Dr. Francis William Bergstrom, assistant professor of chemistry, Stanford University. *Project:* A study of the methods used in certain European institutions for the investigation of heterocyclic compounds containing nitrogen.

Dr. Kenneth T. Bainbridge. *Project:* Continuation of research in nuclear physics at the Cavendish Laboratory of the University of Cambridge. Dr. Bainbridge has recently been appointed to an assistant professorship of physics at Harvard University.

Dr. Arnold Dresden, professor of mathematics, Swarthmore College. *Project:* The preparation of a book on the calculus of variations, an attempt to unify the three points of view which are now dominant in this field, at Pisa and the Institute for Advanced Study at Princeton.

For biological investigations, the following fellowships are announced:

Dr. Harold Kirby, Jr., associate professor of zoology at the University of California, will make studies, chiefly in South Africa and Madagascar, of the Protozoa living in termites, for the purpose of contributing toward a solution of problems in the field of host-parasite relations.

Dr. George Oswald Burr, associate professor of botany at the University of Minnesota, will carry on research in the field of photosynthesis, in certain European laboratories.

Dr. Allan Lyle Grafflin, instructor in anatomy at Harvard University, will make certain investigations of kidney structures in fishes, and collect material for later detailed microscopic studies, at Naples, Italy, and Plymouth, England.

Joseph Fulling Fishman, formerly third deputy commissioner of correction of the City of New York, will shortly enter upon the fellowship previously awarded him for making studies in the field of penology abroad.

Arthur Loveridge, who is now in Kenya on a fellowship, has received a further grant to continue his ecological studies of the vanishing vertebrate fauna of the tropical rain-forest remnants of East Africa.

Dr. Michael Heidelberger, associate professor of biological chemistry at Columbia University and chemist to the medical staff of the Presbyterian Hospital, New York, will go to the University of Upsala, Sweden, to carry on researches on the molecular weight of thyroglobulin, the hormone of the thyroid gland.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

STROBOPHOTOGRAPHY IN BIRD SINGING

THE same problems of notating folk music encountered by anthropologists have been met by ornithologists in notating bird singing. The sluggishness of the ear in perceiving only gross effects, the limitations of the conventional notation system and the habit of reference to the European system of music are all opposed to finished work by both groups of scientists. As in the case of folk music,[1] the odd intervals, subtle turns, twists, intonations, quavers, trills, tremolos, slurs and unusual rhythmical and melodic performances have necessarily been passed over in the song of birds.

The application of methods of photographing auditory stimuli and a plotting of the measures on the pattern notation has revealed in a preliminary way some gratifying results in the musical performances of the nightingale, the European mocking-bird (*Hyppolais icterina*), the chaffinch (Pinzón), the garden warbler (Luruja), the canary and the canary-finch (*Fringilla-canaria*). The possibilities of this approach are illustrated in Fig. 1, representing one of the musical autographs of the European mocking-bird. This note sequence is repeated four times with little variation of each pitch pattern in the repetitions.[2]

The notes of the European mocking-bird are brief and almost continually changing in pitch, explaining why the study of intervals by ear is a difficult one. Note that the compass of the song is over three octaves.

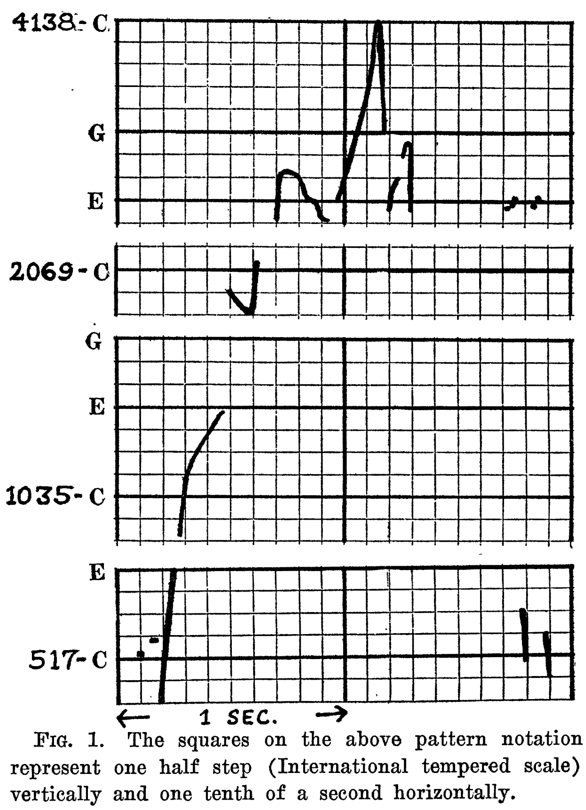

FIG. 1. The squares on the above pattern notation represent one half step (International tempered scale) vertically and one tenth of a second horizontally.

[1] M. Metfessel, "Phonophotography in Folk Music." University of North Carolina Press, Chapel Hill, 1928.

[2] The photograph was taken from Polydor phonograph record No. B-9509, with the needle placed 2 cm in from the first groove on the record.

This pattern notation was secured by photographing the sequence on the strobophotograph.[3] It automatically plots a pitch graph on a vertical measure of 1 cm for each half-step of the tempered musical scale, and a horizontal measure of 50 cm for each second. The phonograph record is played at 15 r.p.m. Fig. 1 is a transposition from the strobophotographic record to a more condensed type of pattern notation.

In this writing it is possible only to mention a few of the effects now photographed:

(1) The predominance of bird notes between 2,500 dv. and 4,000 dv. suggests the frequent use of the vowels in s*ea*t and s*i*t in syllabifications of bird music. Resonance regions of these vowels are generally found between these pitches. There are no vowels in bird song, but the vowel-like character of pure tones at the pitches of the resonance regions has been known to psychologists from the early work of Köhler.

(2) The rapid chirps of the canary often are timed so as to produce a decreasing curve of rate resembling that of muscular fatigue. In a typical case, the chirps begin at a rate of 27 times per second. Each chirp is a discrete unit, a starting and stopping of the note. The chirps come in rhythmical groups of two on approximately the same pitch, the first of each pair being more intense and slightly longer in time. They drop off in rate to three per second during the seventh second. In the sixth second the chirps become trill-like, and in the seventh they change to tones with a falling inflection of about a half-step. Other variations of the pitch patterns of the canary chirps have been isolated. There is the slurred chirp on two notes a little more than three half-steps apart, and the single rapid chirp with a falling inflection of but a half-step. Most of the chirps at the beginning average .025 sec., with the pause between chirps as short as .01 sec. Such performances are impossible by human voices or whistles.

(3) Likewise the rapidity of the trills and warbles are beyond human duplication. The typical warble of the garden warbler has a rate of 50 per second and a rise and fall extent of more than a whole-step. Other warbles of the same bird reveal a rate of 70 per second and extent averaging a half-step. Especially interesting is the double-note of the garden warbler, in one instance with two separate and simultaneous pitches sounded 260 dv. apart, and producing fluctuations at that rate. Another case reveals beats 30 times per second. These would be heard as warbles, but the warble is a rise and fall of successive pitches on the scale, rather than two simultaneous pitches.

A typical trill of the nightingale has a rate of 60 cycles per second and about .5 step in extent; that of the European mocking-bird a rate of 30 per second and an extent of between 1 and 1.5 steps. The human trill is about 7 times per second, with an extent averaging 1.25 step. Some tremolos reach a rate as high as 14 per second, which is likewise the warble rate limit of bird imitators. One of the warbles of the European mocking-bird has an average extent of 1.8 steps and an average rate of 5.5 per second. Such a slow rate is a rarity.

(4) The interplay of noises with tones is an important charactersitic of the birds thus far studied. The general pitch level of the noises is ordinarily between 500 dv. and 1,500 dv.

(5) The "burring" of tones is frequently noticeable. ("Burring" resembles human humming and whistling at the same time.) It is different from the beating effect of the garden warbler in that the "burring" involves notes in the low and high registers, often 2,000 dv. apart.

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[3] *Cf.* two articles by the writer: (1) "A Photographic Method of Measuring Pitch," SCIENCE, 68: 430–432, 1928; (2) "The Strobophotograph," *Jour. Gen. Psychol.*, 2: 135–139, 1929.

THE PURE CULTURE OF PARAMECIUM

THE need for a uniformly multiplying culture of animal cells in the absence of bacteria and other kinds of life has long been felt. The efforts to obtain *Paramecium* in pure culture have been particularly numerous, but the first reported success, by Glaser and Coria,[1] has only recently appeared. Since this work, describing the pure culture of *Paramecium caudatum,* has not been confirmed, their experiments were repeated in an attempt to verify the results.

Glaser and Coria developed an enormously complex medium consisting of liver extract, yeast cells and fresh rabbit kidney. The liver extract (0.5 per cent. Eli Lilly Company's No. 343) was passed through a bacteriological filter. To this filtrate, yeast which had been killed at 75° C. and pieces of kidney from a freshly killed rabbit were added, using aseptic precautions. The paramecia were washed through tubes of sterile medium in order to remove bacteria. From inocula of as many as 870 of these ciliates per 10 cc of the medium, luxuriant growth was obtained. Tests with the usual bacteriological media indicated sterility. Microscopic examination revealed small rods with a superficial resemblance to bacteria, but which, in the opinion of these authors, were "cilia torn from the Paramecia."

The author repeated this work, following the method of Glaser and Coria as closely as possible,

[1] *Jour. Parasit.*, 20: 33, 1933.