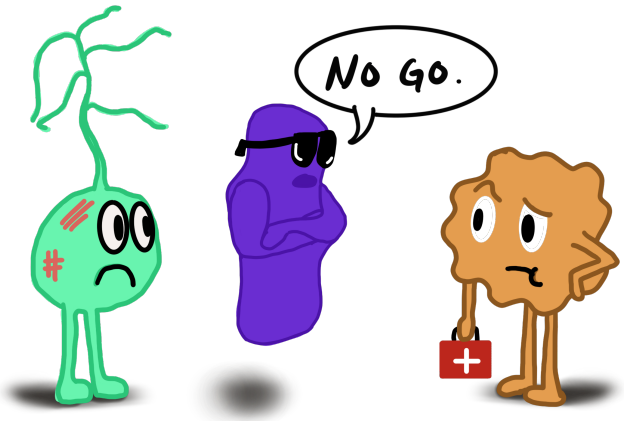
Why is it so difficult to heal the brain?

By Ricky Cantua Pina

One of the most remarkable machines in the natural world is able to perform countless operations seemingly with little effort from the operator. This machine sends messages at hundreds of miles per hour between interwoven components, all working in tandem to perform tasks difficult even for advanced computers. What is this fascinating contraption? *The brain* - a tangle of stringy cells called neurons, which form trillions of connections with each other, firing signals at shockingly fast speeds, all to give you the ability to read these words without much input from you. There are approximately 86 billion neurons in the adult human brain, a large number of cells but each one precious in its contribution to our neuroanatomy. Such a complex arrangement of cells, however, is susceptible to damage that may lead to severe consequences. You may have heard that neurons cannot regenerate, so when you lose or damage some of your nerve cells, you're out of luck. This is partly true. The brain, part of the central nervous system (CNS), opts to maximize stability over regenerative capabilities to ensure connections are preserved. When brain cells are damaged, there are only a handful of regions that have the ability to generate new neurons to fill in the gaps. The peripheral nervous system (PNS) is composed of neurons outside of the brain and spinal cord. As opposed to the CNS, the PNS possesses several mechanisms to repair neural damage and regrow damaged connections between cells. Researchers in the 1980s noticed this and thought, "Can we fix CNS damage by introducing PNS cells?". So they tried that! In 1984, Dr. Kwok-Fi So and Dr. Albert Aguayo found that when a region of the optic nerve was damaged, regeneration was able to be achieved when neurons from other areas of the body were introduced in the area. This advised the scientific community that the secret to neural regeneration may not lie in the nerves themselves, but in the surrounding environment.

So what makes the brain incapable of regeneration? The brain itself! Scientists believe one of the main factors in the brain's incapacity to regenerate is the high expression of factors that inhibit proliferation, or the growth of cells. For example, one of these is a protein called Nogo (neurite outgrowth inhibitor). As the name suggests, the protein is a sort of "Stop" signal



that inhibits the ability of neurons to regrow connections.

Scientists have found several similar factors in the brain that inhibit regeneration but note that artificially introducing growth factors can work to counteract this phenomenon. The problem with this is that it's very difficult to deliver chemicals specifically to the brain due to a protective membrane known as the blood-brain barrier. The body is very selective when it comes to what is allowed into the brain, which is usually beneficial to prevent outside chemicals from affecting the brain, but not so beneficial when that's exactly what our aim is. Despite all this, there is a recent development that may be a promising avenue for neural regenerative medicine.

Stem cells are a growing area of interest in the field of modern regenerative medicine. Stem cells are a unique class of cells that can proliferate indefinitely and give rise to specific cell lineages. These cells are invaluable to researchers and medical professionals as they have the capacity to regenerate damaged or missing sections of tissue. One of the most important findings in stem cell therapy has been the work of Dr. Kazutoshi Takahashi and Dr. Shinya

Yamanaka in 2006, who showed that normal body cells can be converted into stem cells, effectively reverting these cells to a state with more regenerative potential. These are called induced pluripotent stem cells (iPSCs), since their potential to proliferate indefinitely has been induced artificially. The brain seems to have some of the most scarce populations of naturally-occurring stem cells, thus scientists are looking into methods of introducing these iPSCs directly into the brain and having them proliferate into neurons that have been lost. Particularly, scientists are interested in alleviating the loss of neurons in neurodegenerative diseases such as Parkinson's disease and spinal muscular atrophy. Research in stem cell therapy and neural regeneration is incredibly complex and has had some tremendous strides but we still have more ground to cover. The only way that this can happen, though, is if we ask questions now. So go on and use those neurons while you have them, ask away and explore the world around you!

References

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