LSU E. J. OURSO COLLEGE OF BUSINESS

Dr. Chun's Numb3rs & LØgic

Traveling Salesman Problem

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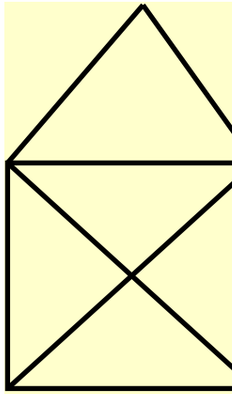
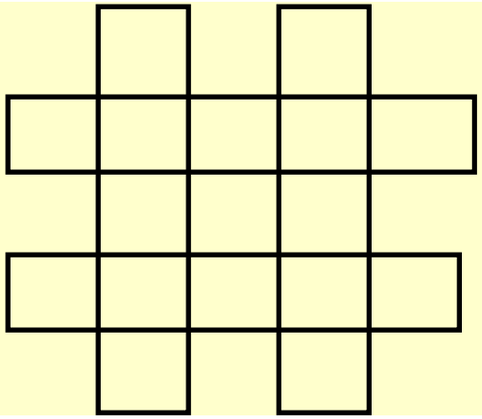
Cherie H. Flores Endowed Chair in MBA Studies

Brain Teasers for Kids

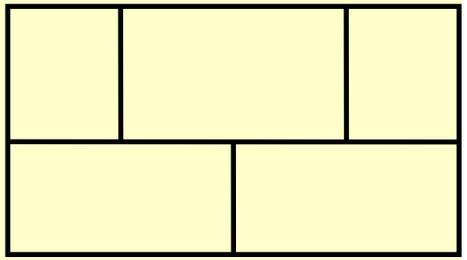
Is it possible to draw these designs in one continuous movement? At no point can you lift the pencil from the paper. You also cannot fold the paper at any point.



5 points



15 points

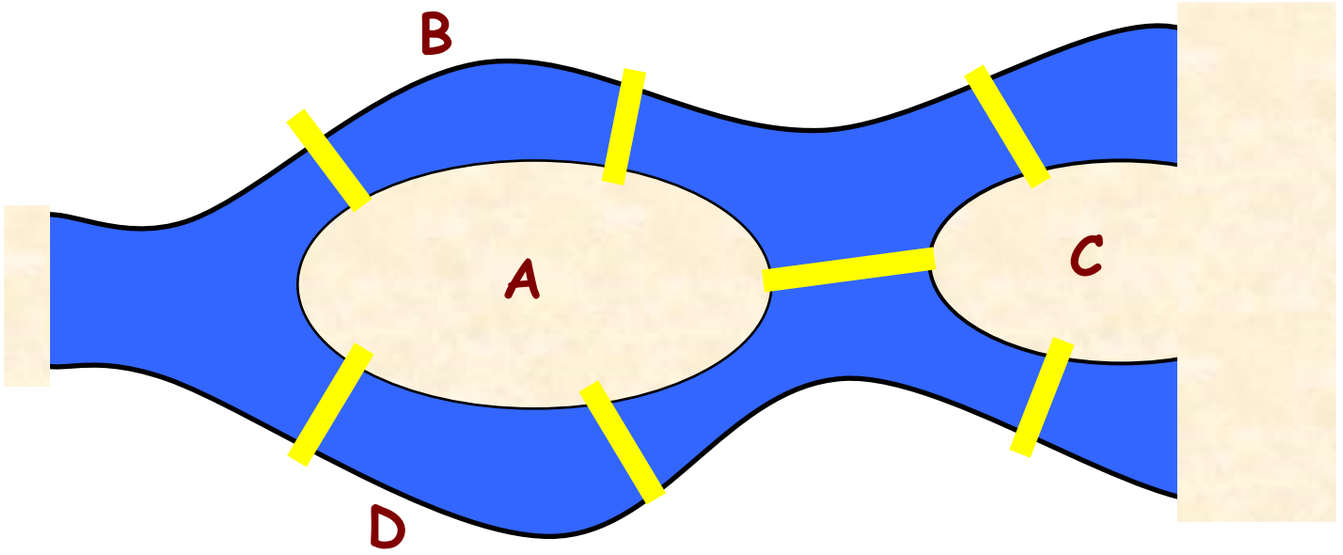


80 points

Brain Teasers for Adults

* The Bridges of Konigsberg

In the town of Konigsberg in Prussia, there were seven bridges across the Pregel River. Is it possible to go for a walk, crossing each bridge once, but not crossing any bridge twice? Its solution by Leonhard Euler in 1735 laid the foundations of graph theory and prefigured the idea of topology.



Brain Teasers for Adults

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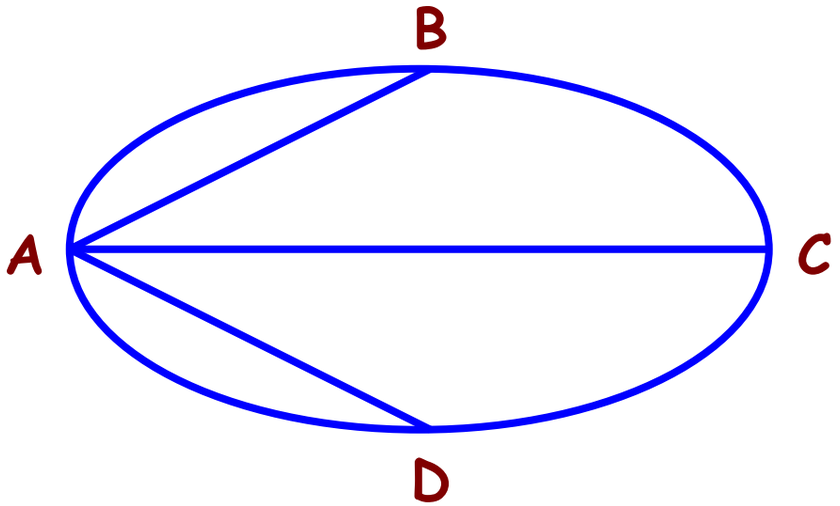
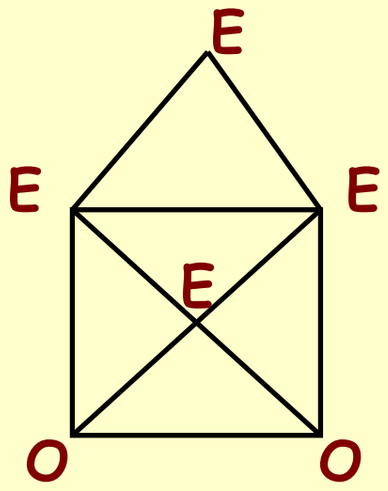


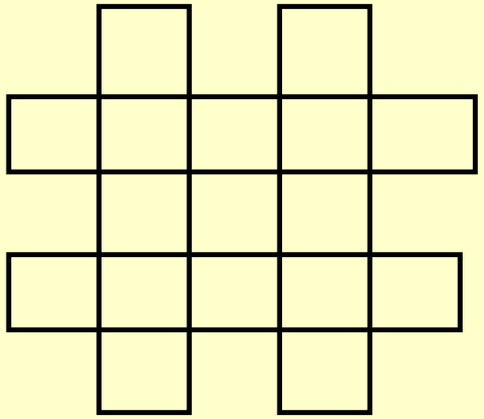
Solutions for Kids

- **Two possible cases:**

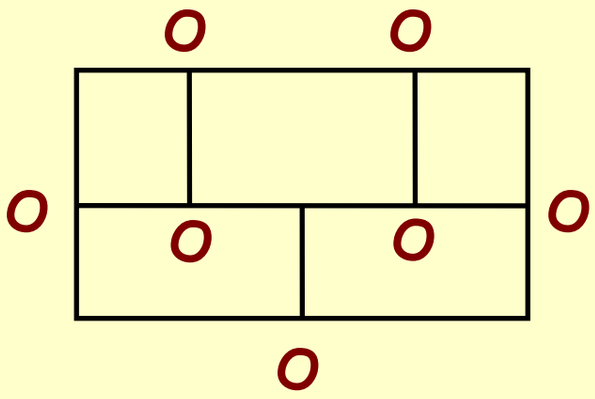
  Case 1. Exactly two odd points

  Case 2. No odd points



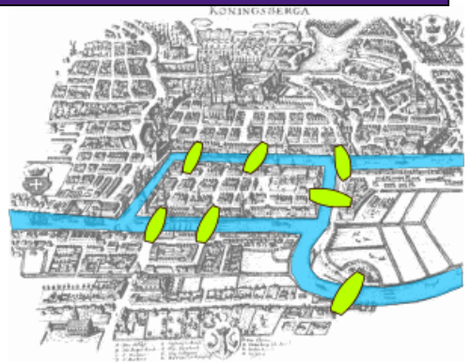


All even points



Impossible!

Solutions for Adults



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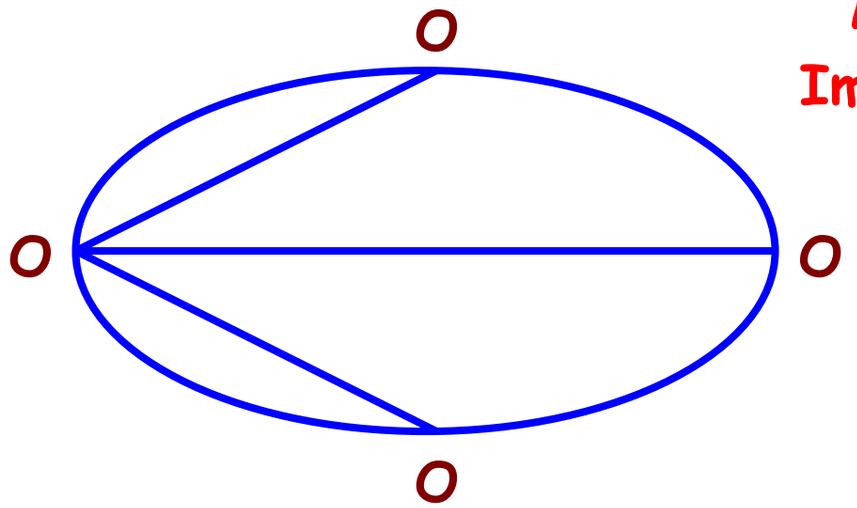
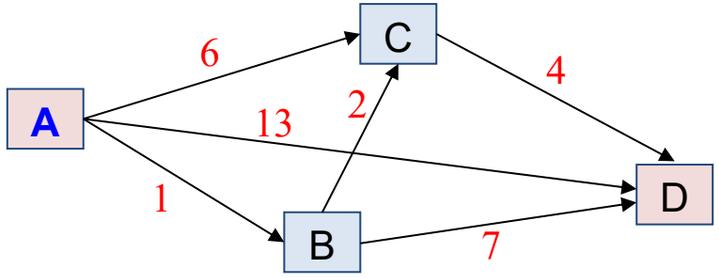


Mission Impossible!

Ex] Garbage collector, Mail carrier, Traveling salesman,…

Traveling Salesman Problem

Given a collection of cities and the cost of travel between each pair of them, the **traveling salesman problem** (**TSP**) is to find the cheapest way of visiting all of the cities and returning to your starting point.

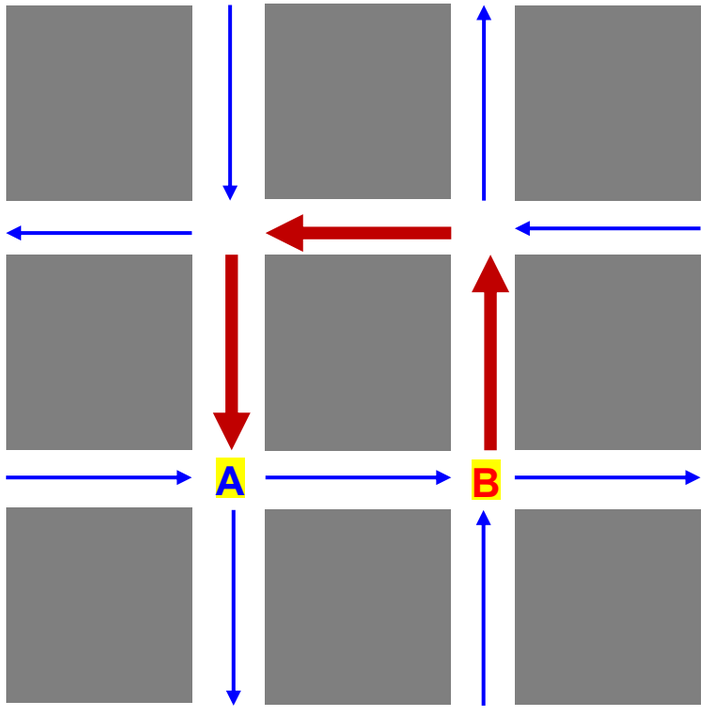


i	A	B	C	D
A	∞	1	6	13
B	1	∞	2	7
C	6	2	∞	4
D	13	7	4	∞

In the standard version, the travel costs are symmetric in the sense that traveling from city X to city Y costs just as much as traveling from Y to X.

* Non-symmetric distance?

- One-way streets in Manhattan:



- City-block distance:

From A to B = 1 block

From B to A = 3 blocks

Traveling Salesman Problem

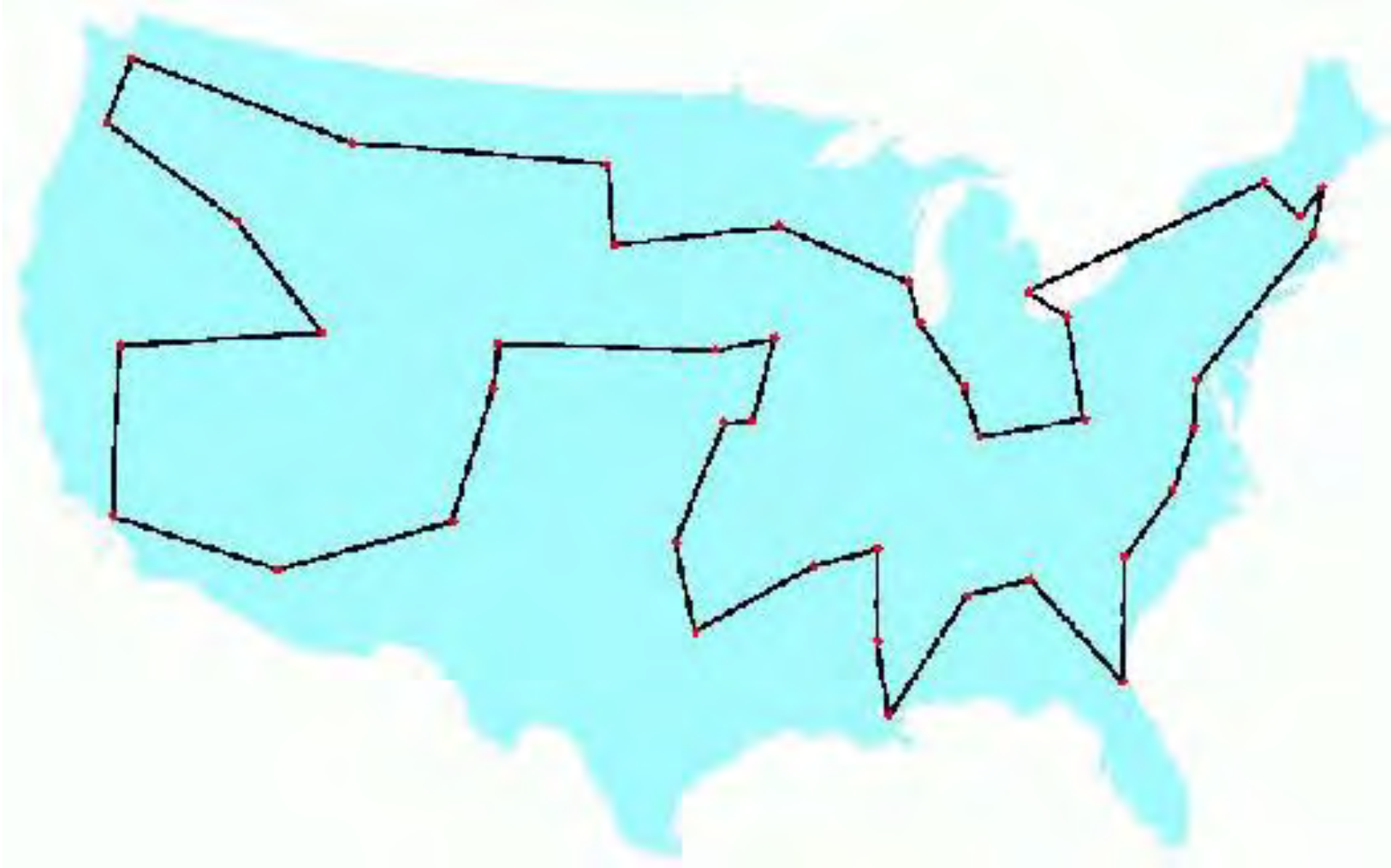
The simplicity of the statement of the problem is deceptive -- the TSP is one of the most intensely studied problems and yet no effective solution method is known for the general case.

Indeed, the resolution of the TSP would fetch one million dollar prize from the Clay Mathematics Institute.

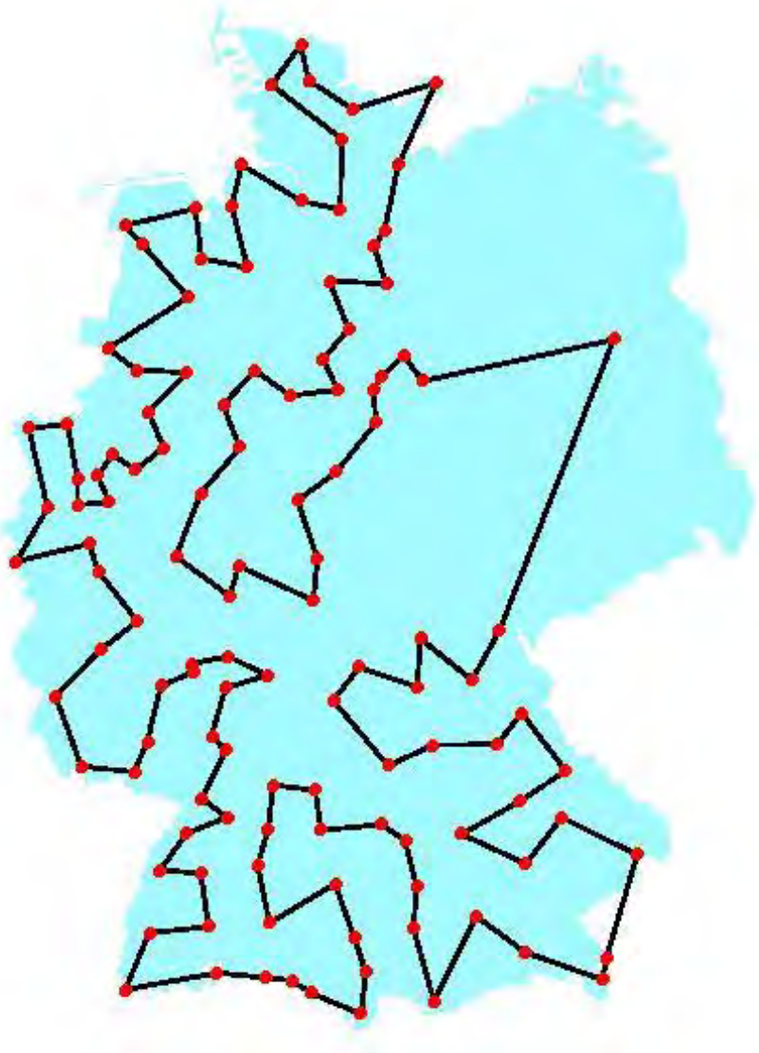
Although the complexity of the TSP is still unknown, for over 50 years, its study has led the way to improved solution methods in many areas of mathematical optimization.

Year	1954	1977	1987	1987	1987	1994	1998	2001	2004
Number of cities	42	120	532	666	2392	7397	13509	15112	24978

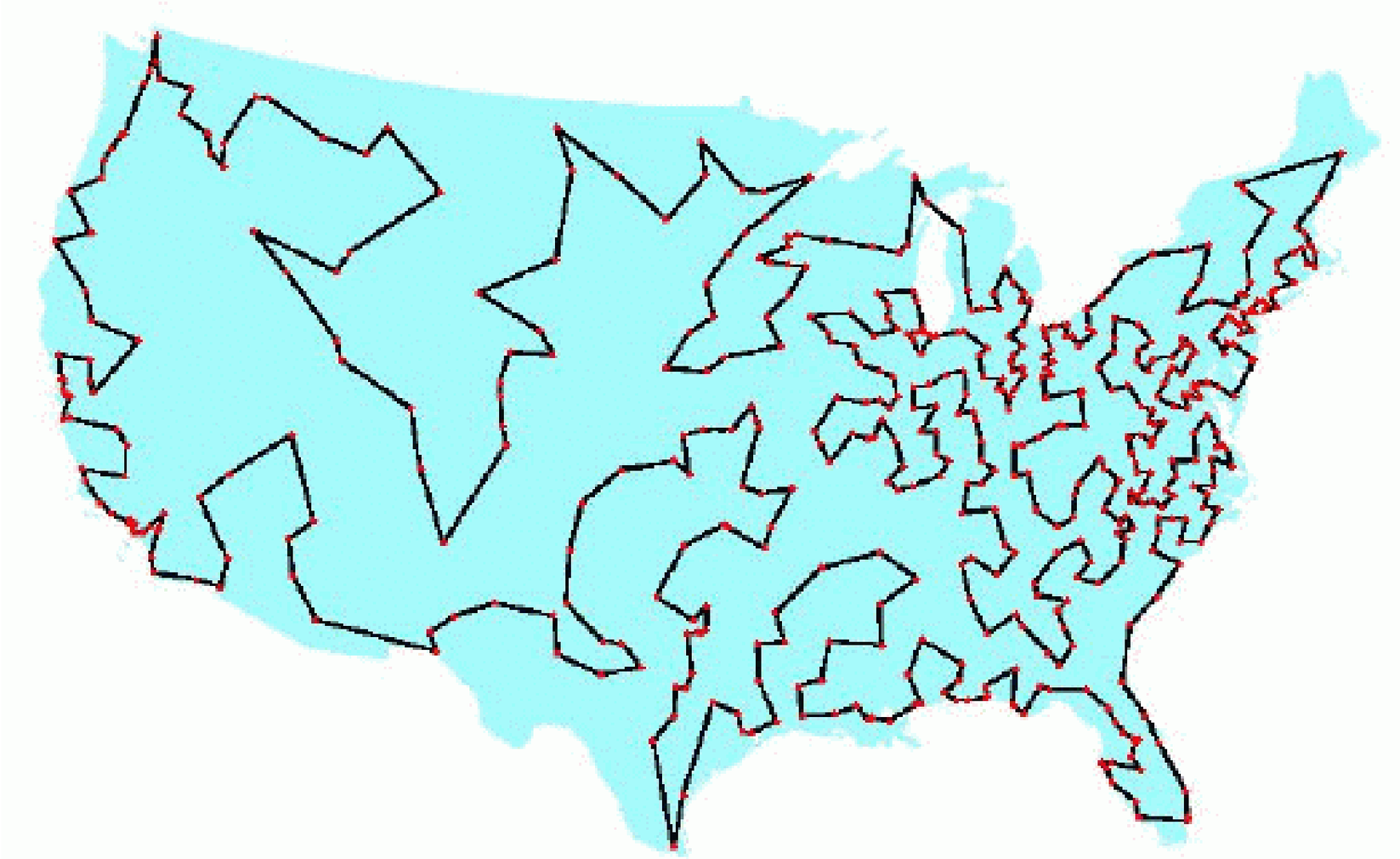
In 1954, Dantzig, Fulkerson, and Johnson solved the optimal tour of 42 cities in the USA.



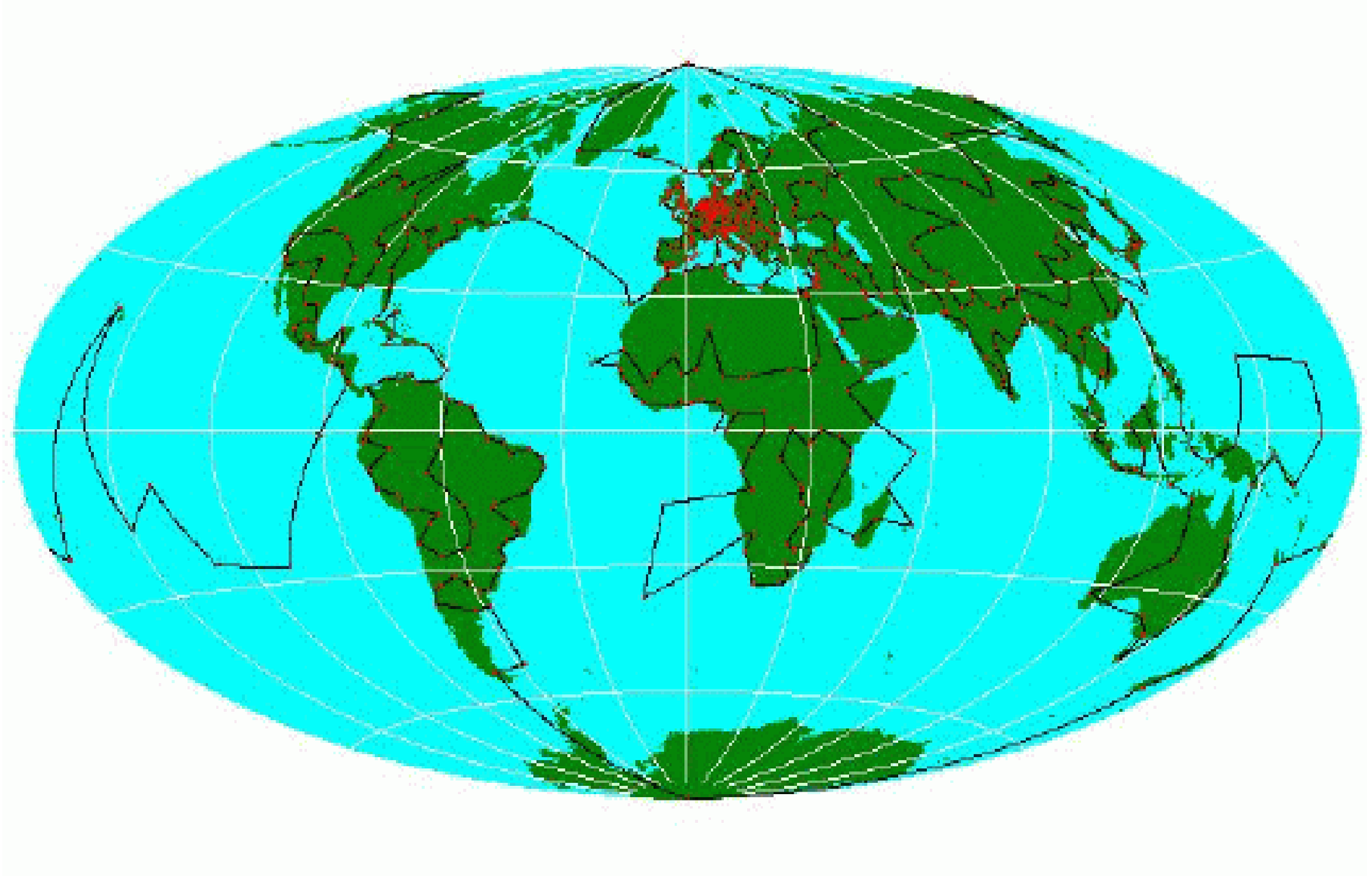
In 1977, the optimal tour of 120 cities in West Germany was found by Martin Groetschel.



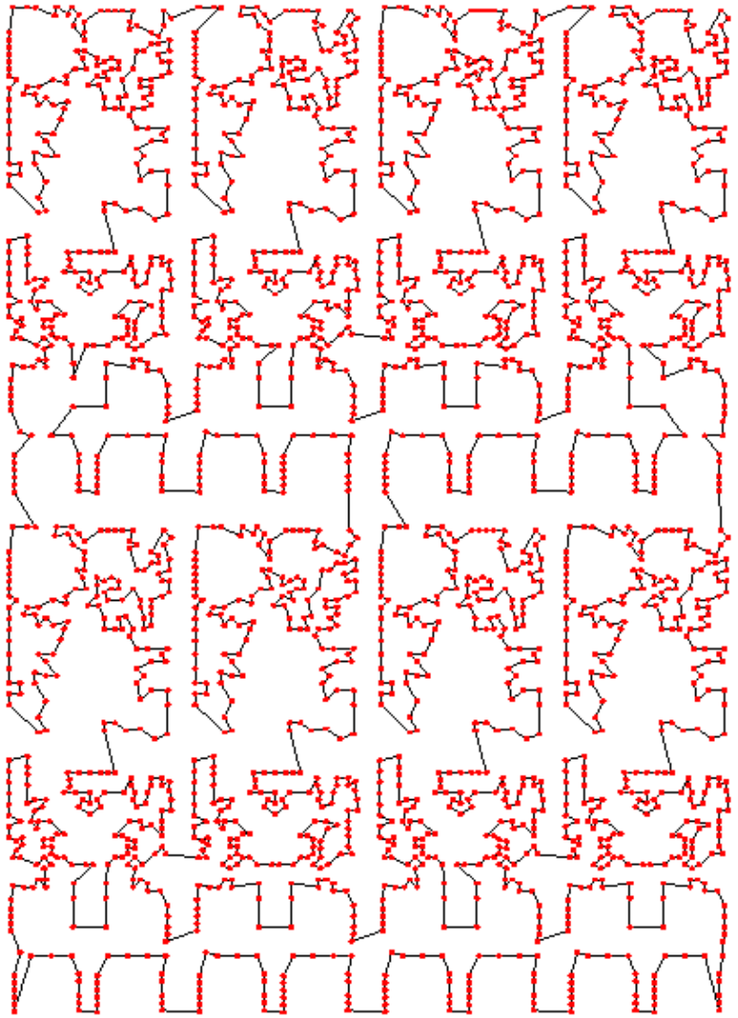
In 1987, the Optimal tour of 532 AT&T switch locations in the USA was found by Padberg and Rinaldi.



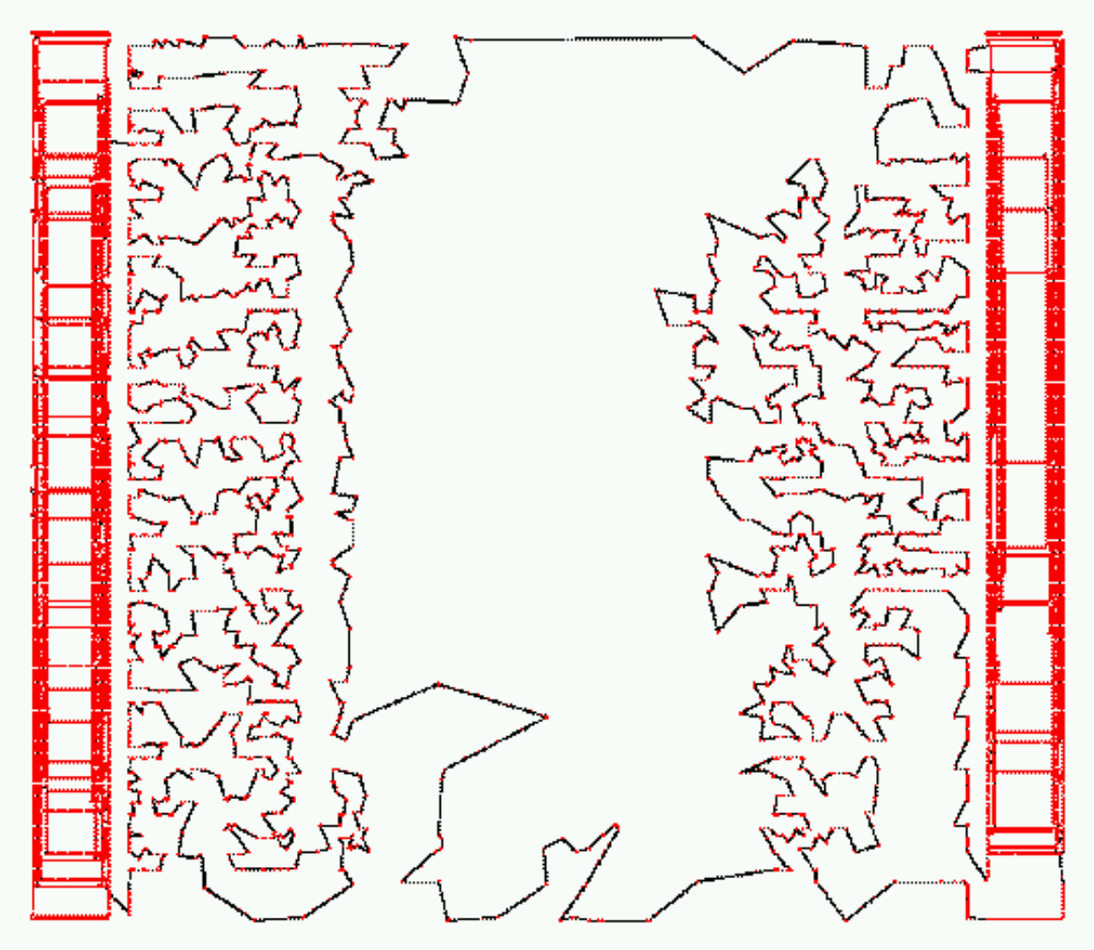
In 1987, the optimal tour of 666 interesting places in the world was found in 1987 by Groetschel and Holland.



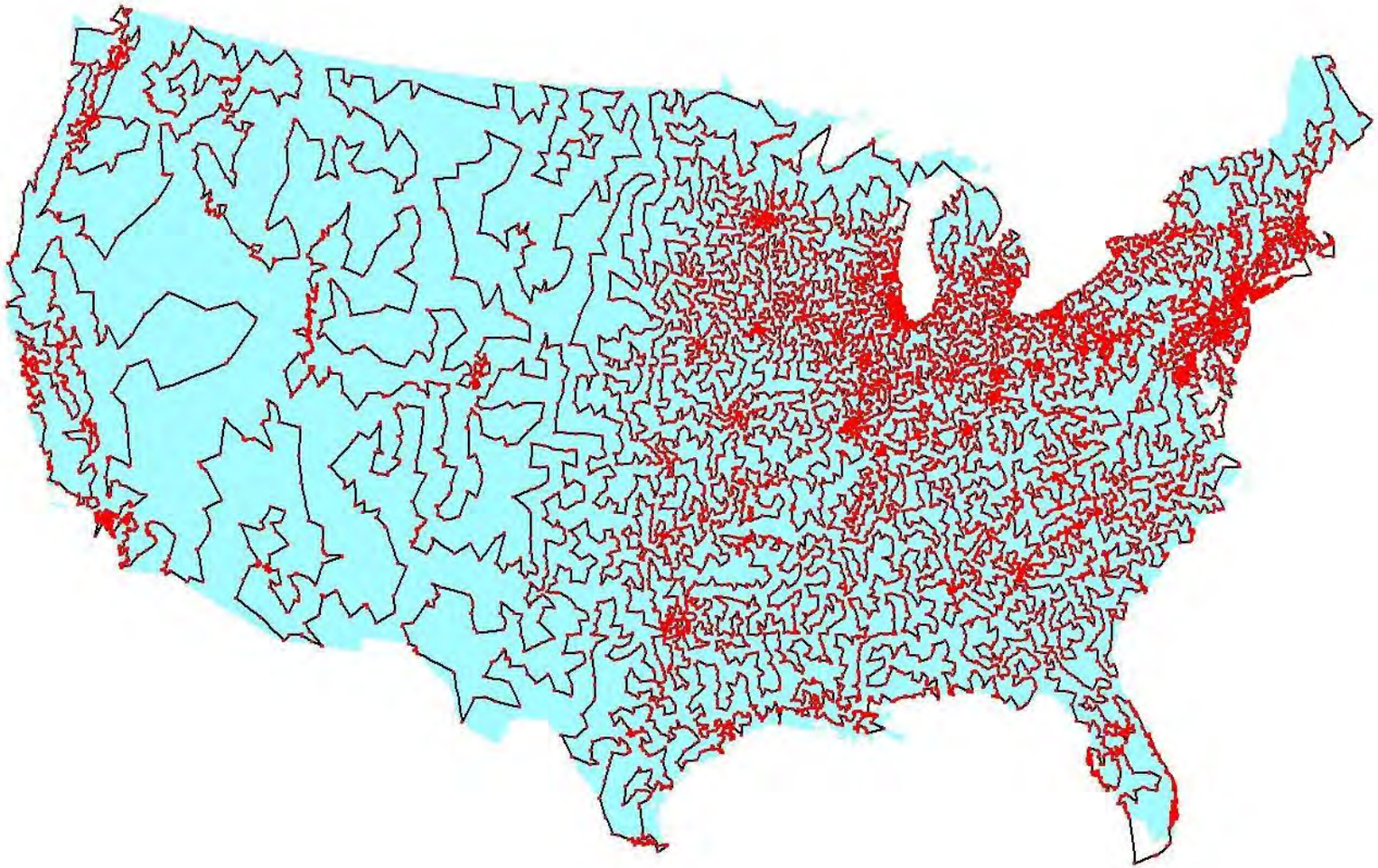
In 1987, Padberg and Rinaldi found the optimal tour through a layout of 2,392 points obtained from Tektronics Incorporated.



In 1994, Applegate, Bixby, Chvátal, and Cook found the optimal tour for a 7,397-city TSP that arose in a programmable logic array application at AT&T Bell Laboratories.

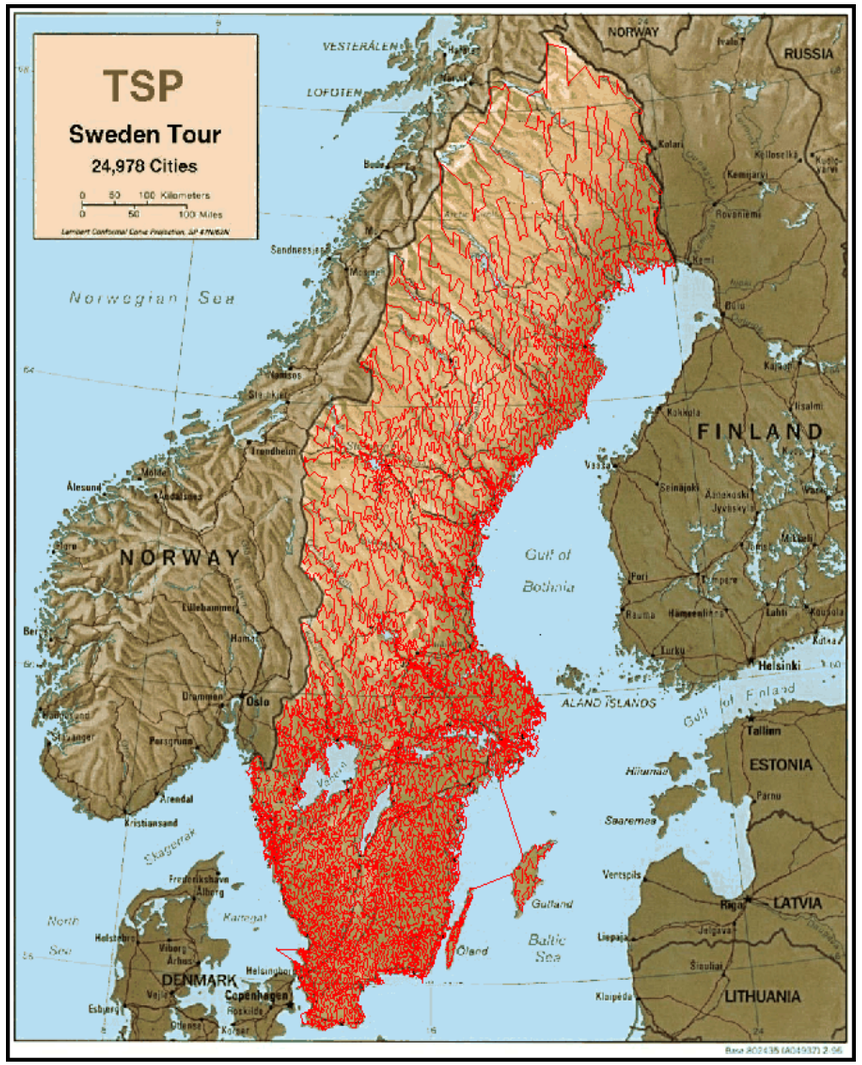


In 1998, Applegate, Bixby, Chvátal, and Cook found the optimal tour of the 13,509 cities in the USA with populations greater than 500.



In 2001, Applegate, Bixby, Chvátal, and Cook found the optimal tour of 15,112 cities in Germany.

In 2004, Applegate, Bixby, Chvátal, Cook, and Helsgaun found the optimal tour of 24,978 cities in Sweden.



In 2020, Professor Young H. Chun at LSU finally solved the traveling salesman problem, received 1 million dollar cash prize, and retired to Bahamas !!!!

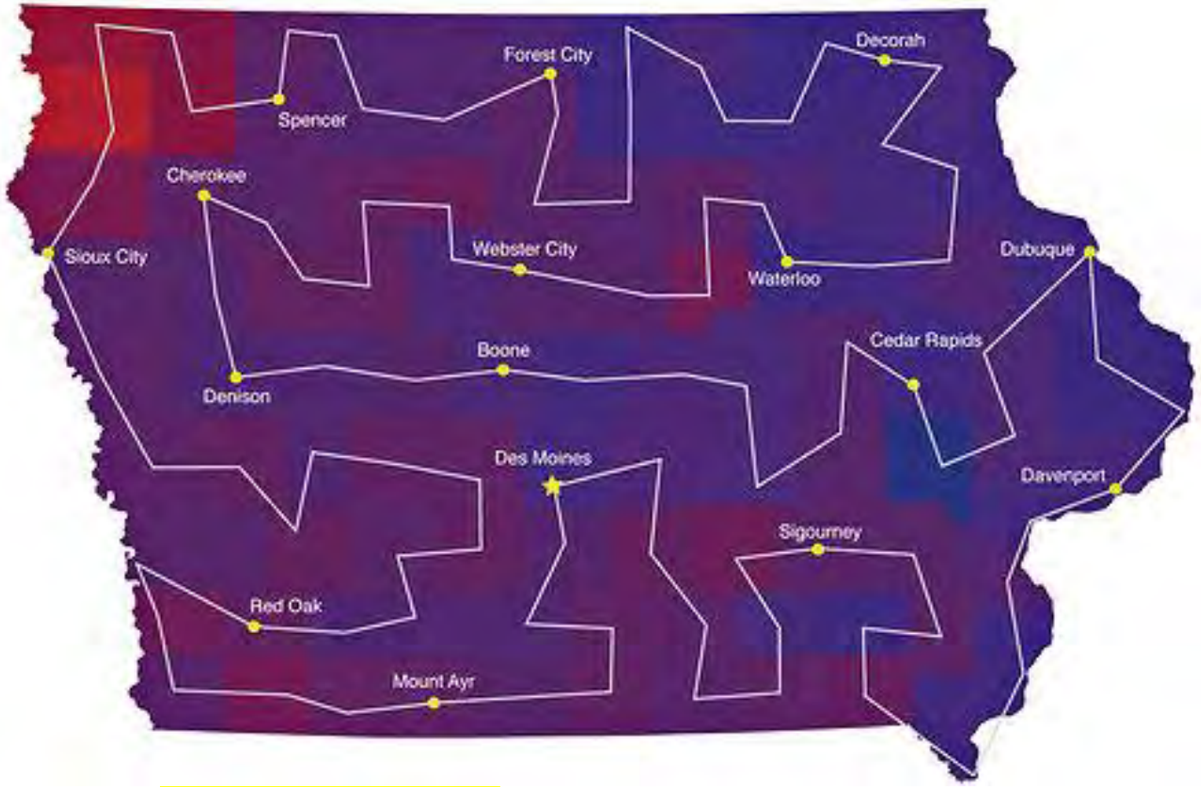
At present, the work is still in progress at his garage…
Want to be his research assistant?

Don't underestimate the power of Excel !
Can Excel solve the TSP?

The Problem of the Traveling Politician

Campaign stops, *New York Times*, 12/21/2011

Given the county seats of all 99 counties (i.e., parishes) in Iowa and the road distances between every pair, what is the quickest way to see all the cities, returning to your starting position?



(The result is a 55.5 hour tour, traveling at legal speed limits.)

2010 Mathematical Art Exhibition, First Prize

"Embrace," by Robert Bosch (Oberlin College, Oberlin, OH)

- Stainless steel and brass
- Diameter = 6 inches
- thickness = 0.25 inches

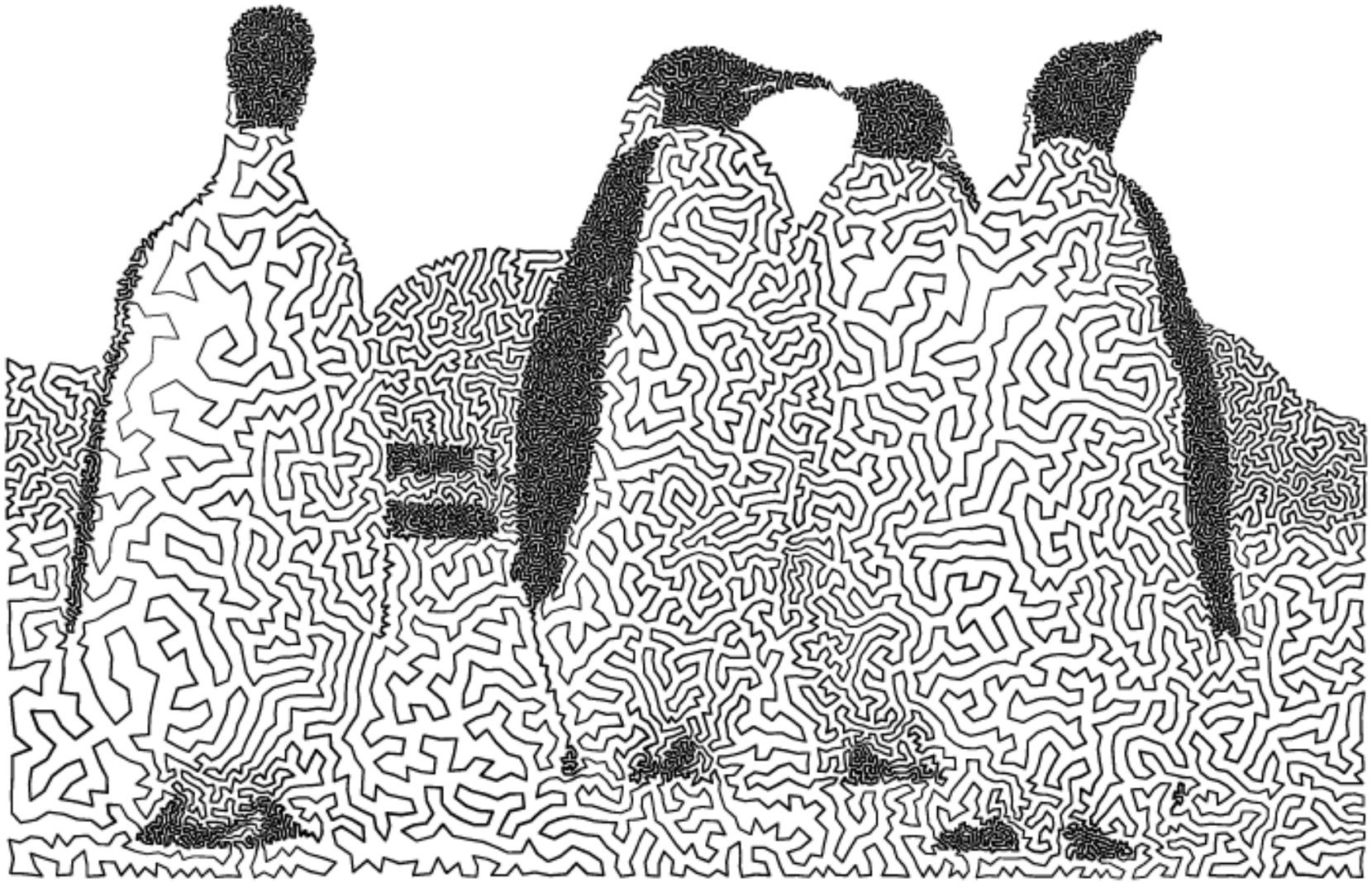
I began by converting a drawing of a two-component link into a symmetric collection of points.

By treating the points as the cities of a Traveling Salesman Problem and adding constraints that forced the salesman's tour to be symmetric, I constructed a symmetric simple-closed curve that divides the plane into two pieces: inside and outside.

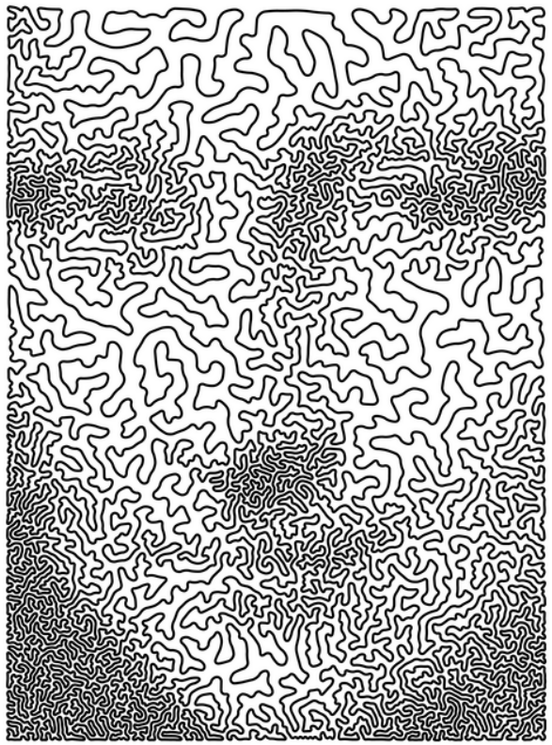
Robert Bosch (Oberlin College, Oberlin, OH)

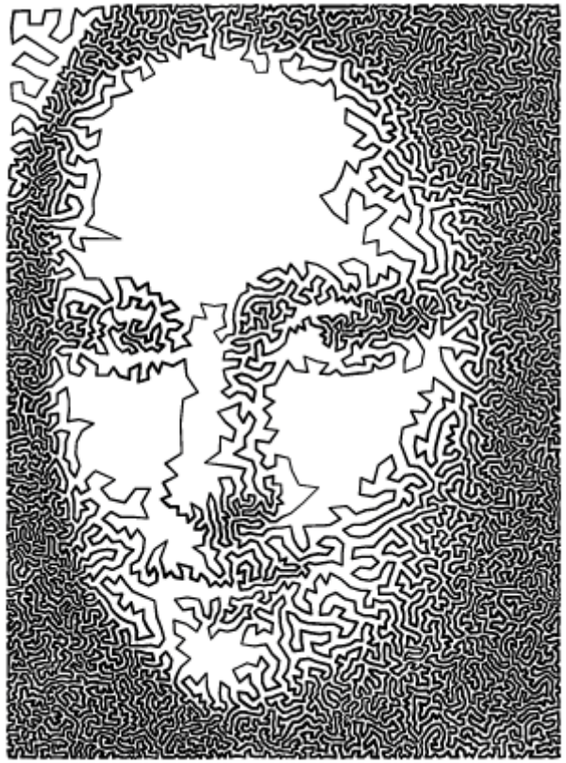
TSP Art

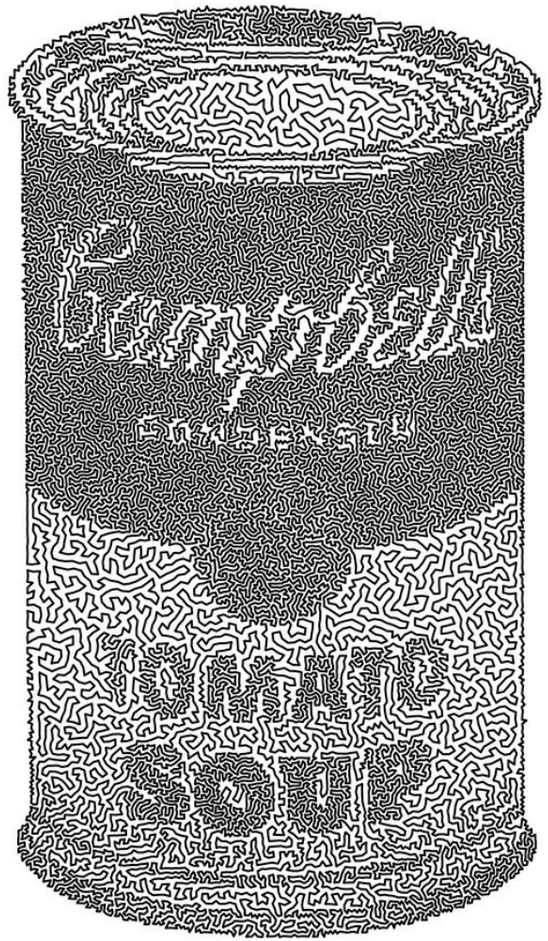
TSP Art



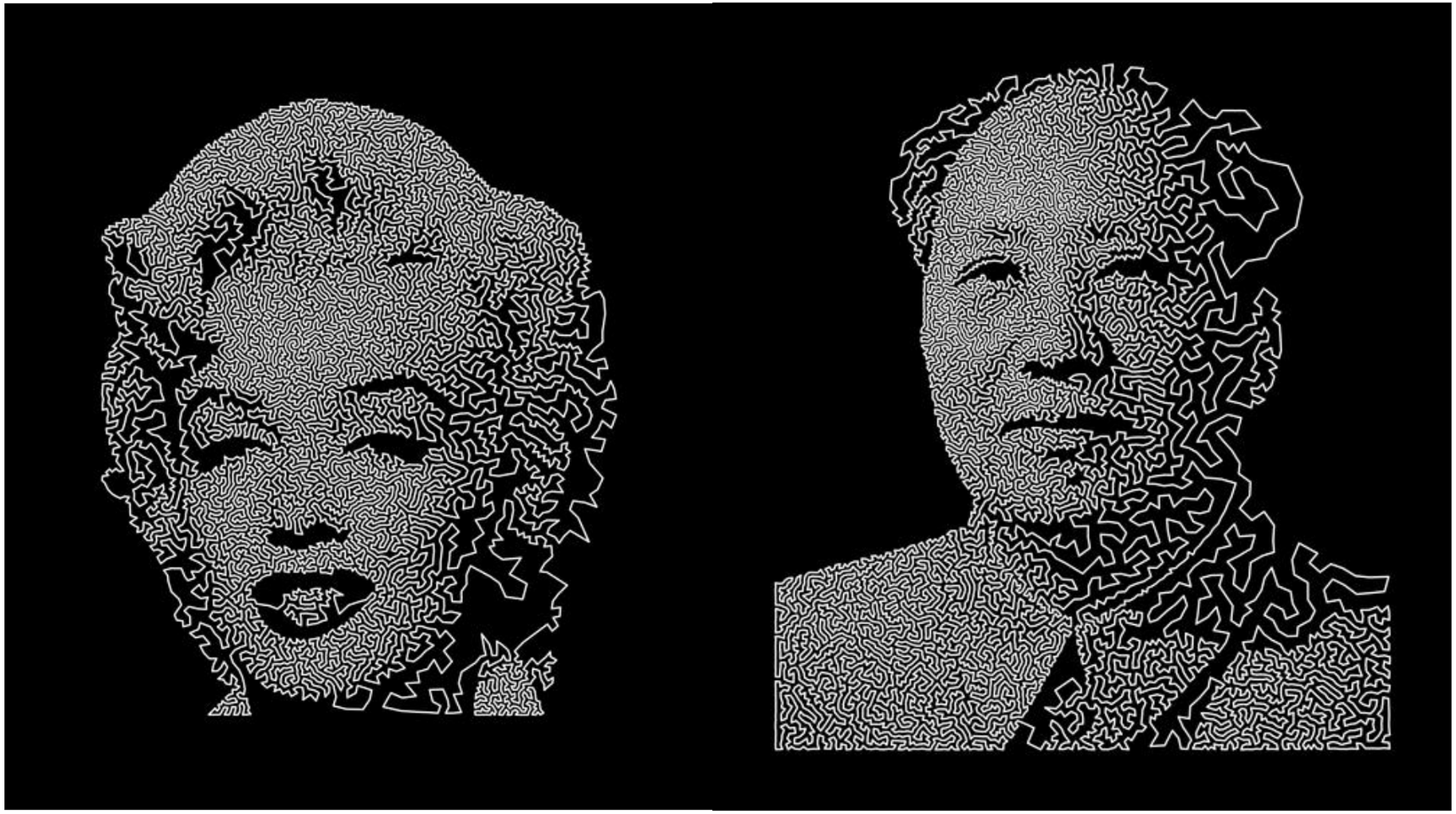
TSP Art







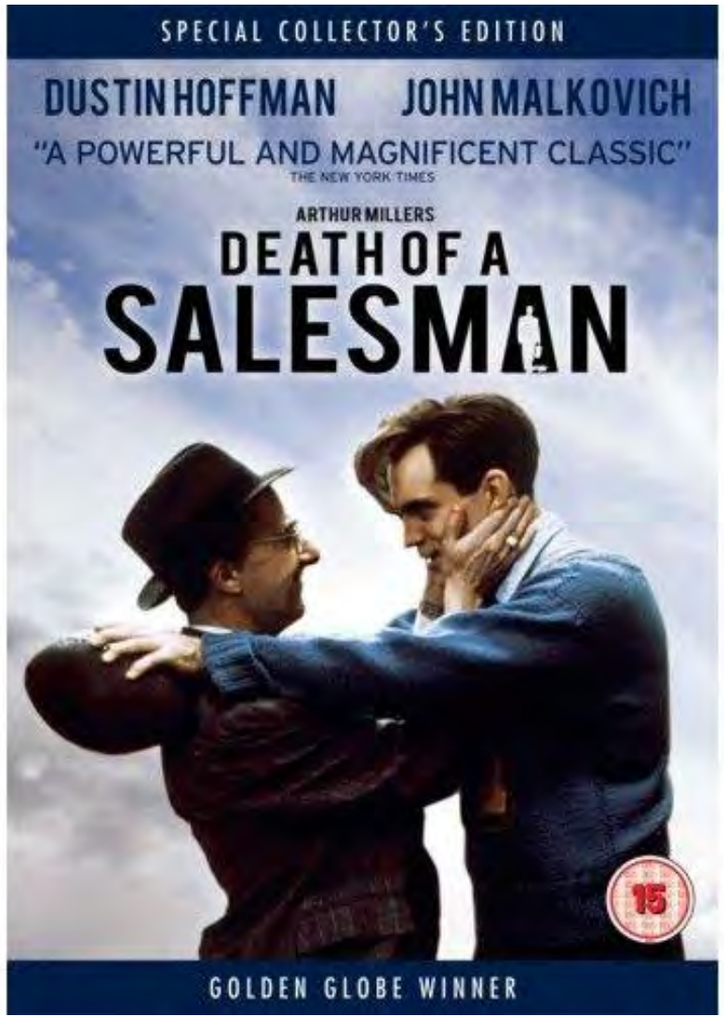
TSP Art



Movie Trivia

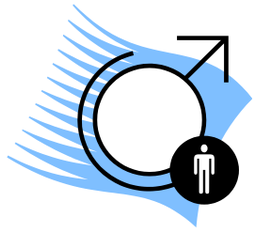
An aging traveling salesman recognizes the emptiness of his life and tries to fix it.

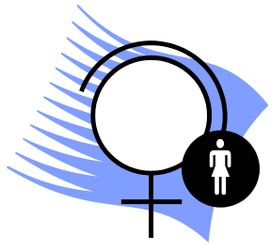
Death of a Salesman (1985)



An aging traveling salesman recognizes the emptiness of his life and tries to fix it.

- Traveling salesman problem => Traveling salesperson problem
- Manpower => Workforce
- Postman => Mail carrier
- Freshman => Frosh?
- Man-made diamond => ?
- Mankind => ?
- Manhole => ?





* Interview question at Google !

Why are manhole covers round, not square or rectangular?

A square or rectangular manhole cover can fall down the hole, while a round manhole cover cannot.

The square cover will fit down the diagonal of the hole (unless the rim it sits on is very large), but no matter how you turn a circle, it never measures less than its diameter.

So for safety and practicality, all manhole covers should be round.

You can also roll a circular manhole cover rather than lifting it.

* More interview questions?

- How many pizzas are consumed each year in the United States?

- How many words have you spoken in your life?
- How many different people's names appear in the New York Times each year?
- How many watermelons would fit inside the U.S. Capitol building?
- What is the volume of all the human blood in the world?