Connections between gut microbiota and the brain

Intestinal bacteria that can boost bravery or trigger multiple sclerosis: An increasing body of research results confirms the importance of the "gut-brain axis" for neurology and indicates that the triggers for a number of neurological diseases may be located in the digestive tract. "The gut microbiome can influence the central nervous system, the development of nerve cells and the immune system. A better understanding of its effect could revolutionize our therapy options," noted Dr Patricia Lepage from the Institut National de la Recherche Agronomique in Jouy-en-Josas, France, at the Second Congress of the European Academy of Neurology (EAN) in Copenhagen.

Gut microbiota influences behaviour

The gut microbiome is the aggregate of human gut microorganisms with all its bacteria, archaea, viruses and fungi. For a long time, it seemed far-fetched to think that the microbiome could also be responsible for processes outside the digestive tract. Yet the scientific community keeps uncovering further amazing details. Recent studies on laboratory animals which grow up without any microorganisms (germ-free) show for example that microorganisms in the gut are even capable of influencing behaviour. Dr Lepage: "Intestinal microbes can verifiably produce neuromediators that have an effect on the brain. Germ free mice showed less anxiety than their conspecifics whose gut was populated with commensal microbiota. However, there is only scant evidence thus far on how this process works in the human brain."

It has been proven in the meantime that the gut and the brain communicate with each other via several routes including the vagus nerve, the immune system, the enteric nervous system or by way of microbial metabolic processes. For instance, intestinal bacteria convert carbohydrates into short chain fatty acids, e.g. in butyric acid. This strengthens the connections between the cells and reinforces the blood-brain barrier, which serves as a cellular wall to protect the brain from infections and inflammations.

Gut microbiome regulates brain processes

For the neuroscientist Prof John F. Cryan (APC Microbiome Institute, University College Cork, Ireland), there is no question that the gut microbiome regulates fundamental brain processes important for the development of neurological diseases: "We studied the brains of germ free mice. In one region, the prefrontal cortex, we found increased myelination compared with animals kept under normal conditions. This may have direct implications for myelin-related disorders. Microbiome-dependent processes have also been shown to include adult hippocampal neurogenesis and microglia activation, i.e. the activation of brain and marrow cells similar to immune cells."

Experimental models on the origin of autoimmunity suggest that the gut microbiome plays an important role in this context, too. This insight opens up a new approach for finding the cause of multiple sclerosis (MS). MS is an autoimmune disease that results from a combination of genetic and environmental factors. Dr Gurumoorthy

Krishnamoorthy from the Max Plank Institute for Neurobiology in Martinsried, Germany: "Apparently, the bacteria that can trigger multiple sclerosis are not disease-causing bacteria but rather useful bacteria needed for digestion." A study with genetically modified mice showed that animals featuring normal intestinal microbiota and subject to no external influences developed inflammation in the brain. By contrast, mice kept in a germ-free environment remained healthy. As Dr Krishnamoorthy explained, the immune system of the mice with normal intestinal microbiota is activated in two phases: First, T-cells become active and multiply in the lymphatic vessels of the intestinal tract. Together with surface proteins in the myelin sheath, they then stimulate B-cells to form disease-causing antibodies. Dr Krishnamoorthy: "Both trigger inflammatory reactions in the brain, which destroy the myelin sheath in phases -- very similar to the way MS unfolds in human beings." This process suggests that it is not disorders in the nervous system but rather a change in the immune system that leads to MS. Researchers assume that gut microbiota in human beings can likewise cause the immune system to overreact to the myelin sheath if a corresponding genetic predisposition exists. It is still unclear, however, which bacteria are involved in the development of MS. Gut microbiome

The microbiome consists of up to 1,000 different types of bacteria and of about 100 trillion cells. As such it has ten times as many cells and 150 times as many genes as the human genome. The microbiome co-evolves with its human host in a symbiotic relationship. The development of the gut microbiome as a finely tuned ecosystem depends on a number of factors: whether and which microorganisms a person absorbs from his/her mother's birth canal at the time of birth; whether a person is subject to antibodies; what food a person eats; infections; stress and genetic predisposition. Elderly individuals who are in poor health often have a lower diversity of microorganisms in their microbiome or inflammation-promoting manifestations.

Sources: EAN 2016 Abstracts: Lepage P, Microbiota and the gut-brain axis; EAN 2016 Abstract Krishnamoorthy G, Microbiota and CNS autoimmunity (Multiple Sclerosis); EAN 2016 Abstract Cryan JF, Gut microbiome: a key regulator of neurodevelopment and behaviour

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