Concepts of bio-electricity

Introduction

What is Bio-electricity?

Bio-electricity is an interdisciplinary theme which refers to the production of electric, magnetic and electromagnetic fields in biological tissue (Cameron, 1996). This essay focus on the production of electric fields for use in organisms rather than in electrical circuits. An electric field is an area around a charged particle created by an electric force; the magnitude and direction of this force is determined by the charge of the particles surrounding it (Dictionary, no date). An example of this in Biology is the electrical system of the heart and the maintaining of membrane potentials in cells in the body.

Bio-electricity in Nature

American Paddlefish

An example of an organism which uses Bio-electricity in an enhanced form is the American Paddlefish (or Spoonbill Catfish). These are large, freshwater fish from North America which have an extensive, paddle-like flat nose.

The extended nose of the fish is embedded with pores with cells called electroreceptors (Thomas, 2016). These pores spread over the fish’s body, from the nose to gill covers, covering around half of its skin (Wilkens, 2001). This allows the detection of weak electric currents in the water they travel in, thus allowing them to hunt their main source of food; plankton. These sensors are extremely sensitive, and are able to respond to electrical fields of less than 1/100th of one 1-millionth volt per centimetre (Wilkens, 2001). All organisms emit weak electric signals (e. g. electrical impulses due to the

beating of the heart), and thus can be detected by these cells. The electrical signal is sent to the brain via the neurons. Paddlefish being able to detect these fields aid their survival, as their environment is generally very dark (Thomas, 2016).

Electric Eel

Another example of Bio-electricity in nature being used in a different way is with the Electric Eel.

It can do this due to the electrogenic cells in its body called electrocytes, each with a negative charge of around 100 millivolts (Scientific American, 2005). These are all modified muscle cells in the eel’s tail. When a signal from a “ command nucleus” arrives to each of the cells, a neurotransmitter is released. These are chemical signals which allow information to be transmitted between nerve cells (Cherry, 2016). As a result of this, a path of low resistance is created, connecting the interior and exterior of each cell. This allows the cells to behave like batteries, with opposing sides of the cell acting as positive and negative terminals (Scientific American, 2005).

This is used to both hunt and kill prey. If in sight, prey can be hunted by the eels the release of high voltage pulses of a frequency of 400/s. If these pulses reach another organism, it will interfere with its neurons, causing them to involuntarily contract. This contraction is extremely strong due to the sequence of the pulses released; each lengthy torrent is succeeded by a pair of rapid pulses, making the process as efficient as possible. As a result of this, the prey can experience complete short term paralysis, allowing the eel to attack. The effect is similar of that of a taser on a human (Yong, 2014).

Similar to that of the Paddlefish, potential prey can also be detected through the use of Bio-electricity. The Electric Eel can send out pulses, again causing the prey to contract involuntarily. The resulting ripples in the water would reveal the location of any organism affected, as the eel is extremely sensitive to movement (it can strike within 20 thousandths of a second from when movement is detected). This provides a further opportunity for the eel to kill (Yong, 2014).

Moreover, the eel can kill prey (or deter predators) by directly shocking them. Though each individual electrocyte can create only a small electric field, the cells are connected as parallel batteries are in a circuit, creating a larger electric field. The combined electrocytes create 3 large electric organs which can take up 80% of the eel's body (Giardina, 2016). This means an average Electric Eel can produce electricity of around 600 volts at 2 milliseconds at a time.

Bio-electricity in Medicine

The use of Bio-electricity to treat human conditions is being increasingly explored. A link between the immune system, the series of processes which works to primarily fight off disease, and the nervous system, processes which involve electrical signals within the body, is being researched.

One of the main method of using our knowledge of Bio-electricity in Medicine is through the stimulation of the Vagus nerve, also known as Cranial Nerve (X). This is one of 12 cranial nerves, which are nerves which begin from the brain stem rather than the spinal cord. These nerves are responsible for the motor and sensory functions of our body (InnovateUs Inc, 2013). Of all the

cranial nerves, the Vagus nerve is the longest, extending through the thorax, heart, stomach, abdominal muscles and others. This links the brainstem to the body and major organs (particularly the heart), allowing information to be easily transferred in an electrical circuit-like system (InnovateUs Inc, 2013).

One of the uses of the Vagus nerve stimulation is the controlling of seizures in epilepsy patients. This is by connecting a small device to the left Vagus nerve in the neck. The device can then send out small electrical impulses via the nerve to the brain. This reduces activity in the brain which can lead to seizures; seizures themselves are caused by abnormal electrical activity in the brain. (Epilepsy Society, 2016).

A second use of Bio-electricity in Medicine is the use of cardiac pacemakers in the treatment of Parkinson’s disease, a neurodegenerative disorder caused by a loss of dopamine producing nerve cells in the brain (NHS Choices, 2016). To help reduce the symptoms of Parkinson’s, which include rigidity, tremors and bradykinesia, doctors are implanting a small electronic device called a neurostimulator in patients (Lazarus, 2014). The device sends out regular electrical impulses to areas of the brain responsible for movement. This allows impulse to block the irregular signals which cause the shaking in patients, giving them more control. The entire process is called Deep Brain Stimulation and is a widely used technique to help improve quality of life in people with Parkinson’s.

Conclusion

In conclusion, Bio-electricity is a naturally occurring phenomenon occurring in humans and animals alike, and is essential to everyday living. Its natural uses explored include communication between the brain and body via neurotransmittors and nerve cells, the detection of prey and predator in animals and its use in hunting. With modern technological advances, its use is being extended to the treatment of disorders in humans including depression, Parkinson's, arthritis and epilepsy, many of which through the installation of electrical devices which send out impulses. With further research and understanding, it is hoped to that it can be used to treat many more diseases, improving quality of life for many more people.

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