W J McGee's "Desert Thirst as Disease"

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with B. W. SIMONS, JR., M.D., and TOM HARLAN

Following the scientists with the United States and Mexico boundary surveys of 1854–56 and 1891–96, W J McGee was one of the first researchers to study the southwestern corner of Arizona Territory. A most keen and ardent field observer, McGee wrote in the fields of geography, meteorology, ethnography, anthropology, and medicine.[1] Although his papers may strike the modern reader as informal and anecdotal, they were influential in their time and remain relevant today for their detail of information.

McGee wrote in a vivid and spirited style for popular and interdisciplinary audiences. One of his most interesting papers, "Desert Thirst as Disease," was delivered to an assembly of Missouri doctors in 1906,[2] but after modest publication and discussion, it languished in archives until a couple of decades ago when it found its way to scholars on the University of Arizona campus. Dr. Bernard L. Fontana, University Field Historian, received a copy from a friend at the Smithsonian Institution (and in turn shared his now-tattered copy

1. William John (W J) McGee was born near Farley, Iowa, April 17, 1853. A fervid reader and inquisitive observer, he taught himself math, astronomy, surveying, Latin and German. Later he picked up sufficient geology, anthropology, and geography to work for the U.S. Geological Survey, to direct the Saint Louis Public Museum, and to head the Inland Waterways Commission, as well as publish over 300 articles, papers, and books. Although his friends called him Don, he always signed with his undotted initials W J. He died September 12, 1912. Cf. Bernard L. Fontana's introduction to W J McGee, *The Seri Indians of Bahia Kino and Sonora, Mexico* (Glorieta: Rio Grande Press, 1971); and, Emma R. McGee, *Life of W J McGee* (Farley, Iowa: private printing, 1915).

2. W. J. McGee, "Desert Thirst as Disease," *Interstate Medical Journal* 13 (1906):1–23.

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with friends), and Arizona archeologist Jonathan Gell, who stumbled across a copy in the Bureau of American Ethnology, supplied a copy to Dr. Annita and Tom Harlan, charter members of the Southern Arizona Rescue Association (SARA). Since then this rare but important paper has been photocopied countless times and passed from hand to hand. Convinced that every would-be rescuer should know what a lost victim may endure when stranded afield in our arid land, the Harlans even have read it aloud at SARA meetings.

The paper itself is divided into two sections. The first chronicles the dramatic case of Pablo Valencia, a prospector afoot for six and a half days without water along El Camino del Diablo, that perilous travel-corridor between Caborca, Sonora and Yuma which was especially infamous with '49ers.[3] Valencia's endurance and McGee's benevolence should give hope to future victims and rescuers alike. In the second section, McGee reworks one of his earlier papers[4] and establishes what he calls the "phases of thirst."

"Desert Thirst as Disease" is an *early* attempt to describe the insidious and dangerous progression of dehydration's signs and symptoms. Although it contains nothing blatantly incorrect or misleading, we may best read it as a preliminary description, not as fully charted exposition. While McGee was a pioneer scientist using the despoblado as his laboratory, medicine itself would soon pioneer its own frontiers. Medical training and study as we think of them today were not established until the 1920s with the standardization of medical curricula and the accreditation of medical schools[5]. The first *clinical* studies of thirst awaited the impetus of World War II,[6] and detailed physiological studies of thirst followed the boom of post-war laboratory technology. Intravenous fluid therapy, now so important in the treatment of dehydration and routinely used in all medical fields, also grew out of that war. Modern emergency medical and paramedical procedures, texts, and widespread services were not implemented until the 1960s.

3. C. F. Alonzo Pond, *The Desert World* (New York: Thomas Nelson, 1962), esp. pp. 314–29; and Bill Broyles, "Desert Thirst: The Ordeal of Pablo Valencia," *The Journal of Arizona History* 23 (Winter 1982): 357–80.

4. W J McGee, "Thirst in the Desert," *Atlantic Monthly* 81 (April 1898): 483–88.

5. Prompted in large part by Abraham Flexner's report, "Medical Education in the United States and Canada," *Bulletin of the Carnegie Foundation for the Advancement of Teaching, Number 4* (1910).

6. Cf. E. F. Adolph and associates, *Physiology of Man in the Desert* (London: Interscience Publishers, 1947).

McGee lacked even the rudimentary "black bag" medical equipment which we take for granted, let alone our sophisticated EKG's and blood analyzers. Viewed today, thirst is a symptom and dehydration a syndrome; neither are diseases. Still, McGee's observations were significant in their time and even today provide one of the most extraordinary and memorable cases of dehydration in medical literature.

Valencia experienced each of McGee's three phases of dehydration (dessication) brought on by prolonged solar-thermal exposure. He was ravaged by intermittent and repeated heat exhaustion (prostration), but *not* by heat stroke (hyperpyrexia) as many readers assume when they note that Valencia faced the Sonoran Desert in August. Had the weather been its usual self with temperatures in excess of 110°F, Valencia most probably would have met heat stroke and perished within a day or two. But, fortunately for him and as documented by McGee's meteorological readings, the weather proved moderately overcast and uncommonly mild, showing a maximum of about 103.2°F on one day, with sub-century readings the remainder of Valencia's trial.[7] Though Valencia suffered from extreme dehydration, his core body-temperature evidently never exceeded the 106–107°F necessary to drive his system over the precipice into heat stroke. This and his superior acclimation partly explain how his willpower and trail-sense could sustain him. Heat stroke knocks people down, completely debilitating them and overwhelming even the strongest courage. Unassisted, a person with heat stroke will surely die.

7. For the full meteorological report, cf. W J McGee, "Climatology of Tinajas Altas, Arizona," *Science* 23 (May 11, 1906): 721–30. McGee read the temperatures twice daily, at 8:00 a.m. and again at 8:00 p.m., using a minimum and a maximum thermometer. Also, McGee hastily concluded his 100-day record and broke camp after sunset on August 28, 1905 to rush one Pablo Valencia to Wellton, Arizona, after Valencia suffered a relapse in his recovery.

This was McGee's second expedition to Tinajas Altas (though he had visited southern Arizona as early as 1894). The earlier trip in 1900 is covered in his "The Old Yuma Trail," *National Geographic* 12 (March-April 1901: 103–7, 129–43.

Monitoring weather perhaps was but an excuse to visit a warm, dry place in search of "a desert cure." At this time McGee was suffering the early stages of yet-undiagnosed prostate cancer. With his own uncertain agony it's no wonder he had "doctoring" on his mind when Pablo Valencia came before him. Cf. his "The Desert Cure," *The Independent* 59 (September 21, 1905): 669–72; and his article which appeared the day after his death, "Symptomatic Development of Cancer," *Science* 36 (September 13, 1912): 348–50, wherein he describes the subjective phases of his cancer.

Although dehydration may lead to hyperpyrexia, it sometimes contributes to the additional (though counter) hazard of hypothermia, where the body's core temperature tumbles *below* viability. Ironically, unwary desert travelers who survive dehydration and heat trauma by day may succumb to the relative chill of night, because their impaired circulatory systems cannot warm and sustain their vital organs. On some days desert temperatures can swing 50°F.

The three stages of dehydration suggested in some modern medical texts are "mild," "moderate," and "extreme."[8] Mild dehydration, involving the loss of up to 5 percent of the body's fluid, manifests itself clinically with a dry mouth and perhaps rapid breathing, a rapid pulse, or headache. This roughly corresponds to McGee's first phase of a dry mouth and a craving for fluid.

The second stage, moderate, has a 5–10 percent degree of dehydration. It shows in the victim's poor skin turgor, sunken eyes, and irritability; although peripheral circulation may appear adequate, the pulse and blood pressure may actually be falling out of control. McGee describes phase two a bit more vividly than today's texts. Among the symptoms he observes scant and sticky saliva and mucus, the tongue sticking to the teeth, eustachian tube discomfort, a smarting of the eyes and a ringing in the ears, shrinking skin, severe headache, distorted thought and possibly hallucinations, all with a rising irascibility. When McGee further divides this phase of functional derangement into two levels, one incipient and the other intensified, he may be overly categorizing what is best viewed as a continuum.

By modern standards the third stage of dehydration shows a loss of 10–20 percent of the body's precious fluid. This is severe and frequently fatal. Here the patient is semi-moribund; his eyes are sunken, dry, and glazed; skin turgor is very poor; the mucus membranes are parched, and the extremities are cold, dry, and mottled. Blood pressure may be unobtainable and the pulse imperceptible.

Not unlike the modern third stage, McGee's phase three also notes that saliva ceases and membranes dry into a tightening film; the tongue shrivels; the eyes set into a winkless, blind stare; the skin shrinks; the heart beat slows and breathing becomes labored and gasping; eventually delirium sets in; cerebral and neural systems

8. E.g., Alan B. Gazzaniga, et al., *Emergency Care: Principles and Practices for the EMT-Paramedic* (Reston, Virginia: Reston Publishing Co., 1979), p. 155.

may never fully recover, even if the victim survives.[9] Without clinical intervention and a positive response, the patient will die. The death rate in third stage dehydration may run 80–90 percent. According to McGee's subjective estimate, Valencia lost 25 percent of his body fluids, but more likely the loss fell in the 15 percent range.

In modern terms, Valencia underwent extended and repeated heat prostration and dehydration, accompanied by decreased blood volume and circulation inadequacy (hypovolemia) and followed by reduced cardiac output with its hypotension. He also faced an imbalance between his blood salts and fluids, and he contended with metabolic acidosis, due to the accumulation of the body tissue's waste-products. In short, his blood thickened and there was less of it, so his heart had to pump harder and faster. Despite his body's arduous efforts, the level of oxygen in the blood declined while the wastes increased, and his organs verged on failure.

At best McGee's remedies, though proven, are home therapy. Fricassee, like chicken soup, contributes fluid, electrolytes and carbohydrates, while not upsetting the stomach. Similarly, mild coffee may help replenish the potassium, as well as adding water and sugar. His ministration of whiskey easily could have dilated blood vessels and dropped Valencia's blood pressure to fatal levels, but this may have been countered by his lucky use of a heart medicine. Plain water, and especially ice water, interferes with the body's protective reflexes and may lead to nausea, cramps or vomiting. Of course, today McGee would consult the most recent medical texts and scientific literature. Dehydration and heat prostration require prompt medical treatment and, if delayed, they may provoke heat stroke and its life-threatening complications of cerebral damage, kidney failure, and heart failure. Heat stroke is a geniune medical emergency which urgently demands the swiftest of field treatment and hospitalization.

Unfortunately, dehydration is not solely a condition of grizzled prospectors in remote desert camps or of mountaineers atop distant summits. It remains an ever-present danger and potential debility *within* the city limits. Most cases of dehydration now seen in emergency rooms involve people working out of doors in summer,

9. In McGee's "structural degeneration," which he divided into accelerated mummification and living death, the body's systems are failing and death is imminent. Incidentally, Valencia apparently underwent a near-death experience while teetering on the verge of total systemic failure.

athletes playing at midday, invalids or elderly lacking proper air conditioning, and small children unattended in closed cars. The flu, tanning, protracted car or plane rides, and just daily routine may nudge anyone into mild dehydration, where a headache, listlessness, and the "blahs" precede actual thirst. Guided by thirst alone during activity or illness, no one drinks fluid as fast as it is lost. The best advice back then and now? Drink early and often—don't save it.

The dread of thirst lurks in the innermost fears of desert visitor and resident alike. Popular images of the dry canteen, bleached cow skull, and circling buzzard mock that land—our land—"out there." "Desert Thirst as Disease" is a powerful historical document and remarkable cautionary tale of the desert Southwest. Here in Valencia's endurance and McGee's humanity we have a unique, compelling tale of thirst which seres our very viscera. But we must come, as McGee and Valencia came, to grips with the specter of thirst before we truly can call this desert "home."✣

Desert Thirst as Disease

W J McGee, LL. D.

I. A CASE OF THIRST

The principal scene of the case is a typical aguaje (i.e., "water") of southwestern Arizona, known since the days of Padre Kino (who apparently passed that way in the expedition of 1701 which proved that California is not an island, and located the "Tinaxa" on his map of 1702) as Tinajas Altas, or "high tanks." The water lies in a number of potholes or water-pockets in a gorge cleaving the northeastern side of Sierra Gila; it is chiefly a residuum of the light midsummer or midwinter rains, though the deeper pools are partly supplied by seepage from the granite ledges and precipices rising ruggedly several hundred feet above the gorge-bottom. The locality is about 75 miles southeast of Yuma, 40 miles south of Gila River, and three or four miles north of the Mexican boundary at a point 50 miles east of the mouth of Rio Colorado. The nearest house—the Southern Pacific station at Wellton—is some 30 miles northward in an air line, over broad sandwastes with scattered sierritas and buttes; water is obtainable at the Fortuna mine, 35 miles northwestward in Sierra Gila, and sometimes in other waterholes in the granites seven miles southward and twenty miles eastward; the abandoned Tule Well is 23 miles eastward, and the nearest certain water in that direction is in Rio Sonoyta sandwash at Agua Salada, some 80 miles away, or Agua Dulce, ten miles further. The region was never permanently inhabited by the aborigines, though temporarily occupied by the Papago Indians at the times of the cactus-fruit harvests, and apparently by the Cocopa and Maricopa Indians as a way-station on a severe and secret route of intercommunication; and hundreds of mortars are ground into the granites about the tinajas, while other relics occur. For the two half-centuries (1750–1848) during which California was a flourishing Mexican province, Tinajas Altas was reputed the sole sure "water" between Rio Sonoyta at Santo Domingo or Quitobaquito and Rio Colorado at Yuma on that desperately hard overland route known as El

Camino del Diablo, which joined the royal roads of Sonora and Sinaloa with the easier El Camino Real along which the old missions of southern California were strung; and during the days of the Argonauts; from '49 to the middle '50s, the same route was the hardest part of the Old Yuma Trail trod by American Pioneers in their long trek to the land of gold. From the single-house settlement of Quitobaquito to the town of Yuma the way is houseless, and apparently never had a fixed habitation save a small adobe at Tule Well; yet the passage of pioneers over the desert stretches was so steady and long-continued that hardly a mile of the 200 from Santo Domingo to Yuma remains unmarked by one or more cruciform stone-heaps attesting death by the wayside: death commonly in its cruelest form—by the torture of thirst. Most of the movement was westward, and the worst reach lay between Tule Well and Tinajas Altas; along this way the cross-shape stone-heaps, each telling its mute tale of tragedy, thicken until within gunshot of the nearly perennial water, where over 60 marked graves—and how many unmarked none know—lie mostly on a single little mesa in plain sight of the pools; for again and again exhausted strugglers fell at the foot of the gentle up-slope, or failed to find water in the lowest pool and were unable to climb the rocks to the higher reservoirs: when, if the next followers were pious folk—as were most of the Mexican pioneers,—the stark bodies were laid in shallow graves laboriously sealed with the sign of the cross.

Such was the site of my camp from May 20 to August 28, 1905—a tentless camp, with a living population of one when Papago Jose was gone for a week or less at a time, of two when either he or the young historian Harrison Ford was present (during the few weeks of his stay), and three with both; or of half a dozen for a few hours at a time when, as happened twice or thrice, prospecting parties passed that way: a camp devoted to meteorologic observation and study of the effects of light on desert life.

Just before noon of Monday, August 14, Pablo Valencia and Jesus Rios drifted into camp horseback en route to the "lost mines" rediscovered by the former some months before. They were supplied with pinole (parched-wheat meal), bread, cheese, sugar, coffee, and tobacco for a week's subsistence, with two 2-gallon and two 1-gallon canteens, and had also a dozen pounds of pressed alfalfa

and twice as much rolled barley for the horses.[1] Jesus is 65, a former vaquero and nearly typical Mexican, claiming familiarity with the country, but erratic and inconsequent and little dependable in statements of fact or in any other way; he rode his own grass-fed horse, which shrank, bronco-like, from barley. Pablo is about 40, of remarkably fine and vigorous physique—indeed, one of the best-built Mexicans known to me. In earlier life he was a sailor on Pacific vessels and afterward a wandering prospector and miner; he was tiding over the summer of 1905 by growing watermelons on a ranchita near Gila City. He measures about 5 feet 7 inches, weighs normally some 155 pounds, and is notably deep-chested and round-bodied, with—for a Mexican—exceptionally robust limbs; he is reputed a large eater and heavy sleeper, and is of phlegmatic disposition, given to drowsing in the shade rather than working in the sun—yet between periods of repose he is of energetic and pertinacious habit, walking barefoot or in sandals (in preference to riding) with a quick and strong up-springing gait carrying him by all but the best horses, openly scorning hunger and thirst and boasting ability to withstand far beyond ordinary men these habitual inconveniences of the range. In a word, he is a particularly fine type of the animal genus *Homo*—a most matter-of-fact man of action in his little world, albeit lightly burdened with acute sensibility, imagination, or other mentality; indeed, an ideal man to endure stressful experience. He rode Jim Tucker's best horse—an animal of exceptional bottom, well inured to desert work.

While their horses ate, Pablo and Jesus lunched with Jose and me, feasting on jerked cimarron (mountain-sheep meat), in addition to their own comestibles. Against my advice (which was to leave at 1 A.M. Tuesday, the moon being about the full), they set out for their El Dorado about five o'clock; but in half an hour they returned, having decided to wait until morning on the ostensible ground that the horses had drank but little, though in reality because my judgment had finally worked in. Next morning Jose stirred up Jesus, and

1. They were outfitted at Yuma by Jim Tucker, miner and rancher; they left there in the saddle after noon on August 12, having shipped a bale of hay and a bag of barley with some of their food and canteens to Wellton; camping on the banks of the Gila north of Blaisdell, they started early Sunday morning and reached Wellton about midafternoon, where they took their freight and fed and watered freely, leaving part of the feed for the return. They started for Tinajas Altas Monday morning "at the time of the morning star" (say three o'clock) and covered the thirty-odd miles in a little over eight hours.

the two pulled Pablo from his saddle-blanket for breakfast; and they got off at daybreak. This was the real beginning of the journey—about 3:45 Tuesday morning, August 15.

Soon after midnight Jesus came in alone, with both horses, reporting that Pablo had sent him back from a point about 35 miles south-eastward to re-water, he himself going forward on foot with a 2-gallon canteen and a stock of pinole, under an agreement—an inane if not insane one in desert life—to rendezvous 24 to 30 hours later not on the trail but on the farther side of a nearby sierra. Jesus drank, ate, watered, fed, and struck the trail again (with five gallons of water, taking one of my canteens) about 3:30 A.M. on the 16th. Next morning about 7 he again came in alone with both horses, reporting that his own animal had broken down after a short distance and that he had ridden the Tucker horse by a better route both to the rendezvous and to where he had left Pablo at the edge of the sand-hills; and that he had been unable to find either the lost man or his trail. He explained that Pablo had probably gone on the Agua Salada (as he had advised all along, misstating the distance, etc.), and proposed after resting to return to Wellton and Yuma. He was indeed exhausted, having ridden some 150 miles in about 52 consecutive hours; while his horse was practically broken down, and the Tucker animal tired. On putting together all statements from both Pablo and Jesus, I was in doubt as to whether or not Pablo had gone on toward Rio Sonoyta, though this seemed probable; yet I thought he ought to have another chance for his life, and so held Jesus at Tinajas Altas and sent Jose (an expert trailer among his tribe of trailers) out on the Tucker horse to find Pablo's track, giving him full instructions as to routes, places for smoke signals, etc. (for I knew the region better than he), and directing him to go to the limit of his horse's endurance and then to his own limit beyond. Jose carried a feed of barley, a couple of pounds of pinole and dates for himself, and two extra canteens; he got off about 10 o'clock Thursday, August 17. Stopping only to send up smokes, he followed old Jesus' ill-chosen trails and easily located the point at which Pablo had left him on the 15th; thence he followed the foot-trail with difficulty in the darkness of the early night. Reaching the sand-hills about moonrise, he left the horse and labored through the dunes seven miles further—then returned as he came, making signal fires here and there. Picking up the horse in the dawn and giving him a half-gallon of water from his hat, he arrived at camp in

speechless exhaustion just before noon Friday, the 18th. I was convinced that further effort would be bootless, since it seemed probable that even if Pablo had not gone on to Agua Salada en route to Santo Domingo he could hardly still survive, for he had already been out over three days with only one day's water—and most of those who die from desert thirst expire in less time; so although Jesus and his horse were still unrestored and the Tucker animal had been moving almost steadily for 80 hours and over 225 miles, I packed Jesus off toward Wellton and Yuma to report his virtual abandonment of the man he had undertaken to guide and protect—supplementing his prospective oral report with a special delivery letter to El Padron (Jim Tucker), to be mailed at Wellton in time for the 2 o'clock train Saturday morning.[2]

So ended the first episode in the Pablo Valencia event, in the afternoon of August 18. I remained uneasy a day or two longer, and next day and the day after climbed a neighboring peak 750 feet high and walked out a few miles on the trail to seek for sign; then Jose and I fell into normal camp routine.

IN THE GRAYING DAWN of Wednesday, August 23, the grasp of sleep on me relaxed in a vivid dream recalling a picture often presented in the ganaderos (half-wild cattle ranges) of western Sonora—the picture of an orderly file of stock, led by a stalwart bull and trailing down to yearlings in the rear, the leader iterating his grave grumbling roar of assurance to the herd which at last—as on the range—rose in quick crescendo into the ear-piercing bellow of challenge and defiance to all other kine. I awoke at the dream-sound to realize its actuality, and turned my head half expecting to see the herd; instead, there stood Jose, just arisen from his blanket, looking down the arroyo. Seeing my movement, he asked: "What is it? I thought it was one of them roaring, lions, like in the Zoo." Now fully awake, I replied: "It must be Pablo; take the canteen." Though wholly incredulous, he mechanically seized a canteen and a strip of manta which with his coat made a pillow, and, after a call in reply,

2. Jesus started about four o'clock P.M. on August 18 and should have reached Wellton between one and two, thus getting the letter into Tucker's hands early the next morning, and he should have himself arrived in Yuma early Sunday morning, August 20; but he slumped characteristically on the Wellton stretch, and made a needless camp beyond, so that he and the letter arrived about the same time on Monday afternoon.

ran down the trail. I soon followed, carrying another canteen and a medicine case; and on the arroyo sands, under an ironwood tree, at the foot of the Mesita de los Muertos with its two-score cross-marked graves, came on the wreck of Pablo, with Jose already ministering unto him.

Pablo was stark naked; his formerly full-muscled legs and arms were shrunken and scrawny; his ribs ridged out like those of a starveling horse; his habitually plethoric abdomen was drawn in almost against his vertebral column; his lips had disappeared as if amputated, leaving low edges of blackened tissue; his teeth and gums projected like those of a skinned animal, but the flesh was black and dry as a hank of jerky; his nose was withered and shrunken to half its length; the nostril-lining showing black; his eyes were set in a winkless stare, with surrounding skin so contracted as to expose the conjunctiva, itself black as the gums; his face was dark as a negro, and his skin generally turned a ghastly purplish yet ashen gray, with great livid blotches and streaks; his lower legs and feet, with forearms and hands, were torn and scratched by contact with thorns and sharp rocks, yet even the freshest cuts were as so many scratches in dry leather, without trace of blood or serum; his joints and bones stood out like those of a wasted sickling, though the skin clung to them in a way suggesting shrunken rawhide used in repairing a broken wheel. From inspection and handling, I estimated his weight at 115 to 120 pounds. We soon found him deaf to all but loud sounds, and so blind as to distinguish nothing save light and dark. The mucus membrane lining mouth and throat was shriveled, cracked, and blackened, and his tongue shrunken to a mere bunch of black integument. His respiration was slow, spasmodic, and accompanied by a deep guttural moaning or roaring—the sound that had awakened us a quarter of a mile away.[3] His extremities were cold as the surrounding air; no pulsation could be detected at wrists, and there was apparently little if any circulation beyond the knees and elbows; the heartbeat was slow, irregular, fluttering, and almost ceasing in the longer intervals between the stertorous breathings.

3. The distance to which the moaning carried was doubtless due partly to the funnel-shape gorge in which the sound was concentrated, while the audibility was, of course, enhanced by our habitude to the desert stillness, seldom broken save by chattering of ravens, cooing of pigeons, or whistling of quails, all beginning later in the day.

The victim was, of course, unable to articulate or to swallow. Water was slushed over his face, head, chest, and abdomen, and rubbed into his limbs and extremities, the skin first shedding and then absorbing it greedily as a dry sponge—or, more exactly, as this-season's rawhide; dilute whiskey was forced into his mouth and rubbed on his chest with prompt effect (doubtless the greater because Pablo was a habitual tee-totaler); and when in half an hour swallowing motions began feebly, both whiskey and a powerful heart stimulant (digitalis-nitroglycerin-belladonna tabloid triturates) were administered internally. In an hour he drank, though most of the water was immediately expelled from the stomach; in two hours he began to partake of food—a bird fricassee with rice and shredded bacon; in some three hours (soon after sunrise) he was able with some help to walk into camp. By this time he had ingested and retained about 2-1/2 ounces of whisky, with 5 ounces of water, and 2 or 3 ounces of food; his external tissues were saturated and softened, circulation was restored sluggishly in his extremities, and his numerous wounds begun to inflame or exude blood and serum. Articulation slowly returned, and in a cracked voice, breaking involuntarily from bass to falsetto, he began to beg pathetically for "agua, agua," and to protest against the "dust" which we were compelling him to sip; he even failed to recognize coffee, which was given in small quantities.

As Pablo's strength returned in the course of the day, two abnormal conditions developed: the more disturbing at the outset began with local inflammation about the cuts, scratches and bruises suffered in creeping the last seven miles over a cactus-dotted and often stony plain, and extended into a general feverish and irritable state doubtless intensified by the long-continued nerve-strain; it was accompanied by pains and inflammation in wrists and hands, feet and ankles, and at one stage I feared loss of nails and sloughing of phalanges, which might have ensued in a less pure and invigorating air. The other disturbing condition was the passing of the hoarse, stertorous breathing into a sort of spasm, apparently affecting stomach, diaphragm, intercostal muscles, and the upper part of the body generally—a combined retching and hiccoughing so severe as to rack the victim from head to foot and induce violent vomiting. A preparation of bismuth in tablets gave some relief, and pepsin-pancreatin tablets taken with food were beneficial; yet the spasms were so severe and persistent as to threaten fatal exhaustion. Toward

evening urinary excretion began feebly, at first accompanied by blood and mucus; it was over two days before movement of the bowels began. The camp dietary was then reduced, but the birds (California quail and Sonora pigeons, shot fresh every morning) fricasseed with rice and minced bacon were nutritious and easily digested: though we longed for watermelon for him. On the third day (Saturday, August 26) vision and audition became normal, and Pablo began to notice things in an infantile way, as if the power of apperception were awakening; he stared at and evidently recognized shrubs and rocks about the camp, scrutinized and curiously felt of his own hands and feet, and also clearly recognized water; while his mind began to place Jose and me in his fabric of definite cognition—for we had been mere shadow-objects before. He surprisedly examined his wounds, which were then healing satisfactorily, and described the spasmodic retching as due to the forming of a "ball" in his stomach. On the second day he had muttered, half to himself, the events of his journey; on the third, he recounted them spontaneously and in reply to inquiries in such manner as to yield a definite and doubtless fairly trustworthy itinerary.

On Sunday, August 27, came in Jim Tucker with four-horse wagon and extra saddle-animals, accompanied by two or three men (all friends of Pablo) to search for trails and remains; at first the patient hardly knew them, and shrank from them as creatures of a nightmare; but they showered him with attentions and forced on him heaping plates of stew, frijoles and fried bacon, and whole loaves of soggy Dutch-oven bread, with the result that the spasms were intensified and accompanied by effusions of biliary matter streaked with blood. For a day Tucker planned going on to the "lost mine," leaving Pablo with me; but the relapse was so serious and the recurrent spasms so severe that by Monday noon I felt compelled to prescribe a return to Wellton. About 4 o'clock the spasm-racked wreck was bedded in the wagon; about 11 p.m., when a halt was made to rest the team—for the nearly trackless sands dragged heavily—I judged there was an equal chance of getting the patient alive to Wellton; at 2 we were moving again, and about 7 we drew into the clean sand-wash in the rear of the station. Twenty minutes later we had raw eggs, and Pablo's crisis was past. Later in the day some watermelons were secured; and next morning we were in Yuma. Pablo was guarded for a few hours, but spent practically the whole of August 31 deliberately and methodically devouring watermelons,

with occasional lapses into slumber; and in a week he was well and cheerful, weighing 135 pounds or more—though his stiff and bristly hair, which had hardly a streak of gray a fortnight before, had lost half its mass and turned iron-gray.

THE NATURE OF THE CASE and the severity of the stress successfully encountered by Pablo Valencia cannot fully be understood without considering the utterly desert character of the region—than which there is none worse in North America save Death Valley and a few other basins not opening toward the sea,—and the torridity of the climate and season. The 100-day record (May 21 to August 28) of temperature and humidity at Tinajas Altas served to define a vapor-zone about Gulf of California in which a large part of our storm-centers find origin; and although most of Pablo's route lay outside this zone and in a hotter and drier belt, the record from the evening of August 14 to the morning of August 23 approximately indicates the attendant climatal conditions. This record, with the means for the 9-day period and also the averages for both August 1–28 and for the 100-day period, is appended—from which it will appear that Pablo was favored by exceptionally low temperature and high humidity; yet the maximum temperatures ranged from 88.5 to 103.2 (averaging 95), and the minimum night temperatures from 78.4 to 93.2 (averaging 84.2), i.e., were always above that somewhat variable yet most important physiologic value which may be termed the *perspiration-point*: the point at which the burden of elimination is transferred either from kidneys and lymphatics to the skin, or from the epidermal to the internal eliminative structures, as the temperature-measure is passed. Pablo was also exceptionally favored by clouds; for although the sky was never wholly overcast, the average of morning and evening cloudiness reached two-tenths of the total sky. He was fortunate, too, in the high relative humidity for a desert range; at Tinajas Altas the percentage of aqueous vapor ranged from 18 to over 60 (averaging 38), indicating that along his route it probably oscillated between 15 and 55 (see table 1).

Pablo's itinerary, taken partly from his nearly meaningless maunderings as speech returned, but chiefly from connected statements largely in reply to inquiries, runs thus:

Tuesday, August 15: Left Tinajas Altas at 3:45, horseback, with Jesus; rode some 35 miles, reaching "sand-hills" about one

TABLE 1

TEMPERATURE AND MOISTURE

DATES (1905)		TEMPERATURE					MOISTURE			
		SELF-REGISTERING THERMOMETERS			PSYCHROMETER			HUMIDITY		
		Maximum	Minimum	Range	Mean	Dry bulb	Wet bulb	Depres'n	Dew point	Relative Humidity	Rain (inches)	Cloudiness (tenths of sky)
August 14.	8 p.m.	99°1	85°1	14°0	92°1	91°0	65°0	26°0	48°0	23.0%	0	0.1
" 15.	8 a.m.	91.8	78.8	13	85.3	90.5	62.5	28	41	18	0	.1
	8 p.m.	98.9	90.9	8	94.9	92	66.5	25.5	51	25	0	.1
" 16.	8 a.m.	92	81	11	86.5	86	69	17	60	42	0	.2
	8 p.m.	99.5	85	14.5	92.2	91.5	71.5	20	61.5	38	0	.1
" 17.	8 a.m.	94	79.7	14.3	86.8	93	68	25	54	26.5	0	.1
	8 p.m.	103.2	93.2	10	98.2	95	69	26	54	25.5	0	.1
" 18.	8 a.m.	95	83	12	89	87	76	11	72	60.5	0	.1
	8 p.m.	96	86.6	9.4	91.3	88.5	73	15.5	66	48	0	.8
" 19.	8 a.m.	88.5	80.5	8	84.5	87	74	13	69	54.5	0	.1
	8 p.m.	98.4	85.4	13	91.9	90	73	17	65	44	0	.0
" 20.	8 a.m.	90	81	9	85.5	87.5	73	14.5	66.5	50	0	.1
	8 p.m.	99.1	87.3	11.8	93.2	89	71.5	17.5	63	42.5	0	.1
" 21.	8 a.m.	89.9	78.4	11.5	84.2	88	74	14	68	52	0	.6
	8 p.m.	91	87	4	89	90	71	19	62	39	0	.6
" 22.	8 a.m.	92.1	81	11.1	86.7	91	69	22	57	32.5	0	.2
	8 p.m.	100	90	10	95	91	71	20	61	37.5	0	.7
" 23.	8 a.m.	91.8	82.1	9.7	86.9	91	69	22	57	32.5	0	.2
Means, August 14–23		95	84.2	10.8	89.6	89.9	70.3	19.6	59.8	38.4	0	.2
Average August 1–28		101.8	81.7	20.1	91.7	92.3	69.7	22.6	56	32.9	.004	.12
Average 100-day period		99.3	77	22.3	88.2	88.9	64.5		46.5	27.1	.0012	.067

o'clock; thence afoot with 2-gallon canteen (full at starting), pinole, tobacco, serape, duck coat, prospector's hammer, canvas specimen-bag, cigarette papers, and matches, faring some ten miles through the sands before stopping to sleep. Drank three or four times, and took pinole twice.

Wednesday, August 16: Starting with the rise of the morning-star, reached the ledge of which he was in quest about midforenoon; after collecting specimens, erected monuments and posted notices for a mineral claim, finishing this work before midday. Ate a little pinole and drank sparingly (as he had done before starting), for the canteen was nearly empty. Starting northward, began search for a road described (falsely) by Jesus, and straggled rather aimlessly over the sands, moistening his mouth occasionally but not swallowing water, until the canteen was empty; at nightfall reached an arroyo in which he fancied signs of water. In the darkness of the early night (before moonrise) abandoned his nuggets, and soon after threw away his stock of pinole and his coat and serape. Failing to find water, he sought sleep in the sands; and when awakened by mouth-dryness obtained some relief—after the fashion of all Mexicans and most Americans in like cases—by occasionally filling his mouth and gargling his throat with urine.

Thursday, August 17: Set out early, seeking trails and tinajas, and working northward; unable to withstand the heat of midday, he lay down in an arroyo and ate calabasitas (wild gourds of intense bitterness), which his stomach rejected. Arising as the sun declined, he threw away shoes and trousers (with money, knife, and tobacco in the pockets), and wandered on northward, finding occasionally old trails which either faded away in a few miles or else led into sands or impassable rocks—trails mostly figments of disordered fancy. One led to an immense tinaja; but it was dry. During the day he had frequent recourse to urine, though he nearly lost the power to swallow; during the night he saved every drop of the execretion in the canteen, which he still carried.

Friday, August 18: In early morning he walked a few miles, but was overcome by the torrid heat and crept under the shade of a paloverde overhanging an arroyo; toward evening he

arose, and chewed paloverde twigs with little effect save to irritate mouth and throat. Setting out northward before sunset he found a mescal (a variety of agave) and chewed the stipes, extracting a little moisture; at sunset he caught a few flies and spiders, which he chewed and tried to swallow. Still he wandered northwardly, having in mind first the rendezvous with Jesus, then the Old Yuma Trail he had traversed years before. Toward morning he became convinced that Jesus had deliberately misled and abandoned him with murderous intent in the plan of thus securing his El Dorado; and his wrath spurred him on with the aim of knifing his deceiver—a potent incentive which carried him miles and doubtless saved his life. He continued to relieve mouth-thirst with urine.

Saturday, August 19: In early morning he found mule-wagon tracks and recognized the Old Yuma Trail,[4] which he followed, but soon fell under the heat and lay all day in an arroyo. In the afternoon he saw one of the large light-green scorpions of the region; it looked luscious, and he captured it, ground off its sting with a stone, and devoured it. As before he used urine, swallowing a part with great difficulty. Toward evening he resumed journeying northward, often falling; near morning he found (or thought he found) Jesus' trail where he had wandered in search of the hopeless rendezvous set for the 16th. Throughout the night he caught occasional glimpses of a coyote trailing him. During all of Saturday and throughout this night on the trail he was buoyed by a new incentive—the hope of reaching Tule Well and casting himself into the moist mud at its bottom and at the worst dying in the dampness and coolness 37 feet below ground; he felt the notion half insane and the hope wholly hopeless, yet unto them he clung as to an inspiration. Meantime, he constantly sought insects to chew, and continued using his urine, now "mucho malo" (very bad).

4. Here I first locate him. Apparently he was then just west of Tule Playa and east of the adjacent sandhill-malpais ridge—i. e., about 27 miles east of Tule well and 50 miles from Tinajas Altas. This trail coincides closely with the International Boundary; Colonel D. Du B. Gaillard gave a good account of it in the *Cosmopolitan Magazine* (October, 1896, pages 592–603) about the time the last Boundary Survey was completed; and I described it, with illustrations of Tinajas Altas and the graves on the neighboring mesita, in "The Old Yuma Trail," *National Geographic Magazine*, Volume XII, 1901, pages 103–107, 129–143.

Sunday, August 20: In early morning he pushed on westward, often sitting down, sometimes falling, and tried crawling—with little success. His vision was vague; the mountains danced, and the cactus and chapparal clumps moved to and fro before his eyes; and before full day he passed the first Tule Well guidepost unseen (Tule Well is a mile or two north of the main line of the trail) and kept on westward to the second one, west of the well—where the sun was growing strong, and he was too weak to work back along the side trail. Regarding his passing of the well as an omen of speedy relief, he hung his hat on the guidepost, and, after creeping to one or two tinajas—known to him of old—which he found dry, he lay all day in the shade of the rocks, utilizing every drop of urine, which now dripped scantily and involuntarily. Toward evening he again bethought himself of Jesus and the pleasure of knifing him, and was inspired to further effort; but he fell so often as he struggled forward that he was only at a remembered camp-site 3 1/2 miles west of Tule Well when day broke again.

Monday, August 21: On reaching at dawn the camp-site, only 19 miles from Tinajas Altas, he felt sure of relief and stretched himself across the trail so as not to be missed by rescuers—there he dozed and slept, starting up frequently at fancied sounds of wheels and hoofs; the buzzards, which had followed him for two days, now came almost within hand-reach. The sleep and coolness (only 91 degrees) of the day and the short distance traversed the night before had their effect; he felt stronger, and toward sunset he set out again westward along the trail, buoyed by the certainty of at least finding full canteens (of which Jesus had indeed left two, at impossible places). The course was down grade, along the arroyo and across the black malpais mesita on which the ancient graves lie thick; and his hope was strong, though the mountains were no longer seen in their places and he had to feel the trail with his hands every few yards to be sure he went aright. He often thought he saw Tinajas Altas with abundant water and food just before him, yet was not wholly cast down on feeling a landmark he knew to be miles away; so he made, with many rests and naps, twelve miles.

Tuesday, August 22: In early dawn his mind was reaching out buoyantly to Tinajas Altas as but a few steps away, when he half saw, and then fully felt all over, the six-mile guidepost (about seven miles from camp), and awoke to the sad certainty that no canteen hung there, and the still more crushing realization that he could not cover the remaining miles of sand—for his urine had ceased to flow hours before, and he felt his last recourse gone.[5] As the sun rose he sought the shade of a shrub and there knelt in final prayer for the dying; then he laid himself down with feet and face to the eastward, made the sign of the cross with a pang over the absence of consecrated water, and composed himself for the end. There—and this was his clearest concept, unreal though it be—with the rising of the sun he died, and his body lay lifeless under the burning rays, though his innermost self hovered about, loth to leave the material husk about which the buzzards waited patiently. The sun swung across the shimmering vault, and darkness fell; in the chill of evening (fortunately an exceptionally cool night—just above 82 degrees) some vague shadow external to his Ego stirred and then struggled aimlessly against chapparal and cactus along the most trying stretch of El Camino del Diablo. Sometimes he felt half alive and wrung by agony of severing spirit and flesh; oftener he felt that the naked body was pushed and dragged and belabored and tortured by something outside; he knew its voice tried to cry out in protest or call for rescue, but did not feel the voice his own. So the night dragged on and on, until at early dawn the vague consciousness knew itself near the camp with the certainty of relief, and was dimly surprised at the bellowing break in a final call.

Wednesday, August 23: After uttering this call, he crawled some 50 yards down the last descent to the arroyo below the Mesa of the Forty Graves. Of this day, with its physical shock and psychical break, Pablo remembered nothing clearly.

5. Pablo thought he left at the six-mile guidepost his hat and underclothes, though they were not found on subsequent search; it is more probable they were left at the western Tule Well guidepost, where he remembered hanging his hat as a signal. His trail here showed that he seldom walked, and then but for a few steps, only to fall again, and mostly crept wanderingly amid the thorny clumps, though sticking fairly to the trail.

Summarily: Pablo was in the desert just eight days (and nights), with one day's water; he rode in the saddle 35 miles and walked or crept between 100 to 150 miles. For nearly seven days, or fully 160 consecutive hours, he was wholly without water from sources exterior to his system, save the few drops extracted from the scorpion, agave stipes, and insects—a desert record without parallel known to me: for half the victims of desert thirst die within 36 hours of deprivation, another quarter within 48 or 50 hours, and nearly all known to survivors within 70 to 80 hours (three days and nights), or hardly half of Pablo's stress. For some five days (August 16–21) he consumed his urine; ordinarily, the reconversion of excreted liquid is hardly helpful if not wholly harmful, yet in Pablo's case it seems to have materially prolonged vitality. For nearly nine days (August 17–26) his bowels were inactive, and for two days his kidneys failed to function. The eight-day siege lost him 35 or 40 pounds (or 25 per cent) of his weight, chiefly through evaporation from skin and membrane; he also suffered fully two-score cuts, scratches, and bruises, each of sufficient severity to give some shock to the system; and his mouth, esophagus, and stomach were seriously deranged by his desperate efforts to relieve the thirst-torture. The most striking feature of the case was the absence of wholly insane delirium: he was, indeed, affected by the revulsion against gold, as shown by the abandonment of his nuggets and the casting away of his money; he was possessed of hallucinations as to the wetness of sands, the moisture of articulates and shrubs, and the nearness of Tinajas Altas; he was obsessed by the desire for vengeance against Jesus, the dream of casting himself in Tule Well, and the delusion of death—yet he never lost his trail-sense, and apparently squandered little vitality in those aimless movements that commonly hasten and harden the end of the thirst-victim.

II. THIRST IN GENERAL

In viewing thirst as a pathologic condition, it is needful to review the role of water in normal physiology. The average human body is about one-fifth solid matter and four-fifths liquid, i. e., H_2O or water. This liquid forms the chief distributing or circulating agency of the organism; it is no less essential to assimilation and metabolism than to circulation in the artero-venous and lymphatic systems; it forms the bulk of the softer tissues and enters into the composition of the harder, and permeates or flows through all structures either by osmosis or through specialized vessels. As an agency connecting the individual with the external, i.e., with environment, water is far more important than "food," more important even than air; water streams through the entire organism, entering chiefly through the alimentary system and escaping through the skin and membranes as well as through the main excretory channels; water as liquid and vapor in connection with the lungs and skin affords the chief means of equalizing and controlling the temperature required for organic existence; and water is undoubtedly the primary requisite for that ionization to which it is customary of late to reduce the chemistry of vital existence and growth. It is in harmony with the essential and distinctive role of water in the normal organism that the average human dietary embraces 4 to 12 (averaging about 6) parts of liquid to one part of solid matter—a mean ration for adults of, say, six pounds of liquid and one pound of dry food; it is in harmony, too, with the demonstrations of Dr. Tanner and others that with water a fast of forty days is feasible but without liquid is fatal in one-sixth of that time: indeed, water is to be regarded not so much a mere solvent of foodmatter as an actual aliment—and by far the most important aliment in the animal economy.[6] Accordingly, in this view of the role of water in the normal body, thirst, in extreme stages at least, is seen to constitute and express a general and fundamental derangement of the vital system.

It may be convenient to define three types of thirst, i.e., (1) the Ordinary Thirst, experienced in humid lands, caves, mines, etc., in which the air is charged with aqueous vapor and the tissues little affected by salts external to the system; (2) the Thirst of the Sea, experienced where the air is heavily charged with vapor and non-potable liquid abounds, while the tissues are subjected to the action

6. The role of water in the human system and its place among food-substances are discussed more fully in "Potable Waters of Eastern United States," Fourteenth Annual Report of the U.S. Geological Survey (1894), pages 5–8; and incidentally in "The Seri Indians," Seventeenth Annual Report of the Bureau of American Ethnology (1898), pages 180–182. The reckoning of ratios of solids to liquids both in body and in food varies with modes of analysis, the interpretation of hydrates, etc., so that the values given above are to be regarded as illustrative and merely approximate rather than definitely quantitative.

of salts; and (3) the Desert Thirst experienced where water is lacking both as liquid and as vapor, and where free salts external to the system are (commonly) absent. The third of these types is, of course, the most distinctive; and it is this alone which I have had opportunity to study in sufficient detail to warrant discussion. My data embrace personal observation on a score or more of thirsty men at divers times and in sundry places; reminiscences gathered personally from a dozen or more survivors of extreme thirst, and from a considerably larger number of men who have chanced to succor the thirsty; portions of the abounding thirst-lore in the arid districts of Arizona, California, Nevada, New Mexico, and Sonora; numerous newspaper and magazine accounts—all more or less pointless and inaccurate; a few unwittingly faithful records like that of Manley in "Death Valley in '49"; conferences with men like artist Lungren, naturalist Merriam, litterateur Lummis, et al., who have both seen and felt; and—safest of all—several personal experiences, one extending over half way through the successive stages.[7]

It is convenient to recognize five phases of desert thirst, falling into three successive stages; the first phase and stage may be considered *normal*, while the remaining stages, each comprising two phases, are distinctively abnormal or *pathologic*—the earlier being marked by *functional derangement* and the later by *structural degeneration*. The phases ensue in fixed order though the rate of progress is variable, ranging—according to heat, air-dryness, stress of exercise, and (more than all else) inurement of the sufferer to desert life—from, say, six hours to several days; while certain features of the later phases may be more or less masked when the progress is retarded either by favorable physical conditions or by special fitness of the organism.

1. *The Stage of Normal Dryness—a.* The normal system deprived of water reacts mechanically with a sensation of dryness in mouth and throat, and instinctively in the general craving for liquid denoted as thirst; in conditions of extreme aridity and heat the sensation of dryness and the instinct of thirst frequently arise without

7. A considerable part of the data were summarized in 1898 in an article entitled "Thirst in the Desert" in the *Atlantic Monthly* (Volume LXXXI, pages 483–488), originally designed as a contribution to the physiology of thirst to be presented before the Medical Society of the District of Columbia (in recognition of the honor of election as a "Member by Invitation"), and only through chance diverted to a purely literary medium; the quoted extracts beyond are from this paper.

actual deprivation in persons not inured to desert life. If not relieved, the initial condition passes into general uneasiness, discomfort, or irritation, accompanied by rise of temperature and other febrile symptoms. Commonly the condition is alleviated by a moderate quantity of water; sometimes fruit acids and other sapid substances exciting flow of saliva are requisite for relief; and in the practical life of the range a pebble or nail carried in the mouth is often efficacious. This stage—and phase—may be of little consequence save as the beginning of a series; it is experienced again and again by all men of arid regions, and excites annoyance rather than apprehension on the part of the patient, hilarity rather than pity among the company—it is the *clamorous* phase, or the stage of complaining.

2. *The Stage of Functional Derangement—b.* In the incipient phase of pathologic dryness a general febrile condition becomes marked and is accompanied by special local symptoms; saliva and mucus in mouth, throat, and nostrils become scant and sticky, and there is a feeling of dry deadness of membranes extending to the epiglottis and even into the lungs—the sensation of inbreathed air changing from one of refreshing coolness (the chief physical pleasure of life in the desert) to one of oven-like heat; the tongue may cling irritatingly to the teeth, or stick to the roof of the mouth; a lump seems to rise in the throat and starts endless swallowing motions to dislodge it; discomfort and pain run from throat to ears along the eustachian tubes and through the tissues; the tympana may snap and drum annoyingly; while the ear-openings itch and the eyes smart. There is feeling of fullness in face and head (doubtless due to shrinking of the skin), usually accompanied by headache and throbbing pains in the nape and down the upper spine; the hearing is disturbed and seeing capricious, so that illusions and hallucinations—especially the delectable pictures engendered by the desert mirage—spring constantly unless checked by connected effort; irascibility arises, and companions quarrel and separate, perhaps to reunite for the very satisfaction of further dispute; the solitary sufferer may soliloquize, largely in impassioned invective—though the voice becomes cracked, husky or hoarse, and given to unexpected breaking into high tenor or dropping into an absurd whisper. The intellections are insensibly distorted more and more as the phase advances; prejudices are intensified, unreasoned revulsions arise against persons and things, while water and wetness are sub-

consciously exalted as the end of all excellence; the victim may gravely, after deliberate discussion in his quavering and ill-controlled voice, discard hat or shoes—for it is in this stage that Mexicans generally and Americans frequently begin to strip themselves of clothing—or spurn the gold which he has been seeking or the tobacco which has been his solace, or perhaps burden himself with a heavy cask or fragile demijohn. The face grows pinched and care-marked, the eyes bloodshot and perhaps tearful, the movements ill-aimed, the utterances capricious, while the temperature rises and the pulse quickens: the sufferer is a walking fever patient, passing or passed into a delirium usually wild and paralyzing in the tender-foot, but concentrated on a central instinct in the desert habitue—the instinct of the trail, or the way to water. The disordered state of body and brain is often revealed by ceaseless talk: the sufferer strains tongue and throat to "talk and talk and talk, without previsión of the next sentence or memory of the last—and all the talk is of water in some of its inexpressibly captivating aspects. A group of ranchmen, tricked by an earthquake-dried spring, craked and croaked of rivers they had forded in '49, of the verdure of the bluegrass region in which one of them was born, of a great freshet in the Hassayamp' which drowned the family of a friend and flooded the valley from mountain to mesa, of the acre-inches of water required to irrigate a field seeded to alfalfa, of the lay of the land with respect to flowing wells, of the coyote's cunning in 'sensing' water five feet down in the sand, of the fine watermelons grown on Hank Wilson's ranch in Salado valley; now and then articulation ceased and lips and tongue moved on in silent mockery of speech for a sentence or two before the sound was missed, when with painful effort the organs were whipped and spurred into action and the talk rambled on and on—all talking slowly, seriously, with appropriate look and gesture, not one consciously hearing a word. When I was deceived into dependence on the brine of a barranca in Encinas Desert, thirst came, and some of the party babbled continuously of portable apparatus for well-boring, of keeping kine by means of the bisnaga—a savagely spined cactus yielding poisonless water—and reveling in milk, of the memory of certain mint juleps in famous metropolitan hostelries on the farther border of the continent, of the best form of canteen (which should hold at least two gallons—three would be better); they were bright men, clear and straight and forceful thinkers when fully sane: yet they

knew not that their brilliant ideas and grandiloquent phrases were but the ebullition of incipient delirium, and seriously contracted for five gallons of ice-cream to be consumed by three persons on arriving at Hermosillo, and this merely as dessert!" This phase is well known on the range, where many survive it and some delude themselves with the notion that it marks all there is of thirst; and scores of survivors have hit on the same expression to denote it: it is the *cotton-mouth* phase.

Thirst in this phase is best relieved by water—water swallowed in quarts, preferably a gill at a gulp with time for breathing between, and snuffed anon into the nostrils—water also slushed over face, head, neck, and chest: and where conditions permit, hot coffee or soup, the nearer the scalding point the better. Some desert rovers limit the quantity—wisely when the water is salt-charged or microbe-laden—though there is little risk to the habitue if the water be pure; the tenderfoot may overcharge his system and so burden his heart and invite collapse next day. When water is scant (as always on the range and often in camp) it may be economized by a method well known in all arid regions—that of alleviating local dryness of the buccal and other membranes by sipping and sniffing a few drops at a time, and allowing the general condition to take care of itself. Many vaqueros and prospectors become artists in mouth-moistening and carry canteens only for this purpose (depending on lavish draughts at camp to supply the general needs of the system), and unwittingly follow the example of desert plants in habituating their external tissues to conservation rather than evaporation of the organic water; the sipped liquid lubricates the membranes, permeates both cavities and tissues, facilitates automatic swallowing of saliva and spitting of effete mucus, and compensates that evaporation accompanying respiration which most effectively controls the body-temperature—as demonstrated by the sweatless but panting dog. On this empirical practice of the range even expert medicine may hardly improve; and unless complications arise, dry medicaments are useless—or worse.

c. The later phase of functional derangement is an intensification of the earlier; saliva ceases, and membrane-mucus dries into a collodion-like film which compresses and retracts the lips, tightens on the tongue until it numbs and deadens, shrivels the gums and starts them from the teeth, and shrinks linings of nostrils and eyelids giving irritating sensations of dust and grit; tears fall until they

are gone, when the eyelids stiffen and the eyeballs set themselves in a winkless stare; the distal tongue hardens into a senseless weight, swinging on the still-soft root and striking foreignly against the teeth with the movement of riding or walking; articulate speech ends, though hoarse moanings or weirdly unhuman bellowings may issue from the throat. Gradually the shrinking extends from membrane to skin; numbness creeps over the face, then over the hands and under the clothes imparting a dry, rattling, hush-like sensation so nerve-trying that few longer resist the impulse to cast off clothing in automatic outreaching for relief; the feeling of fullness in the head increases and extends to the chest; the sufferer spasmodically snatches at hat and hair and tears the scalp with his nails, while breathing becomes labored and gasping; the heartbeat grows slow and heavy, and each pulsation brings kaleidoscopic gleams before the eyes and crackling and tearing noises in the ears, perhaps passing into singing sounds simulating—and sometimes mistaken for—sweet music from some unseen source; the head throbs painfully, and excruciating twinges shoot from the nape down the spine and through neck and shoulders; the hearing is more and more disturbed and the seeing distorted by the desiccation of the tissues, and hallucinations arise constantly to pass quickly into complete delirium in all but the best-inured, and even in these unto insanity of all senses save that of the trail. When Doctor Merriam was caught on the threshold of this phase of thirst he was impressed by the labored beating of his heart, and gained a sense of the gradual thickening of his blood as its liquid portion evaporated; "he was unable to see, or saw in mirage-like distortion when they were pointed out to him, the familiar birds and mammals of which he was in search. A prospector, later in the stage, tore away his sleeve when the puzzling numbness was first felt; afterward, seeing dimly a luscious-looking arm near by, he seized it and mumbled it with his mouth, and greedily sought to suck the blood; he had a vague sense of protest by the owner of the arm, who seemed a long way off, and was astounded two days later to find that the wounds were inflicted on himself. Deceived by a leaky canteen on the plateau of the Book Cliffs of Utah, I held myself in the real world by constant effort, aided by a bit of mirror an inch across whereby forgotten members could be connected with the distorted face in which motionless eyes were set; yet I was rent with regret (keen, quivering, crazy remorse) at the memory of wantonly wasting—actually throwing away on the ground!—certain cups of water in boyhood, and gloried in the

sudden discovery of a new standard of value destined to revolutionize the commerce of the world—the beneficient unit being the rational and ever-ready drop of water! I collected half a dozen double-eagles from each of four pockets, tossed them in my hand, scorned their heavy clumsiness and paltry worthlessness in comparison with my precious unit, and barely missed (through a chance gleam of worldly wisdom) casting them away on the equally worthless sand." With the advancement of this phase, fever burns more and more fiercely; yet several observers have concurred in denoting it by perhaps the most distinctive local condition: it is the phase of the *shriveled tongue.*

In this phase, too, the thirst is relieved only by water—water in gallons, applied inside and out, but with caution as to rate lest the desiccated tissues be saturated so suddenly as to set up dangerous disorganization. Save in cases of the strongest constitution, the water should be supplemented either by some febrifuge (perhaps aconite) or, if the sufferer is so inured that his tissues are toughened, by a heart-tonic to hold up the circulation despite the dilution of the blood as the alleviating water finds its way into veins and arteries. In the absence of water little can be done: heart-stimulants or nerve-tonics might be beneficial if available, though alcohol usually does more harm than good; the experiment of moistening membranes of mouth and throat (and of nostrils and windpipe and bronchia by inhalation) with glycerine—perhaps dilute—would be worth trying; while unguents applied to the tightening skin of chest, neck, and head might be beneficial. The over-stressed system seems to respond sluggishly and slightly to ordinary drugs; when I left my party in Seriland in the closing days of 1895 and trudged over the sierritas and sand-wastes 55 miles to the ranch of San Francisco de Costa Rica for water and less essential supplies, all liquids in the medicine case (except laudanum and castor-oil) were consumed: a brandy and blackberry compound, listerine, extract of witch-hazel, sweet oil, cascara extract, eye-water, et al; but no effects were reported—or detected. It is in this phase if not before that most sufferers are led, either by aimless instinct or the reasoned desire of keeping membranes moist, to have recourse to urine—either their own or the still saltier stale of their stock: a desperate device which sometimes saves life at the cost of some poisoning of the system, but doubtless hastens the end of the uninured.

3. *The Stage of Structural Degeneration—d.* The passage of the thirst-patient into the earlier phase of this stage depends largely on

his physical condition, especially his inurement to heat and dryness (as well illustrated by the case of Pablo Valencia); the tenderfoot makes the transition quickly and completely, while the well-inured victim whose membranes and skin are toughened and habituated to conservation of organic water may resist the tissue-disorganization up to and even beyond dissolution when the air is dry enough and the heat high enough—the dissolution in this case being a progressive mummification of the initially living body, beginning with the extremities and slowly approaching the vital organs. In the ordinary case the fourth phase begins with an acceleration of the drying process due to disorganization of external tissues: the collodion-like coating on the lips cracks open and curls up, and the clefts push into membrane and flesh beneath so that thickened blood and serum exude; "this ooze evaporates fast as formed, and the residuum dries on the deadened surface to extend and hasten the cracking; each cleft is a wound which excites inflammation, and the fissuring and fevering proceed cumulatively until the lips are everted, swollen, shapeless masses of raw and festering flesh. The gums and tongue soon become similarly affected, and the oasis in the desert appears in delirium when the exuding liquid trickles in mouth and throat; the shrunken tongue swells quickly, pressing against the teeth, then forcing the jaws asunder and squeezing out beyond them, a reeking fungus on which flies—coming unexpectedly, no one knows whence—love to gather and dig busily with harsh grating sound, while an occasional wasp plunks down with a dizzying shock to seize or scatter them; and stray drops of blood escape the flies and dribble down the chin and neck with a searing sensation penetrating the numbness: for the withered skin is ready to chap and exude fresh ooze, which ever extends the extravasation. Then the eyelids crack and the eyeballs are suffused and fissured well up to the cornea and weep tears of blood; and as the gory drops trickle down the shrunken cheeks are welted with raw flesh. The sluggishly exuding ooze seems infectious; wherever it touches there is a remote, unreal prickling, and lo, the skin is chapped and dark red blood dappled with serum wells slowly forth. The agony at the nape continues, the burden of the hear-throb increases, but as the skin opens its pain passes away; the fingers wander mechanically over the tumid tongue and lips, producing no sensation save an ill-located stress, when they, too, begin to chap and swell and change to useless swinging weights. The throat is as if plugged with a hot and heavy mass, which gradually checks the involuntary swallowing motion,

causing anon a horrible drowning sensation, followed by a dreamy gratification that the trouble is over. The lightning in the eyes glances and the thunder in the ears rolls, and the pressing brow-bands tighten; the thoughts are but vague flashes of intelligence, though a threadlike clue may be kept in sight by constant attention—the trail, the trail, the elusive, writhing, twisting trail that ever seeks to escape and needs the closest watching: all else is gone until water is 'sensed' in some way which only dumb brutes know. Rice remembered hearing his horse (which, startled by a rattlesnake, had escaped him twenty hours before, and which he had trailed in half-blind desperation) battering at the cover of a locked watering-trough with fierce pawing like that of a dog digging to fresh scent; the vaqueros, awakened by the horse, found the man wallowing, half-drowned in the trough; he always ascribed the bursting of his lips and tongue to his earlier effort to get moisture by chewing stray blades of grass (supplemented by urine), and he never consciously recognized the natural symptoms of the fourth phase. When my deer-path trail on the Utah plateau turned out of the gorge over a slope too steep for the fixed eyes to trace, I followed the ravine to stumble into a chance water-pocket with a submerged ledge, and there soaked an hour before a drop of water could be swallowed; then, despite a half-inch cream of flies and wasps, squirming and buzzing above and macerated into slime below, I tasted ambrosia! A poor devil on the Mohave desert reached a neglected water-hole early in this stage; creeping over debris in the twilight, he paid no attention to turgid toads and a sodden snake and the seething scum of drowned insects until a soggy, noisome mass turned under his weight, and a half-fleshed skeleton, still clad in flannel shirt and chaparejos, leered in his face with vacant sockets and fallen jaw: he fled, only to turn back later, as his trail showed, seeking the same water-hole, and during his days of delirium in the hands of rescuers raved unremitting repentance of his folly in passing the 'last water.' " On June 30 last, Frank Seaman, who had set out across Colorado desert westward from Indio with too little water, struck the railway and stopped a passenger train by standing on the track and refusing to budge, despite whistlings and warning cries; he was nearly naked, his flesh blood-streaked and caked with dust, his tongue swollen to twice its natural size; his lips were blackened and cracked open, and his finger-ends worn to the bone from digging, coyote-like, in the arroyo sands and gravel for water; he was carried into Colton, and there slowly recovered. On Septem-

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ber 1, Tom Newton and William Peterson (inured prospectors, both) started with insufficient water from Rhyolite on a search for the far-famed—and nine-tenths fabulous—gold of Death Valley; Peterson succumbed on the third day, and Newton was picked up the day after by another prospecting party, naked and delirious, his body inflamed and swollen, with the skin burst in places; the rescuers reported that he was aimlessly "leaping about in the sun like a frog," doubtless in semi-voluntary spasms, akin to those so persistently racking Pablo Valencia, due, perhaps, to uric acid poisoning of the muscular tissue. A bronco-thrown vaquero picked up by Don Pascual Encinas after three days of deprivation was expressly described by the strenuous old "Conqueror of the Seri" as "sweating blood and fighting buzzards;" and his phrase may fitly be applied to the phase of desert thirst in which the external tissues inflame and begin to break down in a *blood-sweat*; the phase is not in the books, but it is indelibly burned into some brains.

In this phase there may be little alleviation: for water, however judiciously administered, brings hurt rather than healing; and even if the degenerated tissues are reorganized, the cerebral and neural structures may scarce recover from the shock—the sufferer, like the Encinas foundling, or like press-reported Hoffman, sole survivor of the ill-outfitted Grindell expedition of 1905, remains little more than a gibbering imbecile for months, if not for life. Yet this is the phase of promise to the physician.

e. In the final phase of desert thirst the external symptoms are little changed: "The benumbing and chapping and suffusion of the periphery and extremities continue, and in this way the blood and serum and other liquids of the body are conveyed to the surface and cast out on the thirsty air, so that the desiccation of the organism is hastened; perhaps the tumid tongue and livid lips dry again as the final spurts from the capillaries are evaporated; thirsty insects gather to feast on the increasing waste, and the unclean blow-fly hastes to plant its foul seed in eyes and ears and nostrils, while the greedy vulture soars low and the ravening coyote licks his chops." The internal or subjective symptoms may be inferred only through extension of the knowledge of earlier stages, and from movements inscribed in the trail of the victim—for in the desert perception is sharpened and scarce-visible features in the track of man or beast open a faithful panorama to the trained vision of the trailer: "the wanderer, striving to loosen the tormenting brow-bands, scores his scalp with his nails and scatters stray locks of hair over the sand; the forbidding cholla, spiniest of the cruelly spined cacti, is vaguely seen as a huge carafe surrounded by crystal goblets, and the flesh-piercing joints are greedily grasped and pressed against the face to cling like beggarticks to woolen garments; with the spines penetrating cheeks and perhaps tapping arteries; the shadow of shrub or rock is a Tantalus' pool in which the senseless automaton digs desperately amid the gravel until nails and even phalanges are torn off; then the face is forced into the cavity, driving the thorns further into the flesh, breaking the teeth and bruising the bones, until the half-stark and already festering carcass arises to totter toward fresh torment. A child in a single garment wandered out on Mohave desert and was lost before the distracted mother thought of trailers; his tracks for thirty hours were traced, and showed that the infant had aged to the acuteness of maturity in husbanding strength and noting signs of water, and had then slowly descended into the darkness and automatic death of the fifth phase of thirst—had at last dug the shadow-cooled sands with tender baby fingers, and then courted and kissed the siren cactus even unto the final embrace in which he was held by a hundred thorns too strong for his feeble strength to break."

In this final phase there is no alleviation, no relief save the end; for it is the ghastly yet possibly painless phase of *living death*, in which senses cease and men die from without inward—as dies the desert shrub whose twigs and branches wither and blow away long before bole and root yield vitality.

AS I PASSED THROUGH YUMA, August 31, 1905, press dispatches were announcing a fatality from thirst in Death Valley, incidentally noting that it was the *thirty-fifth* of the season in that valley alone; unnumbered others occurred elsewhere during the same season, including a straggler whose remains were found two months later by the Jim Tucker and Pablo Valencia above mentioned. Does it not behoove the makers of medical science to assume seriously the duty of devising preventive and remedial measures against a death-cause so frequent, so widespread, so distressful, and so intimately connected with those organic functions and structures on which they speak with authority; and does not the behoof rest especially on the medical men of the Key City of the Southwest—Saint Louis?✣