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'Aqualisation' of neuraxis: Wondrous neuraqua CSF

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Domenico Cotugno (Cottunius), Professor of Anatomy at Naples, pioneered an adequate description of CSF in 1764. The term cerebrospinal fluid (CSF) was first used by Francoise Magendie in 1827. Since then, the term and the concept have served medicine well, meriting now a more wholesome appreciation. CSF as a term/concept turns out to be too abrupt, not telling whether the fluid is from/around/across/within the neuraxis, nor has any allusion to the wide subarachnoid space that has the temerity to extend well beyond the lower limit of the so-called spinal cord.

The 18-lettered term 'cerebrospinal fluid' may be replaced by an 8-lettered neologism 'neuraqua', which is evocative, euphonious, euetymologic and extensively embracing. Anatomic and physiologic data render it clear that neuraqua is all around, through, in and from the neuraxis, being secreted not only by the choroid plexus but also by the 'brain parenchyma' itself. Neuraqua makes the neuraxis, inflates it from within to shape the ventricles, surrounds it to render it weightless and moves through the neuraxial wall to make one continuous neuraqual whole that suspends not only the whole neuraxis but every single neuron, neuroglial cell and synapse.

Neuraqua that renders the neuraxis essentially weightless can be called buoyaqua or buoyneuraqua. This is in line with the fetus rendered, in utero, weightless by the amniotic fluid, to deserve the appellation amnionaut, much like the weightless astronaut in the outer space. The neuraxis is *neuraquonaut* by the simple expedient of having its specific gravity almost identical with that of the neural substance. 'The brain weighs about 1400 g in air, but in its "water bath" of CSF it has a net weight of only 50 g.' The buoyed brain keeps the wider part of the brainstem off the unvielding foramen magnum so that the vertebral arteries are free of pressure, nor does it exert weight on the underlying/overlying venae magna (venous sinuses). The Pascalean hydrodynamics of neuraqua make it a fail-safe cushioning medium for the neuraxis, so strong that it requires repeated raining of punches

before a boxer develops dementia pugilistica.

The near isodensity (difference of 4%) of neuraqua and neuraxis offers the possibility of their commutativeness whereby one becomes the other, a ceaseless two-way traffic. No wonder that the commonest form of (socalled) hydrocephalus is *normal-pressure hydrocephalus* wherein the age-related shrunken brain enlists the help of an additional volume of neuraqua to fill in the intracranial gap.

The neuraqual universe can now be given its subsets. Cytoneuraqua forms neural tissue, neuroglia too, providing them with a separating milieu of intercytoneuraqua or extracytoneuraqua. The manifest neuraqua is ventraqua, in ventricles, to give them and maintain their shape and buoyaqua that fills the subarachnoid pace. The neuraqual *advaitism* should be self-evident. No subset is separable from another, all the subsets making a gestalt whole that ceaselessly communicates and commutates.

The buoyaqual compartment is a double-walled cushion between arachnoid and the pia meriting the appellations subarachnoid/suprapial/intermeningeal/ interleptomeningeal neuraqua. Myelocanalicular (i.e. in the central canal of the cord) neuraqua and Sylviodochal neuraqua (in the Sylvian aqueduct) are small but significant subsets. The triad of neuraqual foramina midline of Magendie and the two lateral of Luschka - allows free communication between neuraqua within and around the neuraxis.

The substratum for all the nuances of neuraqua is a miracle called aqua, H₂O or plainly water. The *Encyclopedia Britannica* bristles with '*Abnormalities in the properties of water*', namely highest specific heat, infinite incompressibility, high dielectric constant that provides it with highest solvency, ionizing power and so on. Guy Murchie in *The Seven Mysteries of Life* poetizes that 'Life on Earth and perhaps life mostwhere, is primarily organized water.... A new-conceived human embryo averages 97 percent water, a newborn baby 77 percent and a grown man 60 percent'. Since neuraxial development dominates early embryogenesis, it pays

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to generalize that it is water that gets configured as our neurons and neuroglia.

Romer, a celebrated anthropologist-author from Harvard, in his classic *The Vertebrate Body*, musing over the endless quarrel embrylogists have had on whether the iridal sphincter is ectodermal or mesodermal in origin, concluded that 'Nature in her pristine innocence forgot to read the textbook of embryology'. Water, in its pristine innocence, exercises its divine right to flout many an established law of physics so as to invite the judgemental slur of 'anomalous' behavior in more than one way.

Among the four basic elements - air, water, fire and earth - water is the simplest. Water manifests its miraculousness by having the daring to expand on cooling, an event scientifically called 'anomalous' for no science can explain why an iceberg that cut into the 'unsinkable Titanic' should have been lighter than the Atlantic water that gently flowed around the sinking ship and its 1503 sunk lives on April 14, 1912. In the lightness of the rocklike ice or mountainous iceberg and the heaviness of the ripple of water resides the ability of marine life to survive merrily despite the deepest frost in the oceans. Nature asked water to *think* transcendentally so as to defy the laws of ordinary physics. Water thinks. At the Last Supper, Christ had no wine to start with. But when he looked into the jug to see how much water there was, water saw its Master and blushed red. So Christ ended up serving red wine to his disciples.

The manifest, thinking ability of water (its sciencedefying anomalous expansion on either side of 3.98 degree centigrade), its mystical emotional capacity, make water best qualified to be the seat of thought, in the animal frame, as neurons. The self-sameness between neuraxis and neuraqua, the two perpetually running into each other to be each other, renders it likely that neuraqua itself thinks, a bold assumption that allows many an imponderable to be, at best, comprehended. Guyton describes the various areas that neuraqua occupies and then generalizes. 'All these chambers are connected with one another and the pressure of the fluid is maintained at a *surprisingly constant level*. The added italics declare physiology's inability to explain the how of the constancy. Neuragual pressure-precision is amazing. At a pressure of 112 mm neuraqua, which is the normal average neuragual pressure, filtration and absorption are equal. Below a pressure of approximately 68 mm, neuraqua absorption stops. Neuraqua knows at what pressure to stop losing itself, so that the neuraxis is not denied its buoyancy.

The survival-symphony between the neuraxis and neuraqua is best illustrated by the spatial enormity accorded to cisterna interpeduncularis housing the hypothalamus and cisterna pontomedullaris cushioning the vital centers in the brainstem. Of the two leptomeninx, the arachnoid jumps all sulcal and flexural

gaps, while pia stays tethered to the surface resulting in every tiny sulcus cushioned by a mini-lake of neuraqua. A large posterior-fossa tumor threatening to compromise the vital centres gets held at bay by an unexplainable interposition of neuraqua. When there is neuraqual rhinorrhoea (CSF rhinorrhoea), the production of neuraqua is stepped up and its resorption brought to a grinding halt. Following accidental/operative trauma, neuraquastasis (neuraqual homeostasis) is maintained to assist recovery and survival. Enormous intracranial tumors remaining compatible with, often symptom-free life is thanks to the neuraqual wisdom in action-ready even to induce cerebral edema and flattening of gyri and the creation of ventricular hydrocephalus that forms a pressure balancing-opposite to the tumor, all these serving as a natural defense mechanism assuring functional integrity of the wider neuraxis. It needs to be noted that the so-called cerebral edema is an exaggeration of normal intercytoneuraqua that is compatible with the integrity and function of the neurons and neuroglia in the edematous zone.

Gray's Anatomy succinctly sums up some facts and figures on neuraqua.

'CSF is clear, colorless liquid which in normal individuals contains a very small amount of protein and differs from blood in its electrolyte content. The intracranial CSF volume has been estimated at 123 ml, some 25 ml in the ventricles and 98 ml in the subarachnoid space. Its ionic composition suggests that CSF is not just an ultrafiltrate of blood but there is active secretion by the choroid plexus epithelium. Choroid plexus epithelial cells have the characteristics of transport and secretory cells with microvilli on the apical surfaces and interdigitations and folding of the basal aspects of the cells. CSF is secreted from the apical surface of the epithelial cells at the rate of 0.35-0.4 ml per minute; this means that 50% of the CSF is replaced in 5-6 hours. A CSF barrier therefore exists and is sited at the choroid plexus epithelium. A dramatic demonstration of the blood-CSF barrier is seen at postmortem in jaundiced adult patients in whom the stroma of the choroid plexus is stained yellow by bile whereas CSF and brain remain unstained. As extracellular fluid from the brain parenchyma also drains into CSF, some 11% of CSF (in the rat) is derived from this extrachoroidal source. Other estimates vary from 30-60%.'

The term *blood brain barrier* is as abrupt and incomplete as CSF. Bloom and Fawcett are at pains to point out that 'it is important to recognize that it applies equally to the spinal cord'. Moreover, *barrier* is synonymous with *block, obstacle, obstruction, a sort of Berlin wall,* which surely neuraqual-secreting endothelium is not. Endothelium, per se, is now accorded extraordinary wisdom and power (*JAnat London*, Oct. 2007). So it pays to realize that what is thoughtlessly called a *barrier* is a highly computerized regulator of the transport between endothelium and neuraqua (either way) meriting the evocative ensemble Neuraqual Endothelial Audited/ Selective Transport (NEAT/NEST). In a deeply jaundiced human *sans* kernicterus, the neuraqual universe can declare to the rest of the yellowed body that our NEST is NEAT.

> In Nature's infinite book of secrecy A little I can read. – Shakespeare

Lyall Watson and Lewis Thomas, from either side of the Atlantic Ocean, have observed that the greatest discovery of the 20th century is of the profundity of human ignorance. We need to know that we know naught. The musings on neuraqua are but an exercise in the sense of wonder. From wonder comes reverence, which begets humility that enforces restraint that helps the practice of the Hippocratic *Primum, non nocere* as also the recently reasoned (*Neurology India*, March 2006) *Secundum, quieta non movere*, that pleads that 'pathologies' at peace with the owner be left unpersecuted. In all 'advanced' countries, iatrogenic (rather *iatral*) morbidity and mortality are competing with cancer and car-accidents. Unless we learn/teach how to wonder, we shall rush in where Angels fear to tread. Should the subject of a 'Sense of Wonder' (SOW) be integral to every medical curriculum?