theorem states that all links may be represented as plats. Again, details of the emerging theory cannot be described here.

An appendix lists 34 research problems of various and, as admitted by the author, partly considerable degrees of difficulty. These give a very good idea of both the complexity and the promise of the existing theory.

The list of references is excellent. It is not arranged in the usual manner by authors but by the years of publication, a style introduced by Ralph Fox.

In summary it may be said that this monograph is an excellent guide to a field of research which is particularly attractive because it involves several mathematical disciplines. It has been planned with great care, and the introductions to the various chapters clearly outline the motivating ideas. It is perhaps not a textbook, but it is a very good basis for a seminar.

W. MAGNUS

Infinite-dimensional Lie algebras, by Ralph K. Amayo and Ian Stewart, Noordhoff International Publ., Leyden, The Netherlands, 1974, 425+xi pp.

Is there a theory of infinite-dimensional Lie algebras? Finite-dimensional Lie algebras over **R** or **C** (and even over p-adic fields) are forced upon us almost as soon as we begin to think about Lie groups; the introduction of linear algebraic groups and related finite groups then makes it natural to allow even more general base fields. Infinite-dimensional Lie algebras, on the other hand, have arisen only sporadically and have been investigated only in special settings, e.g.: free Lie algebras (cf. N. Bourbaki, *Groupes et algèbres de Lie*, Chapter 2, Hermann, Paris, 1972); simple algebras of infinite type (E. Cartan, S. Sternberg, V. Guillemin, V. G. Kac); Lie algebras of formal vector fields (I. M. Gel'fand, D. B. Fuks); Banach-Lie algebras (cf. P. de la Harpe, Lecture Notes in Math, vol. 285, Springer, Berlin, 1972); Lie algebras defined by generalized Cartan matrices (V. G. Kac, R. V. Moody).

Amayo and Stewart concentrate entirely on certain algebraic aspects of infinite dimensional Lie algebras, emphasizing in their preface the "surprising depth of analogy" between these and infinite groups, but adding: "This is not to say that the theory consists of groups dressed in Lie-algebraic clothing. One of the tantalising aspects of the analogy, and one which renders it difficult to formalise, is that it extends to theorems better than to proofs." This seems a fair assessment.

Their book has 18 chapters, which to some extent can be read independently of each other, grouped by the authors under six headings: (1) subideals and "coalescent" classes of Lie algebras; (2) the Mal'cev correspondence between locally nilpotent Lie algebras and certain locally nilpotent groups, along with a study of various locally nilpotent radicals; (3) finiteness conditions, especially minimal and maximal conditions on subideals; (4) properties of finitely generated solvable Lie algebras suggested by P.

Hall's work on solvable groups; (5) "neoclassical" Lie algebras resembling finite-dimensional Lie algebras over fields of characteristic 0, with emphasis on simple summands and Levi factors; (6) varieties of Lie algebras, the question of existence of a finite basis for a variety, Engel conditions, and work of A. I. Kostrikin and Yu. P. Razmyslov on the restricted Burnside problem.

Of these topics, (1), (3), (4), and (5) especially reflect the interests and contributions of the authors, and are to a great extent *sui generis*. On the other hand, the Mal′cev correspondence and the theorem of Kostrikin are more widely known in view of their applications to group theory. The exposition of the Mal′cev theory is based on papers of Stewart, and proceeds from the Campbell-Hausdorff formula in the "local" setting to a "global" group-algebra correspondence. The exposition of Kostrikin's theorem is carried through only for a weakened (but still quite difficult) version, since the full proof involves an exceedingly long combinatorial argument. This beautiful theorem asserts that a Lie algebra satisfying the nth Engel condition is locally nilpotent provided the base field has characteristic 0 or else characteristic $p \geqq n$, and implies an affirmative answer to the restricted Burnside problem for primes p and all m: The order of a finite m-generator group of exponent p is bounded by a function of m and p. (This follows by passing from a group of exponent p to an associated Lie algebra over the field of p elements which satisfies the $(p-1)$st Engel condition.) The authors appropriately ask, as number 43 in their concluding list of open questions: "Can Kostrikin's proof be simplified?" Their account of this proof and of the more recent construction by Razmyslov of nonnilpotent groups of prime exponent are adapted from lecture notes of J. Wiegold.

The calculus of classes and closure operations developed for groups by P. Hall is used systematically throughout the book, with constant gain in efficiency and occasional loss in readability. The authors provide a full index of notation, as well as an extensive bibliography. Arguments are organized and written down very carefully, though sometimes fairly technical results have to be quoted from the literature. As might be expected, different proofs and even different theorems are frequently required according to whether the characteristic is 0 or not. (One quibble: The "Tuck-Towers theorem" quoted on p. 259 is really due in essence, if not in so many words, to Chevalley. But the reference [39] is not the right one; instead one has to go back to his *Théorie des groupes de Lie*.)

As to our initial question, the cautious reply would be: Not yet. The disparate sorts of Lie algebras found in the areas mentioned at the outset are not easily organized into a coherent general theory. In their book, Amayo and Stewart have achieved a fairly high degree of coherence by emphasizing those notions which have analogues in infinite (discrete) groups; group theorists will correspondingly find the book useful and attractive, though its appeal to the general reader will be more limited.

J. E. Humphreys