



# **Module Theory: Endomorphism rings and direct sum decompositions in some classes of modules**

## **(Progress in Mathematics)**

*Alberto Facchini*

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This expository monograph was written for three reasons. Firstly, we wanted to present the solution to a problem posed by Wolfgang Krull in 1932 [Krull 32]. He asked whether what we now call the "Krull-Schmidt Theorem" holds for artinian modules. The problem remained open for 63 years: its solution, a negative answer to Krull's question, was published only in 1995 (see [Facchini, Herbera, Levy and Vamos]). Secondly, we wanted to present the answer to a question posed by Warfield in 1975 [Warfield 75]. He proved that every finitely presented module over a serial ring is a direct sum of uniserial modules, and asked if such a decomposition was unique. In other words, Warfield asked whether the "Krull-Schmidt Theorem" holds for serial modules. The solution to this problem, a negative answer again, appeared in [Facchini 96]. Thirdly, the solution to Warfield's problem shows interesting behavior, a rare phenomenon in the history of Krull-Schmidt type theorems. Essentially, the Krull-Schmidt Theorem holds for some classes of modules and not for others. When it does hold, any two indecomposable decompositions are uniquely determined up to a permutation, and when it does not hold for a class of modules, this is proved via an example. For serial modules the Krull-Schmidt Theorem does not hold, but any two indecomposable decompositions are uniquely determined up to two permutations. We wanted to present such a phenomenon to a wider mathematical audience.

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