E1 Stimulus and Response

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Stimulus, response and reflexes

Stimulus (pl. stimuli)
A change in external or internal environment that is detected by a receptor and elicits a response.

Response
A change in behaviour in reaction to a stimulus.

Reflex
A rapid and unconscious response, e.g. the response to pain:

Reflexes are the product of natural selection. Rapid and unconscious responses allow for danger avoidance with minimal harm to the organism - so pain is a good thing!

The pain reflex is moderated by the spinal cord rather than the brain - shorter paths, faster responses and no conscious decisions needed!
The pain reflex

Also known as the somatic reflex arc

Vocabulary varies between sources

beneath the skin:
- pressure and puncture receptors

Afferent = inflowing:
- we use 'sensory neuron'

Association = relay:
- we use 'relay neuron'

Efferent = outflowing:
- we use 'motor neuron'

The parts of a reflex arc are labeled in the order in which action potentials pass through them. The five components are the sensory receptor, afferent neuron, association neuron, efferent neuron, and effector organ.

http://msjensen.cehd.umn.edu/1135/Links/Animations/Flash/0016-swf_reflex_arc.swf
Functions of the players in the reflex arc

- Receptor cells detect change in environment
- Dorsal root ganglion (passage for neuron)
- Cell body
- Sensory neurons connect receptor to CNS
- Relay neurons coordinate response
- Synapses join neurons or neuron to effector
- Motor neurons connect CNS to effector
- Ventral root ganglion (passage for neuron)
- Effector takes action, e.g. muscle contraction

White matter
Connects sections of the CNS

Grey matter
Environment for relay neurons

Back (dorsal side)
Front (ventral side)

http://www.waukesha.uwc.edu/lib/reserves/zoo234diagrams.html
Instincts

Automatic behavioural responses to stimuli
Also known as Fixed Action Patterns (FAP).

These behaviors are fixed in the species and are genetically coded. They are triggered by stimuli, such as day-length (mating), presence of mates (mate dances or displays) or others.

Many species will migrate seasonally in order to avoid harsh environmental conditions or to find new areas for foraging or hunting.

FAPs, or instincts, are the result of natural selection. The most effective automatic responses to stimuli give the individual a survival and/or reproductive advantage, and so are passed on.

Greylag goose response to eggs out of place:

Wildebeest migration:

http://kickyoutube.com/watch/?v=HYM6LqDJLiM

Yawning is thought to be an example of a FAP in humans - we respond to the stimulus of others by yawning ourselves!

Other human FAPs include the suckling, grasping and crying instincts in newborns.
Natural Selection Influences Fixed Action Patterns
Example: Blackcap (*Sylvia atricapilla*) migration changes

Normal FAP:
Chicks hatch and fly SW to Spain for winter
(migration to avoid harsh winters)

Alternate behaviour:
Some flew NW to UK - where birdfeeders provide easy sources of food.

Advantage:
Shorter flight distances and easy supply of food from bird enthusiasts allow blackcaps to return to German breeding sites ahead of Spanish migrants and be more reproductively successful.

Natural Selection:
Genes for NW migration passed on and proliferate in population.

Experimental evidence:
Eggs taken from nests of both populations of blackcaps. NW hatchlings flew NW, even though there were no parents to follow - likewise with the chicks of SW migrators - strong suggestion of genetic basis for direction in migration.

Genetic and morphological differences are now apparent between the two populations.

http://www.birdersworld.com

Original paper: *Nature*
http://www.nature.com/nature/journal/v360/n6405/abs/360668a0.html

Neat article: Not Exactly Rocket Science
Natural Selection Influences Fixed Action Patterns

Example: Butterfly (*Heliconius cydno*) mate preference

Normal FAP:
*Heliconius* has a huge range of colours and individuals will mate with any other variant.

Alternate behaviour:
Yellow *Heliconius* butterflies have developed preference for yellow mates.

Advantage:
Suggested link between wing pigment and visual processing: yellow individuals may be able to see yellow mates more easily. Population may become better adapted to specific niches.

Natural Selection:
Yellow individuals are becoming reproductively isolated through sexual selection. This is the Wallace Effect and is likely to result in them becoming a separate species.

Experimental evidence:
Observations of yellow *Heliconius* shows a strong preference for mating with other yellow individuals. Previous speciation of *Heliconius* shows that hybrids are possible, yet selected against as they are less well adapted to the local niches.

The two colours of *H. cydno alithea* are genetically identical, except for the colour and preference, suggesting genetic link for mate preference and colour-linked genes, or even the same gene?

Source article:
Not Exactly Rocket Science

Selection against hybrids paper (Royal Society)
More examples of changes due to natural selection:

Great tits breeding earlier:

Rapid evolution of Malawi cichlids:

http://notexactlyrocketscience.wordpress.com/2008/01/30/malawi-cichlids-how-aggressive-males-create-diversity/

More Reading:

How can evolutionary responses to climate change be measured?

Migration won't prevent climate-change induced extinction

Evolution and genetics of migration in insects:
"The results of your physical exam are fine, except for your reflexes: They're more 'dog-like' than 'cat-like'."

For more IB Biology resources: http://sciencevideos.wordpress.com