**Brief Report**
Volume 16:1, 2022

Journal of Generalized Lie Theory and Applications

ISSN: 1736-4337

Open Access

# A Brief Note on Introduction to Homological Algebra

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## Brief Report

The field of mathematics known as homological algebra investigates homology in a wide algebraic environment. It is a relatively new field, with roots in Henri Poincaré and David Hilbert's work on combinatorial topology (a forerunner to algebraic topology) and abstract algebra (theory of modules and syzygies) around the end of the nineteenth century [1].

The rise of category theory coincided with the development of homological algebra. Homological algebra is primarily concerned with homological factors and the complex algebraic structures that they involve. Chain complexes are a common and useful notion in mathematics that may be investigated through both their homology and cohomology. Homological algebra provides a method for extracting information from these complexes and presenting it as homological invariants of rings, modules, topological spaces, and other 'physical' mathematical objects. Spectral sequences are a strong tool for doing this [2].

Homological algebra has played a significant role in algebraic topology since its inception. Commutative algebra, algebraic geometry, algebraic number theory, representation theory, mathematical physics, operator algebras, complex analysis, and the theory of partial differential equations have all benefited from its impact. K-theory, like Alain Connes' noncommutative geometry, is an autonomous science that uses homological algebra methods [3].

Topological spaces, sheaves, groups, rings, Lie algebras, and C*-algebras are just a few of the objects for which cohomology theories have been developed. Without sheaf cohomology, current algebraic geometry would be nearly impossible to understand.

The concept of precise sequence is central to homological algebra, and it may be utilized to conduct actual computations. The derived factor is a classic homological algebra tool; the most basic examples are factors Ext and Tor [4].

With such a varied collection of applications in mind, it was only reasonable to strive to standardize the whole topic. After repeated efforts, the subject finally settled down. The following is a rough outline of the history:

- Cartan-Eilenberg employed projective and injective module resolutions in their 1956 book "Homological Algebra."
- 'Tohoku': A famous study by Alexander Grothendieck that used the abelian category notion and was published in the Second Series of the Tohoku Mathematical Journal in 1957. (to include sheaves of abelian groups).
- Grothendieck and Verdier's derived category. Verdier's 1967 thesis was the first to use derived categories. They are triangulated categories, which are employed in a variety of current theories.

They progress from computability to generality in this way.

The spectral sequence is the ultimate computational sledgehammer; it is required in the Cartan-Eilenberg and Tohoku techniques, for example, to calculate the derived factors of a composition of two factors. In the derived category method, spectral sequences are less important, but they nevertheless play a role when concrete calculations are required [5]. Attempts at 'non-commutative' theories that extend first cohomology as torsors have been made (important in Galois cohomology).

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**How to cite this article:** Saxena, Rupali. “A Brief Note on Introduction to Homological Algebra.” J Generalized Lie Theory App 16 (2022): 316.

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**Received:** 03 January 2022, Manuscript No. glta-22-54715; **Editor assigned:** 05 January 2022, PreQC No. P-54715; **Reviewed:** 19 January 2022, QC No. Q-54715; **Revised:** 25 January 2022, Manuscript No. R-54715; **Published:** 02 February 2022, DOI: 10.37421/1736-4337.2022.16.316