fied. Strangely enough, modern general physics texts say little or nothing about hardness, though in relation to touch it is one of our most common experiences in the physical world. Older physics texts usually listed hardness as one of the important properties of matter but went little further. A leading text of fifty years ago said, "Hardness is a property that can not be measured," and a popular dictionary says that "hardness is the quality or state of being hard." Neither of these statements is useful. The difficulty is that the word is not only asked to do double duty in the world of common experience and in the technical world, but it is also asked to do multiple duty in the technical world as all the various present-day hardness tests measure different sets of properties. The term "sets of properties" is used advisedly because a single type of hardness test such as the indentation of a steel surface with a diamond point may involve many properties such as compression, shear, slip, fracture, etc. To make matters bad, the relative amounts of these properties may vary as the test progresses. And to make matters still worse there is, as Williams himself has said, no known method of hardness testing (even magnetic methods) which do not change the hardness of the sample as the test progresses either by cold working, magnetic working, etc. This reminds one of quantum measurements in the remote atomic realms in which the act of measuring defeats the object of the measurement. Such defeatism may be a characteristic of all measurements pushed to an extreme, but here one faces the problem in the realm of everyday practical measurements.

New tests for hardness are continually being invented, and many comparisons of the results of different tests have been made, but the problem can not be satisfactorily solved until the test elements are reduced to utmost simplicity and clearly defined. From such a viewpoint it appears that the problem of hardness is one in which the recognition of the value of the operational viewpoint is particularly desirable. Just as in the case of velocity and other apparently simple concepts, the concept of hardness can have no real meaning aside from the operations which have been performed. The operations performed here, however, are much more complicated than those of reading a clock and a scale of length to get a velocity, even though we recognize the relativistic complications in the concept of velocity. But here, though the operator may only turn a wheel or release a lever, the testing machine is itself performing a set of complicated operations. Take, for instance, indentation by a diamond point and consider the many elements as indicated above into which the apparently simple operations can be resolved. This manifold of operations must be understood if the measurement is to have meaning in terms of them. This is exactly the standpoint taken by Professor Williams, who without actually using the term operational viewpoint has spent many years prying into the multiplicity of operations which go to make up a particular hardness test. But the field is so large and the types of training which are needed are so varied in even apparently simple investigations, as the author has shown, that there is plenty of work for the future. Some idea of the amount of work already done can be obtained from the bibliography of approximately 2,000 references in Professor Williams' book.

The confusion in the past over the question of hardness has been largely due not only to the large variety of methods of testing hardness but especially to the conflicting viewpoints of metallurgists, physicists and others who are only now being drawn together by a clearer recognition of the fundamental principles involved. For instance, one example of a radically different viewpoint from that outlined above is the work of D. Landau, who by a method of dimensional analysis has arrived at a formula for hardness $H = CE^mL^n$ where H is a numerical measure of hardness; C is a constant; E is the modulus of elasticity; L is the compression elastic limit, and m and n are small positive numbers. Such a procedure may imply the existence of an absolute standard or it may set up an arbitrary standard which the formula approximates. But it implies that we know much more about the dimensions involved than we actually do and it neglects the operations on which a knowledge of such dimensions is based and which vary from one experimental procedure to another. Neither would the operations involved be easy to apply to a series of samples.

If workers in the field will recognize the fundamental character of the operational viewpoint a considerable forward step would be taken toward a common meeting ground for those workers of diverse interests, and widely different types of training whose views in the past have often seemed irreconcilable. But to further such a position it will be necessary to do much more experimental work in clarifying and defining the operations involved, excellent though the beginning already made may be.

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THE POSSIBILITY OF PREVENTION OF TUBERCULOSIS BY NON-POISONOUS CHEMICAL AIR DISINFECTION AND BY KILLED VACCINES

OF all diseases tuberculosis is one of the most common and also costly to handle, since it is relatively refractory to all known methods of treatment, except prolonged rest in bed. The great desirability of preventing this infection is therefore obvious, but methods of accomplishing this purpose are too few and for some time but few advances in method have been obtained along the lines recently pursued. One conspicuous advance was the determination of the lethal action of ultra-violet light on tubercle bacilli, *in vitro*[1] and in air.[2] Good diagnosis also has been obtained and this has made possible a policy of detection and slaughter of infected livestock, and a parallel policy of detection and segregation of infected humans. The perfect fulfilment of these policies would doubtless be quite effective, but is severely hampered in various parts of the world by the tremendous cost of execution. This country alone has roughly two million[3] tuberculous humans, and in comparison with other countries our own is an island of safety. In recent years, as frequently pointed out in your columns,[4] a group of scientists at this university have given us a brilliant new lead: Chemical air disinfection in closed spaces. With respect to tuberculosis this lead has remained undeveloped.

I have recently determined, by guinea pig test, the fact that tubercle bacilli (Ravenel bovine-type), in fine suspensions at 70° F are rapidly killed by immersion and agitation in propylene or triethylene glycol of 60, 70, 80 or 90 per cent. strengths. Of 82 guinea pigs subcutaneously inoculated with tubercle bacilli subjected to such treatments for 3-, 5-, 10- or 15-minute periods, not one animal showed as large and numerous lesions as control animals, at the site of injection, regional and iliac lymph nodes, spleen, liver and lungs. Rapid and extensive destruction of pathogenicity invariably occurred. In 80 per cent. propylene glycol this destruction was complete within 5 minutes and in triethylene glycol within 15 minutes. Even in lesser concentrations death was often complete within 15 minutes. Minor irregularities in the outcome may have been due to variations in the size of bacillary aggregates in various tests.

Since the glycols, as vapors, are infallibly attracted to moist dust in the air, and kill almost all non-spore-bearing bacteria[5] if suspended in properly humid air, it is difficult to escape the conviction that a useful degree of chemical air disinfection of tubercle bacilli might be worked out by a sustained attack. Killing *in vitro*, however, is slower than that reported for some other pathogens.[6] Also, the practical success of the scheme will, at best, depend upon actual maintenance of effective glycol vapor concentrations in the vicinity of infectious bacilli. The rapid mastery of numerous difficult problems, both experimental and engineering in nature, merits, in my opinion, the allocation of large funds. The inspiration for this attack must be obvious to all bacteriologists, but the originators of the method are fully engaged on other problems, and for this reason any inquiries should be directed to myself.

Incidentally the possibility of an anti-tuberculosis vaccine of bacilli suspended in a glycol seems worth examination. Such a vaccine, if found effective, would have the advantages accruing from permanent freedom from contamination, low temperature killing, high dispersion and consequent relative ease of absorption in tissues, etc. This subject derives enhanced importance (a) from the frequent inacceptability or unavailability of living vaccines, such as BCG; (b) the enormous, rapidly approaching need in the post-war world; (c) the rather tardy appreciation of moderate degrees of immunity, by the rabbit protection test;[7] and (d) the consideration that protection against only the first of a series of minute subfatal infecting doses might often decide the whole outcome: Most investigators now accept the proposition that complete conquest of a primary infection imparts a moderately enhanced resistance, at least as great as that conferred by BCG.[3]

The similarity in structure between the glycols and glycerol,[8] a normal metabolite of many organisms, enlarges the horizon for "fooling" our pathogens.

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[1] E. Mayer and M. Dworski, *Am. Rev. Tuber.*, 26: 105, 1932.

[2] W. Wells and M. Lurie, *Am. Jour. Hyg.*, 34: (Sect. B) 21, 1941.

[3] R. G. Bloch *et al.*, *Am. Rev. Tuber.*, 37: 174, 1938 and *Am. Jour. Roent. and Rad. Ther.*, 49: 463, 1943.

[4] O. H. Robertson *et al.*, SCIENCE, 97: 51, 1942, and 495, 1943; 98: 479, 1943. Also *Jour. Exp. Med.*, 78: 387, 1943.

[5] Just as the sulfa drugs may help to cure tuberculosis by quelling secondary invaders, the glycols may become indispensable treatment in sanatoria, for attacking these agents while still in the air.

[6] Killing in air is being subjected to provisional tests. Bacilli in sputum droplets will obviously be in a different state of aggregation than the warty, coherent colonies somewhat incompletely broken up here. A thin film of mucus on air-borne bacteria has been found by Robertson to be favorable to their killing by glycols; the mucus presumably retains moisture, and therefore traps glycol.

[7] T. S. Potter, *Proc. Soc. Exp. Biol. and Med.*, 54: 145, 1943; *Jour. Am. Med. Asn.*, 124: 527, 1944. E. Opie *et al.*, *Jour. Exp. Med.*, 66: 761, 1937; *Am. Jour. Hyg.*, 29: (Sect. B) 155, 1939.

[8] C. H. Boissevain, *Proc. Soc. Exp. Biol. and Med.*, 54: 342, 1943. As to the penetrating power of glycols for bacteria, see also T. G. Randolph and R. F. Mikell, *Am. Rev. Tuber.*, 49: 109, 1944.

SALMONELLA ISOLATED FROM HUMAN MESENTERIC LYMPH NODES

STUDIES have been made investigating Salmonella from pig's mesenteric lymph nodes, the papers of Hormaeche and Salsamendi,[1,2] Rubin,[3] Edwards, Brunner and Rubin[4] and Varela and Zozaya,[5] all

[1] *Arch. Urug. Med. Cir. Esp.*, 9: 665, 1936.

[2] *Ibid.*, 19: 375, 1939.

[3] *Jour. Bact.*, 40: 463, 1940.

[4] *Proc. Soc. Exp. Biol. and Med.*, 44: 395, 1940.

[5] *Rev. Inst. Salub. Enf. Trop.*, 2: 311, 1941.