

ECAP6007 – Biological and Cognitive Neuroscience

Dr Stuart Jones.



Introduction.

Dr Stuart Jones.

Room CJ214

Email: s.a.jones@uwtsd.ac.uk

Telephone: 01267 676697

Aims

- # To enable students to critically evaluate the contribution new technologies have made to our understanding of human behaviour and cognition.

Learning Outcomes.

- # • demonstrate a critical understanding of conceptual and historical issues relating to Biological and Cognitive Psychology;
 - # demonstrate a critical understanding of how drugs and hormones influence brain activity and subsequent behaviours, examining empirical research involving neuroimaging techniques in this field;
-

Learning Outcomes

- # demonstrate a critical understanding of how approaches in Neuroscience have contributed to the development of the field of Cognitive Psychology (e.g. attention, the study of perception, learning, memory, thinking and language);
 - # take responsibility for their own learning and skill development; including effective personal planning, self-reflection and project management skills.
-

Content.

- # Examination of the dynamic development of biological and cognitive neuroscience in the last two decades.
 - # Examination of the benefits and limitations of evidence derived from neuroscientific research with particular reference to learning and cognition.
 - # Examination of the biological basis of behaviour and the impact of neuroimaging techniques in relation to the understanding in this field.
-

Content.

- # Exploration of the impact neuroscientific research may have on traditional empirical evidence within Biological and Cognitive Psychology.
 - # Exploration of a range of approaches developed within neuroscience used to enhance our understanding of relating to disorders of attention, perception, learning, memory, thinking and language.
-

Recommended Reading

- # Bear, M., Connors, B., & Paradiso, M. (2016).
Neuroscience: Exploring the brain (Fourth edition). Wolters
Kluwer
 - # Carlson, N. (2011). Foundations of behavioral neuroscience
(8th ed.). Allyn & Bacon
 - # Gazzaniga, M., Ivry, R.B., & Mangun, G. R. (2014).
Cognitive Neuroscience: The Biology of the Mind. Norton.
-

Recommended Reading List

- # Purves, D. (2008). Principles of Cognitive Neuroscience. Sinauer Associates.
 - # Kemmerer, D. (2015). Cognitive neuroscience of language. Psychology Press
 - # Higgs, S., Cooper, A., Harris, M., & Lee, J. (2015). Biological psychology. SAGE.
-

Module Breakdown.

Lecture:	Lecture content:
1	Introduction / Recapping
2	Techniques in Neuroscience 1.
3	Techniques in Neuroscience 2.
4	Drugs and Behaviour
5	Cognitive Neuroscience - Memory
6	Cognitive Neuroscience - Language
7	Cognitive Neuroscience – Attention
8	Cognitive Neuroscience – Social Cognition
9	Assessed Presentation
10	Sensation and Perception

Assessments

ASSESSMENT

- # Assessment Component 1 Exam (2.5 hours) 50%
 - # Individual Presentation (15 minutes) 50%
-

Examination

- # Exam – 2.5 hours.
 - # Students must choose TWO of the four questions to answer during
 - # the scheduled examination.
 - # Date –TBC – EXAM PERIOD (JANUARY).
-

Assignments

- # Individual Presentation (15 minutes) 50%
 - # Critically review ONE of the journal articles selected in the field of Cognitive Neuroscience
 - # For exact title and date please see Moodle.
-

What is Neuroscience?

What is Neuroscience???

What is Neuroscience?

- # Neuroscience – The scientific study of the nervous system.
 - # Seen as a branch of Biology.
 - # Interdisciplinary.
 - Psychology, Maths, Physics, Computer Science.
-

Terminology.

- # Neuroscience and Neurobiology.

- # Used interchangeably

- # Are they the same?

Other terminology.

Biological Psychology.

Biopsychology.

Psychobiology

Neuropsychology

Cognitive Neuroscience.

- # Term identified by Gazzaniga and Miller.
 - # Late 1970's.
 - # **Cognitive neuroscience** is concerned with the scientific study of biological substrates underlying cognition.
-

Cognitive Neuroscience.

- # Attempts to discover how mental activities are executed in the brain.
 - # Provides hypotheses about specific cognitive capacities – supplies proposals about how specific functions might be executed in the brain.
-

Cognitive Neuroscience.

- # Reliance on new techniques for studying the brain of normal participants.
 - As opposed to brain damaged ones.
 - # “Brain in Action”.
 - # E.g. Short term and Long Term memory.
 - (Smith and Jonides, 1994; Squire et al, 1993).
-

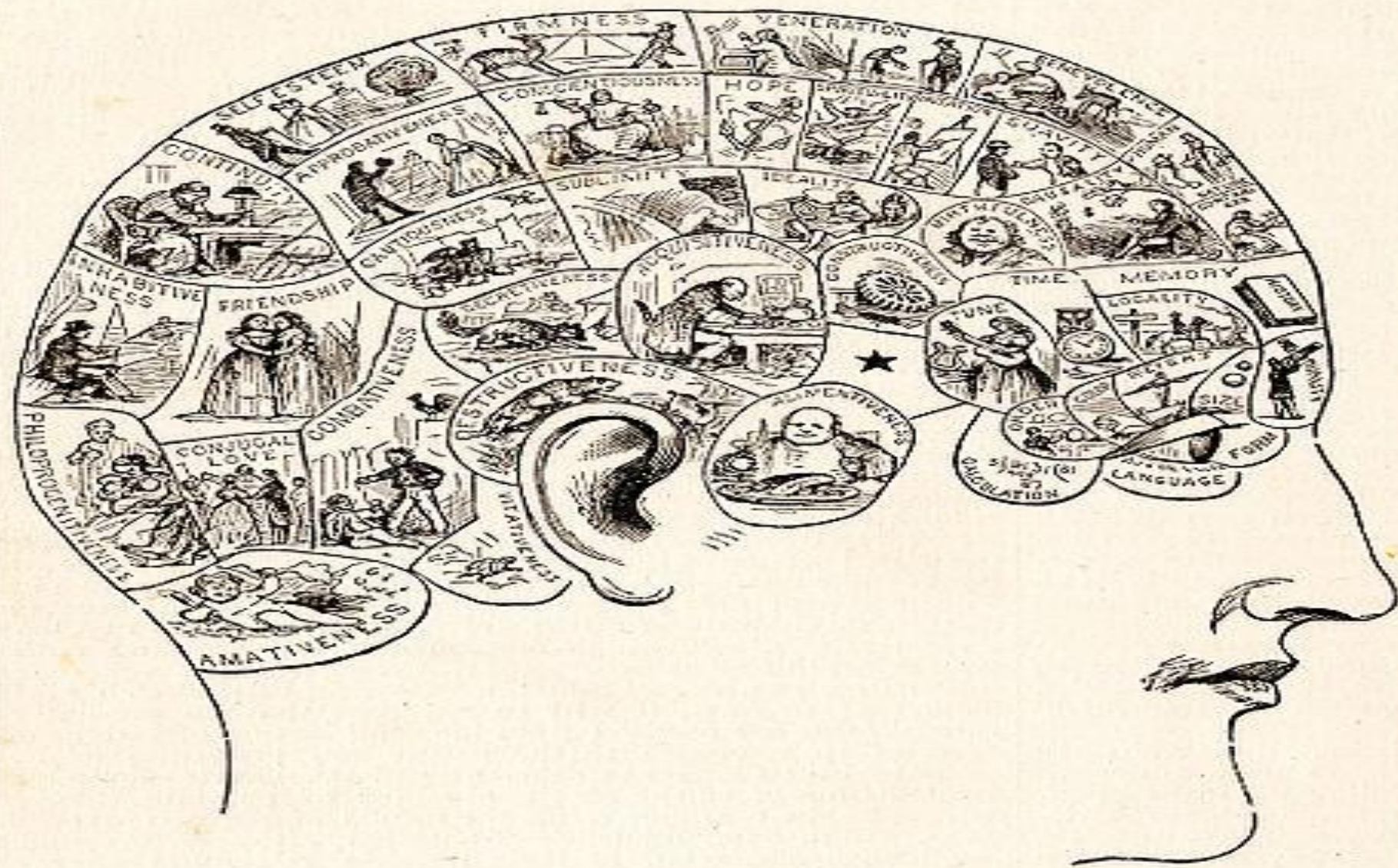
Discussion Point.....

- # What potential ethical issues could the study of the “brain in action” bring.
 - # What are the ethical risks and how might neuroscientists attempt to manage / minimise these risks.
-

Origins of Cognitive Neuroscience.

- # Phrenology.

- # 1800's.



Phrenological Chart of the Faculties.

Brain Organs.

- # 1) Reproduction.
 - # 2) Love for ones offspring.
 - # 3) Affection and Friendship.
 - # 4) The instinct of self-defence and courage; the tendency to get into fights.
 - # 5) The carnivorous instinct; the tendency to murder.
 - # 6) Guile; acuteness; cleverness.
 - # 7) The feeling of property; the instinct of stocking up on food (in animals); covetousness; the tendency to steal.
 - # 8) Pride; arrogance; haughtiness; love of authority; loftiness.
 - # 9) Vanity; ambition; love of glory (a quality "beneficent for the individual and for society").
-

Brain Organs

- # 10) Circumspection; forethought.
 - # 11) The memory of things; the memory of facts; educability; perfectibility.
 - # 12) The sense of places; of space proportions, of time.
 - # 13) The memory of people; the sense of people.
 - # 14) The memory of words.
 - # 15) The sense of language; of speech.
 - # 16) The sense of colours.
 - # 17) The sense of sounds; the gift of music.
 - # 18) The sense of connectedness between numbers.
-

Brain Organs

- # 19) The sense of mechanics, of construction; the talent for architecture.
 - # 20) Comparative sagacity.
 - # 21) The sense of metaphysics.
 - # 22) The sense of satire; the sense of witticism.
 - # 23) The poetical talent.
 - # 24) Kindness; benevolence; gentleness; compassion; sensitivity; moral sense.
 - # 25) The faculty to imitate; the mimic.
 - # 26) The organ of religion.
 - # 27) The firmness of purpose; constancy; perseverance; obstinacy.
-

The Brain

- # Often described as the most complexly organised structure in the Universe (e.g. Ramachandran, 2003).
 - # Just look at the facts that we already know.
-

Neurons.

100 – 150 billion neurons.

Making approximately.....

- 1, 000,000,000,000,000
- 1 quadrillion connections.

Responsible in all humanities achievements.

1 quadrillion.



- # 1 000 000 000 000 000 gallons?
 - # Close to 2.73 times the estimated total earth water reserves !
-

1 Quadrillion.

- # 1 000 000 000 000 000 miles?
- # Close to 169 light-years
- # 1.1 millions times the distance between the Sun and the Earth

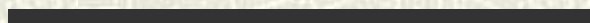




With advancing technology we are becoming more and more aware of how the human brain functions.

Could this be the greatest revolution of all?
(Ramachandran, 2003)

How close are we to fully understanding the brain and its relationship with behaviour?





Insights into the human brain is not just beneficial for scientists.

Bridging the gap between Science and the Arts.

What makes us tick.

Feelings, emotions, thoughts, ambitions, love, beliefs – all related to brain activity.

Recap on Hormones



'Hormone'

Greek '*Horman*' = *to excite*'

Chemicals secreted by one group of cells and carried through blood to other parts of body

Act upon specific target tissues - specific physiological effects

Endocrine glands

(*'endon'* = *'within'*; *'krinein'* = *'to secrete'*)

Secrete hormones within the body

- ***exocrine glands***, such as tear glands, salivary glands and sweat glands – outside the body (*'exo'* = *'out'*)

Early Hormone Research.

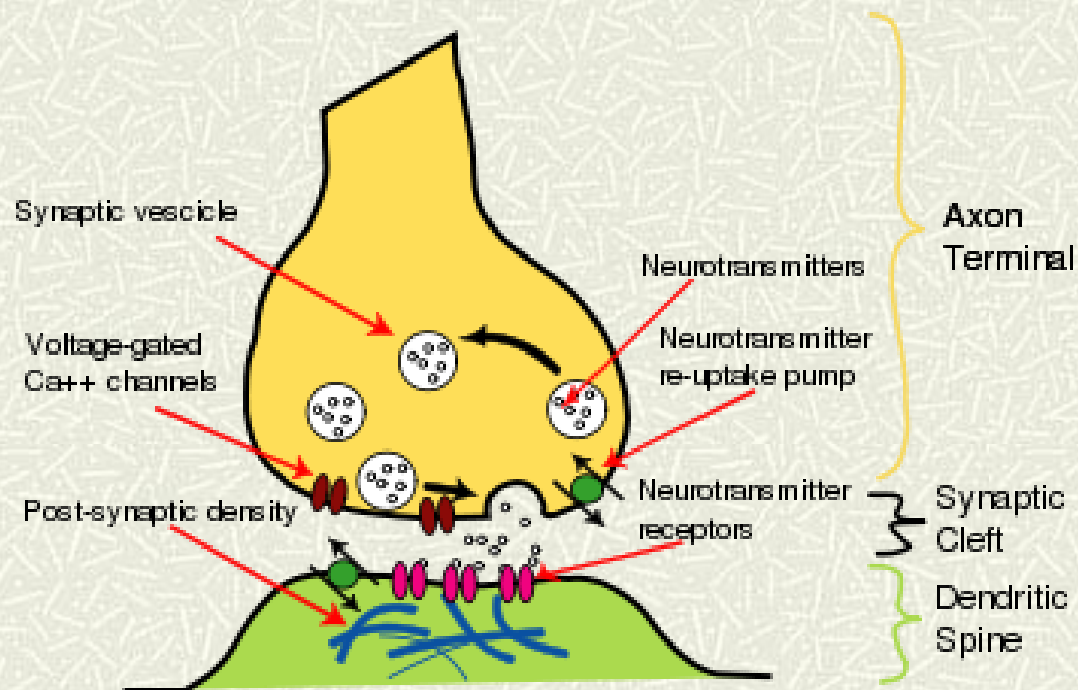
- # 1849 – First major endocrine experiment.
 - # A.A.Berthold (1803-1861).
 - # Castration of juvenile roosters.
 - # Results?
-

Early Hormone Research.

- # Results see Handout 1.
 - # Group 3 – results intriguing.
 - # Testes release a chemical into the blood that affects male behaviour and structure.
 - Cannot be Nerve supply.
-

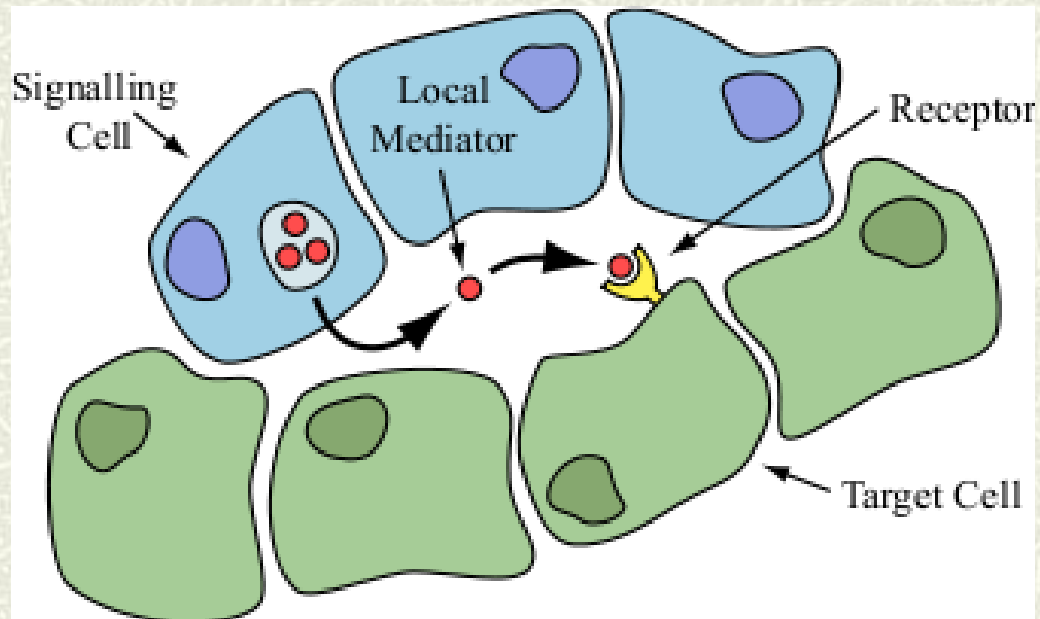
Neurocrine communication (a.k.a. Synaptic communication).

Released chemical signal diffuses across the synaptic cleft



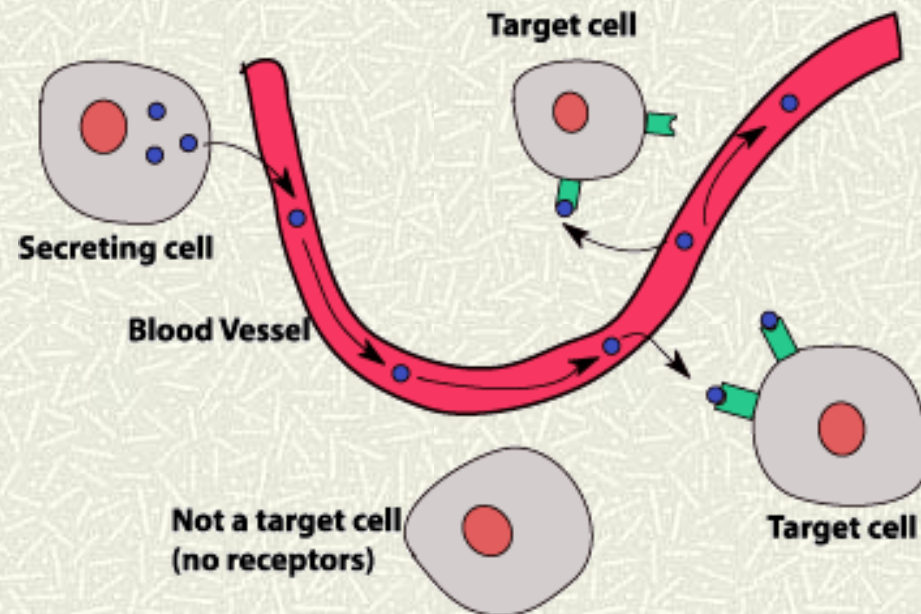
Paracrine communication

Released chemical signal diffuses to nearby target cells and the strongest impact is on nearby cells



Endocrine communication

Chemical signal - a hormone released into the bloodstream to selectively affect distant target organs



Pheromone communication

Communication between individuals.

Pheromones (Greek '*pherein*' = 'to carry')

Released into the outside environment to affect other individuals of the same species



Allomone communication

Chemical signals released by members of one species to affect behaviour of individuals of another species

Allomones ('*allos*' = '*other*')

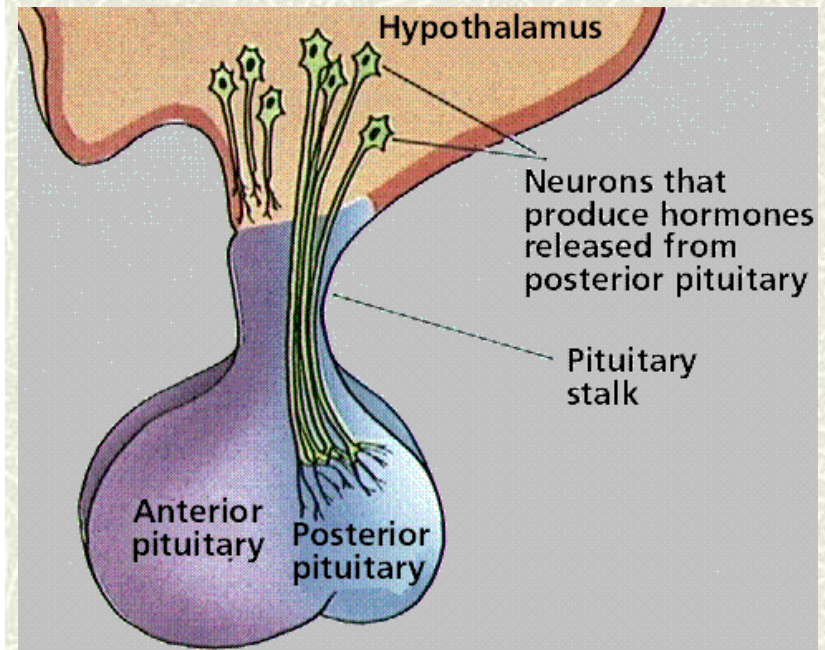
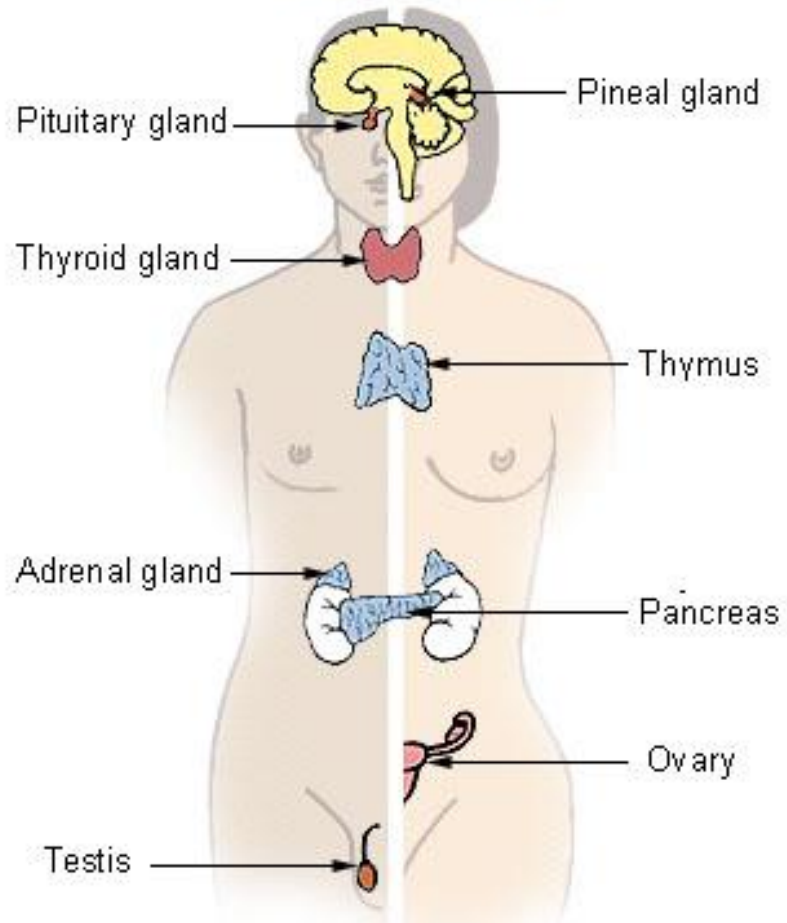
Can carry messages between animal species or between plants and animals



Endocrine system

Major Endocrine Glands

Male Female



Endocrine System.

Handout – Major endocrine glands and their functions.

Organization of Hormones

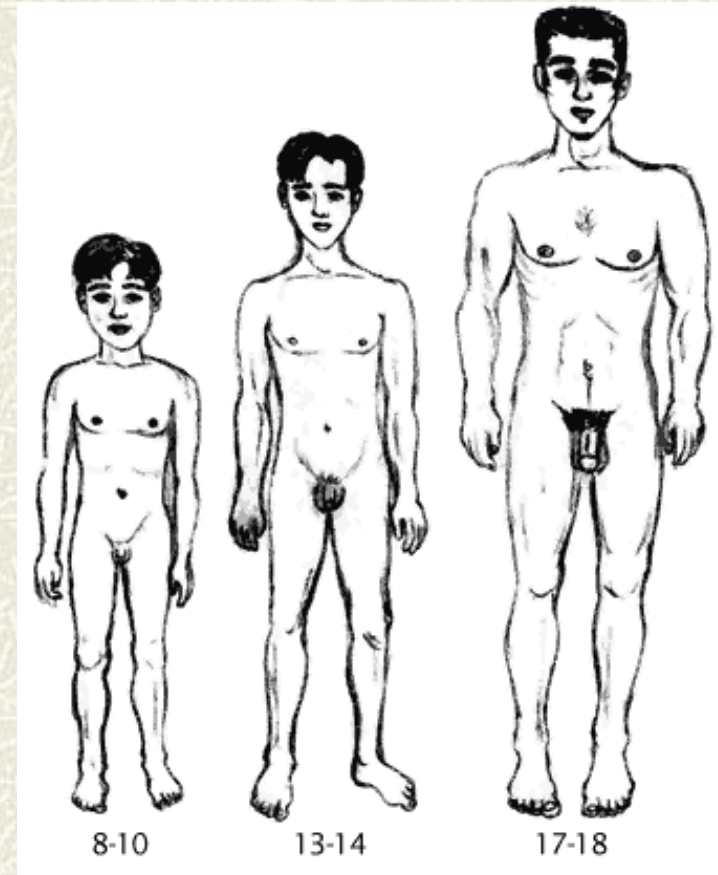
- # In essence hormone action can be organised into 9 general principles.

Organization of hormones – Nine principles

1. Hormones act in a *gradual* fashion

Activate behavioural and physiological responses hours or weeks after entering the bloodstream

Changes may persist for days, weeks or years after hormone release is activated



Nine principles...

2. Hormones tend to act by ***changing the intensity or probability*** of evoked behaviours

Not a switch to turn behaviours on or off regardless of context



Nine principles...

3. Both quantities and types of hormones released are influenced by environmental factors

The ***relationship between behaviour and hormones is reciprocal***

i.e. hormones change behaviours and behaviours change hormone levels



Examples.

- # Testosterone.
- # Related to Aggression.
- # In Some species males who lose encounters show a reduction in level.

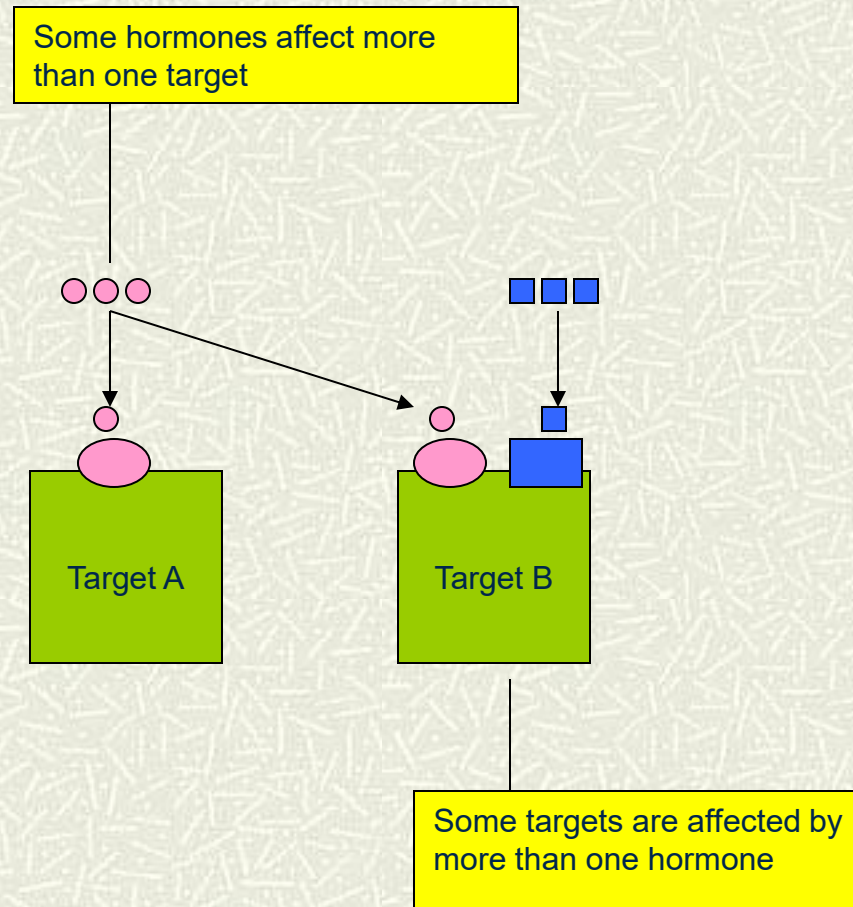


Nine principles...

4.

A hormone may have **multiple effects** upon different cells, organs and behaviours

A single type of behaviour or physiological change can be affected by many **different hormones**



Nine principles...

5. Hormones are produced in small amounts and often secreted in bursts

This *pulsatile secretion* is sometimes crucial for the small amounts of hormones to be effective

Nine principles...

6. The levels of many hormones vary rhythmically throughout the day, and many hormone systems are controlled by circadian 'clocks' in the brain



Nine principles...

7. Hormones interact: the effects of one hormone can be markedly changed by the action of another hormone
 8. The chemical structure of a given hormone is similar in all vertebrates - but the *function* hormone serves can vary across species
 9. Hormones can affect only cells possessing a receptor protein that recognizes the hormone and alters cell function. Different vertebrates - often same brain regions possess same hormone receptors
-

Differences between neurotransmitters and hormones.

- # Neurotransmitter = Chemicals released from a nerve cell....
Electrochemical impulse.
 - # Hormones – Chemicals secreted by Endocrine Glands into
bloodstream. More wide spread.
 - Both essential for everyday living.
 - Breedlove et al (2010).
-

Regulation of hormones

Hormonal systems manufacture hormones and also detect and evaluate effects

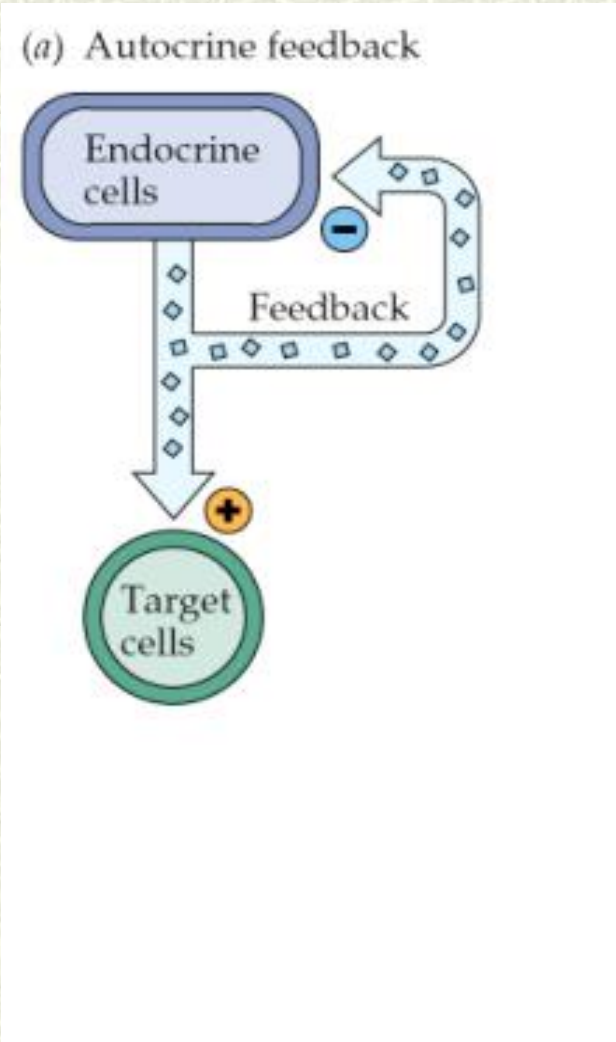
Secretion monitored and regulated

Negative feedback system – output of the hormone feeds back to inhibit the drive for more of that same hormone

1. Simplest kind of regulation system - endocrine cell releases a hormone that acts on target cells - but same hormone feeds back to inhibit the gland that released it.

This is an ***autocrine response***

Autocrine Feedback



Regulation of hormones

2. Endocrine cell reacts not to its own hormone, but to biological response that hormone elicits from target cells

If initial effect too small, additional hormone released

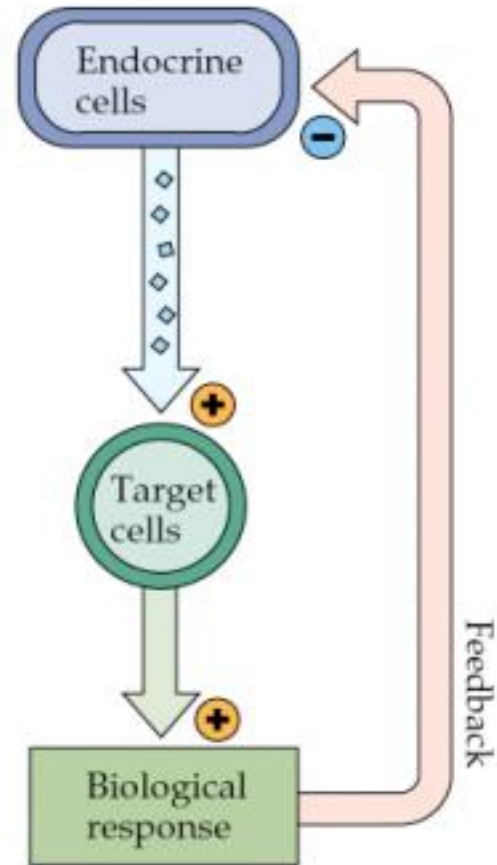
If effect is sufficient, no further hormone released

e.g. ***Insulin***

- Following a meal, glucose from food enters blood stream, causing insulin to be released from the pancreas.
 - Insulin causes glucose to enter muscle and fat cells.
 - As level of glucose in blood falls, pancreas secretes less insulin
 - So a balance tends to be maintained
-

Target Cell Feedback

(b) Target cell feedback



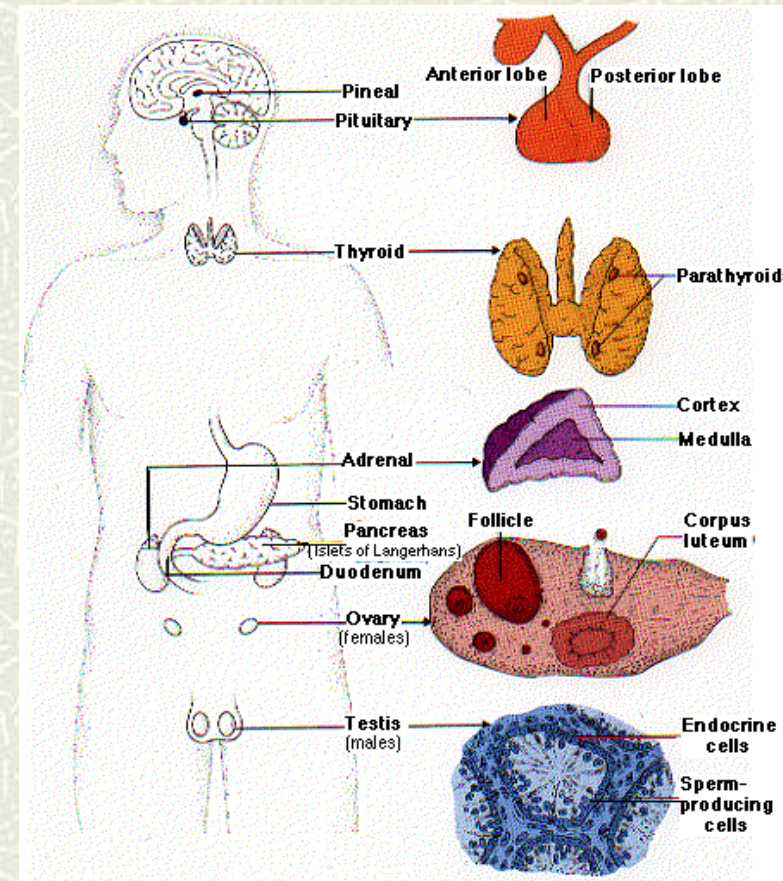
Regulation of hormones

3. More complex endocrine system includes the brain - usually hypothalamus - as part of the circuit that controls the endocrine gland

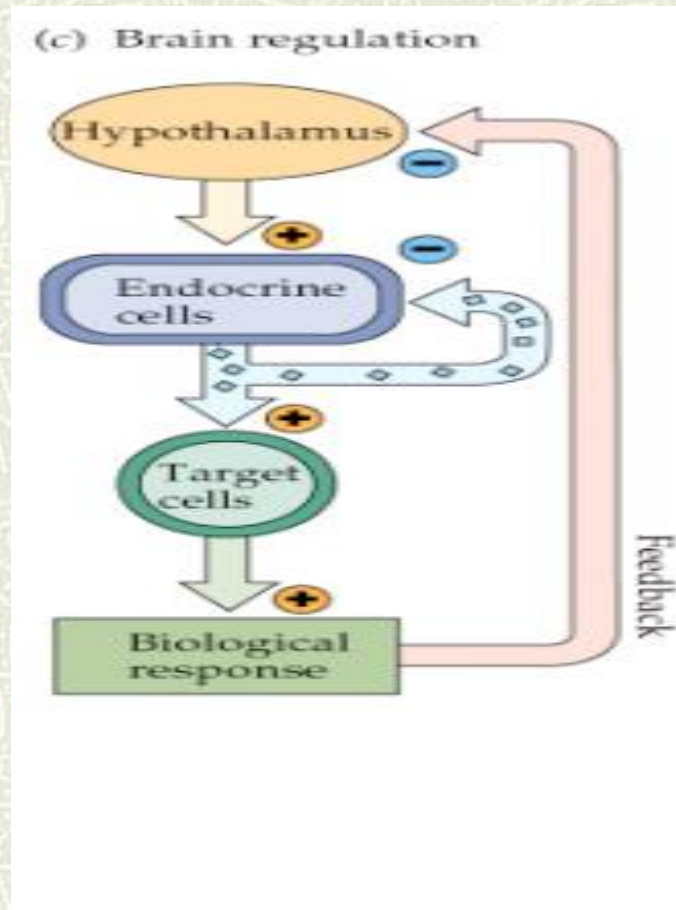
e.g. Alarm!

Hypothalamus directs adrenal medulla to secrete adrenaline

When brain detects these effects it exerts negative feedback on the hypothalamus to reduce further hormone output



Brain Regulation



Regulation of hormones

4. Several anterior pituitary hormones affect secretion of other endocrine glands

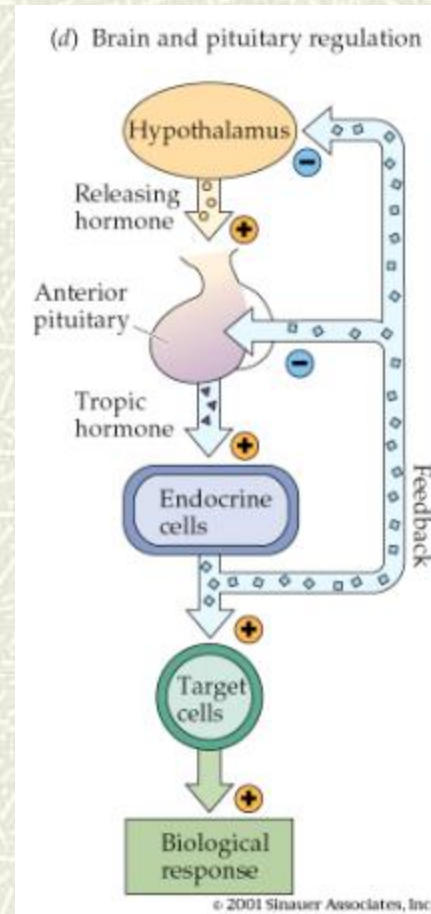
Anterior pituitary hormones - ***tropic hormones***

Hypothalamus uses another set of hormones called ***releasing hormones*** – to control the pituitary release of tropic hormones.

So - releasing hormones (brain) affect release of tropic hormones (pituitary) - which affect the release of hormone from another endocrine gland

Negative feedback: from hormone of the endocrine gland to both the hypothalamus and the pituitary

Brain and Pituitary Regulation



Regulation of Hormones.

Handout – Breedlove.

Affects of hormones on social behaviour

e.g. **Oxytocin**

1. Stimulation of mother's nipple - brain activity
2. Increased brain activity - inputs to hypothalamus
3. Cells in hypothalamus produce oxytocin - released from posterior pituitary
4. Oxytocin causes cells of mammary glands to contract - releasing milk
5. Baby, rewarded with milk, continues sucking



Oxytocin involved in other social behaviours

Pulse of oxytocin released during orgasm in both men and women (Carmichael et al, 1994)

In non-human animals, ***oxytocin*** and ***vasopressin*** (peptides) modulate many social processes (Lim and Young, 2006)

- 
-
- # Oxytocin levels and time spend together (Carter, 2002) – Rats.
 - # Social Amnesia (Ferguson et al, 2000).
 - # Oxytocin - bonding with their mates.
 - # Male Prairie Voles – Vasopressin facilitates males preference in a partner.
-

Endocrine pathology – extreme effects on human behaviour

Both ***deficient*** and ***excessive*** hormone secretion are associated with a variety of human physiological, anatomical and behavioural disorders

(Erhardt and Goldman, 1992)

Examples -

Parathyroid deficiency – build up of deposits of calcium in basal ganglia - symptoms resemble schizophrenia

Excessive thyroid release - intense anxiety

Decreased thyroid release - cognitive impairment and depression

Inherited form of ADHD in children - decreased sensitivity to thyroid hormone

Excessive glucocorticoid exposure also associated with ***steroid dementia syndrome*** (memory and attention problems) (Wolkowitz et al, 2004)

Long-term excess of glucocorticoids - ***Cushing's syndrome***

