given) of the dean. And there is the direct testimony of a few discharged laboratory workers that the doctors are liars. Evidently somebody is. There is unanimous agreement that nearly all the experiments are medical and dietary; not surgical. The surgical ones are done under the same precautions as on humans.

These are questions of physical fact, capable of ascertainment. Until they are agreed on, there is nothing to discuss on the scientific or human side. Why argue whether it is useful or ethical to "torture" animals, unless in fact they are tortured?

149 Tamalpais, Berkeley.

DEHYDRATION IN HEAT EXHAUSTION AND IN FATIGUE

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The need of an adequate supply of water for the physical well-being of the body is being more and more appreciated during the last few years. The work of Roundtree[1] and of Newburgh[2] have added greatly to our knowledge of what has been called the "water balance." Evidently the most important phase of the balance is to keep the body adequately supplied with water, as an ordinary oversupply is easily taken care of by the automatically increased urinary output. The promptness of this response is common knowledge among beer drinkers and should be more frequently acted upon when we look for a diuretic.

WATER THE GREAT DIURETIC

Water has only recently demonstrated its prime position as the greatest diuretic we have ever had. It is only lately that we have recognized the fact that most bladder irritations, scalding and burning at micturition are due to a lack of volume in the urinary output. During the hot weather scores of patients go to the doctor with these irritations. That they are due to urinary concentration on account of low water balance is demonstrated by the promptness with which they disappear when the patient takes an adequate supply of water. This fact seems almost too obvious to have been missed so long.

How many centuries of wasted diuretics have we been guilty of and how very recent is the knowledge that water is the supreme and practically the only real diuretic. Should not every layman, much more every doctor, know that one cannot get water out of a body without putting it in? How many dollars have found their way to the doctors' pockets because of scalding, irritating urination, when summer heat dehydrates the body and people fail to heed the automatic call for more water? Many of these patients have been given soothing diuretics and nostrums without number. The bladder has been washed, cystoscoped, probed, and treated. Up to ten pounds of water is lost by perspiration in one day. How many persons realize that pounds of water must be taken to replenish these amounts? Think of two to three quarts of water intake and less than a pint of kidney output in one day on the desert.

It is generally recognized that the circulation is much more comfortable and efficient when the blood vessels are well filled. Starling's[3] law of the heart for the greater efficiency of the stretched heart muscle over a full cavity has had its accuracy demonstrated in many observations and studies. As a farmer said to me the other day, "I drink plenty of water because I think the heart will do better work when it has something to work upon." "The blood volume must be maintained" has become a slogan in all departments of medicine.

The most obvious instances of loss of volume have received exhaustive study during the last few years. Hemorrhage and shock from injury probably take first place. Surgeons have recognized the need of water here and have developed a very efficient method of replenishing the supply with transfusions and with intravenous and subcutaneous injections. In these conditions the relative amount of fluid volume is more easily evaluated, although here and elsewhere it would be a tremendous boon to have a simple and reliable method of estimating the actual amount of fluid volume present in our patients at any one time.

The lack of blood volume following diarrhea, cholera, and other depleting diseases is receiving attention. We are also beginning to study the problem of an adequate intake of water generally—in health and in disease. More and more we are urging our patients to drink freely. Still more emphasis should be placed upon this advice.

This paper hopes to create more interest in the third major avenue for the escape of water from the body—the skin. Transpiration, perspiration, and evaporation are the great unnoticed causes of dehydration.

TRANSPIRATION

This is the greatest factor in the control of water balance and is of paramount interest in the study of heat exhaustion and fatigue. The accompanying table furnishes a picture of the average of intake and output in maintaining the water balance in the body.

Table 1.—*Water Balance**

Water Intake	*Grams*
Drinking water	300
In coffee, milk and soup	580
In solid food	720
From oxidation of 100 grams of protein	41
From oxidation of 100 grams of fat	118
From oxidation of 244 grams of carbohydrate	135
	1894
Water Output	
In urine	750
In feces	300
Vaporized through skin and respiratory tract	700
	1750

* From Du Bois.[4]

Note that the amount vaporized is practically equal to the output from the kidneys. It takes no longer than one day on the hot desert to demonstrate that the water vaporized through the skin and respiratory tract will become several times the amount of urine excreted. This becomes evident when studying the enormous amounts lost by perspiration in hot industrial plants, among the stokers of coal-burning vessels, in hot mines, in fact in any occupation which calls for excessive muscular exercise.

STORAGE RESERVOIR

Approximately 75 per cent of the body weight is water.[1] A large part of this volume is held in the tissues, which act as a storage reservoir. The intercellular spaces, as well as the cells of the body, constitute this reservoir. This is the supply called upon promptly in hemorrhage, excessive perspiration, and the ordinary needs of the body. In ordinary surgical shock much of the fluid volume of the blood, instead of simply concentrating in the large veins, also escapes into this reservoir and for some reason fails to make its usual return into the blood vessels when needed.[1,5] One of our problems is to keep this storage reservoir filled.

CONTROL OF TEMPERATURE

In the regulation of the temperature of the body the most important factor is the water balance. Normally this goes on automatically and the loss of water is supplied through the sense of thirst. which calls for more water when the supply runs low. This automatic response to the sense of thirst normally suffices to fill the storage reservoir throughout normal animal life. However, it does become necessary often in the treatment of disease to supplement artificially the amount of water intake to maintain an adequate supply. The sense of thirst is sometimes insufficient or may be ignored, or there may be inability to secure water, to drink it, or retain it.

The normal metabolism of the body—the combustion of food substances by the oxygen taken in—constantly produces heat in the body,[6] and when we remember that the normal temperature of the body is 98½ degrees Fahrenheit it becomes obvious that very adequate mechanism is required to regulate the amount of heat produced and the amount of heat lost. This process is looked upon as very complicated, but many of the factors are very simple, the most important one being the control of the circulation in the skin. Cold contracts and heat dilates. Vasomotor control and heat-regulating apparatus have been sought for and found in the medulla, but the principal ordinary control is the direct effect of heat upon the skin. Heat causes dilation of the blood vessels and cold causes contraction, thus regulating the loss of heat.[7,8]

HEAT LOSS

Heat is lost from the body by direct radiation, convection, conduction, and evaporation; but in the presence of excessive heat the greatest dependence is upon evaporation from the lungs and skin. Smith [9] found that under average conditions the heat loss by radiation, conduction, and convection from the skin is two or three times the amount lost by evaporation. Wiley and Newburgh [2] found that under conditions of high temperatures the amount lost by evaporation with sweating is very much more, and, obviously, is often enormous.

EVAPORATION

All investigators emphasize the fact that, in the final analysis, lowering of body temperature in excessive heat is dependent upon the evaporation of water from its surface. Water passing from a liquid to a gas (vapor) takes up heat from its environment. Thus heat is taken from the body, thereby cooling it.[5] It is the same process which cools water in the Spanish olla. The dry desert wind, passing over the moist porous jar, evaporates water from its walls, and the heat of evaporation coming from the jar and its contents cools the water in it.

Haldane [10] says: "Evaporation permits the body to tolerate temperatures which would otherwise be totally incompatible with life." In the absence of evaporation, he places the upper limit of safety at 88 degrees Fahrenheit if at rest; at 78 degrees Fahrenheit if working in still atmosphere. Above these temperatures some evaporation is essential. When the environmental temperature reaches blood heat, evaporation must play the sole rôle of stabilization.

HUMIDITY

A high humidity of the surrounding air adds greatly to the difficulty of keeping cool on account of the lack of evaporation. Heat exhaustion on the desert is relatively rare because of the speed of evaporation in the dry air. A combination of high temperature and high humidity may bring on profuse perspiration; but there being no evaporation a rapid depletion of fluid takes place without adequate cooling.[10,11,12,13] A 100 per cent humidity with 100 degrees temperature could be endured but a very short time because there could be no cooling since there could be no evaporation. Something approaching this must have been the condition in Peking in 1743, when eleven thousand are said to have died in one week.

LOWER BLOOD PRESSURE

After exercise blood pressure rises to meet the call for the support of muscular activity and heat dissipation by evaporation; but when the stage of exhaustion is reached, inadequate blood volume and failure to respond to this call results in a fall in blood pressure: thus, 118 to 96, 110 to 92, 116 to 80.[9,11,14,15,16,17,18]

PERSPIRATION—WATER LOSS

The loss of heat being so largely the result of evaporation, the amount of water lost by prespiration keeps pace with the need of lowering the temperature of the body, and an estimate of the amount of water lost by sweat becomes significant. Many careful estimates have been made, and the amounts are often enormous. Haldane [10] reports the following from an account by Dr. A. E. Boycott on visiting mines in England: "As you know, the men are reported to wet the drill holes by pouring the sweat out of their boots." The amounts recorded under various conditions of temperature and humidity range from one liter an hour in extreme conditions to forty grams per hour in ordinary room temperature.[4,6,16,19,20,21,22,23]

CHLORID LOSS

With profuse perspiration there is excessive loss of chlorids which are so necessary in the metabolism of the body.[9, 23, 24] This problem has had careful study, and the necessity of replenishing these chlorids in all forms of dehydration has been properly emphasized.

MECHANICS OF EXHAUSTION

The obvious result of this excessive loss of water is to lower mechanically the blood volume, producing a condition almost identical to that following hemorrhage or surgical shock. The sense of exhaustion is due to the difficulty of the circulation maintaining an adequate blood pressure in the nerve centers. We know that unconsciousness follows a sufficient drop in blood pressure. The sense of well-being depends upon constant blood pressure. Exhaustion is one of the first evidences of loss of blood, faintness, deprivation of food and drink, and shock, inadequate volume in the blood vessels. Fatigue for the same reason is in large part a sense of this approaching exhaustion from lack of fluid in the blood vessels. As a demonstration that this loss of water is the cause of fatigue and a sense of exhaustion, I have with great satisfaction made the following simple test. After excessive perspiration following eighteen holes of golf on a hot day or a strenuous two or three hours in the operating room, I have repeatedly taken a couple of glasses of water, reclined on a couch for ten minutes until the water was absorbed and have then been able to slip into the continued duties of the day, feeling entirely rejuvenated and fit to go on. The fatigue is overcome by the simple process of filling the blood vessels after the supply there and in the storage reservoir has run low.

CYANOSIS

During the later stages of heat exhaustion there is usually cyanosis, which often persists after death. During an aggravated heat spell in New York in which the victims were too numerous for the beds in the New York Hospital, deaths were so numerous that funerals were delayed, and a large number of corpses accumulated.[25] A casual look by a visitor brought the report, "Why, they are all negroes." It was the cyanosis which persisted postmortem.

It may have been this same period of severe heat of which Lambert [26] writes: "The unconscious patients presented a striking picture. Their skins were dry, hot, and flushed; or cool, pale, and livid; or cyanotic, with a clammy perspiration. Many with a temperature of 108 degrees Fahrenheit did not regain consciousness at all, and though the temperature came down the pulse remained frequent, dyspnea and cyanosis often being marked, and such finally died."

The cyanosis and the flush of dilated blood vessels on the surface have misled us into thinking that the flagging heart was laboring against a plethora of blood and we have resorted to bleeding. Osler's "Practice of Medicine," [27] says the life of S. Weir Mitchell was saved from this condition by bleeding. As a matter of fact, just the opposite is true. The heart is laboring with empty arteries, for all the blood is attracted to the dilated capillaries and veins on the surface of the body by the normal process of cooling by perspiration and evaporation. Not enough remains in the deeper arteries and veins to maintain adequate blood pressure. The blood volume has been lost through the skin. The depleted supply is still being used for the desperate need of cooling the body from the heat which is destroying it. Again I say what a boon it would be to have a satisfactory method by which to measure blood volume in the body. Introduce 1,000 to 2,000 cubic centimeters of normal saline or 5 per cent dextrose into the veins and see how promptly the perfectly normal heart takes up its work.

PATHOLOGY

The pathology of heat exhaustion is that of dehydration. Wall and Wakefield: [28] "The major change was rigid contraction of the left ventricle, and venous congestion of all the veins in the body." Prudden and Delafield [29] refer to H. C. Wood, Jr., calling attention to the rigid condition of the wall of the heart. Osler and McCrae: [27] "The arteries seem to empty themselves and send the blood to the periphery."

CASE REPORTS

The following cases illustrate exhaustion as the result of dehydration.

Case 1.—I attended O. L. about 1922 after he had been relieved from the Navy, where he was serving as a cadet at Annapolis. He was a young man, aged 20, near the close of his first year at Annapolis, making his first cruise which took him from Baltimore to Honolulu. He writes as follows:

"In thinking over what happened to me, in the light of this idea (dehydration), the following recollections may interest you. The cruise was from Annapolis to Honolulu. I was assigned to the engine room from Annapolis to Panama, and to the boiler room from Panama to Honolulu. The temperature in both rooms was high, and got higher as we reached the tropics; moreover, the boiler room was under a forced draught. I should guess that the temperature there was between 120 and 130 degrees Fahrenheit. There was little physical exertion in the engine room, but in the boiler room I was working as a coal passer, which meant lugging cans full of coal from the bunkers to the furnace door. These cans were about the size of a large ash can. As I recollect, the first stage of the trip brought us little serious discomfort aside from mild seasickness. However, the water they gave us was distilled water, and I remember getting very sick of it. It tasted heavy and flat, and although I wanted to drink it, toward the end of the trip it began to nauseate me. Therefore, for several days prior to reaching Panama, I probably did not drink enough water. However, I felt well enough, and spent one day on shore leave at Panama. I remember a craving for fruit, and that I ate nearly a whole pineapple.

"After leaving Panama I lasted three or four days in the boiler room before I finally collapsed. I remember that my feeling toward the water increased in violence during this time. I craved a lot of it, yet I hated the stuff because it tasted so flat. My stomach was so upset that I ate very little food. I do not remember any specific craving for salt at the table.

"After I finally collapsed they assumed that I had influenza, presumably because of a high fever. However, there was no attempt to give me more water. In fact, I think I got even less than usual, perhaps only two or three glasses a day. I remember that for breakfast and supper they always gave me a cup of cocoa. I had a craving for orange juice or fruit juice of any sort, but there was none available. It certainly looks as if dehydration and lack of a proper salt balance were factors in the case."

✓ ✓ ✓

Case 2.—W. G. F., aged 67, collapsed from heat exhaustion in August, 1931, after a morning spent walking many miles through his orange grove in a temperature approximating 115 to 120 degrees Fahrenheit. He was unconscious, pulseless, cyanotic, and breathing heavily. When I saw him at the hospital twenty minutes later, his consciousness had partially returned. His pulse was very feeble, rate 50, blood pressure, systolic 96, and diastolic 60. He was immediately given intravenous injection of 1,000 cubic centimeters of a 5 per cent dextrose solution. This brought about a very prompt reaction, so that within one-half hour he was in a fairly normal condition. He took water by mouth very freely thereafter, and by morning, seventeen hours from onset, the total taken was 3,640 cubic centimeters plus the 1,000 cubic centimeters given intravenously, a total of 4,640 cubic centimeters of fluid. During all this time there was an output of urine totaling 450 cubic centimeters, showing the tremendous depletion of his storage reservoir. His total excess of intake over output must have approximated the total blood volume in his body. He continued to improve very rapidly, and was able to leave the hospital forty-eight hours after admittance, practically well, and has remained so.[80]

This is the patient whose condition instantly suggested dehydration with the obvious treatment. This case was reported in the *Journal of the American Medical Association,* 1931.[80] After careful search I failed to find the record of a similar use of this method by anyone before.

✓ ✓ ✓

Case 3.—Dr. J. C. King, former president of the California Medical Association, writes: "Many years ago the Southern Pacific Company ordered new rails laid across the desert, in July and August. Soon cases of sunstroke appeared. I cared for as many as a dozen in one twenty-four hours. The camps were supplied with a tank car of water from Indio, one each week. The water would be subject to a temperature from 120 to 140 degrees Fahrenheit each day. It soon became rotten and unpotable. I ordered a car of water to each camp each day. The foreman refused to obey the order. I appealed to the superintendent in Los Angeles, but he claimed no authority. I carried the same to San Francisco, and then to New York before I could obtain what I wished. As soon as fresh water was supplied daily, the cases of heat prostration diminished and, in about a week, ceased. The foremen were supplied with ice and used water freely. The laborers were not given ice and used water sparingly because it was so nasty."

TREATMENT

In the face of all this evidence of dehydration the treatment of heat exhaustion in any of its various forms, and of the preliminary fatigue as a result of dehydration, obviously consists in the administration of water. Fortunately the apparatus is now available in practically all hospitals, and the methods are well developed to administer water hypodermically and intravenously in the urgent cases. One thousand cubic centimeters of saline solution or five per cent dextrose intravenously is the prime indication in the really depleted patient. The method is the same as that used to overcome surgical shock and needs no detailed discussion. The *American Journal of Surgery*[81] gives an excellent summary of various methods. As soon as the patient is able, copious drafts of water should be given.[17]

As a preventive measure, we must constantly urge more water—drink more.

Industrial plants are giving considerable attention and health authorities are pushing the campaign to supply an adequate, wholesome, palatable, and convenient supply of water. From the standpoint of heat exhaustion, fatigue, and shock, it would be hard to overestimate the importance of this movement. Various amounts have been recommended, but for the average individual under moderate strain of mental and physical exercise, six or eight glasses per day is ordinarily needed. Under conditions of extreme heat such as encountered by workers in steel mills, foundries, hot mines, or in the holds of coal-burning vessels, two or three times more is required. The experience of Hunt[82] in India in desert conditions would indicate an amount up to thirteen liters as desirable. He says that the common consumption of water in India is thirteen liters a day.

CONCLUSIONS

1. We have reviewed the literature carrying the growing accumulation of evidence that dehydration is the important factor in heat exhaustion, and have illustrated the application of this principle.
2. The study of fatigue shows that dehydration is a large factor, especially in the face of copious perspiration.
3. In acute heat prostration, intravenous use of water, saline or dextrose, is a life-saving procedure.
4. An abundant, convenient, and palatable supply of water should be a first concern for all workers in hot, humid environment, brain workers as well as muscle workers.
5. Most people need the advice: Drink more water.

Glenwood Block.

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FOCAL INFECTIONS*

IN RELATION TO CARDIAC AND VASCULAR DISEASE

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Discussion *by William J. Kerr, M. D., San Francisco; Charles Miner Cooper, M. D., San Francisco; Fletcher B. Taylor, M. D., Oakland.*

THE purpose of this paper is to draw perhaps more forcibly to your minds facts long since known and to make, at the same time, a plea for more thorough and intelligent handling of focal infections which may be of the greatest consequence to the patient's future well-being. The impression which I get in reading a number of the more recent books on heart and vascular diseases is of the rather casual way in which the relationship of focal infections is treated by the authors, though they mention quite commonly that such relationship exists.

* Read before the Alameda County Medical Association, January 16, 1933.

CAUSATIVE ORGANISMS IN ENDOCARDITIS

Thayer, in 1925, from a study of 199 cases of acute and subacute bacterial endocarditis, supported by 138 autopsies, gives the following causative organisms:

	PER CENT		PER CENT
Streptococcus	57	Gonococcus	11
Pneumococcus	14	Influenza	4
Staphylococcus	13	Staphylococcus albus	1

In acute pericardial disease, Preble reported 244 cases divided as follows:

	PER CENT		PER CENT
Pneumonia	34	Sepsis	4.7
Rheumatic fever	28.4	Typhoid	1.7
Nephritis	11		

He does not mention the cause of the nephritis, probably mostly secondary to infection elsewhere. Rheumatic fever is coming to be rather generally accepted as due to a streptococcus; so that, if we eliminate pneumonia and typhoid, sepsis, rheumatic fever and nephritis furnish 64.3 per cent of his total.

White states that infectious aortitis, besides that due to syphilis, is also occasionally found as an acute lesion in rheumatic fever, typhoid, and tuberculosis; and further states that endarteritis may result from the same group of infections mentioned in Thayer's table.

He also says that in the treatment of aortic disease there is no effective treatment for atheroma, but "avoidance of overexertion and overeating and *protection against infection are advisable.*"

Speaking of the treatment of angina, the same author states: "Finally, there may be some special disease like syphilitic aortitis or *a focal infection,* the treatment of which results in abolition, at least for the time being, of the angina pectoris. Such trouble should be looked for and treated, but excessive zeal in therapy is to be avoided; too much surgery or medicine or tooth-pulling may do much more harm than good."

FOCAL INFECTIONS IN RELATION TO MYOCARDIAL DISEASE

In discussing focal infections in relation to myocardial disease in particular, White and others take the stand that they may aggravate already existing heart disease, and that such conditions as chronic cholecystitis, prostatitis, pyelitis, infection of gums, apical abscesses of teeth, sinusitis, etc., appear to be responsible for relatively unimportant disorders of cardiac rhythm, in particular extrasystoles of premature beats. White states that measures looking toward the elimination of such foci "are usually justifiable (if the circulatory condition permits) and may relieve the patient of his temporary state of ill health, or at least cause improvement." He warns against removing more than a few infected teeth at one sitting, and concludes that "the wisest course, then, is to view focal infections, so far as the heart is concerned, neither with overmuch fear nor with excessive disregard, etc." All of which leaves us with a very indifferent attitude toward the problem and its importance.

I grant that I have not seen any brilliant cures of bacterial acute endocarditis as the result of the