This thesis is concerned with computational complexity aspects of graph homomorphisms and related concepts. We are mainly interested in various polynomial time versus NP-complete dichotomies. These results are especially popular thanks to the seminal result of Hell and Nešetřil providing the complexity dichotomy for graph homomorphism problems and the recent breakthrough result proving the complexity dichotomy for constraint satisfaction problems.

The thesis is divided into three parts, all unified by the common goal to provide complexity classifications of various graph homomorphism problems. The first part is about list homomorphism problems for signed graphs. We study the complexity of such problems and obtain a structural description and dichotomy first for the case of targets being signed trees and then for the so-called separable graphs.

The second part focuses on graph covering projections, also known as locally bijective homomorphisms. To the best of our knowledge, we are the first to initiate cataloguing the complexity of the corresponding problems for (mutli)graphs with semi-edges. We have three larger goals here. (1) Providing the complete dichotomy for one- and two-vertex target graphs. (2) Discuss and propose the right definition of graph cover in the case of disconnected targets. (3) Explore what happens when we introduce lists into the problem.

The final part is dedicated to acyclic colourings, which can be viewed as special constrained colourings and hence homomorphisms to complete graphs. We study the effect of restricting the class of input graphs to those with a forbidden induced subgraph by providing a partial complexity dichotomy in the case where the number of colours is a part of the input and the full dichotomy when the number of colours is fixed.