runs in the family. **Limitation:** many things run in families, but, that are not necessarily genetic. They could be due to the environment.

Twin studies can yield better evidence about the possible influence of heredity, because identical twins have the exact same genotype…they share 100% of the same genes. **Fraternal** twins only share 50% genetic relatedness…the same as any two siblings born to a set of parents at different times. Twins of both types, however, are raised in more similar environments (same age, configuration of relatives, etc.). If identical twins are more similar on a given trait than fraternal, the assumption is that it is probably genetic. Can also look at twins reared together vs apart.

Adoption studies assess genetic influence by comparing adopted children with both their biological and adoptive parents…if they are more like their biological parents (who they have never met) on a trait, it is probably genetic.

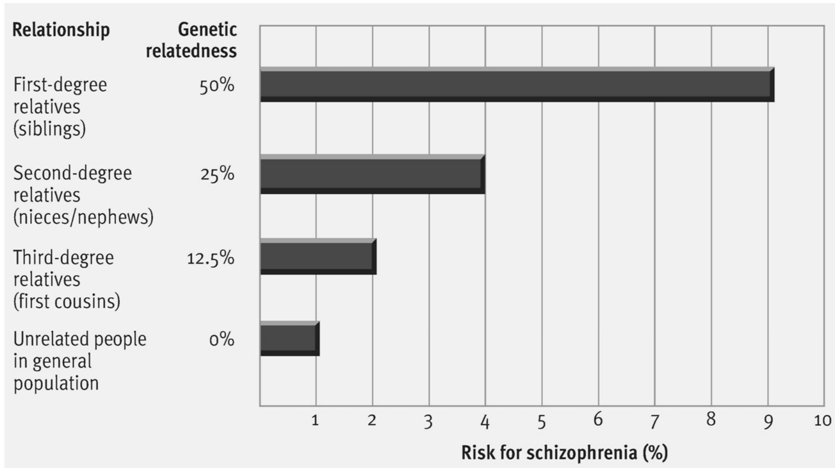

Figure 3.28

Family studies of risk for schizophrenic disorders. First-degree relatives of schizophrenic patients have an elevated risk of developing a schizophrenic disorder (Gottesman, 1991). For instance, the risk for siblings of schizophrenic patients is about 9% instead of the baseline 1% for unrelated people. Second- and third-degree relatives have progressively smaller elevations in risk for this disorder. Although these patterns of risk do not prove that schizophrenia is partly inherited, they are consistent with this hypothesis.

One example of behavioural genetics research is schozophrenia

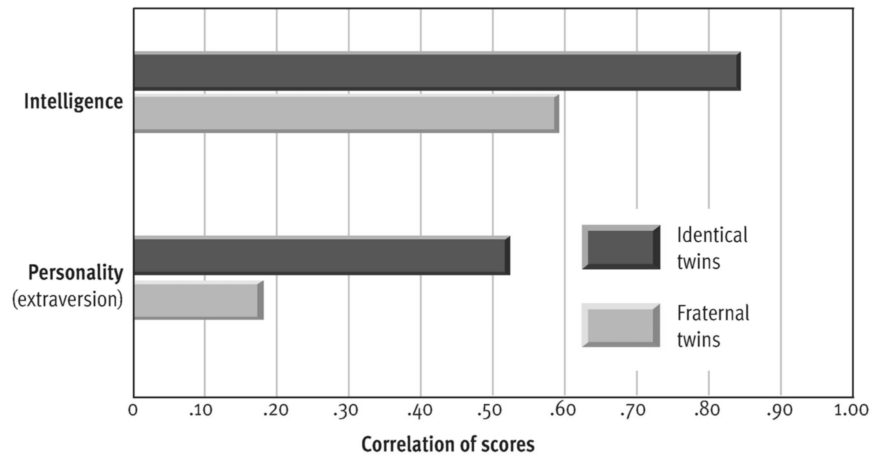

Figure 3.30

Twin studies of intelligence and personality. Identical twins tend to be more similar than fraternal twins (as reflected in higher correlations) with regard to intelligence and specific personality traits, such as extraversion. These findings suggest that intelligence and personality are influenced by heredity. (Intelligence data from McGue et al., 1993; extraversion data based on Loehlin, 1992)

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As an example of the role of the environment, notice that even for identical twins, personality characteristics only overlap with a correlation of .50.

Our Genetic Inheritance: Gene-Environment Interaction

- Environmental factors interact with genetic factors to influence many traits. For example, early malnourishment may affect height and cognitive abilities

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One thing we have learned over time is that we are a product of an interaction between genetic and environmental factors.

Modern Approaches to the Nature vs. Nurture Debate

- Molecular Genetics: the study of the biochemical bases of genetic inheritance
  - Genetic mapping: locating specific genes
  - The Human Genome Project
- Behavioural Genetics
  - The interactionist model
  - Richard Rose (1995) “We inherit dispositions, not destinies.”

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Continuing on this theme of genetics versus environmental determinants of behaviour, modern advances in molecular genetic technology have allowed for genetic mapping…which is the locating of specific chromosomes and genes involved in phenotypic expression. While this is a promising area of research, initial progress points toward the complexity of polygenic inheritance rather than yielding simple answers to the nature nurture debate.

The behavioural genetics field has yielded much the same conclusion…there will be no simple answer to the “is it nature or nurture” question…Richard Rose quote – “we inherit dispositions, not destinies.”

8. Evolution's Role in Behaviour

- Evolutionary Psychology: studies how natural selection and adaptation help explain behavior and mental processes

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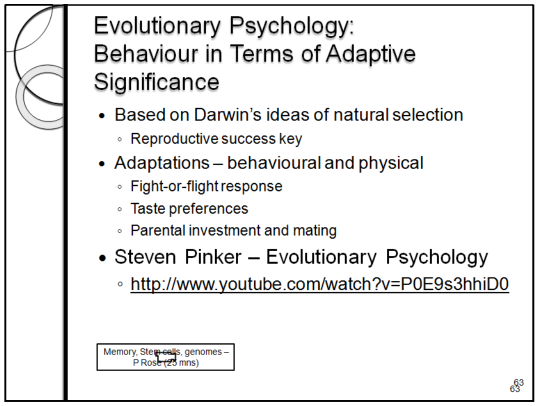
Finally, Evolutionary Psychology studies how natural selection and adaptation help explain behaviour and mental processes



The field of **evolutionary psychology** is a major new field in psychology.

It is based on the work of Charles Darwin and the ideas of natural selection and reproductive fitness…i.e. that variations in reproductive success are what really fuels evolutionary change.

Evolutionary theorists study adaptations, or inherited characteristics, that increase in a population because they help **solve** a problem of survival or reproduction during the time they emerge…giraffes and long necks.

Some of these continue to exist even when no longer needed, for example the fight-or-flight response may have been very helpful in primitive times, but now it is related to a number of stress-related diseases. Similarly, humans show a taste preference for fatty foods…this was adaptive in a hunter/gatherer society, when dietary fat was **scarce**…but fat preference can now result in obesity, heart disease, etc. While this may lead to decreased longevity, the effect on reproductive success is more difficult to gauge.

Another important concept in Evolutionary Psychology is **Parental investment** refers to time, energy, survival risk, and forgone opportunities that each sex has to invest in order to produce and nurture offspring. **Trivers** (1972) suggested that a species' courting and mating patterns are based in parental investment. When parental investment is high for females and low for males, **polygamy** results – i.e. a mating system whereby each male seeks to mate with multiple, females and each female seeks only one male. However, the opposite, p**olyandry** occurs when each female seeks to mate with multiple males and each male with only one female – this emerges when parental investment is high for males and low for females. **Monogamy** emerges when male and female parental investment is roughly equal.

Steven Pinker VIDEO

Extra video: Dr. Eric Kandel and Dr. Gerald Fischbach discuss the progress being made toward understanding how the human brain functions. They also discuss what is being done to understand mental illnesses and the relationship between the body and the mind.