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THE INTERMEDIATE SNAIL-HOST: AN AGENDA FOR FUTURE STUDY

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The strategy for the control of schistosomiasis has shifted from one directed towards the interruption of transmission to one of reducing morbidity. As a consequence of this change, it appears prudent to reassess the role of the malacologist and malacology and identify the future direction to be taken by the discipline. The present paper addresses these concerns; first, by reviewing the role of the snail-hosts in the epidemiology and control of schistosomiasis, and, secondly, by suggesting areas for future study. The possible application of newer methods in biotechnology for the resolution of malacological problems are discussed.

During the past 5-7 years, the global strategy for the control of schistosomiasis has changed from one of transmission control, in which control of the snails-hosts was foremost, to one of morbidity control, in which chemotherapeutic agents are the primary tools and control activities are incorporated as part of the local health care delivery system. As a consequence of these changes, it appears prudent for the malacologist to reassess his role and that of his discipline within the framework of the new strategy. There is a need, moreover, to delineate subject areas which are apt to be most profitable for future study and research. The present paper is an attempt to address these concerns; first, by reviewing the status of particular areas associated with the snail-host's role in the epidemiology and control of schistosomiasis and, second, by posing a series of questions and problems which may foreshadow the trend of future research. Many of the problems the malacologist faces today can be resolved adequately by using existing technology, providing the right questions are asked; however, others will require the application of the "new biotechnology", and we will enter the era of molecular malacology. In truth, molecular biologic techniques have already been applied to certain aspects of the host-parasite relationship.

Basic to all studies on the snail-hosts is a sound taxonomy, for taxonomy serves as a primary information system for the discipline and gives meaning to all other biological studies. To paraphrase Shakespeare, a snail by any other name may or may not be the same, and it is critical that we know which may be a host. More progress has been made on the taxonomy of the hosts of schistosomiasis during the past two decades, than in the entire period subsequent to the designation of the genus *Bulinus* by Müller in 1781. These advances in host taxonomy are due, in part, to the judicious application of chromatographic, electrophoretic, and immunologic techniques by a variety of investigators. These techniques and their application to malacology have been reviewed by Michelson (1973, *Malac. Rev., 6:* 44-47), Wright (1974, *Biochemical and Immunological Taxonomy of Animals*, Acad. Press), and Davis (1979, *Pulmonates*, v. 2, Acad. Press). In addition, the application of numerical toxonomic methods using multivariate and cladistic analyses, as exemplified by the studies of Davis et al. (1983, *Proc. Phila. Acad. Nat. Sci., 135:* 177-199; 1986, *PPANS, 138:* 426-442) and by Kristensen and his associates (1987, *Rev. Zool. Afr., 101:* 55-67), has provided new insights into molluscan systematics.

It can be predicted, with a reasonable degree of certainty, that both DNA probes and antigen capture systems will be the next tools employed by taxonomists for delimiting closely related taxa and for the rapid identification of species under field conditions.

The role of snail-hosts in the transmission of schistosomiasis is influenced and, to some extent, controlled by a diversity of factors; some environmental, others related to the

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parasite, and still others innate to the snail (Fig. 1). Althought the effects of the environment on the snail-hosts have been documented repeatedly and the considerable literature reviewed by Appleton (1978, *Malac. Rev., 11:* 1-25) and Christensen (1979, *J. Helminth., 53:* 7-14; 1980, *Acta Tropica, 37:* 303-318), the mechanisms by which most environmental factors exert their actions remains unknown and is a fertile area for future inquiry.

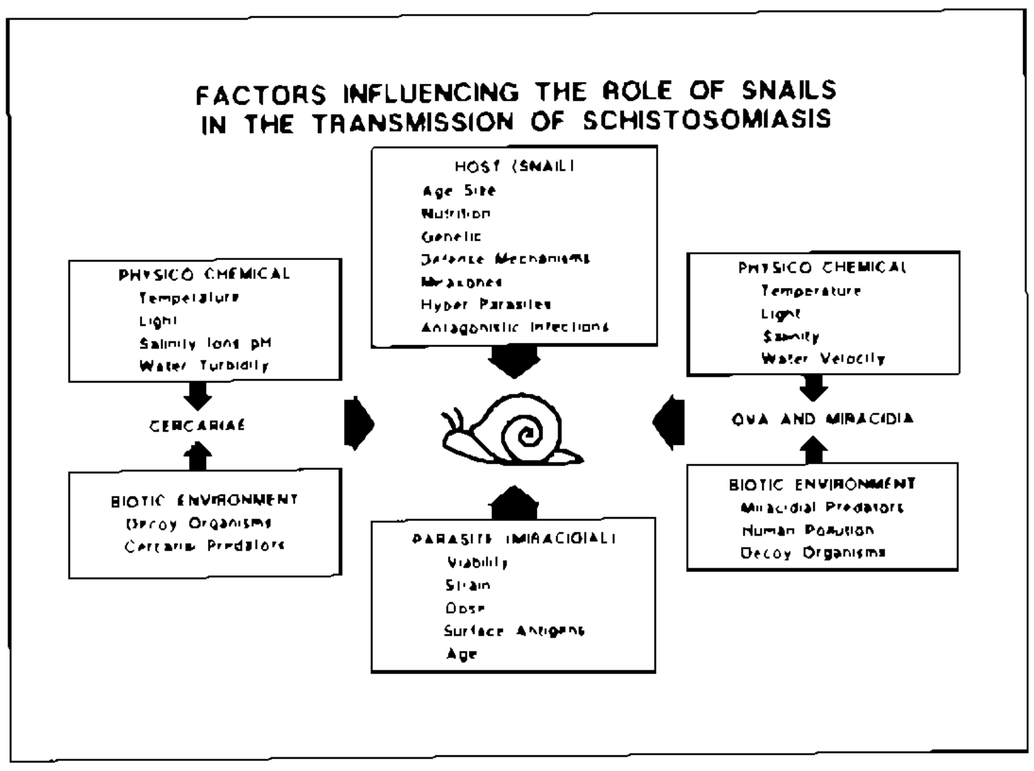

Fig. 1: factors influencing the role of snails in the transmission of schistosomiasis.

One of the most exciting and productive areas of malacological research during the past decade has been the investigation into the nature of snail-host susceptibility to schistosome infection. Experimental studies by Abdul-Salaam and Michelson (1983, *Exp. Parasit., 55:* 132-137), Yoshino & Chang (1978, *J. Parasit., 64:* 752-754; 1983, *Parasite Immunol., 5:* 317-320), Loker et al. (1982, *J. Parasit., 68:* 84-94), Bayne and his associates (1986, *Parasitology, 92:* 653-664; 1987, *Dev. Comp. Immunol., 11:* 321-329), as well as others, have demonstrated the following: (1) the ultrastructural basis of the encapsulation response of the snail-host to resistant strains of the parasite; (2) the presence of circulating parasite antigen(s) in infected snails and the activation of the host's defense mechanisms; (3) that extensive interactions occur between snail plasma and the surface membrane of larval schistosomes; (4) the nature of epitopes on snail amoebocytes; and (5) the presence of molecular mimicry between the schistosome parasite and the snail-host. The basic and fudamental studies on the molecular genetics of the snail-hosts, as exemplified by Mulvey and her associates (1981, *J. Hered., 72:* 308-312; 1982, *Am. J. Trop. Med. Hyg., 31:* 1195-1200) and those of Woodruff and his colleagues (1985, *J. Hered., 76:* 355-360) are also exciting and represent a quantum leap in our understanding of snail strains and populations. It becomes apparent, therefore, that problems associated with the snail-host/parasite interaction are now being addressed at the molecular level by malacologists employing electron microscopy, gel electrophoresis, fluorescent antibody techniques, antigen capture assays, monoclonal antibodies, and Western blot procedures.

A historical resume of the methods used to control the schistosome snail-hosts is presented in Fig. 2. Progress in the development of either new or more cost efficient means of snail control has not been particularly promising, and the advent of new molluscicidal compounds is likely to be impeded by both financial and environmental constraints. Recent trends toward the development of plant molluscicides seems stimulated more by their promise of stemming the flow of hard currency from endemic areas for purchase of chemical agents, than by the promise of these natural agents to be superior to synthetic substances. Biological control, often advocated as an alternative to the use of molluscicides, has enjoyed a resurgence as a consequence of the promise offered by several molluscan competitors. The potential of biological control as a rewarding area for future study is promising, particularly if one is not trapped into viewing the technique solely in terms of predators, parasites, pathogens, and competitors. The role of pheromones, genetic manipulation, and fertility control, as means for exercising biological control, have scarcely been explored and warrant further study.

Richards, in a series of papers from 1970-1983, demonstrated the genetic diversity of the host snails *Biomphalaria glabrata* and *B. straminea* and lent credibility to the concept of snail control by genetic manipulation. Woodruff (1983, *Comparative Pathobiology*, v. 8, Plenum Press) has discussed this technique in detail, and Fletcher (1983, *Comparative Pathobiology*, v. 8, Plenum Press) has developed a mathematical model to show the possible effect of introducing resistant snails in susceptible populations. Techniques for inserting resistant genes into susceptible snail-hosts are a possibility of the future and offer a new dimension to the concept of genetic manipulation.

The medical malacologist is frequently identified as an individual whose sole task is to control snail-hosts. Unfortunately, this represents a myopic view which emphasizes the ultimate objective of the malacologist's research effort, rather than stressing his commitment to the study of the biology, ecology, and control of those molluscs which contribute to the transmission of disease and toxins to man and his domestic animals.

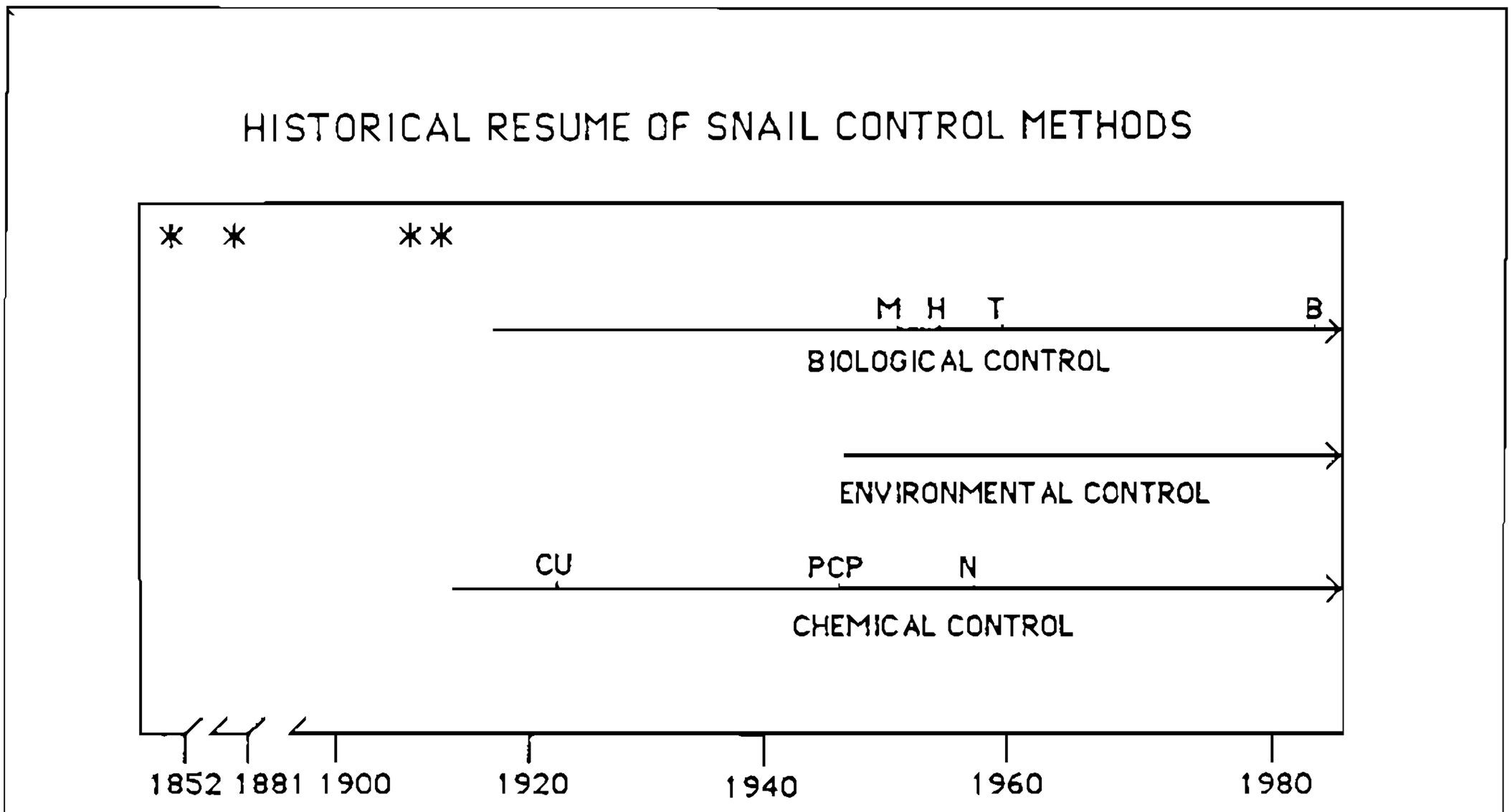

Fig. 2: historical resume of snail control methods. Asterisks indicate the discovery of human schistosomes by Bilharz in 1852, the demonstration of the role of snails in the life-cycle of a trematode parasite by Leuckart and Thomas in 1881, the discovery of the host-snail of *Schistosoma japonicum* by Miyairi and Suzuki in 1913, and the discovery of the host-snails of *S. mansoni* and *S. haematobium* by Leiper in 1915. The letters M, H, T, and B on the top arrow indicates the time at which *Marisa, Helisoma, Tarebia*, and *Biomphalaria straminea* were recognized as potential biological control agents. The letters CU, PCP, and N represent the time at which copper sulfate, pentachlorophenate, and niclosamide were first used as molluscicides for the control of schistosomiasis.