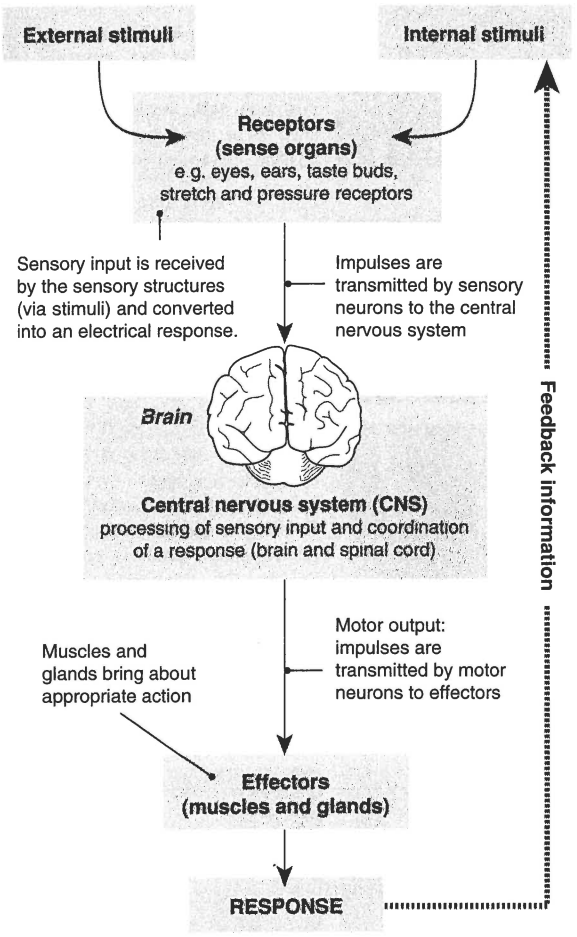
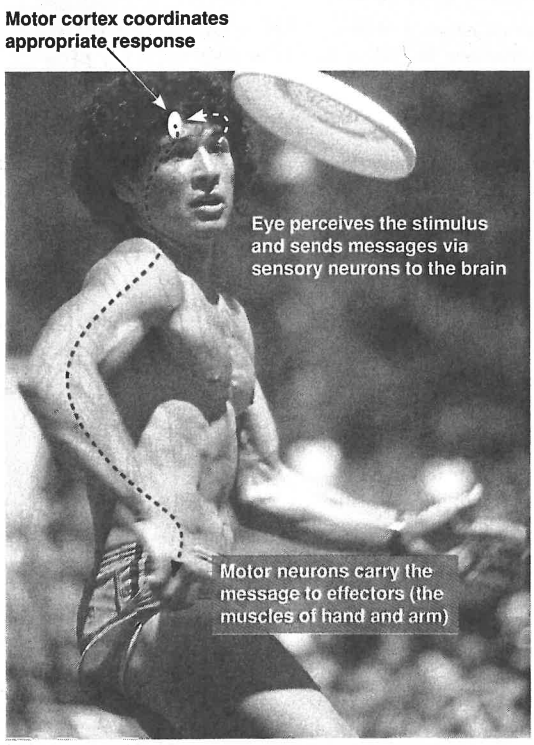
Nervous Regulatory Systems

An essential feature of living organisms is their ability to coordinate their activities. In mammals, such as humans, detecting and responding to environmental change, and regulating the internal environment (**homeostasis**) are brought about by two coordinating systems: the nervous and endocrine systems. Although these two systems are quite different structurally, they frequently interact to coordinate behavior and physiology. The nervous system contains cells called **neurons** (or nerve cells). Neurons are specialized to transmit information in the form of electrochemical impulses (action potentials). The nervous system is a signaling network with branches carrying information directly to and from specific target tissues. Impulses can be transmitted over considerable distances and the response is very precise and rapid. Whilst it is extraordinarily complex, comprising millions of neural connections, its basic plan (below, left) is quite simple, structured around reception of sensory input, integration or processing of the information, and formulation of a response.

Coordination by the Nervous System

The vertebrate nervous system consists of the central nervous system (brain and spinal cord), and the nerves and receptors outside it (peripheral nervous system). Sensory input to receptors comes via stimuli. Information about the effect of a response is provided by feedback mechanisms so that the system can be readjusted. The basic organization of the nervous system can be simplified into a few key components: the sensory receptors, a central nervous system processing point, and the effectors which bring about the response (below):





In the example above, the approach of the frisbee is perceived by the eye. The motor cortex of the brain integrates the sensory message. Coordination of hand and body orientation is brought about through motor neurons to the muscles.

Comparison of nervous and hormonal control

	Nervous control	Hormonal control
Communication	Impulses across synapses	Hormones in the blood
Speed	Very rapid (within a few milliseconds)	Relatively slow (over minutes, hours, or longer)
Duration	Short term and reversible	Longer lasting effects
Target pathway	Specific (through nerves) to specific cells	Hormones broadcast to target cells everywhere
Action	Causes glands to secrete or muscles to contract	Causes changes in metabolic activity

1. Identify the three basic components of a nervous system and explain how they function to maintain homeostasis:

   (a) _____

   (b) _____

   (c) _____

2. Describe two differences between nervous control and endocrine (hormonal) control of body systems:

   (a) _____

   (b) _____

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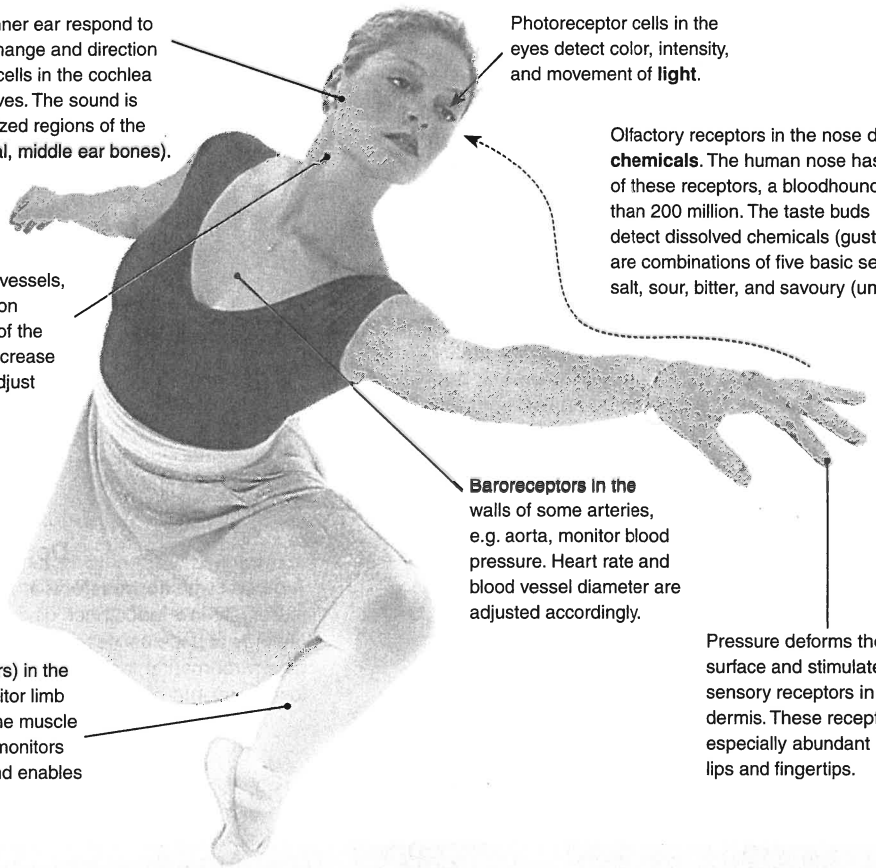
Related activities: *The Nervous System, Hormonal Regulation*
Weblinks: *Nervous System Animation*

Detecting Changing States

A **stimulus** is any physical or chemical change in the environment capable of provoking a response in an organism. All organisms respond to stimuli in order to survive. This response is adaptive; it acts to maintain the organism's state of homeostasis. Stimuli may be either external (outside the organism) or internal (within its body). Some of the stimuli to which humans respond are described below, together with the sense organs that detect and respond to these stimuli. Note that sensory receptors respond only to specific stimuli, so the sense organs we possess determine how we perceive the world.



Hair cells in the vestibule of the inner ear respond to **gravity** by detecting the rate of change and direction of the head and body. Other hair cells in the cochlea of the inner ear detect **sound** waves. The sound is directed and amplified by specialized regions of the outer and middle ear (pinna, canal, middle ear bones).

Photoreceptor cells in the eyes detect color, intensity, and movement of **light**.

Olfactory receptors in the nose detect airborne **chemicals**. The human nose has about 5 million of these receptors, a bloodhound nose has more than 200 million. The taste buds of the tongue detect dissolved chemicals (gustation). Tastes are combinations of five basic sensations: sweet, salt, sour, bitter, and savoury (umami receptor).

Chemoreceptors in certain blood vessels, e.g. carotid arteries, monitor carbon dioxide levels (and therefore pH) of the blood. Breathing and heart rate increase or decrease (as appropriate) to adjust blood composition.

Baroreceptors in the walls of some arteries, e.g. aorta, monitor blood pressure. Heart rate and blood vessel diameter are adjusted accordingly.

Pressure deforms the skin surface and stimulates sensory receptors in the dermis. These receptors are especially abundant on the lips and fingertips.

Proprioreceptors (stretch receptors) in the muscles, tendons, and joints monitor limb position, **stretch**, and **tension**. The muscle spindle is a stretch receptor that monitors the state of muscle contraction and enables muscle to maintain its length.

Pain and temperature are detected by simple nerve endings in the skin. Deep tissue injury is sometimes felt on the skin as referred pain.

Humans rely heavily on their hearing when learning to communicate; without it, speech and language development are more difficult.

Breathing and heart rates are regulated in response to sensory input from chemoreceptors.

Baroreceptors and osmoreceptors act together to keep blood pressure and volume within narrow limits.

1. Provide a concise definition of a **stimulus**: _____

_____

2. Using humans as an example, discuss the need for communication systems to respond to changes in the environment:

_____

_____

_____

3. (a) Name one internal stimulus and its sensory receptor: _____

(b) Describe the role of this sensory receptor in contributing to **homeostasis**: _____

_____

_____

***Related activities**: The Basis of Sensory Perception*

***Periodicals**: Sense and sense ability*

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