sq mi.) The total number of townships in each life zone was thus found, and these figures were then multiplied by 36 to convert to square miles. It is not known how Bailey computed his estimate, but it is natural to suppose that he drew the map first and then used it as a basis.

Table 1 shows the three sets of available figures for the areas of life zones of New Mexico.

Evidently Bailey was wide of the mark in several cases, and the actual values of the zone areas in square miles may be taken to lie somewhere near the following figures: Lower Sonoran, 19,500; Upper Sonoran, 79,000; Transition, 19,700; Canadian, 4,000; Hudsonian–Arctic–Alpine combined, 200. The latter two zones are not separated on Bailey's map. Probably the Arctic–Alpine in New Mexico does not include more than 75 square miles. This would leave about 125 square miles for the Hudsonian.

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Glycols and Atomized *E. coli*

THE recent article by Nagy and Mouromseff concerning the effect of propylene and triethylene glycols on atomized *E. coli* (*Science,* **112**, 593 [1950]) deserves careful comment, since their conclusions are at great variance with those found by many other investigators. They interpret the results of their experiments as showing that glycol vapors are not germicidal but simply accelerate the settling out of airborne bacteria, thereby diminishing the bacterial population of the atmosphere. It is apparent from their data that they were dealing with bacterial aerosols containing many large particles, since only a bacterial cloud of predominantly large particle size would give such high initial settling plate and electrostatic precipitator recoveries. The use of unusually high atomizing pressures (50 psi) with a relatively coarse atomizer upon a culture containing an organism that is relatively fragile would tend further to eliminate the presence of viable bacilli in the finer particle size fractions of the dispersed aerosol. It has long been recognized that glycol vapors are relatively ineffective against large particles, especially if they are still in the liquid state in an atmosphere of high humidity. The use of more efficient sampling techniques than those dependent primarily upon the process of sedimentation would have greatly increased the significance of the experimental results they present.

Another very unfortunate feature is the lack of any quantitative information concerning the actual amount of either propylene or triethylene glycols present in the air of the treated environment at the time of atomization of the bacterial culture. In reporting the experiments performed in the 16-cu-ft chamber, no statement is made concerning the method of glycol vaporization. Since the concentration of glycol vapor is a critical factor in determining its efficacy as an aerial germicide, the omission of these data vitiates any conclusions that have been drawn. Furthermore, the operation of a commercial vaporizer (capacity unstated) for only 1 hr in the schoolroom (the dimensions of which are not given) prior to the atomization of the bacterial culture would make it unlikely that adequate germicidal concentrations were attained during the experiments cited. Equally deficient in essential information are the duct and room tests, in which no concentrations of glycol vapor are reported.

In summary, the data cited by Nagy and Mouromseff lack significance because of (1) the absence of definition and precision relative to the particle-size characteristics of the bacterial aerosol studied, (2) the use of sampling techniques appropriate only to the evaluation of large particles, which are relatively inefficient in determining the presence of viable organisms dispersed in the air as particles of less than 3 μ in diameter, and (3) the complete absence of any determinations of the glycol vapor content of the air.

In addition to lack of appreciation of the requirements for adequate experimental studies on aerial disinfection, numerous incorrect quotations from earlier work and apparent unawareness of the crucial experiments demonstrating the lethal action of propylene and triethylene glycols on various species of airborne bacteria make it evident that these authors did not acquaint themselves with the literature on this subject. That the effect of glycol vapors is not due, as Nagy and Mouromseff conclude it is, to a marked increase in the settling rate of bacteria-containing droplets, was clearly shown many years ago in this laboratory (Chicago) and has been corroborated since by others.

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WE appreciate the opportunity to answer the criticisms of Robertson, Lester, and Puck regarding our paper on the effect of glycols on atomized *E. coli*. The numerous papers on this subject, most of them by the investigators at the University of Chicago, deterred us for some time from publishing our results. Our tests, therefore, were devised to determine where the previous investigators may have erred. A more careful reading of our paper by them would have answered all their criticisms.

Our early tests on the use of glycols, which were not published, date back to 1941, and they all showed that vaporized or atomized glycols only increased the rate of settling of organisms and were not germicidal. The tests were interrupted by the war. Our interest was renewed when there was placed on the market a "vaporizer designed and manufactured by the research group who were instrumental in the original discovery" (quoted from instruction sheet supplied with vaporizer). This vaporizer was used for most of the tests in the 64-cu-ft box, schoolroom, and air ducts.

The air in the 64-cu-ft box was saturated with glycol as stated in the paper (Table 1, test 4). In the schoolroom there was a visible fog, as well as evidence of condensation of the glycol on the windows and desks. It will be noticed that the relative humidity was in the optimum range. Having access to all the literature on the subject, we were fully aware that the glycols were most effective at or near saturation. We were also aware, however, that both Puck (*1*) and Robertson *et al.* (*2*) stated that lesser amounts than saturation were germicidal. Finally, our tests show that sufficient glycol was present to greatly increase the rate of precipitation of the organisms. In no instance did we observe any germicidal effect.

The question of the particle size and rate of settling was also anticipated in making our tests. It will be seen from the paper that we used two types of sprayers. With both types, as shown in Tables 1 and 2, the organisms were settled over a period of time. Thus, in the 64-cu-ft box, which was 4 ft high, there were still some organisms in the air, and they were viable 20 min after spraying. Simple calculation using Stokes' law will show that these droplets were 3 μ or less in diameter. Likewise, the particle size of the bacterial clouds in the schoolroom was very small. Assuming the organisms fell a distance of 6–7 ft onto tables containing Petri plates in a period of 45–60 min (Table 2), the diameter of the particle, according to Stokes' law, was less than 3 μ.

In our tests a sampling technique was used that would collect most of the organisms. If we are to assume that Puck's theory and calculations (*3*) are correct, and that a bacterial particle increases in size and weight upon absorbing glycol, then we must use Petri plates or some other means to catch the rapidly precipitating particles. Our tests corroborate Puck's theory that rapid absorption of glycol does occur, as evidenced by the rapid precipitation of the bacterial clouds. However, in the Robertson *et al.* (*4, 5*) crucial experiment wherein they used a 60-l glass-walled chamber, all the organisms in the presence of glycol vapors would have been precipitated in 2.5 min and the air would have been sterile, just as they reported. Their Hollaender-Dallavalle sampler on the outside of the chamber could not have determined the precipitated organisms on the inside of the chamber. Thus, to overcome the obvious error in the above authors' apparatus, we used a 64-cu-ft chamber so that we could place the Petri plates in the chamber and increase the time of settling. Also, some of our tests were made with the electrostatic precipitator to collect the small, as well as the large, particles. The results were the same as on the Petri plates.

In conclusion, we have cited only the literature pertinent to the immediate problem. We have again rechecked our references before writing this letter and find no incorrect quotations. To those versed in the field of aerobiology, sampling of air for microorganisms has been a very difficult problem. It is not surprising, therefore, that the original investigators may have mistaken the rapid precipitation of bacteria for a germicidal effect.

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Book Reviews

Microbiology: General and Applied. William Bowen Sarles *et al.* New York: Harper, 1951. 493 pp. $4.50.

Our increasing awareness of the importance of microorganisms in the fields of industry, food, agriculture, medicine, and public health has created a growing desire for more adequate general information. As a result, many schools now offer a survey course in microbiology. The students entering such a class have widely differing backgrounds and interests and, in most cases, this will be their only formal contact with the subject. An interesting, up-to-date textbook that presents the various aspects of microbiology simply, briefly, and clearly is needed to supplement the class discussions and laboratory experiments. The authors of *Microbiology: General and Applied* have most ably satisfied this need.

Microbiology introduces the reader to the microorganisms: algae, molds, yeasts, bacteria, viruses, higher bacteria, and protozoa. In discussions on the physiology of living cells, the many functions and reactions to environmental influences are explained simply and understandably with a minimum of the chemical formulas that bewilder students with little or no chemistry. There are well-illustrated descriptions of the equipment required for experimentation in the laboratory and the techniques employed in the use of the microscope, the isolation of pure cultures, and the study of growth characteristics. The industrial importance of the various microorganisms producing commercial solvents, fermented beverages, antibiotics, dairy products, and so forth is thoroughly presented; and the essential role of bacteria in soil fertility is lucidly explained. The objectives and methods for the