trons, N, per unit of time to be very great. These N electrons are accelerated by the difference of potential between the clouds and, after having been accelerated, meet with molecules of the air; and in thus colliding with the molecules generate light quanta—the light of lightning. Part of the light thus generated, however, is absorbed by electrons in other molecules, in their immediate neighborhood. These absorbing electrons are liberated as photoelectrons or beta electrons and become a part of the electron beam which constitutes the lightning discharge. The original electrons which started from the negative cloud and made collision with air molecules after the initial collision recoil and are free electrons in a potential field. There are now 2 N electrons in the discharge per unit of time. These 2 N electrons are now accelerated, make collisions with molecules, and generate light quanta. This process is repeated many times during the discharge of electricity from the negative cloud to the positive cloud. At each repetition of the process the number of electrons in the discharge is doubled, so that there occurs in the electric discharge N, $2N$, $4N$, $8N$. . . . It is the generation of the radiation—ultra violet, visible, infrared, and radiant energy radiation—which produces the heat, which causes the expansion, which, in turn, sets in motion the air waves we hear as thunder. The rate at which the lightning travels between the clouds is nearly, though not quite, that of light. The rate at which sound travels is only a small fraction of the velocity of light. If, now, the lightning is traveling toward the observer and the sound is traveling in the same direction, the sound produced by the lightning in the last part of the lightning flash will reach the observer first; and since the number of electrons in the discharge, having doubled at each collision with molecules, have increased possibly a hundred-thousandfold, the heat expansion would be comparable and the thunder would be heard as a loud crash, at first, followed by a gradually decreasing rumble, fading out to a very low rumbling sound coming from the beginning of the discharge.

If the lightning discharge takes place away from the observer, the sound of the first part of the discharge will be heard first, and the thunder will gradually increase in loudness, ending with a loud crash.

If the discharge is in any direction other than the two mentioned, the thunder will be heard as some variant of the two patterns described. The time of the lightning discharge is very brief, as the duration of the flash indicates. The reason why the thunder is prolonged is due to the difference in the distance of the different parts of the discharge from the observer.

In the case referred to by Professor Jones there must have been a very great number of lightning flashes passing in different directions between different clouds. The fact that there was no visible lightning was unusual but entirely understandable to the science of electrical discharge. When electrons collide with molecules of air they generate radiant energy quanta, but not necessarily of visible frequencies. The low-frequency radiation generated produces heat, and the consequent expansion of the air produces thunder. We may therefore have a thunderstorm without visible light.

The above cause of the rumbling of thunder has been deduced from a general theory, not yet published, of electric discharges through air. There is no doubt that the four causes mentioned by W. J. Humphreys will have their influence in causing rumbling, but I believe that the chief cause for rumbling is the one elaborated above.

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"Freezing" Behavior in Rats

Dr. Riess is properly conservative in the title of his recent article, "A possible explanation of 'freezing' behavior in rats," (*Science*, 1945, 102, 570), but the conclusions drawn in the report go somewhat beyond the data presented. It is stated that eighteen of the 124 rats raised in groups of six to a cage manifested the behavior in question, whereas only two of the "other group," raised in isolated, single cages, did so. The data are, of course, quite uninterpretable, statistically or otherwise, without a statement of the size of the "other group." Furthermore, the author evidently feels that his observations carry the implication of a connection between submissiveness, as developed in a social situation, and "freezing" behavior in the maze. Since three (of the eighteen) animals living in groups were "dominant and winners in fighting" (the other fifteen being submissive individuals), and since two animals who presumably had no opportunity for social interaction also showed "freezing," it would be more correct to say that the behavior may be related to social factors, or that social conditions seem to be *a* factor in producing the phenomenon, than to conclude that the behavior is "the result of the hitherto uncontrolled factor of social interaction in the living quarters of the experimental animals."

Prompt communication to fellow scientists of experimental results having wide current interest is certainly desirable and to be encouraged, but this desideratum is neither incompatible with, nor warrants the abandonment of, the usual standards of scientific reporting.

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A Correction

IN a recent note, "A possible explanation of 'freezing' behavior in rats" (Bernard F. Riess, *Science*, 1945, 102, 570), the author was guilty of a serious omission which completely vitiated the meaning of the article. A comparison was made between two groups of animals, one living in multiple-animal cages, the other in isolation. In giving a description of the groups, the population of the multiple-housed animals was given as 124 and that of the second group was inadvertently omitted. There were 84 animals in this second group. This makes it possible to evaluate the difference between the two groups. The author apologizes for the omission.

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