# Books and Perspectives

## Most Everything You Wanted to Know About Allometry, But Were Afraid to Ask

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*Scaling: Why is animal size so important?*
Knut Schmidt-Nielsen. Cambridge University Press, Cambridge, 1984, xii + 241 pp. Hardcover, $29.95, Paper $9.95.

We are all well aware of the influence on the behavior of animals of chemistry: of salts, proteins, hormones, and endorphins. We are less cognizant of the importance of physical laws in the design and function of living systems. Laws of physics determine rates of diffusion and heat transfer, govern application of force and, thus, the dynamics of locomotion; they impose constraints on what it is physically possible for an organism of any given shape and size to accomplish.

One of the most obvious changes that vertebrate organisms undergo as they develop from neonate to sexually mature adult is an increase in body mass. The newborn rat, for example, weighs 5 or 6 g, the adult rat 350 g or more. There are important physical consequences of this 60-fold increase in weight. The infant rat, even if totally mature at birth, could not be a miniature version of the adult of its species. It would have to be a shrewlike creature, driven by the enhanced metabolic needs imposed by its great surface area-to-volume ratio and the resultant exorbitant rate of heat loss to employ specialized morphological and behavioral adaptations not useful to the larger adult.

Allometry, the biological study of size and its consequences, is an approach of broad application in understanding differences in the form and function of organisms of disparate body size. It can bring order out of chaos in large collections of descriptive, comparative data, make salient both discontinuities in the phenotypes of phylogenetically related organisms and exceptions to descriptive rules. It is the field that, in S. J. Gould's (1971, p. 239) inimitable (if irreverant) definition, "explains why any fly can walk up a wall, but only Jesus could walk on water," that gives lie to any number of commonplace beliefs (that dinosaurs had relatively small brains, that birds have lighter bones than mammals), and provides the evidence for others (The human brain, for example, is in absolute terms, smaller than an elephants and, relative to body weight, is smaller than a shrew's. Its sole claim to superiority in mass is indicated by the magnitude and direction of its deviation from the allometric function relating brain-weight to body-weight in mammals). Surely, an approach to the study of living systems as broad in applicability as allometry has implications for understanding of the changes in morphology, behavior and physiology of developing organisms: some of these changes may be directly related to the steady increase in body mass that occurs early in life. Yet allometry has had only a marginal impact on our discipline, perhaps because it has seemed esoteric, unfathomably mathematical, and generally inaccessible to the developmental psychobiologist.

We are, therefore, fortunate now to have available an affordable, readable, and fascinating account of the application of allometric methods to a wide variety of problems in vertebrate physiology

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and behavior. Knut Schmidt-Nielsen has written an introductory text both requiring a minimum of mathematical background (all the major and many of the minor arguments are present in verbal as well as mathematical form) and providing three introductory chapters that permit the numerically naive to follow much of the formal presentation (though a few minutes spent with a high-school algebra text refreshing my memory of logarithms was a big help). The remaining 14 chapters apply allometric methods to issues as diverse as the size of birds eggs, the longevity of mammals with brains of different sizes, physical constraints on the maximum and minimum size of organisms, and the speeds at which fish swim and birds fly.

Of particular interest to developmentalists are three chapters discussing the relationships among metabolic rate, thermoregulation, and body size, two others on heart-rate, blood-gas transport and circulation, and two more on locomotion. In each, Schmidt-Nielsen is concerned not only with the descriptive relationships between size and the characteristics of organisms, but also with the implications of those relationships for the understanding of physiology and functional morphology. One comes away from the volume with an enhanced appreciation of the organism as an integrated system, each of its many parts constrained and modified by interaction with others.

Those already familiar with D'Arcy Thompson's (1917) classic *Growth and Form* or Kleiber's (1961) *The Fire of Life* will find important conceptual advances in Schmidt-Nielsen's work. Schmidt-Nielsen consistently moves beyond the use of allometry as a descriptive technique, using allometric relationships as a tool for understanding the functions of physiological processes and their interrelationships. His lucid explication of problems in measurement, sampling, extrapolation, and correlational analysis will also prove useful to any working scientist.

It is, however, not only the facts to be found in this intriguing volume that capture the imagination, but also the possibility that allometry may provide a useful tool for the ordering of some of the wealth of data already collected on developmental phenomena as well as a heuristic for identifying potentially fruitful research problems. Schwartz and Rosenblum's (1983) pioneering chapter on allometric influences on primate mothers, infants, and their interactions points to the potential value of allometry to the study of phenomena that characterize our field, but there is clearly more to be done. Schmidt-Nielsen makes no reference to developmental issues in his discussions of the consequences of scaling, and other recent overviews of the field (e.g., Gould, 1966; Peters, 1983) make only minimal use of developmental material. A true field of developmental allometry has yet to emerge, and there are important contributions to be made in filling the lacuna.

As a formal field of enquiry, developmental psychobiology is still in its formative years; developmental psychobiologists have exploited only some of the many biological tools of potential use in understanding the development of behavior. Allometry is one of several such tools that have generally failed to capture the attention of workers in our field. Although it is highly improbable that we all will become allometrists, we should be aware of the potentials (and limitations) of allometry for the analysis of developing organisms. Schmidt-Nielsen's *Scaling* is not an easy read, but the effort required to understand the material is more than amply rewarded. The volume will be of value to all interested in the function, design, and ontogeny of living systems.

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