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Editorial Note

The translated reviews by V. Herout and H. Z. Levinson published in this issue describe the trends in studies designed to elucidate the role of low-molecular-weight products as regulators in biological systems. Until recently the problem of chemical control was developed mainly in relation to the control of functions at the level of the organism. This problem was investigated in greatest detail for the hormonal system of mammals. During the last 15–20 years, the range of these studies has expanded significantly—new data have been obtained on hormonal control in lower animals too, particularly in arthropods, as well as in higher and lower plants.

The problem of the possible role of metabolites excreted by the organism to the surrounding medium has remained much less thoroughly investigated. Numerous facts long known to biologists have shown that these substances can function as regulators in specific interrelations between organisms. Thus it has been shown at the level of a phenomenological description that many biological phenomena, such as, for example, the mutual influence of plants (allelopathy), the interrelation between plants and insects, and the wide variety and complexity of control in communities of social insects and certain behavioural responses of fish can be accounted for only if it is assumed that chemical substances excreted by individuals into the medium play the role of regulators acting on the behaviour and vital activity of other individuals. However, owing to the inadequacy of analytical methods, the apparent analogy between hormonal control within the organism and control in social groups involving metabolites entering the medium (in "hormonal" amounts) for a long time remained largely a speculative hypothesis, which has been reflected in the appearance of terms such as "ectocrines","exohormones", and "environmental hormones".

Quite recently (at the end of the 1950s and at the beginning of the 1960s) the idea of the regulatory importance of the metabolites excreted into the medium received rigorous experimental support as a result of the employment of new physical chemical methods (chromatography, NMR, and mass spectrometry). The studies by Butenandt and Karlson, who isolated the sexual attractant (pheromone) of the silkworm and established its structure, can probably be regarded as the beginning of this new period in research on exohormones. Further studies showed that the system of chemical communication employing signalling substances (pheromones) is present not only in insects but also in higher animals, up to primates.

Even more complicated and varied chemical control mechanisms have been observed in studies on non-trophic relations in biocenoses—stable communities of various species of living organisms populating a given region. Owing to the external and dense network of trophic relations (food chains—"who eats whom") subtler relations of a purely regulatory signalling type have been discovered in communities. In other words, it has been found that ecology cannot be restricted to the study of the energy flux and metabolism in communities but must also take into account the no less important flux of signalling substances carrying information about the presence, behaviour, and physiological state of various species constituting the given biological system. This aspect of ecological studies is in fact reflected in the term "chemical ecology" which appeared recently. Some idea about the subject and scope of this concept is provided by the titles of the articles in the collected volume "Chemical Ecology" published in the USA in 1970: "Plants and Chemical Environment", "Chemical Interactions between Plants and Insects", "Hormonal Interactions between Plants and Insects", "Intraspecies Chemical Communication in Animals", "Chemical Protection Against Arthropods", etc.

For chemists the most significant aspect of this problem is the question of the nature of the substances whereby chemical control processes are achieved. It appears evident (apparently G. Frenkel' was the first to draw attention to this) that metabolites involved in basal metabolism, providing the organism with energy and constructional material, cannot behave as chemical regulators of this kind (because such metabolism is of the same type for all living beings) and that these must consist of substances the metabolism of which is fairly specific to various species. The set of such natural products, sometimes referred to as "secondary metabolites", is extremely large, particularly in plants. Isoprenoids, alkaloids, certain aliphatic and aromatic compounds, and antibiotics are usually included among them. Some of these substances (for example steroids) are known to be involved in the control of the most important biological functions at the level of the organism. However, it remained obscure for a long time whether the majority of the others fulfil any kind of function in nature or whether they are simply the metabolic "waste" of the organisms producing them. Chemical ecological data have now demonstrated convincingly that at least some of the "secondary metabolites" do in fact play the role of regulators in the interrelations between organisms at the level of populations and communities.

Thus both at the level of the organism and at the level of communities of organisms, there is a characteristic chemical communication channel between individual components of the biological system, certain types of low-molecular-weight natural products being widely used as signals.

The problem of the way in which this chemoregulating system functions is still obscure, but in one of its main aspects the problem is essentially one of chemoreception. One must emphasise that the latter hardly reduces to the problem of the mechanism of signal reception by specialised organs of taste and smell in animals but embraces the entire range of interactions of the signal molecule with the receptor in a particular biological system.

Another important aspect of the problem of chemical control is related to the study of the question of the organisation of the system governing the chemical communication channel. Interesting data on this question were obtained by Sutherland, who found that in many cases the hormonal control system in the animal organism is constructed as a system of primary messengers (hormones), which induce in the target cells the formation of a secondary messenger (cyclic adenosine 3,5'-monophosphate, cyclic AMP). Possibly the principle of this type of hierarchy of signal systems is as common as the principle of the hierarchy of the control systems in biological organisation.

The entire range of problems associated with chemical control is of undoubted interest to chemists. The literature on this general problem is extremely large and could not be covered by the two reviews published here. Therefore we felt it necessary to include an additional list of references, which provides more complete information about the principal trends in studies on chemical control phenomena.

This list of references, divided into several fairly arbitrary sections, is quoted at the end of the list of references in Levinson's review.

ADDITIONAL REFERENCES

I. General Problems of Chemical Ecology

"Chemical Ecology" (edited by E. Sondheimer and J. Simeone), Acad. Press, New York, 1970; E. P. Odum, "Fundamentals of Ecology" (Translated into Russian), Izd. Prosveshchenie, Moscow, 1968; "Mekhanizmy Biologicheskoi Konkurentsii" (Mechanisms of Biological Competition) (collected translations edited by R. L. Bert and A. L. Takhtadzhyan), Izd. Mir, Moscow, 1964; S. S. Shvarts, Izv. Akad. Nauk SSSR, Ser. Biol., 822 (1972); B. Pierson, Scientific American, **220**, No. 2, 22 (1969).

II. Problems of Hormonal Control and Chemoreception

E. Sutherland, Science, 174, 401 (1972); W. Burdette, Cancer Res., 32, 1088 (1972); K. Nair and M. Menon, Experientia, 28, 577 (1972); K. Thiman, "The Natural Plant Hormones" in "Plant Physiology" (edited by F. Steward), Acad. Press, New York, 1972, Vol. VIB, Chapter 5; A. Srb, "Development Genetics" in "Plant Physiology" (edited by F. Steward), Acad. Press, New York, 1972, Vol. VIC, Chapter 10; F. Steward and A. Krikorian, "Integration and Organisation: Control Mechanism" in "Plant Physiology" (edited by F. Steward), Acad. Press, New York, 1972, Vol. VIC, Chapter 12; "Advances in Chemoreception", Vol. I, "Communication by Chemical Signals" (edited by J. Johnston and D. Moulton), Appleton, New York, 1970; "Olfaction and Taste", "Proceedings of the Fourth International Symposium" (edited by D. Schneider), Wissentsch. Verlag, Stuttgart, 1972; A. V. Minor and N. L. Sakina, Neirofiziologiya, 5, 415 (1973).

III. Pheromones

M. Beroza (Editor), "Chemicals Controlling Insect Behaviour", Acad. Press, New York, 1970; D. Gilmour, "The Metabolism of Insects" (Translated into Russian), Izd. Mir, Moscow, 1973; Ya. D. Kirshenblat, "Telergony—Khimicheskie Sredstva Vozdeistviya Zhivotnykh" (Telergones—Chemical Agents of Animal Activity), Izd. Nauka, Moscow, 1968; D. Evans and C. Green, Chem. Soc. Rev., 2, 75 (1973).

IV. Chemical Interaction of Plants (Allelopathy)

G. Grummer, "Mutual Influence of Higher Plants—Allelopathy" (Translated into Russian), Izd. Nauka, Moscow, 1957; A. M. Grodzinskii, "Allelopatiya v Zhizni Rastenii i Ikh Soobshchestv" (Allelopathy in the Life of Plants and Their Communities), Izd. Naukova Dumka, Kiev, 1965; F. Went and L. O. Sheps, "Environmental Factors in Regulation of Growth and Development: Ecological Factors" in "Plant Physiology" (edited by F. Steward), Acad. Press, New York, 1969, Vol. VA, Chapter 5, p. 375; A. D. Rovira, Bot. Rev., 35, 35 (1969); C. H. Muller, Vegetatio, 18, 348 (1969); C. Cook et al., J. Amer. Chem. Soc., 94, 6198 (1972); W. Grow et al., Tetrahedron Letters, 1353 (1971).

V. Chemical Control of the Interrelations between Plants and Insects

D. Wood, R. Silverstein, and M. Nakajima (Editors), "Control of Insect Behaviour by Natural Products", New York, 1970; D. E. Breedlove and P. Ehroch, Science, 162, 671 (1968); K. Wada et al., Agr. Biol. Chem., 35 (1), 115 (1971); A. Braun, "Abnormal Growth in Plants" in "Plant Physiology" (edited by F. Steward), Acad. Press, New York, 1969, Vol. VB, Chapter 9.