WATER

AS A MIRROR OF THE WISDOM AND GOODNESS OF GOD.

A Thanksgiving Discourse,

PREACHED AT NEPONSET, BOSTON,

BY

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November 26, 1874.

BOSTON:
CHARLES W. KIMBALL, REGISTRY OF DEEDS, COURT SQUARE.
1877.

This Discourse, in a modified form, has appeared in "The Congregational Quarterly."

DISCOURSE

RESPOND WITH THANKSGIVING UNTO JEHOVAH, . . . WHO COVERETH THE HEAVEN WITH CLOUDS, WHO PREPARETH RAIN FOR THE EARTH. — *Ps.* cxlvii, 7, 8.

ONE of the sweet-voiced poets sang, centuries ago, —

"A vapour, or a drop of rain,
Once lost, can ne'er be found again." [1]

Once lost, it can never be identified certainly, yet will it be seen again a thousand times, — may be seen perchance by the eye that had lost it, though without recognition. Some morning in June, a pretty dew-drop, smiling all over, is perched on the tip of a spire of grass; at the shake of your cane it flies away. But in August, you may see it again in the feathery curl of a pink cloud fifteen thousand feet skyward; or in December, you may see it in the birdly guise of a snow-flake alighting delicately on your coat-sleeve; or after a twelvemonth or two, you may inhale it with the breath of an Alp rose as you toil up one of the summits of Switzerland; or half a dozen years hence, you may see it oozing from the heart of an elegant deer which your rifle has surprised in its Adirondack home.

Here is a goblet of Cochituate: if we might read the biographies of its constituent drops, should we not open our eyes with amazement? As we turned page after page in this volume of water, how strange and thrilling might be its revelations! One particle may have been with that "mist" which furnished moisture to the Garden of Eden; another particle may have fallen in that rain which suggested our text to the Hebrew poet; a third may have gemmed the brow of the Man of Sorrows amidst the darkness of Gethsemane; another may have

[1] Herrick.

been in that jet of steam from the teakettle, which gave the juvenile Scotchman, James Watt, a clue to the steam-engine; and yet another may have assisted in strangling little Allie Hammond as the Ville du Havre went down into the depths of the Atlantic.

But whatever may have been the incidents in human history with which this goblet of fluid has been associated, no one should doubt that its career has been replete with adventure. In the countless centuries since The Beginning, ten thousand times it has risen from land and sea in transparent vapor; ten thousand times it has appeared in the flocking clouds,

"Shepherded by the slow, unwilling wind";[1]

ten thousand times it has been precipitated in dew or in frost, in rain or in snow. Sometimes it has tripped gayly along in the mountain brook, and again it has marched in the solemn procession of ocean currents from the equator to the pole, and from the pole to the equator. It has swum with silent icebergs, and leaped with roaring avalanches. It has wrought at building the magnificence of forests and at painting the loveliness of flower-gardens. It has run and thrown its whole weight against the laboring mill-wheel, and it has put its soft shoulder under the merchant-ship and borne it away to other climes.

My friends, there is no other substance in nature which I have studied with such a sense of the wonderfulness of the Creator. And while its adaptations, so manifold, so complicated, so exquisite, so invariable, are eminently fitted to inspire adoration, its uses, so numerous, so valuable, so delightful, so indispensable, are supremely fitted to awaken gratitude. We shall therefore subserve the purposes of a Thanksgiving occasion while we contemplate

THE WISDOM AND GOODNESS OF GOD AS THEY ARE REFLECTED IN SEVERAL OF THE CURIOUS PROPERTIES AND PRECIOUS USES OF WATER.

The way in which water is constituted is not to be overlooked. It was discovered by Cavendish, only ninety-three

[1] Shelley.

years ago, that this familiar substance is not an element, but that it is a compound made of two gases. Under suitable conditions, these elements, oxygen and hydrogen, animated by a mysterious impulse called chemical affinity, rush into each other's arms with great vehemence, and so closely are they united that their individual peculiarities are wholly disguised. You see nothing in the water that reminds you of oxygen, nothing that reminds you of hydrogen. Thank God to-day that it is so.

Last year our city paid $47,000 for the water which was consumed by the fire-engines in extinguishing mischievous fires. During the conflagration in November, 1872, there was water enough expended by your firemen to flood the sixty acres of the Burnt District ten and one-half inches deep. Now hydrogen, one constituent of water, is extremely inflammable; it is the fuel with which the compound blowpipe produces the intensest heat that is known. Oxygen, the other constituent of water, is the fire-principle itself, the agent, the only agent,[1] which is capable of causing combustion. Therefore, to flood a burning city with the *elements* of water, would be like showering it with kerosene and fanning it with a hurricane. If the constituents of water, instead of being chemically combined, were simply mixed, mechanically mixed, like the oxygen and nitrogen of the air, they would be utterly unqualified to extinguish fire.

Burning is the rapid union of oxygen with some other substance, — a process which is attended with the evolution of heat. Fire can live in air, because the air has plenty of oxygen that is free to carry on combustion. Fire cannot live in water, though it contains a hundred times as much oxygen as the same volume of air; and the reason is that its oxygen is not *free*, but is held prisoner by hydrogen, with a grip from which it cannot escape. I repeat that, without oxygen, fire must die; in water, though eight-ninths of it is oxygen, fire cannot obtain any, because the hydrogen is so churlish: hence it is that your city is dotted over with two thousand and six hundred fire-hydrants.

[1] The idle and obscure exceptions latterly noticed in iodine, chlorine, cyanogen, etc., need not be recognized here.

Turning from the chemical constitution of water, we pass to consider *its metamorphosis by the agency of heat.* At ordinary temperatures it is liquid; at higher temperatures it is gaseous; at lower temperatures it is solid. The facility with which it passes from one of these states to another, is a prime element of its value. Ice becomes liquid at a temperature of thirty-two degrees; iron becomes liquid at a temperature of eighteen hundred and thirty-two degrees: had the Creator endued water with the same reluctance to exist in the fluid form that iron exhibits, it would be of no use to us; I might add that we could not live in the same world with it. Water turns into vapor at a temperature of two hundred and twelve degrees; to vaporize iron would require [1] a temperature so high that it has not been ascertained: were water as unwilling as iron is to assume the form of vapor, there could be no living thing on earth, either plant or animal.

View water in its *gaseous* form. From ocean, lake, river, and every moist surface, the vapor of water is busily rising into the atmosphere. We do not see this vapor, for the air dissolves it, just as a cup of tea dissolves a spoonful of sugar. The tea takes up the sugar until it is saturated, until it can hold no more; and the excess that may be present will become visible at the bottom of the cup. In like manner, if there is more vapor in the atmosphere than it can hold in solution, the excess will become visible in the form of mist, fog, or cloud.

As heat is the agent by which evaporation is induced, we look to the glowing climate in the neighborhood of the equator for the largest harvests of vapor. These harvests, borne upon the wings of the winds — those busy expresses of the sky — are distributed everywhere, northward and southward, the great trade-winds transferring their precious freight at the termini of their routes, to the variable winds, whose routes pass the door of every spring and every garden, from the tropics to the poles.

According to the observations of Dr. Hale during a term of three years, three-quarters of the rain which falls in Boston, returns from the city to the sky by evaporation. According

[1] Lockyer, Elem. Astron.

to Prof. Cooke, not more than one-quarter of the rain flows through the channels of the rivers. It is estimated by Maury that, in the region of the trade-winds, the surface water evaporates daily to the depth of half an inch. A layer of intertropical water fifteen feet thick is thus transformed into invisible vapor each year. In our neighborhood the evaporation may perhaps be one-fifth or one-quarter of that in the Torrid Zone, — say three or four feet. From one sixtieth to one two-hundredth of the bulk of the air is vapor. On an average, there may be eight gallons of it in one thousand of air. If this invisible water which is dissolved in the atmosphere were to be precipitated evenly all round the globe, it would make a watery envelope five inches thick.

Since the blue-fish, the coral-polyp, and the crimson-leaved dulse are no more dependent upon the ocean in which they live than corn, horses, and men are upon the vapor-ocean in which they live, we must certainly admire the arrangement which supplies this moisture by active and regular exhalation from sea and land. And since an excess of moisture in the atmosphere would be hurtful and disastrous, we do not fail to admire that the air was so constituted that it could hold only a limited quantity — being obliged to reject any superfluity that might be offered it. These rejected portions of water you see loafing around in mists, fogs, and clouds — waiting for something to turn up. They will be assigned to duty presently. — Notice, furthermore, how beautiful and how benignant is the provision that the capacity of the air for vapor shall increase with the rise of temperature; for as evaporation is a cooling and refreshing process, the strong heats of summer bring with them their own antidote. Air at a temperature of sixty-two degrees takes nearly five times as much vapor as air at twenty degrees.[1] Verily, one would suppose that no particle of vapor or globule of cloud ever allowed itself to forget that exhortation of the Hebrew poet, — "Ye waters above the heavens, praise Him!"

You are aware that in becoming vapor or steam, water is immensely expanded; that is, its microscopic particles are separated by much wider spaces than before. A single pail

[1] Prof. Guiot.

of water, when converted into steam, will fill seventeen hundred pails. Reflecting upon the development of energy which attends this process, James Watt invented the steam-engine. His patent was dated one hundred and five years ago. No king of Great Britain, not all her kings during a thousand years, have done so much to extend her dominion, as was done by this humble Scotchman. In acquiring India, Great Britain added sixfold to her population; in acquiring steam-power, she added ninefold to her working-force. It was as though Watt had secured to his country the gratuitous labor of seven or eight nations like the United States. And every sinewy locomotive that rushes into our city, and every lordly steamship that glides into her harbor, is a fresh and impressive exemplification of our indebtedness to water, and to Him who endowed it with its serviceable properties. The Old Colony Railroad, in 1873, paid over $6,000 for the water which it used in this city alone. The same year the Cunard Steamship Company purchased $4,500 worth of Cochituate.

Let us now watch aqueous vapor as it mutates into the *liquid* form. At every puff of the locomotive, a cloud is projected into the air. It is condensed steam. While it was in the boiler, it was transparent and invisible. As it mingles with the cold air above the hot funnel, it ceases to be vapor. Every bit of steam shrinks, when chilled, to a much more minute particle of water. The liquid particles thus produced form what Tyndall[1] calls a kind of water-dust, of exceeding fineness, which floats in the air and is known as cloud. The chilling of atmospheric vapor is effected in part by the mingling of warm, moist air with currents of air that are cooler; and it is effected in part by the expansion of the vapor-laden air as it ascends where the pressure of the atmosphere upon it is diminished.

Cloud, then, is partially condensed vapor — in the form of minute bubbles of water; these light globules collapse, and coalesce in drops which are too heavy to float, and therefore descend, constantly increasing in size by accumulations of moisture from the air through which they fall. Thus, the cloud may say, —

[1] In Forms of Water.

"I am the daughter of the earth and water,
And the nursling of the sky;

I bring fresh showers for the thirsting flowers,
From the seas and the streams."[1]

At Lake Cochituate, the rainfall last year amounted to forty-five and one-half inches, about three feet and three-quarters; six-tenths of this rain was received into the lake. The rainfall at Boston exceeded that at Natick by about ten inches; it amounted to fifty-five inches, about four feet and a half. There were ninety-nine rainy days; on twenty-one of them, over an inch of water was registered, and on three of them there was a fall of two inches or more. The wettest month was November, when the rain that fell amounted to seven and one-third inches; the fall in June was scarcely one-eleventh as great, — less than two-thirds of an inch.

In studying how wondrously the constituents of nature are adjusted to each other, you will recognize the contrivance to make rain fall gently. In finding its way to the earth, it must filter through the oxygen and nitrogen of the air, and these elements are buoyant enough to retard its descent. Were it not for this arrangement, if rain-drops were to fall through a vacuum — without resistance, they would riddle an umbrella like volleys of buckshot.

Notice, also, by the way, that the rain is our servant in cleansing the air. There is soot nestling in it, and dust, with other foreign matter, perhaps chlorine, iron, and nickel; the advance-guard of a shower or rain-storm has orders to wash out these substances.

When the condensation of vapor takes place on the earth's surface or any of its furniture, rather than in the atmosphere, it is called *dew*, or if deposited in a solid state, frost. As vapor comes in contact with the chilling surfaces of objects which have radiated their heat during the night, it condenses into drops, —

"orient dew,
Shed from the bosom of the morn
Into the blowing roses."

By this providential device, vegetation has a partial supply

[1] Shelley.

of moisture during seasons of drouth. The deposit amounts annually to about five inches. Now the dew has two laws which are specially worthy of notice.

On a cloudy evening we say, "No dew to-night," or "No frost." The reason there will be none is, that the canopy of cloud will reflect back a portion of the heat which the earth radiates, so that surfaces will not become cold. Can it be the result of chance, inquires a scientist,[1] that the supply of dew fails only when the clouds give promise of a copious draught of liquid nourishment from the rain? One loyal to God replies, "He adjusteth the waters by measure."

Again, the dew is minutely discriminating in the bestowal of its favors. It is partial towards those objects which need moisture, being far more generous towards plants than towards patches of naked earth. The Great Designer arranged for this state of things by ordaining that the various species of vegetation should have radiating surfaces of such sort and such amplitude that they would cool more rapidly than barren roads and rocks, and receive in consequence a greater supply of dew. It is therefore a mere remnant of dew which sheds its idle tears over unproductive wastes. Oh the wisdom of the Creator! "He apportioneth the waters by measure."

Few are they who apprehend how small a proportion of our aqueous liquid appears in the form of dew, rain, spring, river, and lake. I have asked several persons how long it would take the rivers of the globe to fill up the ocean basins if they were emptied. The replies range from one year to ten years. If the Danube, Nile, Mississippi, Amazon, St. Lawrence, and every other river should keep their waters rolling for ten years, and then for nine times ten years, the task would be unaccomplished; there would still be required for its completion 39,900 years!

There is a third form in which water exists; it may be a *solid.* You might never suspect its presence in certain dry substances, such as lumber, sugar, and starch. In a pound of iron-rust there are three ounces of this solid; in a pound of lime there are four ounces.

If we dissolve alum in water, and allow the water to evapo-

[1] Prof. Cooke.

rate slowly, we have as a residuum a crop of transparent, eight-sided crystals. They contain solidified water, and cannot maintain their crystalline form without it. Azurite, a very beautiful stone, gets its form in water, and is dependent upon it Most of the crystals found in rocks — many of them precious gems — are formed in a similar manner, from minerals in solution.[1] But the formation of the larger ones has probably occupied thousands of years.

Moreover, all water, at low temperatures, turns into crystals. A compacted mass of them, usually formed from liquid, we call ice. Crystals composed of frozen atoms of vapor, elegantly clustered in six-pointed stars, we call snow-flakes.

Though snow is an emblem of cold, yet it serves the vegetable world as a beautiful blanket; it is as warm as wool. To this divine provision we owe it that plants are not destroyed.

How much blessing abides in ice, I need not attempt to portray. In this city several hundred thousand tons are used annually, while our traffic in it employs nearly ten thousand men.

Having contemplated thus at length the three characteristic states of water, we move on and inspect its *density.* In the adjustment of this property, there is revealed a sagacity which is unerring and benign.

If the water of the sea were heavier, says Gaussen, all the fishes would be borne up to the surface, and would be unable to swim in it; they would accordingly die, as they do in the Dead Sea, the water of which is only a quarter heavier than distilled water. And if the water of the sea were lighter, the fish would be too heavy to swim, and would sink down and die at the bottom.

But human navigation, as well as that of fishes, is dependent upon the existing density of water. A vessel which would not float on alcohol, or olive-oil, or even fresh water, might float on the brine of the Atlantic. A sea-captain informs me that a vessel drawing fourteen feet in the Mississippi, may not draw so much by three inches in the Gulf of Mexico. Let the specific gravity of water be reduced a few degrees, and every

[1] Cooke.

ship on the sea would sink. Thus the easy interchange of commodities and of ideas, upon which the welfare of mankind is so vitally dependent, would become impracticable.

The density of vapor is also admirable. In this rarefied form, the water that is needed to moisten the air and to form rain, can be elevated by the agency of gravitation. If men were obliged to do this work, they would have no leisure. You may compute, from data furnished by Prof. Leslie, that the silent elevation of aqueous fluid by gravity is equivalent to the labor of our whole race, together with that of 133,000 other worlds, of similar grade.

Very admirable, also, is the density of ice. It is a general law of nature that substances are expanded by heat and contracted by cold. Water obeys this law until within seven or eight degrees of the freezing point, when it begins to disobey it by expanding. If it were to continue to observe the general law, ice would be denser than water and would sink as fast as it formed, so that our rivers and lakes would become solid and never be thawed.[1] We owe it to this exceptional behavior of water that our earth is habitable.

Our attention might be pleasantly occupied with the locomotion of water — liquid, solid, and aeriform — upon the earth,[2] beneath it, and above it; but we pass at once to *its solvent power*, a pre-eminent property, upon which[3] its use chiefly depends. As a solvent, water acts in this way: it reduces solids that are in contact with it, into fluids, and diffuses them through itself without any other change. If you drop a thimbleful of common salt into a cup of water, it soon disappears; the water dissolves it, that is, liquefies it and mingles it with itself. A pound of the fluid will dissolve five and three-quarters ounces of salt, or two pounds, even three pounds, of sugar.

Water is the most powerful solvent known; indeed there are few substances which it does not dissolve to some degree. As it circulates — soaking, trickling, flowing — it filches an atom from this and an atom from that, becoming more and

[1] Prof. Peabody, in Bib. Sac.

[2] The motive-force of the streams of Europe, according to Daubrée, is equal to 300,000,000 horses working incessantly the whole year.

[3] Encyc. Brit.

more charged with foreign matter until it reaches the ocean. Look to your own river for an illustration. The rain which supplies Punkapaug Pond, percolates the soil and the rocks, sucking off morsels as it can, — here a bit of animal matter, there a bit of vegetable matter, then an atom of gypsum, etc., until with endless toil it has gathered[1] into its bosom organic matter (*i. e.*, matter of vegetable or animal nature), gypsum, common salt, Glauber's salt, muriate of magnesia, sand, clay, coal, and iron. These substances, you understand, are not held in suspension — making muddy water, but they are converted into liquid, and are indistinguishable from the aqueous liquid with which they are mingled. In a hundred thousand pounds of Punkapaug water, there are three pounds of dissolved matter, of which one pound and thirteen ounces is organic, and one pound and three ounces mineral. Now, while this fluid is washing along down the channel of the Neponset, it keeps applying its tongue to everything within reach, that if possible it may lick off a little taste of it. After a stroll of a dozen miles it reaches tide-water at the Lower Mills, where it has nearly twice as much organic matter, and more than twice as much mineral matter, as it had at the pond.

Water dissolves carbonate of lime (*i. e.*, chalk) with special facility, and this is the leading mineral found in river-water. It generally constitutes one-half of the solids which streams hold in solution, and it sometimes constitutes nine-tenths of them. The ingredient which is next in prominence is gypsum (sulphate of lime). About a thirtieth part of sea-water is solid matter that is in solution. (All such solids are frequently called *salts*.) More than three-fourths of the whole is common salt. We may compute from data furnished by Maury that if all the ingredients dissolved in the ocean were restored to the solid form, and spread evenly over the State of Massachusetts, they would bury every acre of it nine hundred miles deep.

We shall presently notice the part which the solvent power of water plays in the vital processes of the plant and the animal. We observe at once that it is this property which qualifies water to be the great cleansing agent of the world. Without the aqueous fluid as a purifier, there could be no com-

[1] A. A. Hayes.

fort, and there could be no civilization. It is this property, moreover, which is the basis of a great proportion of the processes employed in the arts and manufactures. There is a single sugar refinery in your city which pays $12,000 annually for the Cochituate which it uses.

Another fact in regard to the property we are considering, is very significant, though it might be easily overlooked; I refer to the fact that the power of water to dissolve substances has been carefully limited. If at ordinary temperatures it had the solvent power which it possesses at the boiling point, our wells, lakes, and rivers would be filled with mineral waters, — as unfit for ordinary use as those of Saratoga.

Advancing a step or two, we survey another cardinal property of water, *its great capacity for heat.*

We first restrict our attention to what is known as *specific heat,* — the quantity required to raise the temperature of a body one degree. Suppose that you have a kettle of water, and a mass of iron of the same form and the same weight; if you subject them to the same amount of heat, their temperatures will not rise together; it will require ten times as much heat to raise the temperature of the water to the boiling point as it requires to raise the temperature of the iron to that point. Thus water is capable of receiving and storing immense quantities of heat. How excellent is the provision that our lakes and oceans shall abate the fervors of midsummer by copiously absorbing caloric, and that they shall soften the inclemency of winter by restoring it to the air!

Remark especially that immeasurable cargoes of heat are transported by ocean currents from the tropics towards the poles, and distributed where there is need of them. The Gulf Stream is a wonderful agency of this kind. It is a gigantic river, more than three thousand times as large as the Mississippi, and moving more rapidly, with a temperature in winter of twenty degrees, even thirty degrees, above that of the adjacent waters. Its color is indigo-blue, and one half of a ship may be seen floating in this stream, while the other is in the common water of the sea. Now the vast cargoes of heat with which this current is freighted are carried over routes three

thousand miles long, and are discharged at innumerable points as there may be demand. In the absence of this arrangement, France and England would be as cold, barren, and desolate as Labrador, while Scotland would be another Siberia.[1]

One feature of the Gulf Stream which I have not mentioned, is too singular and too significant to be neglected in a discourse of this kind; I refer to the fact that this current does not flow on the bottom of the sea, but on a cushion of cold water. This is a Divine contrivance for preserving the heat which the stream is transporting. That bed of water which it flows over is a non-conductor of heat, so that it loses only two degrees of temperature in moving six hundred miles;[2] whereas if the stream were flowing on the earthy bottom of the sea, it would lose all its heat long before it reached the points for which it was designed.

Let us now turn our attention to what is called *latent heat,* — that quantity which becomes concealed in a body while producing some change in it other than rise of temperature, as fusion or evaporation. Suppose we heat ice to a temperature of thirty-two degrees; as it melts, its temperature will rise no higher while we add one hundred and forty degrees. When that liquid freezes again, this heat of fusion, as it is called, will be set free during the process of congelation. Prof. Morley shows us that the freezing of a body of water to the depth of thirty inches, liberates as much heat as would be radiated by red-hot cannon-balls covering an equal area nine and three-quarters inches deep. One may see how this law operates to retard the approach of the winter's cold, as well as to preserve the snow-covering in the spring — defending the vegetable kingdom from the attack of early frosts.

Suppose again that we have water at two hundred and twelve degrees; to convert it into steam (which shall have a temperature of two hundred and twelve degrees), we must add one thousand and thirty degrees of heat. When this steam shall be condensed into water, it will have these one thousand and thirty degrees of heat to impart. The familiar method of heating buildings by steam is founded on this extraordinary capacity of vapor for heat. Nature also has a steam-heating

[1] Maury, Phys. Geog. of the Sea. [2] Maury.

apparatus, with the boiler at the equator and the condensers all over the earth. Vapor stored with heat is borne far and wide into regions where more warmth would be welcome, and when the vapor condenses in dew, rain, or snow, its vast stores of heat are set free; the force which was latent becomes sensible. A rain one inch deep brings heat enough to warm the atmosphere eleven degrees.[1] A snow of the same weight (say, ten inches[2]) would warm the air more than twelve degrees.

This ordinance that water shall absorb great quantities of heat in mutating into vapor, is the basis of several modes of refreshment. You sprinkle your room on a hot day, expecting that the water, in turning into vapor, will gather up and carry away with it a large quantity of the heat which oppresses you. The same principle explains how it is that water is cooling to the face or the tongue, and how it is that perspiring relieves one of heat.

Just here, though it be not quite relevant, glance at the skill and the benignity with which the boiling point of water has been adjusted.[3] If water boiled at the same temperature as ether, the vapor rising from the ocean would be twenty-five times as much as it now is, the sun would be perpetually hidden by clouds, the rains would be deluges, and the snow of one day might bury our city. If, on the other hand, water boiled at the same temperature as oil of turpentine, the vapor given off by the ocean would be less than one fourth of its present amount, scorching sunshine would prevail, and the Desert of Sahara would widen over the world.

How striking is the skill and kindness which are displayed in the relations of water to heat!

I would gladly speak of the geological agency of water,—noticing that all the stratified rocks were formed by deposits of various substances on the bottom of the ocean, at the rate of—perhaps—an inch a year;[4] that on a mountain-side in Wales there is an ancient sea-beach which is one thousand

[1] Prof. Morley, in Bib. Sac.

[2] It requires ten inches of snow to make one inch of water, when the flakes are large; five inches, when they are small.

[3] Vide Morley.

[4] Charles Kingsley, Town Geology.

four hundred feet above the present sea-level; how the huge bowlder came, and whence—

> "Like a sea-beast crawled forth, that on a shelf
> Of rock or sand reposeth, there to sun itself";[1]

how Castle Rock in Minnesota, and the Matterhorn, in Switzerland, were sculptured; how the destruction of the earth, and its reconstruction, are carried on; and how the fertility of soils is perpetually replenished.

I would gladly speak of the æsthetic function of water,—reminding you that we are indebted to it for the lovely blue of the firmament; for the ever-changing beauty of the clouds ("Behold, the glory of the Lord appeared in the cloud!"); for the prettiness of the gushing, mossy spring,—

> "A thirsty giant at one draught could drink it";[2]

for the wild charm of mountain brooks,—

> "Cold wellé streames, . .
> That swommen full of smallé fishes light,
> With finnés rede, and scalés silver bright";[3]

for the enchanting reflection of land-scene and sky-scene; for Staubbach, Keelfoss, and Niagara; the weird grandeur of Mammoth Cave; the sublimity of glaciers and icebergs; and the majesty and the tragicalness of the oceans.

But time would fail me.

We may not overlook the relations of water to vegetable and animal life. Contemplate, therefore, some of *its relations to plants*. That the importance of water to a plant is most vital, is evinced by the fact that about four-fifths of its substance is water.[4] A part of this is in the form of sap, and a part is in solid form, chemically united with other substances: water and carbon (*i. e.*, charcoal) are the sole constituents of woody fibre, starch, and gum.

Study for a moment the process of nutrition. The leaves of the plant—its tender twigs also—are full of microscopic mouths (or should we rather say nostrils?) through which respiration is carried on. Somebody has counted 120,000 of these

[1] Wordsworth. [2] Moreau. [3] Chaucer. [4] Tissandier.

tiny organs on a square inch of lilac-leaf. The plant inhales, through its leaf-pores, carbonic acid (carbon and oxygen in the form of gas); and the carbon thus inhaled is the material of which the framework of the plant is mainly constructed. Through the leaves the vapor of water is also inhaled to a limited extent, especially when previous heat or drought has dried the plant. Hence it is that fainting herbage revives so promptly at the scent of water, even a stingy sprinkling of it,—perchance

"Those maiden showers,
Which by the peep of day do strew
A baptism o'er the flowers."[1]

And now what does the plant exhale through its leaves? Oxygen (the most of which was a constituent of the carbonic acid that it inhaled), and the vapor of the water which ascends through the stem—after its duties are completed. This evaporation from the leaves, were the atmosphere not provided with vapor, would proceed so rapidly that the necessary moisture could not be supplied through the roots, and the plant would soon droop and die.[2]

Go now to the other end of the plant, and apply your microscope to its rootlets. Their fresh tips are seen to bear minute, hair-like fibrils, which thrust themselves laterally among the particles of the soil. These fibrils are extensions of some of the superficial cells of the rootlets into slender tubes. Through the lips of such fibrils and of all fresh cells, the plant sucks the water, ammonia, and mineral salts which it requires from the earth. The water, having first dissolved the other materials, is the vehicle which conveys them into the plant and carries them where they are to go. Two thousand grains of the fluid pass through the plant for every grain of mineral matter that is fixed in it.

Seeing, then, that water dissolves nutriment for the plant and conveys it where it is needed; that it combines with carbon to form woody fibre, starch, and other solids in the plant; that moreover it distends the vessels of the plant, gives flexibility to it, and keeps it cool,—we cannot fail to appreciate the boundless value of water to the vegetable kingdom.

[1] Herrick. [2] Johnston, Chemistry of Common Life.

View now some of the *relations of water to animals.* I need not pause to remark that the animal kingdom is absolutely dependent upon the vegetable kingdom: the fact is too obvious. Observe at once that at least five-sixths of an animal, five-sixths of a human animal[1] is water. It exists in chemical combination as a solid, being an ingredient of dry bone, dry flesh, etc.; and it exists in fluid form among the tissues, and in the veins and arteries. Of the blood, seventy-eight parts in every hundred are water. We have glanced at the nutrition of plants: the nutrition of animals is like it. Water dissolves our nutriment and distributes it through the body; it takes up tissues that are effete, having completed their functions, and carries them off through the kidneys and the skin. As water is continually exhaled by the leaves of a plant, so is it continually exhaled by the human skin and human lungs. The evaporation from the skin, in the form of insensible perspiration, amounts to a pound and a half (or more) daily, while the exhalation from the lungs amounts to a pound daily.

You should notice distinctly that the vapor of water is as essential to animal life as water in its liquid form. If the air about one were perfectly dry,[2] his skin would become parched and shrivelled, and thirst would afflict his feverish form. Were the air that he breathes free from watery vapor, he would soon breathe forth the fluids which fill up his tissues, and dry up into a withered and ghastly mummy.

Add, withal, that human food is mostly water,—at least five-sixths of it. Suppose each kind of food to be divided into one hundred parts: forty-five parts of bread would be water; of egg, seventy parts; of potatoes, seventy-five; of beef, seventy-eight; of apple, eighty; of milk, eighty-six; of watermelon, ninety-four; of cucumber, ninety-seven. Note that in the most wholesome and delicious forms of food, to wit, the fruits, the nutritive matter is especially diluted with water.

How wonderful that the protoxide of hydrogen should have been endowed with properties so multifarious and so versatile, and should have been so accurately adapted to such dissimilar and multitudinous uses!

[1] New Am. Cyc. [2] Johnston.

Make room for one word of municipal history. The Indians of this region called the peninsula now covered with Boston, Shawmut,[1] with a reference to the sweet springs[2] which welled up among the hills. When, in 1630, Winthrop and his associates were invited by Blackstone (the only citizen of Boston) to come over from Charlestown and settle on the trimountain peninsula, the excellence of the water and its abundance were the chief inducements offered.

In process of time, the peninsula became populous, and the sweet springs were inadequate to supply the needs of the people. They dug wells, but the water yielded was not such as might become a place named Shawmut. In 1834, there was a census taken of 2,767 wells; the water of one-fourth of them was found to be undrinkable, and the water of only seven — one in three hundred and ninety-four — could be used for washing.

Sitting on her three hills, the city thirsted; she turned her eyes appealingly to Spy Pond and Punkapaug, to the Charles and the Neponset, to Farm Pond, Long Pond, and many more, and her great heart called upon them to bring her relief. Twenty-three years in vain; then Long Pond — twenty miles away — relented, slipped off her country gown, arrayed herself in Cochituate robes, and under the escort of gravitation hastened from Natick to Needham, to Newton, to Brookline, to Roxbury, to Boston, and presented her vast wealth of waters, soft and sweet, to the famishing city.

This joyous event was celebrated[3] Oct. 25, 1848. At daybreak there was a salute of one hundred guns, the bells of the city ringing an accompaniment. The streets were decorated with flags, bunting, and evergreen, interspersed with mottoes and emblematic devices. The procession was two miles long. On the Common there were songs and prayers and orations. As a column of water eighty feet high leaped from the fountain into the air, the excited multitude were breathless for a moment; they then looked around upon each other — laughed aloud — swung their hats and shouted — and some even wept. Forthwith a chorus of children, standing

[1] Rather, Mushauwomuk. S. G. Drake. [2] Josiah Quincy, Jr.
[3] Documents of Water Board, in Public Library.

near, sang, "Thanks be to God! He laveth the thirsty land. The waters gather; they rush along; they are lifting their voices." The sun was just setting, and his last rays tinged the summit of the watery column. Again the bells began to ring and the cannon to peal, while rockets leaped blazing into the sky and burst with ecstasy.

For more than a quarter of a century, Boston has luxuriated upon the bounty of Cochituate Lake. Last year she consumed about 18,000,000 gallons daily, — at a total cost of only thirteen cents per thousand gallons.

While you are seated with a happy group around the Thanksgiving dinner, suppose a decree were issued from The Throne that the protoxide of hydrogen should be enjoyed no longer; suppose our Creator to issue the proclamation, "Let water in every form be banished from the planet Earth"; what an appalling scene would be witnessed at your festive board! Every goblet is instantly dry; in the coffee-cup nothing is left but a little sediment of carbon, ash, and oil; the sugar-bowl loses three-fifths of its weight and offers mere charcoal; the milk-pitcher is deserted by seven-eighths of its contents, and the residue is oil, sulphur, nitrogen, and the like; the bread diminishes by one-half, and what remains is chiefly coal-dust; the meat shrinks to one-fourth of its normal dimensions, and the remnant is no more edible than ashes; the six pounds of fruit give place to a single pound of soot; the precious opal in your wife's marriage-ring, drops into a little pinch of silicious sand; the table, and the chairs around it, and the dining-room itself, resign more than half of their substance, and the rest is a shapeless collection of powdered coal and earth; while five-sixths of your son, your daughter, your wife, yourself, disappears, leaving, instead of each, a peck of ashes, — twenty or twenty-five pounds of charcoal and nitrogen, seven or eight pounds of phosphate of lime, and one or two pounds of common salt!

Dismal and ghastly would be *a Thanksgiving without water!* — not a single specimen of animal life — man, dog, bird, or polyp — surviving; not a remnant of vegetation, — oak, wheat, lily, or lichen; not a fabric composed of organic material, —

rail-car, ship, carriage, fence, house, or penholder; but the vegetable and animal kingdoms in their entireness would be resolved literally into dust and gas, while the very rocks themselves — a majority of them[1] — would participate, more or less, in the gigantic and horrible transmutation. Without water, old Chaos would come again, — "the earth without form and void."

Fellow citizens, do we not well to celebrate the transcendent intelligence and transcendent love which provide our earth with a substance like water? Is it not becoming that on one Thanksgiving occasion the main pabulum of life should be the mainspring of our gratitude and rejoicing? "Respond with thanksgiving unto Jehovah, . . . who covereth the heaven with clouds, who prepareth rain for the earth." The Hindoo adores the Ganges; the Egyptian worships the Nile; they recognize in those waters visible images of the Deity. And surely "the voice of the Lord is upon many waters." We shall not too much resemble the Hindoo and the Egyptian if we see the wise thoughts and kind feelings of God reflected in the raindrop, the dew-drop, and the snow-crystal; in the moisture of the soil, and in the vapor of the air; in Neponset River, in Cochituate Lake, and in the glorious Atlantic.

[1] Tissandier.