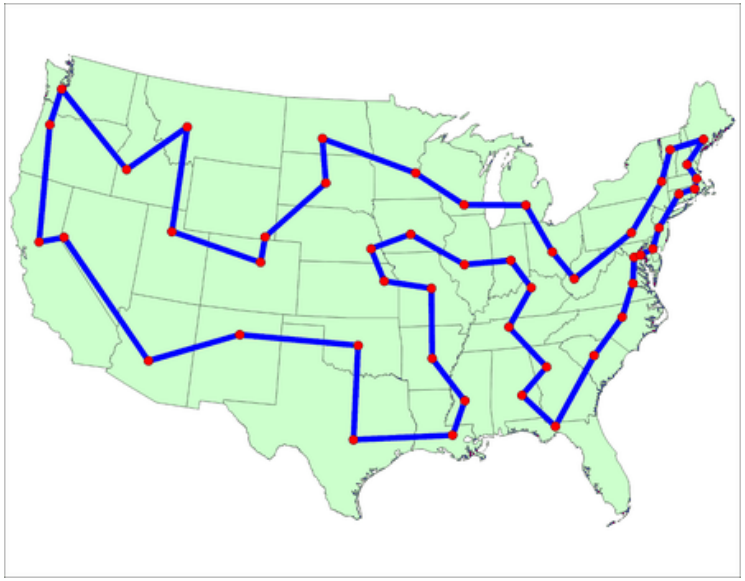
# Combinatorial Optimization

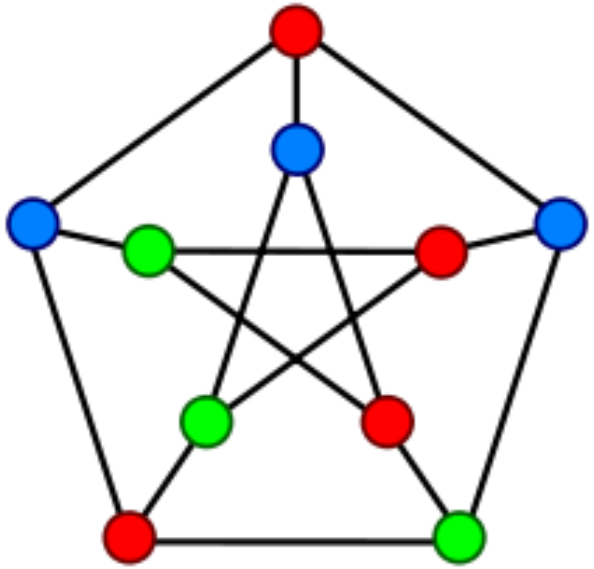
- Developing efficient algorithms to find an optimal object when exhaustive search is infeasible e.g. the *Travelling Salesman Problem*: given a set of cities with pairwise distances between them, what is the shortest tour that visits every city exactly once, and then returns to the starting point?
- Supervision: Steven Kelk



Optimal Traveling Salesman Tour through US Capital Cities

# Graph Theory

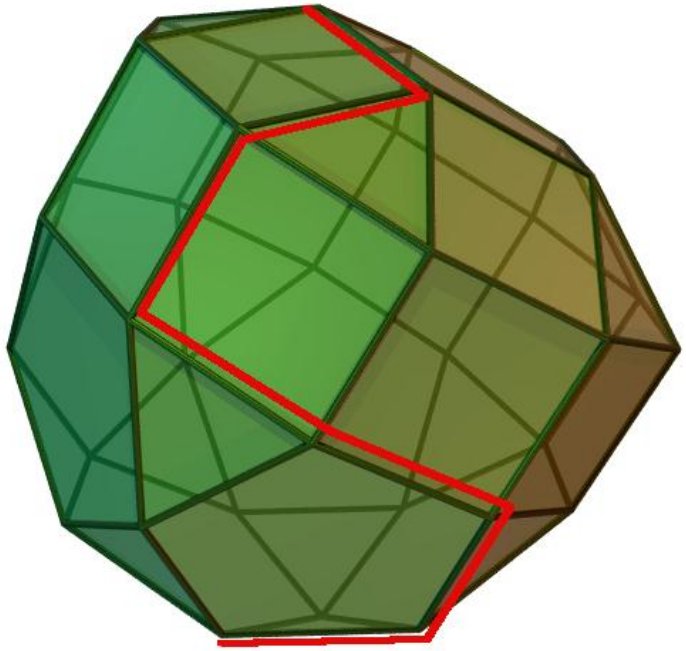
- Graphs (sets of points connected by lines) are at the cornerstone of applied operations research, but also give rise to many beautiful mathematical questions. For example, what is the smallest number of colours required to colour the points of a graph such that no two adjacent points have the same colour?
- Supervision: Steven Kelk



The "Petersen graph" needs at least 3 colours.

# (Integer) Linear Programming

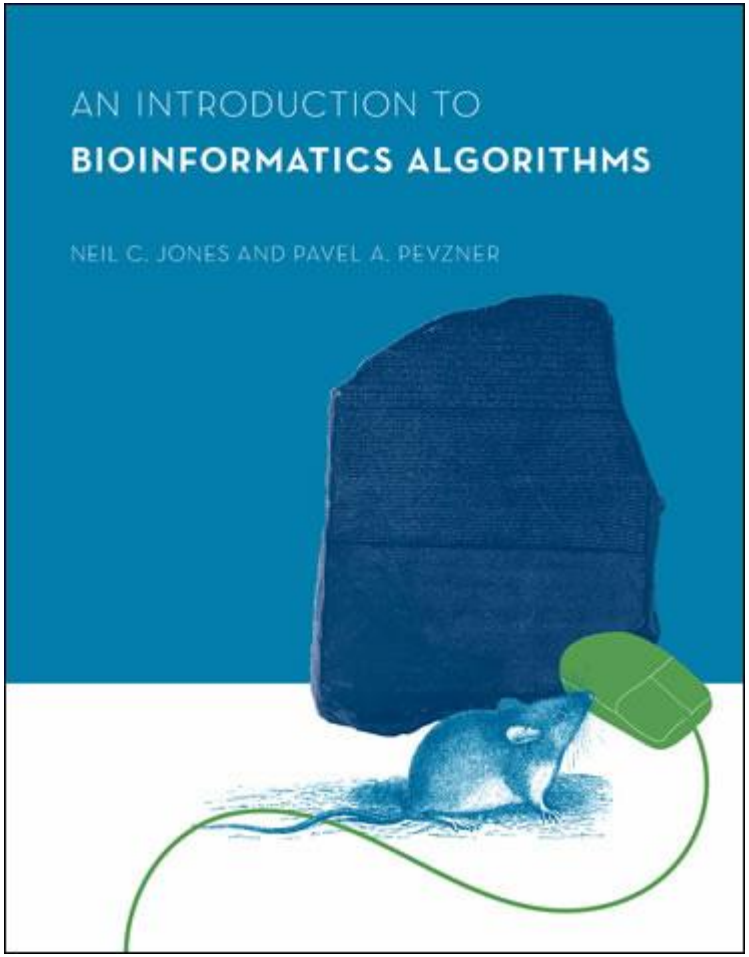
- (Integer) Linear Programming allows many allocation problems to be solved optimally by modelling them as the optimization of a linear objective function subject to a set of linear constraints. (I)LP revolutionised operations research in the twentieth century.
- Supervision: Steven Kelk



The Simplex Method solves LPs by moving from cornerpoint to cornerpoint

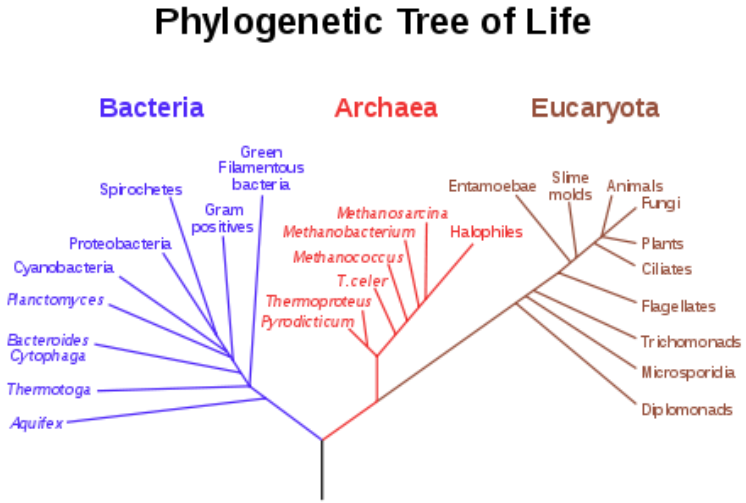
# (Algorithmic) Bioinformatics

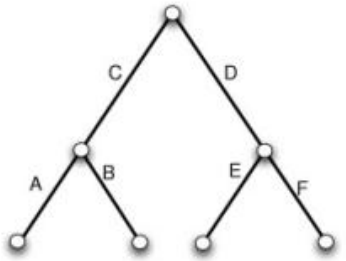
- Developing efficient algorithms to solve discrete optimization problems arising in bioinformatics.
- See books such as *An Introduction to Bioinformatics Algorithms* (Jones and Pevzner) for more background.
- Supervision: Steven Kelk



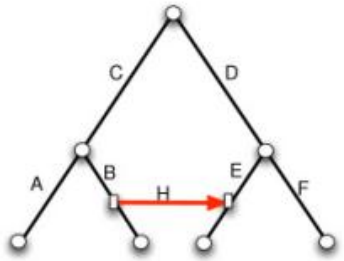
# Phylogenetics, Phylogenetic networks

- Given the DNA sequences of a set of modern-day species, can we infer how they evolved from a single common ancestor millions of years ago?
- The problem is already hard enough for evolutionary trees, but what about difficult-to-model events such as hybridization?
- Supervision: Steven Kelk




(a) Phylogenetic tree




(b) Phylogenetic network