Vosmaeropsis and *Leucandra,* as well as species of genera with basal nuclei, such as *Leucascus* and *Leucetta.* Burton's synonymy of these species is based on "external appearance [which in reality varies considerably from species to species] and the general form of the skeleton"; he has rejected the opinions of previous authors, which are based on character complexes, including position of choanocyte nucleus and consistent differences in spicule types and canal system structure. In setting limits to his species, he also seems unconcerned about geographical disjunction.

It should be pointed out that Vacelet [*Syst. Zool.* **10**, 45 (1961)] and Sarà [*Monit. Zool. Ital.* **71**, 229 (1963)] have shown that the complex of characters used by Bidder to separate the Calcarea into two subclasses are not distributed consistently among the species of pharetronid calcareous sponges. The work of these authors therefore bears out Burton's doubt about the usefulness of choanocyte nucleus position in systematic studies of calcareous sponges and leads me to recognize my error in placing the Pharetronida as an order in the subclass Calcinea [*Syst. Zool.* **7**, 97 (1958)]. It does not necessarily follow, however, that Bidder's classification should now be abandoned. The character complexes used by Bidder still provide a valid basis for subdividing the bulk of the Calcarea into two subclasses, according to data available so far. The pharetronids, a group of calcareous sponges with fused skeletons, may be interpreted in one of two ways. On the one hand, they may represent a polyphyletic group in which the pharetronid type of skeleton has arisen independently from several families of Calcarea. The pharetronids would then be comparable in their origin to the lithistids among the Demospongiae, according to the views put forth by de Laubenfels [*Paps. Tortugas Lab.* **30**, 1 (1936) and *Treatise on Invertebrate Paleontology* (Univ. of Kansas Press, Lawrence, 1955), pt. E, p. 21]. On the other hand, they may represent an early offshoot of the Calcarea, which has diverged in its own right since its origin in late Paleozoic times (the earliest fossil pharetronids date from the Permian). The characters that consistently occur together in the Calcinea and Calcaronea and thus provide a basis for separating these subclasses may have changed in a random fashion among the Pharetronida. It can only be hoped that additional discoveries of pharetronids comparable to those of Vacelet and Sarà will provide further material for evaluating the alternatives presented here.

Burton's monograph is important, therefore, not only as a catalog of the described species of Calcarea but also in pointing out a number of problems about the structure of these animals which need further study. How general is the occurrence of syconoid and leuconoid canal systems within a single individual, an observation which Burton uses to help justify his synonymy of *Sycon ciliatum* and *Leuconia fistulosa*? Will the significance of Bidder's complex of characters break down completely when more species of nonpharetronid Calcarea have been studied in detail? Is extrusion of spicules a sufficiently wide occurrence among species of Calcarea to cast doubt on the importance of the presence or absence of spicule types in species definitions? Answers to these questions are essential to an evaluation of Burton's simplified classification. Burton has concluded that, in the light of the confusing variability which he has observed in characters among the Calcarea, the best solution for the practical museum taxonomist is to become an extreme lumper. On the contrary, it is my feeling that it is best to err on the side of splitting until individual species complexes have been analyzed in a critical manner. Calling attention to differences rather than submerging them seems to me to be of greater value to future revisers of animal groups.

There is little doubt that many tangled synonymies will be uncovered among the 500 known species of calcareous sponges when thorough revisionary studies have been made. Burton has laid the groundwork for such studies by bringing together information on all species described so far. In my opinion, however, his extensive synonymies must be viewed with extreme skepticism at this time.

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Numerical Taxonomy and Biological Classification

Numbers and numerical concepts have of course always been used in biological classification. Toward the end of the 19th century, these procedures and concepts began to be affected, usually for the better, by increasing sophistication of methods. One development, which is not discussed by Robert Sokal and Peter Sneath in their book **Principles of Numerical Taxonomy** (Freeman, San Francisco, Calif., 1963. 375 pp. $8.50), involved the treatment of numerical characteristics of organisms not as measurements of individual types but as parameters of variation in populations. Associated with that biometric approach were methods of inference from sample to population and methods of establishing confidence intervals for populational parameters. Other important developments had to do with similarities and differences among populations and with the recognition of associations, which permitted taxonomic formalization of groups, sets, or clusters of populations. Obviously these had always been leading concepts of taxonomy, even in creationist-typological days, and they are still more so in our modern evolutionary-populational taxonomy. What was new was the invention and application of concretely quantitative measurements to these taxonomic procedures.

That quantitative approach has made considerable progress since the 1890's, but the most sophisticated procedures met opposition and still are used only by a minute fraction of practicing taxonomists. Apart from sheer inertia, there were many reasons for the opposition and lack of use. One reason was, and is, that a single measure of similarity involves an enormous loss of information, mainly on the character, direction, and origin of differences, essential for really meaningful classification. Divorced from their *biological* significance, the results as pure numbers can too readily lead to banal or false conclusions. Another reason for limited acceptance was and is that the selection, measurement, and coding of multiple characters and their combination into a measurement of similarity is a highly subjective and arbitrary matter. It can be repeated or understood by a second worker only if he knows and adopts the same data, methods, and conventions. Moreover, in most fields the most thoroughly numerical taxonomic studies did not produce classifications that were clear improvements over earlier ones, so that the additional labor hardly seemed worthwhile. Protistology and especially bacteriology provide the principal exceptions to that statement, and it is significant that one of the present authors, Sneath, is a bacteriologist. The attitude of the authors is more appropriate to his field than to any other.

Perhaps the most serious problem was that more and more different characters and kinds of characters were entering into progressive taxonomy. A sufficiently satisfactory key or typological classification may be based on a few characters, perhaps of only one kind, but evolutionary taxonomy must use all possible. It must evaluate their nature and direction, and also of course their degree. Multivariate coefficients of similarity clearly might help toward the latter evaluation, but the computation involved was discouraging to taxonomists, or quite beyond their capacities, when the numbers of characters rose into the dozens and higher. Attempts to deal mechanically with quantity were clearly less satisfactory than more conventional simultaneous treatment of quality and quantity. If only on those grounds, advanced quantitative methods of this sort had little chance for further development before the 1950's when electronic computers began to be generally available.

It must be admitted that all these difficulties still exist. Some of them are, however, alleviated by Sokal and Sneath's book. The heart of this book is a highly useful discussion of measurements of resemblance and association potentially useful in taxonomy and of methods for recognizing, describing, and arranging sets or clusters.

In addition to basic concepts and formulas, fairly detailed and simple instructions for actual calculation are given. With a small number of characters, these can be carried out on desk calculators and hence are valuable for learning and comprehension. The actual research procedures recommended are, however, almost completely impractical without large, powerful computers.

Almost everyone will agree that the concepts and methods so well discussed by Sokal and Sneath are or can become a most important adjunct to taxonomy. They are already so recognized by many evolutionary taxonomists. Unfortunately, however, the authors have made themselves leaders of a small group which, with the fervor of conversion, holds that these numerical methods bearing on certain aspects of classification are not simply adjuncts to taxonomy but, in themselves and completely, *are* taxonomy. That viewpoint and their fervor have led them into many unintentional misrepresentations and exaggerations, to unjustified antagonism toward much recent progress of the science, and to retrogression in taxonomic principles. (Ultramodern machine computation has curiously led to a conscious revival of pre-evolutionary, 18th-century principles.)

The present ferment in taxonomy is a healthy sign. Eventually taxonomy will surely profit by the incorporation of a "numerical taxonomy," less rigid and less fanatical. This book by Sokal and Sneath will be a milestone in that desired development, but in the meantime I fear that its biased attitude has done not only some good but also some harm to taxonomy and, indeed, to its own basic thesis.

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Communicative Systems of Animals: Acoustic Behavior

The study of animal communicative systems has been a dominant theme in the remarkable growth of interest in animal behavior during the past decade. Sparked by von Frisch's exciting discoveries on bee dancing, and supported by the postwar development of electronic instrumentation and other special methods and apparatus, data on animal communication have contributed a thread of continuity that, in some ways and at some times, has seemed to be the principal axis of synthesis in the entire field of animal behavior. Of all the possible and proved kinds of animal communicative systems, acoustical ones received the most attention first. There are probably two reasons: (i) portable recording devices and excellent sound-analyzing instruments became available quite soon after World War II and (ii) acoustical signals seem to capture the imagination more quickly than other less noticeable or less easily recorded and translated kinds of informational transfer. Review articles on acoustical communication in the different vertebrate and arthropod groups were appearing as early as the mid-1950's, and the first book on the topic, in which modern techniques were utilized, was *L'Acoustique des Orthopteres*, also edited by R.-G. Busnel, which was published in 1955 as the outcome of an international symposium held in April 1954. In 1958, Hubert and Mabel Frings published a bibliography containing 1752 references on sound production and hearing in insects. Work on vertebrate acoustical behavior was developing a little more slowly, with certain investigations especially prominent during the early and middle 1950's—spectrographic studies of bird songs by Borror and Reese (Ohio) and by Thorpe and Marler (Cambridge), experimental work on bat sounds and echolocation by Griffin (Harvard) and by Möhres (Tübingen), and investigations on amphibian acoustics by Blair (Texas). The International Committee on Biological Acoustics, an organization of workers on animal acoustics, was developed as the result of a meeting held at University Park, Pennsylvania, in 1956; that meeting was sponsored by the National Science Foundation and organized and hosted by the Frings. In 1961 the Cornell Laboratory of Ornithology began publishing a small quarterly, *The Bio-Acoustics Bulletin*, under the editorship of William R. Fish, which in turn began an annual review of bio-acoustical work, with contributions by various authors on invertebrates, amphibians and reptiles, birds, underwater acoustics, techniques, and methods. As Busnel notes in his preface to this book, several books and symposium volumes on bio-acoustics have been published during the past seven years.

This volume, **Acoustic Behaviour of Animals** (Elsevier, New York, 1963. 933 pp. Illus. $45), edited by R.-G. Busnel, is a remarkable compilation, and a tribute to the energy and perseverance of its editor, who was chiefly responsible for the idea and for the long, arduous task of seeing the book through to publication. Some of the "chapters" are exhaustively detailed—for example, Bernard DuMortier's three-section treatment of arthropod acoustics: (i) morphology of sound emission apparatus, (ii) physical structure of acoustical signals, and (iii) etho-