Understanding Hydration

By Melonie Montgomery

About 8 years ago, I began creating a cellular analyzer to take the guesswork out of the Wellness information being widely quoted within the health care field. I gathered all of the information modalities, which had become standard in the industry proven to indicate health concerns before they became health problems.

This has resulted in the *Optimal Wellness Test* which has been a compilation of research into the many different fields of science including; Microscopy, Standard Blood panel analysis, Standard Urine panels analysis, Standard Saliva panel analysis, Bio-Terrain analysis, REAMS testing by Dr. Carry Reams, Bioelectric Impedance Machine (FDA approved system), symptomology, medical diagnosis, history intakes, and general questionnaires. Each one of these systems has several areas where they over lap or provide validation for the others as well as provide invaluable scientific data.

Before we begin to discuss hydration and the *Optimal Wellness Test,* we need to have some language commonly understood from which to speak.

What Is Hydration?

Hydration is a mathematical measurement of the fluid levels in the body. The more hydrated you are the more efficient you are with transporting nutrients, hormones, and flushing toxins.

Intra-Cellular & Extra-Cellular

There are two types of water in the body, intra-cellular and extra-cellular. Extra-cellular is the fluid outside an individual cell while intra-cellular is the fluid found inside the cell.

The extra-cellular fluid has two components: intravascular (intravascular means inside the vessels) and the extravascular. The intravascular is the blood plasma and it makes up about 20% of the extra-cellular fluid volume. The extravascular (outside blood vessels) surrounds the cells of the body and accounts for about 80% of extra-cellular fluid volume.

Both of these types of water are necessary for optimal health or Wellness of every cell in the body. In order for the cells to be biologically active, they must be able to utilize water.

What is *Wellness*?

Wellness, in regards to the *Optimal Wellness Test* is a higher level of what is healthy rather than simply "normal" as defined in mainstream medicine. Where as mainstream medical testing and health guidelines simply look at whether a person falls into what we consider normal ranges, the fact of the matter is that normal is no different than using the word "survival." Normal ranges from implementing medical tests involving body fluids (saliva, urine and blood), as well as other objective measurements, only tell you if a person is not in a danger zone in terms of developing a serious health issue. We can all agree that we are looking for is Wellness!

When it comes to the understanding of water, there is a great discrepancy between experts in the field. This is not an attempt to evaluate other ways of looking at or evaluating hydration. Fenestra Research and other knowledgeable people in the field of research and water technology base all information about water and hydration contained herein on scientific data, analyzed, compiled, and evaluated over the last 50 years. Most importantly, we all must remember that no one has seen water molecules, so the theories about clusters, structures, water memory, and geometric shape are just that, theories.

For simplicity, we will explain the four basic parameters that we feel are key to evaluating cellular hydration. There are currently 39 areas measured using the Fenestra Research Labs proprietary analysis *Optimal Wellness Test.* Many of the areas not explained here also contribute to an understanding of a specific individual's hydration level. However, for brevity, we will discuss only the four primary areas here.

Why Is Hydration Important?

- Water transports all substances inside the body
- It is the main solvent for vitamins and minerals
- A well-hydrated system delivers nutrients to the cells
- Delivers oxygen to the cells efficiently
- Increases blood oxygen levels
- Removes waste materials from the cells
- Helps to removes toxic material from liver and kidneys
- Critical for efficient function of energy-generating cycles
- Provides electrical energy for brain function
- Required for the synthesis of neurotransmitters
- Can reduce depression, stress and anxiety
- Can restore normal sleep cycles
- Increases the efficiency of the immune system
- Required for the production of hormones
- Can reduce PMS symptoms

- Helps to regulate ocular pressure
- Helps to regulate adhesion index of blood cells
- May reduce risk of heart attacks and strokes
- Necessary for all digestive functions
- Can prevent constipation
- Reduces the skin's signs of aging
- Aids in weight loss
- Enhances joint flexibility and strength
- Enhances athletic performance.

*Water is an essential nutrient that is involved in every function of the body.

Important Scientific Discoveries

There have been many scientists that have paved the way to understanding how we hydrate.

British scientists in the early 1950s, Alan Hodgkin and Andrew Huxley, made a major scientific breakthrough in proving that ion transport through nerve cell membrane produces a signal that is transmitted from nerve cell to nerve cell. Their work provides us with the necessary understanding of the concepts of ion transport.

Alexis Correl, who kept a chicken heart alive for 37 years and received a Nobel Prize, stated that a secret of life is to feed and nourish the cells and let them flush out their waste and toxins. He found that if you can provide the appropriate nutrition for a cell and remove the waste material it would never die. He formed the currently used method of measurement "Dynes", the unit of force to accelerate 1 gram to 1 cm per second. Alexis Correl lowered surface tension in water and it resulted in water that proved to help make it easier to absorb nutrients and release toxins. He showed the body's cells require a surface tension of 45 in order to be permeated and hydrated.

Aquaporin Channel

The discovery of Aquaporins in 1988 was the result of research by **Peter Agre** from Johns Hopkins University, who won the **2003 Nobel Prize** in Chemistry for the discovery of water channels. (The other half of the prize went to **Roderick MacKinnon** from Rockefeller University "for structural and mechanistic studies of ion channels."

Aquaporins are water channels found in proteins. These water channels form pores in the membranes of cells and selectively conduct water molecules through the cell membrane, while preventing the passage of ions (such as sodium and potassium) and other small molecules.

Now we understand that a single water molecule alone passes through the Aquaporin channel while the minerals travel through the ion channels.

Why is this information important to us researching water and hydration? It provides the information we were once lacking: for understanding how a water molecule passes into the individual cell. Now we know that a water molecule in order to hydrate the cells must be free of gases and/or mineral bonds to pass through the Aquaporins one at a time.

With the measurements taken as part of the *Optimal Wellness Test,* I now have the ability to accurately and quickly measure the hydration levels in anyone's body. One will begin to understand with the scientific material mentioned below, how taking samples from the body can allow us a look at cellular hydration or dehydration.

Currently we have tested over 35,000 subjects using the *Optimal Wellness Test* and based on this very large amount of data we can say with great certainty that about 94% of everyone we have ever tested is dehydrated. The question is, how much water should humans be drinking for adequate hydration?

The correct way to calculate ounces of good clean water you need to drink daily is to take your weight and divide that number in half. This method provides you with the correct number of ounces of water you should be drinking each day. In many cases, dehydrated people are drinking the correct amount of water but they are drinking a poor source of water or a product with too many other additives to hydrate them correctly.

What I have learned about hydration is very simple and yet very complicated when viewed in its entirety. The correct balance for water is with a relatively low specific gravity, middle of the road surface tension, and a balancing of the conductivity and resistivity numbers. The pH of water must also be within range when the water is bottled, produced, stored, and consumed to stabilize the properties above. The specifics of these numbers will not be presented here as they are proprietary information.

Hydration & Four Associated Parameters

There are four Optimal Wellness key parameters used to determine overall hydration:

- Conductance
- Resistivity
- Surface Tension
- Specific Gravity

To measure the four components that allow for a hydration computation, it is necessary to analyze fluids from the body in the form of saliva, blood, or urine. Blood is used to look at availability of a substance in the delivery system, urine allows a look at what is being removed from the body, and saliva is used to look at what our bodies are recirculating or holding on to. By using these fluids, we can provide a scientific mathematical representation of the four parameters leading us to the perfect cellular balance for Wellness hydration number.

The foundation of considering the electrical properties in the Hydration Parameter is the basic formula C = R/V, which is called Ohm's Law. We can access some basic knowledge about intra and extra-cellular hydration through the interplay of voltage with both Conductivity and Resistivity. Conductivity is related to intracellular hydration and Resistivity is related to extra-cellular hydration. The other two key parameters have more to do with chemical content but all are required to evaluate hydration in the cellular body. Conductivity

Conductivity is a measurement of the amount and quality of electrical current in the body. Salts are electrolytes and they are responsible for the electrical conduction of information in the body. Conductivity is a look at the quantity of current flow within the biological specimen and is an indicator of osmotic pressure, heat loss, and fluid balance. The quality, purity, hydrogen charge, pH, and amount of solids in the water being consumed contribute to the conductivity number. A more scientific definition is: the reciprocal of the resistance in ohms, measured between the opposing faces of a 1 cm cube of liquid at a specific temperature. The basic unit of conductance is the Siemens (S) and was formerly called the ohm. Because a measurement gives the conductance, specific techniques have been worked out to convert the measured value to the conductivity, so that the results can be compared from different experiments as well as different samples. This is done by measuring a cell constant for each setup, using a solution of known conductivity. Cell Conductance x K = Conductivity (we will call this Equation 1).The cell constant is related to the physical characteristics of the measuring cell. K is defined for two flat, parallel measuring electrodes as the electrode.

The cell constant, K, is equal to the area normal to the current flow in centimeters squared, divided by the length in centimeters between the two electrodes. With solutions of low conductivities, the electrodes can be placed closer together or produced smaller so that the cell constant is less than one. This has the effect of raising the conductance to produce a value more easily interpreted by the sensitive meter. With high conductivity solutions, the electrodes are placed farther apart or produced larger to achieve the rectify results. Different cell constants are used as range multipliers in either of the circumstances above.

The conductivity of a material is an inherent property; specific pure water at a particular temperature will always have the same conductivity. The variables of that pure water sample depend on: how the measurement is made, how big a sample is being tested, how far apart the measuring electrodes are, among others.

Separation distance (d) divided by the electrode area (A). For a 1cm cube of liquid, K = d / A = 1cm-1
(Equation 2)

In the lab, the measured cell value is entered into the meter, and the conversion from conductance to conductivity is done automatically. The K value used varies with the linear measuring range of the cell selected. Typically, a cell with K = 0.1 cm-1 is chosen for pure water measurements, while for environmental water and industrial solutions a cell with K of 0.4 to 1 cm-1 is used. Cells with up to K = 10cm-1 are best for very high conductivity samples. For some solutions, such as pure water, the conductivity numbers are so low that some researcher prefers to use resistivity and resistance instead. The resistivity is the reciprocal of the conductivity (R = 1/C), and the resistance is the reciprocal of the conductance. Resistance units are in ohms, and 1 ohm = 1/Siemens. From Equation 1 and Equation 2, it can be seen that conductivity units are in Siemens/cm, and therefore resistivity units are in ohm-cm. The resistivity of ultra pure water is 18 megaohm/cm.

Measuring Conductivity

During the process of the *Optimal Wellness Test* a voltage is applied to two flat plates immersed in the solution, and the resulting current is measured (See Above). Using the Ohm's Law, the conductance = current/voltage. Our advanced technology uses 2-electrode conductivity instruments as complex AC waveforms and by using the cell constant, measured temperature, temperature coefficient and reference temperature, we analyze and report sample conductivity. . The electrodes we use in the Fenestra Analyzer are of the highest quality metal, sensitivity, and accuracy. We use platinum electrodes that are coated with platinum black before calibration. This coating is extremely important to cell operation, especially in solutions of high conductivity. Electrodes are platinized to avoid errors due to polarization.

Resistivity

Resistivity gives us a look at the flow of ions across cellular membranes or the relative concentration of conductive ions in the biological fluid. The slight difference in the concentration of minerals found in the plasma vs. the amount found inside the cells creates a voltage slope called the membrane potential. Therefore, resistivity is a direct reflection of the body's ability to conduct electrical currents. The relationship between electrical

resistivity and electrical conductivity is inversely proportional. (See explanation in the conductivity section above.)

Electrical resistivity (also known as specific electrical resistance) is a measure of how strongly a material opposes the flow of **electric current**. A low resistivity indicates a material that readily allows the movement of **electrical charge**. The SI unit of electrical resistivity is the **ohm meter**.

Resistivity measurements are made by the four-point probe method. The Fenestra Analyzer's current sources generate the excitation current and the millimeter is used for measurement of the voltage developed across the sample.

Electrical resistivity can also be defined as:

$$\rho = \frac{E}{J}$$

Where *E* is the **magnitude** of the **electric field** (measured in **volts** per **meter**)
J is the magnitude of the **current density** (measured in **amperes** per **square meter**).

Finally, electrical resistivity is also defined as the inverse of the **conductivity σ** (**sigma**), of the material, or:

$$\rho = \frac{1}{\sigma}$$

Mathematically the temperature dependence of the resistivity ρ of a metal is given by the Bloch-Gruneissen formula:

$$\rho(T) = \rho(0) + A(\frac{T}{\Theta_R})^n \int_0^{\frac{\Theta_R}{T}} \frac{x^n}{(e^x - 1)(1 - e^{-x})} dx$$

Where ρ(0) is the residual resistivity due to defect scattering, A is a constant that depends on the velocity of electrons at the fermi surface, the Debye radius and the number density of electrons in the metal. Θ_R is the Debye temperature as obtained from resistivity measurements.

Surface Tension

Surface tension is defined as:

> *The force acting on the surface of a liquid, tending to minimize the area of surface quantitatively*

As a biological phenomenon, the surface tension of fluids in the body can be compared through technological analysis with that of pure water. Higher surface tension implies a decreased capacity for cellular permeability for any given fluid. Many factors come into play when it comes to surface tension and the association with the components that control electrical flow through the body.

Surface tension of a fluid can be defined as inward molecular attraction forces, which must be overcome to increase the surface area. Surface tension is the energy required to increase the surface area of a liquid by a unit amount. In water the intermolecular hydrogen bonds are involved in the inward attraction forces. The surface tension of water at 20 degrees centigrade is 7.29 x 10-2 J/m2.The body's cells require a surface tension of 45 in order to be permeated and hydrated.

These measurements are typically measured in dynes/cm, the force in dynes required to break a film of length 1 cm. It can be stated as surface energy in ergs per square centimeter. Water at 20°C has a surface tension of 72.8 dynes/cm compared to 22.3 for ethyl alcohol and 465 for mercury.The electrical resistivity ρ (*rho*) of a material is usually defined by the following:

$$\rho = \frac{RA}{l}$$

Where:
ρ is the static resistivity (measured in ohm meters)
R is the electrical resistance of a uniform specimen of the material (measured in ohms)
l is the length of the specimen (measured in meters)
A is the cross-sectional area of the specimen (measured in square meters)

Specific Gravity

Specific gravity is defined as the ratio of specific weight of the material to the specific weight of **distilled water**. (S = specific weight of the material/specific weight of distilled water). This indicates if the specific gravity is approximately equal to 1.000, then the specific weight of the material is close to the specific weight of distilled water. If the

specific gravity is large this means that the specific weight of the material is much larger than the specific weight of distilled water and if the specific gravity is small this implies that the specific weight of the material is much smaller than the specific weight of distilled water. In water, the intermolecular hydrogen bonds are involved in the inward attraction forces. The surface tension of distilled water at 20 degrees centigrade is 7.29×10^{-2} J/m^2 .

From a mathematical point of view, specific gravity is very similar to density. Since the units will cancel out in any computation, it simply means that the only difference between specific gravity and density is that there are no units associated with specific gravity, as is the case with density.

Specific gravity of any body fluid reveals the content of solids in that solution, with higher concentrations of solids –both intra and extra cellular numbers are effected, raising the specific gravity number as a possible indicator of dehydration. Higher surface tension implies a decreased capacity for cellular permeability for any given fluid.

ORP (Oxidation-Reduction Potential)

This measurement is included, even though it is not a standard measurement for hydration in the *Optimal Wellness Test*. Many people have been asking about how ORP relates to cellular hydration. The general conception seems to be that the lower the numbers, the better hydrating the water is. Before we decide if ORP is of any importance to hydration, let's make sure we understand the details of measuring, evaluating, and working with ORP.

The Oxidation-Reduction potential is a true value and is the actual measure of the fluids millivolt (mV) potential. This is a measurement of the fluid's ability to donate or accept electrons. The higher the ORP, the more reduced intermediates are in the specimen, meaning the fluid is active, charged, and has the ability to create energy. When the fluid is oxidized, the fluid has lost its capacity to create energy. Now understand that these definitions are general ones and not meant to be applied to the body's water intake choice. The relative tendency of different substances to lose electrons (relative reduction potentials) varies depending on the number of electrons in the outer shell and on the size of the atom or ion. As it is impossible to measure the absolute potential of a substance. A standard reference has been established using the hydrogen reaction: 2H++ 2e- = H2 This reaction is assigned a potential of 0.0000 volts. The standard reduction potentials, Eo, are applicable under the following conditions: Temperature of 25ºC, Ion Activity (Concentration) of 1.0 (unless otherwise noted), 1 atmospheric pressure (for gases).

In practical applications, oxidation-reduction potentials (ORP) vary as a function of:

The standard reduction potential **Eo** of each half reaction

The relative ion activity (concentration)
Temperature
Number of electrons transferred in the half reactions

When it comes to looking at water with the ORP measurement, it is important to know: If one or both of the half reaction involve hydrogen or hydroxyl ions, then the ORP measurement becomes pH dependent. As the pH of the solution varies, the potential of the reaction will vary. The dependency of the potential on the pH is specified by the Ernst equation. The Ernst equation has a coefficient in the long term that depends on the Absolute Temperature, T, and the number of electrons transferred, n. Most industrial applications have a number of different reactions occurring simultaneously. Each reaction often has a different number of transferred electrons. When a temperature compensated pH meter or controller is used with an ORP Electrode, you must plug the temperature compensation connections with a fixed resistor of the value expected at 25ºC for the measurement to be of any value.

Free Radicals

When the number of protons and electrons in an atom are not balanced, the atom is said to be ionized. If the atom has more protons in the nucleus than there are electrons in orbit around the nucleus, the atom is said to be a positive ion. When there are more electrons than protons, the atom is a negative ion. A free-radical is a positively charged oxygen molecule ion which is missing an electron. The free-radical wants balance so it will pull an electron from wherever it can. In acquiring balance for itself, the free-radical damages other biological molecules in the body. Is this beginning to sound familiar? This chemical reaction is responsible for forming those damaging free-radicals that we are hearing so much about. Neutralizing free-radicals with anti-oxidants has been touted as helping to slow down the ageing process and help keep us healthier. Anti-oxidants are substances that either give up an electron or combine with and share their electrons with the free-radical to satisfy the demands of a free-radical for balance. Now that we understand what a ORP measurement is, does it make sense to have very low ORP numbers in ones water?

Comments about the Interplay of all Four Hydration Parameters

It might be assumed that the four properties of fluids as measured with the four different Fenestra tests are much better if they go farther and farther into higher and lower ranges. But the uniqueness of the Fenestra technology is that the testing and computation process is all built into the hardware and software. Fenestra technology works with the interface of different parameters to extract specific evaluations. For example, different levels of hydration, and hydration levels that change over time with any given modality. The key is balance for any given parameter in terms of the interplay with other parameters in revealing whether or not there is an increase or decrease in Wellness. This is not to say that

every number being in the middle of the road for every person is best. In fact, because this system offers such a diverse and specific look at each individual's biochemistry, no one product or one technique is perfect for everyone.

Lastly, we are often asked what we believe to be the two most important measurements in maintaining optimal Wellness. The answer is **hydration** and **pH**. If either of these parameters are not within Wellness range, one cannot utilize nutrients, remove toxins, or maintain correct enzymatic reactions. *In fact, there are about a million other required reactions* in the human body that cannot happen if hydration and pH are not within range.

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