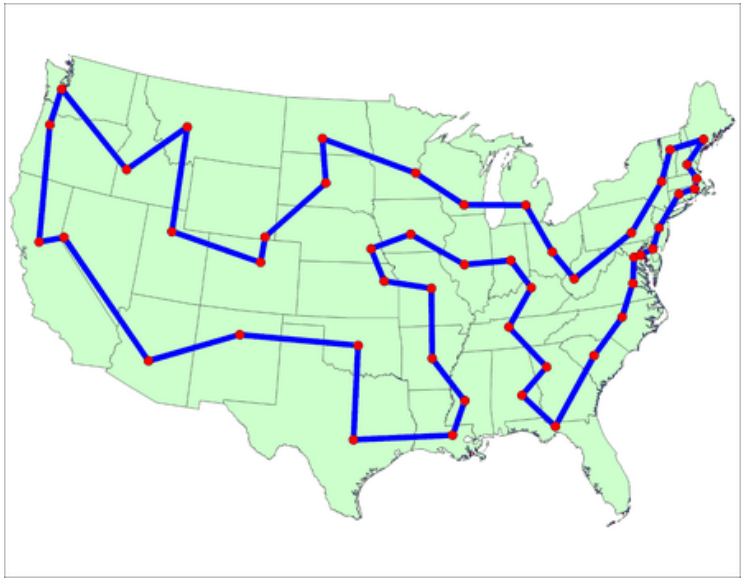
Combinatorial Optimization

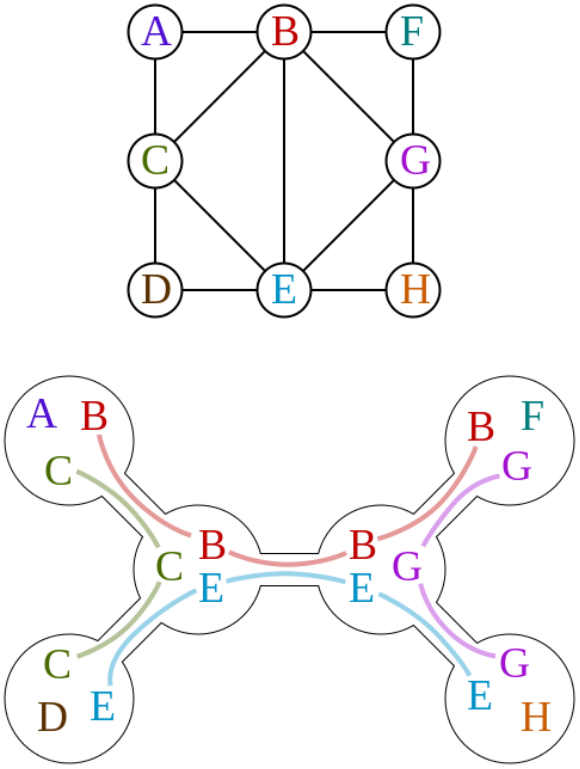
- Developing efficient algorithms to find an optimal object when exhaustive search is infeasible e.g. the *Travelling Salesman Problem*: given a set of cities with pairwise distances between them, what is the shortest tour that visits every city exactly once, and then returns to the starting point?
-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



Optimal Traveling Salesman Tour through US Capital Cities

Algorithmic Graph Theory

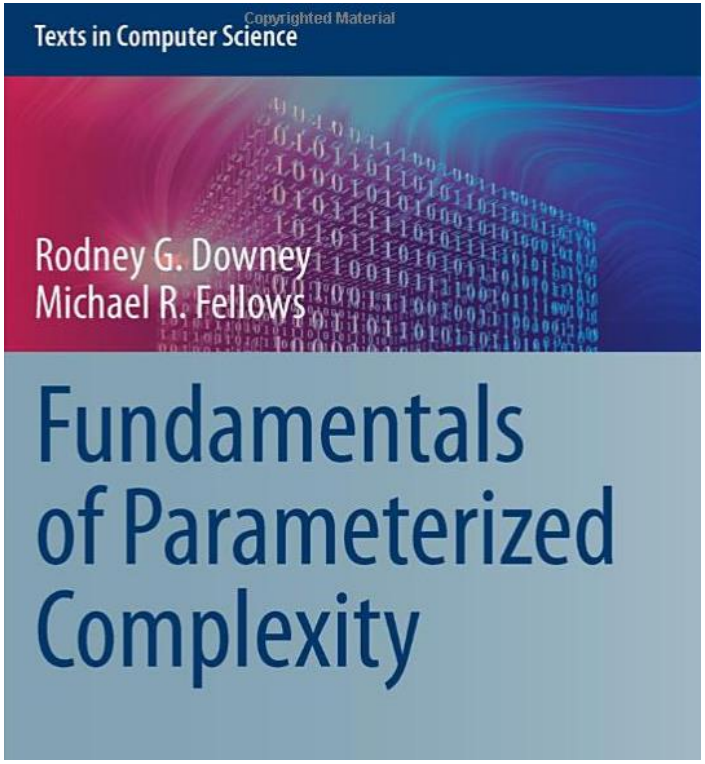
- Many NP-hard problems on graphs can be solved efficiently (even in linear time!) if the *treewidth* of the graph is comparatively small. Such width parameters are a topic of intense research interest and are a central part of the field known as algorithmic graph theory.
- Under which circumstances do the graphs that emerge from real-world applications, have bounded width?
- Supervision: Steven Kelk



The graph shown at the top has treewidth 2. (Wikipedia)

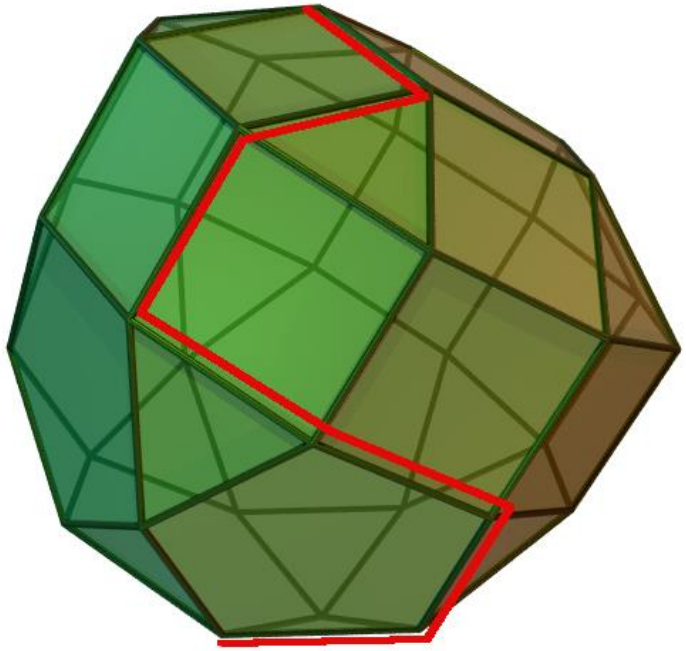
Fixed parameter tractability

- Fixed-parameter (FPT) algorithms have running times of the form f(k).poly(n) where n is the size of the input, f(.) is a function that does not depend on n and k is some parameter of the input (e.g. the treewidth of a graph, as discussed on the previous slide).
- FPT algorithms can be useful for solving NP-hard problems in practice.
- Which NP-hard problems arising in practice permit (efficient) FPT algorithms?
- Supervision: Steven Kelk



(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

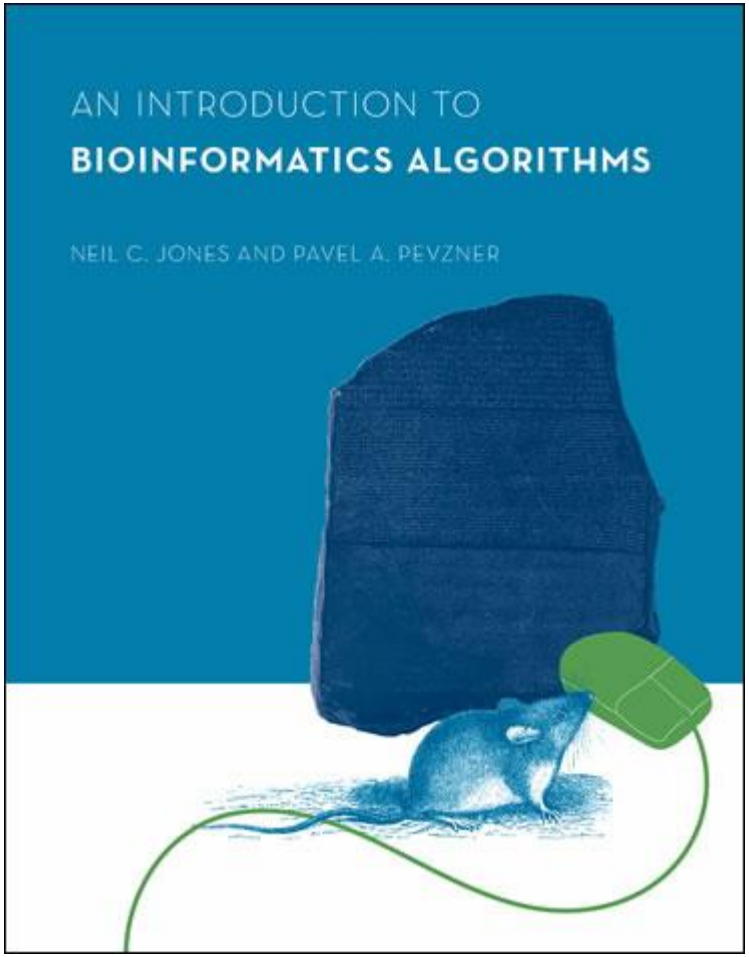
Constraint Programming (CP)

- Constraint Programming (CP) concerns (like ILP) solving problems by specifying constraints that desired solutions must satisfy, but unlike ILP the constraints are higher-level and much more expressive, which makes modelling real-life problems much easier.
- There is a growing literature on combining the expressive power of CP with the raw optimizing power of ILP.
- Supervision: Steven Kelk

MiniZinc is a medium-level constraint programming language. Source: http://www.minizinc.org/

(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