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# Mechanism of Drug Action into Cytotoxicity in Pharmaceutical Cancer Therapy

**Pierre Schmitt***

*Department of Pharmaceutical Sciences, University of Montpellier, Montpellier, France*

***Corresponding author:** Pierre Schmitt, Department of Pharmaceutical Sciences, University of Montpellier, Montpellier, France, E-mail: pierreschmitt@gmail.com*

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## DESCRIPTION

Cytotoxicity, a fundamental concept in biomedical, pharmaceutical and environmental sciences, refers to the ability of substances to cause toxic effects on cells, often resulting in cell death. This phenomenon is important for evaluating the safety, efficacy and potential therapeutic applications of drugs and chemicals, as well as assessing environmental impacts on living organisms. In biomedical research, cytotoxicity assays serve as critical tools for assessing the toxicity of various substances, including pharmaceutical drugs, chemicals and nanoparticles. These assays provide valuable insights into how substances interact with cells, influencing their viability, morphology and function. Understanding cytotoxicity is essential for determining the safety profiles of potential therapeutic agents before clinical trials.

One of the primary applications of cytotoxicity testing is in drug development. Pharmaceutical companies rigorously evaluate new drug candidates to ensure they selectively target diseased cells, such as cancer cells, while minimizing harm to healthy tissues. Anticancer drugs, for instance, rely on inducing cytotoxic effects specifically in cancer cells to stop their growth or induce programmed cell death.

Cytotoxicity can manifest in different forms. Necrosis occurs due to unregulated cell death caused by external factors such as physical trauma or exposure to toxins. Apoptosis is characterized by distinct cellular changes, including DNA fragmentation and membrane blebbing and is a controlled process crucial for tissue homeostasis and eliminating damaged or unnecessary cells. Autophagy, another cellular process, involves cells degrading and recycling their components, often as a survival mechanism under stress but can lead to cell death if prolonged. These mechanisms of cell death are studied to understand how substances impact cells and tissues, influencing their biological responses and potential therapeutic outcomes.

Several methods are used to assess cytotoxicity, each offering unique advantages depending on the research objectives and types of cells under study. The MTT assay measures cell viability by assessing the conversion of MTT (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) by mitochondrial enzymes in viable cells, with reduced MTT indicating decreased cell viability. The LDH release assay quantifies cytotoxicity by measuring Lactate Dehydrogenase (LDH) released from damaged cells into the culture medium, indicating cell membrane damage and cytotoxic effects through increased LDH levels. Apoptosis assays detect changes in cellular morphology, DNA fragmentation and activation of apoptotic markers such as caspases, providing insights into programmed cell death pathways and aiding in the understanding of drug and chemical mechanisms of action. These assays collectively offer quantitative and qualitative data on cytotoxic effects, important for researchers studying the impacts of substances on cells and tissues.

Cytotoxicity plays a important role in cancer therapy, where the goal is to selectively target and eliminate cancer cells while sparing healthy tissues. Many chemotherapeutic agents exert their effects through cytotoxic mechanisms, disrupting vital cellular processes like DNA replication or microtubule formation. Understanding the cytotoxicity of these agents helps oncologists tailor treatment regimens to maximize efficacy and minimize side effects.

Cytotoxicity is a fundamental concept with broad implications across biomedical research, pharmaceutical development, environmental sciences and toxicology. By elucidating how substances interact with cells and tissues, cytotoxicity testing informs the design of safer and more effective therapeutic interventions, contributes to environmental protection efforts and advances our understanding of disease mechanisms. As research continues to evolve, the ability to gather cytotoxicity data for improved health outcomes and environmental sustainability also evolves.