Review Article

A trend in future bioenergy - A review

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ABSTRACT

The most important demand for today's world is electricity. This idea helps in generating sustainable energy by a natural phenomenon occurring in humans that is the transmission of nerve impulse from the sensory to the central nervous system or vice versa. The bioelectric potential across a cell membrane is typically about 50 mV, and this potential is known as the resting potential. Once a nerve is activated, an electric pulse is generated due to difference in potential between two neurons. The beauty of such pulse is that it is continuous until it reaches the destination. Hence, we can target one action such as movement of arm, holding objects, or movement of fist so that we can locate the nerve responsible for the impulse from brain to the target tissue and tap the potential between each neuron along the entire length which consists of millions of neurons, where each neuron acts as individual cell, when we consider the entire length, the whole network acts like small individual cell connected in series the voltage adds up nearly producing few hundreds to thousand volts which are sufficient to produce electric energy and store for later use. This can have a huge impact on global economy. This energy can be used up in various applications such as charging of gadgets on the go and as a light weapon for armed force to protect themselves from enemies by producing high electric shock waves for short span and many other useful applications.

KEY WORDS: Bioelectric potential, Cells arranged in series, Concentration imbalance of ions, Nerve impulse, Target tissue

INTRODUCTION

Electric energy is the huge demand for all the developing countries across the world. The present-day technologies developed completely depends on electricity, from television to electric cars need electric power as a source of energy for their functioning. Electric energy has a vast influence on economic status of a country. According to Benjamin Franklin, disturbance in the subatomic level of an atom acquires a charge and this atom is said to be a charged body when a charged body flows electric current is produced. Electric current may be direct current (DC) or alternating current (AC) depending on whether the current varies with respect to time and the former remains constant with respect to time while the later forms a sine wave with respect to time.[1] Various technologies that produce electricity are hydroelectric, wind, solar, geothermal, natural gases, nuclear, and fossil fuel such technologies are mostly not ecofriendly. Production of electricity from fossil fuel causes accumulation of greenhouse gases in the atmosphere leading to global warming and environmental issues. Bioelectricity is a perfect eco-friendly solution to the present technology; it is the potential and electric current developed by the living organism. This idea helps in generating a sustainable source of bioenergy which can be used for running the gadgets.

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NEURAL SYSTEM

A nerve cell is a type of specialized cell which is the fundamental unit of signal processing, an electrically excitable cell that processes and transmits information through electrical and chemical signals. For example, if you want to eat, your nerves are triggered to perform that specific function.[2,3]

There are three different types of neurons, each with a slightly different function.

1. Sensory neurons carry signals from sensory receptors to the spinal cord and brain. Together, the spinal cord and brain make up the central nervous system (CNS). Sensory receptors are specialized

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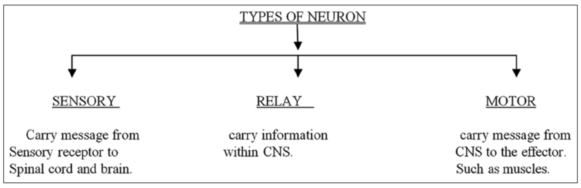
cells. They detect changes in the environment, called stimuli, and turn them into electrical impulses. Sensory neurons carry these electrical impulses to the spinal cord and brain. Each organ has receptors sensitive to particular kinds of stimulus, for example, sound, movement, and touch.[2]
2. Relay neurons carry messages from one part of the CNS to another.
3. Motor neurons carry signals from the CNS to an effector - a part of the body that produces the response to the signal. Effectors include muscles and glands.[2]



NERVE STRUCTURE AND SIZE

Nerve consists of three main parts:
- Cell body
- Dendrites
- Axon.

Cell Body

The nucleated cytoplasmic portion of a neuron is termed as cell body or soma. Typically, each cell body which may be 4–100 µm in diameter may be fusiform, pyramidal, preform, or irregular stellate in shape. Cell body contains a large spherical central nucleus along with a large number of Nissl's granules within the cytoplasmic matrix called neuroplasm. The Nissl's granules contain ribonucleoprotein and are involved in protein synthesis. The neuroplasm also contains mitochondria, Golgi bodies, melanin, and lipochrome pigment granules. The amount of these cell organelles varies with the functional activity of the cell. Therefore, the number of neurons present in an adult is same as that present at birth. Delicate cytoplasmic threads called neurofibrils are present throughout the entire length of axon and dendrites arising from cell body. The cell body is present in a gray matter of the CNS -brain and spinal cord.

Dendrites

The short cytoplasmic processes of cell body which receives stimulus from other neuron are called dendrites**.** The dendrites conduct nerve impulses induced by stimuli toward the cell body. The dendrites at their origin from cell body are 5–10 µm in thickness, but gradually their thickness decreases by profuse branching.

Function

Dendrites receive impulses from axon of another neuron through synapse and conduct the impulse toward the cell body, and therefore, it is called the receptive organ.

Axon

The long cytoplasmic process of cell body which transmits impulse from cell body to other neuron is termed axon. Axon is considerably longer than dendrites. The axon arises from the cell body in a conical elevation called axon hillock, which is devoid of Nissl's granules. The length of axon is variable and depends on the functional relationship of the neuron.[4]

Size of Nerve

The nerve cell is the smallest functioning unit of nervous system. Nerve cells are usually shaped like trees and range around few micrometer. From the round, pyramidal, or spindle-shaped cell body, the dendrites (Greek: Dendrites = tree-like) branch out like the top of a tree and the single axon travels out like the trunk. The dendrites receive information from other nerve cells and pass it down to the cell body where the information is processed. This information is then passed along through the nerve cell's trunk which is called axon (Figure 1). The length of this extension differs depending on the kind of nerve cell. It can span from a few millimeters up to 1 m.[5]

DISTRIBUTION OF NERVES

- 12 pairs of cranial nerves.
- 31 pairs of spinal nerves.

Distribution of Cranial Nerve

12 pairs of cranian nerves as mentioned in Table 1.

Distribution of Spinal Nerve

31 pairs of spinal nerves as mentioned in Table 2.

TRANSMISSION OF IMPULSE

Meaning of Polarized State

Neurons are the excitable cells because their membranes are in a polarized state. The membrane around the neuron is called the neural membrane, and the membrane around the axon is called axonal membrane. The cytoplasm present inside the axon is called the axoplasm.[7] The neurons are surrounded by a fluid outside them called extracellular fluid. The fluid inside as well as outside the neuron possesses ions such as sodium ion, potassium ion, chloride ion, and calcium ion. Some are positively charged while others are negatively charged. Due to the differential concentration of the ions on the two sides of the axonal membrane, on the inner (toward axoplasm) and the outer side (outside the neuron), the membrane of the neurons are said to be polarized.[8] Hence, the development of positive and

Table 1: Functions and location of various cranial nerves[6,7]

Name	Origin	Distribution	Nature	Function
Olfactory	Olfactory lobe	Nasal cavity	Sensory	Smell
Optic	Optic lobe	Retina of eye	Sensory	Sight
Oculomotor	Floor of midbrain	Eye, muscles of eyeball	Motor	Movement of eyeball
Trochlear	Floor of midbrain	Oblique muscles of eyeball	Motor	Rotation of eyeball
Trigeminal	Pons	Head, face, jaw, teeth	Sensory motor	Forehead, upper eyelid, side of nose
Abducens	Pons	External rectus muscle of eyeball	Motor	Rotation of eyeball
Facial	Pons	Anterior 2\3 tongue muscle of face, neck, and chewing	Sensory motor	Taste facial expression movement of the neck
Auditory	Pons	Organ of corti in cochlea	Sensory	Hearing equilibrium
Glossopharyngeal	Side of medulla	Posterior 1\3 tongue and muscle of pharynx	Sensory motor	Taste and touch movement and pharynx
Vagus	Side of medulla	Muscles of pharynx, vocal cord, lungs, heart, esophagus, stomach, intestine	Sensory motor	Vocal cord, lungs, respiratory reflexes, peristaltic movements, speech, slowdown heartbeat, swallowing
Spinal accessory	Side of medulla	Muscle of palate, neck and shoulder	Motor	Muscles of pharynx, larynx, neck, shoulder movement
Hypoglossal	Side of medulla	Muscles of tongue and neck	Motor	Movement of tongue

Table 2: Classification of spinal nerve[6,7]

Type of nerve	Number of pairs
Cervical nerve	8 pairs
Thoracic nerve	12 pairs
Lumbar nerve	5 pairs
Sacral nerve	5 pairs
Coccygeal nerve	1 pair

negative poles across an axonal membrane makes the membrane polarized (Figure 2).

Ion Channels

The neural membrane contains a variety of passages called the ion channels. These ion channels are actually the pores formed by the proteins presents in the membrane of neuron. These ion channels are selectively permeable to different ions.[9] It means that the ion channels are not equally permeable to all the ions. The channels allow the passage of only one type of ion, say sodium or potassium or calcium or chloride ions, and resist others. The ion channels that always remain open are called leak channels, whereas the channels that remain closed but can open due to a specific stimulus are called gated channels (Figure 4). The presence of voltage-gated ion channels gives these neural cells the property of excitability, the ability to respond to certain stimuli, such as mechanical pressure, touch, chemicals, sound, or even just voltage applied.[8]

The Resting Potential (the Neuron at Rest)

When the charge separation across the axonal membrane is maintained, the neuron is said to be at rest. This condition is called resting potential. A resting neuron is negatively charged on the inside and positively charged on the outside. Such a charge separation is called polarization, and thus, resting neuron is said to be polarized.

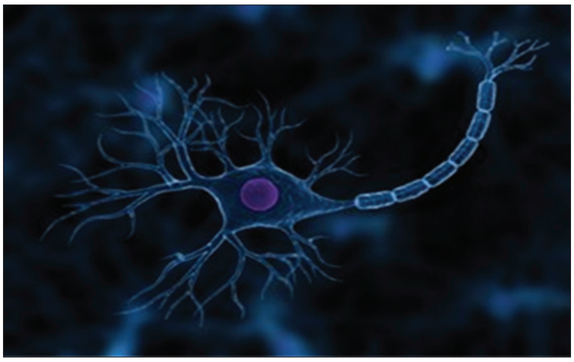


Figure 1: The structure of nerve[10]

At resting potential, the axonal membrane is comparatively more permeable to potassium ions and nearly impermeable to sodium ions. Similarly, the membrane is impermeable to negatively charged proteins present in the axoplasm.[11] The axoplasm contains a high concentration of potassium ions and negatively charged protein and low concentration of sodium ions. In contrast, the extracellular fluid contains a high concentration of sodium and low concentration of potassium. These ionic gradients across the resting membrane are maintained by active transport of ions by the sodium-potassium pump which transports three sodium ions outward

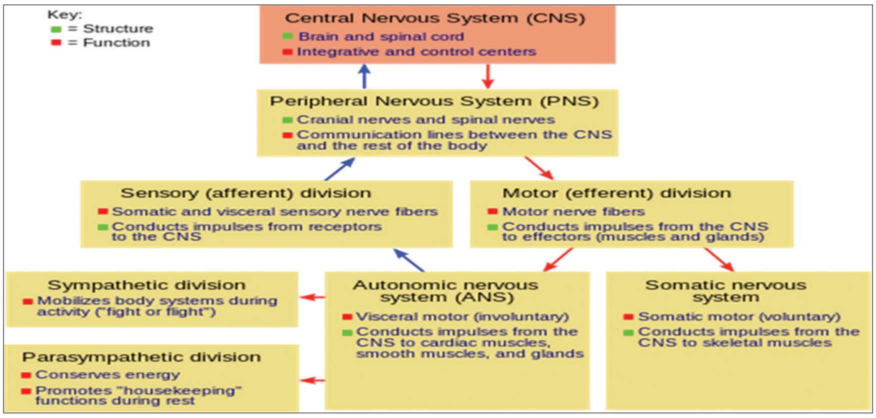


Figure 2: Pictorial representation of complete structure and function of nerve[12]

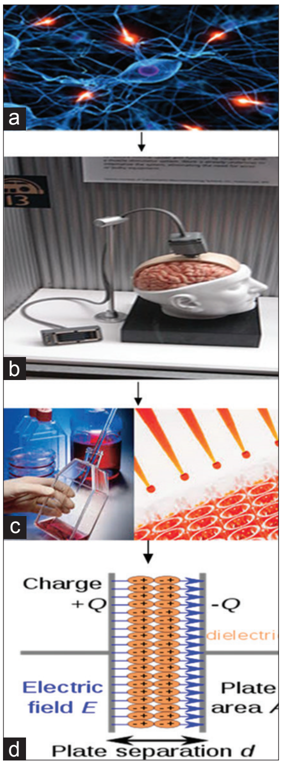


Figure 3: Flowchart of proposed methodology. (a) Selection of nerve network, (b) Determining the region of operation in brain [13], (c) Laboratory development of nerve network [14], (d) Using low voltage capacitors [15]

for two potassium ions into the cell on the cost of one ATP. Thus, the outer surface of axonal membrane possesses a positive charge while its inner surface becomes negatively charged.

The Action Potential (Initiating a Nerve Impulse)

The transmission of a nerve impulse, called an action potential to differentiate it from the resting potential, occurs in four phases.

1. Initiation of an action potential by a sufficiently large stimulus called a threshold stimulus
2. It's transmission along a neuron

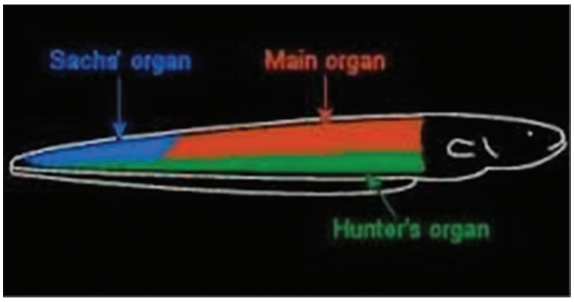


Figure 4: Electric organs of eel [16]

3. It's transfer to a target cell, which can be a neuron or a muscle cell and
4. It's effect on target cell.

Action potential is all-or-none phenomena, that is, they do not occur without sufficient stimulus, but once they start, they cannot be stopped.[17] Every action potential causes the same amount of voltage change in the neuron's interior. There are no longer or small action potentials, only large and small stimuli.

Action potentials temporarily disrupt the polarization of a neuron, resulting in depolarization. When a stimulus is applied to a site on the neuron, the closed voltage-gated sodium ion channel suddenly opens, allowing sodium ions to enter into the neuron.[9] This sudden movement of positive ions into the neuron causes the neuron's interior to develop a positive charge relative to its exterior.[11] Next, the voltage-gated sodium ion channels close and voltage-gated potassium channels open and potassium ions are swept out, thus restoring the resting potential called repolarization.

Repolarization

As the sodium ion channels close after 0.5 ms, the membrane becomes extra permeable to potassium ions due to the opening of potassium ion gates. With the pumping of potassium ions, the neuron interior becomes negatively charged and the potential falls back to resting potential.[8,11] The phenomenon of change of membrane potential from excited state to resting state is called repolarization. However, potassium ion channels remain open for a bit longer period so that the membrane potential becomes more negative than −70 mV. It is called hyperpolarization. It takes about 1–5 ms for repolarization.

THE DESIGN AND USAGE OF CAPACITOR

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to temporarily store electrical energy in an electric field.[18] The forms of practical capacitors vary widely, but most contain at least two electrical conductors (plates) separated by a dielectric (i.e., an insulator that can store energy by becoming polarized). The conductors can be thin films, foils, or sintered beads of metal or conductive electrolyte. The non-conducting dielectric acts to increase the capacitor's charge capacity. Materials commonly used as dielectrics include glass, ceramic, plastic film, paper, mica, and oxide layers. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, an ideal capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates.

When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge +Q to collect on one plate and negative charge −Q to collect on the other plate. If a battery has been attached to a capacitor for a sufficient amount of time, no current can flow through the capacitor.[19] However, if a time-varying voltage is applied across the leads of the capacitor, a displacement current can flow. An ideal capacitor is characterized by a single constant value, its capacitance. Capacitance is defined as the ratio of the electric charge Q on each conductor to the potential difference V between them.[18,20] The SI unit of capacitance is the farad (F), which is equal to one coulomb per volt (1 C/V). Typical capacitance values range from about 1 pF to about 1 mF.

The larger the surface area of the "plates" (conductors) and the narrower the gap between them, the greater the capacitance is.[21] In practice, the dielectric between the plates passes a small amount of leakage current and also has an electric field strength limit, known as the breakdown voltage.

Working Principle

A capacitor consists of two conductors separated by a non-conductive region. The non-conductive region can either be a vacuum or an electrical insulator material known as a dielectric.[21] Examples of dielectric media are glass, air, paper, and even a semiconductor depletion region chemically identical to the conductors.[22] The conductors thus hold equal and opposite charges on their facing surfaces, and the dielectric develops an electric field. In SI units, a capacitance of one farad means that one coulomb of charge on each conductor causes a voltage of one volt across the device.[20]

PROPOSED METHODOLOGY

- Step 1 - Selection of a nerve network
- Step 2 - Identification of brain region which gets activated due to this nerve network
- Step 3 - Developing this whole nerve network in tissue culture laboratory
- Step 4 - Using conducting wire, which acts like capacitors
- Step 5 - Collecting the charges and storing it for future use (Figure 3).

Selection of a nerve network - the nerves are activated by stimulus such as jumping, running, and movement of arms. Hence, we can select one particular stimuli and target the neural network. After selection of neural network, next process is mapping the brain to find the region which gets activated during this particular stimulus. A brain–computer interface (BCI), sometimes called a mind-machine interface, direct neural interface, or brain–machine interface, is a direct communication pathway between an enhanced or wired brain and an external device. BCIs are often directed at researching, mapping, assisting, augmenting, or repairing human cognitive or sensory-motor functions. Neural network is developed in the laboratory from stem cells and proper nutrient medium. Using minor capacitor like similar device can be developed which controls charges from each neurons and works as a like small battery. Hence by connecting all cells together the much larger voltage can be obtained and stored.

ESTIMATED AMOUNT OF ENERGY BY THE PROPOSED IDEA

The neural network contains nearly few millions of nerves which form a long chain, when a stimulus is applied, the neural network is activated, the information first travels to the first neuron, this neuron takes the stimulus, and an action potential is developed the potential of nearly −70 millivolts is generated. The charge is induced in one of the parallel plates of the capacitor, hence the capacitor gets charged, and when this set up is arranged for all the neurons in the neural network, each one acts like a small battery of 70 volts. If we consider the neural network to have nearly one million neurons then the total potential developed will be roughly 700 volts which can be used later on.

PROPOSED APPLICATIONS OF NEURAL ENERGY

The main purpose of this research is to efficient utilization of energy, the static charges from each and every neuron are tapped by small capacitor which acts like individual battery. Hence, we can add all batteries in series. Later this energy can be converted into AC or DC depending on the type of usage and if exemplify this energy can be utilized on uses of electronic gadgets.[23] It can be used as a light combat device for defense personnel.[24] The electric eel has three pairs of abdominal organs that produce electricity: The main organ, Hunter's organ, and Sach's organ. These organs make up four-fifths of its body and give the electric eel the ability to generate two types of electric organ discharges: Low voltage and high voltage.[16] These organs are made of electrocytes, lined up, so a current of ions can flow through them and stacked, so each one adds to a potential difference (Citation needed). When the eel finds its prey, the brain sends a signal through the nervous system to the electrocytes.[24-26] This opens the ion channels, allowing sodium to flow through, reversing the polarity momentarily. By causing a sudden difference in electric potential, it generates an electric current in a manner similar to a battery, in which stacked plates each produce an electric potential difference. In the electric eel, some 5,000 to 6,000 stacked electroplaques can make a shock up to 860 volts and 1 ampere of current (860 watts) for 2 ms. Such a shock is extremely unlikely to be deadly for an adult human, due to the very short duration of the discharge. When such cells are made to be activated by our neural network, then this combination can be deadly and can be very useful at the time of emergency.[26,27]

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