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WATER'S EXCLUSION ZONE

Bioengineer Gerald Pollack found that water adjacent to common types of surfaces or exposed to sunlight creates so-called "exclusion zones," where dissolved substances (solutes) are excluded in favor of a more ordered, or less random, molecular network. Applications of this unusual behavior within water's network include removing salts, pollutants, and even microbes without expensive filters or the energy required to force water through synthetic membranes. He also discovered an electrical charge separation between ordered water and the more common forms of disordered water, thus creating a battery—albeit a tiny one. The electrical charge separation created by light may someday lead to the production of a usable electric current, which is based on a process that mimics photosynthesis in plants. Water treatment and energy production are among the highest priorities for researchers currently exploring hydromimicry.

WATER AND ARCHITECTURE

In addition to management schemes and sustainable technologies, water can also serve as a design tool for architecture. The flow forms and rhythms of water in the natural world create an imagery and symbolism that architects use to create spatial relationships between different aspects of a building. Water connects and, in some respects, defines the relationship between physical and energetic aspects of the planet via complex cycles operating on its surface and within its interior. From the ancient architects of Europe's fountains and cathedrals to the modern designs of Frank Lloyd Wright to the famous Blur Building of Switzerland, both the substance and essence of water have been utilized to create a wide variety of visual and sensory effects. Because water is an integral component (both visible and invisible) of everything in our environment, we respond to its presence in architectural designs.

FRACKING GROUNDWATER

The topic of "natural gas fracking" has made front page news during the last several years—more for its role in contaminating groundwater aquifers than in extracting cheap energy. The allure of hydraulically fracturing geologic formations is to permit trapped natural gas to flow efficiently from its source rocks to subsurface locations where it can be more easily extracted. An unfortunate consequence of such fractures is that they permit the gas (primarily methane) and the associated hydrofracturing fluids (used to enhance the process) to contaminate adjacent drinking water aquifers. Whereas the fossil fuel industry is currently focused on producing nontoxic fluids and, perhaps, stripping the flammable gases from domestic water supplies, potential water-related problems don't end there. Fractures that remain open following the gas extraction act as conduits for any future pollutants that may be either released to or produced within near-surface soils.

OCEANIC HIGHWAYS

Small organisms located miles beneath the ocean surface are unlikely to be affected by winds and other weather conditions at the surface—or are they? Marine scientists have discovered that the same sea surface events that affect our climate and the distribution of fresh water around the globe also generate oceanic currents that can extend as deep as the seafloor, transporting otherwise stationary organisms across entire ocean basins. As a result, marine life originating on the seafloor in one part of the ocean can end up thousands of miles away. One might wonder whether changing ocean conditions (particularly the increased temperature and acidity linked to global climate change) would affect organisms relocated so far from home. While some species are adversely affected by the more "hostile" conditions, many others have demonstrated a surprising tolerance to conditions associated with their move.

WATERSHED PATTERNS

The fractal attributes of water, ranging in scale from molecular to planetary, were discussed in a previous synopsis. Fractal relationships among the patterns created by water's sculpting landscapes have been used to interpret and predict watershed characteristics. Spatial fractals have permitted the delineation of entire watersheds or their subsections for purposes of establishing appropriate boundaries and of predicting the soil properties that affect the infiltration and subsurface flow of water. Spatial analyses have also been used to identify interconnected channel networks and the nodes (exact locations) that may be most critical for flooding. Temporal fractals have permitted the formulation of algorithms for modeling surface flows and discharges within watersheds (essential to sustainable development), for estimating how quickly various pollutants move through landscapes, and for designating which watershed sections are most vulnerable to floods and pollution.

THE MASTER RESOURCE

Analysts often divide critical resources into five major categories, which include water, food, energy, human health, and ecosystem function. Water is placed at the center because it is required by each of the other four and, as such, is the subject of studies that estimate the resources available for future use. Each region has different threats to water quality and quantity depending on its geography, climate, population, and susceptibility to contamination. Whereas threat identification and quantification is a logical first step to reducing future water impacts, similar approaches have produced disappointing results. From an economic perspective, water's cost has been subsidized because the industrial, energy, and agricultural sectors are so dependent on it. Some experts have suggested that fostering a "culture of water" may be the best way to elevate this substance to its master status.

SPACEY WATER

The distribution and origin of water within the solar system is a mystery that continues to unfold as astronomers report their new findings. Gas-giant planets like Uranus and Neptune have rather strange magnetic fields that may be due to an unusual type of water known as "superionic," whereby the oxygen atoms form a lattice or crystalline structure through which the smaller hydrogen atoms are able to flow. Superionic water is created at temperatures and pressures much greater than those present on Earth and has a distinct yellow glowing appearance. While on the subject of solar system water, the latest theory regarding an extraplanetary source of earthly water is that asteroids, rather than comets, were the primary contributors. Based on the relative abundance of deuterium (an isotope of hydrogen) in water, asteroids seem to be more likely than comets to have contributed this vital substance to the inner solar system planets such as Earth.

ALGAE'S WORLDS

Whereas the ability of freshwater algae to produce hydrogen gas (as a clean energy source) was discussed in a previous synopsis, it seems that these algae possess a much broader repertoire. Researchers have shown that several genera of microalgae are capable of surviving in municipal wastewater and converting inorganic pollutants (e.g., ammonia, nitrate, phosphate) into natural oils that can be used for biodiesel. The required lipids are produced in the algal cells over a timespan of about a week, after which the algae are harvested and mechanically pressed to extract the oil. Finally, the algae are either composted or used as a feedstock to produce methane and ethanol. The seawater cousins of freshwater microalgae, known as phytoplankton, play an equally critical role in the oceans where they form the base of the food chain and assist in regulating atmospheric levels of oxygen and carbon dioxide.

CONFLICTS AND WATER

A substantial number of papers and books have been written about the role of water in global, regional, and local conflicts. On the local level, improved access to clean drinking water can keep children in school by preventing chronic disease and reducing the time required to collect and haul water. Children can realize greater economic and professional opportunities, thus reducing poverty and increasing so-called human or internal security. External security that is threatened by water conflicts is nothing new, but the added burden of climate change on water resources has increased the probability of regional, international, and even tribal disputes. Disagreements over rights to transboundary waters of diminishing quantity and quality are particularly problematic on a worldwide basis. How might this situation be different if people perceived water as a gift, rather than an inherent right, as apparently did many of our ancestors.

WATER JAZZ

The topic of underwater sound was discussed in a previous synopsis, but water as a subject for musicians and nature-oriented composers has produced some remarkable works and demonstrated that the sounds of water have a recognizable rhythm and pitch. The sounds of waterfalls and breaking waves have been relaxing muscles and soothing nerves for millennia. Recently, a British scientist suggested that water displays a quantum coherence that is similar to jazz because it permits both local freedom and global cohesion. Water has a vibrational range spanning more than 50 octaves, which corresponds to everything from molecular interactions to planetary rumblings. The extent to which water orchestrates or underlies these phenomena is unknown; however, the analogy of different water structures or networks playing the role of various instruments or musical tracks within a jazz tune is a thought-provoking one.

GEOENGINEERING WATER

Geoengineering remains a controversial "fix" for climate change due, in part, to its potential effects on planetary water. Ocean fertilization is a technology that adds soluble iron to the surface in an attempt to stimulate phytoplankton (microscopic algae) proliferation and consumption of CO_2. Ecologists warn that massive blooms could reduce local biodiversity and question whether the carbon-rich algal biomass would actually reach the seafloor before being respired back to CO_2. Similarly, geoengineering projects ranging from building berms and artificial reefs to importing clays and exotic plants have been proposed for Gulf Coast marshes devastated by oil spills, hurricanes, and altered hydrologic regimes. Critics note that past geoengineering schemes have been largely responsible for the present damage. So, is yet another round of geoengineering prudent or might nature restore the marshes before it's too late?

GPS TRACKING OF WATER

Using the global positioning system (GPS) to assist us in finding a place where we have never been is now fairly commonplace for most of us. Geoscientists utilize GPS networks to measure the movements of the planet's surface and, more recently, to measure attributes of the terrestrial water cycle in the form of snow cover, soil moisture, and plant water content. This is possible because a portion of the GPS signal reflects off the land surface near the antenna before reaching the satellite. Water scientists and managers use this data to monitor the real-time progress of droughts, floods, precipitation, and the uptake of soil water by vegetation that is characteristic of different regions. The largest GPS network currently consists of 1100 sites (antenna) scattered throughout the Western USA. Data from this network can be downloaded from the internet by researchers interested in the dynamics of local water cycles and watersheds.

TAP VERSUS BOTTLED

The quality of drinking water available from various sources has become a major controversy among experts, advocates, and the public. The bottled water industry has flourished for the last few decades based on the assumption that tap water is often contaminated with pollutants (e.g., metals, solvents) and additives (e.g., fluoride) that are removed by the processes used to prepare most bottled waters. The current backlash against bottled water is fueled by the arguments that it wastes energy (in many ways), creates more plastics (impacting human health and the environment), and is less regulated (for quality) than is tap water. While the dispute continues, no clear choice is provided to people who are genuinely concerned. Several water advisory groups suggest the use of home water filters, ranging in scope from activated carbon to reverse osmosis units, to treat tap water as an example of a hybrid choice that requires people's active participation with their own water quality.

EATING WATER

The term "eating water" refers to the observation that the largest component of a person's water footprint (about 90%) is devoted to food in the form of crop and animal production. By comparison, domestic water supply and industrial product contributions are relatively small. Most of this eaten water is *green*, meaning that it is rainfall consumed directly by food crops or by grasses that feed animals. In arid regions where rainfall alone is insufficient for food crops, *blue* water present in surface or subsurface environments (e.g., lakes, rivers, aquifers) must supply the remainder. Finally, agricultural and livestock operations produce biological and chemical wastes that must be diluted by so-called *grey* water to concentrations that meet water quality standards for health or ecosystems. The combined volumes of these three waters compose the major portion of a human water footprint; hence, changes in diet and food waste may be the ultimate keys to water conservation.

EPIC DROUGHTS

Australians have endured drought conditions for decades and, recently, Californians (and many living in the Western USA) are facing a similar situation. Neither of these two epic droughts is unexpected, as both regions are subject to cyclic rainfall patterns. Moreover, neither situation has or will be addressed solely by imports or technologies, which have permitted Californians to engage in activities (e.g., irrigated agriculture, population growth) that exceed the carrying capacity of local water resources. The state's water agencies have placed restrictions on residential and industrial water use, but this represents a small fraction of the water consumed in the state. Most of the water is used by agriculture (now impacted), fueling arguments that less water-consumptive crops should be cultivated and more desert-compatible lifestyles should be adopted. In any case, the focus is slowly shifting from technological miracles to rational activities.

CIVILIZATION COLLAPSES

Whereas short-term droughts can have a detrimental effect on the economy and ecology of regions, longer-term water shortages have collapsed entire civilizations. Researchers posit that the great Roman civilization thrived by importing grains that were grown in distant water-rich areas, which eventually experienced declines in production due to climate variations. As a result, insufficient water to produce food for the huge urban population of Rome may have initiated its collapse. Similarly, the highly advanced Mayan civilization probably succumbed to long-term drought, even though the frequency of hurricanes may not have decreased. At some point, the waters of the Yucatan's subsurface limestone system were insufficient to irrigate the crops required to feed a huge population. These collapses suggest that large populations dependent on consistent water supplies are vulnerable to even modest changes in climate.

PLASMA FROM WATER

Plasma is the so-called fourth phase of matter that joins the more familiar solid, liquid and gaseous phases. Most of the matter in our universe is plasma, which consists of charged particles (e.g., positive ions and free electrons) that are present in stars, outer space, and common electrical devices. Subjecting water to sufficient electrical or thermal energy breaks the chemical bonds that hold it together, producing a plasma stream that can be used to cut metals or to generate hydrogen gas as a fuel. Creating plasma from water can also serve as a means of treating potable water via producing the kinds of free radicals that are often used for disinfection and detoxification. Advantages of this plasma method include the relatively energy-efficient plasma reactors, the small volume of water required to generate sufficient plasma, and an absence of chemical byproducts resulting from the conventional treatment of drinking water.

WATER FROM PLASMA

As the predominant form of matter in our universe, plasma and its associated electrical currents seem to be ubiquitous in the cosmos and may give rise to more recognizable forms of matter—including water. The interaction of solar wind (plasma) with oxygen-containing dust particles in the cosmos may have created much of the water on the earth and moon. Moreover, a planet in the constellation Ophiuchus appears to contain huge amounts of supercritical water that results from the planet's high pressures and temperatures. This "plasma water" possesses the properties of both a gas and a liquid. Plasma currents in interstellar space are known to contain dust particles, as well as hydrogen and oxygen ions, leading some scientists to posit that water is continuously created via plasma discharges. From the photospheres of red giant stars to the water jets of quasars, is most of the water in our universe created electrochemically?

FOGGY RESOURCES

An underutilized water resource in coastal arid regions is the fog or low-lying marine clouds present in the evenings and early mornings. Condensation of the fog on native plants has permitted their growth despite precious little rain in regions such as California and Chile. Several working groups around the world have developed simple catchment technologies to condense fog water and collect it to provide everything from garden irrigation to a premium drinking water. Each square meter of collection surface (a fine mesh) can produce 2 to 7 gallons of water daily that varies in quality depending on air pollution overlying the sea and coastal hills. There are studies currently underway to pinpoint the most productive places to collect fog water, which is produced under a narrow range of topographic, oceanic, and atmospheric conditions. Unfortunately, the heat associated with urbanization has reduced the extent of fog near coastal cities.

ENSO AGAIN?

The press is buzzing with the prospect that a 2015-2016 ENSO event could be the most powerful in almost 20 years. ENSO (El Niño/Southern Oscillation) is the combined oceanic and atmospheric event resulting from unusually warm surface waters in the eastern equatorial Pacific Ocean. Drought-stricken Californians hope ENSO ushers in a wet winter; however, ENSO events don't always bring heavy rains and the global climate has changed in the last two decades. Even if heavy rains do arrive, they will not end the drought conditions in one winter, but they may result in widespread urban flooding. Most urban runoff in California cities is diverted into concrete canals that empty into polluted coastal waters. Los Angeles is now building stormwater capture basins to utilize the runoff as a water resource to treat or to recharge aquifers. In either case, Californians are learning they cannot take any water for granted.