known antibiotic as the original strains. We could thus demonstrate by this method that this unknown antibiotic was different from streptomycin in spite of their spectral similarities.

In order to ascertain the relative degree of specificity of the resistance thus obtained, we developed strains from two parent cultures which were made highly resistant to crystalline penicillin G and examined their resistance towards penicillins F and X. It was found that the "normal" *Staph. aureus* 6538 was sensitive to penicillins F, G, and X in concentrations of 0.063, 0.078, and 0.039 μg./ml., respectively, while the "resistant" strain required 0.625, 0.625, and 1.25 μg./ml. Similar results were obtained with *Staph. aureus* 209.

These results indicate that a strain with acquired resistance against one penicillin is also resistant in the same order of magnitude to the two other penicillins. Such phenomena of group resistance of the same degree have been known for a long time with substances other than antibiotics, as in the case of resistance to various sulfonamides. We have also shown group resistance against various inorganic and organic mercury compounds with a strain of *Pseudomonas aeruginosa* made resistant to merthiolate. Thus, it becomes evident that the acquired resistance of bacteria is not as specific as are immune bodies produced by chemical substances, demonstrated by Landsteiner and co-workers.

It is likely that antibiotics and other antibacterial substances of diverse chemical structure can be differentiated by this method, as shown by Robbins and ourselves. However, the fact that three different penicillins cannot be differentiated by a penicillin G resistant strain of *Staph. aureus* indicates the limitations of this technique.

Our results will be published in detail at an early date. Upon the completion of our study, P. G. Stansly, in a letter to the editor (*Science*, 1946, **103**, 402) suggested the possible use of this method which has been employed by us.

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Nuclear Fission Bomb as Initiator of Earthquakes

In the California earthquake of 1906 the potential energy stored was 1.7×10^{24} ergs (N. H. Heck. *Earthquakes*. Princeton, 1936); the energy liberated in the Charleston earthquake of 1886 was estimated as 1.4×10^{25} ergs. At Freehold, New Jersey in 1938, the earthquake liberated 10^{15} ergs of the energy stored in the pre-earthquake strain in the crust of the earth at that locality. This gives us the order of magnitude of potential energies expended in seismic disturbances, but it gives only a little about the magnitude of energy necessary to initiate an earthquake.

It would be safe, however, to assume that the "trigger" energy need not be more than the potential energy of the earthquake itself in order to release the seismic strain already existing. A release of "trigger" energy of more than 10^{25} ergs is likely to result in a small earthquake if the "trigger" acts at the time of relaxation in the earth's crust and/or far away from the strained locality. Such a relaxation usually takes place shortly after a period of an excessive seismic activity. Energy amounting to 10^{25} ergs liberated at the time and at the place of maximum strain may result in a major earthquake dangerous not only to those who pull the "trigger," but also to those who have little or nothing to do with the experiment.

Early after Pearl Harbor, a plan to induce an earthquake in Japanese waters and to ruin by means of the earthquake so produced the key industrial centers of Japan was seriously considered by military and scientific authorities here. This plan was found feasible if between 3,000 and 6,000 tons of TNT were exploded near the Pacific shores of Japan. The plan was not carried out because the nuclear fission bomb was under way, and probably it was expected to prepare the bomb and release it over Japan much earlier than this actually happened.

In the artificial induction of an earthquake it is not only the quantity of energy released but the speed of its release that is of primary importance. If a line of a strain stretching for hundreds of kilometers exists in the crust of the earth, a much smaller quantity of energy than 10^{25} ergs, liberated very quickly on a spot of the line, will break the equilibrium, and the crust fissure starting at the point of explosion will proceed along the line of the strain with the velocity of sound in the rock crust.

In the rupturing or faulting process of the California earthquake, the energy of 1.7×10^{24} ergs was released during several hours, perhaps days. Not more than 60 per cent of this energy was liberated within approximately nine minutes. This gives

$$\frac{1.7 \times 10^{24} \times 0.60}{9 \times 60} = 1.9 \times 10^{21} \text{ ergs/sec.}$$

as the power of the earthquake.

During the explosive decomposition of one kilogram of TNT, the quantity of energy released is 820.7 big calories, or 3.5×10^{5} kilogram meters. The speed of release of TNT energy is about 0.000009 second. Therefore, the power of explosion of 5,000 metric tons of TNT is

$$\frac{3.5 \times 10^{5} \times 5{,}000 \times 1{,}000 \times 9.8 \times 10^{7}}{9 \times 10^{-6}} = 1.9 \times 10^{25} \text{ ergs/sec.}$$

The last figure shows that the power of explosion of 5,000 tons of TNT should be sufficient to initiate an earthquake. The nuclear fission bomb released over Hiroshima was (according to published reports) equivalent to 20,000 tons of TNT. It is not clear whether the equivalent refers to the amount of energy liberated or to the power of the explosion. Even assuming that the latter variant is the correct one, the power of the nuclear fission bomb was of the order of 10^{26} ergs/sec.—amply sufficient to initiate an earthquake, if exploded on or under the surface of land or sea.

It was estimated by the author (*Earthquakes on the expanding earth*. Transactions of 1944, American Geophysical Union) that the strength of the solid shell of the earth to the depth of 60 kilometers in a section along a great circle of our planet is such that 1.5×10^{28} ergs is necessary to crack the earth's shell into two halves three meters apart. Nuclear fission energies are approaching this critical output, and further experimenting with large nuclear fission bombs must be carried out with great precautions.

In particular this refers to the scheduled experiments to be carried out by the Navy in the mid-Pacific on a certain date in June. The author is afraid that there may be no survivors to report on the experiment if the bomb of Hiroshima-size is exploded on or under the ocean surface, and if the preceding months are below their normal seismic activity.

If a rupture in the ocean bed caused by the test is sufficiently deep and therefore hot, the flow of water into the crack and the steam formed therein will deepen and broaden the rupture. The bulge of steam may produce a siesmic tidal wave which may sweep away all ships—the targets and nontargets.

Furthermore, if the nuclear fission bomb in the planned experiment is larger than that released over Hiroshima, the "mushroom" of steam and dust from the bottom of the sea may surpass that of Krakatoa in the year 1883 by many times, both in volume of the erupted matter and in the height to which it is erupted.

The solar constant was slightly affected for several decades by the dust thrown out in the Krakatoa (C. G. Abbot and F. E. Fowle. *Volcanoes and climate.* Smithsonian Misc. Collection, 1913, Vol. 60, No. 29, 15). The climate of the earth may be affected unfavorably for many decades if the quantity of dust erupted as a result of the experiment is several times that resulting from the explosion of Krakatoa.

This consideration requires an extreme cautiousness in scheduling the experiment. The strain in the earth's crust must be estimated first, and the experiment performed at the time of a minimum strain.

If all precautions are taken, this test may be of considerable value to seismology and tectonophysics. With the exact time of explosion, its energy, and location of epicenter known, the time and the path of travel of different types of seismic waves can be studied with great precision. The experiment may be especially valuable for better study of surface and shallow waves, and waves going through the core of the earth. Records of seismographs in such an accurate seismological experiment may give a better understanding of the structure of the earth's crust and its depth, thus contributing to the science of tectonophysics.

The author is especially interested in observations on the direct transverse wave (S′) through the core and in the continued records for 14 days after the explosion. The absence of a focus of S′ wave at the antipode of the explosion spot would favor the writer's hypothesis of a heavy gaseous core of the earth, and occurrences of excessive earthquakes during the half-lunar period after the explosion would give valuable data for evaluation of the lagging coefficient of earthquakes after the maximum strain has been reached.

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