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EARTH STRUCTURE AND EARTH ORIGIN¹

By Professor KIRTLEY F. MATHER

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In his book "The Solar System and Its Origin,"² Henry Norris Russell presents a critique of the several theories of earth origin, which may fairly be taken as representative of the attitude of most astronomers toward this problem, responsibility for the solution of which they share with geologists. Full consideration is given to the planetesimal hypothesis of Chamberlin and Moulton and to the modifications of that hypothesis which have been proposed by Jeffreys and Jeans. The obstacles which forbid whole-hearted acceptance of any one of these hypotheses are forcefully presented. The conclusion is frankly stated "that no one can yet say how our system originated in detail"

It is nevertheless apparent that the most hopeful

¹ Address of the vice-president and chairman of Section E, American Association for the Advancement of Science, Richmond meeting, December 28, 1938.

² New York, 1935.

line of research leads toward some hypothesis of origin during an encounter between the sun and another heavenly body. In other words, the fundamental principle of the planetesimal hypothesis is accepted. Future investigators are most likely to work toward the discovery of the particular modification of that hypothesis which will best fit the facts now known or to be ascertained.

Commenting specifically upon the planetesimal and tidal theories, Professor Russell states: "It is here that the two theories part company—the planetesimal supposing that the existing planets were formed mainly by the slow agglomeration of small cold bodies, and the tidal that they were all once liquid and have picked up much less matter in later times. This difference, while very important to the geologist, is really rather small from the standpoint of the astronomer."⁸

³ *Loc. cit.*, p. 102.

malian forms, particularly the rat, to respond differentially to auditory stimuli. Still greater difficulty has been encountered in the attempts made to train these animals to localize the direction of sounds and to discriminate pitches and loudnesses. Experimentalists are in general agreement that in problems related either to the peripheral or to the central aspects of the auditory modality one of the major problems is the development of a methodology for training the infra-primate subject. Two major difficulties relative to the available procedures in this field of investigation can be found in the literature. First,¹ certain methods require prolonged training periods and so preclude the formulation of any very detailed operative program. Second,² other methods of training eventuate in such decidedly abbreviated responses to auditory stimulation that it is difficult, if not upon occasion impossible in the later stages of learning, to determine whether the animal has or has not responded.

The apparatus and training procedure described at this time, it is believed, overcomes to a certain degree these difficulties. The apparatus consists of a modified living cage, the floor of which is an electric grid. Located within this cage and resting on the grid is a small platform which may become if need be a second grid. Acclimatization of the animal, in our experiments the rat, is permitted by placing it in the cage some hours before beginning the preliminary training. During this initial training period the animal is given a series of twenty shocks per day and is required to jump upon or down from the secondary grid-platform. Following the acquisition of this shock-escape response, a buzzer or a thousand-cycle tone is presented and is followed by the shock. All animals so far tested learn rapidly within the range of individual differences to escape the shock by making the appropriate shock-avoidance response. Thus in this experimental arrangement only one response can be made, namely, movement away from the present position. The rapid learning of the rat which has thus far been observed permits in terms of the time element the initiation of a more detailed operative program involving a study of cerebral mechanisms in audition.

The modified cage arrangement described above permits numerous modifications. It is believed this apparatus could be enlarged and consequently utilized for larger mammals, such as the cat, the dog and the guinea pig. Certain evidence already available shows the possibility as well as the plausibility of training animals to discriminate between tones on the basis of pitch and loudness differentia. A further modification for the study of auditory localizing behavior is in

progress. Obviously, however, the size of the cage floor, the size of the second grid and the construction of the walls of the cage will depend upon the nature of the study as well as upon the size of the animal subject. In this particular arrangement the walls have been constructed of galvanized iron. A screened top with mirror arrangements obviates certain recording difficulties. The use of the solid walls thus makes impossible an alternative wall-clinging response. From one point of view, however, it is suggested that this response itself might be found sufficient for the determination of a statistically reliable response to sound stimuli.

The values of this modified living cage method in training the rat to respond to sound stimuli are numerous. First, the method is sufficiently simple to make unnecessary the cradle arrangements use by Britt³ and Schlosberg.⁴ Second, the experimental arrangement is comparatively close to the normal living conditions of the animal. The artificiality of the Y-maze arrangement⁵ in relation to sound stimuli is somewhat obviated. Third, as a corollary of the above, the rapidity with which modifications in behavior occur makes possible the study of certain little understood brain mechanisms in at least one sense modality. Fourth, the response of the animal under the conditions of these arrangements is always clear-cut and observable. Fifth, the use of shock as an incentive seems from several points of view to be superior as a motivating agent over food. Shock can be controlled and measured in more rigorous fashion. Sixth, the possibility of the study of certain other sense modes in relation to cerebral function is suggested by the method of training just outlined.

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³ S. H. Britt, *Jour. Comp. Psychol.*, 19: 243, 1935.

⁴ H. Schlosberg, *Jour. Genet. Psychol.*, 45: 303, 1934.

⁵ L. A. Pennington, *Jour. Comp. Psychol.*, 25: 195, 1938.

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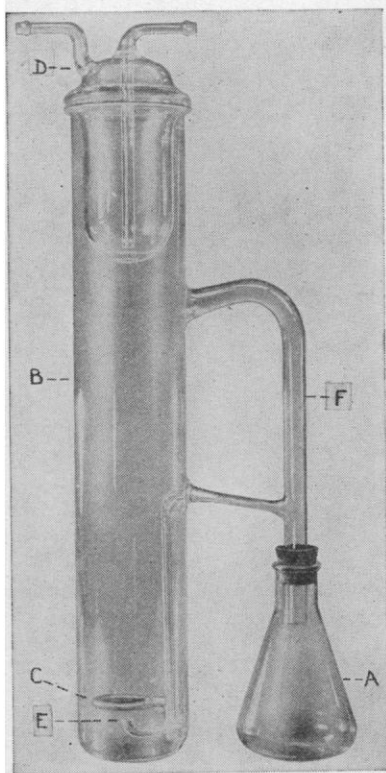
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¹ L. A. Pennington, *Jour. Genet. Psychol.*, 46: 264, 1935.

² W. R. Brogden and E. Culler, *SCIENCE*, 83: 269, 1936.



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*"A Rapid and Simplified Method of Extracting Urinary Estrogen" by S. L. Leiboff, M.A., and Abraham B. Tamis, M.D., in the Nov. 1938 issue of the "Journal of Laboratory and Clinical Medicine," pp. 178-180.

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