effective in disrupting the thalamocortical relations seems to be a part of a system which passes anteriorly, from the medial group of nonspecific thalamic nuclei, through the nucleus ventralis anterior and thence to the orbital cortex. The exact role of the orbital portion of this thalamocortical system is not known, but previous workers have presented neuroanatomical and electrophysiological evidence of thalamo-orbital relationships (*8*). Additionally, Magoun (*9*) has called attention to the fact that the frontal lobe, and particularly the orbital region, may be involved in an inhibitory role. He cites results which "point to the existence of a nonspecific, thalamo-cortical system, the low-frequency excitation of which evokes large slow waves as well as recruiting responses and spindle bursts in the EEG. These characteristically bear a close relation to internal inhibition, behavioral drowsiness and sleep, although they can display dissociation from such behavior." The blocking of recruiting responses and spindle bursts, as shown by our results with orbital lesions only, suggests that it is such a system which we are interrupting.

MARCOS VELASCO
DONALD B. LINDSLEY
Departments of Psychology and *Physiology* and *Brain Research Institute, University of California, Los Angeles*

References and Notes

1. R. S. Morison and E. W. Dempsey, *Amer. J. Physiol.* **135**, 281 (1942); D. B. Lindsley, J. W. Bowden, H. W. Magoun, *Electroencephalog. Clin. Neurophysiol.* **1**, 475 (1949).
2. E. W. Dempsey and R. S. Morison, *Amer. J. Physiol.* **135**, 293 (1942); H. Jasper, *Electroencephalog. Clin. Neurophysiol.* **1**, 405 (1949); T. E. Starzl and H. W. Magoun, *J. Neurophysiol.* **14**, 133 (1951).
3. D. B. Lindsley, J. W. Bowden, H. W. Magoun, *Electroencephalog. Clin. Neurophysiol.* **1**, 475 (1949).
4. M. Verzeano, D. B. Lindsley, H. W. Magoun, *J. Neurophysiol.* **16**, 183 (1953).
5. A. Arduini and C. Terzuolo, *Electroencephalog. Clin. Neurophysiol.* **3**, 189 (1951); W. A. Spencer and J. M. Brookhart, *J. Neurophysiol.* **24**, 26 (1961).
6. D. P. Purpura, *Intern. Rev. Neurobiol.* **1**, 47 (1959); P. Buser, *Electroencephalog. Clin. Neurophysiol.* **16**, 18 (1964).
7. J. Hanbery and H. H. Jasper, *J. Neurophysiol.* **16**, 252 (1953); E. Eidelberg, W. Hyman, J. D. French, *Acta Neurol. Latinoamer.* **4**, (1958), 279 (1960); K. L. Chow, W. C. Dement, S. A. Mitchell, Jr., *Electroencephalog. Clin. Neurophysiol.* **11**, 107 (1959); N. M. Weinberger, M. Velasco, D. B. Lindsley, *ibid.* **18**, 369 (1965).
8. W. J. H. Nauta, in *The Frontal Granular Cortex and Behavior*, J. M. Warren and K. Akert, Eds. (McGraw-Hill, New York, 1964), p. 397; T. E. Starzl and D. G. Whitlock, *J. Neurophysiol.* **15**, 449 (1952).
9. H. W. Magoun, *The Waking Brain* (Thomas, Springfield, Ill., 1963), pp. 68–69, 173.
10. Supported by U.S. Navy contract Nonr 4756 (03).

11 June 1965

Solar Distillation of Water from Soil and Plant Materials: A Simple Desert Survival Technique

Abstract. *Water obtained from soil and plant materials by a simple distillation technique can provide a means for survival under desert conditions. A hemispherical hole in soil (in some cases containing cut plant material) is covered with plastic film formed and held in a conical shape by a rock placed in the center. Water collects on the under side of the plastic, runs to the point of the cone, and drops into the container. A yield of 1.5 liters per day of potable water was obtained from a single "survival still."*

People stranded in desert areas are frequently without a source of water. We propose a simple technique that utilizes solar energy to distill potable water from soil and plant materials. The component parts of our "survival still" are a piece of clear plastic about 2 × 2 m, either square or circular, and a container in which to collect water. The container should have a wide mouth, say 15 cm in diameter, and a capacity of 2 to 4 liters. In emergencies, a container can be fashioned of plastic film, aluminum foil, or other waterproof material, with small rocks being used for support. A convenient, but not essential, component is plastic tubing, 1.5 m long and about 5 mm in internal diameter. With the tubing, water can be sucked from the container without disturbing the still. The essential components of the still can be folded to a pocket-sized package. A diagram of the survival still is shown in Fig. 1.

The principle of operation is the same as it is for conventional stills (*1–3*). Solar energy passes through the plastic and is absorbed by the soil or plant material, resulting in evaporation of water, followed by condensation on the cooler plastic. The condensed water runs down to the point of the cone and drops into the container, from which it is collected.

The still is constructed by digging a hemispherical hole about 1 m in diameter and about 0.5 m deep (Fig. 1). The center is excavated an additional 20 cm or so to receive the container. If the plastic tubing is used, one end is taped to the inside of the container and the other led out of the hole. The plastic cover is put over the hole and held in place with soil around the edge. The plastic is then pushed downward in the center to form a cone having an angle of 25 to 40 degrees from horizontal. A rock or other weight is placed in the center directly over the container to maintain the conical shape and reduce wind flutter. Additional soil is placed around the edge to hold the plastic firmly in place. The plastic film should be 5 to 10 cm above the soil in the hole and should touch the soil only on the rim of the hole. Construction time is from 15 to 30 minutes.

Table 1. Daily yield of water, in milliliters, from five survival stills located near Phoenix, Arizona. Stills 1 and 2 were in a loam soil with an initial water content of about 18 percent, and stills 3, 4, and 5 were in a desert sand containing 2 to 8 percent water at the time of installation. Rainfall, measured in Phoenix, was 34.3 mm during 1–12 April and 4.0 mm on 12 May 1965.

Date	Loam soil		Desert sand		
	Still 1	Still 2	Still 3*	Still 4*	Still 5†
21 April	1340	900	710	470	180
22 April	2080	1670	1310	1350	260
23 April	1560	1360	1160	800	125
24 April	1900	1675	1180	1000	190
25 April	1685	1430	1030	790	120
26 April	1800	1520	220	550	50
27 April		1460	770	475	120
28 April	2100	1400	690	410	110
29 April	1960	1300	485	260	65
30 April	1830	1130	365	190	30
26 May	1000	840			
23 June	490	465			

* Located in a wash or depression where water would collect during a rain. † Purposely constructed in an unfavorable site—a coarse sand in which rain water rapidly drained away, leaving little water stored in the sand.

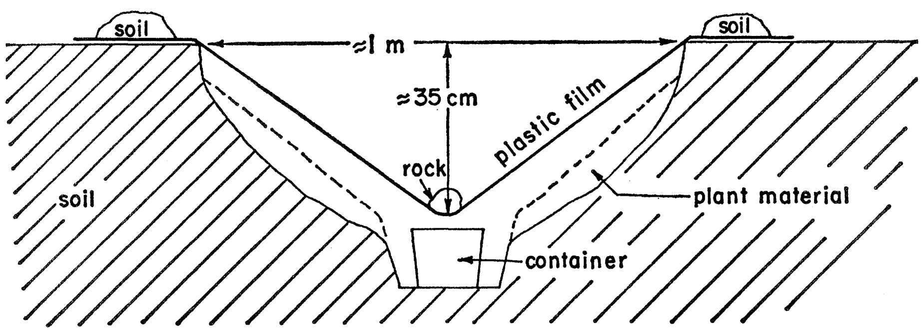

Fig. 1. Diagram of "survival still."

It takes from 1 to 2 hours for the air to become saturated and condensate to start dripping into the container.

After prolonged periods without rain, only a small amount of water can be collected from the soil alone, and in such cases water from the soil can be augmented by placing cut plant material, especially cactus, into the survival still. Plant materials should not touch the plastic film since this could cause the water to be slightly flavored. Sea water or brackish water can be purified by building a still where the soil or sand is kept moist by the underlying water table or the soil can be kept moist by periodically adding polluted water. If polluted water is poured into the hole, it should not be poured near the rim where the plastic film touches the soil. Water that condenses near the rim may touch the soil before running down the collector. If the soil is contaminated on the rim, the collected water may be contaminated. This could be alleviated by placing small rocks around the edge of the hole to raise the plastic slightly above the soil.

Almost any clear plastic film will work. However, because of their nonwettability, some plastics are not as satisfactory as others. Water droplets form on the film but may drop off before reaching the container. We have found that DuPont's Tedlar (100 BG-30), adherable on both sides, is sufficiently wettable to overcome this problem. We have used 25-μ (1-mil) adherable Tedlar with encouraging success. Other plastics can be made wettable by a mechanical scratching technique discussed by Daniels (*1*, p. 178).

On 20 April 1965, five stills were constructed at several locations, and soil alone was used as the water source. The results are given in Table 1. The data indicate that a loam soil is more productive than desert sand when rainfall is the only source of water. This is because the fine-textured soil will store more water than sand. The quantity of water that can be collected depends upon the water content of the soil. For a given still, the daily yields decrease roughly in proportion to the reciprocal of the square root of the time after installation. In cases where the soil under the still is kept moist by an underlying water table, the yields should remain relatively constant with time unless a crust of salt accumulates on the soil surface. If this occurs, the still can be moved to a new site.

On 25 May 1965, six stills were constructed in a desert area to determine the amount of water that can be obtained when desert vegetation is used as a supplementary source of water. The results are given in Table 2. Yields were measured at several times during the day for the first few days of this experiment. The highest yielding plants, saguaro, barrel, and prickly pear cactus, produced about 1 liter during the daylight period of 8:00 a.m. to 8:00 p.m. and 0.5 liter from 8:00 p.m. to 8:00 a.m. After 5 days, the yields began to decrease. Replenishment with fresh plant material after 5 days should insure a continuous yield of about 1.5 liters per day.

Solar energy, which is needed to operate the stills, is almost unlimited in desert areas. On the few cloudy days that might occur, yields will decrease, but usually the need for water will also decrease. If it rains, water will collect in the cone formed by the plastic. The efficiency of utilization of solar energy (yield per unit area per unit time × heat of vaporization of water, in relation to solar energy per unit area per unit time) is about 15 percent, compared with 25 to 40 percent for conventional solar stills (*1*). Further work may increase the efficiency of the desert survival stills without increasing their complexity. However, the still described here is so simple that construction of several would appear to be the most practical means of increasing yield. From a practical standpoint, the size of the still described here is optimum. The limitations are set by available widths of plastic sheets and by the effort required in digging the hole. (Instead of making one large hole, one could make several holes of the size described here.)

The principle of using solar energy to distill water is well documented by Daniels (*1*), and its use to mine water from the soil has been demonstrated by Kobayashi (*2*). Solar distillers for life rafts have been developed by Telkes (*3*). Our proposal is to combine materials provided by nature in the desert —sunshine for energy, soil or desert plants as a source of water, and soil and rocks as construction materials—with a sheet of plastic to provide a reliable means of obtaining potable water from seemingly dry and unyielding sources. It is well known that

Table 2. Yield of water, in milliliters, from six survival stills with plant materials and soil as water sources. The initial water content of the soil was 3 percent. Before cutting, the saguaro and barrel cacti were about 40 cm high and 20 cm in diameter. The amount of cholla, prickly pear, and creosote bush was just enough to fill the volume indicated for plant materials in Fig. 1.

Date	Soil and cholla cactus	Soil and saguaro cactus	Soil and creosote bush	Soil and prickly pear cactus	Soil only	Soil and barrel cactus
26 May*	485	865	325	575	115	430
27 May	650	1570	370	2165	330	1955
28 May	460	1430	210	1965	215	1850
29 May	265	1150	110	1515	120	1565
30 May	170	965	45	1205	70	1450
31 May	185	805	90	980	100	1475
1 June	55	715	125	775	120	1375

* The yields given in the first row were from time of installation on 25 May to 8:00 a.m., 26 May. Subsequent data are for 24-hour periods. Installation times were 12:45, 1:15, 1:30, 4:00, 4:20, and 5:00 p.m., respectively.

panic caused by thirst makes people wander to an almost certain death within hours. A modest but dependable source of water may prevent these tragedies.

RAY D. JACKSON
C. H. M. VAN BAVEL
U. S. Water Conservation Laboratory, U.S. Department of Agriculture, Tempe, Arizona 85281

References

1. F. Daniels, *Direct Use of the Sun's Energy* (Yale Univ. Press, New Haven, 1964).
2. M. Kobayashi, "A method of obtaining water in arid lands," *Solar Energy* 7, 93 (1963).
3. M. Telkes, *Solar Distiller for Life Rafts* (Office of Scientific Research and Development Report PB 21120, USA Office of Technical Services, 19 June 1945).

9 July 1965

Sarcolemma: Transmitter of Active Tension in Frog Skeletal Muscle

Abstract. *Maximum tetanic tension developed by frog muscle fibers was measured before and after they had been injured at one end so as to break myoplasmic continuity but to leave the sarcolemma-tube connection to the tendon. The lateral mechanical coupling between myoplasm and sarcolemma is adequate to bear and transmit the maximum active tension developed during stimulation.*

All current models of the structure of striated muscle, such as the sliding-filament hypothesis (*1*) or the somewhat older hypothesis of a folding polypeptide chain, have in common the assumption that the contractile machinery is in the myofibril and that the myofibril transmits the tension developed by it to the tendons. We have thought that force developed by the myofibrils may be transmitted laterally to the sarcolemma and thence to the tendons; we have, therefore, measured the tension developed before and after breaking the myoplasmic column by injury.

Bundles of two or three fibers were isolated from the semitendenosus muscle of the frog *Rana pipiens*. One end of each bundle was cleaned of connective tissue so that, as far as possible, only sarcolemma made the connection to the tendon. Except for the use of No. 26 hypodermic needles as dissecting knives, the techniques were the same as described in 1940 (*2*). The fibers were mounted in a bath of frog Ringer solution kept at 18°C or at room temperature. Tensions were measured with a strain gauge and changes in length with a rack-and-pinion device. Maximum isometric tetanic tension was determined by adjusting the length of the bundle; stimulation was by square-wave pulses, 50 per second and of 1-msec duration. Each bundle was then placed on a microscope slide, stretched slightly, and held in place by tucking the tendons under rubber bands. The end that had been cleaned of connective tissue was injured by gentle pressure with a thin glass rod. Such pressure at first causes strong local contracture; after 10 to 30 minutes a localized clot of myoplasm forms and retracts, forming a retraction clot and leaving only the sarcolemma tube connecting the uninjured part of the fiber and the tendon. When the break in the myoplasmic column was complete in all fibers, the bundle was remounted and maximum tetanic tension was redetermined. The stimulus voltage was doubled. The muscle length at which maximum tension could be developed was greater after injury than before.

The injured fibers sometimes remained excitable for several hours. After injury, seven bundles had active tensions, varying from 30 to 100 percent of the original tension; four single-fiber preparations developed 70 to 80 percent. Experience has shown that an injured fiber is an unstable and failing preparation, so that the variation in results is not surprising, but large tensions were transmitted around a complete myoplasmic break.

Figure 1 shows two single-fiber preparations that were preserved in 50-percent glycerol for 1 day after the experiment. Their appearance is essentially the same as that of living fibers at this magnification.

The one bundle that gave as much tension after injury as before consisted of three fibers, each about 55 μ in diameter. Maximum tension developed before and after injury was 264 mg, or about 3.7 kg/cm^2, which is average for fibers of frog muscle.

The apparently empty stretches of sarcolemma tube are filled with fluid. Electron microscopy (*3*) has resolved the sarcolemma into four layers: the outermost consists of unidentified fine filaments, the next is a braidlike layer of collagen filaments, the third resembles matrix of basement membrane, and the innermost is the plasma membrane. Clotting destroys most of the plasma membrane, but the other three components persist in the sarcolemma tube; tensile strength of the tube is presumably due to the collagen layer.

If the thickness of the sarcolemma is taken as 0.1 μ (*4*), the sarcolemma tubes of the fibers that developed tensions of 3.7 kg/cm^2 bore a tension of 510 kg/cm^2. This is quite similar to the ultimate tensile strength measured in tendon, which is around 600 kg/cm^2 (*5*). Active tension was proportional to the cross section of the uninjured part

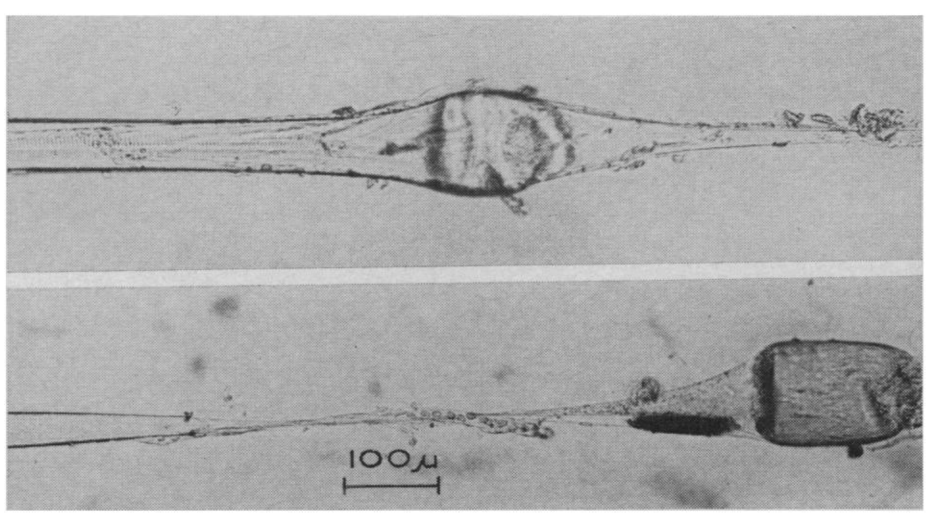

Fig. 1. The injured ends of two single fibers of muscle prepared as described in the text and preserved in 50-percent glycerol. In the larger fiber (top), clear, striated myoplasm at left is in contact with the retraction clot in the middle. The sarcolemma, the dark line at the outer edge of the fiber, continues as sarcolemma tube on the right of the clot and connects to a tendon which is not pictured. In the smaller fiber (bottom) the retraction clot has separated from the myoplasm which appears compressed to a cone. Striations here are irregular and obscured by granules.