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Biomimicry Workshop - Team H20, Final Challenge

***Introduction:***

Water is an essential ingredient for the existence of life. All species must be adept at collecting, storing and distributing water, or suffer the consequences and perish. With humans as the exception, organisms collect and store only the amount of water needed for survival. Water is distributed to points of use using low energy processes such as gravity, capillary action and evapotranspiration, which do not require energy sources other than the sun and do not result in carbon emissions. In contrast, humans tend to collect and store more water than is needed to sustain life, sometimes using it for other purposes such as electricity generation. Human distribution methods are often energy intensive, requiring pumps, motors, and electronic metering systems, and resulting in huge amounts of loss from evaporation and leaks in the distribution system. Large amounts of energy are used to collect water from surface water and groundwater sources, transport the water to treatment facilities and then redistribute treated water to a variety of points of use through miles of waterlines. **We took on the challenge to examine nature for ways to collect, store, and distribute water with minimal energy use while contributing to the overall health of the local ecosystem.**

***Process:***

With the help of an EPA research assistant, Nessly Torres and our own investigations using AskNature.org, we developed an extensive list of organisms that exhibited unique and ingenious strategies for collecting, storing and/or distributing water. We were particularly intrigued by species that could perform this feat in dry, harsh climates.

* Useful water collection methods were demonstrated by the Namibian Desert Beetle and the Thorny Devil. The Namibian Desert Beetle collects atmosphere moisture from fog using tiny hydrophilic bumps on its back that aggregate fine water particles into droplets, while the Thorny Devil uses micron-sized channels in its flesh to collect water from surface sources and rain events.
* The Barrel Cactus can store large volumes of water collected during storm events for use during drier times by expanding its accordion shape and utilizing its thick waxy skin as a barrier to evaporative loss. In contrast, the Pill Bug is able to reduce moisture loss during dry periods through conglobulation, or rolling up in a ball.
* Water distribution in nature takes place in nature a variety of ways, but there were two methods that we found most useful in meeting our challenge. One is using gravity to channel water flow directly to the point of use, such as the Agave plant and the Nambian Desert Beetle. The second is capillary action whereby water can be lifted over 300 feet vertically, as in the case of the Giant Redwood.

***Product:***

While we initially struggled with how best to assemble our research and create a product that would guide us in selecting from Nature’s wealth of strategies to meet the goal of our challenge, Tayrn Mead of the Biomimicry Institute helped guide us toward developing a matrix methodology. In this approach, we developed a series of questions within each of the six Life’s Principals categories that related to each of the functions (collection, storage, distribution) (Table 1). The information collected using these questions is then used to identify site-specific strategies for collecting, storing and distributing water with minimal energy use while contributing to the local ecosystem. The matrix approach allows us to use this tool in any environment, from arid regions to rain forests, and on any scale, from a garden plot to a community.

Some of the questions are fairly generic, such as local precipitation and climate, whereas others focus heavily on local conditions and examples of success. However, all of the questions are relevant in any environment and for any sized project. This allows the project team to focus on local data collection and assimilation for development of site-based strategies, thereby expediting the design process, while keeping Life’s Principals at the forefront.

***Conclusion:***

Team H2O is made up of folks who, on paper at least, would seem to be on the opposite ends of the spectrum. With three engineers versus an environmental studies student and a riparian ecologist, the cards would seem to be stacked on the side of an engineered solution. However, through use of the Biomimicry approach to meet our challenge, we were able to arrive at a mutually agreeable solution within our interdisciplinary team. Differing perspectives and conflicting approaches led to a more robust solution, a solution which encourages us to consider each of Life’s Principles and that builds off the knowledge of the local people and local environment. Thank you, Nature.

***Team H20***

Mary Blanchard – Civil Engineer, San Juan National Forest

Greg Hill – Environmental Student

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Myla Kelly – Coordinator, Peaks to Prairies Pollution Prevention Center, Montana State University

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| **Desired Action** | **Life’s Principles And Nature’s Strategies Associated with each Desired Action** |
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| **Adapt to Changing Conditions** | **Be Locally Attune and Responsive** | **Be Resource (energy and material) Efficient** | **Integrate Development and Growth** | **Evolve to Survive** | **Use Life-friendly Chemistry** |
| **Collection** | * What are local climate conditions and extremes
* Is there variability in water need by season and how does that correlate to precipitation and stream flows
* How does nature respond to seasonal variations in water availability to maintain a stable ecosystem
* How can the collection system be designed and implemented to be dynamic
 | * Local annual precipitation
* Depth to groundwater
* Groundwater aquifer characteristics
* Watershed characteristics
* How do native species collect water
* What speed is required to collect water
* What are the threats and competition to collection/supply
 | * What materials are available locally
* What are local natural basins that collect water
* How is water collected locally with little or no energy use
* How is waste mitigated and used
 | * How are energy, water, and other resource recovery/reuse achieved
* How can collection systems minimize flooding
* How can manmade development be sized and structured to utilize resources available locally without reducing the abundance and distribution of those resources throughout the ecosystem
 | * What multiple, local, source locations are available
* What are the different methods available
* What catastrophes could disrupt each water collection source and how would nature adapt to this disruption
* How have historical events (geologic, climatic, disturbances)shaped nature’s collection strategies
 | * What passive collection methods are available / locally viable
* If pumping is required, is solar or another form of renewable energy available
* Avoid using repeating/ continuously polluting pumps or toxic chemicals
* What materials or mechanisms are available locally that best mimic nature’s collection strategies and reactivity with water
* How may materials or mechanisms to collect water be leveraged to compliment each other
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| **Distribution** | * How does water movement in the vegetation and across the landscape change with season
* Is there a continuous need for water
* Can distribution systems handle much more/less water than usual
 | * What are potential source elevations relative to points of use
* Local geology, topography
* Existing distribution infrastructure
* How do native species move water
* How may interruptions to distribution be mitigated
 | * Local topography
* How do local natural collection basins relate to the point of use
* Is solar energy or gravitational potential plentiful which can be utilized to passively move water
* Can energy be recovered to use in the process
 | * Can natural water routes be utilized instead of installing pipes
* Can distribution systems function to clean water
* How is the distribution within the local ecosystem integrated such that one species waste becomes another’s source
* How does nature provide for the sustainable distribution of water throughout the local ecosystem
 | * What methods of water distribution can be observed locally
* Can distribution system be moved/modified easily to evolve with changing sources/needs (i.e. not burying pipes which are expensive to move)
* How does the local ecosystem modify distribution methods to adapt to changing (seasonal or catastrophic) conditions
* What events of the past (geologic, climatic, disturbances) have shaped natures distribution strategies
 | * Can non-manmade distribution systems be utilized
* Can local materials be utilized as pipes (i.e. bamboo)
* What materials or pipe are available locally that best mimic nature’s distribution strategies and reactivity with water
* How is required water quality achieved
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| **Storage** | * What climatic conditions may affect water storage (freezing, ambient temperatures, cloud cover verses sunny days, atmospheric moisture, etc.)
* What geologic conditions may impact storage
* How do natural systems provide for storage to offset use during dry seasons
 | * Local climate conditions
* Budget
* How do native species store water
* How much water does the local ecosystem need to function
* What contingencies exist
 | * What locally available materials can be used to store water
* What natural components of this system provide the most successful water storage
* How do the local systems minimize water loss
* How is the stored resource protected?
 | * Can storage areas provide habitat for local species
* Can storage be distributed and local to collection
* How does nature successfully cull the local species and provide storage during periods of drought to prevent collapse of the ecosystem (what is sacrificed for the good of the whole)
 | * Can local plants be utilized to store water (i.e. cactus)
* How many different methods can be observed locally
* How does nature vary storage strategies to adapt to changing climate trends (seasonal and long-term)
* What events of the past (geologic, climatic, disturbances) have shaped natures storage strategies
 | * Can non-manmade storage containers be utilized
* What materials does nature use locally to most effectively store water
* What materials or storage containers are available locally that best replicate nature’s storage strategies and reactivity with water
* How is storage maintained to protect the quality of the water
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