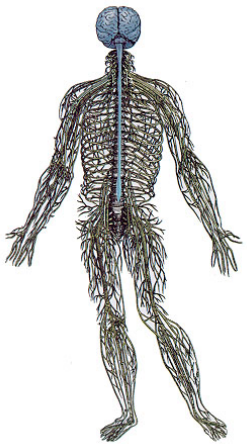
Autonomic Nerves to the Rescue!



The Human Nervous System is a complex array of subsystems[i], but it's the autonomic (involuntary) part of it that will make it possible for us to catch the train today. Stimulation of these nerves is outside of conscious control, but it isn't hard to tell when things have kicked into high gear. Our cardiac muscle, smooth muscles, and glands are affected and this results in changes to heart rate and force of our heartbeat, increase or decrease in glandular secretion, constriction or dilation of our vascular system and bronchial ways, and changes to our pupils and eyelids. Typically, the sympathetic division is in charge when we are under stress (as when we are about to miss the train) and the parasympathetic division is in charge when we are at rest (or coming to rest after the crisis!). Normally, the two work opposite one another to maintain homeostasis, but in a moment of panic, the parasympathetic system stimulates what is known as the "fight or flight" response.

Things get started and heat up in a hurry at the very moment we look at the clock on the mantel and realize, "OH NO! IF I DON'T GET MOVING *RIGHT NOW* I AM GOING TO MISS THE TRAIN AND I'LL BE LATE FOR WORK AGAIN!" The rising panic and alarm sets off a synaptic chain of reflexive transmissions that fire through the nervous system like an electrical storm:[1]

The hypothalamus is activated by various brain areas during times of stress, and this sends excitatory signals down the spinal column, stimulating the sympathetic system. Adrenaline (epinephrine, or E) and noradrenaline (norepinephrine, or NE) are secreted into our blood stream (neurotransmitters) by the adrenal medulla, ensuring a good supply to sustain

[1] In fact, it is the sympathetic reflex response that triggers moments of superhuman strength in times of panic, enabling people to do things they otherwise could not do, such as lift a car to remove an injured person from underneath, or swim and rescue someone even though they are normally afraid of the water and usually won't go near it.

sympathetic responses during the crisis, and our liver immediately begins to convert spare glycogen to glucose to provide more energy (lipolysis of fat in adipose tissue may also take place, depending on the duration of physical exertion.).

The iris muscles relax slightly and our pupils dilate, but they will still respond to light (parasympathetic response) unless we've gone completely mad with panic (which is not likely to happen over a missed train). The levetor palpebral muscle retracts (lifting the eyelid), and the ciliary muscle of the lens relaxes slightly (which should bring close objects sharply into focus). The result is a wild-eyed and very alert appearance—in fact, our senses are sharper. The pupil change allows a bit more light into the eye so our ability to see peripherally may sharpen in response (and thus our awareness of our surroundings increases, which is particularly handy if we've been startled in a dark alley or have missed the night train).

Secretions in our salivary glands and oral and nasal mucous membranes are inhibited, and our mouth goes quite dry quite fast, while at the same time kidney secretions are reduced as our body switches into its "CONSERVE FLUIDS" mode of operation. Blood vessels in the head constrict (not so much that we don't need to think as we need the blood elsewhere). In fact, vessels constrict where ever we don't need the normal flow, and they dilate and move more blood where we DO need the flow, so we can drop what we are doing and *just run for the* train—namely in the coronary arteries, skeletal vessels, and the brain.

This sympathetic response permits increased oxygen and nutrition supply and corresponding removal of waste products in the skeletal muscles, allowing them to work very hard as we run to catch the train. Even before we begin to run, the heart rate increases and the force of the heartbeat intensifies, instantly switching to "FLIGHT" mode as we grab what we need and run for the door. We start breathing harder (our airways dilate to assist air exchange) and our blood delivers an ever-increasing demand for oxygen and meets the need for increased

carbon dioxide output as we take in and expel greater and greater amounts of air. We aren't thinking about how hard it is to run, or how far it is – we probably aren't thinking much at all, we are simply running as though to save our own lives (and it might feel that way if we've already been late too many times before and the boss issued our final warning already!).

In our digestive system, smooth muscle contractions (peristalsis) and secretion of digestive juices are inhibited, and the vessels here constrict. Digestion is delayed (it takes energy to digest food, and when we are in a panic we need our energy for other things—we will pick up where we left off where our breakfast is concerned, but only after things return to normal.). Sphincters along the digestive system, and in the urethra and anus contract, and the bladder wall relaxes. All digestion and elimination is on hold, and this sympathetic response allows things to remain idle where they are, preventing the loss of substances from any number of orifices as we make a made dash for the platform (although the anal and urethral sphincters are under voluntary control, this extra bit of contraction ensures that things stay on hold while we panic!).

Our skin (sweat glands, blood vessels, and contraction/relaxation of the arrectores pilorum) is completely under the control of the sympathetic nervous system, and it will respond as the situation demands. If we've bolted out the door on a cold January morning in a panic, having forgotten to dress properly for the weather, our skin will still work to conserve heat and protect us from the cold while trying to maintain internal body temperature even though we are running full out. If, on the other hand, it is a warm July morning, our skin will flush with heat and permit us to perspire and lose both heat and fluid to maintain body temperature while we are working so hard to catch the train.

As we near the station and realize we are going to make the train (it is off in the distance, approaching the platform), we stop to catch our breath and calm down. The

sympathetic system backs down and in areas where the parasympathetic system can take over, things begin to relax. Our heart rate slows and the force of our heartbeat and our respirations return to normal; the coronary arteries and the bronchi constrict under control of the parasympathetic response, also returning to normal. Our breakfast begins to digest again and the pancreas increases its secretions of pancreatic juice and insulin; metabolism returns to normal. We might feel a sudden urge to find the privy if our large intestines and bladder were already full when we panicked, as muscle contractions in the bladder and rectum will occur (and if we are lucky enough, our urethral and anal sphincters are still completely under voluntary control, and we can wait until we get to the office!). Finally, our eyelids may fall to half mast and our pupils will constrict, returning to normal. As we relax and things slow down, we might even look sleepy to passers-by. Finally, we can settle onto the train and snooze a bit on the way to work, but the cycle will start all over again when we awaken with a start and realize we have just slept through, missed our stop, and will be tardy for work anyway.

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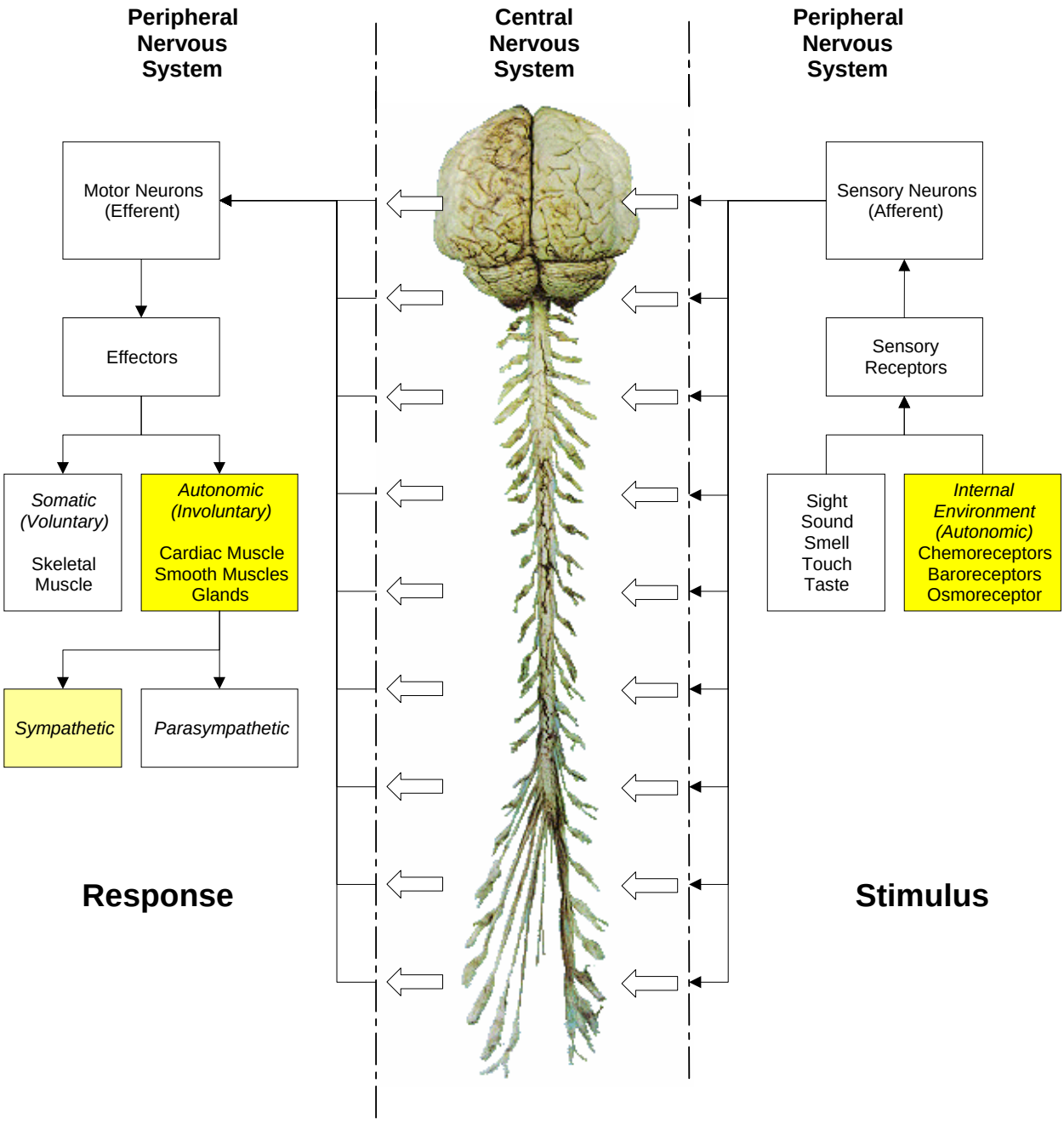

Figure 1: The Human Nervous System, Autonomic System Highlighted

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[i] The human nervous system is essentially divided into two main parts, the Central Nervous System (CNS) and the Peripheral Nervous System (PNS). Figure 1 (page 4) illustrates the divisions of the nervous system, and the functions are summarized as follows:

Central Nervous System: Comprised of the brain and spinal cord.

Peripheral Nervous System: Comprised of the cranial (12 pairs) and spinal (31 pairs) nerves. Subdivided into the following functions:

Sensory (Afferent): Reception of sight, sound, smell, taste, touch (special senses), somatic, cutaneous, or 'common' senses – those that tell us we are hot, cold, in pain, etc, internal environmental stimuli (autonomic, such as chemical, osmotic, or pressure changes), and proprioceptors (originating in muscle and joints, and contributing to our ability to maintain balance and posture). This system sends signals to the spinal cord and brain.

Motor (Efferent): Effects responses either voluntarily (skeletal muscles) or involuntarily (heart muscle, smooth muscles, and glands). This system receives signals from the spinal cord and brain.

Somatic Nervous System: This portion of the nervous system contains "voluntary" motor nerves, or those that we can control consciously; these are also involved in reflexive muscle contractions.

The Autonomic System: This portion of the nervous system contains those nerve functions that we cannot normally control consciously, such as heart rate, smooth muscle contractions, and glandular secretions (although some very developed and enlightened individuals may be able to affect this area consciously). This system is further subdivided into:

Sympathetic Nervous System: Responsible for "Fight or Flight" type responses.

Parasympathetic Nervous System: Responsible for normal or 'at rest' responses.