The Effects of the bio-inspired pulsed electromagnetic fields on ATP and health

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Abstract:

All cells in the body need Calcium, Oxygen, Glucose, Potassium and Magnesium etc., to correctly function. Calcium, Oxygen and Glucose are essential for the production of ATP (Adenosine Triphosphate). ATP is the basic 'fuel' needed to drive the mitochondria that are the cells' main energy producers. So it is very important that cells are able to produce enough ATP. The more ATP that is produced, the healthier cells are and the healthier we are. It is also known that electromagnetic signals have considerable effects on ATP levels. If ATP can be measured, then the cells' healthiness can be defined and evaluated. So it is necessary to investigate how to measure ATP, the effects of bio-inspired electro-magnetic signals on ATP levels and the relationships between ATP and cells' health (human health). There has been a lot of research on ATP, however, as far as the authors are aware, there has been limited research on how to measure ATP and the effects of electromagnetic fields on ATP, especially, the effects of bio-inspired electromagnetic fields. In this paper, certain equipment for measuring ATP for hygiene monitoring is employed to measure the ATP levels of a number of people with and without bio-inspired pulsed electromagnetic fields (BIPEF) to investigate how BIPEF influence the ATP levels of people and by directly connecting their health.

The test results show that most people's ATP levels are significantly increased (up to 600% increase) after they stayed in the BIPEF for a period of about 20 minutes. The averages of ATP% increase are 241% for British group and 111% for Chinese group. The findings confirm that the BIPEF does have significant effects on people's ATP levels. This means that the cellular biosynthesis processes of those people in the bio-inspired pulsed electromagnetic fields have been enhanced. So their energy and health are positively affected.

Key Words: Cells, ATP measurement, Bio-inspired electromagnetic fields, health

1 Introduction

Health is an energy dance; the more energy our cells have the healthier we will be. The health of our body is totally dependent on the health of our cells. The cell is the basic structural, functional, and biological unit of all known living organisms. Cells consist of cytoplasm enclosed within a membrane. The membrane of a cell oscillates at certain magnitudes and frequency[1-6]. The more cell oscillation there is, the more active and energetic the cells are and the higher the ATP levels and cell health. Historically, humans have lived in an earth environment with extremely low natural frequencies (ELF) that the planet produces both high in the atmosphere (Schumann (7.83Hz)) as well as on and below the planet's surface (Geomagnetic (10Hz))[7]. Schumann and

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Geomagnetic frequencies are vital to the wellbeing of all living things. It has been found that if we are in an environment with bio-electro-magnetic signals generated by mimicking natural Earth and body cell's frequencies (ELF's) and magnitudes, then our cells will be more energetic and active, so that we are healthier. There have been many reports about the influences of electromagnetic fields on healthy conditions of human beings [8,9,10-15].

Some studies have found that man is emitting electromagnetic energy in the frequency range of 0.5 – 30 Hz and the currents in orders of magnitude of microamperes.[6] There were harmonic components on frequencies of 2 Hz, 3 Hz, 4.2 Hz, 16.8 Hz and 21.3 Hz, incidental with the cardiac, breathing and cerebral functions in humans.

All cells in the body need Calcium, Oxygen, Glucose, Potassium and Magnesium etc., to correctly function. Calcium, Oxygen and Glucose are essential for the production of ATP (Adenosine Triphosphate). ATP is the basic 'fuel' needed to drive the mitochondria that are the cells' main energy producers. So it is vital that cells are able to produce enough ATP. The more ATP that is produced, the healthier cells are and the healthier we are. It is also known that electromagnetic signals have considerable effects on ATP levels. If ATP can be measured, then the cells' healthiness can be defined and evaluated. So it is both theoretical important and practically valuable to investigate how to measure ATP, the effect of bio-inspired electro-magnetic signals on ATP level and the relationships between ATP and cells' health (a direct correlation to human's health).There has been a lot of research on ATP. [16-18] However, as far as the authors are aware, there have been limited researches on the effects of electromagnetic fields on ATP, especially, the effects of bio-inspired electromagnetic fields. In this paper, equipment for measuring ATP for hygiene monitoring is employed to measure ATP of a number of people with and without electromagnetic fields to determine how electromagnetic fields influence ATP levels in people and hence their health.

Following this section, cell structure and functions will be firstly discussed in Section 2. ATP, its generating principle and functions will be secondly analysed in Section 3.Then the bio-inspired electromagnetic fields will be discussed in Section 4 and the effects of electromagnetic fields on ATP and health will be investigated in Section 5. In Section 6, the experiment results and findings will be presented.

2 Cells and their structure and functions

2.1 Cells

The cell is the basic structural, functional, and biological unit of all known living organisms. A cell is the smallest unit of life that can replicate independently, and cells are often called the "building blocks of life". The cells continuously grow and develop, split, regenerate and die. For adult people, about 25 million cells are splitting up every second and blood cells are constantly renewing at a rate of about 100 million per minute. Cells consist of cytoplasm enclosed within a membrane, which contains many bio-molecules such as proteins and nucleic acids.[25]There are unicellular (consisting of a single cell; including bacteria) or multicellular (including plants and animals). In this paper, only animals or human beings' multicellular eukaryotes are discussed.

The cell was discovered by Robert Hooke in 1665. In 1839, Matthias Jakob Schleiden and Theodor Schwann developed cell theory[26,27]. The theory states that (1) all organisms are composed of one or more cells, (2) that cells are the fundamental unit of structure and function in all living organisms, (3) that all cells come from pre-existing cells, and (4) that all cells contain the hereditary information necessary for regulating cell functions and for transmitting information to the next generation of cells.

A eukaryote contains a nucleus and other organelles enclosed within membranes as shown in Figure 1.The key difference between eukaryotic cells and prokaryotic cells is that eukaryotic cells have membrane-bound organelles. Especially the nucleus contains the genetic material and is enclosed by the nuclear envelope. Besides, eukaryotic cells also contain other membrane-bound organelles such as mitochondria and the Golgi apparatus etc[28].

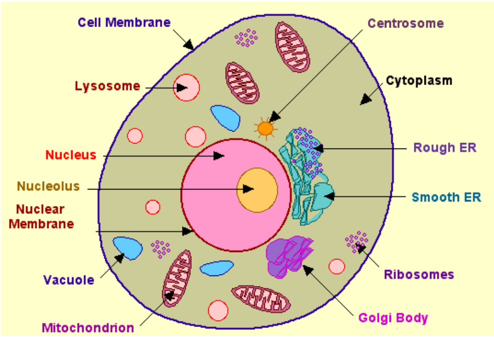

Figure 1 a typical animal cell
(source:http://www.enchantedlearning.com/subjects/animals/cell/[29])

2.2 Cell structure

A typical eukaryotic cell consists of the plasma membrane, cytoskeleton, genetic material, and a number of organelles including solitary nucleus and Golgi apparatus, numerous as mitochondria, peroxisomes and lysosomes and the gelatinous fluid cytosol that fills the cell and surrounds the organelles as shown in Figure 1.[28]The key difference between eukaryotic cells and prokaryotic cells is that eukaryotic cells have membrane-bound organelles. Especially the nucleus contains the genetic material and is enclosed by the nuclear envelope.

2.3 Cell functions

2.3.1 Membrane

The cell membrane (plasma membrane) serves to separate and protect a cell from its surrounding environment. It is made mostly from a double layer of phospholipids. Due to the factor that the phospholipids are amphiphilic (partly hydrophobic and partly hydrophilic), the layer is called a phospholipid bilayer. A variety of protein molecules is embedded within this membrane and these protein molecules works like channels and pumps that selectively allows different molecules into and out of the cell. That means that membrane is 'semi-permeable' and it can either let a molecule or an ion pass through freely, to a limited extent or not at all. There are receptor proteins on cell surface membranes. This kind of proteins make cells be able to detect external signalling molecules such as hormones. The nucleus and extranuclear electrons are charged bodies, the basis unit of a cell. These charged bodies are moving and changing ceaselessly at a high speed and emitting electromagnetic waves without interruption as well.[30] Cell membranes maintains the electric potential of the cell.

2.3.2 Cytoskeleton

The functions of cytoskeleton are(1) to organize and maintain the cell's shape; (2) to anchor organelles in place; (3) to facilitate during endocytosis (the uptake of external materials by a cell) and cytokinesis (the separation of daughter cells from mother cells); and (4) to move parts of the cell. The eukaryotic cytoskeleton is composed of microfilaments, intermediate filaments and microtubules. There are many proteins associated with them. Each of them controls a cell's structure by directing, bundling and aligning filaments, respectively.

2.3.3 Genetic material

There are two different kinds of genetic material: deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA is used for cells' long-term information storage. The biological information is encoded in its DNA sequence. RNA is for information transport (e.g., mRNA) and enzymatic functions (e.g., ribosomal RNA). Transfer RNA (tRNA) molecules are for adding amino acids during protein translation.

2.3.4 Organelles

Organelles are parts of the cell. Each organelle is adapted and has special and vital functions, analogous to the organs of the human body.

(a) Cell nucleus is the cell's information centre, the most conspicuous organelle found in a eukaryotic cell. It houses the cell's chromosomes. Almost all DNA replication and RNA synthesis (transcription) occur in cell nucleus. The nucleus is spherical and separated from the cytoplasm by the nuclear envelope. The nuclear envelope isolates and protects a cell's DNA from various molecules that could accidentally damage its structure or interfere with its processing.

(b) Golgi apparatus mainly processes and packages the macromolecules such as proteins and lipids, synthesized by the cell.

(c) Mitochondria produce energy for the cell. Mitochondria are self-replicating organelles. Cellular respiration occurs in the cell mitochondria. This set of metabolic reactions and processes converts biochemical energy from nutrients (by oxidative phosphorylation, using oxygen to release energy stored in cellular nutrients, typically pertaining to glucose, into (ATP), and then release waste products. Nutrients that are commonly used by animal and plant cells in respiration include sugar, amino acids and fatty acids, and the most common oxidizing agent (electron acceptor) is molecular oxygen (O2). It is theoretically believed that 38 ATP molecules can be made per oxidised glucose molecule during cellular respiration (2 from glycolysis, 2 from the Krebs cycle, and about 34 from the electron transport system). However, this maximum yield is never quite reached because of losses due to leaky membranes as well as the cost of moving pyruvate and ADP into the mitochondrial matrix, and current estimates range around 29 to 30 ATP per glucose.[31]

(d) Endoplasmic reticulum(ER) is a transport network for molecules targeted for certain modifications and specific destinations. The ER has two forms: the rough ER and smooth Erith rough ER has ribosomes on its surface that secrete proteins into the ER and the smooth Relocks ribosomes. The smooth ER plays a role in calcium sequestration and release.

(e) Lysosomes contain digestive enzymes (acid hydrolases). They digest excess or worn-out organelles, food particles, and engulfed viruses or bacteria. Peroxisomes have enzymes that rid the cell of toxic peroxides. The cell could not house these destructive enzymes if they were not contained in a membrane-bound system.

(f) Centrosome is the cytoskeleton organiser and produces the microtubules of a cell. It directs the transport through the ER and the Golgi apparatus.

(g) Vacuoles are often described as liquid filled space and are surrounded by a membrane. It sequesters waste products.

(h) Ribosome is a large complex of RNA and protein molecules. They each consist of two subunits, and act as an assembly line where RNA from the nucleus is used to synthesise proteins from amino acids.

2.4 Cellular biological processes

2.4.1 Metabolism

Cell metabolism is the process by which individual cells process nutrient molecules. Cells grow through cellular metabolism. There are two kinds of metabolism: catabolism and anabolism. In catabolism, the cell breaks down complex molecules to produce energy and reducing power, and in anabolism, the cell uses energy and reducing power to construct complex molecules and perform other biological functions. Complex sugars can be broken down into simpler sugar molecules such as glucose that is broken down to make ATP.

2.4.2 Replication

Cell division involves a single cell (called a *mother cell*) dividing into two daughter cells. This leads to growth in multicellular organisms (the growth of tissue). Unlike prokaryotic cells divide by binary fission, eukaryotic cells usually undergo a process of nuclear division, called mitosis, followed by division of the cell, called cytokinesis. A diploid cell may also undergo meiosis to produce haploid cells, usually four. DNA replication, or the process of duplicating a cell's genome, always happens when a cell divides through mitosis. This occurs during the S phase of the cycle. In meiosis, the DNA is replicated only once, while the cell divides twice. DNA replication only occurs before meiosis I. DNA replication does not occur when the cells divide the second time, in meiosis II.

2.4.3 Protein synthesis

Cells are capable of synthesizing new proteins, which are essential for the modulation and maintenance of cellular activities. This process involves the formation of new protein molecules from amino acid building blocks based on information encoded in DNA/RNA. Protein synthesis generally consists of two major steps: transcription and translation. Transcription is the process where genetic information in DNA is used to produce a complementary RNA strand. This RNA strand is then processed to give messenger RNA (mRNA), which is free to migrate through the cell. mRNA molecules bind to protein-RNA complexes called ribosomes located in the cytosol, where they are translated into polypeptide sequences. The ribosome mediates the formation of a polypeptide sequence based on the mRNA sequence. The mRNA sequence directly relates to the polypeptide sequence by binding to transfer RNA (tRNA) adapter molecules in binding pockets within the ribosome. The new polypeptide then folds into a functional three-dimensional protein molecule.

2.4.4 Movement or motility

In multicellular organisms, cells can move during processes such as wound healing, the immune response and cancer metastasis. For example, in wound healing in animals, white blood cells move to the wound site to kill the microorganisms that cause infection. Cell motility involves many receptors, crosslinking, bundling, binding, adhesion, motor and other proteins.[32,33] The process is divided into three steps – protrusion of the leading edge of the cell, adhesion of the leading edge and de-adhesion at the cell body and rear, and cytoskeletal contraction to pull the cell forward. Each step is driven by physical forces generated by unique segments of the cytoskeleton.

3 ATP, Its functions and biosynthesis

3.1 Introduction to ATP

ATP is a nucleotide triphosphate used in cells as a coenzyme often called the "molecular unit of currency" of intracellular energy transfer.[34] ATP transports chemical energy within cells for metabolism. ATP is generated through photophosphorylation, aerobic respiration, and fermentation. ATP is used by enzymes and structural proteins in many cellular processes such as biosynthetic reactions, motility and cell division. One molecule of ATP contains three phosphate groups and is produced by a wide variety of enzymes including ATP synthase from adenosine diphosphate (ADP) or adenosine monophosphate (AMP) and various phosphate group donors. There are three main ATP biosynthesis mechanisms:1) substrate-level phosphorylation, 2) oxidative phosphorylation in cellular respiration and 3) photophosphorylation in photosynthesis.

ATP is consumed in metabolic processes as an energy source and converted back into its precursors. So, ATP is continuously reproduced. At any one time, the human body contains just 250g of ATP, about the same amount of energy of a single AA battery. The amount of ATP used by a person is about our own body weight each day.[35]

ATP is used as a substrate in signal transduction pathways by kinases that phosphorylate proteins and lipids. ATP is also used by adenylate cyclase to produce the second messenger molecule cyclic AMP. The ratio between ATP and AMP is used as a way for a cell to sense how much energy is available and control the metabolic pathways that produce and consume ATP.[35] Apart from its roles in signalling and energy metabolism, ATP is also incorporated into nucleic acids by polymerases in the process of transcription.

3.2 Physical and chemical properties

ATP consists of adenosine and three phosphate groups (triphosphate). The adenosine is composed of an adenine ring and a ribose sugar. The phosphory groups, starting with the group closest to the ribose, are referred to as the alpha (α), beta (β), and gamma (γ) phosphates. ATP is highly soluble in water and is quite stable in solutions between pH 6.8 and 7.4, but is rapidly hydrolysed at extreme pH.[36] So it is very important that the people should be in pH 6.8 to 7.4 to maintain ATP level that is required for a healthy condition.

ATP is an unstable molecule in unbuffered water, in which it hydrolyses to ADP and phosphate. This is because the strength of the bonds between the phosphate groups in ATP is less than the strength of the hydrogen bonds (hydration bonds), between its products (ADP + phosphate), and water. Thus, if ATP and ADP are in chemical equilibrium in water, almost all of the ATP will eventually be converted to ADP. A system that is far from equilibrium contains Gibbs free energy, and is capable of doing work. Living cells maintain the ratio of ATP to ADP at a point ten orders of magnitude from equilibrium, with ATP concentrations fivefold higher than the concentration of ADP. This displacement from equilibrium means that the hydrolysis of ATP in the cell releases a large amount of free energy.[37]

The standard amount of energy released from hydrolysis of ATP can firstly be calculated from the changes in energy under non-natural (standard) conditions. Then, the result of the calculation is modified to biological concentrations. The net change in heat energy (enthalpy) is −30.5 kJ/mol at standard temperature and pressure of the decomposition of ATP into hydrated ADP and hydrated inorganic phosphate, with a change in free energy of 3.4 kJ/mol.[38] The energy released by cleaving either a phosphate (P_i) or pyrophosphate (PP_i) unit from ATP at standard state of 1 M are:[39]

$ATP + H_2O \rightarrow ADP + P_i \quad \Delta G^\circ = -30.5$ kJ/mol (−7.3 kcal/mol)
$ATP + H_2O \rightarrow AMP + PP_i \quad \Delta G^\circ = -45.6$ kJ/mol (−10.9 kcal/mol)

These values can be used to calculate the change in energy under physiological conditions and the cellular ATP/ADP ratio. However, after taking AMP into consideration a more representative value, called the Energy charge, is increasingly being used. The values given for the Gibbs free energy for this reaction are dependent on a number of factors, including overall ionic strength and the presence of alkaline earth metal ions such as $Mg^{2+}$and Ca^{2+}. Under typical cellular conditions, ΔG is approximately −57 kJ/mol (−14 kcal/mol).[40]

3.3 ATP biosynthesis

3.3.1 Introduction

The ATP concentration inside the cell is typically 1–10 mM.[41] ATP can be produced by redox reactions using simple and complex sugars (carbohydrates) or lipids as an energy source. Before being synthesized into ATP, complex fuels first need to be broken down into smaller and more simple molecules. Carbohydrates are hydrolysed into simple sugars, such as glucose and fructose. Fats (triglycerides) are metabolised to give fatty acids and glycerol.

The overall process of oxidizing glucose to carbon dioxide is known as cellular respiration and can produce about 30 molecules of ATP from a single molecule of glucose.[8] In eukaryotic organisms, ATP can be produced by three main distinct cellular processes: 1) glycolysis, 2) the citric acid cycle/oxidative phosphorylation; and 3) beta-oxidation. Both glycolysis and the citric acid cycle/oxidative phosphorylation are components of cellular respiration. The majority of this ATP production takes place in the mitochondria, which can make up nearly 25% of the total volume of a typical cell.[42]

3.3.2 Discussion of the main biosynthesis

1) Glycolysis

In glycolysis, glucose and glycerol are metabolized to pyruvate via the glycolytic pathway. Glycolysis generates a net two molecules of ATP through substrate phosphorylation catalysed by two enzymes: PGK and pyruvate kinase. Besides, two molecules of NADH are also produced. NADH can be oxidized through the electron transport chain and additional ATP is by ATP synthase. The pyruvate is generated as an end-product of glycolysis and is a substrate for the Krebs Cycle.[43]

2) Citric acid cycle/oxidative phosphorylation

In the mitochondrion, pyruvate is oxidized by the pyruvate dehydrogenase complex to Acetyl group, which is fully oxidized to carbon dioxide by the citric acid cycle. This biosynthesis is also called as the Krebs Cycle. Every "turn" of the citric acid cycle produces two carbon dioxide molecules, one molecule of the ATP equivalent guanosine triphosphate (GTP) through substrate-level phosphorylation catalysed by succinyl-CoA synthetase (three molecules of the reduced coenzyme NADH) and one molecule of the reduced coenzyme $FADH_2$. Both of these latter molecules are recycled to their oxidized states (NAD^+ and FAD, respectively) via the electron transport chain. In this process, additional ATP is produced by oxidative phosphorylation. in addition, 2–3 ATP molecules are synthesised through the oxidation of an NADH molecule and1–2 ATP molecules are generated through the oxidation of on guanosine triphosphate e $FADH_2$.[19] Although the citric acid cycle itself does not involve molecular oxygen, it is an obligatory aerobic process because O_2 is needed to recycle the reduced NADH and $FADH_2$ to their oxidized states. In the absence of oxygen, the citric acid cycle will cease to function due to the lack of available $NAD^+$and FAD.[44]The majority of cellular ATP is generated by this process.

In oxidative phosphorylation, protons are pumped out of the mitochondrial matrix and into the intermembrane space by the passage of electrons from NADH and $FADH_2$ through the electron transport chain. This creates a proton motive force that is the net effect of a pH gradient and an electric potential gradient across the inner mitochondrial membrane. Flow of protons down this potential gradient-that is, from the intermembrane space to the matrix- provides the driving force for ATP synthesis by ATP synthase. This enzyme contains a rotor subunit that physically rotates relative to the static portions of the protein during ATP synthesis.[45]

Since most of the ATP synthesized in the mitochondria are used for cellular processes in the cytosol, it must be exported from its site of synthesis in the mitochondrial matrix. The inner membrane contains an antiporter, the ADP/ATP translocase, which is an integral membrane protein used to exchange newly synthesized ATP in the matrix for ADP in the intermembrane space.[46] This translocase is driven by the membrane potential, as it results in the movement of about 4 negative charges out of the mitochondrial membrane in exchange for 3 negative charges moved inside. However, it is also necessary to transport phosphate into the mitochondrion; the phosphate carrier moves a proton in with each phosphate, partially dissipating the proton gradient.

3). Beta oxidation

Fatty acids can also be broken down to Acetyl-CoA by beta-oxidation. Each round of this cycle reduces the length of the acyl chain by two carbon atoms and produces one NADH and one $FADH_2$ molecule for generating ATP by oxidative phosphorylation. Because NADH and $FADH_2$ are energy-rich molecules, dozens of ATP molecules can be generated by the beta-oxidation of a single long acyl chain. The high energy yield of this process and the compact storage of fat explain why it is the densest source of dietarycalories.[47]

4). Fermentation

Fermentation entails the generation of energy via the process of substrate-level phosphorylation in the absence of a respiratory electron transport chain. In most eukaryotes, glucose is used as both an energy store and an electron donor. The equation for the oxidation of glucose to lactic acid is $C_6H_{12}O_6 \rightarrow 2CH_3CH(OH)COOH + 2\ ATP$.

3.4 ATP Functions in cells

3.4.1 Metabolism, synthesis, and active transport

ATP transfers energy between spatially separate metabolic reactions. ATP is the main energy source for the majority of cellular functions. This includes the synthesis of macromolecules, including DNAand RNA, and proteins. ATP also plays a critical role in the transport of macromolecules across cell membranes, e.g. exocytosis and endocytosis.

3.4.2 Roles in cell structure and locomotion

ATP is critically involved in maintaining cell structure by facilitating assembly and disassembly of elements of the cytoskeleton. In a related process, ATP is required for theshortening of actin and myosin filament cross-bridges required for muscle contraction. This latter process is one of the main energy requirements of animals and is essential forlocomotion and respiration.

3.4.3 Cell signalling

1) Extracellular signalling

ATP is also a signalling molecule. ATP, ADP, or adenosine are recognised by purinergic receptors. Purinoreceptors might be the most abundant receptors in mammalian tissues.[48]In humans, this signalling role is important in both the central and peripheral nervous system.[49]

2) Intracellular signalling

ATP is critical in signal transduction processes. It is used by kinases as the source of phosphate groups in their phosphate transfer reactions. Kinase activity on substrates such as proteins or membrane lipids are a common form of signal transduction. Phosphorylation of a protein by a kinase can activate this cascade such as the mitogen-activated protein kinase cascade.[50]

ATP is also used by adenylate cyclase and is transformed to the second messenger molecule cyclic AMP, which is involved in triggering calcium signals by the release of calcium from intracellular stores.[51] This form of signal transduction is particularly important in brain function, although it is involved in the regulation of a multitude of other cellular processes.[52]

3.4.4 DNA and RNA synthesis

In the synthesis of the nucleic acid RNA, adenosine derived from ATP is one of the four nucleotides incorporated directly into RNA molecules by RNA polymerases. The energy driving this polymerization comes from cleaving off a pyrophosphate (two phosphate groups).[53] The process is similar in DNA biosynthesis, except that ATP is reduced to the deoxyribonucleotide dATP, before incorporation into DNA.

3.5 Discussion

ATP is the main energy source for cells and supports various functions such as muscle contraction and protein production. It is the energy currency of life.ATP is the high-energy molecule that stores the energy we need. It exists in the cytoplasm and nucleoplasm of cells. All the energy dependent physiological mechanisms obtain ATP directly from the stored ATP.[8]Whennutrients in the cells is gradually oxidized, the released energy is used to re-form the ATP so that the cell always maintains a supply of this essential molecule. Karp quotes an estimate that more than 2×10^{26}molecules or >160kg of ATP is formed in the human body daily![25] ATP is remarkable for its ability to enter into many coupled reactions, both those to food to extract energy and with the reactions in other physiological processes to provide energy to them. So it can be believed that ATP levels can be used to evaluate how active cells are and hence how healthy people are.

4 Bio-inspired electro-magnetic fields

4.1 Cell Potential in biological systems[9]

Cell potential is also called membrane potential or transmembrane potential or membrane voltage). It is the difference between the interior and the exterior electric potentials of a biological cell. All animal cell membrane is composed of a lipid bilayer. There are proteins embedded in the lipid bilayer. The membrane works as both an insulator and a diffusion barrier to the movement of ions. The proteins serve as Ion transporters/pumps that actively control ions moving across the membrane and hence the ion concentration gradients are established across the membrane. The gradients also form the ion channels that allow ions to move across the membrane down those concentration gradients. Ion pumps and ion channels are electrically equivalent to a set of batteries and resistors in the membrane. Therefore, a voltage difference exists between the two sides of the membrane, usually with a negative voltage in the cell interior as compared to the cell exterior ranging from –40 mV to –80 mV.

The membrane potential has two basic functions: battery for power provision and way for transmitting signals. First, membrane potential provides power to operate a variety of molecules in the membrane. Second, it transmits signals between different parts of electrically excitable cells such as neurons and muscle cells. Signals are also generated by opening or closing of ion channels at one point in the membrane. Meanwhile, a local change is triggered in the membrane potential. This change can also be affected by either adjacent or more distant ion channels in the same membrane. The potential change can cause those ion channels open or close, reproducing the signal.

For those non-excitable cells and excitable cells in their baseline states, the membrane potential is held at a relatively stable value, called the resting potential. For example, typical values of the resting potential range of neurons are from –70 to –80 millivolts, just under one-tenth of a volt. The opening and closing of ion channels can induce a deviation from the resting potential, called a depolarization if the interior voltage becomes less negative (for example, from –70 mV to –60 mV), or a hyperpolarization if the interior voltage becomes more negative (for example, from –70 mV to –80 mV). In excitable cells, a sufficiently large depolarization can evoke an action potential, that means that the membrane potential can change rapidly and considerably for a short time (on the order of 1 to 100 milliseconds). The potential's polarity is often reversed.

There are numerous types of ion channels, some of which are chemically gated and some of which are voltage-gated. Voltage-gated ion channels are controlled by the membrane potential and meanwhile, the membrane potential itself is influenced by these ion channels, so feedback loops are formed. This leads to complex temporal dynamics of membrane potentials, including oscillations and regenerative events such as action potentials. These oscillations and regenerative events are important for cells to continuously grow and develop, split, regenerate and die. For adult people, about 25 million cells are splitting up every second and blood cells are constantly renewing at a rate of about 100 million per minute. In the process of cellular split-up and renewal, the charged bodies of nucleus and extranuclear electrons as the basis unit of a cell are moving, changing ceaselessly at a high speed and emitting electromagnetic waves without interruption. The magnitude and frequency of the electromagnetic signals vary with various organs of animals and humans. Some study found that man is emitting electromagnetic energy in the band of interest. This band was situated deliberately to the frequency interval of 0.5 – 30 Hz and the currents in orders of magnitude of microamperes.[6] There were harmonic components on frequencies of 2 Hz, 3 Hz, 4.2 Hz, 16.8 Hz and 21.3 Hz, incidental with the cardiac, breathing and cerebral human activity. These findings provide the important information for designing and developing equipment that can be used to generate the signals following the bionics principle. It is important to investigate the interactions between electromagnetic fields on those frequencies and humans.

4.2 Schumann and Geomagnetic Filed

German atmospheric physician W. O. Schumann proposed the idea that the space between the Earth surface and the ionosphere behaves as the resonance cavity – energy for this cavity is supplied with thunderbolts.[9] So, thunderbolts generate electromagnetic standing waves propagating around the globe. Those waves are reflected from the ionosphere back to the Earth surface and then back to the ionosphere. So, value of the Schumann resonance depends on the distance of the ionosphere from the Earth surface, which is subject to the Sun activity.

This value is subject to the magnetic storms disturbing the ionosphere above all and the Schumann resonance trails off, so it is created by terrestrial activities and modified or modulated by extra-terrestrial activities. The following correlation is interesting as well, resulting from that all – wave length. We can find out by calculation, that λ = c/f = 2.997 924 580. 108 /7.83 = 38.3 thousand km. This number is not accidental and it is close to the value of the Earth circumference.[7]This proofs that the extremely low natural frequencies (ELF) that the Earth produces is about 7.83Hz. Humans live in an Earth environment with extremely low natural frequencies (ELF) that are produced both high in the atmosphere (Schumann (7.83Hz)) as well as on and below the planet's surface (Geomagnetic (10Hz)). Schumann and Geomagnetic frequencies are vital to the wellbeing of all living things. So it is also important to investigate the interactions between electromagnetic fields with Schumann frequency and humans. These two main frequencies are in harmony and act as a balance to each other. The description Yin and Yang can be applied.

5 Effects of electro-magnetic fields on ATP and Health

There has been a lot of research on ATP[16-23]and there have been also many reports about the findings of the influences of electromagnetic fields on healthy conditions of human beings[8,9,10-15]. However, as far as the authors are aware, there have been limited researches on the effects of electromagnetic fields on ATP, especially, the effects of bio-inspired electromagnetic fields.

It is known that cells communicate with each other by means of direct metabolic exchanges or through the transfer of ions or molecules that act as messengers. Multi-cell signals originate in the interaction of ligands with membrane receptors. These signals can activate a closely connected series of biochemical reactions. The biological membranes represent multi-molecular operative structures and even a slight alteration in the composition of the membrane can lead to significant changes in its functions. Electromagnetic fields can influence this communication between cells and within the cells themselves due to their ability to activate or change the motion of the electrical charges.[54] In fact, some literature illustrates the possibility of inducing biological effects in cells when appropriate electrical and magnetic fields are applied to have a direct effect on the membranes [55].
Up to now, the results obtained imply that the membrane receptors (e.g., the gluco-protein complexes) are able to decipher electrical signals at a well-defined frequency and amplitude by reacting in a specific way. The energy transformed from the electrical fields is absorbed and directly coupled to guide biochemical reactions. These results have served as the basis for some applications in the therapeutic field, particularly in the reproduction of bone tissue. [56].

As discussed in Sections 4.1 and 4.2, some study found that man is emitting electromagnetic energy in the band of interest. This band was situated deliberately to the frequency interval of 0.5 – 30 Hz and the currents in orders of magnitude of microamperes.[6] There were harmonic components on frequencies of 2 Hz, 3 Hz, 4.2 Hz, 16.8 Hz and 21.3 Hz, incidental with the cardiac, breathing and cerebral human activity. In addition, humans live in an environment on the earth with extremely low natural frequencies (ELF) that the Earth produces both high in the atmosphere (Schumann (7.83Hz)) as well as on and below the planet's surface (Geomagnetic (10Hz)). Schumann and Geomagnetic frequencies are vital to the wellbeing of all living things. These findings convincingly show that if we are in an environment with bio-inspired electro-magnetic signals generated by mimicking natural Earth and body cell's frequencies (ELF's), ATP levels of our cells should be considerably enhanced compared with those under other electromagnetic fields. Then, we will be more energetic and active so that we are healthier. So it is important to study, design and develop equipment that can be used to generate the bio-inspired electromagnetic signals.

Among various equipment available on the market, Magnafield®, owned by Magnacare Health Group UK, is a leading product that is based on the findings of natural Earth and body cell's frequencies (ELF's) and amplitude. In this paper, this equipment has been applied to investigate the effects of bio-inspired electromagnetic fields on ATP levels of human beings and their health.

6 Test results and findings

6.1 Tests

To investigate the effects of bio-inspired electromagnetic fields on ATP and health, some tests have been done. Magnafield® was used to generate bio-inspired electromagnetic signals, as shown in Figure 2. Neogen's AccuPoint Advanced ATP Hygiene Monitoring System and AccuPoint Advanced Surface Samplers were used to measure ATP. This is a handheld device that accurately detects ATP, as shown in Figure 3.

Figure 2 Magnafield® for generating bio-inspired electromagnetic signals

Figure 3 Neogen's The AccuPoint Advanced ATP Hygiene Monitoring System and AccuPoint Advanced Surface Samplers for measuring ATP

16 people have been invited to join the Test. 8 People are for from UK and8 from China. The age of people is from 15 to 67. There are 14 males and 2 females. They are generally

considered as healthy. The disciplines of the people from UK are different from those from China. The people from UK are mainly in sport related discipline while those from China are relatively young students. The other details of the people are listed in Tables 1 and 2. For each people, two times of ATP tests have been carried out. The first time was about 0.5 to 4 hours after diner. The second time test was about 20 minutes after the first time, during this period, the people stay in the bio-inspired electromagnetic fields.

6.2 Test results

The Test results are listed in Tables 1and 2. Table 1 lists the results for the people from UK and Table 2 for the people from China. In the table, $L_1$of Column 5 and L_2 of Column 6 are the ATP readings for the first time test and the second time, respectively. $\delta L=100*(L_2-L_1)/L_1$ of Column 7 is ATP% increase.

Table 1 the Test results of ATP test for the ten people from UK

People	Gender	D.O.B.	Discipline	L_1 (RLU's)	L_2 (RLU's)	$\delta L=100*(L_2-L_1)/L_1$	Date
No 1	F	07/07/1995	DANCE	441	957	117	26/03/16
No 2	M	20/01/1983	BOXING	192	245	28	26/03/16
No 3	M	18/10/1996	BOXING	184	842	357	26/03/16
No 4	M	02/12/1996	BOXING	131	899	586	26/03/16
No 5	M	08/08/2001	BOXING	437	3213	635	26/03/16
No 6	M	14/03/1996	BOXING	595	998	68	26/03/16
No 7	M	16/03/1963	BOXING	772	882	14	26/03/16
No 8	M	13/01/1948	GOLF	391	873	123	26/03/16

Table 2 the Test results of ATP test for the ten people from China

People	Gender	D.O.B.	Dinner time	Test time	Time from dinner to test (minutes)	L_1	L_2	$\delta L=100*(L_2-L_1)/L_1$	Date
No 1	M	30/08/1991	08:25	10:10	105	1253	1751	40	03/03/16
No 2	M	21/08/1989	11:35	15:00	205	974	1043	7	12/03/16
No 3	M	25/03/1993	11:35	16:00	265	328	538	64	12/03/16
No 4	M	27/11/1992	08:00	09:35	95	146	281	92	13/03/16
No 5	M	12/12/1993	11:00	15:50	290	268	525	96	13/03/16
No 6	M	24/04/1992	19:00	20:20	200	412	690	67	13/03/16
No 7	F	01/10/1992	08:20	09:35	75	174	869	399	30/03/16
No 8	M	16/08/1992	11:30	14:05	155	768	1710	123	30/03/16

Figures 4 and 5 shows the distribution of ATP% increase for the two groups with Figure 4 for British group and Figure 5 for Chinese group.

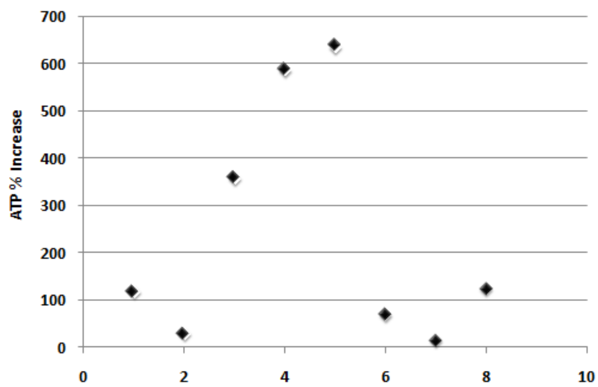

Figure 4 the distribution of ATP% increase for British group

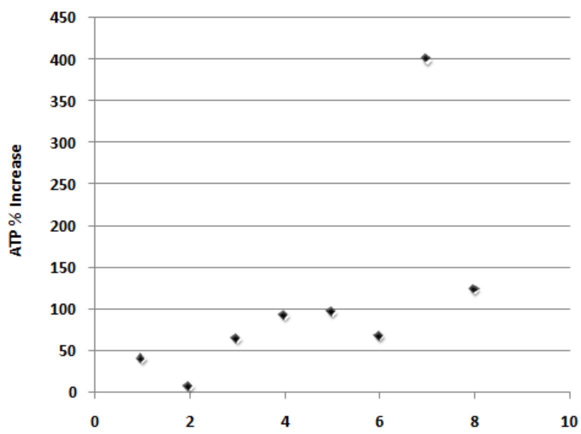

Figure 4 the distribution of ATP% increase for Chinese group

6.3 Analysis and findings

From the test results, it can be shown that:

1) Most people's ATP levels have been significantly increased (up to 600% increase) after they stayed in the bio-inspired pulsed electromagnetic field about 20 minutes.The averages of ATP% increase are 241% for British group and 111% for Chinese group. From Figures 4 and 5, it can observed that more people's ATP% increases are around 100%. That experimentally verifies that the BIPEF do have the significant effects on people's ATP levels. As discussed in Sections 3 and 4, the cellular biosynthesis processes of those people in the BIPEF have been enhanced. So people will be more energetic. This findings have been verified by a boxing man when he does the routine exercise on running machine.
2) The influences of BIPEF on ATP vary a lot for different people, from as little as 7% to as large as 635%. This is a very interesting phenomenon. The reasons for this occurrence are possibly that:

   (a) the sensitivity of people with different conditions to the BIPEF cannot be the same. It can be reasonably believed that age, health condition, test time from dinner and food quality etc., can all be the factors that are related to the people's sensitivity.

   (b) The Accupoint ATP monitoring system is one of the most accurate in the world and designed specifically to test levels of ATP in samples from any source. The issue facing researchers is not one of equipment accuracy but rather one of sample regularity. Once that issue is resolved then we should see far more accurate readings. There is no question that positive differences are seen using BIPEF it is the accuracy and consistency of sampling that must be addressed. This research is mainly for investigating if there are any influences of the BIPEF on people's ATP, the how accurate the test results are not vital to our findings.

   (c) It is believed that this is the first time to study the influences of the BIPEF on people's ATP, so the persons who carried out the test are not experienced to accurately use the AccuPoint Advanced Surface Samplers to collect the test sample. In addition, there are not previous researches on where and how to collect the test samples. When use Neogen's the AccuPoint Advanced ATP Hygiene Monitoring System to test ATP, the amount of the collected sample is very important to obtain consistency of results. After discussions with the experts from Neogen, it was decided that the test samples are collected from the roof of the mouth. From our test practices, it was found that it is very difficult to control the amount of sample collected for different people since the amount of saliva in their mouths are different. To minimise the test errors, the people were asked to rinse their mouth before the test.

   d) From Table 2, it can be noticed that though there is not a strong correlation between the datasets of Columns 6 and 9, it is very reasonably convinced that the duration time from dinner to the test seems to plays a considerable role in ATP increase. For example, from Chinese group, the biggest ATP% increase was with the person who has shortest duration time (75 minutes via 399%). These findings conform to the theory of ATP generation, as discussed in Section 3.

e) From Table 1, it can be noticed that No.5 (youngest, at 15 years old) has the biggest ATP% increase (635%). Though it cannot be proved that the test results are very accurate, it is comfortable to conclude that age plays a role as well in ATP increase. It is possible that the cells are more active and hence more sensitive to the external excites of the BIPEF.

3) Though some meaningful findings have been obtained from this research, it has to be pointed out that there are a number of limitations associated with this research, as discussed above. So further research should be carried out.

(a) to investigate all main factors that affect the test results and identify how to improve Neogen's the AccuPoint Advanced ATP Hygiene Monitoring System and AccuPoint Advanced Surface Samplers or to design and develop a new system that is suitable for ordinary people to carry out ATP tests.

(b) to identify where are the best body part for collecting samples and establish the standard collection method.

(c) to study the relationships between ATP increase and the factors of age, healthy condition, age, test time from dinner and food quality, especially for people staying in the environment of different frequency and magnitudes of BIPEF.

(d) to study the relationships between the people's health and ATP levels with the purpose of design and develop a new ATP-based health enhancement and management system.

(e) to investigate new methods for athlete training and race performance improvement by monitoring their ATP levels, training methods and foods.

7 Conclusions

The paper presents the research for investigating the effects of bio-inspired electromagnetic fields on people's ATP levels and their health.

1) Cell structure and functions have been discussed and ATP, its generating principle and functions have also been analysed.
2) The bio-inspired electromagnetic field and its effects on people's ATP and health have been investigated.
3) The test results show that most people's ATP levels have been significantly increased (up to 600% increase) after they stayed in the bio-inspired electromagnetic field about 20 minutes. The averages of ATP% increase are 241% for British group and 111% for Chinese group. That experimentally verifies that the BIPEF do have the significant effects on people's ATP levels. With ATP level increase, the cellular biosynthesis processes of those people in the bio-inspired electromagnetic fields have been enhanced. So people will be more energetic and healthy. These findings have been verified by a professional boxer when exercising on running a machine.
4) The limitations of this research have been discussed and further researches have been analysed.

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