My talk starts by turning back the clock to 1979-1983, introducing the ideas that culminated with the fundamental representation theorem of graphs (the Aldous-Hoover theorem). I will then show how these ideas connect to a probabilistic interpretation of matrix factorization methods, explaining why matrix factorization is fundamentally not as expressive as it could be to describe finite graphs. I will then turn to early machine learning attempts to represent graphs and how these attempts connect to graph mining algorithms. I will introduce the concept of representation learning with graph neural networks (GNNs) and explain its connections to statistical graph models and the Weisfeiler-Lehman isomorphism test. Finally, I will introduce a newly proposed general framework for graph representation learning using deep neural networks, which is directly rooted in the ideas that gave us the Aldous-Hoover representation theorem. This new representation framework points to novel graph models, new approaches to make existing methods scalable, and provides a unifying approach connecting matrix factorization, graph mining algorithms, and graph neural networks. I will end my talk with a few open problems.

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