Leonardo Da Vinci

"Occasionally heaven sends you someone who is not only human but divine, so that through his mind and the excellence of his intellect we may reach to heaven."
Vasari, Lives of the Artists

Three engineers were trying to decide what type of engineer God was when he created the human body. The first engineer, an electrical engineer, said, "God had to be an electrical engineer like me. Just look at the nerves and how the body communicates with electrical signals". The second guy said, "No you got it all wrong. God was a mechanical engineer. Just look at the how the muscles and joints work together. Look at the dynamic flow of the blood and how the heart operates like a mechanical pump." The third guy told his two friends they were both wrong. He said, "God had to be a civil engineer because who else would design a waste water system through a recreational area". ☺

I feel that the quote at the beginning of the report describes Leonardo Da Vinci perfectly. When I think of God as an engineer I believe that he created Da Vinci, so that through his mind and the excellence of his intellect, we may better understand, "living and artistic engineering." In this report, I will present Leonardo Da Vinci as a Master of Water with an artistic understanding of the correlation between: the engineered human body and how the forces of nature revolve around fluid mechanics.

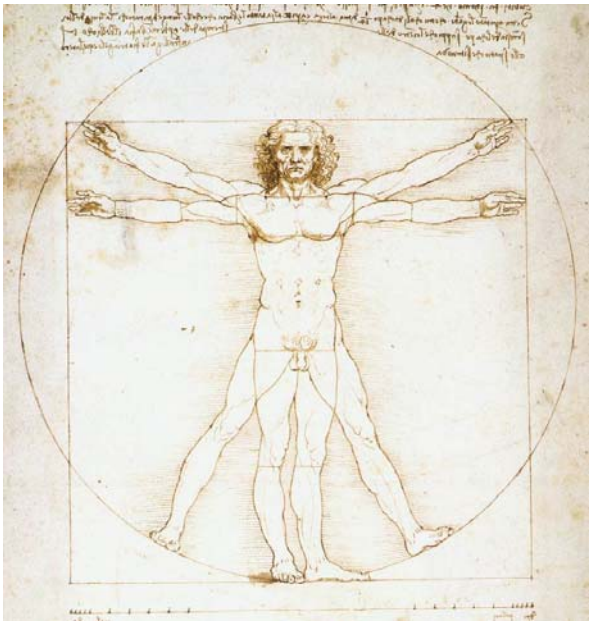
The following quote is derived from the same general analogies and distinct parallels that Leonardo Da Vinci used when he made the connections between the living human body and the living earth.

> "The earth has a vegetative spirit in that its flesh is the soil, its bones are the configurations of the interlinked rocks of which mountains are composed, its tendons are the tufa, and its blood is the water in the veins; the lake of blood that lies within the heart is the oceanic sea, and its breathing is the increase and decrease of the blood during its pulsing, just as in the sea is the flux and reflux of the water; and the heart of the spirit of the world is the fire that is infused throughout the earth, and the seat of the vegetative spirit is in the fires, which various locations in the world spouts forth in mines of sulphur and in volcanoes."
>
> (Codex Leicester, 1508)

These connections can be envisioned twofold by looking at the human body and the living earth as a whole, while also mirroring the configured parts of each separately. Da Vinci labeled the human side of the analogy as "microcosm", and the living earth as "macrocosm". Through experimentation and dissection, Da Vinci was able to become more familiar with the microcosm dimension of the comparison, and with his artistic

ability he described his understanding of the body as a whole, and each individual part, visually.(2)

Referring back to the lighthearted joke at the beginning of the report, I feel that if God were classified as any of the three types of engineers described (when he created the human body), you will in fact gain a better understanding of how Da Vinci made the connections that show how, "harmonious proportions make the component parts react simultaneously…to be seen together and separately."(1) In this way, microcosm is related to macrocosm. Da Vinci was convinced that the study of the components of the human body and the functions of each individual component would lead to a better understanding of the powers of the universe. Much like an electrical or mechanical engineer, he investigated the systems of the nerves and arteries, anticipating a connection between the principles of blood circulation with the further analysis of external fluid mechanics. Da Vinci also used structural analysis, much like a civil engineer, to further analyze how important proportion was in not only the human body, but also in sounds, weights, time, and position. This structural example is a great illustration of an artistic accomplishment that was inspired by Da Vinci's quest to fully understand the engineered human body and how the forces of nature revolve around it. This drawing by Leonardo, now in the Academy at Venice, was reproduced in an edition of Vitruvius' book, published in 1511. It is a great illustration demonstrating how the same human body can be inscribed in a square, and then when spread outward occupies a circle revolving around the navel. These proportions of the human body are related to the most perfect geometric figures. Man is the measure of the universe, it proclaims.(1)



When trying to understand the forces of nature that revolve around fluid mechanics, the use of geometric configuration can simplify the complexity of the irregular features of earth into a easier understood basic situation. However, the different

forces of nature can even turn a stable situation into a compound system subject to continuous change. For example, as the rain falls on the mountains, carrying the eroded rocks, soil, and silt to the lower regions, mountains collapse and dammed-up lakes burst flooding the lands below. These internal parts of the living body of the earth are very unstable. Just as in a human body, the substance of the earth is not in uniform density, and as a result of collapses, tremors, and eruptions it creates a net effect of significant water movement in relation to each other. An example of a nearby significant transport of water that was very close to Leonardo Da Vinci is the filling of the Mediterranean Sea. Proportion plays a big role in the explanation of the Mediterranean. Every valley has been carved by its river, and the proportion between the valleys is the same as that between the rivers. In this case the Mediterranean, which moves from the sources of the Nile to the Western ocean, represents the stability factor in the equation. The river which was formed by different forces finally creates a balance by carrying the water back out of the system.(1,2)

Certain natural analogies and metaphors began to emerge as Leonardo further investigated the systems of the human body that perform necessary functions, with relation to powers of the universe. A specific example dealing with fluid mechanics would be a forest of trees, with roots, trunks, and branches. Using this analogous system Da Vinci was able to devise a scheme that demonstrated how the human nervous and vascular systems in isolation were much like trees. Leonardo pointed out the similar characteristics inherent in the role the germinating seed plays with the roots and branches and the function the heart plays for the veins. This parallel is drawn from fluid mechanics in that the total cross-sectional area at any level in the system should equal every other. In comparing the case of the germinating seed that supplies roots and branches the total amount of air that enters the trachea is equal to the number of stages generated from its branching. This compares with how the total size of the branches added together equals the size of the trunk of the tree. In a human body Da Vinci was able to take advantage of Bernoulli's Law that stated that the amount of fluid passing through a tube at any point was proportional to the area of the cross section of the tube. Leonardo was now able to understand the different pressure systems that enabled the

heart, as the origin of this "sea of blood" to disperse the blood throughout the human body in a system of branch like veins.(2)

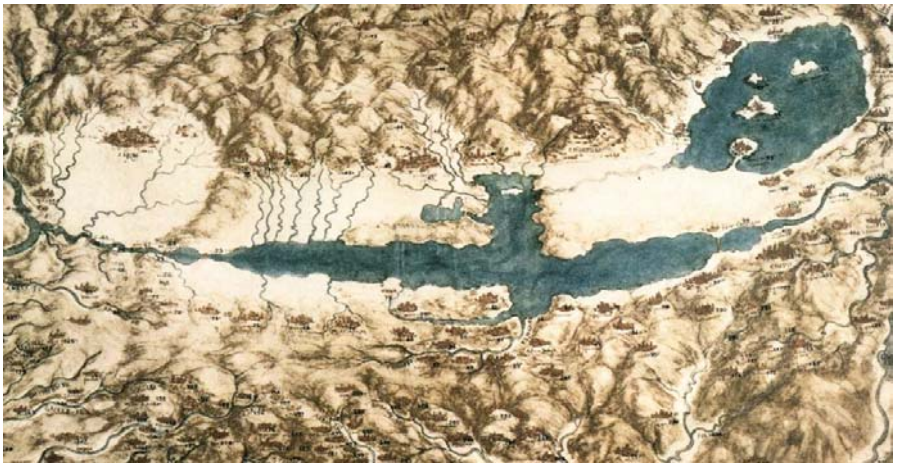
In order for Leonardo to state this assumption as a physical law, he needed to look at it from a different perspective and see if there is a correlation between this mechanism that performs necessary functions in the human body and a similar mechanism in a macrocosm case. It turns out that if you compare the flow of blood from the heart to the veins, it is inversely proportional to the flow of water from the rivers into the massive sea. This understanding of cross-sectional area can be used analyze pressure oriented-flow [power flow], which can be implemented to the development of other practical engineering projects.(2)

After analyzing the different restrictions of pressure and flow, Da Vinci began establishing laws that governed the release of this power and transmission. The best conclusion that evolved from this understanding was the realization that it was better to work with water than against it, as water could be readily pushed around. Why not control this power and use it for mechanical work?(1)

Now that Leonardo Da Vinci had these laws that described the different forces and different flow patterns of water, he was able to put his ideas to practice. He began developing and systematizing schemes of canalization, irrigation, and drainage. Other engineering accomplishments were created by the utilization of waterpower for pumping, sawing, and grinding applications. This awareness of the power of restrained water to create *turbulenza*, or vortices that eroded the rock, also enabled Leonardo to prevent a house on the bend of a river from being fatally undermined.(2) He was able to devise redirected flow patterns upstream from the bend of the river, and now instead of worrying about the effect of erosion, he was able to use fluid mechanics to avoid the problem. Da Vinci was indeed involved in providing practical services as a "Master of Water," he also did not shy away from large involved projects that required the intense analysis of forces and flow. For his work at the port of Piombino, it required the knowledge of the natural movements of water.(1,3)

His understanding of all the components involved in the entire process that revolves around the role that fluid mechanics plays in the irregular geometric configuration of the living earth also influences another one of his artistic

accomplishments. The schemes for the maps that Leonardo Da Vinci formulated are



extraordinary. His maps have been described as a blend of order and chaos that create a rhythmic ensemble that goes far beyond simple description. The greatest part about his maps in my mind is that every one of his maps always conveys the living body of the earth as a living entity. This perfectly related to Da Vinci's preliminary understanding that he gained from analyzing the human body, and subsequently applied to experiments in dynamics. Several of his maps depict rivers that actively pursue turbulent courses, and then finally "breathe" into the sea, completing the final remarkable inspiration of living flow.(2)

For Leonardo, the "beauty" of flow is to be discovered in the unique relationship between a microcosmic scheme, such as the body's circulatory system, and the macrocosmic complex structure of waterways, and the power inherent in each. The test of one is to be found in the existing dynamics of the other. He found a preliminary explanation for the phenomenon of human blood flow, such as it related directly to fluid mechanics' principles, specifically power flow, but he could only infer how a power source like the heart muscle could initiate life-giving flow within arteries and arterioles, and veins and capillaries [although he could not have been aware of the smaller organelles]. His model was based on what he learned from observation about water flow, and how impeded flow could supply potential and kinetic energy, so that he was virtually on top of discovering an important formula within Bernoulli's Law (Codex Madrid I). Leonardo would study wavelength, aerodynamic flow, cresting of water, watermills, and irrigation design along the same lines. For him, transport of fluid also carried energy, and he could see how the power could be harnessed and circulated to create work. His sketches show how he intended to discover in dimension near-perfect quality, and he

drew his conclusions on these measures from classical models that relied on perfect shape, [geometric] form, effect, and result, and we know that he relied on certain classical philosophy to help him make conclusions. Mostly he was a field observer, so he could not be helped in ascribing perfect form with perfect systematic production—in this case fluid flow. In this way, engineering and art found perfect synthesis within him, and his models reflect this.

List of Sources

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LEONARDO Da Vinci Italian painter (b. 1452, Vinci, d. 1519, Cloux, near Amboise. Illustration)