shorten the pulse length. This will permit the counting of scatterers in more densely populated regions. In addition, a measurement of the echo intensity will help to establish the size range of the scatterers. The possibility exists of using a surface-controlled camera in conjunction with the transducer. This should constitute marked improvement over the random picture-taking technique now in use.

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1 November 1954.

Pure Cultures of Fungi Produced by Ants

Experiments and observations elucidating the mechanisms by which pure cultures of fungi are cultivated and maintained in the nests of attine, or fungus-growing, ants have been conducted in Panama and Florida in 1954, and at Swarthmore College in 1953–54, with similar results. The ants' habit of stripping the leaves of economic plants causes the larger attine species to be ranked as major agricultural pests throughout much of Latin America. Heretofore, an explanation for the ability of the ants to create pure cultures of fungi despite the constant bringing in of alien bacteria and fungi has been lacking.

The attine ants are found exclusively in the New World and primarily in the tropical regions. The fungi that the ants cultivate have not been recognized outside of ant nests, and the ants are dependent on the fungus for their food supply. In most of the species, a nest, consisting of one or more chambers in which a fungus garden is developed, is formed in the soil. The fungus garden is usually formed on a vegetal substrate, such as triturated leaves. Removal of the ants from a fungus garden causes it to be soon overwhelmed by alien fungi and bacteria. The fungi are clearly unable to maintain themselves and do not grow except under the care of the ants.

The northernmost of the fungus-growers, *Trachymyrmex septentrionalis* McCook from New Jersey, has been kept under observation since September 1953, at Swarthmore. Two types of fungi appear regularly in the artificial cultures and have been cultured on potato dextrose and Sabouraud's agar. A few workers are able to maintain a fragment of fungus garden in its normal condition on an agar plate, despite flourishing alien fungi of *Penicillium, Aspergillus,* and *Mucor* types and bacterial colonies that are close to the garden. The ants walk over these regularly as they forage for substrate.

In Panama, fungus gardens and parts of colonies of *Cyphomyrmex costatus* Mann and species of *Atta, Trachymyrmex,* and *Apterostigma* were kept under observation at the Gorgas Memorial Laboratory, and their fungi were cultivated on Sabouraud's agar. Several types of fungi were produced. *Atta* and *Trachymyrmex* strains produced bromatia, a concentrated form of gongylidia that is eaten by the ants, and which grew in these artificial cultures much as in ant nests. These were fed back to the ants after culturing for 2 mo or more. The ants accepted them as food and used them as a nucleus for a fungus garden. As at Swarthmore, it was found that the ants of these genera could maintain fragments of fungus gardens in the pure condition on agar plates despite a forest of surrounding alien fungi.

At the Archbold Biological Station in Florida, *Trachymyrmex septentrionalis seminole* Wheeler and *Cyphomyrmex rimosus minutus* Mayr were kept under observation in the same manner. Ants of *T. septentrionalis seminole* from Florida adopted and cultivated fungus gardens of the New Jersey form at Swarthmore.

This Florida *Cyphomyrmex* fungus developed, on Sabouraud's agar, two strains quite different from that of the Panama *Cyphomyrmex costatus* or from that of any of the other attines. One strain developed a morel-like or vermiculate form that has been recorded in the literature [*Rev. de Ent.* **16**, plate 1, Fig. 2 (1945)], and which the author developed in 1935 from the same ant in Trinidad. After the fungus had been reared in artificial culture for more than a month, it was fed back to the ants, which used it as food and cared for it as though it were their normal fungus.

On the basis of these and other data to be published more extensively elsewhere, it is postulated that the salivary and anal secretions of the ants may play a primary role in creating conditions for pure cultures of ant fungi. Identifications of these fungi are desired, and cultures will be submitted to mycologists upon request.

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27 September 1954.

Modern Cosmology and the Fixed Stars

Herbert Dingle's article, "Science and modern cosmology" [*Science* **120**, 513 (1 Oct. 1954)] is a most provocative and explicit statement of the uneasiness and dissatisfaction that any thoughtful student of modern cosmology must feel. It might be remarked, however, that this unhappy situation cannot wholly be blamed on the "newer" cosmologies; it reflects as well a growing realization that general relativity itself is inadequate to the claims that are often made in its behalf.

Dingle, of course, makes no such rash claims, and rightly stresses the *relativity* of the theory, the emancipation of physical reality from coordinate systems. This, with the allowance for curved metrics and consequently the incorporation of gravitational "forces" as inertial effects, is the great advance—and it is truly

an advance in physical understanding of an observed world.

The claims sometimes made for the "Mach principle," on the other hand, are misleading. We have *not* reached any further understanding of inertial effects per se; Einstein's metric is still "Euclidean in the small"; a Foucault pendulum still mysteriously honors the distant configuration of Newton's fixed stars. Here indeed we have real physical facts, as unexplained now as when Ernst Mach was writing. So might not our "younger cosmologists," as they peruse the history of science, profitably also contemplate the mystery of absolute rotation, and search for the illuminating principle, yet to come, that will explain accelerative "forces," and relate the great, small, and distant in our universe? This must surely be a problem for physical insight, with mathematical ingenuity only of accessory use.

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Acclimatization?

Carroll B. Nash has presented some very interesting data on heat death temperatures and exposure times for *Goniobasis livescens* [*Science* **119**, 773 (1954)]. For this he deserves commendation. I seem, however, to perceive some important implications in his data that are not brought out clearly in the text.

Reference to Table 1 of his paper shows that greater mortality occurred among the slowly heated snails than among the quickly heated ones when the time of exposure to the *maximum* temperature was short. As this exposure time was extended to 30 min and longer, the rapidly heated snails died just as often as the slowly heated ones. It appears as if this were direct evidence that heat penetration was forcing an increase of internal temperature during the longer exposure periods.

Evidently most *G. livescens* will die if they are exposed for 60 min to a temperature of 36°C, that is, if their internal temperature is elevated to this point. Consider, then, what happened to the "acclimatized" group, which, having been held at 36°C for 5 min, was heated to 37°C for 5 min, then to 38°C and so on, and was finally warmed to 41°C for 1 min and then cooled. Their complete mortality simply suggests that they were heated through, and, as is the case with many creatures, their "constitution" simply could not stand that. The rapidly heated group, however, suffered very little from their 1-min exposure because they were clearly not heated through in the time allotted.

It is unfortunate that Mr. Nash has not presented the weights of the individuals that died or survived in each test. Since the weights varied from 0.3 to 1.1 g, and the volumes, therefore, varied in this same ratio, it is clear that the smaller individuals underwent a much more severe test than the larger ones because of their much larger surface area/volume ratio. It would be interesting to know whether the individuals that died when rapidly heated for 5 and 10 min were the small ones of their respective groups.

The data, therefore, tell nothing about "acclimatization" except that it is dubious. The pertinence of "rate of heating" can be established by simple relationships between thermal conductivity and size of the individual snail.

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24 November 1954.

With the exception of the presumed relationship between the size of the snail and its rate of heating, I find no implications in the data cited by Dingle that are not apparent in the original article. The snails were divided into groups of "large," "medium," and "small" individuals, with the same ratio of individuals of these three groups in each of the 87 sets of snails. Because of this, it is unlikely that the surface area/volume ratio significantly contributed to the differences of mortality rate in the several sets of snails. No correlation between mortality rate and body size was apparent from the data, and the individuals that died when rapidly heated for 5 and 10 min were not disproportionately representative of the "small" snails.

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Relationship of Motive to Author and Statement

The question of how beliefs and feelings are changed has been a persistent problem in social psychology. Clearly, the question is important, for an answer would also provide information on such related problems as conformity, uniformity of ideas, and persuasion.

It has been known all along that people change their ideas, not necessarily all at once, but subtly and unconsciously. It was once felt that these changes were brought about in a mechanical, thoughtless, and irrational fashion. However, Asch (*1*) showed experimentally that changes in beliefs and ideas are not mechanical and irrational, but that cognitive factors are involved.

As an example, one finds a higher degree of acceptance for the statement "There is nothing sacred about the American Constitution. If it doesn't serve its purpose it should be changed as often as necessary" when it is attributed to Franklin D. Roosevelt instead of to Earl Browder. Asch's contribution was to show clearly that, with the change in attribution,