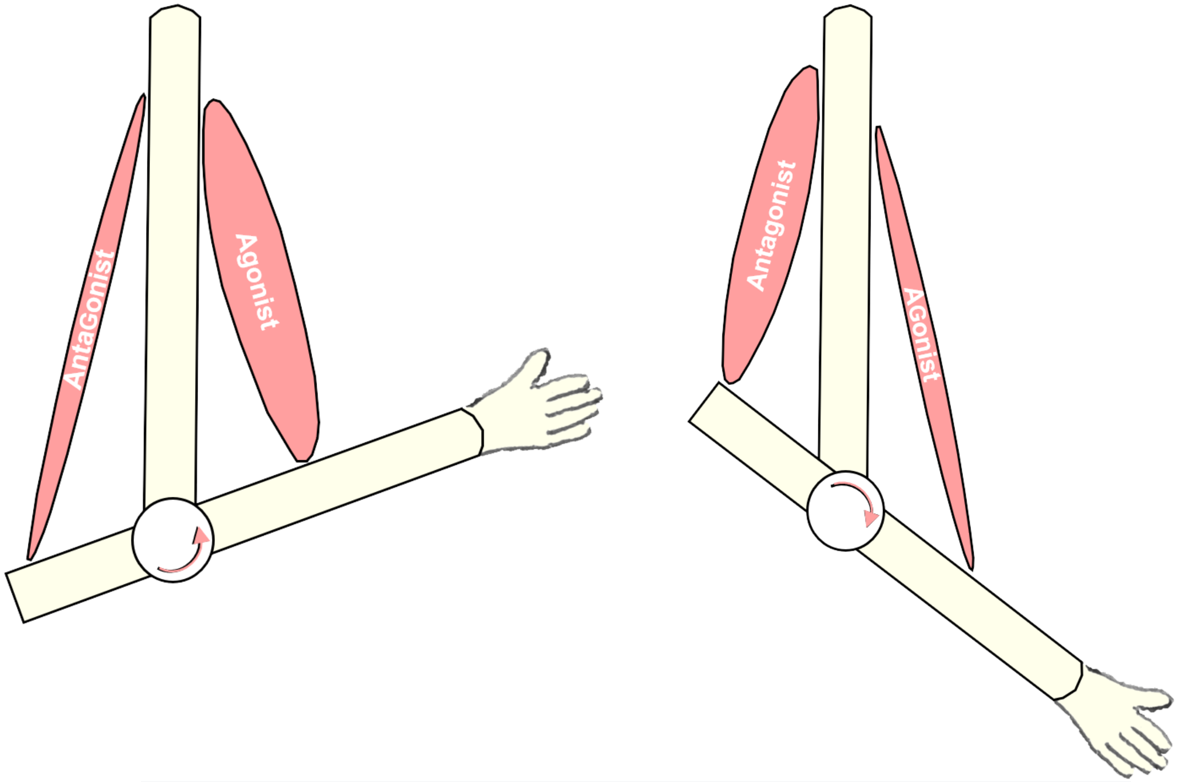
Why am I symmetrical?

Bruno Krüger • Sours-Allee 3a • 55276 Dienheim
27th October 2020

Symmetry of Bilateria and Man in Five Lessons

The evolutionary step towards bilaterally symmetrical body shapes took place in proximity to the emergence of central nervous systems. It was followed by the Cambrian biodiversity explosion 540 million years ago. The basic idea of this article is that the temporal coincidence of the emerging CNS and the Cambrian explosion is a basis for explaining a fundamental evolutionary step of self-organizing life forms.

Lesson 1 … Flexor and extensor muscles are basic building blocks for the symmetrical body shape



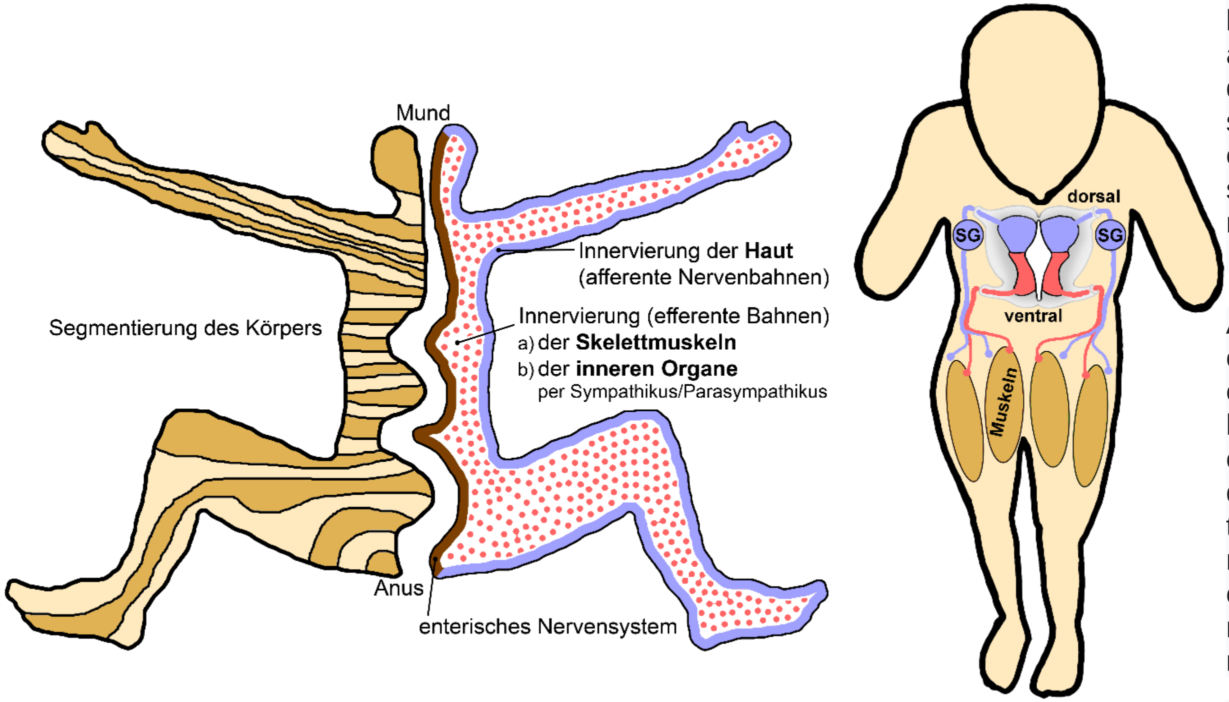
With the emergence of bilaterians, the bilaterally symmetrically built tissue animals, the third cotyledon of embryo development was added. Bones, muscles and connective tissue emerge from the cells of the newly gained middle cotyledon, known as the mesoderm. These elements model the three-dimensional shape of a body.

The third cotyledon, or better the body cells resulting from it, realize (1) all the necessary support functions, in higher development forms this happens with bones and cartilage, (2) all connection functions with muscles and tendons that connect them to the bones, and (3) a tension network with so-called fascia (connective tissue).

The basic division into flexor and extensor muscles is relevant for the self-organized generation of symmetry. All muscles of the body are thus arranged as opponents - agonist and antagonist. The antagonist principle allows the controlled positioning of body elements up to fine motor skills. It allows the brain to learn about the body: what is where and how can different stimuli be classified …

<u>Depiction:</u> Flexor and extensor muscles, building blocks of the symmetrical body shape

Lesson 2 … The central nervous system is the driver of the symmetrical body shape



Depiction: Bundling of nerve stimuli via the spinal cord to the central nervous system

Bones, muscles and connective tissue emerge from the cells of the cotyledon of embryo development, the mesoderm, which has been added since the Bilateria. This contrasts with the endoderm as the origin of the cells of the internal organs, for example for digestion and breathing, as well as the ectoderm for cells of the skin and their irritability. Both are cotyledons, which to a certain extent organize a two-dimensional inner and outer envelope surface. As an early feature of segmentation of the body, cell nodes, the somites, as primordial vortices emerge in cotyledon stage to the right and left of an axis of symmetry.

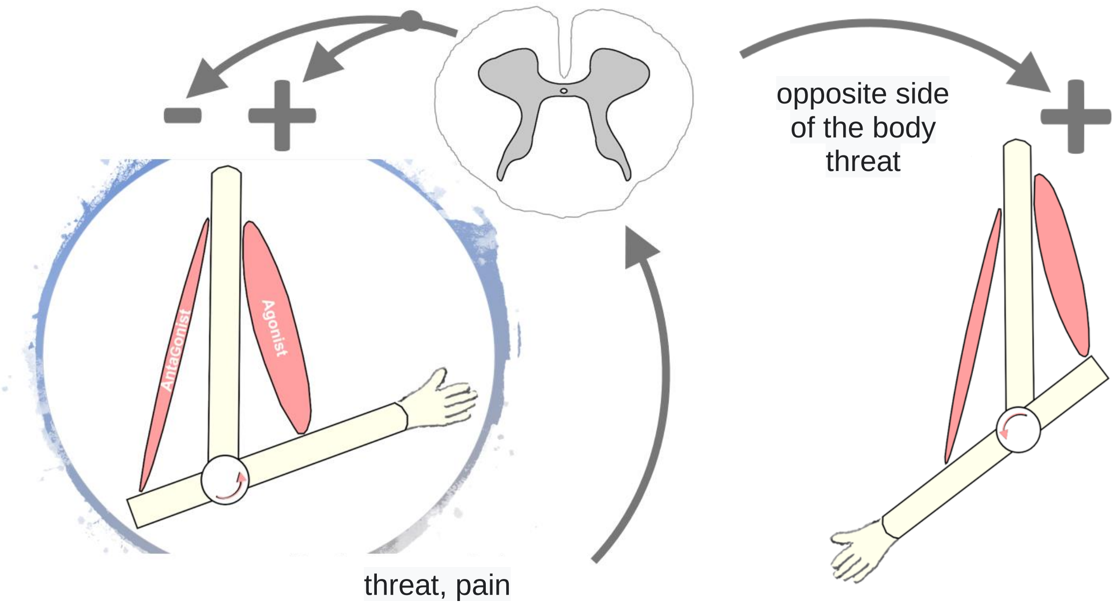
All nerve cells also emerge from the ectoderm. The innervation of the skin essentially contributes to the sensory system that we consciously perceive. Their afferent, ascending nerve tracts are bundled for each body segment in the spinal ganglia of the spinal cord and from there connected to nerve cells in the sensitive, dorsal part of the spinal cord or via the posterior tract to the thalamus of the brain. The consciously controllable skeletal muscles are innervated by nerve cells in the motor, ventral part of the spinal cord. These are in turn controlled via intermediate neurons in the spinal cord or via the pyramidal tract from the motor cortex of the brain.

The central nervous system as the basis of conscious perception and motor skills is the driver of bilaterally symmetrical body shapes.

https://www.kruegerGold.de

The first and second lesson introduce the antagonistic principle of all muscles in the body and a classification of the control by the nervous system. With the common origin of all body cells from the cotyledons of embryogenesis, the role of muscles in the evolution is made clear.

Lesson 3 … Muscle reflexes and symmetrical interaction of opposing body parts



Depiction: Reflexes show symmetrical interaction of opposite sides of the body

Nerve cells or neurons transmit stimuli. The transmission of stimuli to another neuron occurs predominantly via chemical, but also via electrical synapses. Chemical synapses use neurotransmitters, so-called messenger substances, which can both increase and inhibit the action potential of a target neuron. A distinction is made according to the shape and size of their dendrites and axons unipolar, bipolar, multi-polar and pseudo-unipolar nerve cells. Nerve cells are differentiated for different functions. Pyramidal cells of the motor cortex are suitable for long distances of up to a meter, interneurons in the spinal cord for short ones.

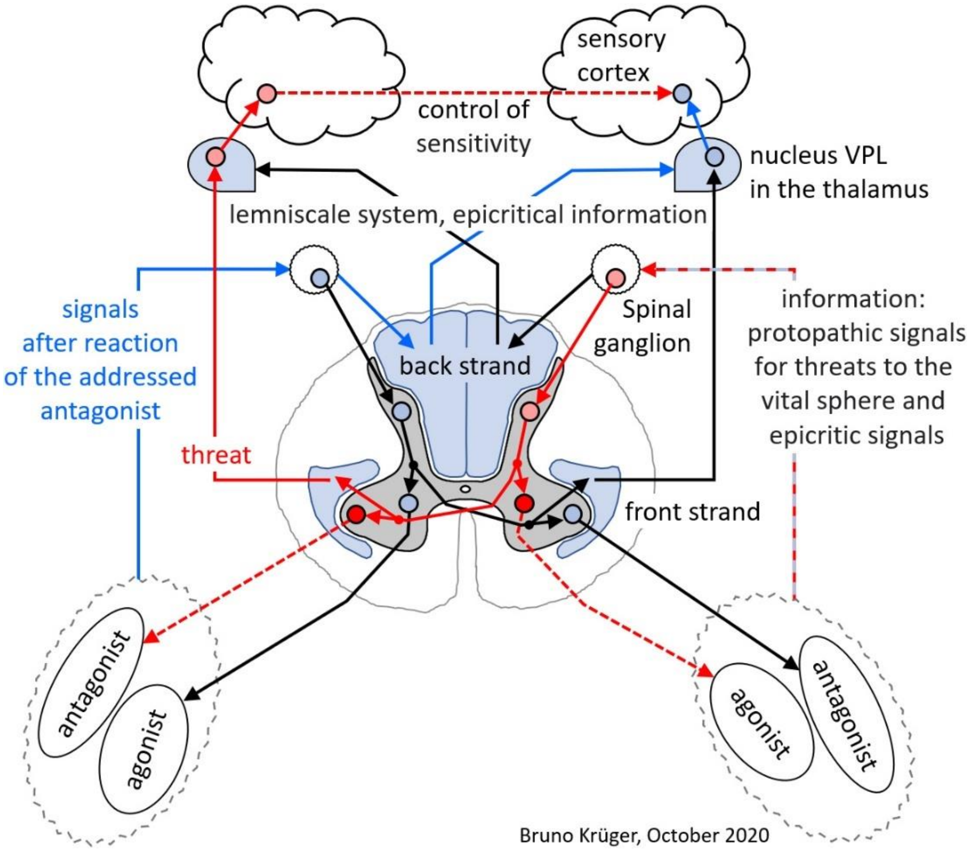
Reflexes result from fast-acting interconnections in the spinal cord. This can be done via just one sensory intermediate neuron, such as in the kneecap reflex, which is known from a doctor's visit. The blow on the patellar tendon activates the leg extensor muscle, in this case the agonist. There are also far more complex formations that even bridge vertebral segments to address the appropriate muscle in the event of threats.

In addition to the muscles, which are divided into agonists and antagonists, there is a symmetrical interaction between opposite sides of the body. When a direct agonist reflex is triggered, with an inhibitory control (in the picture: '- ‘) of the antagonist, an antagonist reflex (in the picture:' +‘) of the symmetrically corresponding muscle pair on the opposite side of the body is triggered in parallel.

https://www.kruegerGold.de

The third lesson gives an impression of how signal transmission works with nerve cells. A special feature is that, depending on the chemical messenger substance of the synapses, subsequent nerve cells are also inhibited. It is also fundamental that reflexes through stimuli that signal a threat to a part of the body are connected directly to the spinal cord level and can even trigger an interaction on both sides of the body.

Lesson 4 … Interconnection of the central nervous system is key to the symmetry concept



The sensitive stimuli reaching the spinal cord via the spinal ganglion transport two fundamentally different types of information:

1. Protopathic information signals pain, heat, cold, gross posture shifts as threats to body areas;
2. Epicritic information signals pressure, touch and sense of position and thus give a more differentiated picture of the body.

Protopathic signals get to the brain via the anterior tract, epicritic signals via the posterior tract and the lemniscal system. The entrance point in the brain for all sensitive signals is the nucleus VPL in the thalamus on the opposite side of the body. Each protopathic signal reaches exactly one intermediate neuron with a direct connection to the sensory cortex.

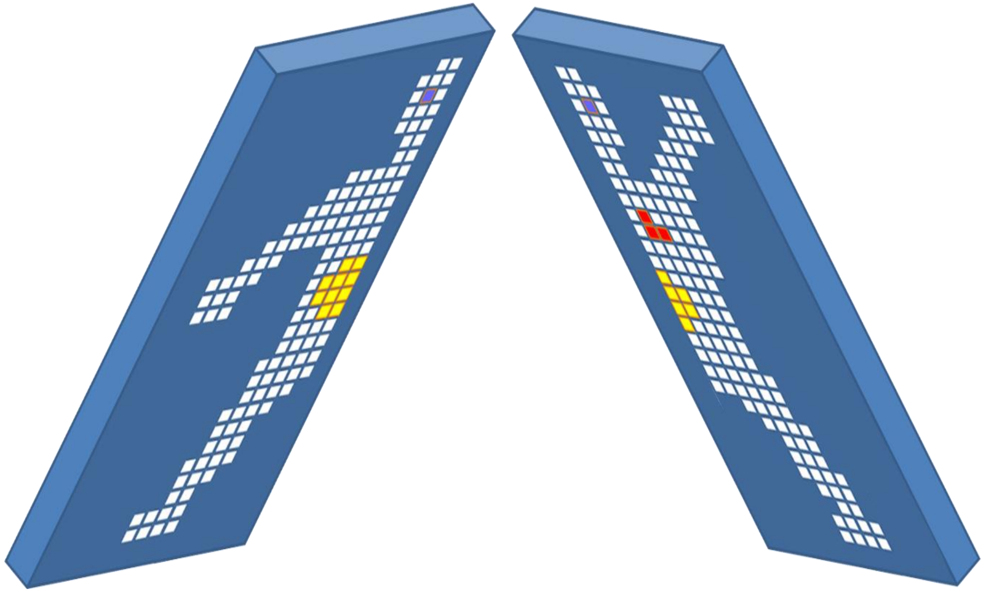
Muscles are organized in pairs as agonists and antagonists. Motor neurons for agonists are in the dorsal field of the anterior horn in the spinal cord, motor neurons for antagonists are in the ventral field. Please refer: https://eref.thieme.de/cockpits/clAna0001/0/coAna00078/4-9836.
Protopathic signals trigger an agonist reflex on their own body side and switch to the other side at the level of the spinal cord. There they are connected to the symmetrically matching antagonist in the ventral field of the anterior horn, from where they emerge from the spinal cord.

The interconnection of the CNS in the spinal cord enables the learning process in the brain and is the key to bilaterally symmetrical body shapes.

Depiction: Interconnection of the CNS in the spinal cord is key to the symmetry concept https://www.kruegerGold.de

The fourth lesson highlights the interconnection of the CNS in the spinal cord as an essential key in the evolutionary step of the bilaterians. The functional separation of protopathic and epicritic stimuli, their separate transmission paths as well as the interconnection and position of the motor neurons for the flexor and extensor muscles stand out as extraordinary features. Other important innovations such as nerve cells appeared earlier in evolution.

Lesson 5 … Learning process in the brain and bilaterally symmetrical body shape create each other



Depiction: Learning process thanks to somatotopic images of body sides

At the beginning of the learning process in the brain there is learning about one's own body, what-is-where. The basis for this is areas in the brain with a somatotopic arrangement, in which the position of individual neurons corresponds to the relative position of the body parts that they represent during information processing. In mammals and humans, the sensory and motor cortex of both halves of the brain each have a somatotopic arrangement - one also speaks of the sensory and motor homonculus or human being. Another area is the thalamus, where the body's sensory signals enter.

Recurring activities lead to the formation of bridges and signal loops between active neurons. A learning process begins. In the case of stimuli that signal a threat to a part of the body, neurons of the sensory system in the thalamus and cortex are energetically activated. Other neurons, which are active because of the reflex-like movement of the body part, are included in signal loops. In the early learning phase, agonist reflexes cause interactions with the respective antagonist on the opposite side of the body. This leads to muscle movements and thus to epicritic signals to the brain on both sides. In the left and at the same time in the right sensory cortex and thalamus, matching neurons are activated, which represent the mirror image of the body part on both sides.

The key point is that signal loops develop between the hemispheres of the brain, which act in the event of intrusive threats and control the sensitivity of the non-threatened side of the body to more differentiated stimuli. This leads to the focus of attention and enables the body to learn.

https://www.integration4.com

The fifth lesson shows how the accumulation of nerve cells creates the self-organization of higher forms of life. The starting point is learning about your own body. All further learning up to the complex knowledge of the human being ties in with it. The core of the insight is that two halves of the brain face each other as mirror-image observers and mutually control the focus of initial learning processes.

Bruno Krüger, October 2020