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Excerpts from his book "**The Sacred Balance**" (Greystone Books / Allen & Unwin 1997)

We are the Air

In North America the history of settlement and conquest has created a powerful myth of the primacy of the individual, free to act and move as an independent entity. But from a biological point of view, this myth is a mistaken and dangerous version of reality. We are not completely independent and autonomous; when we look carefully at the interactions at every level between our bodies and the element that surrounds us, we see how completely we are embedded in air, all of us caught together in the same matrix.

Air is a physical substance; it embraces us so intimately that it is hard to say where we leave off and air begins. Inside as well as outside we are minutely designed for the 'central activity of our existence - drawing the atmosphere into the centre of our being, deep into the moist, delicate membranous labyrinth within our chests, and putting it to use. Breathing is controlled by the oldest part of the brain, the respiratory centre of the brain stem, a relic that originated before the dawn of consciousness.

Breathing is such a vital act that it has never been given over to the control of the later arrival - the conscious brain. Automatically, whether we are awake or asleep, that ancient link to our evolutionary past commands every single breath. From a newborn's forty breaths a minute, our inhalations slow to thirteen to seventeen in our later years but can escalate to eighty during vigorous exercise, all without a conscious thought. If breathing is interrupted, most people suffer irreversible brain damage after two or three minutes without air and the finality of death within four or five minutes.

Our bodies possess an extraordinary number of built-in safety measures, fine-tuned to obtain just the right amount of air. In the aorta and carotid arteries, oxygen chemoreceptors constantly monitor the level of oxygen in the blood. When oxygen levels fall, the receptors send out impulses to the muscles of the diaphragm and ribs to increase the rate of breathing. Carbon dioxide or acid chemoreceptors respond to rising levels of acidity in the blood, which result when dissolved carbon dioxide forms carbonic acid. Again, the receptors send messages to the muscles of the diaphragm and ribs to increase respiration to eliminate the carbon dioxide.

There are also mechanoreceptors guarding the airways and lungs. In the lungs, stretch receptors detect pulmonary inflation. When you take a breath, the receptors send a signal that regulates the length of time before your next breath. Additional receptors coordinate breathing with levels of muscular activity, and other nerve centres regulate respiration when you are anxious, in pain, sneezing or yawning. You can override your unconscious control of breathing by deliberately holding your breath. But soon the rise in blood-borne carbon dioxide forces you to take a breath. Since the window of survival is only a few short minutes, your body has evolved a host of strategies to ensure a steady supply of the substance it cannot do without.

Oxygen is the crucial component; it has the ability to combust by sharing its electrons with other elements. This process, known as oxidation, can be so rapid as to ignite a fire or can be imperceptibly slow, as when iron rusts, or at controlled rates, as when metabolism takes place in living organisms. In a cell, oxygen breaks down molecules such as carbohydrates and fats, releasing energy in the form of heat. In the process, oxygen becomes a part of liberated carbon dioxide or other breakdown products. Oxygen lights the fires of life and keeps them burning.

The Universal Glue

Since the entire gaseous contents of alveoli are not exhausted at each breath (when we are resting, only a tenth of the air is expelled), the air that is left keeps the alveolar sacs inflated and prevents them from collapsing. So air always remains within us and is as much a part of our bodies as any tissue or organ. We are a part of the air, which in turn is a part of all green plants and every other breathing creature.

After sharing space in a room with others, try a very simplified thought exercise. If you multiply the volume of air in the room by Avogadro's constant (the number of atoms in one mole of substance: 6.022×10^{23}), you will get an estimate of the number of atoms in the air in that room. (Assume the air is always mixed completely.) Then divide the number of atoms in the air by the volume of air inhaled times the number of breaths per minute times the time spent in the room times the rate at which oxygen and carbon dioxide diffuse across lung cell membranes. Even the crudest calculation reveals that each of us very quickly absorbs atoms into our bodies that were once an integral part of everyone else in the room, and vice versa.

The eminent Harvard astronomer Harlow Shapley once performed another thought exercise about air. He pointed out that while 99 per cent of the air we breathe is highly active oxygen and mildly reactive nitrogen, about 1 per cent is made up of argon, an inert gas. Because it is inert, it is breathed in and out without becoming a part of our bodies or entering into metabolic transformations. Shapley calculated that each breath contains about 30,000,000,000,000,000,000, or 3.0×10^{19}, atoms of argon plus quintillions of molecules of carbon dioxide. Suppose you exhale a single breath and follow those argon atoms. Within minutes, they have diffused through the air far beyond the spot where they were released, travelling into the neighbourhood. After a year, those argon atoms have been mixed up in the atmosphere and spread around the planet in such a way that each breath you take includes at least 15 atoms of argon released in that one breath a year earlier! All people over the age of twenty have taken at least 100 million breaths and have inhaled argon atoms that were emitted in the first breath of every child born in the world a year before! According to Shapley:

> "Your next breath will contain more than 400,000 of the argon atoms that Ghandi breathed in his long life. Argon atoms are here from the conversations at the Last Supper, from the arguments of diplomats at Yalta, and from the recitations of the classic poets. We have argon from the sighs and pledges of ancient lovers, from the battle cries at Waterloo, even from last year's argonic output by the writer of these lines, who personally has had already more than 300 million breathing experiences."

Air exits your nose to go right up your neighbour's nose. In everyday life we absorb atoms from the air that were once a part of birds and trees and snakes and worms, because all aerobic forms of life share that same air (aquatic life also exchanges gases that dissolve back and forth at the interface between air and water).

Air is a matrix that joins all life together. It is constantly changing as life and geophysical forces add and subtract constituents to the composition of air, and yet over vast stretches of time the basic composition of air has remained in dynamic equilibrium. The longer each of us lives, the greater the likelihood that we will absorb atoms that were once part of Joan of Arc and Jesus Christ, of Neanderthal people and woolly mammoths. As we have breathed in our forebears, so our grandchildren and their grandchildren will take us in with their breath. We are bound up inseparably with the past and the future by the spirit we share.

Every breath is a sacrament, an affirmation of our connection with all other living things, a renewal of our link with our ancestors and a contribution to generations yet to come. Our breath is a part of life's breath, the ocean of air that envelops Earth. Unique in the solar system, air is both the creator and the creation of life itself.

The Oceans Flowing Through our Veins

Had the earliest human explorers been transgalactic adventurers from another part of the universe, their first sight of this planet might have led them to name it Water. From space, you can see that ours is not the green planet but the blue planet, with its great oceans and its gossamer veil of clouds. An astounding 70.8 per cent of Earth's surface is ocean; with an average depth of 3.73 kilometres, the oceans contain a total of 1370 million cubic kilometres of water. When inland seas, lakes, glaciers and polar icecaps are included, a total of 379.3 million square kilometers - 74.35 per cent of the planet's surface - is covered by water. The landmasses above the surface are just bumps. If the solid part of Earth were to be smoothed and levelled, a single ocean would wrap the entire globe to a depth of 2.7 kilometres.

Human beings are landlubbers on this watery planet, island people marooned on dry land, surrounded by and dependent on an alien element, an old home we left long ages ago and yet carry still within us. Water is the raw material of creation, the source of life. When the waters break, the child is born from them, just as the gods of old parted the dark, primeval ocean and fashioned the Earth, just as the first land creatures struggled up out of the tide. Perhaps that is why water is at the heart of human ritual. Baptism, for example, often welcomes the child into the human family, washing away the past, marking a new start. The powerful symbolism of water - as transformation, purification, sharing - permeates our lives. Water flows through our memories: that sunlit swim in a creek, that wish made as a coin falls into a fountain, the spray onto the dirt floor preceding a sumo wrestling match. Our literature is saturated with our uncertain relationship with this crucial substance - the water we come from, the water we cannot do without, the water that may drown us or sweep away our world.

The ocean - shifting, changeable, mysterious - has a powerful influence on human life and grips the human imagination. Rising and falling around Earth's shores, it moves to more than terrestrial rhythms. Pulled three ways, by Earth, the moon and the sun, the tides wax and wane day by day, month by month, season by season, beating out the dance of planet, satellite and star. Somehow we have always known this and listened for unEarthly messages in the motions of the sea. The ancient Greeks called the messenger Proteus the old man of the sea, herdsman of the ocean's seals. He saw the future and would tell you the truth about it - if you could catch him. Metamorphosis was his escape; changing his shape from lion to dragon to a stream of water, becoming a flame, a tree, he slipped through your fingers in a dizzying series of transformations. In the same way, the waters he represented are eternal shape-shifters, continually transforming themselves and the rest of the planet. They bring us a strange and ancient truth that is hard for us to grasp: a vision of the sources of life and its endless metamorphoses.

<u>The Hydrologic Cycle</u>

If air is the fuel, the spirit that animates all living things, water 'gives them body and substance. Water was absolutely necessary for life as we know it to have evolved. Life originated in the oceans, and the salty taste of our blood reminds us of our marine evolutionary birth. But we, like many other animals and plants, cannot live on salt water. Our lives are made possible by the hydrologic cycle, the miraculous process whereby salty water is transformed into fresh water by evaporation and is redistributed around the planet. Energy from the sun causes water to evaporate from the ocean as water vapour, which rises into the atmosphere and then falls back onto the land as precipitation. Water reaching Earth's surface as rain seeps into the ground or runs into rivers and lakes and eventually returns to the oceans.

The hydrologic cycle is crucial to all life, though sometimes we may wish it were not. "It's raining again!" is a common complaint in Seattle and Vancouver. "It poured for five days," a disappointed tourist grumbles in the Choco rain forest in Colombia, forgetting that

the lush splendour he has come so far to experience was created and maintained by the rain he deplores. Prairie farmers gazing gloomily upwards into a cloudless sky understand the hydrologic cycle better than that. So do aboriginal people, whose rain dances beg the clouds to cry, and cultures in other parts of the world, whose elaborate festivals entreat the gods to send the life giving monsoons.

Living organisms are active participants in the hydrologic cycle, absorbing and filtering water and breathing it back into the atmosphere. Plants play a particularly important role through transpiration, or the loss of water through their leaves.

A forest is an intricate device for catching, holding, using, and recycling water. You might call it a living sponge, except that it is far more complex. That tangle of tree roots snaking across the forest floor absorbs water while holding the soil so effectively that creeks don't flood and the water flowing in them is clean and clear after many days of rain. Held in the soil, in roots and trunks and branches, the water is slowly meted out over days and weeks, and any excess is returned to the air. Millions of tonnes of water in tropical rain forests are lifted from the soil and thrust back into the sky by transpiration. Large areas of forest create their own local weather, raining on themselves and remaining moist during dry spells. At the same time, they modify the climate of the entire region and beyond. When large tracts of tropical rain forest are removed, the barren soil hardens, causing rain to evaporate or run off rapidly.

Biographical data

David Suzuki, born and raised in Canada from Japanese parents, is Canada's preeminent science broadcaster. He also carries a global reputation as a geneticist, professor, public lecturer, and environmental and civil rights activist. He lives in Vancouver.

Suzuki has been described as "one of the world's most effective popularizers of science, alongside Carl Sagan and Jacques Cousteau," mainly for his award-winning CBC program *The Nature of Things*. He has written numerous booksellers, including *Genethics, Wisdom of the Elders, Metamorphosis, Time to Change* and *The Japan We Never Knew: A Journey of Discovery*. He is also founder and chairman of the Suzuki Foundation, an organization dedicated to worldwide environmental issues.