the phases of knowledge of this "marine mammal" would be completely different from the earth-bound creatures that we are.

Modern science originated in observing the sky. Man has always been fascinated by periodicity, but what must be remembered is that planets and stars move in a void. We can isolate the celestial bodies. We can discuss the relation between two bodies (such as Earth-Sun) or among three bodies (such as Earth-Sun-Jupiter). These observations of the sky provided the starting point for the classic laws of nature formulated by Galileo, Kepler and Newton, with their determinist descriptions and the affirmation of an equivalence between past and future.

If man were a "marine mammal", the description of nature would be completely different: the void would be replaced by fullness. In addition, in order to describe this fullness it is necessary to abandon the classic Newtonian laws, bearing in mind water's resistance to movement: it is necessary to speak of entropy and turbulence. It would no longer be possible for phenomenology to reject the difference between past and future, a temptation to which classic science succumbed. Instead of the problem of two bodies, man as "marine mammal" would be confronted by collective phenomena. Irreversibility and randomness would be the starting points for describing nature. The possibility of simplified schematic situations, such as those of two or three bodies, would only be cleared up progressively.

These conclusions curiously coincide with the vision offered us during the last few decades by the science of disequilibrium. The physics of complete domination of nature, situations of equilibrium, determinist descriptions — these are the exceptions. What better illustration of these conclusions than the physics of water? Water is never in a state of equilibrium. It exists as a molecular formation because of the hydrogen bridges that unite the water molecules. These formations are in a constant process of transition. Water is a unique substance. It leads us to the current scientific paradigms concerning concepts of disequilibrium, irreversibility and randomness.

I am pleased to form a part of this celebration of water during the 1998 Universal Exhibition in Lisbon. We might even state that water transcends the opposition between permanence and movement. When one looks at the sea, one feels two sensations: that of being before something that has been eternally present since the origin of life, and that of incessant and renewed movement. What better symbol for our society in transition, in search of a form of coexistence between the custody of the cultural treasures of the past and the need for moving the world toward a renovation that might strengthen human dignity?

NOTES

In "Agua", published by the magazine Atlántica, in conjunction with the 1998 Universal Exhibition in Lisbon.

[1] Wahl, Jean: *Traité de Métaphysique*. Payot, Paris, 1968.

THE PASSAGES OF WATER

KLAUS LANZ

Thalassos. Oceanus. Moana nui. Il mare. The sea.
Vast. Limitless. Depths beyond imagination. Bright and dark. Division and connection. Enemy and provider. Depending on perspective, the ocean may represent the ultimate obstacle or eternal promise.

Despite centuries of seafaring, tales and poetry, science and measurement, the ocean's true nature still escapes the human mind. Even today, in the age of instant global communication and space travel, we know surprisingly little of the inner workings of these immense bodies of water. A most striking example is the Gulf Stream, that massive marine river pushing warm water from the Gulf of Mexico into the North Atlantic. Scientists understand now that this flow of heat saves Scandinavia despite its high latitude from the fate of a Siberian climate. But no-one can explain what exactly regulates this water movement or predict how this delicate Atlantic heater will react to changes in climate.

Another marine mystery has been christened El Niño: an extraordinary warming of surface water in the south-eastern Pacific, it turns global weather patterns upside down, causing floods in dry regions like Sudan and Kenya and bringing drought to Indonesian rainforests by altering monsoon pathways. The ocean turns out to be an organism, with its different seas connected and listening to each other. An organism with veins of currents carrying the sun's warmth from tropical seas to temperate latitudes and nutrients from coasts to the high seas.

The oceans also charge the winds that blow across their surface with moisture, extending their reach into the terrestrial third of the earth. Together with the sun's rays, marine moisture carried across the continents is the most important regulator of the land's heat budget. It brings cool relief to parched fields, it melts ice and snow after long winter months. Without atmospheric moisture, the sun's desert heat and the space cold of an arctic night would render the earth as uninhabitable as the moon.

THE CHALLENGE OF THE LAND

Where the water in the oceans comes from is an ancient question. And why there is little or no water on the moon and on the other planets of our solar system. Scientists are still debating whether the water in the primeval oceans was formed by a chemical reaction from hydrogen and oxygen formerly bound in rocks, or whether the earth has been bombarded (and still is) with millions of ice meteors from outer space, over aeons filling the lower parts of the earth's surface with water.

Little doubt is left that life was born in the oceans. And that it evolved there for hundreds of millions of years before the first life forms dared to establish their place on land. In fact, while the greening of coastal wetlands and estuaries commenced with the first primitive plants, life in the ocean had already

matured to a universe of blue and green algae, of mussels, water snails and even primitive fish.

The reason for this delay in terrestrial inhabitation is simple. Plants and animals were exposed to a harsh and hostile environment on land. Particularly, they had to cope with irregular and sometimes failing supplies of water. While their marine counterparts were conveniently floating in the primeval brine of the oceans, solving the water problem became one of the main challenges for life on land. Even if water was present, it fell from the sky and was markedly different from sea water. Rain is virtually free of the salts and minerals necessary for the making and functioning of biological cells. The new terrestrial organisms had to evolve strategies to thrive on freshwater alone and to get those vital elements from other sources.

Today, another couple of hundred million years of evolution later, two different worlds exist — sea and land. Terrestrial plants and animals have a reversed biology. They now depend on freshwater, and for all of them — with the exception of a few salt-tolerant specialists — the saltwater of the oceans is useless or even toxic. Some, like frogs or crocodiles, need a constantly wet environment. Desert rodents, on the other hand, never drink. They survive on the water in their food and can even produce water from atmospheric oxygen and the hydrogen contained in dry seeds. Some desert plants as well have taken their independence from regular water supplies seriously. Their seeds will survive dormant for years without a drop of water. But the first shower will make them burst into the brilliant bloom of desert flowers.

Humans as well depend on freshwater, needing about three litres every day. When venturing into waterless areas, the necessity to carry three kilograms of water for every day of travel places severe restrictions on the distances that can be covered. Desert dwellers like the Bedouins of Arabia have developed water conservation to a fine art. Their caravans can travel for days without having to find fresh water supplies and can thus cross the most hostile tracts of land — even the infamous Rub` al Khali, the Empty Quarter of southern Arabia.

FRESHWATER HARVEST

Despite the abundance of water on our blue planet, surprisingly little is available to sustain life on land. The oceans with their salty water make up 97.2 per cent of the global water balance; another 2.15 per cent is locked up in glaciers and polar ice caps. Of the remaining 0.65 per cent, most is deep groundwater buried, inaccessible, hundreds of meters below the surface.

So the water of all the springs, ponds, puddles and streams, the flow of rivers, the rain, snow, the moisture of the soil, the clouds, the water that humans have collected in pipes, canals and reservoirs; all this accounts for hardly a fifth of one per cent of water on earth. Altogether but a few dew drops condensed from the ocean's breath.

Yet not even the arrival of the dew can be relied on everywhere. The distribution of rainfall on land is most uneven. While people in the tropical belt can set their clocks waiting for the daily downpour, other latitudes may see no rain for years. Many regions suffer from strongly erratic and unpredictable rain patterns, evidence that the climate zones are slowly shifting. The arid belts bordering the deserts are expanding, leaving millions of people without water and food.

Meteorologists describe the global water cycle from which all rain originates as a most delicate organism. Therefore, the greenhouse effect with its marked rise in global temperatures brought about by burning fossil fuels, will find its most tangible expression in changing patterns of precipitation. Computer models predict that dry regions will become even drier and wet regions wetter. Winds will be stronger and rains more forceful, resulting in increased flooding and erosion.

GUARDIANS OF THE RAIN

The best insurance against the hydrological havoc of climate change is healthy landscapes. Natural vegetation reflects the location's geology, climate, altitude and, most importantly, its water balance. In turn, the plant cover profoundly moderates the flow of water. Forests store far more rain than grasslands; that's why springs are rightfully called daughters of the forest. The older and maturer a forest, the more efficient it becomes in catching the rain, in storing water, in moistening the air in dry spells.

Yet forests are on the decline world-wide today. In the wide and gentle valleys along lowland rivers, they have disappeared virtually everywhere. They have had to make place for pasture, arable land, streets, railways and cities. Likewise, wetlands and swampy plains along the rivers were drained, further accelerating the flow of water. In the highly developed river plains of modern Europe, hardly a drop of rain or dew is allowed to follow its natural path. Before it has a chance to moisten the soil or be absorbed by plant roots, it is funnelled into a drain, ditch or canal and conducted into the next river.

Humanity seems ill-prepared for climate change and the violent rains likely to accompany it. Computer models for climate change predict that while rains will become stormier, shorter and harder, they won't be more prolific. In combination with faster run-off this means that less water would be potentially available than is the case today.

Holding on to the precious liquid endowed to the land by the ocean's moist breath is not too hard a task. Trees are one crucial factor, groundwater the other. In a dense forest, hardly a drop of rain finds its way to the ground directly. Water drips from branches, leaves and needles, runs down tree trunks to be slowly absorbed by ferns, brush and mosses. Heavier rains will reach the forest floor and replenish the groundwater, especially in winter when trees and other vegetation in temperate zones are at rest. The water collected underground during the cold and wet months will keep springs and streams murmuring and singing throughout the hottest summer.

Rivers play an equally important role in modulating the terrestrial water cycle. Their floodplains are potent buffers for heavy rains, and at the same time sustain a veritable corridor of life. Hundreds of species of birds, fish, amphibians and insects thrive on seasonally flooded habitats alongside rivers.

Like forests, rivers have an intimate relationship with groundwater. They are accompanied by a much slower shadow river underground which they feed at high water, and by which their flow is augmented in times of drought. Where rivers are narrowed and straightened, where their waters are confined

between dykes, the aquatic bonds with their floodplains and their groundwater are severed. The sponge-like qualities of river valleys are lost, and so is the precious rainwater delivered to the land by oceanic rainclouds.

CLOSING THE CYCLE

More strikingly than any other aspect of contemporary life, modern cities reflect society's disquieting ambivalence towards water, the life-giver. Cities are hot, dry and dusty places. Not necessarily because of the absence of rain, but because every drop hitting roofs, streets and parking-lots is meticulously collected, sewered and discharged downstream. No chance to refresh the air, to fill up the groundwater, to nourish a tree. Rain is regarded by city planners as a problem, as a nuisance requiring expensive infrastructure to eliminate.

The obvious idea to make use of rainwater, be it for washing, watering gardens and parks or even toilet flushing, is not *en rogue* with mainstream water engineers. Tokyo for instance, with as much as 2,500 cubic meters of rainfall per year — a very wet city indeed — uses virtually none of this free gift from above. Instead, 2,000 million cubic meters of drinking water every year are imported through mighty and expensive pipelines from distant reservoirs up to 300 kilometres away. The rain, needless to say, is swiftly conducted back to the sea.

The lack of respect for rain is resulting in ever increasing water abstractions from nature, and has cost many of the world's aquatic ecosystems dearly. Today, once mighty rivers like the Colorado in North America or the Indus in South Asia hardly make it to the sea. Every single drop has been appropriated, abstracted and used. Likewise, underground water reservoirs are being exploited at disquieting rates. All along the Mediterranean coast and on many islands, seawater is now penetrating the substrata from which the groundwater has been pumped. Once groundwater becomes salty, it is irretrievably lost as a drinking water resource.

Freshwater is a finite resource. Recognising the limits requires making better use of every litre of rain, every litre pumped from rivers and wells. Agriculture in particular holds a huge potential for greater water efficiency. Irrigation alone currently accounts for 80 per cent of all water uses world-wide. Yet still, spray irrigation is widely applied although in a hot climate less than one fifth of the water reaches the plant roots. More sophisticated technology such as drip irrigation could easily cut water consumption in half. Growing drought-resistant crops such as millet, lentils, groundnuts and figs, instead of maize and cotton, could reduce water demand even further.

Reusing water is another way to deal with scarce resources. However, most water users leave their foul footprints: detergents from households, agricultural pesticides, and industrial chemicals all end up in water. Hence, used water is usually regarded as waste, collected in sewers, treated and returned to nature in a doubtful state.

In view of the scarcity of freshwater available on earth, humanity can no longer afford water pollution. We will have to learn that wastewater is actually a valuable resource that can be recycled for irrigation, industrial purposes and many other applications. However, in order to be able to purify and reuse wastewater, we must keep it free of toxic and persistent pollutants. Already, some industrial companies in Scandinavia and Canada are showing the way by introducing wastewater-free technologies which internally recycle process water.

Closing the cycles could drastically reduce water consumption. At the same time, it would rectify one of the main causes of marine pollution. Rivers world-wide carry millions of tons of unwanted chemicals from mining, industry, agriculture and households into coastal waters. It is a disgrace for our century of technical progress that we have not stopped spoiling and injuring the cradle of all waters, the ocean.

THE PRESENCE OF THE DEW

Many cultures and religions believe that every morning is a repetition of earth's creation, a tangible expression of the eternal renewal of life. Dawn is adorned with morning dew, a cloak of pearls seen shining in the first light, then vanishing. Dew is regarded as the silent messenger of higher powers, joining the black of night and the bright light of day, bringing together sky and earth, ocean and land. For centuries, it used to be highly revered and protected as the agent representing birth and beginning. Humanity must realise that in the 21st century as well, the presence of the morning dew is much more than a religious symbol of life. It is the very essence of survival.

AVOIDING WATER WARS AND ENSURING FOOD FOR ALL

BY PROF M. S. SWAMINATHAN

1. INTRODUCTION

A recent study carried out by the U N Commission on Nutrition, of which I am a Member, reveals the following facts.

Childhood malnutrition, especially stunting, is closely related to potentially permanent brain damage. About 1 billion children will suffer physical and mental impairment by 2020.

About 1 billion adults in developing countries are underweight. Such adult malnutrition impairs work capacity, lowers resistance to infections and markedly amplifies the risk to future generations.

There is a fundamental link between maternal and childhood malnutrition and the subsequent susceptibility of the child in adult life to dietary diseases, such as diabetes, high blood pressure, heart disease and some cancers.

New analyses reveal that 30 to 50% of adults in South Asia are underweight; there are about a billion malnourished adults worldwide.

Such serious problems facing us as we approach a new millennium can be solved only by a new social contract between governments, civil society organisations, mass media and donor agencies which will ensure water, food and sanitation to every