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Log gradient estimates of the heat equation on manifolds.

We will first review a number of log gradient estimates for the heat equation by Li-Yau, Hamilton and Perelman and their application in geometry and topology. Next we present a recent result showing a sharp Li Yau estimate for all compact manifolds and impossibility of sharp estimate for all noncompact manifolds, answering an open question by several people. Recent extension by X. Song, L. Wang, M. Zhu and Z will also be mentioned.