Comments and Communications

Replacement Control and Biological Control

This note is prompted by the writers' interest in the control of pest plant species through natural replacement by desirable species. Our purpose is to compare replacement control with "biological control," which denotes control of insect or plant pests by parasitic or predatory organisms. References to biological control in current literature do not include control by replacement. *The Control of Weeds* (Whyte, R. O., Ed. Aberyswyth, Great Britain: Imperial Bur. of Pastures and Forage Crops, Bull. 26, Jan. 1940) and *Weed Control* (Robbins, W. W., Crafts, A. S., and Raynor, R. N. New York: McGraw-Hill, 1942), both of which refer to the work of many investigators, do not recognize replacement as a method of biological control.

Replacement control and biological control are similar in that both employ natural means, and both require man's intervention to create conditions favorable for the restrictive process to begin its course. In biological control the objective tends to be specific, such as the control of a particular pest (prickly pear cactus) by a particular kind of organism (moth-borer). In replacement control, though the immediate objective may also be the elimination of a particular kind of plant species, the process involves the control of other plants of similar habits of growth. Furthermore, its objective may be multiple in effect, as: control of a plant pest, plus control of an insect that is the vector of a disease, and, consequently, control of the disease, plus improved forage, plus improved plant cover as a protection for the soil.

Biological control makes use of a predator-prey or a host-parasite relationship. A specific parasite or predator must be found and introduced free of its own parasites and predators, and it must be harmless to useful species. If an endemic organism is to be used, the conditions that favor its development and activity must be discovered.

Replacement control makes use of the natural process involved in secondary plant successions, and it applies almost exclusively to uncultivated lands and usually to those used for grazing. The kind of replacement used on cultivated lands, that of obtaining a dense, vigorous stand of crop plants to eliminate certain kinds of weeds, makes use of only one part of the process of plant succession, namely, competition. The time is usually short, involving only the current generation of plants. Replacement by means of secondary successions requires a few to many years and successive generations of plants. It is a complex process involving a series of plant communities, even though these communities themselves may be simple as compared to the original stable plant communities. For instance, in semidesert vegetation the process of replacement goes forward from an initial simple community of summer annuals, through another of broad-leaved winter annuals (not grasses), then winter annual grasses, to native perennial grasses and shrubs. These native perennials form stable communities similar to the original, even if not identical as to all the minor, associated species. Thus in any strict sense the reestablishment of stable communities of native perennials is not a complete return to the climax.

In replacement control, man's part is to protect the vegetation of the area from destruction by animals by excluding domestic animals for the necessary time and, if needed, by temporarily reducing such wild animals as rabbits and other small rodents. If this is done, there will be, in time, a successful control of the obnoxious weed species. An illustration taken from actual demonstrations in a semidesert vegetation can be given: Russian thistle replaced by a growth of mustards, and the latter in turn replaced by a cover of downy chess. The first, a summer annual that is a pest in itself in crops such as grain, is also a favorable summer host for the breeding of the beet leafhopper, vector of the virus of the disease called curly top. The second, the mustards, also weeds, are winter annuals and are also favorable winter and spring hosts of the beet leafhopper. The third, downy chess, a winter annual grass, is not a host for the beet leafhopper, yields more forage than either of the others, and affords better protection for the soil. The entire change from the first stage, Russian thistle, to the third, the annual grass, takes place in 5 or 6 years (Piemeisel, R. L., *Natural Replacement of Weed Hosts of the Beet Leafhopper as Affected by Rodents.* U. S. Dept. Agri. Cir. 739, 1945). Under proper conditions this temporary cover of quick-growing annuals is in turn replaced by native perennials, grasses, and shrubs that yield a more stable cover and more reliable forage, and are not favorable for the building up of a large number of beet leafhoppers.

Although the two methods of control are alike in that they both employ natural means, biological control is similar to chemical and mechanical methods of control in its dependence on direct destruction of the pest, whereas replacement control depends on prevention of growth or on indirect destruction through crowding and competition. Biological control has been put into practice in a number of instances; for example, on cactus in Australia and on insects in citrus-growing districts. Control by replacement has scarcely made a beginning in practice, but it has great potential possibilities for the future. Though this method has not been used intentionally as a control of particular pests on any large scale, some of its underlying principles have been tried or advocated for a long time in the improvement of plant cover on grazing lands, where the objective has been increased forage or better protection for the soil. Good range management includes replacement of pest plant species, which is the best means of controlling them.

The effectiveness of replacement control for any given case can be determined by appropriate experimental procedure. Experience with curly top indicates that the time required to make replacement effective compares favorably with the time required for effective control through the development of resistant varieties. As a long-term solution the method is undoubtedly less expensive than other methods, such as (1) mechanical (cultivating, hoeing, mowing, etc.), (2) chemical (dusting, spraying), and (3) fire, which generally entails recurring efforts and expense.

The term biological control, taken in its broadest sense, should include control by replacement through plant successions. If its present meaning, which limits it to the action of parasitic and predatory organisms, is to be continued, then replacement control or some term more appropriate for the process involved may become coordinate with biological control. Communications are requested from those interested in this problem of terminology and also from those who know of any instance where a term has already been used for the method of control that makes use of plant successions.

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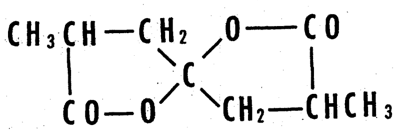
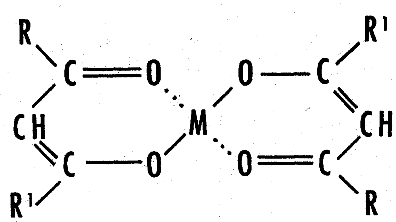
Solution of the Problem of "Internal Compensation" in Meso Compounds as Afforded by Studies on Analogous Coordination Complexes

A controversy concerning the meaning of "internal compensation" in meso compounds—whether meso compounds with staggered configurations are optically active —has occurred in past issues of SCIENCE (Noller, **102**, 508 [1945]; Wright, *Ibid.*, **104**, 190 [1946]). In a recent communication (*Ibid.*, **112**, 26 [1950]), Kurt Mislow proposed an experimental solution of the problem: the resolution of DL-isomers of spirans such as 3,8-dimethyl-1,6-dioxaspiro [4.4]-nonane-2,7-dione (I).



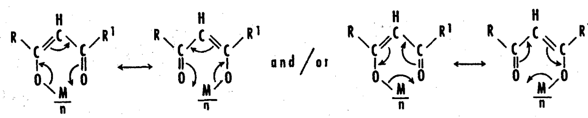
I

Certain 4-coordinate complexes of 1,3-diono-type compounds with divalent and trivalent cations are fully analogous to these spirans (II). As is generally known,



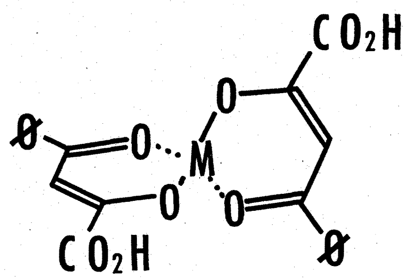
II

such compounds behave as if they consist of two 6-membered rings joined at the metal atom in spiran fashion; e.g., the compounds undergo no reactions that are characteristic of free carbonyl groups (Werner, *Ber.*, **34**, 2584 [1901]). The resonance picture in III explains this behavior.



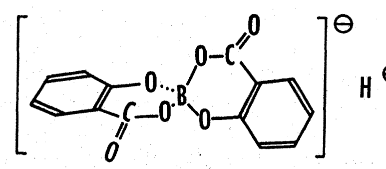
III

Several examples of this type of coordination complex have been successfully shown to possess optical activity: bis(4-phenyl-2,4-dioxobutanoato-2,4-O,O) beryllium (II) and the corresponding zinc compound (IV), by Mills and Gotts (*J. Chem. Soc.*, 3121 [1926]); and hydrogen bis(2-hydroxybenzenecarboxylato)borate (III) (V), by Boëseken (*Proc. Acad. Sci. Amsterdam*, **27**, 174 [1924]). A similar silver compound is also optically active. All these examples have staggered configurations. Those that are meso but not staggered—i.e., "trans planar"—do not possess any optical activity; e.g., the Pt, Pd, Ni, and Cu complexes.



IV

M = Zn or Be; tetrahedral configuration around M



V

tetrahedral configuration

These examples afford direct experimental proof that Noller and Mislow are correct: staggered configurations of meso compounds give rise to optical activity, just as is to be expected on the basis of the symmetry criterion.

It might be mentioned further, in view of Mislow's suggestion to resolve the DL mixture of spirans by chromatography on a lactose column, that, at least in the case of coordination complexes, chromatography on a column of finely powdered, optically active quartz is very likely to succeed. Kobayashi and Nakamura (*J. Chem. Soc. Japan*, **56**, 1339 [1935]; *Bull. Chem. Soc. Japan*, **11**, 38 [1936]), and Kuroya, Arini, and Tsuchida (*J. Chem. Soc. Japan*, **64**, 995 [1943]) found that such quartz, shaken with solutions of certain racemic coordination complexes (similar to the use of decolorizing charcoal), preferentially adsorbed one of the optical antipodes (which one depending on the sign of rotation of the quartz).

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