SHADHRAH 4 شذرة ٤

Why does ice float on water?

When al-Bīrūnī asked this question in a letter to Ibn Sīnā almost a thousand years ago, he did not have the tools now used to study molecular structures, hence he did not know that in a water molecule, two atoms of hydrogen are attached to one atom of oxygen at an angle of 104.5°, and that therefore, upon freezing, water molecules cannot stack upon each other to form compact layers as they would if this angle was 180°. Of course, he was also unaware of the important role played by the mutual attraction between hydrogen and oxygen atoms—and the resultant hydrogen bonding—in the structure of this most important of all compounds that is involved in nearly all biological, geological, and chemical processes and without which life is impossible. Al-Bīrūnī did not know that in ice, each water molecule is typically linked with four others through hydrogen bonding, forming an ordered crystal structure whereas in its liquid state, these hydrogen bonds break and reform on a picosecond time scale, allowing a statistical distribution of the different possible coordinations. This flexibility eventually makes liquid water denser than ice, hence ice floats on water.

Ibn Sīnā's response to al-Bīrūnī's question was also not informed by discoveries which now form part of every sophomore chemistry textbook. Neither of them had any way of ascertaining the nature of hydrogen bonds, which are ten times weaker than the covalent bonds between oxygen and hydrogen, but which still require a lot of energy to break, resulting in slow melting of ice at above zero temperatures.

Unaware of the ephemeral patterns formed by bonding in the liquid state of water, Ibn Sīnā wrote back to al-Bīrūnī saying that upon freezing, water preserves airy parts in its lattices which prevent ice from sinking. This explanation is, of course, not satisfactory and our current understanding of the molecular structure of water is far superior to what both Ibn Sīnā and al-Bīrūnī knew. There is, however, a common domain of understanding that has not changed

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over centuries: everyone knows that without water, life perishes and no amount of technological development can allow humanity to store all the water required to sustain life on this planet; it has to be regenerated through a vast cycle which is only possible due to the peculiar properties of water such as condensation, evaporation, its relatively high boiling point, its specific viscosity, and other properties. This knowledge is available to everyone and does not require any sophisticated tools or scientific training; every single rain drop falling from the sky brings with it a refreshing reassurance of the veracity of this phenomenon.

Al-Bīrūnī and Ibn Sīnā did not have the advantage of using X-ray absorption spectroscopy to investigate the structure of water, but both of them were scientists whose worldview was informed by the Qur'ān and both of them knew that there were *signs in the water pouring down from the sky, giving life to earth after it had become lifeless, causing all manner of living creatures to multiply thereon* (*al-Baqarah*:164). This they knew to be true, just as they knew that there was much more to be discovered in the *change of the winds, and the clouds that run their appointed courses between the sky and the earth*, for therein were *signs for those who use their intellect* (*al-Baqarah*:164).

They knew this because they operated within an ordered cosmos in which all living things were known to have been created from water by a Wise Creator Whose inexhaustible knowledge was beyond the fancy of any creature and Who had created everything with a measure, for a fixed duration and for a purpose. They did not know the chemistry of the water molecule that allowed ice to float on water but they knew that, had the ice been heavier than water, oceans would freeze solid during the long winter months, making it impossible for any kind of marine life to exist. They also knew that this disruption in the oceans would eventually make it impossible for any life to exist on this planet, because they were conscious of the presence of another force in the physical universe that unified its numerous components into a synchronized and harmonic whole that operated in a manner beneficial to life and existence. They did not have the precise details of the solar and lunar orbits but they knew that there was something extremely meaningful behind the alternation of the day and the night and in the precise movements of the sun and the moon.

This worldview, gleaned from the Qur'ān, was not merely a static dogma; it was informed by a process of careful observation and reflection that investigated the physical universe in order to understand what lay behind the orderly appearance of the night and the day, the sun and the moon, the stars and the planets. Ibn Sīnā and al-Bīrūnī were not merely interested in cataloging facts; they were more interested in using the scientific data to understand the mysteries beyond the realm of the physical universe and this is why their scientific endeavors were meaningfully linked to a spiritual realm beyond the physical.

This inherent link between the physical and the spiritual realms was part of the vast enterprise of science in the Islamic civilization. It was like a unifying ray of light that infused arches built by Muslim architects with an unearthly luminosity just as its metamorphic qualities led Muslim astronomers to transform their dry facts and figures into an understanding of the orderly rotation of the planets and stars that pulsated with the consciousness of the living presence of the Creator.

This is not an idealized recall of a tradition that has suffered a devastating blow during the last three centuries and that has now been pushed beyond the pale of existence by modern science built upon a worldview quite contrary to its predecessor; this metaphysical aspect of the Islamic scientific tradition can be ascertained through thousands of manuscripts and books still at our disposal. This Islam and science nexus can still be "experienced" by walking through the winding streets of Fez, planned hundreds of years ago in a manner that was typically Islamic. Closed and windowless to the outer world, the walls of the houses standing in these ancient quarters protect an open courtyard from the stray glances of pedestrians and allow the dwelling places inside to receive light and air. These streets are circular because only the concentric circles provide equitable access to a center, which is not only the center of the material world thus constructed, but also the spiritual center of the community: the central mosque. These streets and the side streets that radiate from the center, like spokes on a wheel, provide maximum access to the mosque as well as to the commercial activity yet do not allow the outside world to intrude into the privacy of the homes. And when the call to prayer is chanted from the high minaret of the mosque, one can still verify that those who designed the dome and the

minaret, using their scientific skills and technological knowledge, knew how to transform space and silence into a chanting remembrance that renews the nexus between God and those who respond to His urgent invitation.

The circular streets—which appear like *cul-de-sacs* but lead to an intricate pattern of life—are living reminders of the importance of privacy in individual matters that is part of the Islamic teachings. The marketplaces in these old cities still pulsate with this worldview; they are not merely impersonal places where faceless traders and equally anonymous customers exchange money and goods; rather they are warm and personal places where relationships are established, news and pleasantries are exchanged, goods are bought and sold and when, in the middle of a bargain, the call to prayer is heard, both the seller and the buyer go together to the mosque, where they stand shoulder to shoulder, facing the same direction.

This is why not only the physical sciences, but also the arts and the crafts that utilized science and technology, were informed by the same worldview and the same aesthetic sensibility that visualized space as a sacred dimension of existence, stretching out to the heavens. Likewise, thousands of traditional goods still being sold and bought in these ancient cities are testimonies to the presence of this integral link between Islam and the scientific tradition it produced, for whether they be carpets, utensils or clothing with intricate designs and motifs, all have living expressions of these inalienable links.

This is true of Fez, just as it is true of all other traditional Islamic cities such as Iṣfahān and Damascus; they all fully utilized technologies based on principles which did not produce fissure with nature; rather, they enhanced the sacred dimension of time and space.

Wuddistan
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