responding readings of the horizontal and vertical detectors were obtained on recorders with matched chart speeds.

Readings of the horizontal detector were corrected to represent scattering intensity for the volume of the beam seen at 90 deg. To simplify comparisons between fogs of different or varying density, the intensity of scattered light was recorded as the ratio of the readings at each angle to a horizontal reading obtained at 90 deg after each angular setting. In the notation used, direct transmission is 0-deg scattering, whereas light scattered directly back toward the source would be 180-deg scattering.

Characteristic curves obtained for the angular variation of the intensity of light scattered in a horizontal plane by the water and ice aerosols and a theoretical curve for monodisperse water droplets are shown in Fig. 1.

All tests of unseeded water fogs showed high scattering intensities at low scattering angles, decreasing scattering to about 125 deg, and a maximum in high-angle scattering in the region of 147 deg. Unseeded fogs did not scintillate.

The theoretical curve was obtained from computed values published by Gumprecht and others (*9*) for the angular distribution of light at 5460 A scattered by water droplets 3.5μ in radius. At 150 deg, it shows a maximum scattering of 3.6 times the 90-deg values. In experimental water fogs, the maximum occurred at 147 deg and was consistently greater than twice the 90-deg value. The occurrence of maximum scattering at an angle intermediate between that shown in the theoretical curve and that found for the fogbow (140 to 143 deg) suggests a particle radius intermediate between 3.5 and 30 μ for the fogs used in these studies and indicates the possibility that the position of maximum scattering might be used as a measure of average particle size in atmospheric fogs.

All tests of seeded fogs showed high scattering intensities at low angles, decreasing to very low intensities at angles greater than 125 deg. Scintillations were observed a few seconds after seeding. In the region of 147 deg, the scattering of an ice aerosol was one-fifth or less than that of a water aerosol having the same scattering at 90 deg. A slight inflection in some ice aerosol curves in the region of 147 deg probably indicates the presence of some water droplets or ice spheres. The ratio of the scattering intensity in the horizontal plane at the maximum in the region of 147 deg to the scattering intensity at 90 deg appears to provide a measure of the relative proportion of spherical water or ice particles to crystalline ice particles in an aerosol.

Conversion of a water aerosol into ice form led to an increase of the 90-deg horizontal scattering at the expense of the 90-deg vertical scattering by as much as 40 percent. It is suggested that this effect is caused by, and provides a measure of, the orientation of the ice crystals in an ice aerosol.

Further studies of the photometry of ice and water aerosols are being evaluated and will be reported later.

References and Notes

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2. W. C. Thuman and E. Robinson, *J. Meteorol.* **11**, 151 (1954).
3. W. J. Humphreys, *Physics of the Air* (McGraw-Hill, New York, 1940), pp. 476–575.
4. H. Bucerius, *Optik* **1**, 188 (1946).
5. G. N. Ramachandran, *Proc. Indian Acad. Sci.* (*A*) **17**, 202 (1943).
6. D. Sinclair, in *Handbook on Aerosols* (U.S. Atomic Energy Commission, 1950), pp. 64–116.
7. H. G. Houghton and W. H. Radford, *Papers Phys. Oceanog. Meteorol., Mass. Inst. Technol. and Woods Hole Ocean. Inst.* **6**, 1 (1938); J. A. Heverly, *Trans. Am. Geophys. Union* **30**, 15 (1949).
8. A. P. Brady, A. G. Brown, and H. Huff, *J. Colloid Sci.* **8**, 252 (1953).
9. R. O. Gumprecht *et al.*, *J. Opt. Soc. Amer.* **42**, 226 (1952).

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Identity of Sweat Glands Stimulated by Heat, Epinephrine, and Acetylcholine

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It has been clearly demonstrated that both epinephrine and acetylcholine activate sweat glands (*1*, *2*). This study (*3*) was undertaken to determine whether acetylcholine and epinephrine stimulate the same sweat glands, or separate groups of glands, and to correlate the response to these stimuli with that evoked reflexly by heat.

On the forearm of each of two subjects an area of skin approximately 0.5 cm in diameter was identified by two small moles. At weekly intervals, after the hairs were clipped short, the test areas were painted with tincture of iodine and then coated with a 50-percent emulsion of starch in castor oil, as described by Wada (*2*). When spontaneous sweating occurred at room temperature, the subject's back was heated with an infrared lamp until he felt a generalized diaphoresis. When on the cool days no spontaneous sweating occurred, the starch emulsion was gently removed with cold water, iodine was reapplied, 0.05 ml of either acetylcholine chloride (1:10,000) or epinephrine hydrochloride (1 : 10,000), each in 0.9-percent NaCl, was injected into the test area intradermally, and the starch emulsion was reapplied. Before application of the starch in each case the moles were marked with a fine spot of India ink.

When the sweating response was clearly represented by isolated black spots a photograph of the test area was taken at a uniform magnification, using an instantaneous flash of light to avoid heating the arm. In each case after the drug injections, the complete absence of spontaneous sweating was verified by inspection of areas of skin similarly prepared but at a short distance from the injection site.

From the original negatives, transparent positives

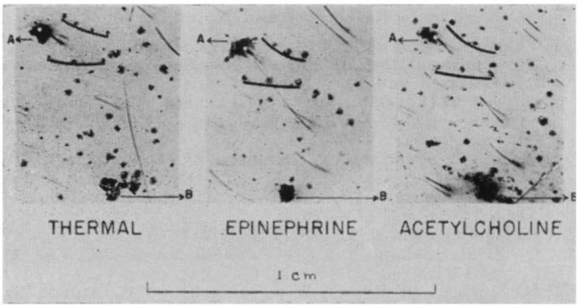

Fig. 1. Sweat responses to the three stimuli in one subject. *A* and *B* are the reference spots (moles), marked with India ink before photographing. The added lines are beneath two groups of sweat spots that appear in all three instances. Other coinciding spots may be seen.

were made so that the spots of sweat appeared black upon a pale transparent background. It was thus possible to attempt superimposition of the photographs in front of a bright light, using the two moles and the clipped hairs as reference points. This simple technique revealed the following: (i) Some of the individual sweat glands were stimulated on one occasion and not on another, despite the reapplication of the same stimulus and the reappearance of an approximately equal number of black spots in the same area. This "responsiveness" of the glands appeared to be capricious. (ii) It was nevertheless clear that, despite this individual variation, a very similar pattern of sweat glands was produced in each case by heat, epinephrine, and acetylcholine (Fig. 1) The similarity in pattern was so obvious that prints from any two stimuli could be superimposed in such a way that a large percentage of the spots coincided.

This visual impression was tested statistically as follows: Some of the positive transparencies were placed in a photographic enlarger, and the shadows were projected upon white paper at a standard distance and over a standard area. The black spots from a given print were then traced in a given color, and upon the same area of paper the spots of another print were traced in another color. Spots touching each other were considered coincident. In this manner the coincidence of spots derived from each subject was tabulated for the following combinations: (i) thermal patterns, (ii) epinephrine patterns, (iii) acetylcholine patterns, (iv) thermal and epinephrine, (v) thermal and acetylcholine, (vi) epinephrine and acetylcholine, (vii) a print produced by any of the three stimuli and the same print turned 180°, and (viii) a print produced by any of the three stimuli and a print produced by another stimulus rotated 180°. Random coincidence of spots would be directly proportional to the product of the number of spots in any two prints if all the spots were of equal size. Since both the differences in size of the spots and the average size of spots were negligible, as compared with the total area, for each pair of prints plotted a value ("J") was computed, representing the ratio of the number of coincident spots to the product of the total number of spots in each print that fell within the tabulated area. The average J-value for one stimulus with another at 180° and one print with another at 180°, or the two combined, was about 0.0027, whereas all other J-values were in the neighborhood of 4 times as great, about 0.01 or more.

No significant difference occurred between average J for the prints compared with themselves at 180° of rotation and average J for different prints so compared ($p > 0.2$). This suggests a random distribution of the sweat glands, and hence all prints compared at 180° were pooled to determine J for chance coincidence. There was no significant difference between J for the prints produced by identical stimuli and J for prints produced by different stimuli ($p > 0.5$). The difference, however, between J for the prints superimposed properly and J for the prints superimposed at 180° was highly significant ($p < 0.001$). In other words, coincidence among sweat patterns evoked by *different* stimuli was as good as that produced by the *same* stimulus on different occasions. The extent of this coincidence was far greater than that demonstrated to occur at random.

This degree of similarity among the patterns evoked by the three different stimuli would not be found if each stimulus involved a different set of sweat glands. The findings are consistent with the view that the same individual sweat glands are stimulated by epinephrine and acetylcholine, at the concentrations used, and reflexly by heat. This demonstration does not imply a dual innervation of the sweat glands.

References and Notes

1. E. E. Kisin, *Vestnik Vernerol i. Dermatol.*, No. 5, 27 (1948) [abstracted in *Chem. Abstr.* **48**, 2323 (1948)]; R. R. Sonnenschein, *Proc. Soc. Exptl. Biol. Med.* **71**, 654 (1949); R. R. Sonnenschein *et al.*, *J. Appl. Physiol.* **3**, 573 (1951); H. Haimovici, *ibid.* **2**, 512 (1950); T. M. Chalmers and C. A. Keele, *J. Physiol.* **114**, 510 (1951).
2. M. Wada, *Science* **111**, 376 (1950).
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Resistance of *M. tuberculosis* to the PAS Salt of INH

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Preliminary tests have shown that the p-aminosalicylate (PAS) salt of isonicotinylhydrazine (INH) (*1*) is unexpectedly highly active in *in vitro* tests against *M. tuberculosis* (H 37 Rv). This tuberculostatic effect was confirmed in therapeutic tests carried out on the guinea pig. Further *in vitro* tests on the activity of the PAS salt of INH (*2*) against *M. tuberculosis* (H 37 Rv) (*3*) and certain resistant strains are herewith reported.

In our *in vitro* experiments (serial dilution tests in