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The Semiconductor Carbon Atom as Nature's Thermistor

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Abstract: **The carbon atom plays a fundamental role in regulating biochemical reactions in living organisms. It does so thanks to its unique properties as a thermistor and semiconductor as well as having a negative temperature coefficient. This paper explores the foundation of these characteristics of the carbon atom. Examples are presented for real-life applications exploiting these unique features of the carbon atom.**

Keywords: **semiconductor, thermistor, carbon atom.**

I. INTRODUCTION

Have you ever wondered why carbon atom is the most common element - other than hydrogen - in proteins, fatty acids, carbohydrates, other organic compounds and most synthetic polymers? Or how a child can survive a short period of moderate hypothermia? Or how plants go dormant in winter?

When Niels Bohr, the 1922 Nobel Prize winner in physics, proposed the wave-particle duality, most physicists thought it was an obscure concept. Bohr's answer was, “Physics is not to say how nature is but how it appears, and theory has to be proven by experiments.” According to Linus Pauling, "Among the most interesting problems of science are resonance and hydrogen bonds and these two will be found to play an important role in such physiological phenomena as the contraction of muscle and the transmission of impulses along nerves and in the brain"[1]. He also pondered the question "What is the nature of electromagnetic phenomena?”

II. THEORETICAL DISCUSSION

In the present communication, we are putting forward the idea that the carbon atom is nature's thermistor since it can act as both a resistor and a conductor depending on the temperature of the environment. We look at examples of the applicability of this phenomenon to perinatal medicine, among others. Thermistors are used as thermometers in electronic instruments. Some of them have extremely high sensitivity. These devices consist of a small piece of semiconductor material whose electrical resistance changes with temperature. Thermistors usually are made up of oxides of various metals, such as nickel, manganese, iron, cobalt or copper and they may get sheathed in epoxy. They are widely used to protect electronic equipment. Temperature changes as small as 10^{-3}C can be detected They are often used as clinical thermometers (with digital readout) as well as in a variety of biological applications [2].

In a similar manner the semiconductor carbon atom is incorporated or embedded in all living organisms and protects them by way of its physical properties. At various temperatures, there are differences in resonance as well as in signals or impulses propagated via the carbon atoms. Under conditions of hypothermia, the carbon atom acts as a resistor and biochemical processes are slowed down, consequently requiring less oxygen and energy (discussed below).

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The carbon atom is the core backbone element of all structures in the organic and hence in the living world. Important properties of the carbon atom include it being the lightest and simplest semiconductor among the known elements as well as having a negative temperature coefficient of resistance. Between temperatures of 0°C and 100°C, the carbon atom can be a perfect insulator or an efficient conductor, respectively, with transitions between the two states at temperatures in-between these two extremes. At room temperature, only a small number of the electrons will be raised by thermal excitation into the conduction band. The material will conduct electricity, although poorly, and for this reason it is called a semiconductor [3].

The movement of the electrons and the transmittance of resonance within and between atoms determine the structure and consequently the physical properties of complex carbon-based molecules up to and including that of polymers. Among physicists, the carbon atom has received more and more attention over the past few decades because of its physical properties. Until recently, the dividing line between the world of quantum physics and that of molecules coincided with the boundary dividing the study of physics from that of chemistry, especially organic chemistry. Since the nuclei of atoms remain unchanged in ordinary chemical reactions, chemistry does not shed light on the nuclear forces and binding energies. Chemistry is concerned with the changes in arrangement of the outermost, external electrons, located on the valence shell. Electrons in the core shell(s) are reducing the influence of the nucleus on the electrons on the valence shell. The unique physical characteristics of the carbon atom bridge the field of quantum physics and the chemistry of our organic world.

In medicine, the way of thinking in physiological terms is about self-regulating biochemical reactions going on continuously in the living organisms. Shorter and longer chains of consecutive steps leading from one organic moiety to a particular biological end-product, all linked together by way of the Krebs-Szent-Györgyi cycle, is how simpler and more complex organisms exist and function in the living world.

The notion of carbon atoms regulating these biochemical reactions by way of their unique temperature-dependent attributes serves to take the thinking about biochemical reactions from the level of complex organic chemical compounds to the subcellular level of individual carbon atoms, which are influencing each other's structures and thereby functions. Looking at atomic and subatomic alterations to explain biochemical reactions of a higher order opens up new and so far unexplored vistas in our quest for understanding the functioning of complex compounds and structures in the organic world.

This novel way of thinking is the link between quantum mechanics and organic biomolecules. We can attempt to elucidate the underlying causes and mechanisms of biochemical reactions in the living world by looking at workings at the atomic and subatomic levels. A new era might be dawning upon us in medicine and biology where we will be thinking of the happenings at the level of nuclei and electrons of organic compounds in order to comprehend how the living world exists and functions. Some examples follow below.

A. Practical Applications of Our Theory:

The carbon atom acts as a biological switch and its unique nature as a resistor or a conductor can explain many phenomena in nature as follows.

The carbon atom will have a protective effect at low temperatures such as when a child's body temperature is lowered below physiological values, being subjected to moderate induced hypothermia for relatively short periods of time. As the body temperature decreases, the resonance of the carbon atom with its neighbours is sufficiently reduced. As the carbon atom progressively behaves more and more as an insulator, intra- and inter-molecular and by extension cellular, communication is reduced, slowing down cellular activities, including the requirement for oxygen. This mechanism can also explain the cardiac arrest recovery in the study of Holtzer [4] in which targeted temperature management was used successfully. This mechanism may also explain the recovery from acute brain and spinal cord injuries from the use of hypothermic treatments [5-7].

The same holds true in instances of accidental hypothermia when a body is exposed to sudden extreme cold, as in the context of falling through ice into frigid waters. The organism will be cooled to temperatures at which metabolic functions are slowed down and oxygen requirement is reduced. The colder the temperature the more the carbon atoms will act as resistors. At the same time, this reduction in biochemical reactions is what will allow the organism the chance to survive for relatively long periods of time, holding out the chance of recovery to normal functioning if the body is warmed up to physiological temperatures.

The cells can be maintained in this altered state only until cellular modifications in the cytoplasm at low temperatures (up to and including formation of ice crystals), become irreversible. However, a slow rate of subsequent temperature increase from moderate induced hypothermia, allows the cells to gradually return to normal function once normal body temperature is attained. It is well known that the cells of different tissues and organs have various degrees of tolerance to hypoxia. Lowering the body's temperature reduces the oxygen requirements. At lower temperatures, various degrees of cellular alterations may occur in particular organs, but more often than not, the changes are so mild as to allow for cellular recovery.

Some other phenomena that can be explained in terms of the carbon atom's unique semiconductor properties, are as follows. Some plants, insects, or mammals survive in winter because, during periods of lower temperatures their metabolism is slowed down. They are said to be hibernating, i.e. they consume minimal energy. It is also known that these species begin to store energy, including in the form of sugars in preparation for winter, so that during the hibernation period the metabolic processes are still ongoing but at a sufficiently reduced rate, still suitable for survival. The obvious question then becomes: How is survival possible for an extended period of time without ingestion of food? The answer lies in the unique features of the carbon atom, namely its semiconductor properties.

Since temperatures are low in winter, the carbon atom acts more as a resistor and helps reduce metabolic activities to a point where minimum energy is required for survival as during hibernation when the plant, insect or mammal is in a more or less dormant state. The carbon atoms, which are also part of the structure of enzymes, act as resistors at the low temperatures in order to minimize energy usage, thereby enabling survival for extended periods of time.

Another example of the carbon atom's unique semiconductor properties is exploited in the phenomenon of babies asphyxiated by their umbilical cord (nuchal cord) in the perinatal period. Measures have to be taken immediately after birth for them to survive without severe damage to the brain (asphyxial encephalopathy) and other organs or tissues. One way to minimize hypoxic damage is to lower the body temperature of the newborn to around 33.5C for 72 hours. Studies have been carried out to identify the most appropriate ways in lowering the baby's body temperature for optimal survival [8-10].

However, none of these studies has put forward an explanation as to how the newborn can survive at these lower body temperatures. We offer the explanation that the carbon atom's ability to act as a semiconductor, its negative temperature coefficient and its behaviour as a thermistor are the major reasons the newborns survive. At lower temperatures, the carbon atom acts as a resistor so that the baby can survive on lesser oxygen requirements, slowing down the metabolic activities and thus no or minimal damage to the brain and other organs ensues.

The lower metabolic rate in the newborn subjected to induced hypothermia, serves two main functions: 1. It prevents or minimizes further hypoxic damage at the cellular level by refraining the biochemical reactions needed for metabolic activities. 2. It 'buys time' to allow the lesed cellular and tissular components to recover from any damage they may have sustained during the asphyxial period. This dual benefit prevents a downward spiral of ongoing damage from taking hold in cells and tissues and organs. In fact, as shown in real-life neonatal intensive care practice, it provides an optimal environment - under certain temperature and time parameters - for the newborn to recover useful functions for life. This approach is somewhat similar to what we do when we twist our ankle or bump our knee: we apply a cold pack to it in order to slow down the biochemical activities in the areas involved.

B. Economic Impact of Practical Applications:

Since the carbon atom slows down the metabolic rate at lower temperatures, which, in turn, slow down cellular and other tissue damages, these properties can be taken advantage of by developing equipment that can be used to purposely lower the body temperature in the healing process and shorten the patient’s stay at the hospital. Patients will heal faster thereby resulting in large cost savings. Portable equipment also can be custom-made so that it can be available for many situations such as ambulances, sporting events, etc. Therefore, the economic impact can be huge.

With a clear understanding of the pathophysiology of tissue and cellular damage at the molecular and atomic level, as outlined above, the focus shifts to the prevention and minimization of life-altering injuries. A case in point is the high prevalence of brain injuries and their sequelae in Canadian society. Statistics available from reports of the Brain Injury Association of Canada show that among 29 OECD nations Canada ranks only 22nd when it comes to preventable childhood injuries and deaths Altogether, today there are 1.4 million Canadians living with acquired brain injury. The societal impact and long-term consequences of lack of closer attention to dealing with injuries with a view to decreasing the extent of tissue and cellular damage carries a very heavy economic burden, currently estimated at $20 billion annually [11].

Another stark reminder and societal cost is associated with spinal cord and central nervous system injuries [12, 13]. Many, many Canadians are living with irreversible spinal cord injuries. The prevalence of people living with spinal cord injury in Canada in 2010 is estimated at 85,556 persons. Of this total, 43,974 people (51%) have sustained spinal cord injury as a result of traumatic causes. About 44% of these people live with tetraplegia and 56% with paraplegia. The estimated life expectancy for paraplegics is about 70% of that of people in the same age group who don't have spinal cord injury, and the figure is about 50% for people living with tetraplegia.

Both incidence and prevalence of spinal cord injury is likely to increase from 2010 to 2030; incidence from 4,300 cases in 2010 to 5,800 cases in 2030 and prevalence from 86,000 persons in 2010 to 121,000 persons in 2030. The most common etiology is motor vehicle accidents, followed by falls. Every year 900 Canadians sustain spinal cord injury, most of them in their most productive young adult years between 16 and 30 years and about 2/3 of them are males. Median survival time is 38 years post-injury, with 43% surviving at least 40 years. The impact on society is staggering! The need for preventing and/or limiting permanent damage to the spinal cord by way of thermoregulatory devices has never been more evident and pressing.

Based on our above model of tissue and cellular damage at the molecular and atomic level, we strongly advocate in favour of the availability and skilled use of thermoregulatory devices on all ambulances, sports fields, physical competitive events, delivery rooms and hospital emergency departments. The advantages are obvious: much fewer people would be left with irreversible physical/mental handicaps as an outcome of injuries, and society at large would benefit not only by decreased costs associated with having to care for injured people with long-term handicaps, but would also see significantly more people returning to productive activities after having fully recovered from potentially life-altering consequences. Make thermoregulatory devices ubiquitous in everyday life, and all of society will be better off for it.

III. CONCLUSIONS

The above examples will serve to support the answer to the question we asked at the beginning of this article: Why is the carbon atom the most common of the elements found in all living species? The carbon atom is a biological switch thanks to its unique features as a thermistor, acting as a resistor or a conductor under the appropriate environmental conditions. Acting on this knowledge will provide immeasurable improvement in the lives of individuals and by extension that of society overall.

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