Une fois qu'on aura trouvé moyen d'orienter une grande fraction des spins nucléaires dans un échantillon, il sera peut-être encore plus intéressant de se concentrer sur l'anisotropie du noyau que d'atteindre des températures encore plus basses. Pour plusieurs réactions nucléaires, il faut s'attendre à une dépendance des diamètres effectifs de la direction par rapport au spin et il est bien plausible que les réactions et les transformations nucléaires et radio-actives ne soient pas indépendantes de cette même direction. Cela est de la musique de l'avenir, mais je peux affirmer qu'à Leyde comme dans d'autres laboratoires de basses températures on s'efforce déjà de projeter les instruments pour jouer de cette musique.

Summary

In three chapters the most important topics of paramagnetism are reviewed. In the first chapter a short introduction to normal paramagnetism is given and then the phenomena of paramagnetic relaxation are described and discussed. The second chapter deals with the resonance phenomena occurring when an oscillating magnetic field is applied perpendicular to a large constant field. In normal paramagnetic substances these phenomena are studied with the aid of centimetre waves while the corresponding resonance for atomic nuclei is observable at common radio wavelengths. It is stressed that the observation of nuclear magnetic resonance has opened a number of new domains of research. Special attention is given to the unravelling of nuclear magnetic relaxation. In the last chapter the attainment of extremely low temperatures by adiabatic demagnetization is described. It is indicated how thermodynamic temperatures have been determined down to 3 millidegrees absolute. Finally it is mentioned that attempts are being carried out to align atomic nuclei at the low temperatures reached.

Ecotype, Ecospecies, and Macroevolution

By Richard B. Goldschmidt, Berkeley, Cal.

The combined efforts of taxonomists and geneticists have succeeded to a considerable extent in solving that part of the problem of evolution which concerns the subspecific level. The detailed work of innumerable taxonomists following in the footsteps of KLEINSCHMIDT, K. JORDAN, MATSCHIE, and RENSCH has shown that many species are best described as "Rassenkreise", i.e. series, and sometimes clines (in J. HUXLEY's term), of subspecies replacing each other in an orderly geographical way over the area occupied by the species. In most cases these subspecies or geographic races do not overlap and where they meet they may form hybrid populations, as subspecies are fertile inter se. Very frequently it is possible to recognize within the subspecies local populations which are again discernible as subunits, and even these may be sometimes successfully subdivided into other distinguish-
able groups down to individual colonies. Though the taxonomist does not apply nomenclatural distinction to these categories below the subspecies, it is important to realize that in many cases, if not in all, further subdivisions would be possible upon the basis of still recognizable hereditary differences. A further important result of this taxonomic work, frequently forgotten by present day evolutionists, is that subspecies and even smaller units are characterized by recognizable differences which are present in every individual. This is obvious, as otherwise the taxonomist could not name and describe subspecies. When the differential characters are of a quantitative nature, the characteristics are means of quantitative series. The individual variants may or may not overlap with those of the adjoining subspecies. Furthermore, a number of such differential traits, constant within the limits of normal variation, combine to characterize the respective subspecies.

Within this basic framework other phenomena have been recognized. The most important of these is the occurrence of additional hereditary traits, i. e., single mutants (including also position effects of chromosomal rearrangements) within subspecific populations, sometimes called forma or varietas. Such mutants may be floating within the populations, i. e. be present irregularly in heterozygous condition and appear as rare homozygous individuals. There is no doubt that these floating mutants are present everywhere though the taxonomist cannot, as a rule, be concerned with them. Sometimes, however, such mutants within a subspecific or still lower group show a regular behavior to the extent of exhibiting definite frequencies in individual populations. It is this type of diversification which lends itself to statistical study and has thus become the main material of the field of study called population genetics, now so popular. As the students of this field tend to consider their material as the most important one for the study of evolution, it should be made clear that they are working mostly on a level below the subspecific one. The subspecies, which is the lowest category recognized in taxonomic nomenclature, are not characterized (except perhaps for few cases such as Coccinellid beetles) as populations of numerically different mutants, or mutant combinations, but by a series of constant traits present in each individual. Population geneticists, when drawing far-flung conclusions from their work, frequently forget to realize the position of their material within the taxonomic picture.

The genetic basis of the rassenkreis aspect of the animal species was analyzed by the early zoological explorers of this field, SUMNER for Peromyscus and GOLDSCHMIDT for Lymantria¹. Much material has been examined since, but it can be stated that no facts or conclusions of basic importance have been added for animals. The decisive facts are: subspecies (and still lower categories, where recognizable) differ in a series of hereditary traits and these differential characters remain typical when the different subspecies are bred under identical environmental conditions. The individual subspecies is characterized by a definite combination of these traits, visible ones which are used by the taxonomist, and invisible, physiological or developmental ones which only the experimenter can analyze. Within a geographically arranged group or clime of subspecies each of the hereditary differential characters varies independently. Thus one might be common to a number of subspecies, another will be different in each of them. One character may show a variation from low to high expression within a clime; another may vary inversely in the same cline, and a third might show its maximal expression within the spatial center of the clime with a decrease toward each end. This shows that the individual differential character has its specific meaning in the evolutionary process within the species, as has the combination of all differential characters. Genetically, the differential traits are based upon all known types of genetical differences, simple mutants, multiple alleles, and, most frequently, multiple factors.

The pioneer work in this field also succeeded in assigning a definite meaning to the subspecific differences. Many of them could be proved to be of an adaptive nature, both visible and physiological or developmental traits. About the same time the botanist TURESSON had shown that different types of plants, like alpine or dune varieties, are genetic types, called by him ecotypes, which are genetically adapted to their specific environment¹. Thus the subspecies and still lower categories may be called ecotypes. The adaptive nature of their differential traits is usually difficult to prove when morphological characters, i. e., those accessible to the taxonomist, are involved, except in the case of protective coloration. Frequently, if not always, visible traits will be the morphological expression, itself not adaptive, of an underlying physiological and adaptive condition. Physiological and developmental traits are easily recognized as adaptive. A typical example is the diapause in the eggs of the races of Lymantria dispar and its reaction to rising temperatures². It could be shown that the different races are genetically different in regard to the temperature sum required to bring about the hatching of the eggs in spring. These differences were exactly those required to fit the normal seasonal cycle of each region, i. e. to ascertain that hatching occurred exactly at the proper time not only to insure food for

³ R. GOLDSCHMIDT, Arch. f. Entwicklungsmech. 179, 277, 591 (1932).