Graph Guided Genetic Algorithms

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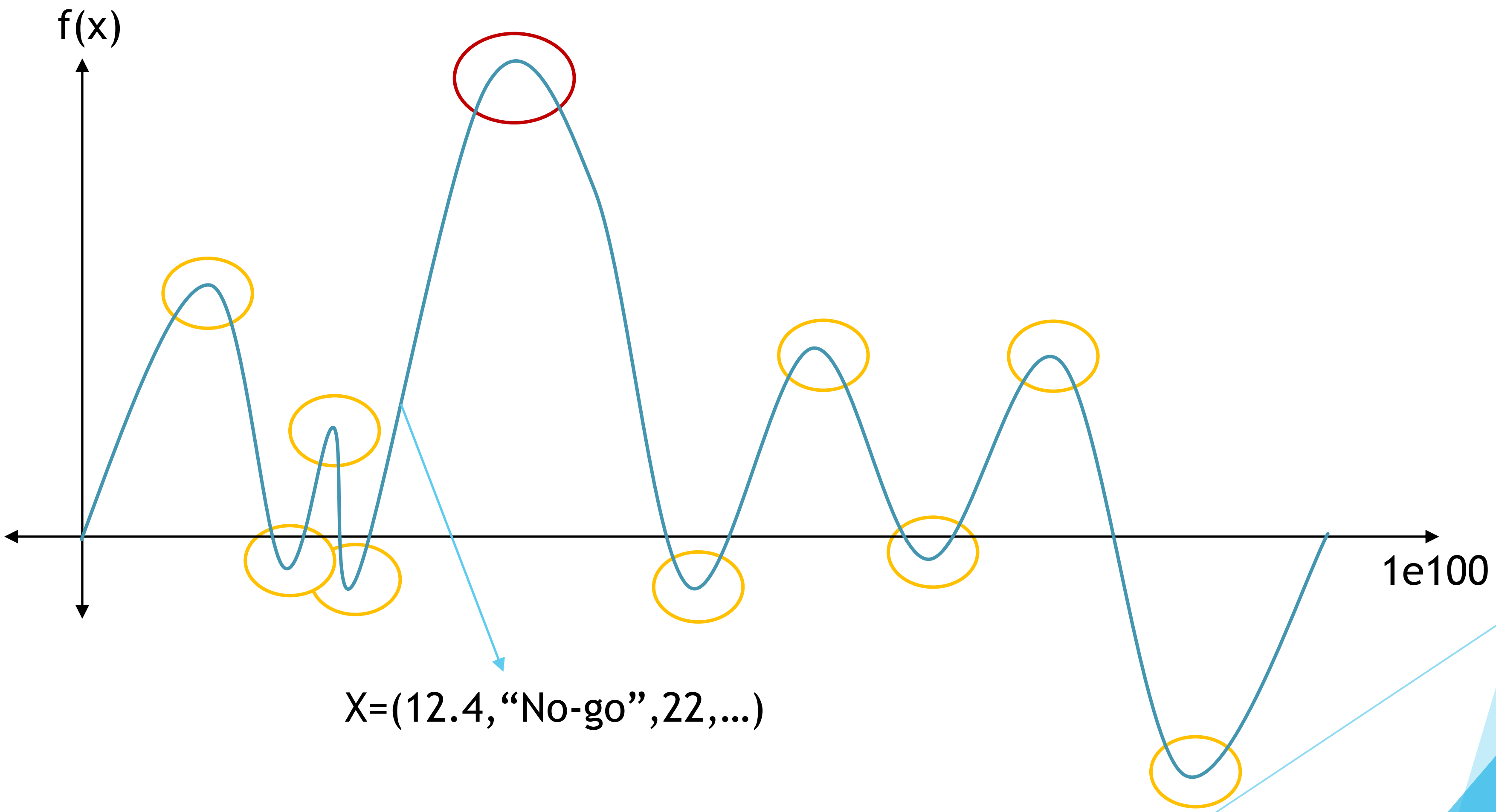
Understanding Genetic Algorithms
Part 1: the Problem

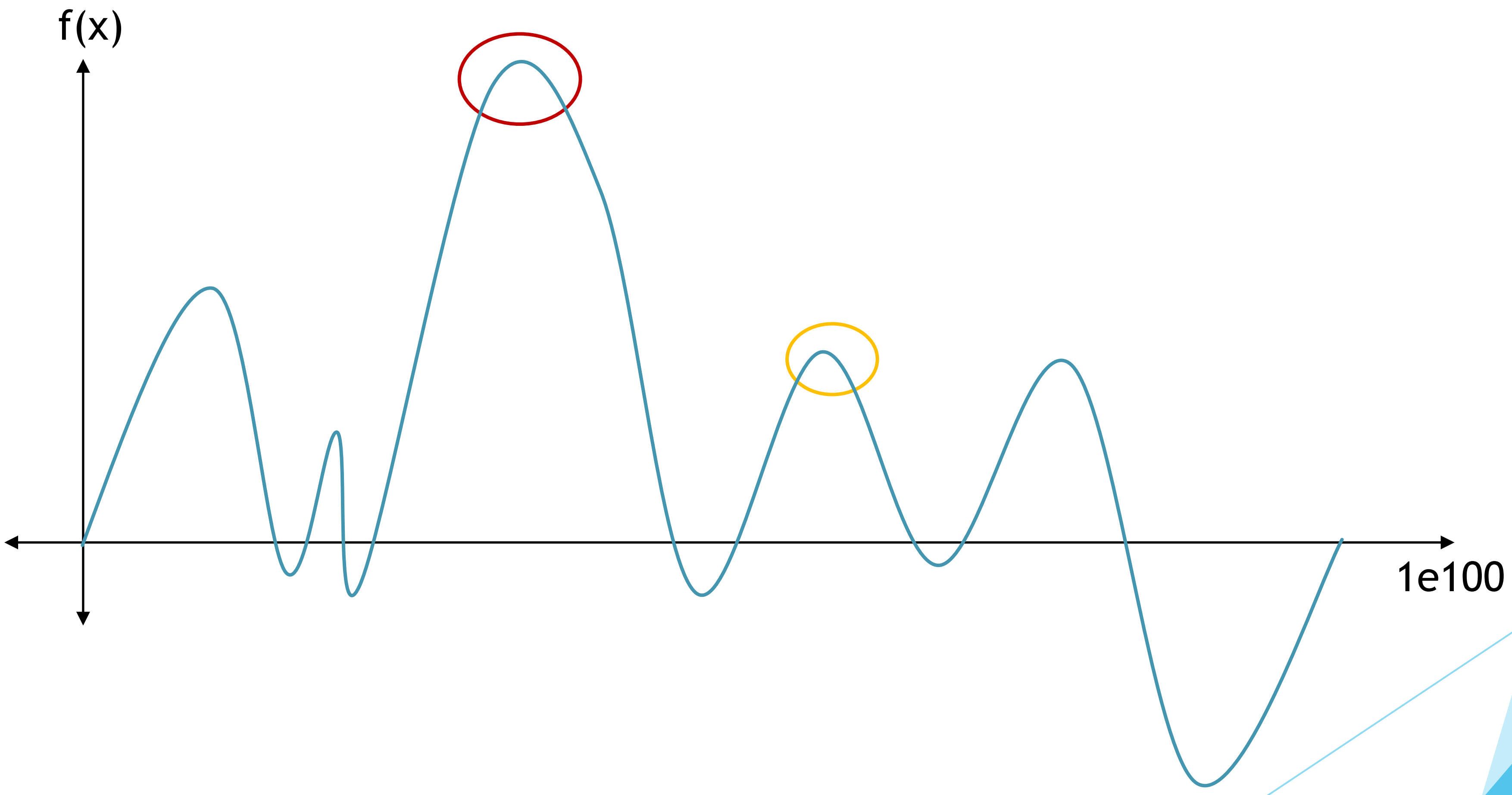


Understanding Genetic Algorithms
Part 2: Just Copy Nature

- Solution == DNA
  - e.g (12.4,“No-go”,22,…)
- Fitness function
  - A method for determining how “good” a solution is
  - Can be a score, where higher is better
- Breeding
  - Combine DNA in different ways
  - E.g (12.4, “No-go”,22,…) + (-3, “Go”, “9) == 2^X possible combinations
- Survival of the Fittest

Understanding Genetic Algorithms

Part 3: Inbreeding is Bad

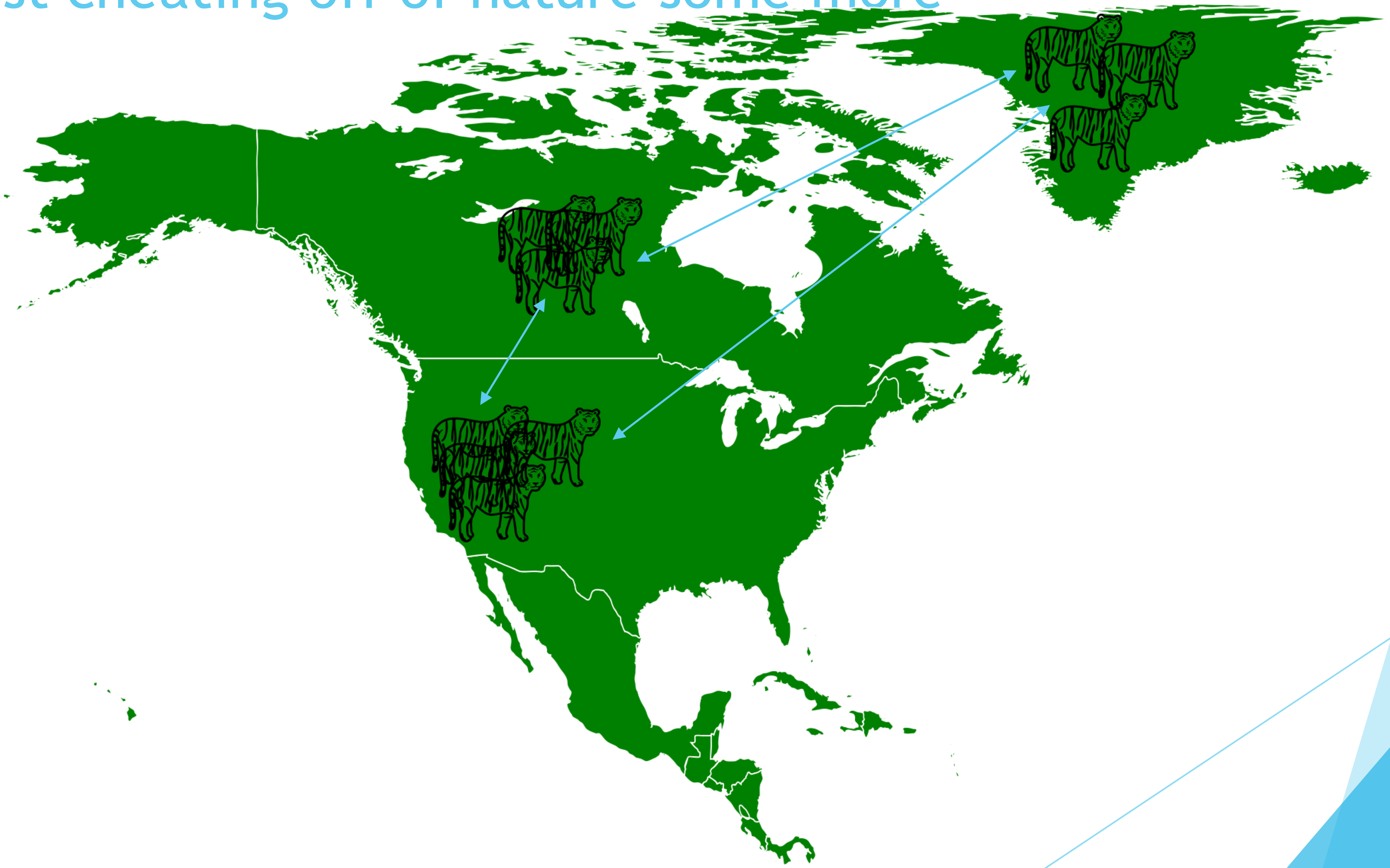


Understanding Genetic Algorithms
Part 4: Or why the X-Men are the Best

- Need a method of ensuring Genetic Variability
- Mutations ensure that we'll jump around the curve

Graph Guided Genetic Algorithms

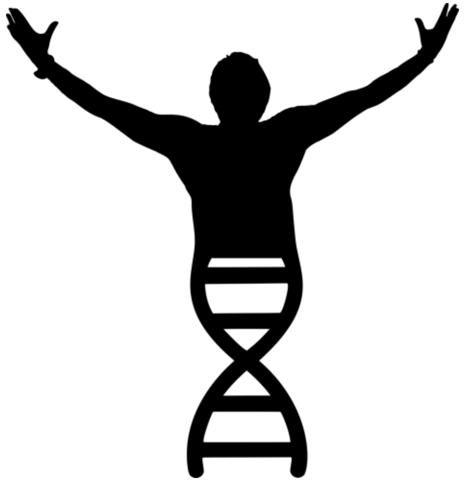
Just cheating off of nature some more

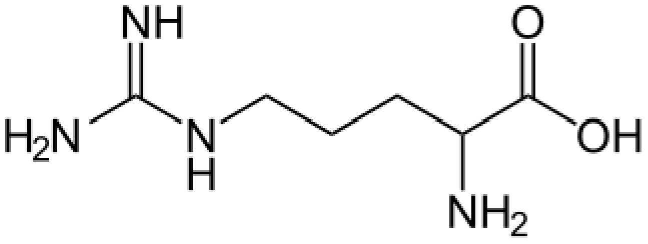


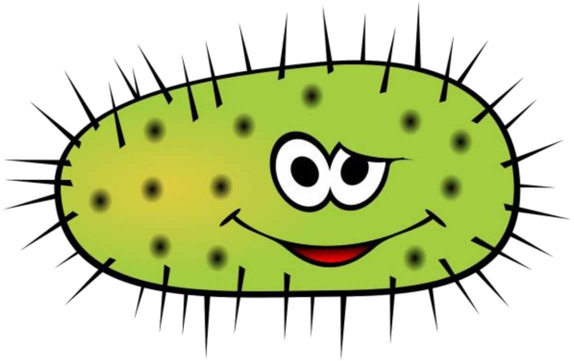
Application: Genetic Engineering

ACGT – building blocks of DNA	“Nucleotide”
Amino Acids – building blocks of proteins	20 in all: (Tryptophan, Valine, Glutamine….)
Group of 3 nucleotides == 1 Amino Acid	4^3 = 64 combinations There are redundancies + start and stop codons

Humans and Bacteria are Different



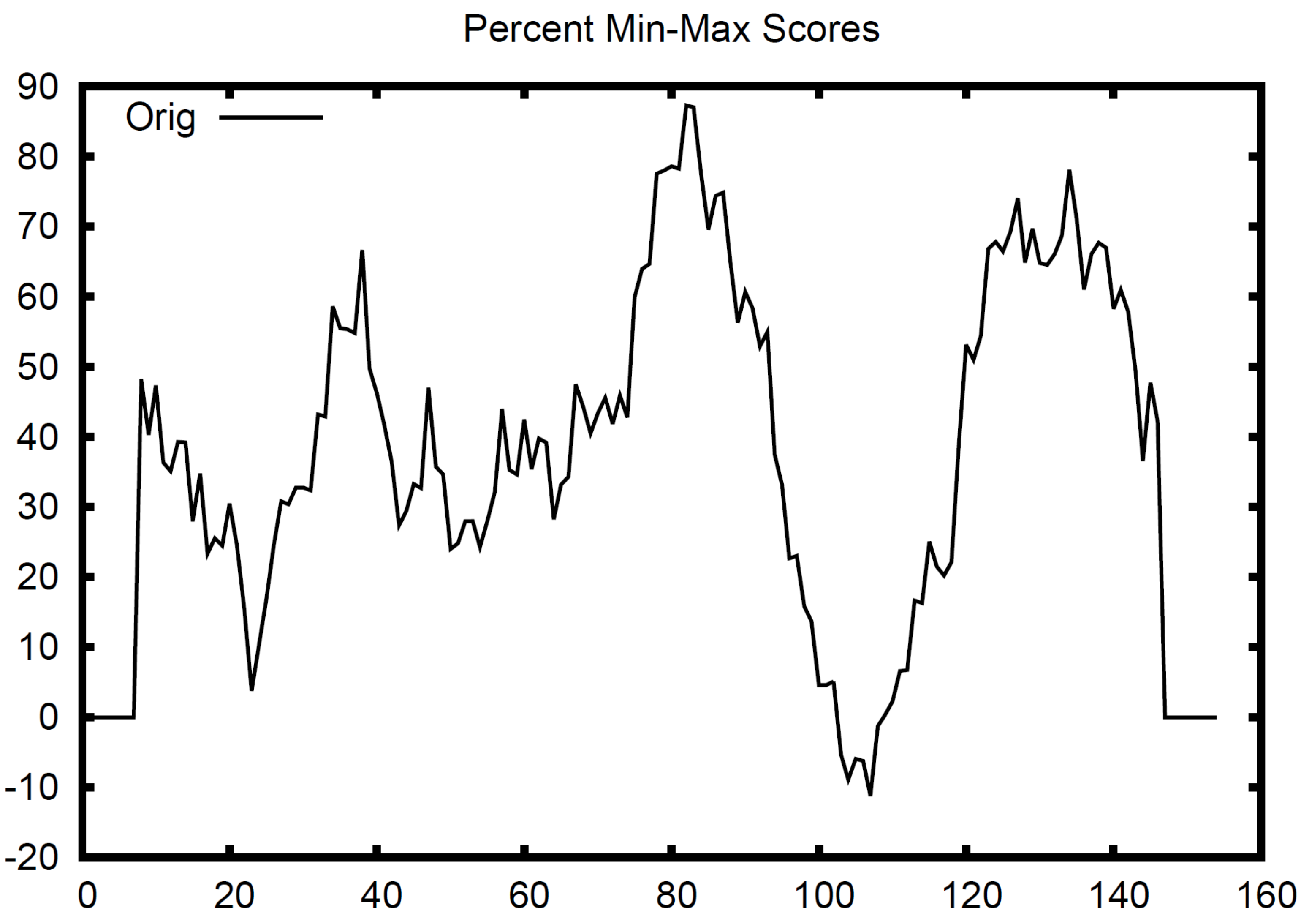




CGT: 0.123
CGC: 0.334
CGA: 0.462
CGG: 0.111

CGT: 0.121
CGC: 0.235
CGA: 0.461
CGG: 0.213

Min-Max Estimations



The Problem

- 22 Possible Start/Stop/Amino Acids, 64 Codons, and DNA length of N
- For a given sequence, roughly 4 possible alternatives for a given Codon
- Search Space: 4^N

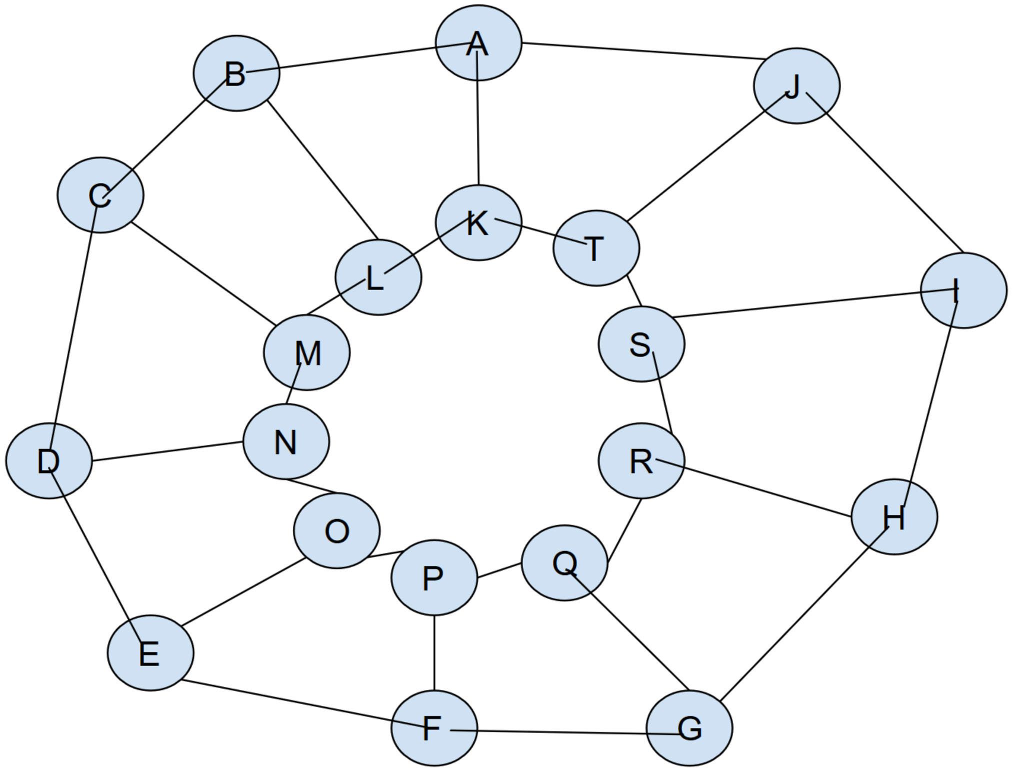
Solution: Genetic Algorithms to solve Genetic Engineering Problems

- “DNA”: the specific Codon encodings which generate the same Protein
- Fitness Function: $\sum |\, \mathrm{MinMax(human)} - \mathrm{MinMax(SolutionInBacteria)} |$
- Breeding:
  - Zip Children: for each position, alternate between taking from parents
  - Skip Children: Zip Children where zip_num > 2
  - Random Children: randomly choose from parents
  - Half and Half: first half one parent, second half the other
  - ….
- Take top 10 each generation

How Graphs Made things Different

- *Graph Based Evolutionary Algorithms* by Bryden K.M. et al
- Take a graph and place a potential solution on each vertex
  - The only mating partners for that vertex are its neighbors
  - Choose from potential mates who to mate with
- Only replace parent if child is better than parent

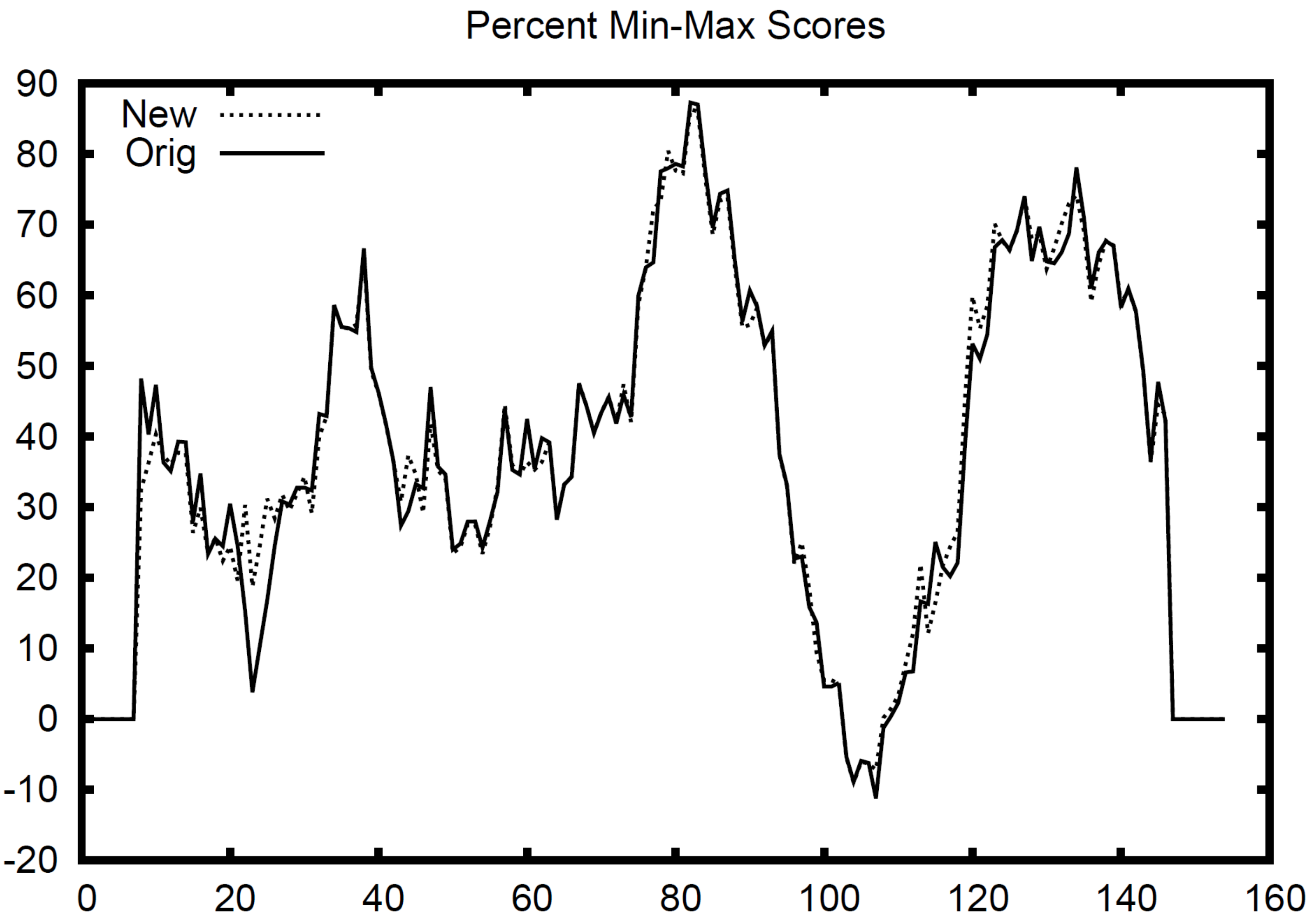
The Graph I Used



Pseudocode

- Take target DNA strand, and create 20 Random variations, place one on each vertex in the graph
- For i in range(100):
  - For v in graph.vertex():
    - Children = []
    - For n in graph.neighbors(v):
      - Children.add(breed(n,v,10))
    - Sort(children)
    - If children[0].score < v:
      - Graph.replace(v,children[0])
- Return sort(graph.vertex())[0]

Results



Percent Min-Max Scores
New
Orig
90
80
70
60
50
40
30
20
10
0
-10
-20
0
20
40
60
80
100
120
140
160

Future Direction

- Add more graphs and start timing, analyzing time and score based on different graphs and their properties
- Multi-thread the breeding process