The Discovery of the Enhanced Property of Water Supporting Life and Ecology

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Authored By: Kokichi Hanaoka Ph.D.

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Introduction

Water − there is no liquid that is more important than water. However, despite its importance, there is no other liquid that is as least understood as water.

In disasters, we often see situations in which life could not be extended without the timely consumption of water. Although a common knowledge is that water travels through water pipes and is readily available from one's faucet, the direct relationship of water and life's sustenance, is least understood. The relevance of water becomes more acute when water is discussed in terms of disasters and water shortages.

Over the past several years, a wide assortment of bottled water products has been noted in supermarkets and convenience stores across the nation. One probable explanation for the expansion of bottled water may be based on an anxiety that consumers have towards tap water.

When one hears the term 'water', we think of it in terms of H_2O. The chemistry symbol of water was taught to us in high school chemistry. In spite of the interest that the H_2O symbol should have created at the time, very few have tried to fully understand this liquid form. Even with the emergence of bottled water awareness, the interest in H_2O has been a superficial discussion topic at best.

Generally, the discussion and understanding of water as a substance is described in its relativity to its color, transparency, taste, odor and aside from these properties, it's rather non-descript presence. Unfortunately, I feel that it is a mistake to approach the understanding of water only from these very basic levels of descriptions.

Water is not characterless, and in particular, it has the characteristic of a medium with high solubility when compared to other liquids. The human body is able to tap into the high solubility character of water to manage its life's activities and thereby positioning the body for an ongoing need for water consumption. Due to the ongoing need for water consumption, failure to consume water for 2-3 days will create a hazardous condition to one's well being.

When comparing the knowledge base that is required to embrace and utilize today's descriptors in units such as "micron" and "nano", the subject of water is a little simpler to comprehend through its unique appearance and functional mechanism. Water serves as main components to the cell structure and blood. Water plays an important role, and sometimes hails as the leading component, in all of life's intricate functions starting with absorption, transport of nutrients, digestion, and removal of waste.

The basis of these life's activities is seen in its application to the human physiology whereby each cell borrows the energy that is provided from the water to carry out its vital function(s). For this reason, the cell structure controls the

maintenance of water and its replenishment. Through this process, the most important function is found in a protein source—aquaporin. This is also referred to as a water channel. The scientist who discovered this function is Dr. Peter Agre, a renowned American who through this discovery was awarded the 2002 Nobel Prize.

Due to this profound discovery of the water channel, our knowledge of the function of water in organisms has been advanced exponentially. Still there are myriad of unknown items with some items still being rather confusing to comprehend and embrace. Although this feeling may be because we have not yet come to a full grasp of water's intricacies along with our own inability to explain, in lay terms, all of the marvels associated with water.

Aside from the high solubility factor of water, water has myriad-and-mysterious characteristics which create phenomena that are not found in other liquids. One of these mysteries is found in its high specific gravity at 4^{o}C as creating a heavier weight in a liquid state than that of a solid state, such as in a form of ice. We know that water, as a liquid, does not easily evaporate or freeze. Surprisingly, as phenomenal as it sounds, water does not freeze below 0^{o}C on account of the hydration characteristics of water. We do know that these unusual characteristics of water have greatly influenced the history of life while leaving us amazed with its wonderful-and-thought-provoking abilities.

Recently, new experiments are being conducted such as through the process of energy extraction from water or finding new functional properties of water. As an example, tap water is processed through electrolysis to produce electrolyzed water. Through the application of electrolysis to water, conducted through an electrolysis machine, the water is separated into two streams of water. One stream being an acidic in pH electrolyzed water and a second stream being an alkaline in pH electrolyzed water. The alkaline pH water is consumed while the acidic water is generally used as a cleaning medium. In addition to a bottled alkaline pH electrolyzed water, today there is a wide assortment of bottled water available. Unfortunately, as a scientist, I am concerned about products that are sold and claim to have scientifically-derived functional properties, when in essence they lack a scientific basis and subsequently fall into the category of "baseless water" which I consider to be shameful towards the trusting public.

The starting point in this book is to introduce the true appearance and shape of water, its wonderful characteristics and the power that it holds so that we can gain a level of water knowledge that is above an unfortunately superficial understanding of water.

This book will introduce the relationship between the human body and water and the characteristics and functionality of water. We all understand water to have a high solubility characteristic and thereby making it highly effective in this function. Recent research indicates that water exposed to certain energetic enhancement processes gain the ability to increase anti-oxidation effects adding

another phenomenal trait to water. The outcome of this research will also be covered in this book.

Based upon the enormity of the subject on water, and from a very humble vantage point of a scientist researching in this very complex field, I wish to contribute to a deeper and wider recognition of the greatness and importance of water. As a result of this, it is my wish that more people will find the importance of a healthier life through the understanding and consumption of functional water and at the same time, providing the appropriate level of importance to this liquid called water. I also wish that our overall understanding that we possess and the valuation that we assign to water will educate and inspire us to learn about other environmental problems and ecology issues that affect nature.

While authoring this book, although I included my personal opinions, I endeavored to write comprehensively and constructively. Despite this, there may be some confusing or contradictory statements that I may make, and for this I ask of you in advance for your understanding and sincerely welcome comments from the readership of this book.

I am grateful to Mr. Kazuo Yamamoto of RRC Publication for the editing and arrangements in the publication of this book.

Dr. Kokichi Hanaoka

Chapter 1: A Functional Water Supporting Life's Activities

One of the intriguing factors of life is how life relies upon water to sustain itself. We will discuss how water interacts with the cell, the vital role of the aquaporin and the quality and quantity of water required for proper fluid replenishment.

Water which creates life and sustains the human body

Humans are not the only ones that cannot sustain life in the absence of water; hence, this also applies to animals and plants. The lack of water does not allow for the existence of animals and plants. Collectively, our existence is contingent upon water.

Water composes the infrastructure of our human body. The energy for life is obtained from the existence and the intricate power of water. Therefore it is not an exaggeration to state that life is dependent upon water as a critical basis for its sustenance.

Although we cannot feel the total presence of water, an average of 60% of our adult male body is made up of water. At birth, and through the growing process, water occupies about 80% of our body due to the many bodily functions that depend upon water. Observing the youthful-looking skin of babies is the precise manifestation of water.

For adult men, water makes up 60% of the body and 55% for adult women. For adult men with a body weight of 132 lbs, there is an estimated 79.2 lbs of water or roughly 9.5 gallons of water. These numbers convert to approximately 18, 2 Liter PET bottles of water.

Of course there are individual differences as witnessed in a heavier person having 50% of their body weight in water. This disproportion is brought about by the fact that the amount of water in one's body is decreased when replaced with larger amounts of body fat. This relationship between water volume and body weight also applies to women. However, contrary to this, a lighter adult male will have as much as 65% of his body weight in water. Generally, human muscle contains approximately 75% of water and 10% of fatty tissues.

As humans age into their senior years, the amount of water decreases to a level of 50%. Concurrent to this aging process, we can see the level of vitality being lost in our skin and an increased manifestation of wrinkles. Again, this is an indication of the lessening levels of water in our body.

We can see how the water content of the human body differs with age and body weight but also indicating that the water content never falls below 50% in any healthy person.

Knowing that the body sustains significant levels of water to maintain its critical function to support our life's activities, perhaps it is time that we lessen our doubt towards the important role that water plays in our daily lives.

Water that satisfies each cell

When discussing the subject of water in the human body, one needs to think about the water included in human blood. Yes, there is a substantial amount of

water found in blood. The blood functions as a carrier of oxygen and nutrients throughout the body in its support for myriad of life's activities. Serum makes up over 50% of blood and a significant portion of this serum is made up of water. The red and white blood cells contained in the blood is also made up of water. Adding these fractions, 83% of serum consists of water which indicates that the portion of water found in blood exceeds the body's average water content of 60%.

From these percentages, it is not wrong to state that blood includes a significant level of water but when converting this percentage to the weight of water found in blood, it roughly equates to 1/13th or 8%. Since this number does not exceed 10% of the total amount of water found in the human body, the percentage of water composing blood is actually low.

We then ask ourselves, where is the largest amount of water found in the human body? Water is found in various key components of the body consisting of the brain, internal organs, muscle, skin and in other parts of the human body. 70% of the water is centered in the brain and internal organs while a single organ, the kidney, is composed of 80% water. As we know, the kidney processes our blood with water being a major component of this organ. Lesser levels of water, such as 10% are found in fatty tissue, 10% in bone, and 20% in bone tissue. Therefore, it is safe to say that there are no parts of the human body that does not possess a certain level of water.

As a point of reference, the human organs consist of many grouping of cells which are not visible to the naked eye. These groupings account for a significant number of approximately 60 trillion cells. Through the activity of these cells, each tissue that is found in the human body is formed.

Each of the tissue that is formed is similar to a bag holding water and which through its cell membrane handle the flow of water. From this we can determine that a significant level of water is subdivided and stored in cells throughout the body. Included in the water of each cell are organelles such as the nucleus that includes the DNA that transmits genetic information, the mitochondria that produces energy, the ribosome that is the synthetic factor of proteins and the various nutrients such as oxygen and carbon dioxide that are floating and mutually working with one another. This complex infrastructure manages life's activities.

Table 1 outlines the amount of water that is found in various parts of the human body. These levels are found in a person consisting 60% of water.

Table 1: Percentage of water found in the human body

Intracellular fluid	**40%**
Extracellular fluid	**20%**
Protein	**18%**
Fat	**15%**
Inorganic substance	**7%**

Intracellular fluid refers to the water found inside the cell. The 40% level is twice the level of the extracellular water level which also includes blood. Taking a case of an individual weighing 132 lbs, 40% of this body weight or 52.8 lbs consist of water found in the cells. The 52.8 lbs will equate roughly to 6.3 gallons of water. We can see that water is subdivided inside the cell groupings made up of 60 trillion cells in the human body thereby providing the infrastructure for life's activities.

In addition to the previously outlined functions of water in the human body, water serves as a medium for biochemical reaction which is used to also form the infrastructure of the internal organs while producing vital energy to make this complex infrastructure perform correctly.

Excluding the cells found in our brain, cells that are found in the rest of the human body are in a continuous state of replacement with new cells. Much like the cells found in skin, with the skin peeling off and with new skin being replaced, the tissues found in the human body act in a similar fashion. This regeneration process is referred to as metabolism.

If a sufficient level of water is not found in the cell, the absence of the metabolism function leads to the death of the cell which in turn leads to the death of the tissue followed by a total human death.

From this series of events, and in relation to the water levels retained in the various cell components of the human body, we find water to be an absolutely critical component to life.

Water which circulates and works inside and outside of cells

In the previous topic, we were able to establish the importance of water present both in the inside and outside of the cell structure, with the emphasis having been placed on blood as performing a significant function. As previously discussed, the fluid outside of the cell is roughly 3.2 gallons and equating to approximately ½ of the water inside the cell. ¼ of this water is found in the blood and ¾ of the water is found in the interstitial fluid.

The interstitial fluid is also referred to as the "tissue fluid" or the cellular interstitial fluid. As the name properly suggests, it is a body fluid found within the spacing of the various tissues and cells.

The function of the body fluid, located within the spaces of the capillaries and cells, relay oxygen and nutrients that are carried by the blood up to the peripheral vessels and then transport it into the cells. Quite contrarily, this body fluid also performs the role of receiving the carbon dioxide and waste and then sending it back to the capillaries. When these tissue fluids enter the lymph vessels, it then becomes known as the lymph fluid.

In these positions, the tissue fluid and interstitial fluid does not only stay within the same space in the tissues and cells but circulate throughout the body. Taking the fluid, working within the tissue spaces, the serum inside the blood that carries the nutrients to the cells is also the fluid that passes through the walls of the capillaries and then exiting out. Most of these fluids transport the nutrients and oxygen to the cells, dissolve the carbon dioxide and the waste, and when reabsorbed by the capillaries are sent back to the kidney via veins for a filtering process. In this process some of the fluids are excreted from the body while other fluids become clean water and are sent back from the heart to the rest of the body.

The interstitial fluid, despite its appearance to be momentarily static within the spaces of the tissues and cells, is actually similar to blood in that it circulates throughout the entire body. We will now take a look at this circulatory process and discuss the precise function that is occurring in this process.

We will start our discussion with the process of digestion and absorption. Consuming food items is a daily function and through this process, we take in various nutrients which become the source of energy for all of our activities. Food is digested in the stomach and absorbed from the stomach and intestines as a solution dissolved in water. During this process a large quantity of water content, such as in the form of saliva and stomach fluid, are used.

Blood is the medium that transports the digested and absorbed nutrients to all of the cells within the entire body. In this flow process, the nutrients absorbed from the capillaries are first dissolved in the blood serum. The arteries then transport it to all of the peripheral vessels located throughout the body. It then exits the peripheral vessels and through the tissues is advanced to the cells. The serum found in the blood and tissue is mostly water and the water's ability to dissolve matter is working during this flow.

This mechanism will be explained more in detail in Chapter 2 further describing water's solubility factor. The water's solubility is relied upon by the blood, cellular fluid and tissue fluid in order to transport nutrients throughout the body. During this flow, various forms of biochemistry reaction take place which also contribute to the management of life's activities.

With the high solubility taking place the water found in the blood, which dissolved the oxygen and other nutrients, is consistently circulating inside the human body. We can see that blood is circulated to the hands and feet and further to the extremities of the finger tips and toes. These are points that are at a significant distance from the heart but due to the fluidity of the blood, and coupled to the pumping action of the heart, the flow of blood to extremities is made possible. Water also has the ability to permeate through narrow channels and spaces and thereby making it a medium with tremendous infiltration abilities. The infiltration ability is brought about by surface tension.

One can remember when a science class demonstrated, in a thin tube, the function of the capillary through the slow elevation of water based upon tension. This same premise is experienced in the human body and referred to as the ability of water to push forth.

In order to view the surface tension of water from a different perspective, one can float an inverted bottle cap on the surface of water to witness that the bottle cap will float. One can also view an insect, the water strider, and how we can see it glide on the water's surface. Both of these processes can be explained by surface tension of water which is keeping both objects afloat.

Table 2 shows the surface tension of water compared to other fluids. The surface tension is illustrated in terms of a dyne. A single dyne is the size of the power generated on a 1 gram object with 1 cm of velocity per square second present and further indicated as 1/100,000 of 1 Newton.

Table 2: Surface Tension of the Fluids (20^{o}C, dyn/cm)

Water	**72.8**
Glycerin	**63.4**
Benzene	**28.9**
Acetone	**23.3**
Ethanol	**22.6**
Methanol	**22.5**
N-Hexane	**18.4**
Ethyl ether	**17.0**

Due to the higher surface tension of water, as shown in the table above, the blood is able to move efficiently throughout the human body. The capillary process or the ability to permeate into many spaces, become concurrently greater as the radius of the flow pipe becomes smaller which is a direct result of the higher surface tension of water. Quite similarly in the plant world, the plants utilize the same mechanism in the absorption of water.

We have established the basis that an adequate amount of water is needed inside the blood. If a circumstance existed in which a percentage of water in the blood became adhesive, and sticky to the touch, the full characteristic that the blood needs to function with cannot be achieved. Therefore, the proper amount of water comprising the blood, coupled to the effective state of this water, is extremely important and that without this proper balance, good health management will be faced with a challenge. As such, healthcare practitioners emphasize the importance of proper water consumption for the maintenance of one's health.

Discovery of the water channel - aquaporin

Blood is a carrier of the essential oxygen to be able to create biochemical reactions inside the cells as well as in the delivery of nutrients. Oxygen absorbed from the lungs through our breathing efforts carry red blood corpuscles.

This red blood corpuscle is also considered a cell. There is roughly a 65% presence of water inside this cell. Since the dissolved amount of oxygen in water is minimal, natural mechanisms will combine the hemoglobin inside the red blood corpuscles with oxygen and transport it to the cells. Hemoglobin is known as the oxygen transporter with a high compatibility to oxygen.

After the blood sent the oxygen to the cells, it receives the carbon dioxide exhaled by the cells and transports it to the lung as a point of discharge. The carbon dioxide dissolves with water and is carried as carbon while dissolution is being applied to the water. By using a substance with the characteristic of hemoglobin, an exceptional setup is created with the water being able to more effectively deliver its influence.

Through this process, the blood with dissolved nutrients and oxygen flow out from the capillaries and when reaching the cell, the water channel – aquaporin located in the cell membrane starts its process of passing water into the cell.

Professor Peter Agre of John Hopkins University discovered the aquaporin (AQP) and its function for the transport of water to the cell. More on the aquaporin will be covered in Chapter 3 but the important fact to note is based upon this major 20th century discovery of the aquaporin and the significance that this discovery has towards our understanding of the phenomenon that occurs in the human body with water transport and permeation.

There are various forms of aquaporin present, an aquaporin that passes water and other aquaporins which pass nutrients and ions through its channels. Additionally, there are channels for the passing of gases and urine. Although there is more to learn about water flow through the human body, we learn of the importance of Professor Agre's discovery which has allowed us to confirm the existence of these channels that sustain every aspect of life.

It has been confirmed that mammals possess 13 types of aquaporin. It has also been learned that each cell contains multiple aquaporins and through the harmony that exists between these multiple aquaporins, the entry and exit of water, nutrients and wastes occur.

Inside the cells, activities of energy-burning and metabolism are performed and carbon dioxide and wastes are generated through biochemical reactions that occur. During these activities, excess water enters and exits through the aquaporin. These are tissue fluids that are absorbed from the capillaries or lymph vessels and sent back through the veins.

Through this process a high dissolution of water occurs creating the forward and reverse flows of the oxygen and nutrients while also transporting carbon dioxide and other waste forms. These elements are filtered in the kidney which serves as a water treatment facility. Excess water and waste forms such as urine, composed mostly of water, exit from the body along with carbon dioxide being removed through the breathing process of the lungs.

We can summarily say that without water circulation, the life's cyclic activities of digestion → absorption → metabolism → excretion will not occur.

Characteristics of heat and cold in support of life.

We know that water that circulates in the body is filtered by the kidney. Aside from the various water forms and compositions that are discharged from the body such as through sweat, urine and bowel, other mediums are returned to a clean water form for continuance of its circulation throughout the body. Despite this, the body is still required to compensate for those discharged mediums through the replenishment of water in order to maintain an overall water balance in the body.

Along with the components that are discharged, such as urine and bowel that are classified as waste items, during our sleep, we discharge water through breathing and sweating which add roughly a cup (200cc) of water as discharge during the night.

Sweat, mostly composed of water, is known to perform the function of adjusting body temperature. When water evaporates, it removes a certain amount of heat which is also described as evaporation heat. Vaporization also places water highest among all substances with 540 calories per gram. This also explains why water can also effectively cool down an overheated body when compared to other substances. Once again, the ability of water is utilized in this function.

The high heat of vaporization, known as evaporation heat, indicates that evaporation does not easily occur primarily due to the difficulty of breaking the molecular bond, despite its fluid nature. This challenge is also seen in the unique placement of the hydrogen bond of water which requires a higher level of energy to loosen this bond. (Please refer to Chapter 2 on this subject matter.)

Even in a discussion on the adjustment to body temperature, it is extremely ideal to find that 60% of the body is composed of water; however, what we know of water indicates that it does not easily heat or cool as a fluid. The amount of heat or thermal capacity required to warm 1 gram of water to 1^{o} Centigrade is extremely significant at roughly 1 calorie. This is about twice the value of comparative heat in such mediums as ethanol and methanol.

Due to the specific heat being high, the temperature and body temperature does not easily change leaving each tissue and each cell below a constant temperature and subsequently allowing stable biochemical reactions to occur.

In addition, water like blood consistently circulate in the body without a moment of rest, and due to this consistency, there are no fluctuations to the body's temperature. Water also has a characteristic for high heat conductivity and in conjunction with this, the chemical reaction and exothermic in the body can be quickly transmitted to its surroundings.

Quite often, our planet earth is also referred to as a water planet based upon the more than 70% of the earth's surface being covered with sea water. This presence of water prevents sudden temperature changes. In a like manner, the presence of 60% of water making up the human body prevents sudden temperature changes; subsequently, water can further be considered as a primary support of life's activities.

Much in the same manner that the evaporation process of water does not occur easily, water itself does water freeze easily. This is referred to as the heat of fusion. This characteristic best describes the body's ability to keep the blood inside the capillaries and circulating throughout the entire body in a liquid state.

The elements which allow the body to maintain the body temperature at about 36.5^{o} Centigrade are the body's tissue and the layer of fat that is located under the surface of the skin. Also proper attire assists in maintaining proper body temperature.

In addition, since the muscle structure and the internal organs do not easily freeze or break due to the combined moisture related to the protein, revitalization is not lost.

Another element, osmotic pressure is also at work when water passes through the blood vessel and cell membrane. Osmotic pressure is found in other areas of our daily lives, such as seen in our daily cooking, in the process of making pickles, removing of salt, using salt as a medium on fish or meat to extract taste. In each of these processes, the water inside the cells will permeate out as a result of the effects of osmotic pressure.

Osmotic pressure occurs on account of the solution density, known as the gradient, between the inside (intracellular fluid) and the outside of the cell. Water works in a higher density due to osmotic pressure if the density variance of the solute includes ion density. This osmotic pressure creates a water flow in various organs and cells. This process also occurs in the water channel, also known as aquaporins. These are all areas in which the body relies upon the properties and ability of water.

A dryness of the throat is a warning signal

As previously indicated, almost 1/3 (approximately 8%) of a person's body consists of blood. A person having a body weight of 132 lbs has a blood weight of approximately 10.6 lbs which is approximately 1.2 gallons that is in circulation throughout the body.

The heart pumps blood through the body at a rate of 70 – 80 ml per pulse beat, also referred to as constriction. Despite the fact that there are individual differences with pulse rates, the heart beats at least 60 – 80 times per minute. If the heart beat was 70 times per minute, a blood volume of approximately 1.3 gallons per minute is sent from the heart into circulation.

Since blood circulation is measured in one-minute increments, the computation would show 1,440 times of circulation (60 minutes per hour x 24 hours) or approximately a volume of 1,867 ~ 2,133 gallons of blood circulating through the body daily.

Blood circulates in the body while carrying oxygen and nutrients to the cells and providing energy to perform the body's functions and also to discharge waste. Through this series of vital processes, the normal circulation of the blood directly relates to the activation of the cells, which in turn increases energy levels and immune levels while providing the body with the necessary healing power to maintain a good level of health.

Although the physical weight of the blood in a person's body is 1/13 of the total body weight, the blood circulates more than 100 times while maintaining its function and providing an amplified effect throughout the body.

We have learned of the importance of blood and also know that if we lose 1/3 of it, survivability becomes difficult.

The blood in circulation collects waste and the discharged water which dissolve this waste into urine, sweat and breath total about 2.7 Liters per day. This corresponds to 5 ~ 7% of water in the body which needs replenishment in order for the mechanisms of the body to continue fully functioning.

For this reason, a sensation of dryness in the throat is felt once 5% of the body's water is lost. A loss of 10% leads to a state of dehydration along with a danger to the normal sustenance of life.

In describing this sensation of dryness in the throat, it does not necessarily mean that the throat has actually dried out. The dryness in the throat is a warning sign from the brain that the osmotic pressure of the body fluid had increased and that the body needs to replenish water. Therefore, when one senses dryness in the throat, it is important to immediately replenish water to the body.

In parallel to the dryness of the throat in serving as a warning, it is an indicator that the salt content in the blood and other body fluids coupled to the ion density has increased; subsequently, other bodily functions cannot be properly performed leading to a secondary urgency for the replenishment of water. One can say that consumption of sea water in an attempt to quench thirst is a bad idea due to the fact that sea water has a salt density of 1.5 times that of blood. With this level of salt, the dryness of the throat will only heighten and thereby creating a more dehydrated state and leading to a dangerous health situation.

Cautions on the quantity and quality of water replenishment

The amount of water that needs to be replenished in a day needs to approximate the same amount of water that has been discharged. Under normal circumstances, 2.0 Liters ~ 2.5 Liters of water is consumed through direct water and through water found in drinks and foods. Subsequently, approximately 1.5 Liter of this intake is through meals and the balance of 1.0 Liter, or approximately 5 glasses, is believed to be consumed between meals in the form of tea, coffee or water.

As previously discussed, the amount of discharge from the body is approximately 2.7 Liters per day; thereby, giving the appearance that there is more water being discharged than the amount of intake water. This is not a problem from the standpoint that water is also being generated within the body.

When nutrients are consumed, due to the activity of the cells, water along with carbon dioxide is also generated. Water is mostly generated from fat. Through oxidation, approximately 107 grams of water is generated from 100 grams of fat and approximately 56 grams of water being generated from carbohydrates. New water created in this format adds itself to the overall circulatory and discharge water that is present in the body.

We have heard of migratory birds flying long intervals of time without an intake of water. The ability for them to fly is due to the amount of nutrient and fat that is stored in their body prior to flight. Through the generation of energy from fat, water is produced and replenished to the circulatory water.

In order for us to live a healthy life, like that of a marathon runner, we must often replenish our water. This replenishment also prevents the increase to osmotic pressure and salt density which occur when a body lacks water. Excluding individuals experiencing difficulties in their kidney, which is the organ responsible for filtering water, many experts point out the fact that we should be consuming 1.52 ~ 1.9 Liters of water daily. Under normal circumstances, it is not considered ideal to consume more than 1.9 Liters of water per day.

One important note is that as we age, the body does not consistently send warning signals regarding our water sufficiency and therefore, it is necessary to practice a regimen of daily water consumption.

As previously mentioned, water is excreted in the form of sweat and breath and larger amounts of water excreted as urine. When these forms of excretion occur, it is most likely that the water content in the blood becomes insufficient.

Therefore, there are many cases in which disease related to blood are found, such as cerebral infarction and cardiac infarction, as a result of an increase in blood pressure occurring in a relatively short period of time.

Due to these potential conditions occurring after awakening in the morning, it is advisable that water be consumed first thing in the morning and prior to sleep.

In the case of alcohol and its diuretic property, the alcohol will reduce the water level in the body. The amount of water discharge, on account of this diuretic effect, will be increased in the form of urine. Because of this effect of alcohol, it is important to consume water pre and post the alcohol intake.

At this point in our discussion of water intake, we can state that water plays a very vital role inside and outside of our cells. Life's maintenance is enabled by the ongoing support of water. We can understand the important function of how a 60% presence of water that is retained in the body performs its routine functions.

Water circulates in the body at every moment and performs the important roles of delivering an energy source, cleaning our system and in handling the discharge of waste. Through these functions, the defense and maintenance mechanisms of the organs work in harmony to ensure that the required quality and quantity of blood and water are maintained in a consistent manner.

The ratio of blood to water remains at 5% even if we drink a glass of water and when mixed with the blood, it circulates throughout the body once every minute. Therefore, sufficient replenishment is a key factor for good health maintenance. Again, being that water performs these critical functions, we must also properly view the quality of water that is being replenished and not only the amount of replenishment.

Chapter 2: Where does this power of water come from?

"H" for hydrogen. "H_2O" for water. Hydrogen bonding bringing out the mystique and power of water. We will discuss how these elements work together to define the intricate properties of water.

One drop of water with an infinite number of water molecules

The thought that our body is made up of water is related to the notion that the birth of all living things, and especially true with us human beings, started in sea water. Inseparable are the notions that water equals life and that living beings require water.

Whenever discussions are held as to whether there is life in outer space, the first topic requiring discussion is the absence or the presence of water and the fact that though water may be present, it may not be in liquid form.

For instance, in the case of the planets that are located closer to the sun, such as in the case of Mercury and Venus and with its land surface having temperature readings in excess of hundreds of degrees Centigrade, if there was a presence of water then there is no doubt that it would have evaporated. Quite to the contrary, the planet such as Mars being located at a distance which creates extreme cold and if water existed here, it would be in the form of ice. Understanding these two extreme factors, as we know today, earth is the only known planet that is blessed with liquid water and the proper infrastructure in place to maintain life.

We are all familiar with the chemical equation of H_2O in which the "H" represents Hydrogen and "O" represents Oxygen. Therefore, H_2O represents the combination of 2 hydrogen atoms and 1 oxygen atom.

A molecule is the basic particle that makes up matter. The planet is exactly a world composed of measurements in increments of $1/100^{TH}$ million centimeters or collectively referred to as a micron world. If these molecules were to gather together to create a physical presence equivalent to the number 10 billion multiplied by a number of 1 trillion, the result would still only represent a single droplet of water.

If we were to look at this number in terms of the amount of water we consume daily, whether it be a glass of water or about 2 Liters of water, the number of molecules making up the single glass of water would be the result of 10 trillion multiplied by 1 trillion or the equivalent of hundreds of 10 trillion multiplied by 1 trillion and in which case the number is considered to be an infinite number. These molecules making up a micron presence are bonded with an electrical charge and preside in a glass or in the human body in a liquid state.

When the surrounding temperature decreases, the bonding of the water solidifies and converts to ice. On the other hand, when the temperature increases, the water molecules move around intensely and as we know it, water turns into gas and into the form of steam.

Not only the water but the hydrogen atom and oxygen atom, which comprise the water molecules, are also bonded with an electrical charge.

Based upon the understanding of water through its molecular structure and its source of energy, this chapter will expand on these subjects and properties.

Birth of hydrogen that composes water

Beginning with hydrogen, 13.7 million years ago, a major explosion referred to as the Big Bang occurred in the Universe paving the beginning of outer space and all matters. On account of this Big Bang, protons and electrons collided and as a result of this merger and fusion, hydrogen was formed. A proton is a particle with a positive electrical charge carrying energy and mass that makeup the nucleus of the atom.

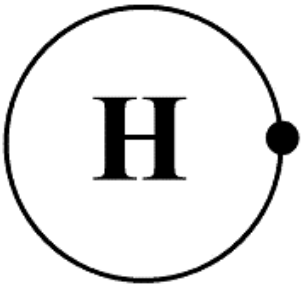
The hydrogen which was the first chemical element to be created has the simplest atomic structure as an atom, 1 proton (atom nucleus) and 1 electron. It is also said to be the element found in the largest quantity throughout the universe. Through the birth of the simple structure of hydrogen came the different and more complex atoms.

There is not much that exists in the form of hydrogen atom on earth but rather as a compound representing water as an element and the basis for the creation of living things. The hydrogen gas produced in industries is in the form of H_2 molecules.

Figure 1 shows hydrogen, an element. The nucleus has 1 proton with 1 electron circling it. H represents the positively charged nucleus (H^+) and it is surrounded with an electron with a negative electrical charge. (This actually represents a simple atomic structure.)

It was mentioned that water molecules are electrically bonded and this applies to all atoms and molecules.

Figure 1: Hydrogen Atom



The chemical equation of a hydrogen atom, which is composed of a hydrogen ion H^+ and the electron e^- is as follows:

$$H^+ + e^- = H$$

In this manner, the hydrogen atom keeps itself electrically neutral through the combination of the proton (+) in the nucleus and the electron (-). However, the hydrogen ion, H^+, which lost an electron (-) due to some form of influence, is called a proton.

As we move forward on water, our uses of the terminologies such as "ion" or "ionization" are essential to our discussion. These two terms will be used throughout this book.

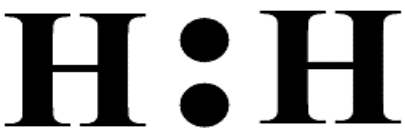
The term "ionization" is the phenomenon which occur when the neutral atom or molecule becomes a positive or a negative ion due to the loss of an electron through the collision of electrons. Upon the receipt of an electron, it becomes a negative ion. The object carrying the charge in this condition is called an ion. In other words, the H^+ which lost an electron (-) is a hydrogen ion, due to the loss occurring through the ionization process.

The description in which 1 proton loses 1 electron, and referred to as a proton, is limited to a hydrogen atom. The origin of the name Proton, with hydrogen as the leading existence and with an atomic number of 1, is derived from the Greek word "Proto" signifying "a first". Through this description, it is known as the first substance to appear in the Universe.

Different elements resulting from hydrogen

The hydrogen atom itself, as a combination of 1 proton and 1 electron, is in an extremely unstable state. When hydrogen atoms are mutually bonded with each other and become hydrogen molecules, stability is reached by the hydrogen atoms. This is the reason why its existence is in a state of a molecule and not as an atom. As shown in Figure 2, the well known hydrogen gas exists in the form of a molecule.

Figure 2: Covalent Bond of Hydrogen



As illustrated in this figure, one electron is mutually shared and through the combination of the electron pairs, a stable existence begins. This kind of a combination method, in the form of electron sharing, is called a covalent bond.

Hydrogen gas (H_2) in this form is colorless, tasteless, odorless and combustible. If this hydrogen gas is burned, even in a combination with oxygen and aside from the creation of energy, the byproduct is water (H_2O). Due to the non-pollutant nature of hydrogen, it is now attracting attention in its use as an alternative fuel for engines.

The hydrogen atom derived from the Big Bang exists in an extremely unstable state. It exists through a repetition of a cycle in the form of a hydrogen molecule then having a solar energy applied to it and then releasing an electron with other elements being generated from the repetitive cycles.

Initially, the proton of the hydrogen atom works itself into the nucleus where it fuses and generates a helium atom. This phenomenon is called a nuclear fusion resulting in a heavier and complex atom being formed. Through this cycle, different elements are formed.

Helium (He) which is an element after hydrogen (H) has an atom with a nucleus composed of 2 protons and 2 neutrons with no electrical charge and with 2 electrons. Next in line is Lithium (Li), Beryllium (Be), Boron (B), Carbon (C), Oxygen (O) and so forth. The elements are arranged in a periodic table with atomic numbers from 1 (Hydrogen) to 8 (Oxygen) (Elements are discovered to 111 Rentogenium).

The eighth element, which is oxygen, bonds with hydrogen and produces water molecules.

Oxygen bonds with hydrogen to produce water

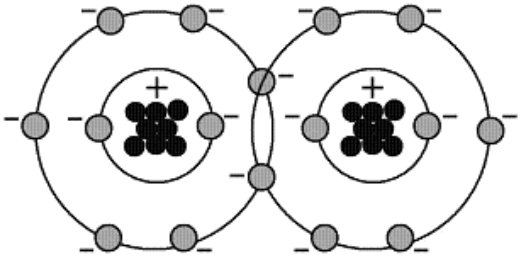
The oxygen that bonds with hydrogen and forms water is not only found in air but is also found in things composed of oxide, such as in the atmosphere, ocean and in the earth's crust. Each of these elements contains a large quantity of oxygen. It is also said that oxygen is widely distributed in outer space although it is known that the first element—hydrogen, is the most abundant in outer space.

In air, oxygen does not exist as an oxygen atom (O) but as an oxygen molecule (O_2). Oxygen makes up 21% of air, with nitrogen making up 78% and the remaining 1% composed of other gases (carbon dioxide, argon, etc.). At a standard temperature and at a standard pressure, similar to hydrogen, oxygen is colorless and odorless and is well known to be an aid to combustion.

It is well understood that oxygen is a basic need for all living things, and especially for the human. The fundamental to this requirement is based upon the fact organisms utilize oxygen for the creation of energy. For this reason, humans will not be able to live if it was deprived of oxygen for a mere few minutes and this indicates the importance of oxygen. A different form of oxygen, Active Oxygen, is formed in the body as a result of breathing and metabolism. Reactive Oxygen Species (ROS) oxidizes and degenerate the body's molecules like the DNA and weakens the non-toxic parts. This will be explained more in detail in Chapter 5. Through the action of photosynthesis occurring in plants, oxygen is being continuously formed on earth. Photosynthesis is the process in which carbon dioxide is absorbed by the plants and oxygen is emitted. It is understood that most of the oxygen existing on earth is generated through the photosynthesis occurring in plants.

This oxygen molecule, as shown in Figure 3, has 2 bonded oxygen atoms (O) with 8 positively charged protons and 8 negatively charged electrons. The two oxygen atoms each have 6 electrons in an outer shell, and they each share one of them to form a covalent bond which creates the oxygen molecule. This is the covalent bond described in the hydrogen molecule.

Figure 3: Covalent Bond of Oxygen



When the earth was formed, water existed in a gaseous state. When the earth started to cool down, the steam originally found in gas form, became water in a liquid state and seawater was formed. Initially, it was thought that the sea water was fresh water with zero salt density and with no minerals or dissolved ions present. However, due to the repetitive process of the evaporation of water and rain, the water that dissolved rock salt found in bed rock flowed to seas and increased the density of salt.

Due to the bond between the two in the form of water, hydrogen and oxygen came into a stable existence. Figure 4 represents the appearance of a balanced-and-stable hydrogen and oxygen forming a water molecule.

Figure 4: Electron Arrangement of Water

This is the form with the oxygen placed at the center and the hydrogen placed at both sides. Water molecules can be illustrated in different layouts as will be shown in Figures 5 and 6. Figure 4 shows that the electrons shared between the oxygen atom and the two hydrogen atoms form a strong covalent bond.

In other words, a stable and balanced water molecule can be created by forming a covalent bond between the electrons of an unstable hydrogen atom and an oxygen atom and if the same molecules make a further bond. This is referred to as a thermodynamically stable state.

To date, water has performed extremely important functions in the inception of living things.

Imagine the shape of a water molecule

We will try and draw the shape and image of water molecules. Although water is colorless and transparent, by the virtue that a water molecule is an object, it will have a shape to it. It is not easy to determine the precise shape of water molecules; however, it is certain that there are 2 hydrogen atoms and 1 oxygen atom, sharing each other's electron and being bonded. The bond is not linear but as shown in Figure 5, it is bent and forming a character "^". This is the shape of the water molecule and its major components.

Figure 5 is described as a spherical pole model. Figure 6 is described as a cloud model. Each of these illustrations indicates the characteristics of water molecules.

Figure 5: Spherical Pole Model of Water Molecule

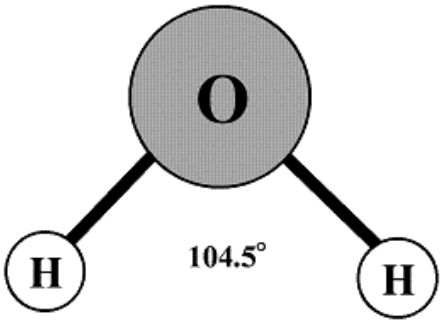
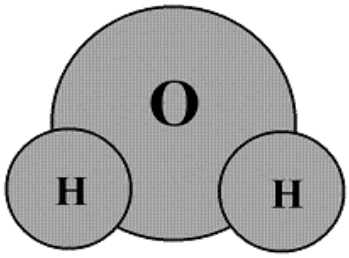


Figure 5 shows the bond of hydrogen – oxygen – hydrogen of water molecules and inclined at a 104.5^{o}.

Figure 6: Cloud Model of Water Molecule



Diameter: 0.3nm

Figure 6 shows the 3 atoms having bond-like spheres. Each atom is made up of a nucleus with the electrons orbiting around it. If a main object is placed at the time these electrons are orbiting, the atoms take on the image of a cloud. These cloud-like atomic spheres are bonded through a covalent bond.

The most significant point here is that the H–O–H is not linearly connected. This is due to the shape generating an electrical inclination and the attraction among water molecules pulling one another with the basis of the next hydrogen bond. This will be the upcoming subject of discussion.

At this point, as illustrated in Figure 6, the water molecule is about 0.3nm (nanometer) at its longest point. One nanometer is 10^{-9} meter, or 1/1,000,000,000TH meter, or 1/1,000,000TH of 1 millimeter. When discussing the size of a cell, we are discussing a measurement emanating in the world of micron sizing as shown in the fraction of 1 micrometer equaling 1/1,000TH of 1 millimeter. However, when discussing the measurement of a molecule or an atom, nano-size measurements apply. Recently, we have been exposed to the term "nanotech" which allows us to express the super minute world of measurement that is being applied to today's technology.

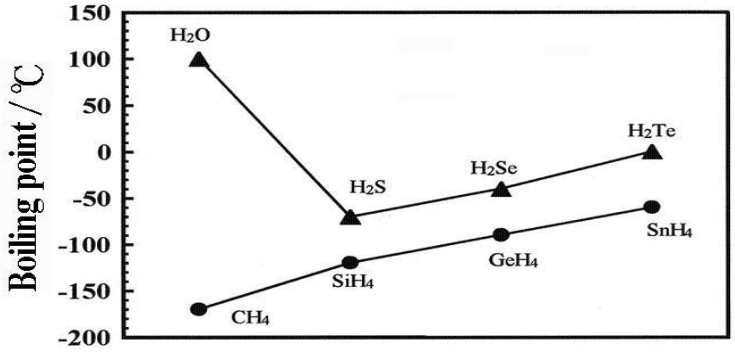
Hydrogen bond that becomes the source of power

A water molecule, expressed as H_2O, is extremely light in weight. Based upon a combination of the simplest hydrogen and the 8TH oxygen, a water molecule has a molecular weight of 18. This is calculated based upon the hydrogen of 1 multiplied by 2 and adding the oxygen of 16. As it gets lighter, the easier it moves and the easier it transforms into gas; however, this not being the case for water.

At a 100^{o} Centigrade and at 1atm, we know that water boils. This is the reason why a sizable amount of water exists on this planet and in a liquid state. The fact that water is a light molecule with a boiling point at 100^{o} Centigrade, in itself, is a surprising fact. Once we begin our comparison of water to other substances, this will become clearer to us.

Figure 7 illustrates the comparison of boiling points with substances having a higher molecular weight than that of water at 18 yet having a same chemical equation as water.

Figure 7: Illustrates The Boiling Point Of The 16th Family Element Compound And A 14th Family Element Compound



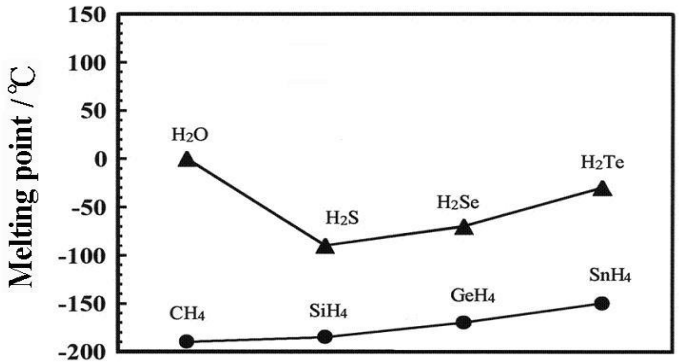
The above scale compares the boiling point of each element at 1 atm from water (H_2O) with the lowest molecular weight element indicated to the right. Hydrogen sulfide-H_2S with a molecular weight of 34. Hydrogen selenide-H_2SE with a molecular weight of 81. Hydrogen Telluride-H_2Te with a molecular weight of 130.

As originally thought, as the molecular weight decreases, the boiling point decreases thus making evaporation easier to occur. As the molecular weight increases, the boiling point increases. This characteristic is shown in the hydrogen sulfide (H_2S), hydrogen selenide (H_2Se) and in the hydrogen telluride (H_2Te). Also indicated by the chart, water is the only element that is showing the opposite effect. Additionally, although the molecular weight is small, the boiling point is high and the evaporation rate is low.

Common sense almost indicates that the water will easily evaporate as long as it was not in an extremely cold place, or during an ice age, but if this was the case, water would not exist on earth in a liquid form. The lower line in Figure (7) indicates the boiling point of the methane (CH_4), silicon hydride (SiH_4), germanium hydride (GeH_4) and tin hydride (SnH_4) indicating compounds of the four families of carbon, silicon, germanium and tin.

Similarly, Figure (8) shows the comparison of the melting point through a solid state, liquid state and gaseous state which is said to be the 3 states of water (H_2O). The figure compares the melting point (freezing point) where a solid form changes into a liquid, or from a liquid to a solid form, with the same substances.

Figure 8: Melting Point of 16th Family Element Compound and 14th Family Element Compound



Hydrogen bond that brings out the mystique of water

Aside from water, there is a small gravitational force referred to as the Van der Waals Force in effect when a molecule comes closer to another molecule. In this gravitational force, the basic principle is that it becomes larger for heavy molecules and weaker as the distance between molecules become farther. This also refers to the phenomenon that the boiling point becomes higher as the molecule becomes heavier and the molecules not being easily separated. Based on this principle, the gravitational force is weak for light water molecules and is easily separated. It also must evaporate at low temperature.

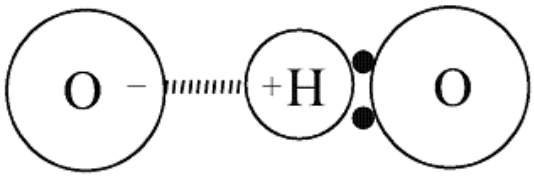
In looking back at Figure 7, compared to hydrogen sulfide (H_2S), water is easier to be separated when the molecular weight is almost doubled. It would appear that

the boiling point should be headed lower, into a negative direction on the graph, but quite to the contrary, it is seen rising to 100° Centigrade.

If we question ourselves as to the why in this rise in temperature, it is because the force of the hydrogen bond is very strong and actually stronger than the gravitational force known as the Van der Waals Force. With this interaction working between the molecules in water, it is not easy for evaporation to occur since the boiling point is high.

Let us look at the structure of the hydrogen bond.

Figure 9: Polarization of Water Molecule



As shown in Figure 9, through the covalent bond, the hydrogen atom (H) of water is strongly bonded with the oxygen (O) that comprises the molecule. Additionally, it has a bonding force with the oxygen (O) of the other water molecule. The bonding force is indicated by the broken line.

Through the electrical inclination of the water molecule, the hydrogen bond is produced. Since the oxygen atom of the water molecule has a strong force to attract the electron (-), this electron of the hydrogen atom is strongly pulled towards the side of the oxygen (O) resulting in the electrons in the black circle becoming a pair and then bonding. The electrons on the hydrogen side, at the opposite side of the bond lessen. Due to the electrical indication of the proton (+), the force that will pull the electron (-) is strong. Through this, a bonding with the oxygen atom of other water molecules will occur.

The hydrogen bond, as shown with a broken line, is stronger than the Van der Waals Force; subsequently, there is a strong bond even for water molecules with a small molecular weight. For this reason, the boiling point of water is also higher than the substance with a large molecular weight resulting in the molecules being not easily separable. Obviously, this force is far weaker when compared to the covalent bond that makes each of the water molecules. As a point of reference, bond energy is 2 – 10 calories per mole.

In 1920, Professor Linus Pauling who received Nobel Prizes in Science and in Peace had conducted the research of hydrogen bonds. Although the research continues, there have been various achievements since then through the work of many researchers.

The hydrogen bond itself suspends water and this is one of the basic mystiques of water.

Based upon the molecular weight, if there was no bond like a hydrogen bond in water, it would boil at approximately 100^{o} Centigrade and freeze at -110^{o} Centigrade. On account of this, we will not be able to see the water in its usual liquid state.

The hydrogen bond plays a very important role in DNA on account of the genetic information that it carries. Also, on account of the hydrogen bond, a higher surface tension is present. This will be explained further in the next chapter.

Water molecules that move like a dancing spectacle

Figure 10: Hydrogen Bond of Water Molecules

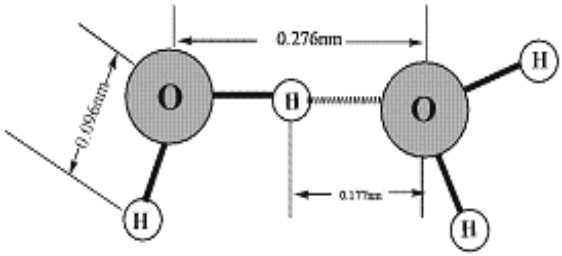


Figure 10 illustrates 2 water molecules creating a hydrogen bond. Actually, water molecules constantly bond, separate and rebond at an extremely high rate of speed. This activity is repeated on an ongoing basis. This speed at which the bonding and rebonding occur is at an average speed of 10^{-12} second. One can imagine this through a series of movements like water molecules dancing as spectacles.

This movement of bonding and rebonding becomes intense as the temperature rises and the activity slows with lowering temperatures. When the temperature lowers below 0^{o} Centigrade the process stops whereby the water in a frozen state appears like a figure frozen in time.

Contrary to this, when the temperature rises, the heat movement of water in the liquid state intensifies and the movements of the water molecules become more active. During this process, the movements appear like a high-speed image repeating the splitting of the water bond, creating evaporation and with the water turning into a gas form. As an example, clothing items that have been washed can be dried at a standard temperature. As another example, when one waters a given area or object, this water evaporates. The reason for these two situations is due to the fact that the water molecules do not reach the boiling point and instead split and evaporate into the air. When the temperature reaches 100^{o} Centigrade, the molecules start to perform the process in tandem.

When water is placed into a boiling state, the evaporating molecules take the heat of vaporization, while reducing the temperature, and place it into a balanced state. Therefore, as we know the evaporation does not occur all at once. Through this, water changes its appearance and shape from a solid to a liquid

and then to a gaseous state. If these 3 states were described in terms of relevant picture forms, water in a liquid state will mimic a video, water in a gaseous state will be liken to high-speed imaging and lastly, a water in frozen state will depict a still picture.

This is the imaging of water as a group of water molecules. The vast number of water molecules which are aligned like humans holding hands, are constantly disengaging and then reengaging on an ongoing basis. This simulates a human pyramid along with an image of a significant-sized game occurring in a significant-sized stadium.

Reasons why water dissolve matter

We stated earlier that water molecules have an electrical inclination, or polarization. In addition, as shown in Figures 5 and 10, water molecules have a unique characteristic like the symbol "〈" or a boomerang. This is related to the high dissolution ability of water.

As we know, water has the ability to dissolve different things and its dissolution ability is extremely high. This is the reason why it can support the life activities of organisms. This point was mentioned earlier in Chapter 1. It is not to be construed that water can dissolve everything because if this was the case, the solid state of organisms cannot be formed. This is described as the dissolution ability, applied to items meant to be dissolved while understanding the fact that items are present that do not dissolve.

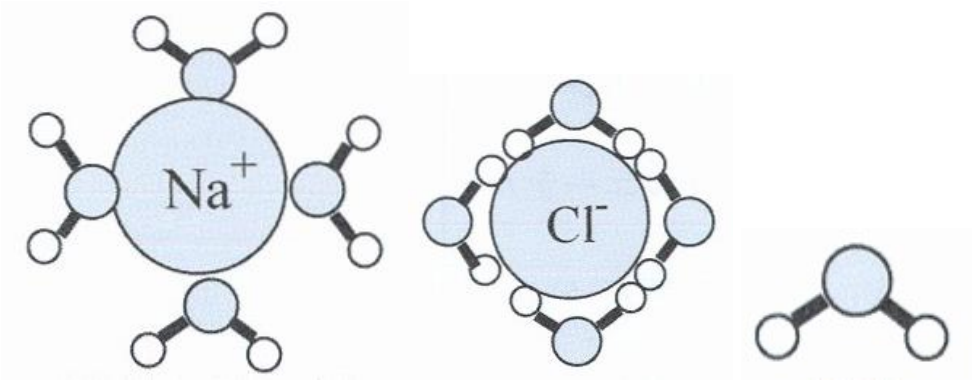
There are various substances that are easily dissolved in water and these are referred to as water-soluble substances. Everyone has experienced the solubility of salt, freeze dried coffee and sugar being dissolved in water.

In the instance of salt, Sodium Chloride (NaCl), if one was to put salt into water one would see that with no action applied to the salt and water, the salt will dissolve in the water. When the salt is in a crystal state, the sodium ion Na^+ and the chlorine ion Cl^- are electrically and firmly bonded with each other in a state of positive and negative charge. This is referred to as the ionic bond.

In the example provided above, if the salt is placed into the water, this ionic bond is cut off and the salt separates into sodium ion and chlorine ion. This process is referred to as ionization and the elements that are ionized and dissolved are referred to as electrolytes.

The question which arises from the example provided above is "why is it that the ionic bond of the salt is cut off in the water?" This occurs on account of the electrical characteristic of the water molecules.

Figure 11: Hydration of the Positive Ion and Negative Ion



Hydration with Sodium Ion Hydration with Chlorine Ion Water Molecule

As mentioned earlier, water molecules have the electrical inclination, also referred to as polarization. From the figure of the water molecule located at the right in Figure 11, the side of the oxygen atom located in the center has a negative polarity and both sides of the oxygen have a positive polarity. For this reason the sodium ion of salt, also referred to as a positive ion, and the oxygen atom representing the negative side of the water molecule, form an attraction and thereby enabling the water molecule to receive the sodium ion.

The chlorine ion, also referred to as a negative ion of the salt, attracts the positive side of the water molecule which is the hydrogen atom. As illustrated in the center portion of Figure 11, the water molecule is definitely enclosed.

If we were to observe a salt crystal, it would look like this in water. The ionic bond is cut and ionization occurs. When water molecules enclose the ions, this is referred to as hydration. The salt dissolves in water due to hydration.

In describing substances that dissolve in water, the ionized ions will be enclosed with water molecules and this state is referred to as a hydrated state.

As a reiteration, since the oxygen side and hydrogen side of the water molecule have different polarities, the negative side represented by the oxygen of the water faces the positive ion and the positive side of the water represented by the hydrogen faces the negative ion resulting in the occurrence of hydration. This feat is possible on account of the structure of water molecules, H–O–H, in a non-linear position but in a bent position as indicated in the illustration. This can also be referred to as a shape-forming branch.

Since there is a hydration structure in water similar to this, matter is dissolved while adding to the description of water as having a high level of dissolution ability.

Non-freezable water and proteins

The hydration phenomenon of water can also be seen in proteins that form the body and work directly in the maintenance of life.

Proteins have extremely large molecular weight which determines the size of the molecules when compared to water. Even a small protein has about 20,000 in molecular weight when compared to the molecular weight of water at 18.

Therefore, even if proteins are placed into water, the small ions will be dissolved but lack the ability to take on a shape that will be enclosed with water. When ions dissolve, it is affected by a push of force, removed and then dissolved.

So far, we have learned that significant changes can be seen in the quality and usage of water. As an example, although water normally freezes at 0^{o} Centigrade, the temperature of water that hydrates with proteins decreases without it further freezing. Water that does not freeze, as in this instance, is referred to as non-freezable water. This characteristic is a very important factor for living things which require a proper management of its life's activities.

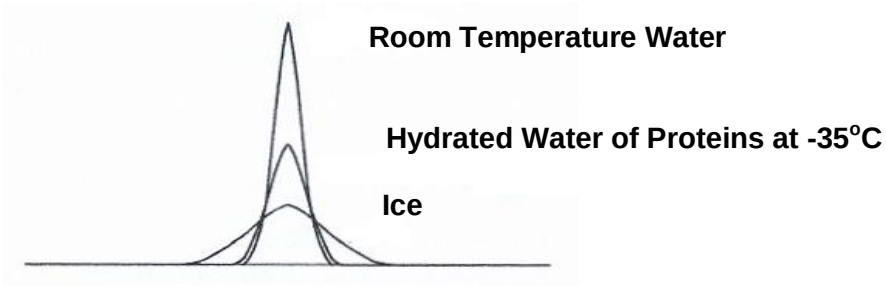
Non-freezable water that hydrates with proteins is not in the usual liquid form, like water at a standard temperature, and also not in a solid state as that of ice. The form will be more gel-like similar to soft jelly.

In the case of water in a liquid state, the water molecules cut off and bond every 10^{-12} second; however, the hydrated gel-like water cut off and bond at a far slower rate of approximately 10^{-7} second. This process of bonding and rebonding is performed at a very slow pace.

The non-freezable water protects the organism and cells, composed of water and proteins, from freezing. In recent years, researchers are taking sperms of mammals and storing it. This is possible on account of the hydration force that is in effect.

A Nuclear Magnetic Resonance (NMR) method is used to measure the speed of thermal motion of this type of water molecule. Figure 12 shows the spectrum comparing the measurement of the water at room temperature, the hydration water of proteins at -35^{o} Centigrade and the thermal motion of ice.

Figure 12: Results of Hydrated Water Using the Nuclear Magnetic Resonance



The middle peak illustrates that the hydrated water of proteins at -35^{o}C is undergoing a thermal motion between ice and water at room temperature.

From The Philosophy Of Water to Science

About 2,500 years ago, and when the Egyptian civilization was still prosperous, Thales a mathematician and philosopher from Greece, stated that "The source of all substance is water".

This philosopher from the past pursued through research the true nature of substance. Thales firmly believed that the origin of substance was from water. He is thought to have presented the Thales Theorem while researching the Egyptian civilization and taking educational classes. Thales Theorem states that the inscribed angle against the arc of the half circle is 90^{o}.

Contrary to Thales, Anaximenes asserted that the origin of substance was air. Heraclitus also asserted that it was air. Another viewpoint was expressed by Empedocles who thought that the four elements of air, water, earth and fire were the origin of substance.

Furthermore, in 300 B.C., Aristotle of Greece known to be the father of science, also thought that air, water, earth and fire was the origin of substance and was an advocate of this thought process.

India, located well outside of Greece, likewise stated that the four elements of earth, water, fire and wind were the origin of substance. In China, it was stated that five elements consisting of tree, fire, earth, gold and water were the origin of substance.

According to Thales, whether it be a single element of water or the four elements of earth, water, air and fire or whether it be the five elements of tree, fire, earth, gold and water, the fact that water is the origin of substance and based upon the concept of an "element", water was common to each of these thought processes.

It was not until the 18th century that this viewpoint was believed by many. Water and air are very essential to the management of human life and the pre-requisite might be the idea that these two components can be readily created.

In 1774, it was confirmed that water was not an element. At this time, a discovery of oxygen as being one of the elements in creating water was discovered. This discovery was made by Joseph Priestley, an English scientist, who discovered it through his research with mercury ash.

In 1776, hydrogen was discovered by Cavendish, an Englishman. He had unexpectedly found steam when he introduced zinc to an acid solution. It was later named hydrogen but at the time it was believed that hydrogen was a combustible substance.

In 1793, Lavoisier, a French scientist, performed an experiment where water was produced when the gas that was discovered by Cavendish was capable of burning in oxygen. Lavoisier, who named it Oxygen, named the gaseous body as "hydrogen", derived from the Greek words "hydro" meaning water and "gennao" meaning to generate.

From the experiment involving oxygen and hydrogen, Lavoisier also discovered that water is a molecule that bonds with 2 hydrogen atoms and 1 oxygen atom. Based on this, he investigated the substance—water. He proved scientifically not only that water was the origin of all matter but that it also possessed the elements and the atoms.

Lavoisier discovered, in the pre-post chemical reaction of substance, the "Law of Conservation of Mass" which indicated that its mass did not change. He was a great scientist that sculptured the basis of modern chemistry. In the world of academics, he left us with distinguished services; however and unfortunately, at the time of the French Revolution, Lavoisier was appointed to become the tax collector and henceforth was considered to be a "part of the Establishment", resulting in his death at the guillotine.

On account of these events, not until the 18th century did it become scientifically evident that water was made up of hydrogen and oxygen

A surprising property where liquid is heavier than a solid

After all of these circumstances came to light, many researchers found interest in water and performed research in this subject, based upon a simple bond between hydrogen and oxygen while the research yielded various characteristics and movements of water.

There is one mysterious property of water where the density of water is heaviest at 4^{o} Centigrade. The mystery lies in this phenomenon whereby the density is the highest in a liquid state rather than in a solid state and where this characteristic is not evident in other substances. As a side note, since density means "weight per constant volume", it is acceptable to simply state it as "weight", if within the same volume. Therefore, water is heavier when in a liquid state than when it is in a solid state, such as in an ice form.

In general, density increases in the order of gas – liquid – solid. Described in a different manner, although a solid state in the same capacity is supposed to be heavier, the density of water is heavier when it is in a liquid state than that of a solid state; furthermore, it is heaviest at 4^{o} Centigrade. Concerning this mystery, a book has been written by Professor Arakawa entitled "Mystery at 4^{o}C" and published through Hokkaido University Publication.

The explanation that was provided in this book starts with nature's sceneries in winter where the river and pond are shown in an ordinary state. However, in this

picture, a mysterious phenomenon is seen where the density of a solid mass in an ice form is floating and sized smaller than the liquid state of water.

From this characteristic, where water is heaviest at 4^{o} Centigrade, an understanding surrounding the environment and how living things survive was gained. Due to the fact that ice at 4^{o} Centigrade sinks to the bottom of the sea, living things are able to survive through the ice ages. This unique characteristic of water has had a significant impact to the history of living things. This explains why fish in a winter pond full of water does not freeze.

Through this ability to compress water, it also created a peculiar phenomenon. This can be illustrated and understood by measuring the decrease in water volume when pressure is applied to the fixed quantity of water. If the water temperature is changed and the compression factor measured, an extremely low value will be measured at approximately 50^{o} Centigrade. In contrast to other liquids, this is one of the peculiarities of water. The peculiarity in compression and the peculiarity in density are thought to be explained through the same reasoning.

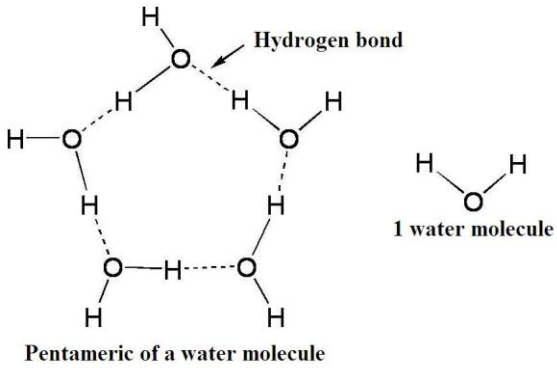
The first indication of a water structure existing in liquid form came in 1930. The existence of the structure was researched through the use of X-Ray scattering by Bernal, an Englishman.

When X-Ray scattering is used, the method applies X-Ray onto water causing the scattering of the electrons found in water molecules. The angle of the scattering of the electrons is then observed. Since the angle of the scattering differs depending on the type and temperature of material, the water structure of the substance can be observed through this angle. In the case of water, the main observation is made on the oxygen which comprises the water molecule. Through the X-Ray scattering method, an observation is possible on how many water molecules have closely approached a single water molecule.

Similarly, there is also a method of viewing the scattering of neutrons inside the atomic nucleus. This is referred to as neutron scattering and in certain respects, a more convenient method to observe the oxygen and hydrogen activities. The only drawback to this method is the physical size of the equipment that is used to perform this investigative function.

What we have learned so far with the X-Ray scattering method and the neutron scattering method is the fact that water is in a liquid state, and as shown in Figure 13, most of the molecules coming together in a single mass. This is referred to as "Pentameric". The size of this mass enlarges or contracts depending upon the temperature.

Figure 13: Pentameric of A Water Molecule



At 25°C, the pentameric is at 85% but it contracts to 55% at a temperature of 95°C. This means that when the temperature rises to 95°C from 25°C, the hydrogen bond of the same water molecules are cut resulting in many smaller masses and independent molecules. This mass of water molecules are generally referred to as water clusters and as the temperature rises, this becomes a smaller water cluster.

This phenomenon is also closely related to melting and boiling points where changes are made to the water density. It is necessary to observe these characteristics from various angles to understand the basic essentials of water and how it maintains human life.

Creating a relaxing environment

We had earlier mentioned in Chapter 1 that for organisms to maintain life, temperature ranges must be in close tolerance. The amount of heat, as measured in the amount of calories required to raise 1 gram of water to 1° Centigrade, has a significant impact on the environment as related to our existence in this environment. Towards the maintenance of our environment, the ocean plays a significant-and-global role through the gentle temperature adjustments that are made through the ocean's currents.

Due to the vastness of the ocean and its ability to store heat in sea water for long periods of time, the ocean plays an important role with temperatures. The function of the ocean mimics the role of a hot water bottle retaining heat. On the opposite side, seawater will never boil as witnessed with the warmest water right below the Equator. Therefore, the impact that sea water and its currents have in the proper maintenance of temperature is significant.

It is also known that water has a physical force associated with it. As we know, the weight of water is 1gram/1milliliter or 1 cc at a temperature of 25°C. If a high volume of water is collected, it possesses great force. Heavy rain, floods and tsunamis caused by earthquakes are some manifestations of the force of water. Through this force, water is being used in hydro-power plants which rely upon the weight and flow of the water for rotating turbines which in turn enable generators to produce electricity. Additionally, because water is a liquid that

does not freeze at room temperature, water provides a transportation medium through rivers and sea transport. These uses of water are significant contributions to the history of mankind. Lastly through the characteristic of water's buoyancy, goods have moved in world trade with fully loaded ships travelling the oceans.

Various kinds of water on earth

There are various forms of water on earth. Sea water, river water, pond water, rain water and the single droplet of water on a leaf constituting the varying forms of water.

The chemical composition of each form of water differs accordingly and is categorized as rain water, ocean water and inland water. Among these categories, ocean water occupies the vast areas of the earth's surface at an approximate coverage of 70.8%. The total surface mass that it covers is approximately 1,400 x 10^6 km^3.

Additionally, in the categorization of water types is circulating water and magma water. Drinking water will fall into the category of circulating water described as water that covers the earth, water that flows, water that evaporates and water that falls back to earth as rain−all occurring as a circulatory cycle of water flow.

Magma water is water which exists on the internal layer of the earth becoming a part of hot spring water or a geyser. Magma water is also referred to as water from the ancient times on account of its geological age.

Due to the inherent characteristic and mannerisms of water, such as its strong ability to dissolve matter, there is no water that can be referred to as "pure water". Sea water and tap water both have an abundance of minerals to it.

Based on the composition of water molecules, water can also be categorized as heavy water and light water. Heavy water is described through the hydrogen atom comprising the water molecule as being "heavy hydrogen". Heavy hydrogen is described as having a larger mass brought about by electrically-neutral neutrons aside from protons that are added to the nucleus of the atom against the usual hydrogen which is comprised of 1 proton and 1 electron. As a chemical symbol, the ordinary hydrogen is categorized as a Protium and represented as ^1H. In the case of a single neutron, or 1 neutron, it is categorized as Deuterium and represented as ^2H. For 2 neutrons, it is categorized as Thorium and represented as ^3H.

Within this category are elements with different quantity of neutrons and masses with different weights, and are called isotopes. Additionally, there are researchers who believe that ^4H and ^5H exist.

Heavy water is water replaced with heavy hydrogen as symbolized in the H of water molecules as H_2O but with the symbols of ^1H or ^2H. These symbols are

recognized with power plants that utilize heavy and light water reactors, as moderators, in the generation of nuclear power.

Heavy water has a mass and a weight that is slightly on the heavier side and has a boiling point at 101.4^{o}C and with a melting point at 3.8^{o}C, which is higher than light water. Heavy water also has heat evaporation that is higher than that of light water. The hydrogen bond is considerably stronger than ordinary or light water and heavy water exists in nature in a very small amount.

Briefly, oxygen is an element with 16 protons. Isotopes ^{17}O and ^{18}O with many neutrons exist in nature. An ordinary oxygen atom^{16}O is 27,000, ^{17}O is 10 and ^{18}O is 55, an extremely small number. There are also other artificially-created radioactive isotopes such as ^{13}O, ^{14}O, ^{15}O and ^{20}O. Through the combination of oxygen and hydrogen, various kinds of water can also be artificially created. Although it is simple for us to verbalize the word "water", there is a significant depth in the knowledge associated with water.

Chapter 3: Water Inside the Body

Sea life and human life. Water and DNA. Water through aquaporins to the cell. The kidney a processing center for water. We will discuss how water travels through the body and myriad of vital functions that it performs in the sustenance of life.

Traces of life that were born in the sea

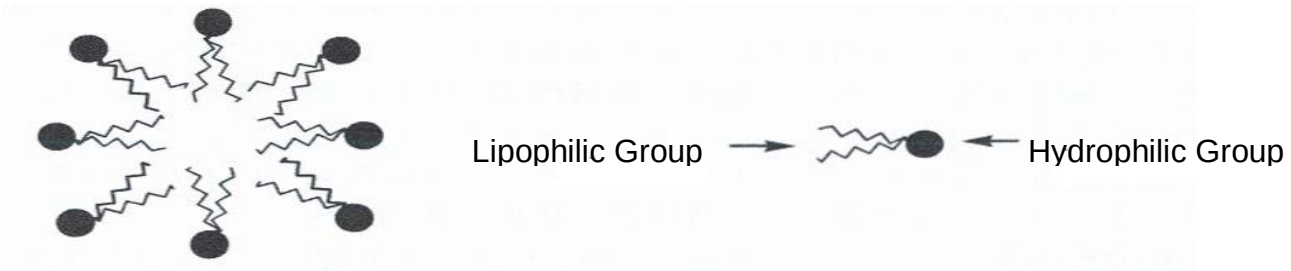
3 or 4 billion years ago, an extremely simple life form came out of the sea. When discussing water and life, these are two inseparable terms. Fossils dating back 3.5 billion years have been found. With earth having been born approximately 4.5 billion years ago, about a billion years later, the first dated fossil was found. As an evolution from this finding, animals and plants including humans and the smallest of organisms made up of cells followed.

The organic matters such as proteins, lipids and sugar that form cells were thought to be generated by living forms. If we were to engage ourselves in a discussion of where living forms originated, endless discussions could result. However, discussions on this subject lessened in 1995 when an American Scientist Stanley L. Miller was able to prove through an experiment he conducted in his college days, that organic matter was naturally formed in the primitive sea.

His experiment-turned-proof involved putting into a flask methane, ammonia, hydrogen, steam formed from water, and gas, which were all presumed to have existed in the primitive atmosphere. These components that were placed into the flask were exposed to a discharge of a spark creating a lightning inside the flask which in turn caused organic matter like amino acids to be formed. Through this experiment, he was able to prove that organic matter was formed through a natural phenomenon without its dependence on other living forms. Later on, amino acids were discovered from meteorites which advanced a theory of organic matter based upon an occurrence in space and thereby becoming an opposing view on the birth of the amino acid.

Initially, it was thought that simple organic matter combined and became complex organic matter. Research into whether this thought related itself to the cell and life had not been researched throughout history. However, research conducted on organic matter formed in the primitive sea indicated that lipid molecules had interesting characteristics and is believed to have formed before the presence of Archaeocytes. Figure 14 represents the appearance of the prototype of the cell membrane. Phospholipids inside the lipid molecule have a structure similar to match sticks. One side is made with a hydrophilic base adapting to water. The other side is made with a hydrophobic base, allowing the cell membranes gathered in water to move around forming a membrane-like structure.

Figure 14: Lipids in the Cell



The portion that does not adapt to water on the hydrophobic side faces inward and aligns where the lipid molecules gather together. With this process going on against the external environment, which is the water, it is believed that this was the timing in which the beginning of the cell membrane or the basis of life began. The aggregate of lipids that are formed at this time are called Micelle.

The Micelle made a boundary in the water with the outer side of it formed by the membrane. This was a significant step in the history of life. The significance of this lies in the fact that various proteins were shut off with the formation of the boundary and thereby creating an internal environment, which can now distinguish itself from the external world, and through this establishment form the original Archaeocyte.

All of this occurring in the micron world of the sea although subsequent journeys encountering some difficulties still needed to maintain the internal bag-like shape of the membrane. The production of some form of energy was required in order to allow a small organism like Archaeocyte to originate.

Mystery of non-freezable water inside the cell

It is known that the human cell, the basic unit of life, controls and executes varying and vital functions. A cell is a small compartment and inside the compartment are small organs consisting of the nucleus, a DNA which stores the genetic information, endoplasmic reticula which passes substance, mitochondria which generates energy, ribosome where protein combine and the Golgi body which modify and store proteins. The combination of these small organs manages the complicated mutual interaction inside the water environment.

This structure is also common in animal cells and plant cells but with the plant cells having organs like the chloroplast to perform photosynthesis.

The E.Coli, among bacteria as the archaeocyte is known as the organism-unicellular to have the same shape which has not changed for the past 1 billion years. Not unique to only one organism but higher animals also have small properly formed organs inside the cells and especially in DNA.

Looking at the component distribution ratio through the weight of the components inside the cell of this E.Coli bacteria, water constitutes 70%, protein 15%, nucleic acid 7%, sugar 3%, lipids 2%, mineral ions 1% and the balance of other minor components constituting 2%.

The water presence of 70% is almost the same volume as with humans. 10% of this is combined water consisting of the hydrating ion and hydroxyl ion.

Combined water is the gel-type water that is formed when proteins and ions, as mentioned in Chapter 2, strongly bond. The combined water, as found in the combined water of spherical proteins, bonding strongly on the first molecular layer of the innermost water, do not freeze even at a temperature level of -190^{o}C.

This finding was reported in the book, "Water of Biological Systems by Hiroshi Uedaira, a former Hokkaido University professor, and published by Kodansha.

When looking at combined water which has structure, differences can be seen between this type of water and the free water which is found inside the cells. The free water molecules move around freely on account of it being difficult to freeze and difficult to evaporate.

Likewise, human cells are similar in characteristic. The water inside the cells performs its very complex functions maintaining life while working smoothly with organic matters such as proteins.

The power of water inside the DNA structure

The three elements in cells, DNA, RNA and proteins, all have a main role in life. The genetic information of the DNA is transferred to the RNA through oxygen and thereby the RNA polymerase causing proteins to form. This process also occurs in water circulation.

The DNA which stores different individual genetic information is formally known as deoxyribose nucleic acid. This nomenclature originates from the fact that it carries the sugar, deoxyribose. DNA is composed of molecules which structure units combining the nucleotides with sugar, phosphoric acid and base forming a chain-like formation.

DNA is illustrated as a double-helix structure appearing like a twisted ladder on two chains of nucleotides. As synonymous to the steps on a ladder, the bases are connected through hydrogen bonds.

The connected bases appear in pairs with a combination of Adenine (A), Thymine (T), Guanine (G) and Cytosine (C) forming the steps through gentle hydrogen bonds. These four types of bases become the genetic information or the basic unit of genetic code. Through this structure, it has become a mechanism to store large amounts of information along with its ability to transmit this information.

This double helix structure of DNA has the hydrophilic sugar and phosphoric acid facing outward and with the hydrophobic bases facing inward. In this setup, similar bases mutually pull one another and create a hydrogen bond. With the hydrophobic substances mutually pulling one another, a state of stability is created and this is referred to as the hydrophobic interaction.

The relationship between the hydrophilic water and hydrophobic water is effectively used and the database of genetic information for a structure like the double helix ladder is established.

For the splitting of the cell, the DNA mechanism is utilized through a copying effort that is conducted. In this process, the hydrogen bond chains will be split

into two with each gaining a new partner with a replicated DNA. This replication process is a feat in itself on account of the hydrogen bond that is easily broken.

Additionally, the RNA as a recipient of the transfer of genetic information producing protein is formally known as ribonucleic acid. This nomenclature originates in the ribose sugar and similarly is a chain-like molecule largely connected to the said sugar, phosphoric acid and bases. The difference being that it is a single chain structure.

As the name itself implies, the genetic information through the DNA and RNA does not only have the role to pass on the shape and characteristics of our body to the next generation but through this information, metabolism is conducted and the individually unique proteins are formed. The RNA receives the information from the DNA through transcription while forming the protein from amino acids and creating the body structure while ongoing metabolism occurs to replace older cells. This forms the basis of life's management.

Understanding that this method is utilized in the cell water, if there is no water, the transfer of information cannot be conducted and the complex and higher-ordered structuring of proteins cannot be formed. The hydrogen bond and the hydrophobic interaction can be conducted due to the very existence of water and we are again reminded of the absolute importance of water.

The wonder of water that changes itself to synchronize with the environment

There is a great amount of research being conducted to study the difference between the water inside the cell and outside of the cell. For example, in 1994, the scientists Thompson, Waterman and Kottam from the Department of Medicine at the University of Texas Southwest, through the red blood cell of adult humans, announced the results of a relaxation study. This relaxation study was conducted to determine the amount of time that was required under a relaxed condition versus a stimulated condition in which the water molecule inside the cell would return to a normal state. This was measured using NMR, Nuclear Magnetic Resonance. The topic of NMR was covered in Chapter 2.

Through NMR it was determined that 1.3 – 1.5% of water has a relaxation time of 2 - 4 x 10^{11} of a second, 0.2% of water has a relaxation time of 10^{11} second and the remaining 98% of water has a relaxation time of 3 x 10^{-1} of a second.

Concerning the time lapse between the time that the stimulation was applied and through the time the water returned to its original state, 1.3 – 1.5% of water inside the cell, when compared to the rest of the water, was 100 times slower and 0.2% of the water was 10,000 times slower. The context in which the term "slower" is used indicates that the amount of the combined water was only as much as 0.2% but that despite this small amount of combined water, structure was still able to be formed.

What we are able to understand from this is that the water creates a double hydration layer around the perimeter of the hemoglobin transporting oxygen located inside the red blood cells. This creates a bond with the hemoglobin molecules. Since this becomes the bond water, it is thought that this creates a state whereby the movement of water molecules is restrained. From this a conclusion can be drawn that the relaxation time has just become that much slower.

Unlike an ordinary cell, there is no mitochondria and nucleus in the red blood cell and for this reason the red blood cell is described as a special cell. Since the water composing this cell is only about 2%, this differs with the ordinary cell. The remaining 98% is the same with the ordinary water, also referred to as bulk water, and does not adversely affect the mutual interaction.

The red blood cells carry the hemoglobin with the oxygen to every corner of the body, and in reverse order, carry the carbon dioxide returning it to the kidney for discharge. For this reason, the red blood cells must freely change in order for it to fit the blood vessels when passing through the capillaries. Therefore, it can be concluded that the movement of the molecule is not the restrained bond water but more the free water that can freely change form.

Additionally, researchers Kenichi Yoshikawa and Hiroshi Terada of Tokushima University, and Yoshimasa Kyogoku of Osaka University had announced the research results covering the three kinds of water that they had studied. The three waters consisted of water that freezes in the range of 0^{o} to -5^{o}C, water that freezes at -10^{o} to -25^{o}C, and water that freezes at -80^{o}C. In these research areas, the inside of the mitochondria was investigated.

Most cells have a small organ which is the mitochondria; however, among these cells there are those that do not freeze at -80^{o}C. The water inside the cell protects the essential organs from the natural environment and assists in the maintenance of life's activities and with the water changing to non-freezing water. Certainly, with these varied characteristics being manifested, the wonders of water are in full effect.

Mineral ions inside the cells

It was mentioned earlier that the living organism, the antecedent of all living things and especially for humans, started in the sea. From this, it was also learned that the share of mineral ions included in the fluid of living things and in the sea water itself are extremely similar.

It is thought that during the cool down period, there were probably no minerals in the primitive sea. When living organisms came to life, different kinds of minerals, especially salt was dissolved into the sea water forming the sea water as we know it today.

This ocean environment was created as a result of the water that dissolved the minerals of the continental bed rock which then flowed into the sea. What resulted from this environment and born in the water became living organisms. This is the reason why the fluid has also become the mineral content that reflects this environment.

The main components of the mineral ion are: 1. Sodium (Na^+), 2. Potassium (K^+), 3. Calcium (Ca^{2+}), 4. Magnesium (Mg^{2+}), 5. Chlorine (Cl^-).

Table 3: Component Distribution Ratio of Ions (Na^+ = a basis of 100)

	Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-
Sea Water	**100**	**3.61**	**3.91**	**12.1**	**181**
Body Fluid	**100**	**6.75**	**3.10**	**0.70**	**129**

Based upon Sodium (Na^+), representing a base of 100, other ions are shown in this table. (These figures were referenced from the book written by Uedaira Hiroshi, titled "Water Viewed from Life" and published by Kyoritsu Publication.)

From the numbers indicated in the table above, except for the magnesium ion, the component distribution ratio of mineral ions, in our intracellular fluid and extra cellular fluid, is closely similar to the composition of seawater. This is certainly another indicator of how life started in the sea. The concentration of sodium ions is the highest among other electrolytes; however, the body fluid of animals including humans is a mere 1/3 of what constitutes sea water. The density of salt in sea water increases together with time and during the time it took for the cell to come to life, it is thought that the salt density was close to the component ratio of sodium in the intracellular fluid.

If we look at the sodium (Na^+) density and potassium density (K^+) of the intracellular fluid and extra cellular fluid, it appears as the following:

Extra cellular fluid: Na^+ = 145 mM K^+=5 mM

Intracellular fluid: Na^+ = 10 mM K^+ = 140 mM

(The unit mM, as indicated above, is density expressed in mM. A millimole in 1 Liter = millimole/Liter and $1/1000^{TH}$ mol indicates 1mM dissolved in 1 Liter of water.)

From this we can conclude that although each ion density differs, the sum of the sodium and potassium ions is at the same value, 150 mM of density. This is an important point since if too high of a level is found in the body, on account of osmotic pressure, the potassium density replacing the sodium will be increased to prevent the salt content from entering inside. There are ongoing adjustments made to keep the total in balance.

In the cell membranes surrounding the cells, there are channels that selectively allow for only sodium to pass through and there are also channels that selectively only allow potassium ions to pass through. Each of the channels is designated as a sodium channel or as a potassium channel. Aside from the ion channels, through which only these kinds of ions pass through, there are also water channels which only allow water to pass through.

Functions of aquaporins

Recently, even amongst ordinary people, I was surprised to know that many individuals use the term aquaporin. As I researched the extent to which the term aquaporin is being used, I found that even the cosmetics industry is in use with it through such phrases as "to make your skin look fresh, it is important to deliver the product through the aquaporin". I also learned that ordinary individuals studying through the information provided on the Internet can now understand what would have been a difficult chemistry terminology to grasp. Especially for researchers, this new phenomenon of a lay person's knowledge level comes as a surprise.

Figure 15: Water Permeation of Aquaporins

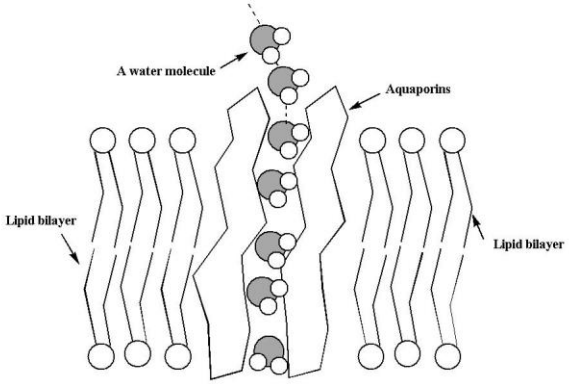


Figure 15 is the cross-sectional drawing of the cell membrane. Aquaporin 1 (AQP1) is one type of protein that is elaborately compiled. The protein is actually compressed between the double layered lipids and in a penetrating position. After Professor Peter Agre discovered the AQP1, other researchers discovered new aquaporins, AQP2, AQP3 and so on. It is also known that plants have considerably more aquaporins. The greater number of aquaporins that are present in plants is thought to be on account of the immobility of plants and therefore their need of more diversified types of water channels. Currently there are approximately 13 types of aquaporins discovered in mammals compared to more than 30 types of aquaporins found in plants, and again, thought to have this higher number of aquaporins on account of its immobility. Since aquaporins are mediums in which water enters and exits cells, research shows that there are many aquaporins in cells that comprise the internal organs relating to water transport within the human body.

As illustrated in Figure 15, a mystery is present in that aquaporins pass each water molecule and clusters of water molecules through but disallowing the passage of ions and hydrogen bonds. The aquaporin, with a diameter of 0.3 nm (nanometer) while passing the water through will disallow other components to pass through. During the flow through of the water molecule(s), the hydrogen bond of water is cut along with the amino acid, Asparagine (Asn), and thereby only allowing water to pass through 1 molecule at a time.

This water channel is made up of proteins but water is believed to pass through at an extremely high rate of speed due to its hydrophobic character. It is thought that 2 billion water molecules pass through the aquaporin every second.

As a point of reference, we humans consume an average of 2 Liters of liquid per day. In comparison to this, the amount of urine that passes through the kidney, the so-called waste filter, can surprisingly process up to 180 Liters per day. From this we can see that a substantial amount of water is circulating throughout our body. This life-sustaining basic can also be attributed to the ability of the aquaporin to process water through at the high rate of speed that it does.

Aquaporins perform a vital function in ensuring that proper water levels are maintained in the body at every given moment. This is done by the aquaporin being sensitive to body indicators monitoring the dryness experienced in our throats and through the necessity of additional water intake, the aquaporin sends signals to the brain requesting for additional water to be made available.

Almost all aquaporins found in animals and plants control water inventory. As such, the precise control of the water level is one of the most important functions for the maintenance of life.

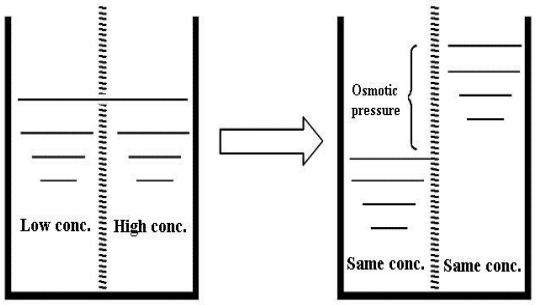
Although there are many unknown portions in the research of aquaporins, as we learn more about the intricate flow of water, we will have a clearer understanding of the human body.

Why is sashimi, a Japanese fresh fish appetizer, not salty?

I am sure that we have heard the term "permeability". Permeability is the functional ability for different components to be dissolved in water and with this function having a significant influence on the movement of water inside and outside the blood vessels and between cells.

As illustrated in Figure 16, brine solutions of different density are placed into both sides of a water reservoir separated by a semi-permeable membrane where only water passes through this membrane.

Figure 16: Osmotic Pressure



This diagram illustrates how a lightly dense brine solution filled to a same initial level, as illustrated through the diagram on the left, and through the presence of osmotic pressure shows how the water level becomes altered with the lower density reservoir becoming lesser in volume. Correspondingly, how the higher water level, as illustrated through the diagram on the right, is increased. This migration causing the subsequent alterations to the water levels, based upon density, as occurring on account of the presence of osmotic pressure.

Osmotic pressure is represented through the millimole value of particles found and placed inside 1 kg of water. The equation for this is mOsm/kg H_2O = mole weight, osmotic pressure density. This equation illustrates the hydrostatic pressure difference when water travels to a higher density, although being a controversial topic based on a reverse osmotic membrane process, this equation describes this principle. This principle also applies to fresh water plants and sewage plant in seawater. Please refer to Chapter 8 for this topic.

Incidentally, we earlier stated that almost all of the salt placed in water dissolves. The positively-charged sodium and the negatively-charged chlorine ionizes and therefore if 1 millimole of salt is dissolved in 1 kg of water, the osmotic pressure will double at 2mOsm/kg H_2O due to the fact that the sodium ion becomes 1 mmol of unit and the chlorine ion also becomes 1 mmol in unit

Since the glucose and the like do not ionize, the osmotic pressure remain at the same level of 1 mOsm/kg H_2O if 1 mmol of glucose is dissolved in 1 kg of water. Additionally, as the dissociation level of the ions become higher, the increase in osmotic pressure and the force to move the water correspondingly increase.

Regarding the historical reference of life having begun in the ocean, discussions on osmotic pressure and its relevance to life has been an ongoing topic. One of the discussions entail what the response system is in reaction to the mechanism of osmotic pressure. In discussing the fact that even living and breathing things in the sea, being made up of the same salt density as the water similar to what was described in Figure 16 and indicated at a level of 3.2%, which do not require an adjustment to the osmotic pressure are invertebrates such as a shellfish, shrimp and jelly fish.

The fishes that properly discharge salt through their gills while taking in less dense water are tuna, mackerel and bonito. These fishes do not necessarily drink sea water and also act in the same manner as the invertebrates. This group has about 1% of salt content in their body fluid along with critical systems in place to consistently maintain this level of salt. This function centers its focus on properly removing the salt through the gills and this explains why tuna and bonito, regularly consumed as sashimi delicacies, are not salty.

In the case of a sea gull, the sea gull consumes sea water and stores this water. As was portrayed in the movie, Jonathan Livingston Seagull, there was a scene in which the sea gull shed tears. There is an interesting secret in these tears in which salt is removed from the sea gull's body through the shedding of these tears. As a byproduct of this, fresh water is produced. For every liter of sea water that a sea gull takes in, since 2/3 of it is salt, it will be compressed and released from its body in the form of tears. The remaining 1/3, comprised of water with approximately a 1% of salt density and at a same level of salt with body fluid, is kept inside the body for use.

If in the case of humans, who do not have the mechanism of releasing salt like seawater fishes and the sea gulls have, if we were to intake seawater, the salt content density inside the body will be increased and a higher level of dryness felt in the throat; subsequently, this becoming an explanation as to why a human cannot consume sea water.

In describing the difference in how drinking water is processed between a fresh water fish and a salt water fish, a fresh water fish releases its drinking water through its gills due to the balance being maintained through osmotic pressure. However, this does not mean that the water is being taken inside the body but quite to the contrary, for the seawater fish which discharges salt from its gills, the sodium and phosphorous of salt is absorbed through the gills.

Over the many generations, the invertebrates have been creating a water formation system in order to maintain the balance of the osmotic pressure by not letting it fall on account of the salt density inside the living organism. Assuredly, the human body also has a like system.

Water and its effect on the kidney

Osmotic pressure in humans is adjusted mainly through the filtering action of the kidney and water supply along with the discharge of urine and water. The average amount of discharge is thought to be approximately 2 liters per day. Through these 2 liters, sodium ions and potassium ions are dissolved. In 1 liter, 85 mmol of sodium ion and 20 mmol of potassium ion, or a total of 105 mmol of positively-charged ions will be dissolved. Similarly, 105 mmol of negatively-charged ions will be dissolved.

If we look at the combination of the positively-charged and negatively-charged ions that are dissolved in water, with the sum ions totaling 210 mmol, the osmotic

pressure of this will be 210 mOsm/kg H_2O. However, at some point, the osmotic pressure of urine with the density of the substance dissolved in urine being high and concentrated, as indicated in the valuation of 500mOsm/kg H_2O, will attribute its difference to an element called urea.

The nature of urea does not allow it to ionize, and instead, is counted as particles working in conjunction with osmotic pressure.

Urea is the waste matter particle of proteins. If we were to analyze the proteins in the body, we will learn that the structural composition of urea changes to ammonia or a compound of Nitrogen and Hydrogen. Since ammonia is harmful, the living organism first converts it to a safe form of nitrogen, while storing it in the kidney and then discharging it together with water from the body. The kidney then uses the medium that is water, dissolves the filtered waste and discharges it in the form of urine.

As discussed in Chapter 1, the kidney filters the water of its waste and once again circulates the water through the body. We ask ourselves, what will happen if the kidney did not work.

A person with a low functioning kidney, as experienced through the chronic renal failure syndrome, relies upon an artificial kidney performing an artificial dialysis. If the artificial dialysis is not performed and water is collected in the lungs, a condition known as pulmonary edema resulting in the retention of water and sodium ions will occur. This causes cardiac failure or sometimes ventricular arrhythmia due to the high potassium blood syndrome that is caused by the storing of potassium ions. There are times in which this condition causes a heart stoppage leading to death.

There are four primary functions for the kidney.

1. **Discharge of the byproducts of protein metabolism. In the case of carbohydrates and fats, it ends up with carbon gas since it is composed of Carbon (C), Hydrogen (H), and Oxygen (O). However, since the proteins have Nitrogen (N) and Oxygen (O), these are digested in the body and then converted to strong acid forms like Nitrate ($NO3^-$) and Sulfate (SO_4^{2-}). The system which maintains the pH level then conducts the discharge from the kidney.**

2. **As mentioned in Chapter 2, the kidney performs electrolyte adjustments. In order to maintain the mineral ion composition, a system is in place to maintain the water and minerals at a fixed level. The adjustment to the water content is mainly done through the Antiduresis Hormone while the adjustment to the minerals, such as sodium ions, is conducted through the chemical substances created inside the body.**

3. **As mentioned in Chapter 3, the adjustment to the balance of base and acid together with the liver was explained. In the kidney, the carbonic acid**

dissolves in water and produces the carbonic acid ions. Through this, the pH level in the blood is maintained at a fixed level.

4. As will be discussed in Chapter 4, the production of hormones such as the rennin, erythropoietin, Vitamin D, Bradykinin, prostaglandin and endoserin is processed by the kidney.

Living organisms use water efficiently as a solvent to control various responses. The water dissolves and discharges, controls the proper acid and alkali balance, and keeps the body at a balanced level. It fulfills an important role to establish a state of homeostasis with homeostasis being the ability to maintain the form and physiological characteristics of the living organism regardless of the differences which exist in the inner and outer environments.

Maintaining a youthful appearing skin

When one discusses skin, it is a familiar part of the body that is described by its smoothness or its roughness or its hydrated state or its dried state. In each of these conditions, almost all descriptions are related to water. Skin is said to be the largest organ with a mass of 1.6m^2 and a weight of approximately 22 lbs. From these two measurements, it is truly a large organ.

As represented in Figure 17, skin is made up of 3 layers of structure consisting of the epidermis, dermis and hypodermis.

Among these three layers of the skin, the outer epidermis is covered with a robust stratum corneum. In the deepest and bottommost layer of epidermis, there are the cells called melanocyte which produces melanin. The melanin appears when infrared rays hit the skin's surface, and while darkening the skin's surface, protect the inner parts. Ironically, this darkening of the skin is referred to as sunburn but the skin is protecting the body.

When the optic nerves feel the sunlight, a signal is sent to the pituitary along with an instruction to produce melanin. According to a book, "Annoying Evolution", a NHK publication narrated by Sharon Moalem a neurogeneticist of Mt. Sinai Medical College in the United States, told that if one wears a sunglass on days with strong sunlight, the information to produce melanin becomes limited and the melanin that protects the body will be controlled and sunburn lessened.

Aside from just wearing a sunglass to protect the eyes, if we do not protect the entire body from infrared rays, additional damage can occur to other parts of our body.

Located in the skin cells are also water channels and aquaporins. In the cell membrane of the epidermis, except for the stratus corneum, there is the aquaporin3 (AQP3). It was also discovered that water entered and exited through this water channel. Although there are other aquaporins that have been discovered, the AQP3 is the most prevalent. Prior to understanding the extent of

the functions of the AQP3, it was thought that dry skin was brought about because of oily ceramides, referred to as skin lipids which connect one cell to other cells, causing a decrease in count and creating a gap between the cells causing evaporation to occur. However, after the function of the AQP3 became better understood, the importance in the knowledge of water being delivered to the epidermis had become a very important theme. Considerable research is being conducted in the cosmetic industry on this very mechanism. The current question centers around how much water can be retained in the skin which in turn is the key to deliver on a well-hydrated and youthful-looking skin.

Dry eye syndrome

If we mentioned the words eyes and water, an immediate reaction would be crystalline lens and tears. Recently, there are many people complaining about a dry eye syndrome. Due to asthenopia an ophthalmological condition the eyes become easily tired with an inability to see things clearly. People experience these conditions due to fatigue brought about through their daily driving and through the use of computers.

The condition of a dry eye, and as the name implies, is a syndrome in which the eyes feel dry due to a lack of tears being produced. This condition is closely related to the function of the aquaporins. Located in the eyes is a glandular system that releases tears referred to as the lachrymal gland occurring in such instances as when tears exit from the lachrymal gland as we cry or a contaminant enters our eye. In a situation of this sort, there are people who are not able to create tears regardless of how necessary tears are. This condition is referred to as the Shane Glen syndrome.

Recently, a discovery of the aqauporin5, AQP5, was made in the glandular system of the lachrymal gland.

Chapter 4: How the wisdom of functional water draws on its power

Electrolysis of water → functional properties → newly-gained effects from functional electrolyzed water. We will discuss how the basic properties found in water are redefined, enhanced and delivered for our well being.

Road to application of functional water

Over the past several years it is likely that the term functional water has entered our vocabulary.

So what is functional water? Although its definition has not necessarily been established by an official entity, one can gather from the phrase that a function equates to an action. With energy added to water a new function creating a new action is formed resulting in water with increased abilities.

In the previous chapters, we had learned about the vital functions that water performs in the body. With functional water, we will be able to see the heightened ability of water to support health along with functional water that provides care to the environment.

In order to create the heightened ability of water, it is assumed that the energy brought to this water consists of several components. The most noted component is the electrical field that is created through a process of electrolysis. At the present time, electrolyzed water that is generated through electrolysis is considered functional water.

When looking at this type of functional water, as enhanced through the energy of an electrical field, there are clear physicochemical changes made to the water and that the degree of this change can be measured utilizing a scientific method.

If I was to define functional water, it will be water that is composed of the following elements. After the addition of energy to the water, there is a clear physicochemical change made to the water and this change affects the person, object or the environment that has come in contact with this water and when noticing the effect, the effect was better and that the effect can be measured through a scientific method.

Water has a direct effect on people's physiology and the environment. For this reason alone, scientific proof becomes a necessary condition. When speaking of a scientific proof, both a material balance and an energy balance is required along with the ability to consistently reproduce the same method and results. It is important that these steps were taken for it to be referred as scientifically supported.

Naturally, in science, there are still a significant number of phenomena that cannot be fully explained. Even in these situations, since it is classified as science, it is necessary to have reproducibility along with scientifically measured numerical values. As long these two conditions are present, even if the subject matter cannot be fully explained, there is no reason to ignore the phenomenon or not to start an investigation of the phenomenon. The development of science starts with the observation of a phenomenon and by thinking why such a phenomenon occurs. The starting of the thought process allows the beginning of scientific research.

As we know today, functional water already provides a wide array of benefits to people and the environment and the possibilities in these areas are ever expanding. For this reason alone, I think that it is necessary to advance the development and dissemination of information while forging a solid scientific footing for functional water.

In order to change the properties of water and to introduce new forms of energy to water, and in addition to the application of electrical current to water, there are other forms of energy that can be applied. Energies such as a magnetic field, ultrasound, vibration, radiation, plasma, temperature and pressure are some forms of energy that can be applied to water. Those energy sources that can be used safely and easily are magnetic field, ultrasound and vibration. In looking at a magnetic field and ultrasound, there has been extensive research conducted and practical applications developed that are scientifically proven.

In particular, the country that had gotten a head start on the research and application of functional water was the former Soviet Union. Functional water had been used as a rust inhibitor in boilers and piping, aging of vodka and also as drinking water.

Functional water made its full-scale Japanese debut in 1994. At the time in 1994 the Functional Water Foundation was established with the cooperation of the President of Taiyo Engineering Inc., Mr. Masao Yoshioka, Professor Yoshiaki Matsuo and I while the three of us became its founding members. This foundation marked the official beginning of the studies and development surrounding functional water. Looking back, I have had many excellent memories of the time but aside from those that were involved with functional water, hardly anybody knew what functional water was.

For two days on November 17th and 18th, 1994, at the Tokyu Bay Hotel, the first Functional Water Symposium was held. At this symposium, research presentations on functional water and basic presentations of water science were held, resulting in a pioneering debut of functional water in Japan.

Since the first Functional Water Symposium was held, it has become a decade and a half of history and of history in the making. Since that point in time functional water has become recognized by an official organization, has been used in medical institutions through its adoption in hygiene management and through the Pharmaceutical Affairs Law, has become the subject for clinical research that is expected to further greater possibilities in its use. Moving forward, further research will develop and it can be expected that the forms of functional water and the knowledge of its effects would increase and spread.

Definition of the typical functional water, “electrolyzed water”

From the various forms of functional water, I will select electrolytic functional water and micro-bubble water, which are both produced with processes that are consistent and reproducible and with clear material and energy balance.

Electrolytic functional water is electrolyzed water, (electrolysis-processed water) generated by the electrolysis of tap water with a small amount of salt added to create a dilute electrolyte solution. The electrolysis process is a straight forward process with over-the-counter technology currently available.

When speaking of electrolysis, I think that many have heard of the name Michael Faraday, a genius scientist from the United Kingdom who in 1833 discovered and authored Faraday's Law of Electrolysis.

In the electrolysis process that was conducted by Faraday, using a glass container, salt was dissolved in water and through the application of electrical current through a pair of positive and negative electrodes, current flowed through the dissolved salt electrolyte, resulting in the deconstruction of water. Through this Faraday discovered the law that the amount of salt broken down was directly proportionate to the amount of electrical current applied. The formula indicating this is was as follows:

$$N = m/M = It/zF$$

Where N = the amount of substance (mole), m = mass (g), M = molar mass (g/mole), *I* = electrical current (ampere), (*t)* = time (seconds), (*z)* = valance of ion and (*F)* = Faraday constant (96,485 coulomb).

To explain briefly, this is a formula to determine the number of moles that are present in the generated product exposed to electrolysis with the amperes of electrical current that are applied through a number of seconds. Even a formula that seems difficult at first glance is not that difficult when explained in this manner. Using this formula, a phenomenon created through electrolysis can be explained with consistency and convenience.

A chemical formula represents and summarizes a significant amount of information despite the limited number of characters that may make up a formula. Through a formula, both the material and energy balance can be illustrated and through the structure of a formula, reproducibility becomes possible if the terms and conditions are the same and with similar results being produced. From this, one can see that the principle of electrolysis is extremely scientific.

On account of Faraday's research and discovery he also created the context for the terms electrolyte, electrode, anode, cathode and ion to be used in. These terms are used in formulas while a term such as ion has found itself into our daily vocabulary.

During this period Japan was under the Edo Shogunate and there was great chaos due to the Great Tempo Famine. It was also exactly 10 years after Siebold came to Nagasaki at which time the most fundamental principle of electrolysis had already been established in Japan.

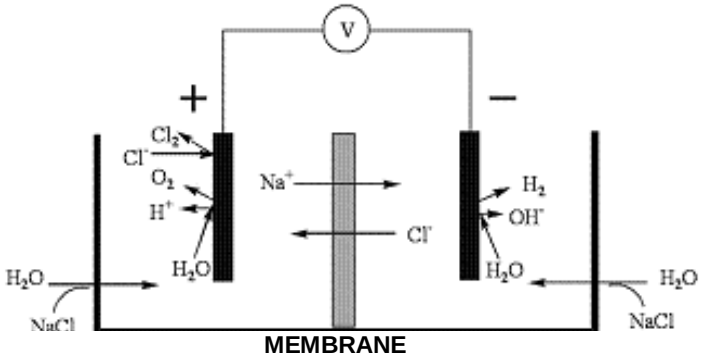
The law of electrolysis that Faraday discovered and authored has been industrially applied and developed in the plating and soda industry and is still being used in these fields. In these industrial applications, high concentrations of water solutions are required but despite this, little knowledge existed in the variance of water properties. Functional water is focused on the properties of water itself while these altered properties enhance and improve upon its functionality.

Electrolysis of water

The principle that generates electrolytic functional water is the principle of electrolysis itself. In general, it is composed of an electrolyte solution of salt and tap water, a combination of positive and negative electrodes and a membrane.

Direct current is the common electrical current flow but alternate current can also be used. Figure 18 illustrates a case in which a salt (NaCl, Sodium Chloride) water solution is utilized with electrolysis.

Figure: 18



As shown in Figure 18 when the electrical current begin to flow the chlorine ion (Cl^-) of Sodium Chloride (NaCl) is attracted towards the positive pole, while emitting its electrons, and becoming chlorine gas (Cl_2) and then dissolving in water. The other sodium ion (Na^+) is attracted towards the negative pole and becomes sodium hydroxide.

The important factor here is that the water itself is undergoing electrolysis at both poles. At the positive pole, water gets oxidized and hydrogen ion (proton H^+), oxygen molecule (O_2) in the form of gas, and an electron (e^-) are created. To express it in a chemical formula, it becomes: $2H_2O \rightleftharpoons 4H^+ + O_2 + 4e^-$

On the negative pole water is reduced, electrons are received and as a result, hydroxyl-ion (OH^-) and hydrogen molecule (H_2) in the form of gas are created. Its chemical formula becomes: $2H_2O + 2e^- \rightleftharpoons 2OH^- + H_2$

The water generated from each side of the positive and negative poles is electrolytic functional water. The water generated from the positive pole and the

negative pole is called Anodic Electrolyzed Water and Cathodic Electrolyzed Water respectively with each of the water properties being different.

What needs to be emphasized first is that the hydrogen ion generated on the positive pole creates a trigger that shows acidity while on the negative pole hydroxyl-ion is generated creating a trigger that shows alkalinity. Due to this, acidic water is created at one pole and alkaline water is created at the other. Furthermore, if the conditions of electrolysis are changed, water with various pH can also be created.

The more the water is close to pure water, the more difficult it is for electricity to pass through the water. Due to this fact, an electrolyte solution like salt is often used in electrolysis. The electrolyte in this case is called an electrolyte agent and if electrolysis is performed, this electrolyte agent itself gets electrolyzed and a new substance created.

In the case of salt (sodium chloride), it is dissolved in water and becomes sodium ion (Na^+) and chlorine ion (Cl^-) and when the electric current flows, each of these ions are drawn to the opposite electrical charge, as shown in Figure 18 of the previous page.

The negatively charged chlorine ion is attracted to the positive pole, and while losing its electrons, becoming a chlorine molecule and dissolved in water to become hypochlorous acid (HOCl). At the same time, the chlorine ion (Cl^-) connects with the hydrogen ion (H^+) that was created on the positive pole and creates hydrochloric acid. Depending on this hypochlorous acid and hydrochloric acid, the pH of the solution on the positive pole decreases and shows a stronger state of acidity.

Additionally, the hypochlorous acid that was created during this process becomes an oxidizing agent in a low pH environment and with high reactivity. These characteristics also produce hypochlorite ions which are used to disable activities of unwanted elements such as bacteria. This entire process is called the oxidation and chlorination of hypochlorous acid. Based upon the intended use of this hypochlorous-active water, the pH can be adjusted to suit the application and its objective at hand.

As previously discussed, while under the electrolysis influence on the negative pole the sodium ion combines with hydroxyl ion and becomes sodium hydroxide resulting in a state of alkalinity.

Through this electrolytic process, functional water is created and is divided into anodic electrolyzed water and cathodic electrolyzed water. Both waters contain dissolved oxygen, created from the positive pole, and dissolved hydrogen, created from the negative pole. At the negative pole, dissolved oxygen in the original water is also included.

In checking the Oxidation Reduction Potential (ORP) of the two waters that are produced through electrolysis, reductive or oxidative, becomes one measurement property of the electrolyzed water. In chemistry, the expressions reductive or oxidative are often used when indicating the state of the water. In simpler terms, ORP is in the indicator which shows whether a substance is easily oxidized and electrons easily lost, or as an opposite reaction, the substance is reduced and electrons easily donated to the substance.

As two measurable indicators of the properties of water, the ORP and pH levels are often utilized. Of recent, terms such as ORP are commonly being used and simple measurement devices are being sold. These indicators of water properties along with other measurement methods will be explained more in detail in Chapter 6.

Effects and possibilities of electrolyzed functional water

Electrolyzed functional water or electrolyzed water is water that has been processed through the electrolysis of tap water containing electrolysis-inducing ions, such as sodium. At the positive and negative poles, different forms of functional water are generated. From each of its different pH levels, it is referred to as Anodic Acidic Water and Cathodic Alkaline Water.

In providing generalized uses of both waters, since the water created at the positive electrode shows an acidic pH, it is used for purposes of cleaning, disinfecting and as a hygiene management water. Since the water created at the negative electrode shows an alkaline pH, it is used as a drinking water. As the research continues on the properties of these two forms of water, their benefits are becoming more apparent.

The functional water created at the positive electrode with its acidic properties uses oxidation and chlorination as its main mechanism. This water was officially approved as a hand disinfectant in December, 1996 by the Ministry of Health, Labor and Welfare (at the time, known as the Ministry of Health and Welfare). In the following year, it was also approved as a cleaning disinfectant of endoscopes.

The disinfecting ability of electrolytic water created at the positive electrode with a small amount of salt has been proven in many experimental cases and is being effectively used by various industries. These various industries involve medical care, food processing, agricultural uses, fishery, and in cleaning applications in which the disinfecting property of this water is being used to its full advantage. As an ecological disinfecting method, and without the use of chemicals, it is expected that the scope of its use will spread further.

The functional water created at the negative electrode showing the alkaline properties is being embraced as a drinking water, and with its continued intake, its effect on the improvement of gastrointestinal symptoms have become more apparent and it is anticipated that with the ongoing research, its benefits will be confirmed on a wider scale.

We would like to further advance our discussions into each form of electrolytic water and its validation.

As mentioned earlier the electrolytic water that shows the state of acidity created at the positive electrode works against bacteria through the application of oxidation and chlorination. The elimination of bacteria using electrolysis is a fairly simple process. This process is often used in medical institutions and its effectiveness in killing bacteria has received high marks.

Table 4 shows the result of the disinfectant test based upon the disinfecting properties gained through the electrolyzed acidic water created at the positive electrode using a sodium chloride solution with 0.2% concentration.

Table 4

Disinfecting Test using Electrolyzed Water of anode side
(Free Chlorine: 30 ppm, ORP: 1100mV, pH: 2.6)

Bacterial strain	No. of Bacteria	30 sec	2 min	10 min	60min
Cladosporium	$8.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Fusarium	$6.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Rhizoctonia	$7.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Candida	$5.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Cryptococcus	$8.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Staphylococcus	$3.5x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Methicillin-resistant staphylococcus aureus (MRSA)	$3.5x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Pseudomonas	$3.5x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Escherichia	$3.5x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Salmonella	$3.5x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Bacillus	$1.1x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Vibrio	$3.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Campylobacter	$1.0x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$
Lactobacillus	$4.9x10^6$	$<10^1$	$<10^1$	$<10^1$	$<10^1$

Unit: CFU/ml*

$$HOCl + R\bullet H \rightarrow R\bullet Cl + H_20 \text{ (Chlorination)}$$

$$HOCl + R\bullet H \rightarrow R\bullet OH + HCl \text{ (Oxidation)}$$

The acidic electrolyzed water created on the anode side disinfects through these 2 types of chemical reactions.

The pH of the electrolyzed water is 2.6 with a level of hypochlorous acid concentration of 30 ppm and with an ORP of +1110 mV. The testing was conducted using the bacteria bacillus (1,100,000), rhizoctonia (7,000,000) and additionally 1,000,000 to 8,000,000 load of other forms of bacteria. A bacillus bacteria, referred to as sporular bacteria, is not easily killed because it forms a shell of spores and in general would require an exposure to a temperature of 120^{o}(C) or greater or a disinfectant with a high concentration. In comparison, the electrolyzed water created at the positive electrode disinfects the bacteria quite easily.

In Table 4, it can be seen that all of the bacteria load decreases to below 10 after 30 seconds of exposure to the electrolyzed water. The unit number reflects the number of bacteria colony per milliliter, whereby CFU/mL is the abbreviation of the Colony Forming Unit.

As a comparison on the efficacy of the disinfecting property of anodic electrolyzed water, we have used commonly-utilized disinfecting agents such as Wellpas, Iodine and Hypochlorous Acid Soda (bleach) at 500 ppm of concentration against the same bacteria. Although we have not provided a table showing this comparative analysis, each of the disinfecting agents show similar disinfecting results and from this we were able to conclude that the electrolyzed anodic water possessed disinfecting-like properties.

This disinfecting ability can be attributed to the effect that the anodic electrolyzed water, through the presence of hypochlorous acid and dissolved oxygen, causes simultaneous chlorination and oxidation reactions at the surface of the bacteria's cell membrane and thereby blocks the membrane function and instantly kills the bacteria.

The bactericidal mechanism destroys the bacteria through the replacement of the H factor in R.H of the organic matter with Cl (chlorination) or OH (oxidation).

Safety of anodic electrolyzed water with strong bactericidal action

Our next discussion will address the safety aspects of anodic electrolyzed water. When working with a disinfectant there are always concerns on the toxic potential of the disinfecting agent. After repeated research, verification and evaluation, a high level of safety has been confirmed for this anodic electrolyzed water.

As a part of this toxicity study, there were various animal studies conducted on mice, rats and rabbits and I will present a few of the results. For this study anodic electrolyzed water with the following properties was utilized.

pH: 2.5
ORP: +1,170 mV
Hypochlorous Acid Concentration: 45 ppm

1. It was reported that in the test to check the toxicity using the colony formation of mice cells, the cell colony formation was reduced by 50% when the hypochlorous acid concentration of the sample fluid was increased by 26 ~ 28%. The concentration value of 26 ~ 28% is equal to 260,000 ~ 280,000 ppm, which is a very high concentration and thereby indicating a high level of safety.

2. In a primary irritation test using rabbit skin, it was reported that there was no irritating property.

3. In an accumulated skin irritation test on a rabbit, it was reported that there was no irritating property.

4. In a rabbit eye irritation test, it was reported that there was no irritation.

5. In a reverse mutation test using cells, it was reported that it had absolutely no mutagenic reaction.

6. In a toxicity test using one time oral administration to a rat, it was reported there was no effect up to 30 ml/kg of oral administration.

Additionally, in a human finger resident microbiota and rough skin test, it was reported that it was relatively safe.

After clearing these various safety tests and during actual usage, it was concluded that through proper use, there were no concerns in the area of safety.

Due to the strong acidic characteristics of the anodic electrolyzed water, there is a presence of a chlorine odor but through controlling the pH value to a 5 pH, the said odor can be eliminated. Electrolyzed water in this range of pH is categorized as "soft oxidized water" while using this description as its selling point. Based upon the application and its wide array of uses, the introduction of these forms of anodic electrolyzed water will be a big help to society.

Cathode alkaline water as a drinking water

The alkaline electrolyzed water which is produced on the cathode electrode is different in characteristic and property from the acidic electrolyzed water produced on the anode electrode and is primarily used as a drinking water. The alkaline drinking water is a diluted electrolyte solution of about 1~2 mM concentration containing small amounts of sodium, calcium and other electrolytes that are found in tap water and electrolyzed with a weak current of electricity.

What is generated on the cathode side is dissolved hydrogen, H_2, and hydroxide such as sodium hydroxide and calcium hydroxide indicating components of alkalinity. The dissolved hydrogen concentration is about 0.3 ppm after its

formation but due to the solubility of hydrogen in the water being low, the hydrogen disappears after several hours of retention in an open container.

When comparing the characteristic of the dissolved hydrogen produced through electrolysis, to that generated by bubbling hydrogen gas, the dissolved hydrogen shows an unbound state of molecules, as shown through experiments. The term "unbound" indicates a high state of reactivity. A substance generally increases its surface area as it becomes smaller resulting in an increase in reactivity. The dissolved hydrogen created through electrolysis has a significantly higher level of reactivity when compared to dissolved hydrogen created through a bubbling process.

This highly reactive dissolved hydrogen has an effect of eliminating free radical in the human body. The free radical is known for its double-edged character where an excess production of free radicals causes illnesses such as chronic diseases. The hydrogen acts as a reducing compound, giving off one of its electrons to the active oxygen converting it to water which is a very safe substance.

Generally, we do not take on a direct intake of hydrogen inside our body.

Despite the fact that hydrogen is useful to our body, because of the methods in which hydrogen is created, care must be taken in the type of hydrogen that is consumed. The hydrogen that is present in electrolyzed water does not contain hydrogen-generating metal and therefore it is relatively safe. When drinking water, it is important that safe and beneficial water be consumed.

Additionally, we have discovered useful functions of the anodic water which will be explained in Chapter 6.

Another functional water – micro-bubble water

By exerting air pressure through a nozzle small bubbles can be produced in water. The bubbles burst due to the water pressure and this phenomenon is called cavitation. Because an ultrasonic wave is produced when the air bubble bursts, this method of creating air bubbles is called ultrasonic wave generation.

This technology is able to control the size of air bubbles from a sizing of micrometer−μm, to nanometer−nm, and this ability is drawing attention due to its very interesting phenomenon. It is called "micro-bubble" or "nano-bubble" resulting in the production of other types of functional water.

The most important characteristics of this micro-bubble water or a nano-bubble water is in its biological reactivity, which was covered in the book "All About Micro-Bubble" published by Nippon Jitsugyo Publishing Company Ltd and authored by Professor Hirofumi Onari of Tokuyama College of Technology.

We will take a look at the principles of this technology and its functions. Professor Onari, one of the developers of the micro-bubble generator and a pioneer in this field, explained in the book the following 5 methods.

1. **Fine pores method.**

   A method of generating air bubbles by creating fine pores in a hard material such as ceramic, metal plate or plastic and infusing air into the water using a compressor.

2. **Pressurized dissolution method.**

   A method of generating micro bubbles by super saturation of air into pressurized liquid and then decompression.

3. **Ultrasonic wave method.**

   This method generates ultrasonic waves in a liquid during which time disturbance in the fluid occurs due to the changing pressure. This generates air bubbles in the lower pressured portion of the fluid.

4. **Air-liquid mixing, shearing method.**

   The method of generating tiny air bubbles by mixing and shearing the 2-phase gas liquid mixture.

5. **Ultra-high speed gyration method.**

   This method generates micro bubbles through an ultra-high speed gyration of 2-phase fluid in which the centrifugal separation of the air and liquid inside the equipment produces gyration and a hollow portion in the center of the equipment. The difference in the rotation speed before and after the equipment outlet results in a cutting and pulverizing action.

   Professor Onari was the inventor of this high-speed gyration method and is currently attempting to discover various practical uses and applications for the micro-bubble water.

Effects of "biological activation" of micro-bubble water

Let me introduce some of the practical uses for micro-bubble water. Through the various experiments using micro-bubbles, the reaction through biological activity amazed Dr. Ooshiro. The amazement was so great, Dr. Ooshiro wanted to know "why this phenomenon occurred and how are we going to interpret the phenomenon and that I can only interpret it as a miracle."

The first experiment involved the biological activity reaction in oysters.

Normally, when an oyster is subjected to external stimulation such as shock, it refuses to open its shell for several hours but by introducing micro-bubbles, it opens its shell in less than 10 seconds. Furthermore, by leaving the oyster exposed to ongoing micro-bubbles, the growth rate of the oysters accelerated.

The research report stated that by spraying and providing micro-bubbles to the cultured oyster, the amount of blood flow in the oyster doubled which is believed to have improved the metabolic function and thereby accelerating its growth. The same results were also confirmed for scallop growth and for this reason micro-bubbles are used in scallop culturing.

Furthermore, Professor Onari in his college lecture explained that by providing micro-bubbles to a human, the amount of blood flow improved significantly.

The application of micro-bubbles to a bath is well known. By bringing the micro-bubbles into contact with a person taking a bath, the person perspires even at a relatively low temperature of 39^{o}C while providing the feeling of comfortable warmth. Even after the bath, though feeling full in the stomach, some participants reported body slimming. It is believed that the micro-bubbles improved the amount of blood flow in the obliterated blood vessels of the body.

It is said that the micro-bubble or nano-bubble water, in addition to air, can also dissolve oxygen and hydrogen and it is also thought that an amount exceeding the saturation value can be dissolved.

Using this technology, if the dissolved oxygen and hydrogen can be significantly increased in the water solution, this will indeed create a new type of functional water. This technology is currently being developed by a number of companies.

In a study by Professor Kenji Kikuchi of Shiga University, on the subject of dissolved hydrogen clusters in electrolyzed water, it has become known that these clusters becomes smaller by introducing the micro-bubble or the nano-bubble.

The diameter of the cluster of the dissolved hydrogen comprising the nucleus of a collective entity of water molecules is about 57,000 microns (57,000/1,000,000m) which when electrolyzed at 0.1A/(dm^2) (0.01 A per 10 (cm^2)) and 480 microns (480/1,000,000m) at 1.2A/(dm^2) becomes smaller according to the research report. The diameter of the hydrogen cluster changes according to the strength of the electrical current during electrolysis. This is undeniably one type of nanotechnology of increasing the concentration of hypochlorous acid.

In recent years, there were attempts to use this micro-bubble or nano-bubble in the field of medicine particularly in cancer treatment. This is similar in trend to electrolyzed water of the cathode side, while both technologies are expected to bring synergistic effects.

Chapter 5: Measuring properties of water

pH, conductivity, Oxidation Reduction Potential, Ion Density and how it defines functional water. We will discuss how these redefined variables create a water to stimulate SOD mimicking activity for eliminating free radicals.

How can we measure the characteristic and function of water?

We ask ourselves as to how we are going to measure the characteristics and functionality of water. If we have a weight scale or fluid measure, we can easily measure the weight and volume of water.

However, in determining the functionality of water it is also important to measure water temperature and the amount or type of dissolved substance (solute) that is present.

Matter dissolved in water is referred to as solute. The water itself which dissolves these matters is called a solvent. Water shows different nature and characteristics depending upon the dissolved solute. There are cases where the water significantly changes its nature depending upon the solute.

There are many measuring instruments that were developed in order to measure the solute dissolved in water and today, it has become easier to measure the type and amount of solute including those that fall into the category of contaminants. However, despite these instruments it is not easy to truly measure water characteristics and its changes.

The most popular method of measuring water's characteristic is hydrogen ion density. To measure hydrogen ion density may sound very complicated but we are just referring to the acid and alkali which are expressed as (pH) levels.

As explained before, the pH value of water generated through electrolysis is divided into acidic for the anode side and alkali for the cathode side and the function is significantly different on each side. The understanding of pH is becoming quite popular and is also a very important index being used in many areas of industry and products.

The index utilizing the oxidation and reduction potential (ORP) measurement is also very important. This index indicates whether a substance is easily oxidized, taking an electron away, or easily reduced, providing an electron.

Mechanism of Conductivity and pH

Based upon the German pronunciation for pH, as "*peha*", I pronounce it as "pea-H", based on the English language. The "H" in (pH) represents the "H" in the word hydrogen and pH is the measurement of hydrogen ion density.

As you know, the pH value of 0 to 7 is acidic, with the pH of 7 being neutral and values from 7 to 14 as being alkaline. Now we will discuss pH.

The concept of using pH as a measurement value was proposed by a Danish scientist named Soren Peder Lauritz Sorensen. The pH value is a simplified measurement value to show the acidic or alkaline density. In 1900, Dr. Sorensen

announced the formula of using the logarithm of the reciprocal of the hydrogen ion concentration.

At 25^{o}C and 1 atmospheric pressure, very little water ionization occurs. The number of ion in a neutral 1 liter of water is 10^{-7} mol for hydrogen ion (H^{+}), and the same number 10^{-7} mol for hydroxyl ion (OH^{-}).

Dr. Sorensen defined the product of the hydrogen ion density and hydroxyl-ion density at 10^{-14} (mol per L)^{2} of water as a constant and named the product as "ion product of water". (1 mol is equivalent to 6.02×10^{23} molecules of the substance). It is expressed in the following formula.

$$[H+]\,[OH] = 10^{-7} \times 10^{-7} = 10^{-14}\ (mol/L)^{2}$$

Through an example, a further explanation is that if the density of the hydrogen ion (H^{+}) is 10^{-14}, the hydroxyl-ion (OH^{-}) will become zero. If the ion is 10^{-5} mol/Liter, then the hydroxyl-ion density will be 10^{-9} mol/Liter, showing that the opposite is true. The reason for this is that the ion density product is a constant at 10^{-14} (mol/Liter)^{2} and therefore, if the other ion density increases, the counter ion will automatically decrease. If both the ion densities are equal, the solution is neutral and if the density is higher at any side, it indicates an acidic or an alkaline solution.

However, if there is an inconvenience in using the numeric exponent of 10, for those who are not familiar with the use of a formula of this sort, this is the primary reason why Dr. Sorensen suggested the use of a logarithmic scale known as the pH scale.

How this became to be known as pH is due to the power of hydrogen ion density, borrowing the letter "p" from the word "power" resulting in the expression–pH.

pH is the logarithm (-log) of the hydrogen ion density. If the hydrogen ion density is 1 (mol/Liter) the pH will be 0, if the hydrogen ion density is 10^{-14} (mol/Liter)^{2} the pH will be equal to 14. Therefore, the pH value is expressed in a range of 0 to 14, with values between 0 – 7 being acidic in pH, 7 being a neutral pH, and pH values between 7 – 14 being alkaline in pH.

Based on this hydrogen ion product, we can now effectively express the acidity or alkalinity of water depending on its hydrogen ion density. With this explanation, I hope you now understand the basic concept of this pH scale that we commonly use in our daily life.

Measuring Conductivity, ORP and Ion Density

The liquid water molecule is slightly separated into hydrogen ion (H^{+}) and hydroxyl ion (OH^{-}). This is the reason why pure water still conducts a minute amount of electricity.

There is no pure water in nature and it was a German scientist, Dr. Friedrich Kohlrausch, who first measured the ability of water to pass current or create electrical conductivity by making pure water. They repeated 42 procedures to completely remove impurities and to produce as close of water to pure water, measuring its electrical conductivity and discovering that electrical current, though at a low level, flowed through it.

Through this research, Dr. Kohlrausch discovered that even pure water has the capability of having some portion ionized, supporting the ion concentration pH concept discussed earlier.

Dr. Kohlrausch repeatedly measured the electrical conductivity of water and obtained a result of 0.0554×10^{-6}/ Ωcm at 25°C.

1/Ωcm represents 1 Volt applied between a 1 cm distance and a 1 Amp of current flow which is a measurement indicating the ease or difficulty for current to flow.

Dr. Kohlrausch then computed the degree of ionization through the electrical conductivity of the pure water and determined the ionization constant of water. The ionization constant, referred to as the equilibrium constant, can be expressed in the following equation.

$$K_{H_2O} = \frac{[H^+][OH^-]}{[H_2O]}$$

As a result, the ionization constant of water at 18°C is 1.1×10^{-16} (mol/L). Since the number of moles of water in one liter is 55.5, substituting this number into the formula will result as:

$$Kw = 1.1 \times 10^{-16} \times 55.5 = 0.61 \times 10^{-14}$$

This resulted in an ionization constant of 0.61×10^{-14} $(mol/L)^2$ at 18°C. This is the value as explained in the section on pH as the ion product of water.

The ion product of water changes depending upon the temperature. The standard reference temperature that is used is 25°C, and as illustrated in Table 5, the ion product of water changes with a change in temperature.

Table 5
Water Temperature and Ion Product of Water $(mol/L)^2$

°C	Kw x 10^{-14}	$(H^+) \times 10^{-7}$
0	0.078	0.28
18	0.61	0.78
25	1.01	1.0
34	2.10	1.45
50	5.4	2.3

The water ion product indicated in the 2nd column, is the product of the positive (+) and negative (-) ions and the 3rd column indicates the value of the electrically dissociated positive ion, H^+.

As indicated in Table (5), the ion product of water changes significantly depending upon the temperature.

If there are too many salts/electrolytes in the water, it will be ionized and there will be a large amount of electrical flow. The purer the water is, the lesser the electrical flow occurring and the resultant decrease in conductivity. By measuring the electrical conductivity, we can determine whether there is a significant presence of salts/electrolytes, or a lack thereof.

A conductivity meter is a compact measuring device which can be readily obtained and is used widely in measuring the pollutants in river and lakes. The more polluted the water with elements which conduct electricity, the higher the electrical flow.

Although I will be explaining the details in Chapter 6, the measurement of oxidation reduction potential, ORP, is a measurement that is frequently made. Again, it measures whether the water is in a reductive state providing electrons or if the water is in an oxidative state removing electrons.

Also, there is measurement of the ion concentration (EC). By using a Total Dissolved Solid (TDS) meter, we can measure the amount of ions in the water. Because it is an ion, it is possible to measure how much current can flow through as electrical conductivity and then converting it into an ion concentration equivalent. By doing this, the ion content of water can be measured electrically.

Through the measurement of the TDS, it is possible to determine if the water is soft or hard water. The terms soft and hard, when used in terms of water, refers to the degree of hardness of water and is determined through the measurement of the calcium and magnesium content (mg) present in 1 Liter of water. The hardness is determined through the sum of the calcium content multiplied by 2.5 and the magnesium content multiplied by 4. The hardness levels in the United States are defined as follows:

Very Soft:	**0 – 70 ppm**
Soft:	**70 – 140 ppm**
Slightly Hard:	**140 – 210 ppm**
Moderately Hard:	**210 − 320 ppm**
Hard:	**320 – 530 ppm**
Very Hard:	**> 530 ppm**

SOD mimicking activity eliminating Reactive Oxygen Species (ROS)

Recently, there are numerous chronic illnesses that are being attributed to ROS. Some experts even pointed out that 90% of the diseases are related to ROS. ROS is also referred to as "oxygen intoxication".
Although many treat ROS as a bad element, in reality we need ROS to maintain our life. The problem stems from the number of excess ROS that are present in the body, with the understanding that an excess count of ROS may damage our cells and result in various illnesses.

Despite the fact that ROS is produced in our system, our body also provides the enzyme which eliminates excess ROS. If this enzymatic mechanism fails to work well, the ROS becomes excessive bringing harm to our bodies. In both reactions, water plays a vital role.

By measuring the SOD mimicking activity, we can determine if there is enough elimination activity of ROS being conducted through the enzymatic activity. Due to the fact that the element of water shows similar activity, its measurement through water is becoming more and more important.

The phrase Superoxide Dismutase (SOD) refers to the oxidation-reduction enzyme responsible for eliminating ROS. ROS, as the name implies, is a type of oxygen. The oxygen we breathe has a fixed number of electrons and does not readily react with other substances.

On the other hand, ROS has an unstable number of electrons and easily reacts with other substances. The reference to an easy reaction implies that an exchange of electrons with other substances are easily conducted and thereby easily creating a state of reduction or a state of oxidation. With this relative ease, ROS can be used as a weapon against foreign invaders to the body such as in the form of bacteria and viruses. However, it is important to remember that an excessive amount of ROS will attack the normal body cells causing a serious imbalance to the body's wellness.

Function and Toxicity of ROS

The existence of ROS and its effect and reaction in our body was discovered by the American Biochemists Fridovich and McCord as recent as the 1960's.

Dr. Fridovich and his group discovered the generation of ROS in our body and the enzyme responsible for eliminating them. Through this discovery, they opened the door for research into ROS.

There are many types of ROS. The most commonly known is hydrogen peroxide (H_2O_2). This is called oxydol or oxyflu and is used as an antiseptic. I think we are all familiar when oxydol is applied to a wound it starts an immediate reaction by creating bubbles and disinfecting the wound.

The most commonly produced ROS in our body is the Super Oxide (SO of the formerly mentioned SOD). This is also known as the super oxide radical ($O_2^-\bullet$) (The symbol "•" indicates an unpaired electron). The normal oxygen molecule (right) has 1 electron on both sides, as illustrated in Figure 19, but a super oxide radical (left) has 1 excess electron.

Figure: 19
Electron Configuration of Oxygen

This superoxide radical is the most commonly produced ROS in our body. Since it has an excess electron it is also referred to as a 1 electron reduction of oxygen. Due to the presence of energy, an electron attaches to the oxygen (reduced), and because of its highly reactive nature due to its unstable state, it produces hydrogen peroxide (oxidation) when it comes into contact with a hydrogen atom or a hydrogen ion (proton). As illustrated in Figure 20, this is the oxydol mentioned in the previous chapter which is used as an antiseptic.

Figure: 20
Electron Configuration of Hydrogen Peroxide

Also, by using the strong energy of UV rays, we can create a strong radical called hydroxyl-radical as illustrated in Figure 21.

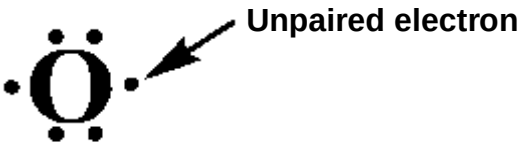
Figure: 21
Hydroxyl-radical Electron configuration

This hydroxyl radical possesses a very strong oxidizing ability and removes an electron through a strong attraction. This indicates that a hydroxyl radical is highly effective in oxidizing life from virus and bacteria entering the cells of our body from the outside.

The process of taking away a string of electrons is through electron reduction and the condition of having 1 electron removed is referred to as a ROS. ROS is generally an unpaired electron, and as shown in Figure 22, an atom or molecule having an unpaired electron.

Figure: 22

Unpaired Electron of oxygen atom



This unpaired electron, as shown on both the left and right-hand side of the oxygen atom along with the single electron located in the left of the superoxide radical, as illustrated in Figure 19, pairs up with the single electron of the hydrogen atom on both the left and right, as shown in Figure 20, resulting in the production of a very stable hydrogen peroxide.

Additionally, in Figure 21, only one of the 2 unpaired electrons of the oxygen atom are paired with the hydrogen atom; therefore, with the other electron remaining as an unpaired electron, it makes it into a highly reactive hydroxyl radical.

Other forms of ROS are LO—alkoxyl radical, HO_2—hydroperoxy radical, LO_2—peroxy radical, and NO—no radical. A single oxygen—$^1O_2$ is also a type of radical oxygen. Compounds of nitrogen and peroxides are also included.

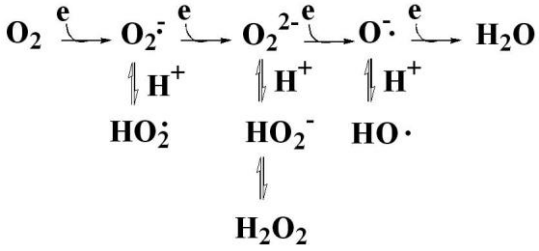
Mitochondria producing ROS

We will discuss more about the ROS. ROS is mainly produced by the mitochondria in the cells and the neutrophil inside the white blood cell.

The Mitochondria is a vital organ present in every cell of every oxygen-breathing organism. The Mitochondria produces Adenosine Triphosphate (ATP) which is the energy source for an organism from within. Water is generated during the process of producing ATP. The water that is produced has 4 electrons attached to each of the oxygen atom. It is believed that 95% of all the oxygen taken inside the body is used during the generation of this water.

Figure 23 illustrates the process of consuming oxygen and the generation of ROS.

Figure 23:
Reduction of 4 electrons of oxygen



Water is produced through the attachment of 4 electrons (e^-) to the oxygen in the sequence that is illustrated above and during this process, the ROS is produced. Looking at the illustration starting on the left, the superoxide radical is produced during a reduction of 1 electron and hydrogen peroxide during the reduction of 2 electrons and hydroxyl radical during the reduction of 3 electrons and water during the reduction of 4 electrons.

The human body produces more than 90% of ATP inside the Mitochondria, and the ROS—superoxide radical, hydrogen peroxide, hydroxyl radical—produced during the process becomes a protective component against external enemies.

There are also drugs being developed using ROS to overpower the pathological cells. The anti-cancer drug adriamycin produces hydroxyl radical by itself which targets and damages cancer cells. However, the problem is that it also damages the healthy cells surrounding the cancer cells and sometimes results in adverse side effects.

Additionally, a separate therapy−irradiation also generates ROS around the targeted site through the irradiation of the water inside the body, which is then showered onto the cancer cells and inflicting damage to it.

Recently, there is an innovative process that is being utilized whereby a weak level of irradiation from different points are concentrated to achieve a high energy ray in order to lessen the adverse effect of this therapy. As indicated here, ROS can effectively damage its enemy but an excessive amount of it inside the body also results in damage to healthy cells.

When the damage is severe, the cell's DNA which is a biological program in order to survive, is sometimes damaged, resulting in an abnormal program that creates abnormal cells. These are called cancer cells, which is a worst scenario that can happen.

The biological body is also equipped with a defense system against this risk and in the creation of this type of an environment. When the generated superoxide radical becomes excessive, the SOD mentioned previously comes into play.

SOD neutralizes and eliminates the superoxide radical inside the water by giving off 1 electron. The chemical formula is shown below.

Transition metals such as ionized copper, iron and manganese, are attached to the SOD in the chemical formula, which functions as the donor and recipient of the electron attached to the so called "missile warhead", figuratively speaking. The metal is called a monovalent when only 1 electron is lost and a divalent, when 2 electrons are lost. The transition metals sometimes become a + monovalent, a + divalent and sometimes a + trivalent, and can be recycled several times while donating and receiving electrons.

$$SOD - Cu^{2+} (Fe^{3+}, Mn^{3+}) + O_2^- \rightarrow SOD - Cu^{1+} (Fe^{2+}, Mn^{2+}) + O_2$$
$$SOD - Cu^{1+} (Fe^{2+}, Mn^{2+}) + O_2^- + H \rightarrow SOD - Cu^{2+} (Fe^{3+}, Mn^{3+}) + H_2O_2$$

As shown in the above formula, the body utilizes SOD and transition metals, which can donate and receive electrons to eliminate superoxide radicals and then separating it into hydrogen peroxide (H_2O_2) and oxygen (O_2). However, a large amount of hydrogen peroxide causes damage to the body and an enzyme called catalase containing manganese and iron is used to eliminate it. Furthermore, an additional enzyme called glutathione peroxidase comes into play, which dissolves effectively the hydrogen peroxide into water and oxygen and thereby eliminating them.

However, there is no enzyme found yet which can eliminate the most toxic among the ROS, which is the hydroxyl radical. According to the experiment of Professor Shigeo Ota and his group at the Nippon Medical School, they found that hydrogen gas selectively eliminates it, which aroused the interest in hydrogen as a scavenger, or a capturing agent.

Sickness caused or triggered by ROS

When an excessive amount of ROS exists above the level that can be processed by the body, causing damage to the healthy cells, there are still some biological mechanisms which can restore the cells. Among them are growth hormones, which work to repair the damaged cells while we sleep at night. This is a very important mechanism to heal the damaged body caused by excessive ROS.

I have listed below sicknesses believed to be caused by the ROS or better known as free radicals.

Circulatory system:	**cardiac infarction, irregular heartbeat, hardened arteries, blood vessel contraction, ischemia and reperfusion injury**
Respiratory system:	**pneumonia, communicable disease, paraquat poisoning**
Digestive system:	**acute gastric mucosal damage, gastric ulcer, chronic ulcerative colitis, Crohn's disease, Behcet's disease, hepatitis, liver cirrhosis, drug-induced hepatic injury, pancreatitis**
Nervous system:	**Parkinson's disease, cerebral edema, brain hemorrhage, convulsions**
Vascular system:	**chronic granulomatis, leukemia, abnormal hemoglobin disease, hyperlipemia**
Endocrine secretion system:	**diabetes, adrenal gland metabolism damage, stress reaction**

Urinary organs:	**glomerular nephritis, side effect of anti-cancer drugs**
Dermal system:	**burn injury, sunburn, atopic dermatitis**
Sustentaculum system:	**arthrorheumatism, autoimmune disease**
Vision system:	**cataract, retinopathy of prematurity, retinal degeneration**

Aside from these, there are another 200 or so types of sicknesses being reported. One can realize that there are many illnesses attributed to ROS or better known as free radicals.

Even if these external enemies do not invade the body, sometimes it malfunctions due to stress or stimulation inside the body, figuratively speaking, releasing a missile called a ROS.

It is a well known experiment that when a rat or a mouse is immersed with only its head above the water for a period of several minutes, it will start to bleed from the stomach due to the misery that it is being subjected to. Repeating this will result in the formation of blisters in the stomach, which will eventually lead to gastric ulcer.

Therefore, even if the external enemies are not inside the body, figuratively speaking, a live bullet will target the body on account of the stress or stimulation, which later may progress to a major illness.

Stress prioritizes the sympathetic nerve of the autonomic nerve, which in turn stimulates the granulated leukocyte of the white blood cells releasing ROS. As a result, the healthy cells are also attacked.

The activity level of the enzyme and SOD responsible for eliminating the ROS decreases with the increase in one's age, and especially from the age of 40 on. As it is becoming widely known today, recommendations are made to take SOD-stimulating supplement food products in order to compensate for the lowered SOD activity level. These are known as antioxidants such as vitamins C, E and B2, and carotene or foods rich with these components. In addition to these components, water is a very important element and it is vital that we take a closer look at it.

In our research on water and in order to determine if water is capable of eliminating excess radical oxygen, it can be verified by using testing methods which mimic SOD activity. In Chapter 6, I am going to explain the important values of the measured results of electrolyzed functional water.

Investigation of water with near-miraculous properties

From among the natural waters around the world, we often hear of a story related to special curative abilities of these natural waters. Having heard of these waters and recognizing the discussions that are had on the healing abilities of these waters, it is a fact that we do not know the precise healing mechanisms of these waters.

Through time, it was well known that the spring water emanating from Lourdes in the Pyrenees mountain range bordering France and Spain was a miracle water of sorts that is able to cure disease. There are also many related books published on this subject. Through a pre-second world war study that was conducted by the French Nobel Prize winner in Medicine, Dr. Alexis Carrel, although he recognized the medicinal effect of the water from Lourdes, he concluded that these effects could not be explained by science.

Through the analysis of this water, it appeared to be just a normal type of water although with a higher germanium content. However, it was true that an unexplainable phenomenon was occurring which could not be solely attributed to the presence of germanium. Lourdes is also a place of Marian Legend which was designated by the Vatican as a catholic holy place where more than 5 million visits are made each year. Due to this fact, the knowledge on the miracle water of Lourdes has spread throughout the world.

Similar to the water of Lourdes, the "Nordenau Water" of Germany is also gaining popularity. In a small village, 200km from Dusseldorf in the North-Western part of Germany, water coming out from a cave is believed to be a "miracle water" of sorts. Due to this fact, from about 10 years ago, many people from around the globe have started visiting this site.

In October 2004, I also visited the site to conduct a study of this water. At the time of the visit, not only were there many visitors at the cave located in the vicinity of Hotel Tommes, but clinics were also set up beside the hotel with doctors providing treatment and follow-up checks to first time patients and to returning patients.

In my visit, I met with one of the doctors in the clinic, Dr. Gardeck and listened to his story about the curative properties of the "miracle water". Dr. Gardeck testified that 80% of all the visiting patients have improved after drinking the Nordenau Water.

I brought this water back to my laboratory in Japan for investigation and found out that it was a weak alkaline water with a pH of 8 and coupled to this was the fact that the dissociation degree of the water molecules was higher than that of normal water. However, for all of the other testing criteria conducted on the water, it showed traits that were the same as other forms of normal water.

In the experiment conducted by Dr. Gardeck and Professor Sanetaka Shirahata of Kyushu University using a mouse model, the Nordenau water promoted the absorption of sugar into the muscle and into the lipocyte thereby lessening the risk of diabetes. This result was reported in a scientific journal.

The two scientists also explain that the water contains a rich amount of active hydrogen which is creating the healing phenomenon. Unfortunately, at the time this speculation lacked a scientific basis.

Active hydrogen refers to the hydrogen atom; however, in reality hydrogen does not exist in an atomic state but rather as molecules. Additionally, active hydrogen possesses an unpaired electron and is therefore classified as a type of free radical. Free radicals can be measured through the electron spin resonance (ESR) technique, but this method is not able to measure the active hydrogen signal.

As a third research, I also tried comparing the Nordenau Water to the water from Tlacote Mexico, also known as curative water.

The SOD mimicking activity of the Nordenau and Tlacote waters

A third water for this discussion involves a natural water possessing similar healing characteristics and is located in Tlacote, Mexico. In 1986, in a small town called Tlacote, 300km north of Mexico City, a planter and a servant drank the water from the well that they had dug and their illnesses were cured. Due to the spreading of this story, many people suffering from chronic ailments living in nearby places, as well as from overseas sites, started visiting this location. Illnesses such as lower back pain, allergic disorder, diabetes and other ailments have been cured by drinking this water. This is the reason why the Tlacote water has become famous as miracle water.

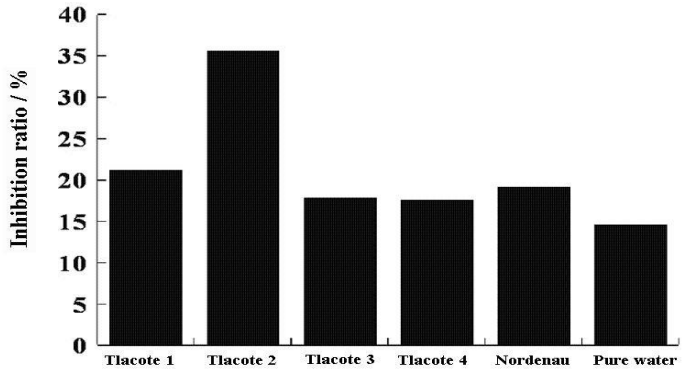
I also studied the SOD mimicking activity of this water after requesting samples from a friend in Mexico.

Based upon my explanation about SOD, it is not only important in the maintenance of the body, but of equal importance, is its function in eliminating the super oxide (SO) of ROS which causes various ailments. An SOD mimicking activity test, as the name implies, refers to the test conducted to verify if it acts like an SOD.

The SOD mimicking activity is computed by measuring the light absorption at 450nm and by adding a fixed amount of L-ascorbic acid through the SOD assay method. The result of this measurement was very interesting. The SOD assay I used generates superoxide radical to which after the addition of the said Tlacote water, the degree of elimination of the superoxide radical was measured using the transmitted absorption spectrum.

Figure 24 below illustrates the measurement result of the Tlacote water from 4 separate sources, as well as the Nordenau water and pure water.

Figure 24:
Comparison of ROS elimination rate between Tlacote and Nordenau Water



From among the 4 locations in Tlacote, 1, 3 and 4 are not from the "miracle" water sources although it came from inside a ranch where all four of these water sources were located.

Results showed that the Tlacote (2) miracle water has a high SOD mimicking activity level when compared to the other waters from inside the ranch, which appeared to have provided curative relief from illnesses. Following the Tlacote (2) water source, is the Tlacote (1) water and in close proximity, the Nordenau water.

Because of the importance of water in our body, it is commonly believed that it is an important component leading to health and that we cannot deny the existence of such natural forms of water that cure disease and maintain the body in a healthy state.

At the present time, it is still difficult to demonstrate the scientific basis and provide an explanation as to why such waters possess healing abilities; however, since such a phenomenon is in fact occurring in the real world, it is also important that we accept such reality.

Leaving science aside for a moment, the mysterious phenomenon and the ability of water to heal is a wonderful fact to know. In the natural world, water nourishes living things and sometimes provides curative effects while supporting its very life.

Will we live longer by drinking melted snow water?

Let us mix some imagination and deduction in considering this topic.

Underground water at a high temperature and under high pressure becomes supercritical water as it exceeds its hydrothermal condition. The magma rising from the earth's crust to the surface dissociates the normal water through a supercritical state into oxygen and hydrogen. The dissociated water, now separated into hydrogen and oxygen, ignites due to the heat applied to it from the earth's crust sending off rumbling sounds. At this very moment, water is produced due to the oxygen and hydrogen.

The dissociation level increases as the temperature rises and decreases as the temperature lowers. The ratio in each condition is called a degree of dissociation. The water produced in this condition contains rich amounts of oxygen and hydrogen. However, due to a much lower temperature and pressure at the earth's surface, the water returns back to each of its original condition over a period of time. As an example, hot spring or spring water contains a small amount of such dissociated water.

Of course, this water has already changed its structure, and is believed to be water with high entropy, or thermodynamic energy. Therefore, natural water is believed to possess a comparatively strong property of dissociated water. It is highly probable that this natural water, sometimes referred to as "miracle water" has curative properties as a result of these characteristics.

It is well known that people from the Hunza, located in the highland of the Himalaya mountain range in Nepal, live long. The people themselves believe that the water is the reason as to why they achieve such longevity. It was confirmed in the study that the water flowing from the mountain stream from an elevation of 2,000 meters above, is rich in calcium, iron, copper and other trace minerals.

Additionally, based on a study, the famous Vilcabamba people in the highlands of South America, known to have many people living beyond 100 years, are also drinking water rich in minerals. From this we can deduce that the water they drink from the melting snow in the highlands is the cause of their long life.

At the present time, there are no known detailed scientific studies about drinking water from melted snow so our deduction will be made from the property of ice. By freezing water at 0^{o}C, the hydrogen bond between the water molecules become stronger forming a crystalline lattice. In this process, the impurities and ion content of the water, especially the water molecules dissociated into hydrogen and hydroxyl-ion, are removed from the ice crystal which makes it a nearly pure water crystal lattice. The ions and impurities then transfer to the portion of the water that is not yet frozen. When everything is in a frozen state, they only attach to the surrounding ice and they are not present inside of the crystal structure.

Therefore, the impurities and ions attached to the surroundings move along with the ice as it starts to melt. As a result, the ion and mineral content needed by our body increases in the said water and because of the increase in concentration of the dissociated hydrogen ion−a proton and the hydroxyl ion−the power to dissolve impurities increases. This increase in ability is believed to enhance various chemical reactions. The characteristics manifested here are similar to water exposed to electrolysis, which is a very interesting phenomenon. This will be covered in detail in Chapter 6.
To further this explanation in the change to the structure of water, the ionization exponent of water at 10^{o}C is 14.53 and 13.53 at 40^{o}C. This means that the concentration of the hydrogen ion and hydroxyl-ion is ten times greater at 40^{o}C than at 10^{o}C. Therefore, it is necessary to be knowledgeable of different structures of drinking water that may be available in our daily lives.

There is also a phenomenon in nature where ionization can be increased without increasing the temperature and this can only be treated as a significant gift from nature. From these physical characteristics, you will understand that water possesses some unique characteristics. Recently, density is the number one characteristic of water that is receiving much attention.

Density and the Cluster of Water

The density of water is highest at 4^{o}C, and decreases at a temperature lower or higher than at this temperature level. Since ice at 0^{o}C has a lower density than liquid water at 4^{o}C, this is the primary reason why ice and icebergs float in water, which again is a unique characteristic of water.

Chapter 6: Investigating the mechanism of functional water and electrolyzed water

Ordinary water to functional water. Functional water and its effectiveness on the immune system. Experimentation with functional water confirming the minimizing of damage to DNA caused by free radicals. We will discuss how these conclusions were drawn through good science.

Cathode alkaline water with great potential

We discussed the method utilized for the generation of electrolyzed water in Chapter 4, which provides new functions to water. We also learned about the use of acidic electrolyzed water, generated on the anode side, in the areas of disinfection and sterilization.

Now, we are going to study the special quality and mechanism of cathodic alkaline water, which is expected to have greater potential than anodic electrolyzed water.

It was explained that you obtain cathodic alkaline water by electrolysis on the cathode side of the electrolysis process and that this water is referred to as "alkaline ion water" or under a general category of "regenerated water". We also stated that the Ministry of Health and Welfare in Japan had approved the effectiveness of this alkaline ion water against conditions such as gastrointestinal abnormal fermentation, chronic diarrhea, indigestion, antacid and gastric hyperacidity.

Electrolyzed water is believed to be effective from the duodenum to the rectum, places where anaerobic bacteria enjoy living. That is the reason why reductive elements are effective in this environment and not an oxidative element.

Oxidation Reduction Potential (ORP) indicates whether an environment is more of an oxidative cause or more of a reductive cause. An oxidative environment shows a higher voltage and a reductive environment shows a lower voltage. The electrolyzed water on the cathode side has a low oxidation potential which is believed to be causing a reductive environment inside the intestine.

The lower voltage value of the oxidation reduction potential of the cathodic electrolyzed water means a higher alkaline pH value and a high concentration of dissolved hydrogen. The higher presence of dissolved hydrogen indicates a low dissolved oxygen concentration.

The dissolved hydrogen of electrolyzed water is highly reactive in nature, which produces a highly reductive environment.

Through experimentation, the effect of dissolved hydrogen on some of the active oxygen inside our body has already been confirmed. We have discussed active oxygen in Chapter 5, where it was already confirmed that electrolyzed water directly reacts to eliminate hydroxyl radicals, which are the most damage causing free radical in our body. However, there is a little bit of a challenge for the electrolyzed water to directly eliminate the most abundant radical, the superoxide radical.

I will discuss this further in a later chapter indicating how cathodic electrolyzed water is able to eliminate the most damaging hydroxyl radical and how it can also

help eliminate the superoxide radical which exists everywhere. These are important points that one must get a good understanding of.

Immunity system experiment using a mouse

Cathodic electrolyzed water is expected to bring various benefits through many experiments that have been conducted using mice and rats.

I will introduce the results of my colleague, Professor Gabriel Fernandes from the Department of Medicine, University of Texas in the United States, who conducted this experiment in 1998. The experiment involved providing tap water and two types of cathodic electrolyzed water to mice with a normal auto immune system and mice with an abnormal auto immune system to determine their survival rates and to observe any immune substance change.

The electrolyzed water was generated using a residential electrolyzed water generator, manufactured by a Japanese company, and electrolyzed water−RW, produced at 1A (ampere) of electrical current per 1 liter of tap water, and another higher energized electrolyzed water−HRW, generated at 1A of electrical current per 1 liter per minute were then provided to the mouse.

Figure 25 shows the survival rate of 20 mice, MRP/lpr with an autoimmune system, while Figure 26 shows the result of 25 mice (NZBxNZW)F1 with an inborn autoimmune abnormality The mice were fed either tap water−TW, electrolyzed reduced water (RW) or strong electrolyzed reduced water (HRW).

Figure 25:
Survival rate of MRL/lp mice provided with tap or electrolyzed water

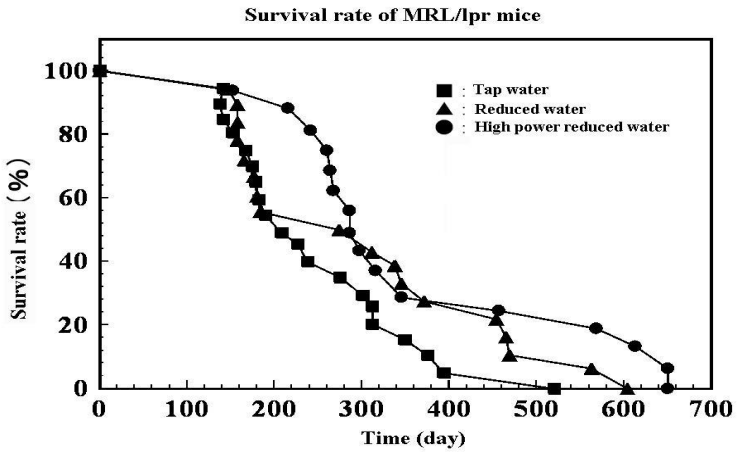
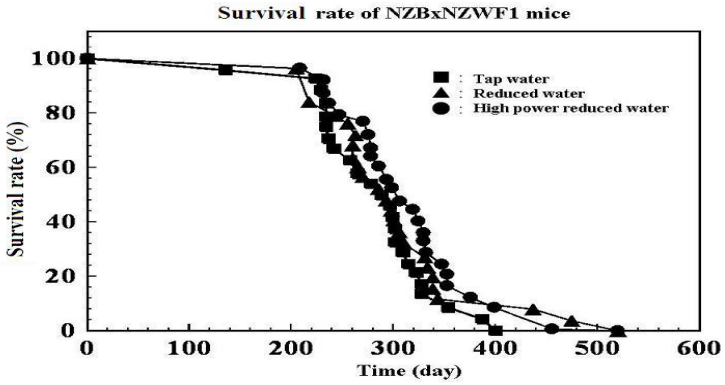


Figure 26:
Survival rate of (NZBxNZW)F_1 mice provided with tap or electrolyzed water



The graph's vertical axis shows the survival rate while the horizontal axis shows the survival days, from which the percentage of mice survival in terms of days is calculated.

The result shows that the average survival percentage is 520 days for mice MRL/lpr with the autoimmune system and provided with tap water, 600 days for mice with autoimmune system provided with electrolyzed water, 650 days for mice with autoimmune system provided with stronger electrolyzed water.

For mice (NZBxNZW)F1 with an abnormal autoimmune system, 400 days was the survival period for mice provided with tap water, 520 days for electrolyzed water and 520 days for strong electrolyzed water.

This indicates that the survival period is longer for electrolyzed water compared to tap water and strong electrolyzed water compared to electrolyzed water. However, in both cases, the electrolyzed water and strong electrolyzed water had similar results.

As indicated in the graph, the results showed a better trend for mice with an autoimmune system.

Change in blood cholesterol level

Figures 27 and 28 below illustrate the blood cholesterol level of mice with an autoimmune system MRL/lpr and without an autoimmune system (NZBxNZW)F1. They were provided either tap water, electrolyzed water or strong electrolyzed water.

The age of mice MRL/lpr with an autoimmune system was 6.5 months, with the test waters provided for 5 months. The mice (NZBxNZW)F1 with an autoimmune system were 4 months old and the test waters were provided for 3.5 months.

For mice MRL/lpr with an autoimmune system, the cholesterol level, per dℓ, was 91±7mg for tap water−TW, 66±4mg for electrolyzed water−RW and 49±3mg for strong electrolyzed water− HRW.

For mice with an abnormal autoimmune system, the electrolyzed water has an effect of significantly lowering the cholesterol level.

Figure 27:
Cholesterol level of mice MRL/lpr given tap or electrolyzed water

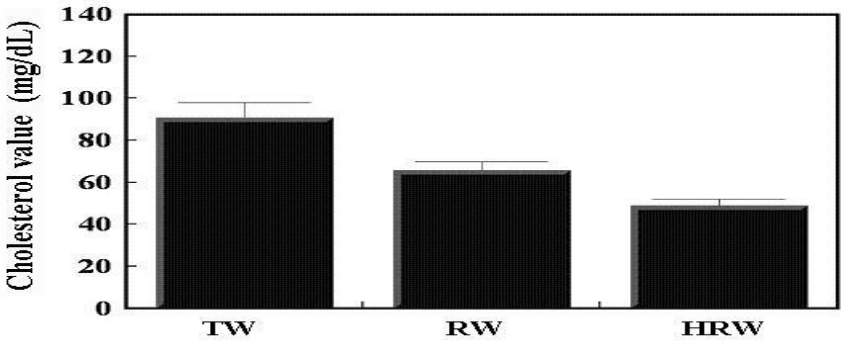
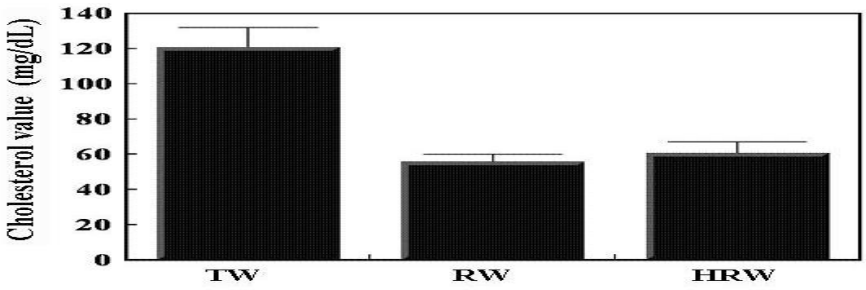


Figure 28:
Cholesterol level of mice (NZBxNZW)F1 given tap or electrolyzed water

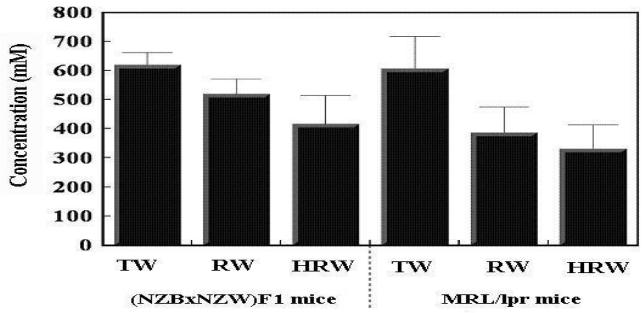


Anti-hydrogen peroxide function

In the same manner, using ammonium ferrous sulfate, hydrogen peroxide was generated in the serum of the two types of mice. The anti-hydrogen peroxide function of electrolyzed water was studied for each mouse by providing them with tap water−TW, electrolyzed water−RW and strong electrolyzed water−HRW.

Figure 29 shows the result of the hydrogen peroxide concentration measured using the 570nm light absorption hydrogen peroxide assay method.

Figure 29:
Hydrogen peroxide concentration of mice given tap or electrolyzed water



In Figure 29, the 3 left bars indicate the results for the mice (NZBxNZW)F1 with an abnormal autoimmune system, which were 620±43 mM for tap water−TW, 520±52 mM for electrolyzed water−RW and 417±98 mM for strong electrolyzed water−HRW which indicates a significant reduction.

The 3 bars indicated to the right in Figure 29, indicate the results for the mice MRL/lpr with a normal autoimmune system, which were 608±110 mM for tap water−TW, 388±88 mM for electrolyzed water−RW and 332±82 for strong electrolyzed water-HRW which also indicates a significant reduction.

Clearly, the hydrogen peroxide concentration has decreased following a pattern of TW>RW>HRW; therefore, the anti-hydrogen peroxide function has increased. Hydrogen peroxide is lowest with HRW, which was exposed to twice the amount of current. This indicates that the dissolved hydrogen concentration in the cathode side was exposed to more electrical energy, thereby resulting in a higher rate of elimination of hydrogen peroxide for the HRW.

Effect against cytokines

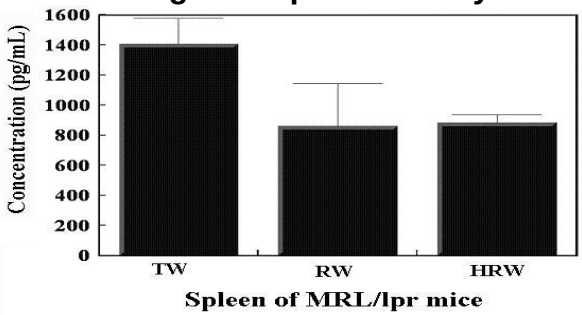
Although this discussion may become more technical, recently hormones related to the immune system called cytokines are becoming popular in the field of immunology and physiological science.

Cytokines are bioactive substances which carry signals between the blood and the immune system organs to lower or raise their activity level. There are many kinds of cytokines such as interferon, interleukin or the tumor necrosis factor, TNF-α.

From among these cytokines, research was conducted on the effect of electrolyzed water on the tumor necrosis factor (TNF-α) using mice. TNF-α is mainly produced by macrophages, but also produced by vascular endothelial cells and adipocytes. TNF-α, as the name implies, was discovered as a cytokine which kills cancer, but in excessive amounts can also trigger the onset of rheumatoid arthritis and possibly Crohn's disease. Therefore, TNF-α can be a double-edged sword, similar to the effects of active oxygen.

To control inflammation and pain, a remedy which suppresses TNF-α seems to be effective. Figure 30 illustrates the result of the measurement of the TNF-α concentration in the spleen of MRL/lpr mice with an autoimmune system that were fed with either TW, RW, or HRW water for a period of 6 months.

Figure 30:
TNF-α of mice given tap or electrolyzed water



The concentration, as illustrated in the graph, shows the following pattern of decline: TW>RW>HRW. In other words, the mice fed electrolyzed water had a lower concentration of TNF-α than mice fed tap water.

This data indicates that electrolyzed water is effective against excess TNF-α.

Effective action for immune system

As a part of the immune system, the white blood cells play a very important role. The white blood cells, which are also referred to as immune cells, are composed of granulocyte, lymphocyte and macrophage, which work together to fight external enemies such as bacteria and virus that invade the body.

Lymphocytes have T cells, which directly fight with outsiders while the B cells produce antibodies that serve as effective interceptors.

A similar experiment was conducted using mice MRL/lpr with an autoimmune system, which were provided with 3 types of water for 6 months to follow and analyze its effect.

A first discussion will discuss the T cell. The T cell is the cell from among the lymph cells originating in the bone marrow and later trained in the thymic gland.

The T cells are classified into two types depending upon the kind of protein attached to their surface. The types of protein are referred to as CD4 and CD8, with each type performing a different function. A T cell which has CD4 is referred to as a Helper T cell and the CD8 is referred to as the Killer T cell.

This experiment was conducted to analyze the T cells by measuring the CD4 and CD8 of the liver and spleen of a mouse. Figure 31 illustrates the CD4 and Figure 32 illustrates the CD8 of the spleen. In both cases the electrolyzed water−RW and the strong electrolyzed water−HRW indicated higher values when compared to

the tap water−TW. This means that the T cells have increased indicating that the cathodic electrolyzed water improved the immune system of the mouse. Additionally, the same result was achieved for the liver.

Figure 31:
Spleen CD4 level of mice given tap or electrolyzed water

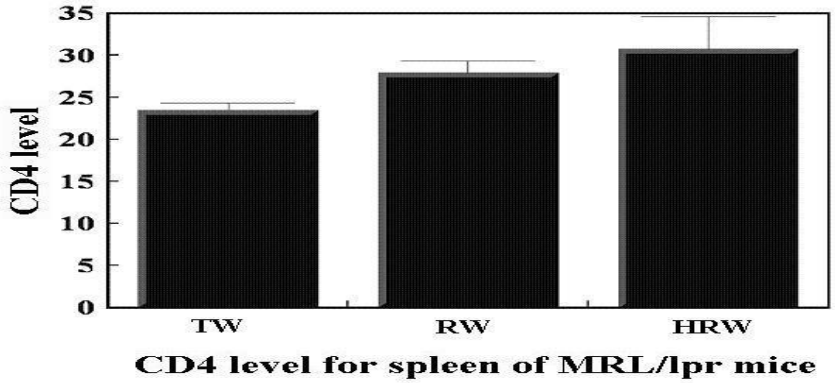
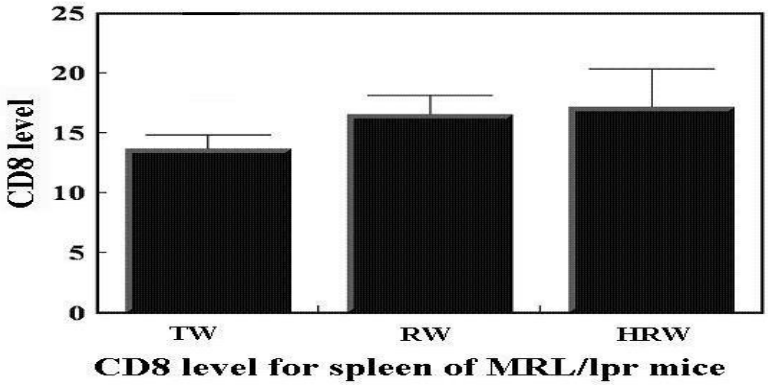


Figure: 32
Spleen CD8 level of mice given tap or electrolyzed water



The B Cells inside the white blood cells, lymphocyte cells of the same immune system, enter the blood from the bone marrow and produces antibodies, an intercepting mechanism based on the instruction sent by the helper T Cells against foreign matter such as bacteria and virus. The B Cells circulate throughout the body by flowing with the blood while a strong concentration is present in the lymphatic node and spleen. The B Cells are measured using a protein called B220.

Figures 33 and 34 illustrate the result of the B220 measurement of mice MRL/lpr with an autoimmune system, which were given 3 types of water for 6 months.

There was no difference seen for the liver between the tap water−TW, electrolyzed water−RW and strong electrolyzed water−HRW, as illustrated in Figure 33.

However, as illustrated in Figure 34, the spleen indicates the B220 level reduction in the order of TW>RW>HRW.

Figure 33:
Liver B220 level of mice given tap or electrolyzed water

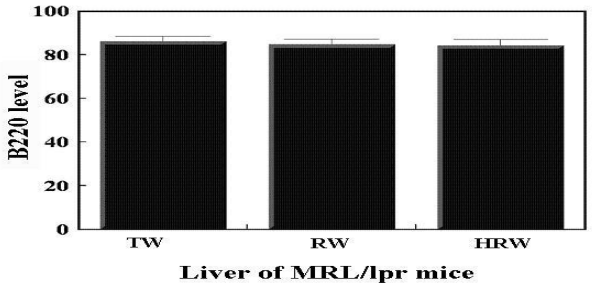
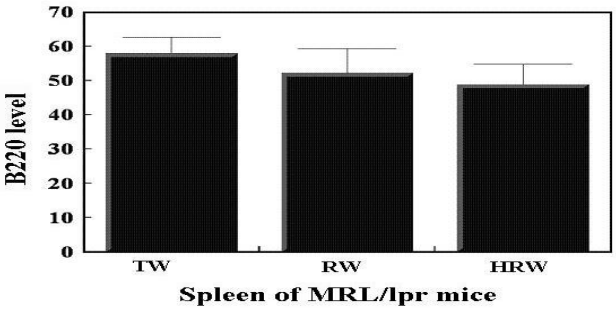


Figure 34:
Spleen B220 level of mice given tap or electrolyzed water



As shown here, when the cathode electrolyzed water is given to mice with an autoimmune system for a fixed period, the T Cells increase while the B Cells decrease or show no change.

The B Cells, which are the cells responsible for antibodies, will show no increase or decrease if the source substance of the antigen is not produced inside the body. In short, it shows the body's normal immune system.

As illustrated here, mice provided with cathodic electrolyzed water have shown improvement of their immune system.

Why did the results appear this way? The water used in this experiment is pH 8.16 for tap water−TW, pH 8.49 for the electrolyzed water−RW, and pH 10.13 for the strong electrolyzed water−HRW.

The pH value of all waters show an alkaline value, but if we take into consideration the neutralization effect of gastric acid, isn't it possible that the phenomenon confirmed in the experiments are due to the pH value?

The dissolved oxygen (DO) was 4.56mg/L for the strong electrolyzed water. By comparison, the electrolyzed water is not that significantly lower than the tap water so it is believed that this is not the direct cause.

The oxidation reduction potential was +566mV for the tap water−TW, -135mV for the electrolyzed water−RW and -496mV for the strong electrolyzed water−HRW. The difference in oxidation reduction potential between the tap water and electrolyzed water was very significant.

As previously discussed, oxidation reduction potential is computed through the dissolved hydrogen concentration and pH value. The tap water, which is not exposed to electrolysis, does not contain dissolved hydrogen. The hydrogen produced through electrolysis dissolves into the water causing a very low oxidation reduction potential level. What we have learned through this is that the higher the dissolved hydrogen concentration, the lower the oxidation reduction potential making it a highly reductive substance.

Therefore, we also need to look at the property of dissolved hydrogen if its level affects the result of the experiment. There are studies reporting that the cluster shape of the dissolved hydrogen created through electrolysis is different than that of dissolved hydrogen created through a bubbling process. (The term cluster indicates bundles of molecules.) We can see that the clusters become more reactive. Therefore, the hydrogen molecules readily react with molecules which strongly attract electrons such as the active oxygen. One can see why we would think in this manner, can we not?

Although only a hypothesis, we can think this is how the dissolved hydrogen was able to reduce the active oxygen resulting in an increase to the immune function of the mouse.

One more important item that we need to focus on is the solvent, which is the property of water having a high dissociation level.

Water in its liquid form shows some electrolytic dissociation, where it separates into hydrogen ion (H^+(proton)) and hydroxide ion (OH^-). When its electrolytic dissociation increases, in other words when the hydrogen and hydroxide ions increase, it is believed that the reactivity of the dissolved substance also increase. This is referred to as the "enhancement effect".

The term enhancement means to increase or strengthen its function. Electrolyzed water has an enhancement effect on the activity of the substance that has been dissolved into it. It is believed that this is the reason for the improved result and this fact had been confirmed through experiments.

I would like to first explain the experiment on the effect of electrolyzed water on the DNA damage caused by active oxygen.

Effect of electrolyzed water on DNA damage

In 2004, Professor Fernandes and I conducted a joint study on the effect of electrolyzed water on DNA damage caused by active oxygen, the result of which was published in the science journal, "Biophysical Chemistry". This study achieved very good results. The results of the key experiments are shown in Figures 35 and 36. The experiment was conducted in-vitro using cell DNA grown in a test tube.

Figure 35:
Electrolyzed water suppression effect of damage to DNA ①

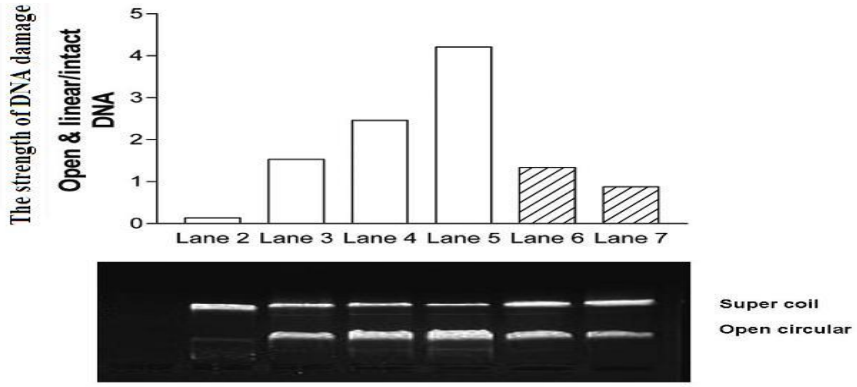
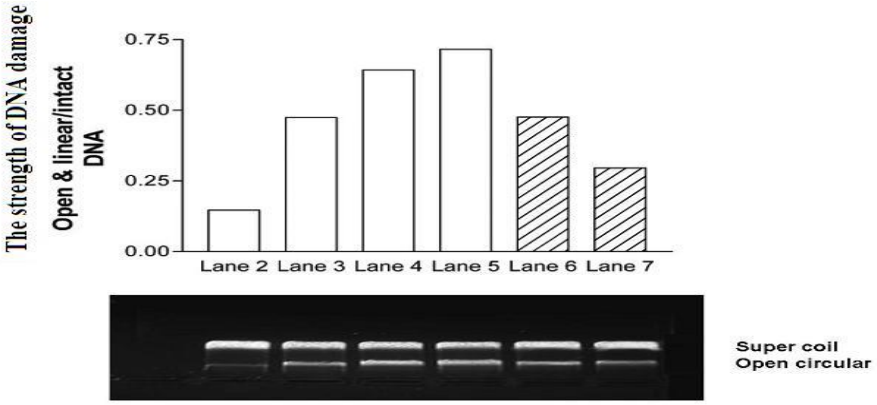


Figure 36:
Electrolyzed water suppression effect of damage to DNA ②



As illustrated in test tube lanes 2 ~ 7 in the horizontal axis, DNA and highly reactive active oxygen – hydroxyl radical, generated through hydrogen peroxide and a cupric substance, were placed in all lanes except lane 2. Later 6 types of water solution with electrolyzed water were added. The DNA damage was later measured using Lane (1) as a negative control group.

This experiment was conducted to determine if electrolyzed water can prevent DNA damage inside the cells caused by hydroxyl radicals.

In this experiment, the water solutions that were added to its test tubes were as follows:

Lane 2:	**Purified water only.**
Lane 3:	**Purified water, added hydrogen peroxide and cupric**
Lane 4:	**Purified water with pH value adjusted to electrolyzed water (0.8A)**
Lane 5:	**Potassium hydrochloride solution (2mM)**
Lane 6:	**Electrolyzed at a current of 0.4A, Potassium hydrochloride solution (2mM)**
Lane 7:	**Electrolyzed at a current of 0.8A, Potassium hydrochloride solution (2mM)**

Except for Lane (2), and as indicated above, this is the measurement of the damage to DNA resulting from the mixing of hydroxyl radical and the water solution. The vertical axis is the strength of the DNA damage.

As illustrated in Figure 35 and in Lanes 6 and 7, the DNA damage caused by hydroxyl radical is less using electrolyzed water. In other words, the experiment confirmed that the electrolyzed water lessens the damage to DNA caused by hydroxyl radicals.

Below the horizontal axis lane is the super helical and open circular DNA. Previously, I have explained the special structure of the DNA in Chapter 3 which is shaped like a circular stair. Open circular means that the hydrogen bond, which is the spiral stair case portion, connecting the 2 chains of the DNA is broken on account of the damage. This means that the more open the circular DNA, the more damage that was incurred. As illustrated in Lanes 6 and 7, the open circular DNA is indeed lesser using electrolyzed water.

Figure 36 shows the result using the same method as outlined above, this time using hydroxyl radical generated from hydroquinone and cupric substance. Indeed, the results indicated the same trend.

As evidenced here, cathodic electrolyzed water shows a strong anti-oxidation property against hydroxyl radicals which are highly damaging. Through this experiment, we discovered this excellent effect.

The truth and misconceptions about electrolyzed water

The effects of electrolyzed water have been confirmed through experiments and that is why it is receiving much attention these days, but there are also some misunderstandings on this subject. One of them is the "cluster theory" indicating that the water molecule of electrolyzed water has become smaller.

A group of water molecules is called a cluster, and this theory claims that by giving the water a small amount of energy, the structure of water molecule changes and becomes smaller.

Although I will explain it briefly without going into much detail, the researchers who started this cluster theory did their research with a different type of water using the Nuclear Magnetic Resonance (NMR) method. This research involved certain water with a certain cluster size as being water with a delicious taste and this observation was reported to the Chemical Society of Japan, and which topic was later highlighted by the mass media. Adding to this media release were comments surrounding electrolyzed water as being good for the body since its cluster size was small resulting in a higher absorption rate which added the impetus to this form of water and creating its misconception.

It is important to note that a water molecule cluster disassembles itself every picosecond, which is 10^{-12} second, while not allowing itself to form as a cluster for even one second in time. One picosecond can be considered as a flash in time and therefore, due to this short duration, it is not possible that a water molecule cluster(s) even exists for a short period of time.

This cluster theory finally ran its gamut when a professor from Hosei University's Engineering Department pointed out that the cluster theory is a misconception and an illusion.

The research regarding the solid-state properties and structure of water is progressing step by step; however, there are still many unknown aspects to water. Everything has not yet been understood. Even if we were to use advanced measuring equipment, but an incorrect measurement, we will invite an unimaginable misconception. As we advance our knowledge into electrolyzed water, we must be ever more careful as to not tarnish its science and integrity with misconceptions. While I begin by repeating this very important caution to myself, it is important for me to emphasize this point to our readers.

Cathodic electrolyzed water is sold generally as "alkaline ionized water" or "regenerated water", and the equipment to produce this form of water is available in the retail market. There is also a trend claiming that electrolyzed water directly eliminates the most common active oxygen, the superoxide radicals. However, in actual studies using Electron Spin Resonance (ESR) and SOD Assay methods, the tests were not able to eliminate the superoxide radicals. But in the study discussed earlier, the specific waters had an anti-oxidation effect against the most damaging of the active oxygen−the hydroxyl radical.

Furthermore, there are researchers claiming that the active hydrogen in the electrolyzed water eliminates active oxygen. Active hydrogen is the hydrogen atom "H" itself. It is generally believed that it does not exist in water at room temperature. However, as explained through the situation regarding the cathodic electrolyzed water, the water molecules are reduced due to the electrode reaction which generated the hydrogen molecules. Through this reaction, and in keeping

with Henry's Law, the hydrogen was dissolved in water in a gaseous state while keeping its state of equilibrium. (In chemistry, Henry's Law is one of the gas laws, formulated by William Henry in 1803. It states that: *At a constant temperature, the amount of a given gas dissolved in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid.*) wikipedia

However, only a maximum amount of 1.75mL of hydrogen molecule can be dissolved in a 1000mL of water at 25^{o}C. Therefore, even if the dissolved hydrogen concentration increased momentarily, it will decline to a near-zero level after some time. On account of this factor, it is best not to expect the antioxidant property of dissolved hydrogen against superoxide radicals. If the water is taken immediately after electrolysis, you can expect some result, but the effect will rapidly diminish within 10 minutes in an open air environment.

Despite what we have explained here, even though the electrolyzed water has no direct antioxidant property against the superoxide radical, it has an enhancement effect on the antioxidant substance, which as a result enables the elimination of the superoxide radicals as we will explain later.

Electrolyzed water is a significantly-interesting phenomenon as shown in various experiments. Although not all of the mechanisms are known, electrolyzed water is a phenomenon and it is certain that something is creating this phenomenon. I am sure that each of these mechanisms will be understood in the future, one step at a time.

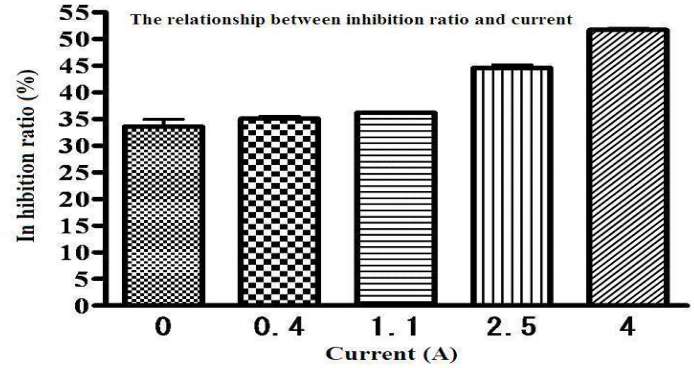
Enhancement power

I am going to explain further the important functions we discovered about the cathodic electrolyzed water. This will cover the solvent function of the water itself.

First, because the dissociation ratio of water molecules of the cathodic electrolyzed water increases, its solubility also increases in the same manner. Furthermore, it also hastens the structuring of water molecules as well as increasing its reactivity. As I have previously mentioned, this also increases the reactivity of dissolved antioxidants, that have been selectively added to the water, resulting in the enhanced effect.

Figure 37 illustrates the result of a study to check the difference in the elimination rate of active oxygen between electrolyzed water and ordinary water with both waters having been mixed with an antioxidant substance. A water solution of 0.8mM of L-ascorbic acid concentration was used for this experiment. L-ascorbic acid, known as Vitamin C is an antioxidant.

Figure 37:
Electrolysis current vs active oxygen elimination rate



The L-ascorbic acid was mixed with non-electrolyzed water (0) and 4 types of electrolyzed water (0.4A, 1.1A, 2.5A, 4A) and the elimination rates of the superoxide radical were compared.

The measurement was carried out using the SOD Assay method. This method involves measuring the color change for determining the elimination rate of superoxide radical after adding this chemical in droplets to each of the water solutions. The change in color was measured using equipment which accurately measures the rate of light absorption.

The vertical axis shows the elimination rate, the horizontal axis shows the current applied during the electrolysis of water. From the experiment, it is very clear that the higher the electrolysis current, the higher the elimination rate or the higher the antioxidant potential.

It can be said that this experiment clearly indicates that the antioxidant potential of the L-ascorbic acid was enhanced.

As mentioned earlier, an electrolyzed tap water, and a non-electrolyzed tap water by themselves will not eliminate superoxide radicals. However, mixing the same amount of antioxidant substance such as L-ascorbic acid (Vitamin C) into electrolyzed and non-electrolyzed water for comparison resulted in a higher elimination rate of superoxide radical by the electrolyzed water. This is what we call an enhancement effect.

Though we have introduced here the experiment using L-ascorbic acid, it can also be confirmed that other antioxidants such as catechin and flavonoid have a higher antioxidant potential in electrolyzed water than in non-electrolyzed water.

This is indeed an amazing function given to the electrolyzed water.

Power of electrically dissociated water

Why does electrolyzed have this enhancement effect? It is unfortunate that the mechanism is not yet totally understood, but I believe this is deeply related to the higher degree of dissociation of cathodic electrolyzed water, that has a "high level of ionic product in water".

Water (H_2O), even in its original liquid state, is partially dissociated into hydrogen ion (H^+) and hydroxyl ion (OH^-). Focusing on this dissociation activity, the pH index was conceptualized to determine if it is acidic or alkaline depending upon the hydrogen ion density.

As a quick review, the pH value is 0 when the hydrogen ion density is 1 (mol/L) and 14 when the hydrogen ion density is 10^{-14} (mol/L). The pH value is defined from 0 to 14.

In the case of electrolyzed water as the dissociation progresses, the water molecule hydrogen ion (H^+) and hydroxyl ion (OH^-) levels increase. In other words, the ion product level increases.

It was already confirmed that the ion product of water increases as the temperature increases and by using a standard temperature condition of 25^oC, the ion product level increased when the temperature increased. The difference also indicated the increased level due to the electrical dissociation.

In the case of electrolyzed water the ion product level also increases, not only due to the variable of an increase in temperature but also due to the exposure to electrolysis. When the electrical dissociation is increased through electrolysis, it shows an improvement in various reactive states as well as its permeability. (If you are a researcher, please refer to Chapter 10 of the book "Ionic Equilibrium" written by James N. Butler, which was published by Willey Inter Science.)

This trend explains the enhancement effect where the electrolyzed water enhances the activity of the dissolved substance that has been added to it.

The concept of p[IP] is important when focusing on the water index regarding this effect. This is what I refer to as the "IP Theory" and I would like to explain a little about this theory.

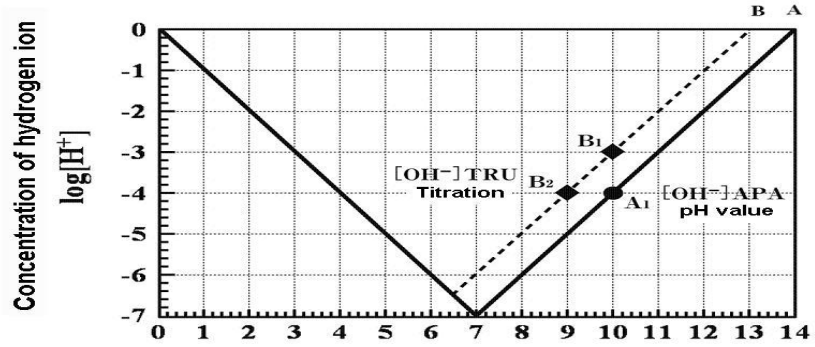
IP is the abbreviation for the property, "Ion Product of Water". It may sound complicated but I will simplify it in my explanation.

The ion product of water, using an example of a pH 10, is 10^{-10} mol/L of hydrogen ion, but as the dissociation activity progresses causing an increase in the plus and minus water molecule ions, the ion product also increases making the pH range narrower.

As an example, the pH value of ordinary water falls into a range of 0 to 14 but once the dissociation activity increases, the ion product of this water becomes a log of Kw=10^{-13} (mol/L). In this example, the pH value becomes 13 and therefore the pH range becomes narrower, now resulting in a scale being 0 -13.

This example is illustrated in Figure 38. Normally, as indicated in the bold line (A) shown in Figure 38, water at 25°C and under 1 atmospheric of pressure has a pH value of 1 to 14. For the pH value of 7 ~ 14 in the lower middle, the H^+ concentration can be shown by measuring the OH^- concentration. As an additional example, the hydrogen ion concentration of a water solution having a pH of 10 will become 10^{-10} mol/L (A_1).

Figure 38:
Change in pH range



However, because the ion mobility of electrolyzed water changes, the ionized ratio also increases which causes a change in the ion product of water. Assuming that the water ion product becomes 10^{-13} $(mol/L)^2$, it becomes a log of (10^{-13}) whereby the pH value becomes 13. As illustrated by Figure 38, the pH range thereby becomes narrower to a scale of 1~13.

While measuring the electrolyzed water using a normal pH meter will indicate the pH value indicated at point (B_1), the true pH value is actually indicated at point (B_2). From this, we can see that there is a difference in measured values and the true values. (As a side note, there is no difference in the values indicated on the acidic side of the pH range. Unfortunately, the method utilized in the measurement of the alkaline range cannot be used to measure the acidic range.)

The apparent value of the hydroxyl ion (OH^-) can be computed from the measured pH value of electrolyzed water. Next, the true hydroxyl ion density can be measured using the neutralization titration method. From the measured apparent and the true value, the p(IP) can be computed using the following formula. This formula was presented by myself in the scientific journal, "Journal of Applied Electrochemistry" in 2001.

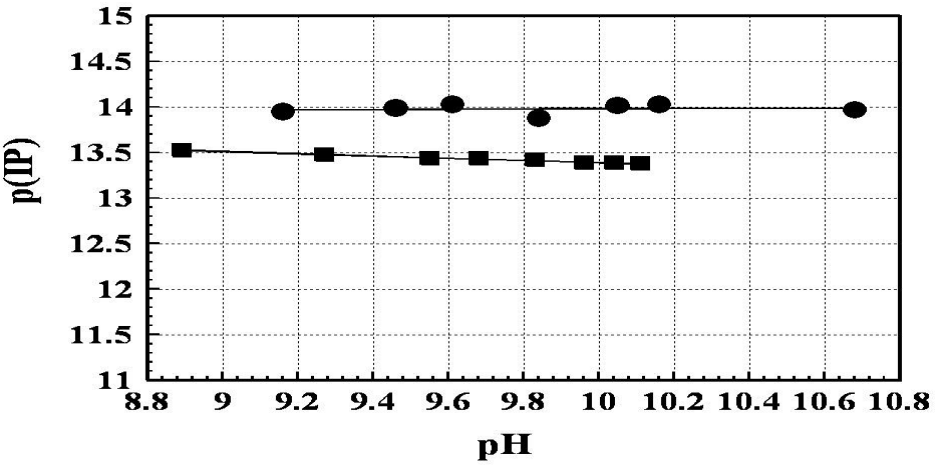
$$p(IP) = 14 + \log \frac{[OH^-]_{APA}}{[OH^-]_{TRU}}$$

In this formula, $[OH^-]_{APA}$ is the apparent hydroxyl ion density and $[OH^-]_{TRU}$ is the true density. Based upon this formula, the p(IP) shows a decreasing trend proportional to the electrical current applied when a diluted sodium chloride solution or another electrolyte additive is electrolyzed. This illustrates an increasing level of water dissociation.

Compared to the pH value, p(IP) will be the index to show the water dissociation level. As such, the lower the number indicated, the higher the level of water dissociation. That is to say, in the same manner as the pH value or the hydroxide ion density of water, it is the same concept as the lower pH value, the higher the hydrogen ion density.

Figure 39 shows the p(IP) result of electrolyzed water and chemically similar water computed by using the pH and titration method. The current applied is 0~1.6A at 25°C.

Figure 39:
Change in dissociation index based on pH of electrolyzed (■) and chemically similar water (●)



The vertical axis shows the p(IP) value while the horizontal line shows the pH value. This is the comparison between the non-electrolyzed chemically similar water, as indicated by "●" whose pH value was adjusted using sodium hydroxide, and electrolyzed water displayed as "■". The chemically similar water is water whose electrolyte composition and density, as well as the pH value, was adjusted similar to the electrolyzed water while the electrolyzed water was produced using applied current.

While the dissociation index of chemically similar water shows that the dissociation index decreases slightly with increasing pH, the water dissociation index of the electrolyzed water has decreased substantially over the entire pH range .

As illustrated here, due to the increase in the plus and minus ion density of the electrolyzed water, at the same pH the dissociation index, p(IP) is lower.

Therefore, when measuring the cathodic electrolyzed water using an ordinary pH meter, the result will only be an apparent value and not the true value.

Actually, it is very interesting that the p(IP) value of electrolyzed water changes this way. Though the reason is still unknown, it is believed that because electrolyzed water increases its electrolytic dissociation due to various reasons, the p(IP) value changes in the same way as the pH range. This is indeed a change in the property of water, which becomes the index for the solvent. I believe that this is a very important factor when considering the advantage and effect of electrolyzed water.

Using the enhancement effect of electrolyzed water

The change in ion product of electrolyzed water as shown here means a change in the percentage of the electrolytic dissociation of water molecules and thereby making the electrical current easier to flow.

What we can deduce from this is that the network, due to the hydrogen bond of water molecules being easily separable (broken), the ability to dissolve matter increases, and thereby raising its permeability.

Furthermore, the water surface tension decreases making it difficult to produce water drops. This phenomenon can also be observed with the increase in temperature and with electrolyzed water. That is, matter becomes more soluble and thereby enhancing the chemical reaction in our body.

Until now, there was no concept that the pH range will change. For electrolyzed water, we may not be able to notice the change in this solvent if we continue to concentrate only on the dissolved substances. Water changes its property in small degrees and enhances the activity of the dissolved substances. This is where our focus must lie and this is what indeed makes electrolyzed water special.

Since we discovered the amazing effect of electrolyzed water generated on the cathode side, I strongly felt that it was worth the research and in order to have this water used by more people in their daily life.

At this point, I will summarize this chapter in a simple manner.

The electrolyzed water produced through a small application of electrical energy on the cathode side has an increase to its dissociation level allowing for the water to more readily dissolve substances. Through this newly-attained ability, it enhances the antioxidant potential of antioxidants such as Vitamin C and Catechin inside our body when ingested as a combination of electrolyzed water and the antioxidant. Electrolyzed water eliminates excessive hydroxyl radicals and thereby making it a safe antioxidant water.

As I have previously explained, there were earlier studies reporting that the cathodic electrolyzed water was very effective against hyperacidity, gastrointestinal abnormal fermentation, indigestion, chronic diarrhea and other conditions.

An additional use for the electrolyzed water is for cooking daily foods such as vegetables, broths and other items requiring water or requiring boiling. It is believed that it will work more effectively in eliminating the active oxygen, which is the cause of various diseases.

Of course, although electrolyzed water brings beneficial remedies, it should not be relied upon as a panacea. As research continues, I am certain that its function and mechanism will be discovered allowing for more people to understand how some of its benefits are derived and thus be able to better embrace this water.

Chapter 7: Progressive Technology and Applications of Electrolysis

An advanced approach to wine refinement, skin care, cooling tower maintenance and precious metals extraction. We will discuss other progressive uses of this technology of electrolysis.

Creating a matured taste and aroma

The electrolysis technology that draws out the wonderful functions of water is not a difficult process. Anyone can easily use the process of electrolysis. Also, it is a great technology from the standpoint that the exchange of electrons is extremely minute and effectively accomplished with a very low level of energy.

Depending on the electrolysis process, the functions and quality of water can be redefined. By properly using these characteristics, further applications can be expected and the scope for its effective utilization widened. We can expect that the utilization value of the new and old technologies of electrolysis will further broaden and will also create business opportunities.

There have been many instances in which the outcome is improved through the application of electrolysis and the use of electrolyzed water. I will like to introduce some examples of its use.

Mr. Tanaka, a good friend of mine and President of Innovative Designs and Technology (IDT) located in Hamamatsu, Japan, does engineering research and development on proprietary electrolyzed water devices. He has obtained notable results in applying electrolysis onto some alcoholic products. He discovered that if wine, shochu, brandy and whiskey are subjected to different forms of electrolysis, they will have comparable properties of long term aged liquors.

In an understanding of liquors, there are brewed liquors in which rice, buckwheat or potatoes are fermented and consumed in this state, and then there are liquors in which the brewed liquors are distilled. However, in most cases, the favorable taste and fragrance are drawn by storing the liquors and allowing for these products to mature in a cask or in a storage container. By doing this, the smoothness and richness are achieved.

Any form of liquor is a solution in which the alcohol and water are blended. Through this mutual interaction, the matured properties are born. The water molecules surround the alcohol molecules and in turn the alcohol molecules encase the water molecules. Because of this interaction, the clusters of each molecule are evenly distributed and the thermodynamic of the entire solution approaches a state of equilibrium. With this, the taste and fragrance becomes rich and full. Under conventional methods, to get to a state of equilibrium, a considerable period of time is necessary.

During the aging process, the water molecules must break the hydrogen bond and form fixed clusters around the alcohol molecules so that the water molecules can surround the alcohol molecules. This state weakens the naturally strong sensation of alcohol and brings out the smoothness.

While Mr. Tanaka believed that this interaction could not be conducted outside of conventional methods, he had researched this process.

Mr. Tanaka created an electrolysis assisted process and processed the wine. Having confidence with his research and process, he had his wine tasted by sommeliers in California. They concluded that his wine had the same level of aging applied to it as wine that had been stored and matured for 10 to 15 years. Although California is comparatively a newer wine producing area, areas such as Sonoma and Napa are internationally famous wine producers.

Mr. Tanaka, who received favorable comments from the California sommeliers, and having gained more confidence with his process, traveled to Budapest, Hungary and processed the locally famous Tokaj wine. This processed wine was tasted by the Budapestan sommeliers and indeed received their stamp of approval that the wine equated wines that had been conventionally aged for more than 10 years.

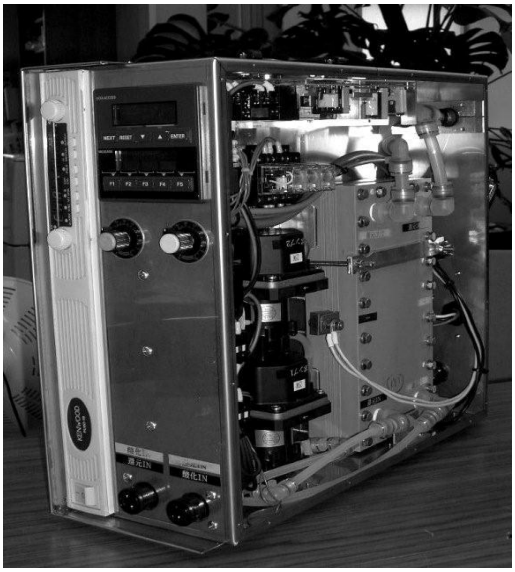
In September 2006, Mr. Tanaka and I had an opportunity to visit Albania with the help of the Albanian Chargés D'Affaires (Ad Interim) in Japan. At the time, we conducted a demonstration of the process on Albanian wine at Tirana, the capital of Albania and Port Duras.

Albania is located in the South Western region of the Balkan Peninsula and is connected to Greece to the South, Macedonia to the East and Combo to the North and is a small country with a population of 3 million people. Not many Japanese people have visited Albania, but it is a very beautiful country facing the Adriatic Sea and a producer of very good wines blessed by the Mediterranean climate. Even here, most of the people who tried the wine were struck with admiration.

Maturing effect with the increase of hydration numbers

Mr. Tanaka had created the device primarily for wine, as shown in Picture (1).

Picture 1:



He stated that, so far, he has been receiving excellent comments concerning his process.

The process operates in a way that the medium flows through the reduction side (negative) of the electrolysis cell, and the counter solution flows through the oxidizing side (positive). Depending upon the situation, the wine may pass through the acidic side. Since the process is a proprietary process, in general terms, this is the flow process of the product.

Professor Minoru Akiyama at the Science Department of Rikkyo University presented a thesis entitled "Evaluation on Maturity of Electrolyzed Distilled Whiskey" based upon his experimentation on how alcohol matures.

Based on this thesis, the matured whiskey has increased hydration numbers compared to a non-matured whiskey. If this is the criteria for smoothness, we can conclude that Mr. Tanaka's method is an effective method for increasing the hydration numbers.

When the water molecules hydrate the alcohol molecules, the water molecules must break their hydrogen bonds, and since this is one of the characteristics of electrolyzed water, hydration is facilitated. Through this process, a smooth texture is created to the alcohol.

This process was unknown until now, but as an excellent application for this process, it is felt that a future exists for it. If a wine product can be treated through this process resulting in aged characteristics being instilled, with these characteristics being similar to results achieved using conventional methods, it will greatly contribute to cost reduction and we the public will be able to enjoy wine with a great taste and aroma similar to that of expensive wines.

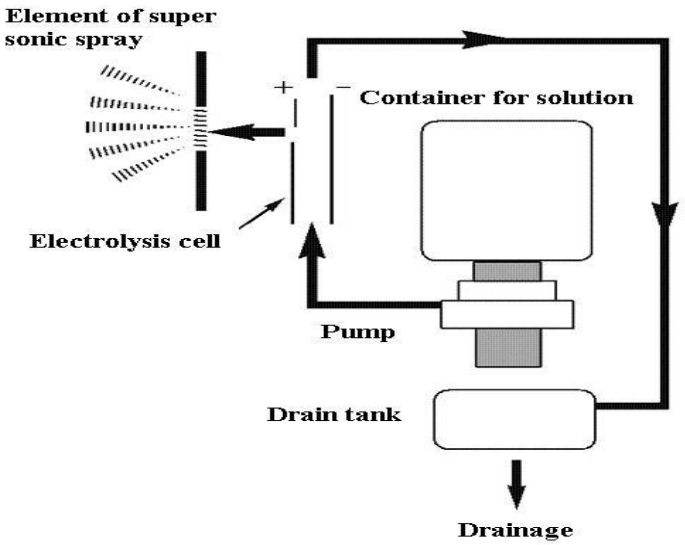
Development and application of a micro electrolysis water device

Chapter 4 spoke about the bactericidal effect of the acidic electrolyzed water created on the anode side. There is a company that has developed a micro electrolysis water device that can generate electrolyzed water in real time.

The Mikuni Corporation, which developed the electrolysis device using a pair of small electrodes without a diaphragm, is a manufacturer known for its specialization in motorcycle carburetion. Its electrolysis device was developed based on the atomization technology applied to fluids with its design based upon their injection methods.

As shown in Figure 40, the base fluid flows between the electrodes with a narrow 1mm gap that produces laminar flow and then exits the unit.

Figure 40:
Small Diaphragmless System for Generating Anodic Water



The first step in the operation of this unit requires a 2000 ppm sodium chloride solution to be placed into the upper part of the reservoir. Turning the switch on activates a metal surface creating 100,000 vibrations per minute onto the solution and resulting in electrolyzed water being created on the anodic side. This electrolyzed water is then atomized while passing through more than 2,000 fine pores located on a 1cm square area. The size of the atomized droplet is approximately 30 microns. The water that is created on the cathode side is disposed.

The atomized electrolyzed water is acidic water with a pH range of 2.5~3.0 and is primarily composed of hypochlorous acid. Being that this solution is produced and used in real time, its sterilization effect is based upon the low concentration of free chlorine when compared to a like solution that has been in long-term storage (thus subject to decay of free chlorine). The solution is safe enough, except in some rare cases, to be used for children that may normally be sensitive to hypochlorous acid.

Through the real time electrolysis applied to a sodium chloride solution, the hypochlorite generated at the anode side is highly reactive and effective. Due to this unique characteristic, a low concentration of 5ppm has a comparable bactericidal effect as a solution that is created at 30ppm and stored prior to its use.

This product has been used for skin care and its convenience of use makes it a viable homecare product. The process used in this device utilizes one of our company's elemental technologies and we feel that this is a very interesting product.

Using this device, Dr. Alpesh Desai, a Dermatologist, studied the use of the solution produced for acne conditions and published his findings in a journal called "Cosmetic Dermatology".

Based on this theory, an experiment was conducted on two groups of patients composed of 31 patients with inflamed and reddish acne. One group was treated with an atomized mist of electrolyzed water with low hypochlorous acid at 5 ppm for 8 consecutive weeks. The second group was not provided with this treatment. When the two groups were finished and results compiled, it was reported that for those patients who were treated for the papula, the former decreased to 49.1% from the baseline, and the latter was at 9.9%.

The average reduction rate of the pustule and papula of the group that used the electrolyzed water was 75.7% and 19.4% respectively and of the group that did not use the electrolyzed water was 42% and 7.8% respectively. It was pointed out that the electrolyzed water generated through this device is effective against acne.

The subjects were women from 15 years of age to 47 years of age and the average age was 24.7 years old. The racial composition was 32% white, 32% Asian, 20% Latina and 16% Afro American.

While the results of this kind of research and alternative medical treatments are becoming more widely known, coupled to more favorable personal experiences that are achieved, the uses for electrolyzed water will probably be further advanced.

Electrolysis technology that removes calcium scale

When a heat exchanger is used over a long period of time, the internal part of the pipe becomes overcome with scaling. This causes a remarkable decrease of thermal efficiency and damage to the pipes.

To prevent this, the process of electrolysis has been used through its treatment of the water circulating in the heat exchanger. In Russia, it is used for rust protection, but for the invention made by IDT, an electrolysis applying technique is used for an efficient scale removing process and at a lower cost of maintenance.

The device that the company has developed dissolves the predominantly calcium-based scaling that has developed in the waterways. The method in which this process works is where the circulatory water is passed through the electrolysis device. Being that the pH of the electrolyzed water is below 8 pH, it is not a situation in which the water is converted into an acidic pH solution. This characteristic is a special feature of this process. The solubility of calcium carbonate is generally low when the pH is in a neutral range. However, when it is exposed to water with higher dissociation ability, an increased level of solubility becomes possible.

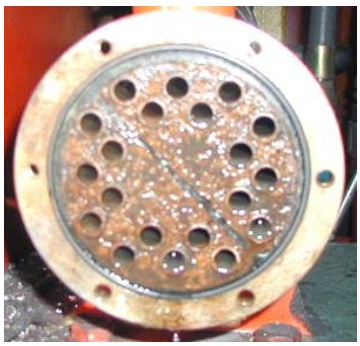
Since electrolyzed water has a high ion density, the entropy of water molecules increases and the molecular movement becomes more activated. As a result, properties which permeate and dissolve become more evident.

This is also an applied technology of electrolysis that is not yet fully understood. However, the merits of a lower operational cost with no harmful environmental effects, when compared to some of the challenges that are faced with the use of chemicals, provide a viable approach.

Picture 2:
Samples of Scale Removal

PRIOR TO ELECTROLIFE

2 WEEKS INTO ELECTROLIFE



2 MONTHS INTO ELECTROLIFE

Extraction of Gold, Silver and Platinum

The electrolysis technology and its applications are extending into various fields of use not only in Japan but throughout the world. I would like to introduce another interesting use of this technology. It was developed by an American Group that is using the process for the extraction of precious metals.

As a method to extract precious metals such as gold, silver and platinum, the historical method of choice has been the use of cyanide. The use of cyanide is most commonly employed; however, due to the environmental concerns that arise with the use of this medium and with safety concerns of potential leakage of a toxic chemical, the use of cyanide has become a major concern within the mining industry.

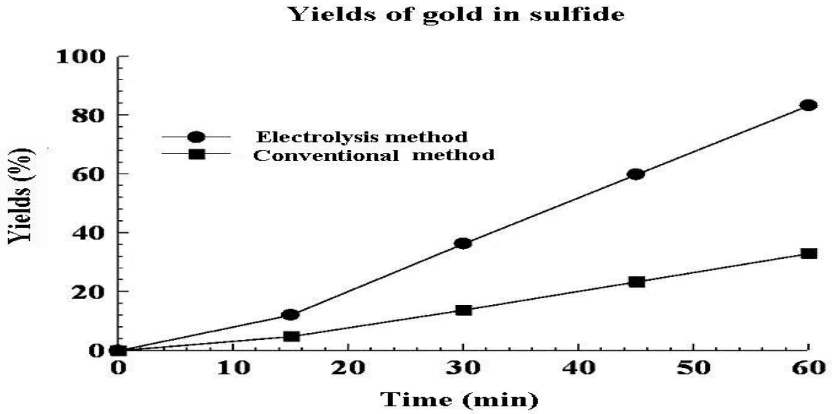
Major accidents due to the usage of cyanide and mercury have repeatedly occurred. In the year 2000, an accident occurred causing an outflow of poisonous elements at the Baia Mare mine in Romania. As a result of this accident, this incident became a turning point in the use of cyanide in the extraction process of gold in the Czech Republic, leading to a ban in its use. In 2001, the German Parliament banned the use of toxic chemical substances for use in mining. Additionally, in Costa Rica, the President banned its use along with the amalgam method for mining. Now in the United States, the states of Colorado and Wisconsin are seeking a ban in the use of cyanide for precious

metals extraction. The United States, next to South Africa, is second in the world based upon the amount of gold mined.
According to the investigatory report of the United Nations, mercury is still being used in gold mining in developing countries like China and Brazil. Yearly consumption exceeds 1,000 tons. I am concerned with the spread of the harmful effects of mercury.

Despite the harmful effects of cyanide and mercury, because there is an ease in the use of these chemicals for the collection of gold and silver, many extraction sites still use these mediums. The American Group succeeded in the development of a new method of extracting gold without the use of these chemicals, but with more reliance upon the various processes of electrolysis and a series of non-toxic compounds.

Results are shown in the graphs. Figure 41 compares the percentage of gold extraction from sulfide ore based upon the conventional method of using cyanide and water compared to using cyanide blended with forms of electrolyzed water.

Figure 41:
Extraction of Gold from Sulfide Ore through Electrolysis Method and Usual Method



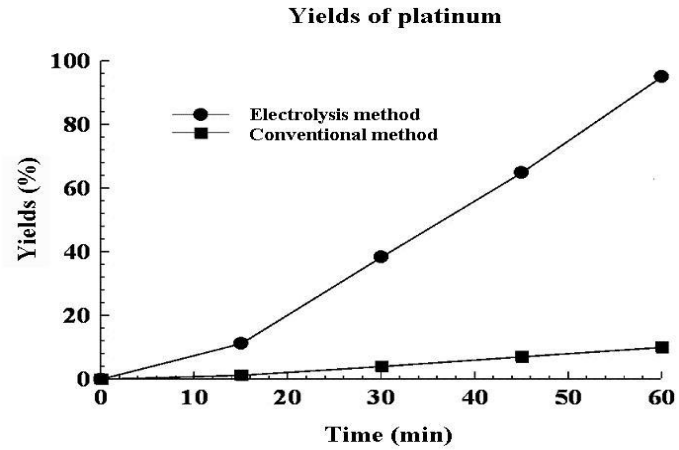
The vertical axis is the percentage of gold extraction and the horizontal axis is the leach time. The symbol "■" indicates the conventional method of leach using cyanide and water and the symbol "●" indicates the new method of leach using cyanide and electrolyzed water.

Please note: Both leaching solutions contained cyanide. This comparison was used so that an "apple to apple" comparison could be made to illustrate the difference in leachability based only on a change to the form of water used.

As we can see from these results, the amount of gold extracted utilizing the new method within a 60-minute period shows an 85% level of extraction when compared to the conventional method yielding only a 30% level of extraction. The new method shows an approximate 3-fold increase in yield.

Similarly, Figure 42 is the comparison of platinum extraction based upon the two methods.

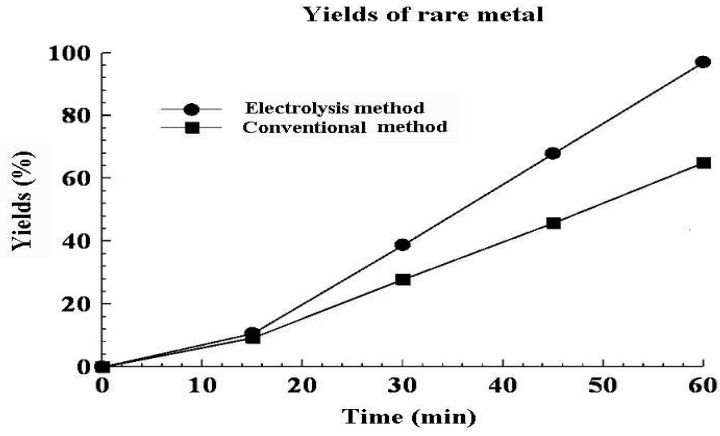
Figure 42:
Extraction of Platinum through Electrolysis Method and Usual Method



In the case of platinum, the conventional method yielded an 18% level of extraction in 60 minutes compared to a yield of 95% through the new method of extraction resulting in about a 5 fold increase in yield.

Furthermore, for the entire rare metals spectrum as shown in Figure 43, an increased yield can be seen across the rare metals.

Figure 43:



The rare metals are widely used in electronic devices and are very important metals to industry. With the new method having an extraction level of 95% within a 60 minute period compared to a 65% level of extraction, this indicates an obvious efficiency to the overall extraction.

The extraction methods using cyanide, including the non-reactive cyanide, create seriously toxic situations and depending on the handling procedures, create serious hazards which can result in significant harmful effects to the environment and to humans.

In comparison to this, the new method for leaching provides an excellent method without any toxic side effects. Since the process flow is proprietary, the new method cannot be divulged in detail but as a metal extraction method, it is not farfetched to see that the time will come when this new method will be utilized to a larger degree by industry. In understanding the current state of concerns expressed in the mining industry, I truly hope that this method will be accepted at a higher level of use.

Knowledge about the expectations of functional water

In the United States, electrolyzed water has shown its advantages even in the cleaning of wine barrels. This method allows for the reuse of these barrels.

In various ways, the applied technology of electrolysis will gradually widen in the future. As I have previously explained, let me briefly summarize all of the characteristics that have become relevant factors during the use of electrolyzed water and its electrolysis-based applications.

1. **Based upon the acidic electrolyzed water formed at the anode side as a result of using tap water blended with salt, a hydrochlorous acid-based electrolyzed water for a wide use in sterilization, bactericidal effects and disinfection can be created.**

2. **We can look forward to the functions and effects brought about by the dissolved hydrogen showing alkalinity in electrolyzed water form.**

3. **We can also look forward to the enhancement effects due to the transformation in characteristics of electrolyzed water brought about by the separation in ion density created on both the anode and cathode sides.**

By properly using these characteristics, we can expect that the scope of new applications will further increase.

The electrolysis of water can advance while new scientific evidence will be attained. This is a wonderful technology based upon minute reactions that are caused by electrons using a very low level of energy.

In addition, the electrolysis process itself is a technology that can be utilized by everyone. By improving the properties of water through the electrolysis process, and developing effective applications based upon this process and coupled to future scientific verifications, further knowledge can be expected.

CHAPTER 8: Expectation and Topics On Water

Global warming, alternative energy and water shortages all constituting today's global concerns. We will discuss how electrolysis, functional water and a new mindset may make a small contribution to today's concerns.

Global Energy and Global Warming

The solar energy radiated to the earth is 1,368 W per m^2 per second. It would be like energy from about 14 10 W bulbs illuminating 1 square meter of earth. This energy supports the lives and activities of living things on earth.

45% of the radiated energy from the sun is visible rays, 45% is infrared rays and 10% is ultraviolet rays. Most of the energy radiated from the earth's surface is infrared rays. These infrared rays are absorbed causing carbon dioxide to vibrate intensely and then the amplified energy is again emitted causing the greenhouse effect. At this point, heat is confined causing rising temperatures.

The fact that the greenhouse effect is created by humans is fairly common knowledge. In 1997, the Third Climate Change Treaty set a target for the nations to work together in reducing this condition. Although this treaty is not able to remedy this problem, it definitely became a critical turning point towards reductive efforts to control the greenhouse effect.

As we know, most of the greenhouse gases are generated by humans. Due to the Industrial Revolution that took place in England and due to the sudden increase in the number of industries created during a very short period of time, the world was not able to cope with this sudden rise in industry.

The energy resources that humans have been using went from trees to the use of coal, fuel and natural gas. Furthermore, we are moving forward in a wider use of nuclear power.

If we speak about power generation, one of the first sources of power involved the use of water through hydro power plants. In this process, the water travels from a high point to a low point and through the energy that is created in this cascade, the water rotates the turbine and generates power. Similar to this process, we have been efficiently using the concept of circulatory water such as through water stored in dams creating energy and then being returned to the rivers.

Water is also used in thermal power plants and nuclear power plants when water is boiled and a turbine is made to rotate using the steam that is generated.

Energy generated from steam was initially used in steam locomotives along with steam boats being powered by steam engines. The characteristics and power of water with its significant buoyancy as a fluid is also being used for sea and river transport.

In addition, the current thinking in obtaining direct energy from water along with the current use of fuel cells is both an efficient use of new forms of energy and a major remedy towards minimizing global warming.

Utilization of Water Energy

Water is made up of hydrogen and oxygen. To extract hydrogen and oxygen from water is not a difficult process. As previously mentioned, it is due to a simple method utilizing electrolysis.

When water is allowed to flow using a pair of electrodes, oxygen is formed at the cathode and hydrogen at the anode and each of these can be extracted individually. This is expressed in the following equation:

$$2H_2O \rightleftharpoons 4H^+ + O_2 + 4e^- \text{ (anode)}$$
$$2H_2O + 2e^- \rightleftharpoons OH^- + H_2 \text{ (cathode)}$$

The fuel cell generates electricity through a reverse flow of this whereby the hydrogen and oxygen are made to react. This is expressed in the following equations.

Equation (A) refers to a condition when the hydrogen of the fuel pole becomes hydrogen ion (H^+) and electron (e^-) due to the action of the catalyst.

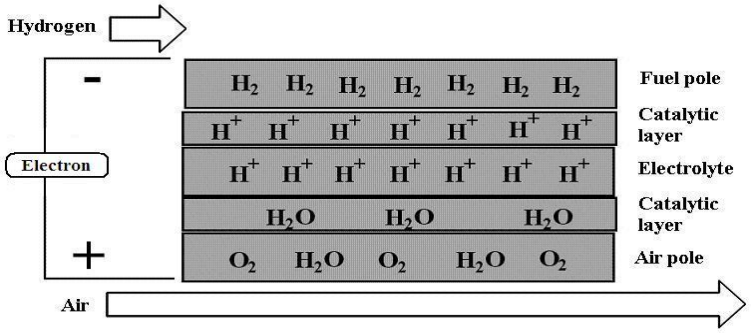
Equation (B) refers to a condition when at an air pole, the hydrogen ion (H+), oxygen (O2) and electron (e-) reacts and becomes water and at this point, if both poles are connected, electricity flows.

(A) $H_2 \rightarrow 2H^+ + 2e^-$ **(fuel pole)**
(B) $2H^+ + 1/2O_2 + 2\,e^- \rightarrow H_2O$ **(air pole)**
(C) $H_2 + 1/2O_2 \rightarrow H_2O$ **+ electrical energy**

Equation (C) indicates a series of processes in which the water is made from hydrogen and oxygen while creating electricity in the process. The series of these individualized phenomena is called the electrochemical reaction.

Figure 44 illustrates a simple structure of a fuel cell.

Figure 44:
Structure of the Fuel Cell



Both the fuel pole and the air pole have a mechanism that allows the gaseous reactants to pass through to permit the necessary reactions to occur.

The hydrogen (H_2) of the fuel pole releases the electrons (e^-) through the effect of the catalyst. Platinum is used here. This then becomes hydrogen ion (H^+) and moves to the layer of electrolytes. Due to the fact that the layer of electrolytes only allows the ions to pass through, the separated electrons (e^-) exit in the outside circuit.

The hydrogen ions (H+) that moved through the electrolytes react with the returning electrons (e-). The circuit and oxygen of the air pole at the opposite-and-lower side becomes what was earlier shown in Equation (B) as $2H^+ + 1/2O_2 + 2\ e^- \rightarrow H_2O$ or water.

The electrons at this point run around the external electrical wire circuit which indicates that the electron movement or electricity flow is inward and thereby generating electricity.

This structure simply states that the oxygen and hydrogen are electrochemically created to react and thereby creating electricity.

In this manner, a fuel cell generates electricity after the hydrogen and oxygen reacts but during this period, water is drained. In contrast to the methods which discharge greenhouse gases, such as carbon dioxide, this power generation method is very environmentally friendly.

For this very reason, the fuel cell gets attention as being an ideal energy source. Practical uses of this power generation system, using hydrogen extracted from natural gas, are now advancing forward and residences are being introduced to this new fuel source. Unfortunately, since the current systems are still costly, primarily based upon the platinum that is used as the catalyst, newer catalyst materials that are less costlier are currently under development. Once these new materials are identified, we can expect fuel cells to be used as a major source of energy.

As a parallel topic, the use of hydrogen extracted from water will be discussed. As previously mentioned, based upon the process of electrolysis, this is not a complicated task. However, at the current time, there are some components of the electrolysis process that do not provide the cost advantage based upon the amount of electrical power that is required to conduct electrolysis. Once this issue is overcome, water can also be used as a source of an environmentally safe energy.

In discussing the feasibility of using electrolyzed water as an energy source based upon the hydrogen becoming the main fuel, the beauty in the use of electrolyzed water is in the infinite reusability of the water after the energy is spent. Although this is still in a theoretical state, it is a subject matter that I am sure will become a main talking point during this century.

Water shortage is a topic of the 21st century

Although this is not a subject matter that currently applies to Japan, the country in which I reside, there is a considerable concern felt for water shortages that are present around the world. The water shortage is described as a global crisis and is one of the largest problems of this century. Aside from this, acid rain is also a significant problem.

Unlike oil, water will not vanish after its use. Through the circulatory process that water cycles through on the planet, which is the river to the sea and through evaporation converted to rain falling back into the river and out to the sea, we can see the beauty of this cycle. However, despite this recycling process that water goes through, there is an inherent concern towards the decrease in the total water levels that is occurring due to changes in the global environment brought about by global warming and desertification.

In parallel to this concern is the question as to when the inventory of the current water will be depleted due to the increase in world population. In addition to the scarcity of water is the concern of the underground aquifers becoming hazardous.

When one travels in the United States on a plane, one can see circular fields utilizing a rotating irrigation system that serves as a central pivot drawing water from the underground and sprinkling it onto these fields. This is a large system which covers a radius of more than 500 m. A large amount of underground water is being drawn by this irrigation system cultivating different crops, such as corn.

Modern civilization is now able to accomplish things in a simpler mode than in past civilizations. However, the current process of drawing up huge amounts of underground water within a short span of time, forces the water levels to gradually decrease requiring further digging to be done, causing the salt percentage to increase and eventually creating a higher salt density and creating further adverse conditions to farming. Additionally, on account of this new variable of a higher salt density, the soil will not return to its original state.

This is not the only example of this kind involving agricultural fields and crops. There are 31 countries in Africa, Asia and South America that have already fallen into a state of chronic water shortage. It is said that 528 million people, equivalent to 8% of the worldwide population of 6.6 billion people, are facing the problem of water shortage and this is a serious number. In addition, there are 1.2 billion people who are unable to drink safe water.

The decrease in the Japanese population has become a problem, but to the contrary, the world population is increasing by 140 people per minute or 200,000 people per day or at a rate of 80,000,000 people per year. In 2005, the world population was expected to be 8 billion people. In the future, it is thought that more countries are expected to face serious water shortages.

Earth, quite often referred to as the water planet, is covered with 70% sea water on its surface with potable water making up only 0.8% of the earth's water. Additionally, the availability of water on the planet is disproportionate with an ongoing decrease in the amount of drinking water available. This is also due to the abnormal weather patterns that the planet is experiencing. This is a frightening phenomenon occurring due to the loss of water in regions with dense populations.

There is a possibility that the troubles around the availability of drinking water can become a source of territorial disputes. Water shortages will certainly continue if the population in the developing countries continues to increase disproportionately to the inventory of drinking water. Such instances of disputes are already occurring because of water levels available in such areas as the Nile Valley and in the Ganges Valley. In the Middle East, it is stated that water is as precious as oil and will become a root cause of disputes. Trouble related to water in rivers crossing international borders are also becoming sources of dispute.

In the case of Japan, about 300 liters per person per day is being consumed. Due to the abnormal weather and global warming, there is no guarantee that water can be secured in all places. Much more, this is a generation in which water and air are not free and concerns on the availability of safe drinking water can be found everywhere you travel in Japan. It has become a country where drinking water is purchased; however and fortunately, Japan is not yet at a point of experiencing international disputes based upon water.

Currently the thinking on "virtual water" in water consumption is being studied carefully. Virtual water refers to the water required in the growing of agricultural products.

For instance, if 1 ton of vegetables are to be imported, the exporting country would need 1,000 tons of water in producing these vegetables. Based on this fact, the virtual water is 1,000 tons, or in other words, 1,000 tons of water is being imported.

To produce 1 ton of beef and pork, 7 tons of grain are necessary. If this is converted to water, it will equate to 7,000 tons. In Japan, the fact that its self sufficiency in foods is low, and therefore having to rely upon imports, the consumption of virtual water is significantly high. The amount of water used in farm products that Japan imports is about 5 billion tons per year and this is equivalent to the amount of water that a population of 40 million people utilizes in a year.

The fact that Japan with its abundance of water is importing this large amount of virtual water from foreign countries will become a significant problem in the future. If a water shortage occurs in food producing countries, an effect will be immediately felt in both the exporting and importing countries; therefore, it

cannot be held for certain that there is no correlation between water availability and international disputes.

The time is nearing that we must seriously think about food security.

Technology in producing fresh drinking water from seawater

The 21st century is referred to as the "water century". Not only is this century faced with problems, it is also a century where resolutions to these problems will more than likely be incubated.

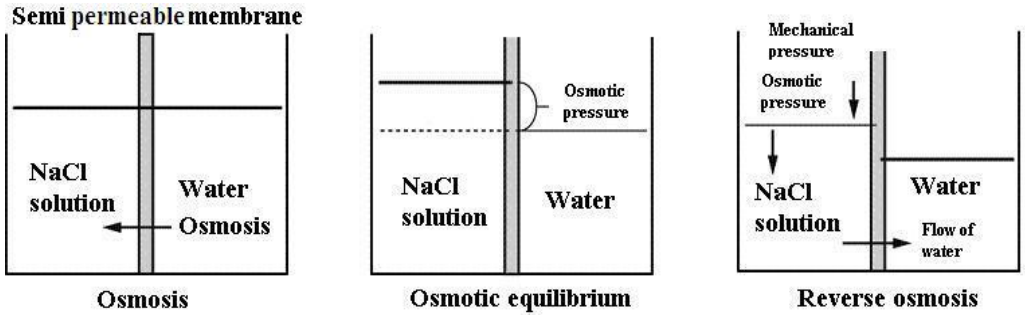
Humans are "thinkers" and have wisdom. As a step to resolving water shortages, the technology to convert sea water to drinking water has already been engineered. 97% of the planet's water is sea water but if the mineral content was to be removed, 96.5% will result in pure water. In other words, if 3.5% of the solids were removed from sea water, fresh water can be obtained. Of course, this will require a major capital investment.

In the Middle East, with many desert zones, the highest priority after state security is how to secure water. The war expense in the Middle East is $100 million per day but at current costs, $100 million is needed to convert 100 m^3 of sea water to fresh water.

Despite this expense, the significant issue of the 21st century is the expansion in the conversion of sea water to pure water and to establish cost reductions to this process. Currently, to convert sea water to pure water, the reverse osmosis process is used, where pressure is used to force water through a membrane separating the salt from the water. In 1953, this method was proposed by Ryde and Breton from the University of Florida in the United States.

Figure 45 illustrates a reverse osmosis membrane process.

Figure 45:
Processing Procedure of Pure Water through Reverse Osmosis



I will illustrate osmotic pressure. From the left hand graph, water that is defined as pure water starts to migrate through the semi-permeable membrane to the salt water side if the salt water (NaCl) and pure water are left sitting. The process that goes on here allows the small water molecules to pass through but not allowing

the larger salt solution molecules to pass. Due to this, as shown in the middle graph, the water level of the pure water decreases while the water level in the salt water side rises. In this process, the water level steadies when the balance between the infiltration power of the pure water equals the hydraulic pressure of the salt solution. The difference in water levels illustrated here is referred to as osmotic pressure.

Lastly, as shown in the right hand graph, if a higher level of pressure is applied that exceeds the osmotic pressure present in the salt water side, the water molecules located in the salt water side gradually migrate into the pure water side. The pure water is then continuously formed.

Since the transfer of water from the salt water side to the pure water side is done in a reversed direction, the process is called reverse osmosis.

Reverse osmosis, as a method to create pure water from sea water, has become popular and utilized in the Middle East and South East Asian countries where water shortage is a serious problem.

As an industrial segment, Japan possesses a top level of technology in producing fresh water through its technology involved in designing and manufacturing of membranes used in the production of fresh water. Excellent technology held by Toray, Nitto Denko, Mitsubishi Rayon, Toyobo and Hitachi Zosen is exported worldwide and with a significant export made to the Middle East. Advanced film technology is used in such processes as water purification and water recycling. This technology is receiving high worldwide acclaim.

This type of technology has become one of the viable and vital remedies towards a resolution to the global water storage.

Likewise in the 21st century we are welcoming the heightened level of concern that has been assigned to the subject of water since water is the essence in supporting life.

We also cannot escape our responsibility of ensuring that an abundance of water is left for future generations.

The proper way to consume water to support good health

As the last part of this book, let us summarize briefly the topics related to ourselves on the proper way of water intake to maintain good health and to sustain a good life.

As previously explained, water is a very essential component of our body which comprises an average of 60% water. In addition, we cannot be without water as it also transmits nutrients to about 60 trillion cells. Water also manages the removal of waste substances and must be retained in the body in a consistent manner.

Retaining water is a very important point. Therefore, the intake of a fixed amount of water is a very basic principle coupled to the proper manner of consuming this water.

A natural reaction of seeking drinking water and other liquids, such as tea and coffee, may be a direct reaction to the level of thirst. As a proper amount for intake, generally 2~2.5 liters of water per day through the forms of drinks and food items is recommended. This intake amount corresponds to the discharge amount, as was explained in Chapter 1.

The water replenished by drinking water and tea, aside from meals, is more than likely a response to thirst. It is important to be sensitive to this warning signal that is indicated through the level of thirst and to replenish your water at the time that the first thirst is noted. The body's sensor to maintaining a consistent water level sends signals to the brain and warns of an impending situation of thirst.

However, during our sleep, the circumstances differ. Even if a higher amount of water exits from the body due to sweating and breathing, the body does not wakeup until a certain level of thirst is felt. Therefore, it is recommended that we consume 1 glass of water prior to our sleep in order to replenish in advance what we may lose through sweat and our breathing. As a before-bedtime water, a lukewarm water is good for this purpose.

Additionally, upon awakening drink 1 glass of water. This is a response not only to the replenishment of water, but also to turn on the sympathetic nerves of the body over the parasympathetic nerves that are dominant during our sleep. This first drink in the morning also activates the movement of our stomach and assists in the prevention of anorexia and constipation.

Another important discipline to remember is that as we age, the signal delivery for thirst becomes somewhat inconsistent; therefore, it is important to develop a discipline of consuming water on a regular basis.

In our water regimen it is important that we consume safe drinking water which means that it is water that is free of bacteria, heavy metals and other unhealthy substances that are outlined as substances of concern and stipulated under the Safe Drinking Water Regulations.

One additional area of concern is in the consumption of drinking water that originates from a temporary storage tank, such as tanks found on roof tops of condominium buildings, where proper maintenance may not conducted on the drinking water. Unfortunately, without proper maintenance of these water storages, bacteria, algae and dust particles may exist in the water. Since the responsibility of the Water Bureaus end at the point of the water entering the storage areas, the maintenance of these water sources become the responsibility of the building owners.

Chlorine is one method of insuring biological safety of drinking water; however, if there is an aversion to the odor of chlorine, then one should procure a water filter which will remove chlorine from the water prior to the point of consumption.

For drinking water that is found in the retail market, we can pretty much place our trust in the manufacturer of bottled drinking water to provide us with a safe drinking water.

Drinking water produced through a residential electrolysis device is another source of a safe and wellness-enhancing drinking water.

For the effective consumption of electrolyzed water, it is recommended that the water be consumed soon after production so that the dissolved hydrogen created during electrolysis can be fully taken advantage of.

Additionally, since the electrolyzed water produced at the cathode has a heightened ability to dissolve matter effectively, using this characteristic, the innermost flavor of vegetables and meats can be extracted when boiling these items in electrolyzed water. Especially when boiling seaweeds and dried fish, both staple food items in Japan, a very flavorful dish can be produced. When using the electrolyzed water for green tea preparation, more vitamin C can be extracted from the tea. If the water is used in the cooking of rice, the absorbed amount of water in the rice will increase. As these cooking traits have been confirmed by professional cooks using electrolyzed water, these outlined effects carry certainty.

Cathode electrolyzed water, an alkaline ion water, is also successfully sold in bottled form and sold in the retail market in Japan. In the United States, a brand labeled Essentia is a well-formulated electrolyzed drinking water. Essentia has been in the market since 1997 and is now the most successful ionized water product that has been enjoyed by a significant number of wellness conscious people. Through the understanding of difficulties surrounding the introduction of a new category of product, I truly believe that Essentia has responsibly created a bottled water product that has been tried by many consumers and with the product having successfully conveyed the benefits of wellness to its loyal following and its expanding customer base. In this regard, Essentia is a true pioneer to the bottled water market.

As explained in Chapter 6, since the cathodic electrolyzed water enhances antioxidants, such as Vitamin C and Catechin, these supplements are effective if dissolved in electrolyzed water and consumed.

The advantages in the use of this water in boiling functions is not only to extract the innermost flavors, but more importantly, to stimulate antioxidant features of various food products by eliminating active oxygen.

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Kokichi Hanaoka

He was born in 1942 in Tokyo, Japan. In 1967, he graduated with a Bachelor of Science degree in Engineering from Shinshu University. In 1973, he finished his Masters Degree at Shinshu University Graduate School and in 1992, he completed his Doctorate Degree at the Shinshu University Graduate School. In 1994, he was a lecturer at the Department of Bio Science at the Tokyo University of Pharmacy and Life Sciences. In 1999, he became a visiting professor at the Health Science Center, Department of Medicine at the University of Texas in San Antonio, Texas. In 2002, he was a lecturer at Hosei University Graduate School. Currently, he is the laboratory director of BioREDOX Bio Science Inc., Doctor of Engineering. Specializations are in Physical Chemistry, Electrical Engineering and Membrane Chemistry.

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Supports Life and Ecology

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