

# 钙离子信号与细胞凋亡

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细胞凋亡的分子机制是什么？这个问题当前引起人们广泛的研究兴。作为重要的第二信使，钙信号在许多生理和细胞活动中都起到了十分重要的作用。钙信号是否也在凋亡的调控中起作用呢？虽然在过去十多年中，许多研究证据都表明钙信号参与凋亡的调控，但是，钙信号如何作用于凋亡过程的具体机理仍然是众说纷纭，不是十分清楚。事实上，许多研究结果仍存有争议。本综述总结了近几年来大量关于钙信号与凋亡研究的成果，集中讨论了两个问题：1) 在凋亡前期“决定阶段”有没有钙离子信号的参与？ 2) 钙离子信号与哪些凋亡调控因子（包括Bcl-2族蛋白）相互作用及如何作用？这问题还牵涉到亚细胞结构中钙库的作用（包括细胞质，内质网和线粒体）。根据我们自己的实验结果，文章对这些文献中不同的说法作了一些具体的评估。最后，文章还提出了一个钙离子信号参与调控细胞凋亡的可能模型。

## Calcium Signaling in Apoptosis

What are the molecular mechanisms by which apoptosis is regulated by external or internal signals? This problem is under active investigation at present. As a major second messenger,  $Ca^{2+}$  signal is known to be a key player in the regulation of many physiological and cellular processes. Does  $Ca^{2+}$  signal also have a role in the regulation of apoptosis? Evidence implicating the involvement of  $Ca^{2+}$  in apoptosis has been reported during the past decade from many studies. The detailed mechanisms concerning how  $Ca^{2+}$  signals may interact with the apoptotic machinery, however, are still not very clearly understood yet. Results from different studies did not always give a consistent picture and sometimes might even be contradictory. In this review, we tried to summarize recent studies on  $Ca^{2+}$  signaling in apoptosis to address two main questions: (1) Whether  $Ca^{2+}$  signaling is involved in the commitment phase of apoptosis? (2) How may  $Ca^{2+}$  signaling interact with the signaling pathway of apoptosis (including Bcl-2 family proteins)? We also discussed the roles of various pools of  $Ca^{2+}$  stored in different subcellular compartments (including cytosolic  $Ca^{2+}$ , ER  $Ca^{2+}$  and mitochondrial  $Ca^{2+}$ ) on the apoptotic process. Based on results from our own studies, we also tried to give a fair evaluation on the various proposed mechanisms suggested in the literatures. Finally, a model summarizing the possible pathways of  $Ca^{2+}$  signaling in apoptosis was given in this review.

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