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Fitness Landscapes II

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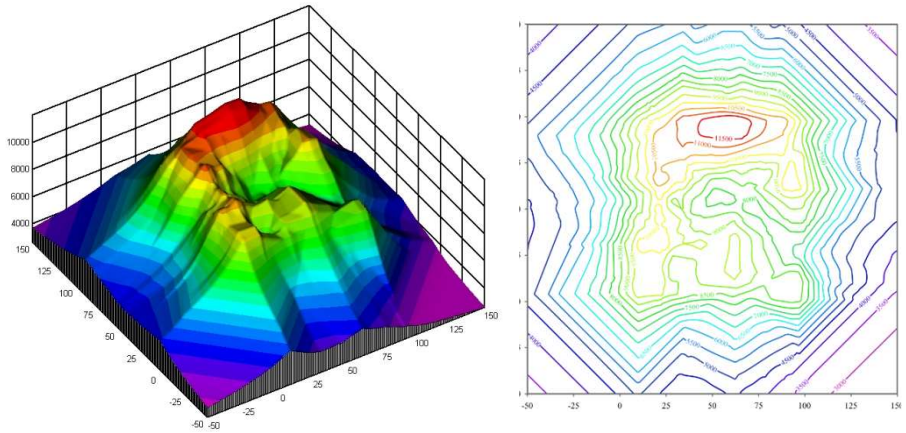
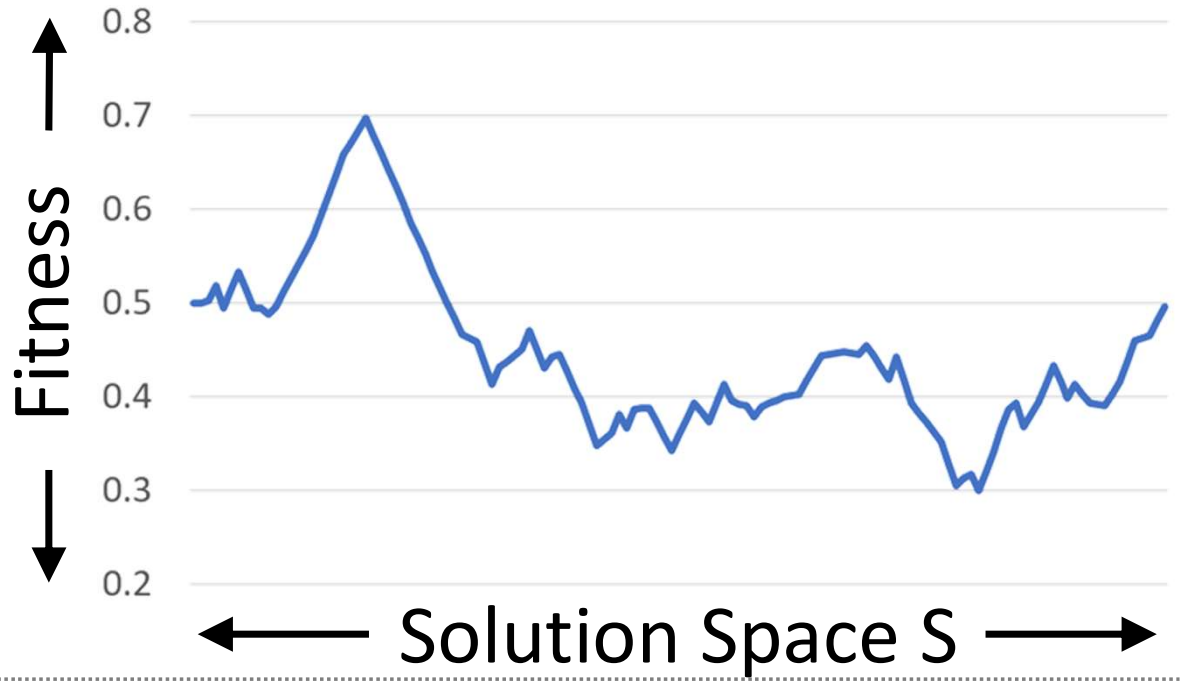
Visualizing Neighbourhoods

- So far we have used a very poor diagram of a search space
- It represents *S* as a *line*; but *S* is typically *high-dimensional*
- Even a 2-D *S* is challenging:



https://en.wikipedia.org/wiki/Contour_line



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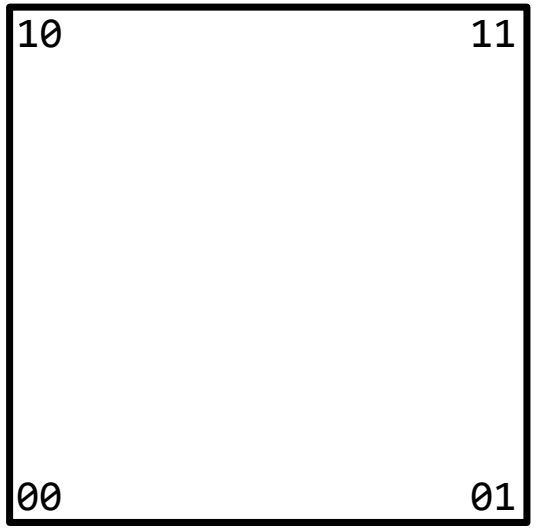
Visualizing Neighbourhoods

- In fact, it's even worse as many GAs search *discrete* spaces:
- Consider a binary genotype of length 1 or 2…



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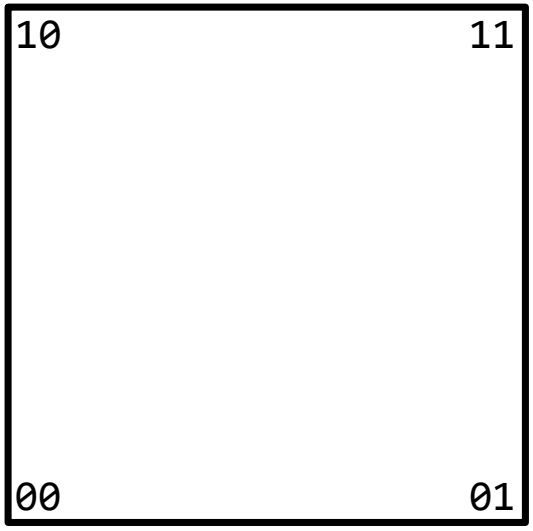
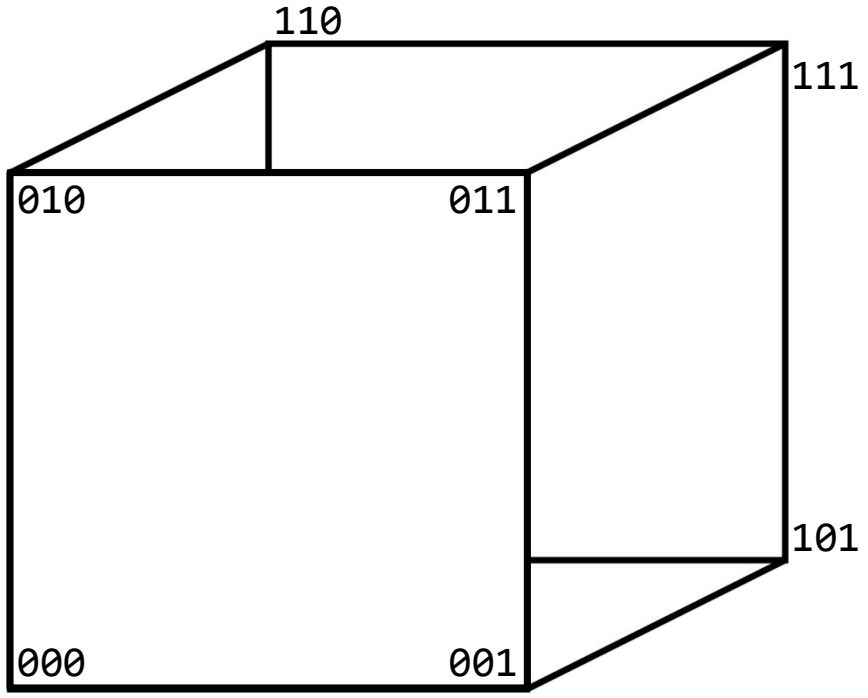
Visualizing Neighbourhoods

- In one, two and three dimensions we are reasonably ok…





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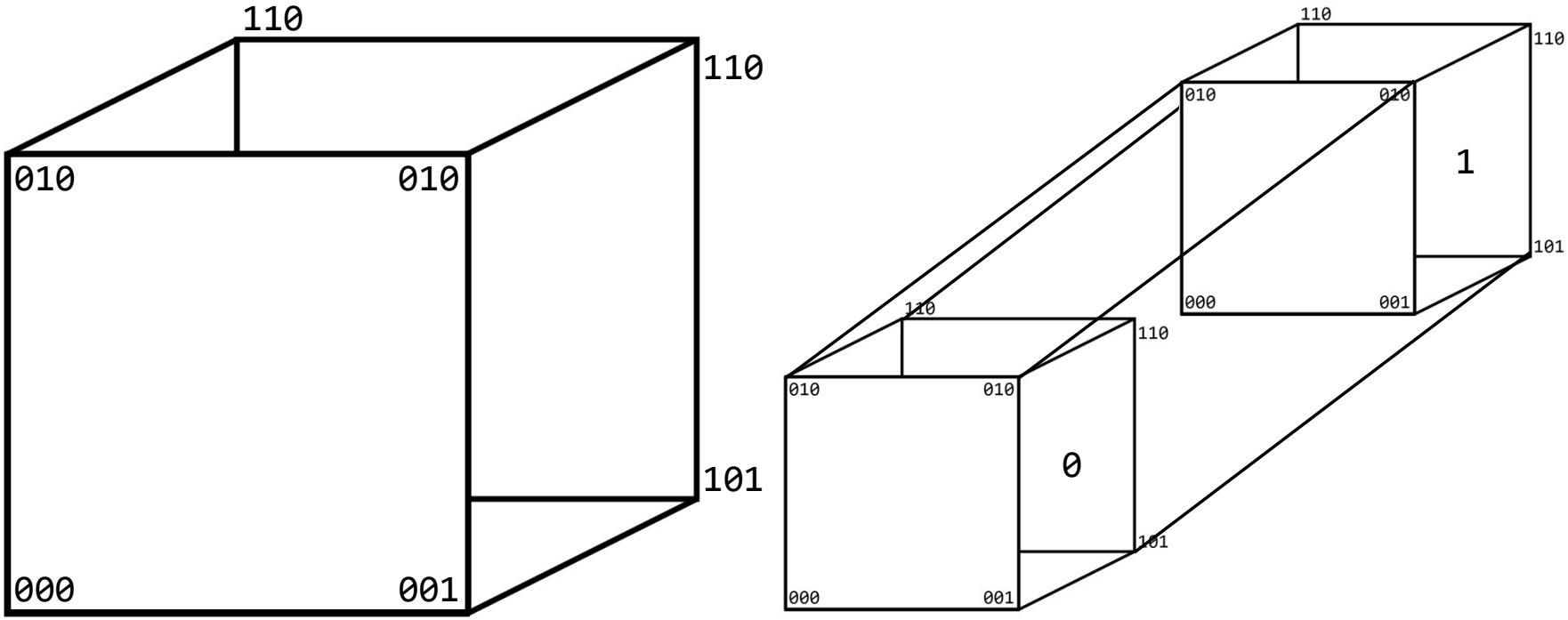
Visualizing Neighbourhoods

- …but a solution space of all length-*L* bit-strings implies that genotypes are located on an *L*-dimensional binary hypercube…



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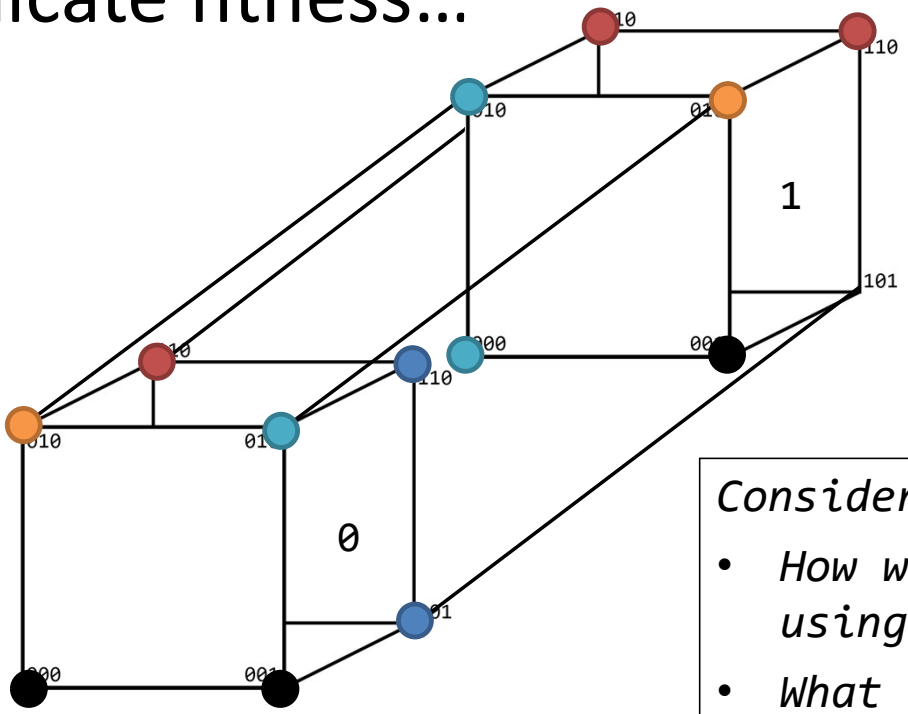
Visualizing Neighbourhoods

- …and each visualized point also needs an extra dimension to indicate fitness…



- Comprehending the structure of real search spaces is challenging!

Consider:

- *How would this diagram change if we were using a ternary alphabet: {-1,0,1}*
- *What about genes with integer alleles?*

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Landscape Metaphors

- A real landscape is three-dimensional, continuous, defined, relatively smooth, and static or changing very slowly.
- But fitness landscapes don't share these properties.
- This means we have to be careful when we use "landscape" language to describe search spaces:
  - Peaks
  - Valleys
  - Ridges
  - Basins
  - Plateaus
  - Smoothness
  - Ruggedness
  - Climbing
  - Drifting

Modality

- A landscape with one global optimum solution (i.e., it has no local optima) is called *unimodal*
- A landscape with two optima is called *bimodal*
- A landscape with many optima is called *multi-modal*
- A set of points that lie on hill-climbing routes that terminate at one local optimum are said to lie within the *basin of attraction* of that local optimum.
    - A unimodal landscape has *one* basin of attraction

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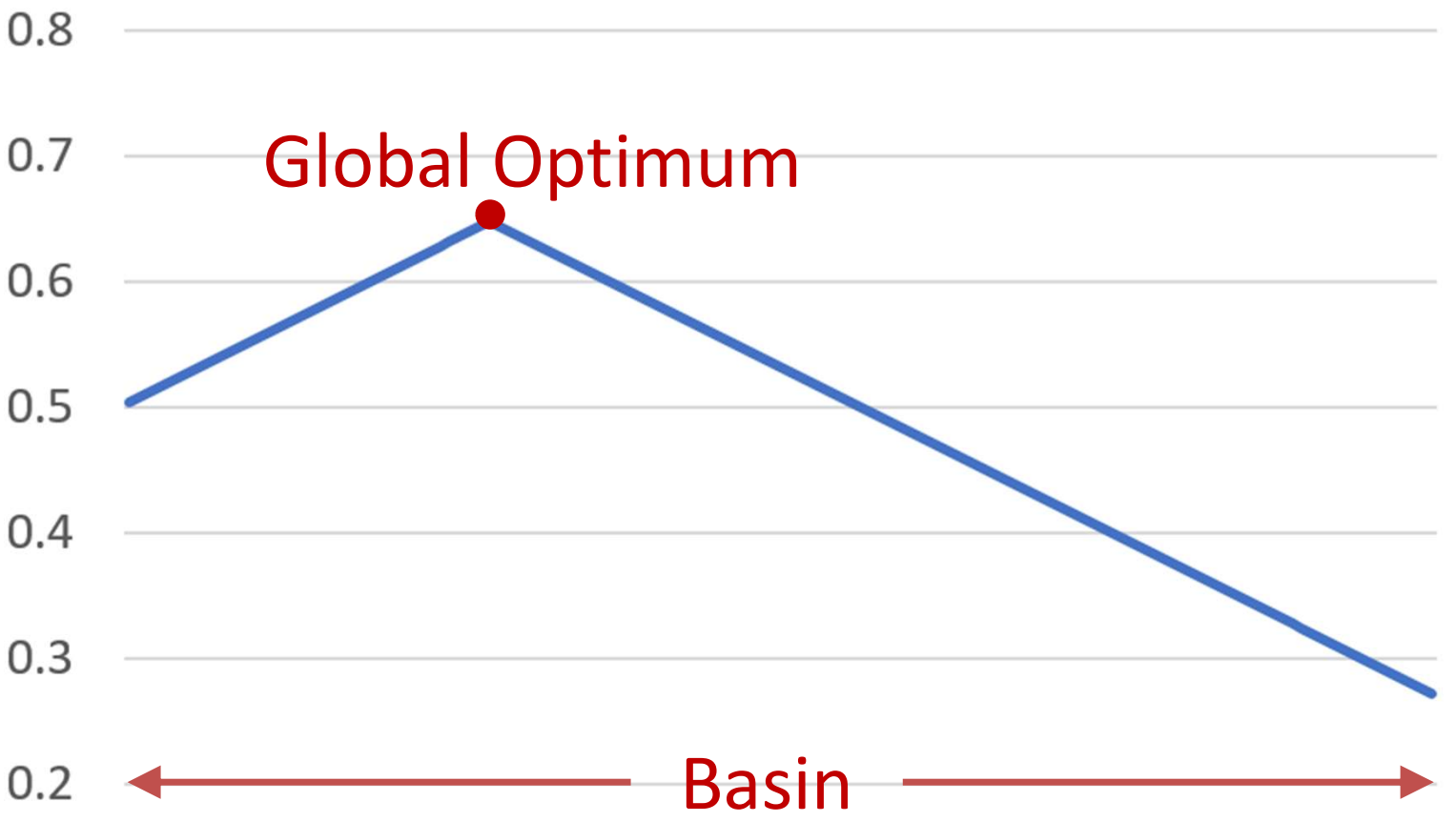
Unimodal

- Trivial problem
- EC is overkill
- Each gene has a *best* allele, independent of the alleles at all other genes



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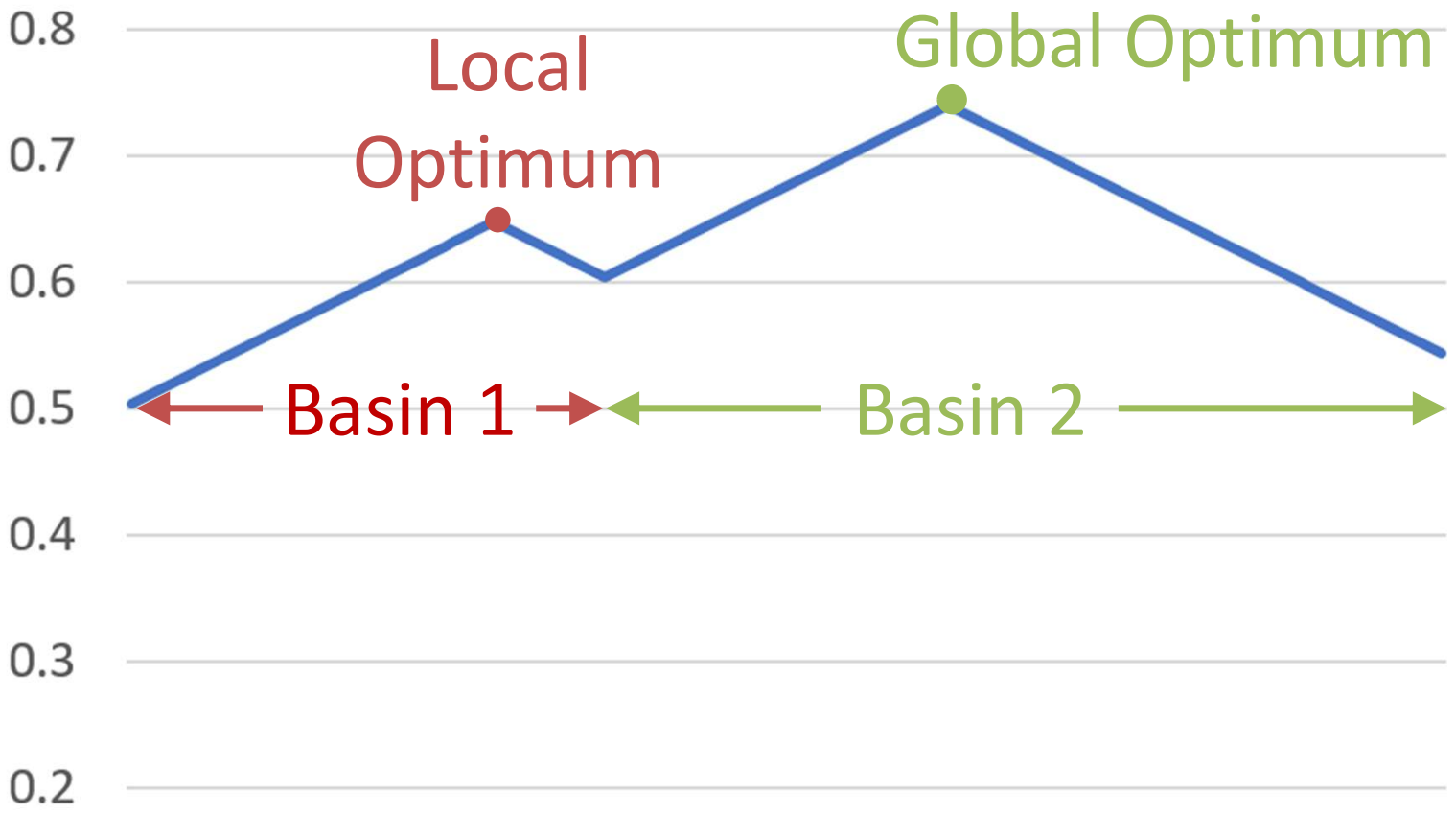
Bimodal

- The best allele for some genes *depends* on the alleles at some other genes.
- GA can't know which basin its population is in.



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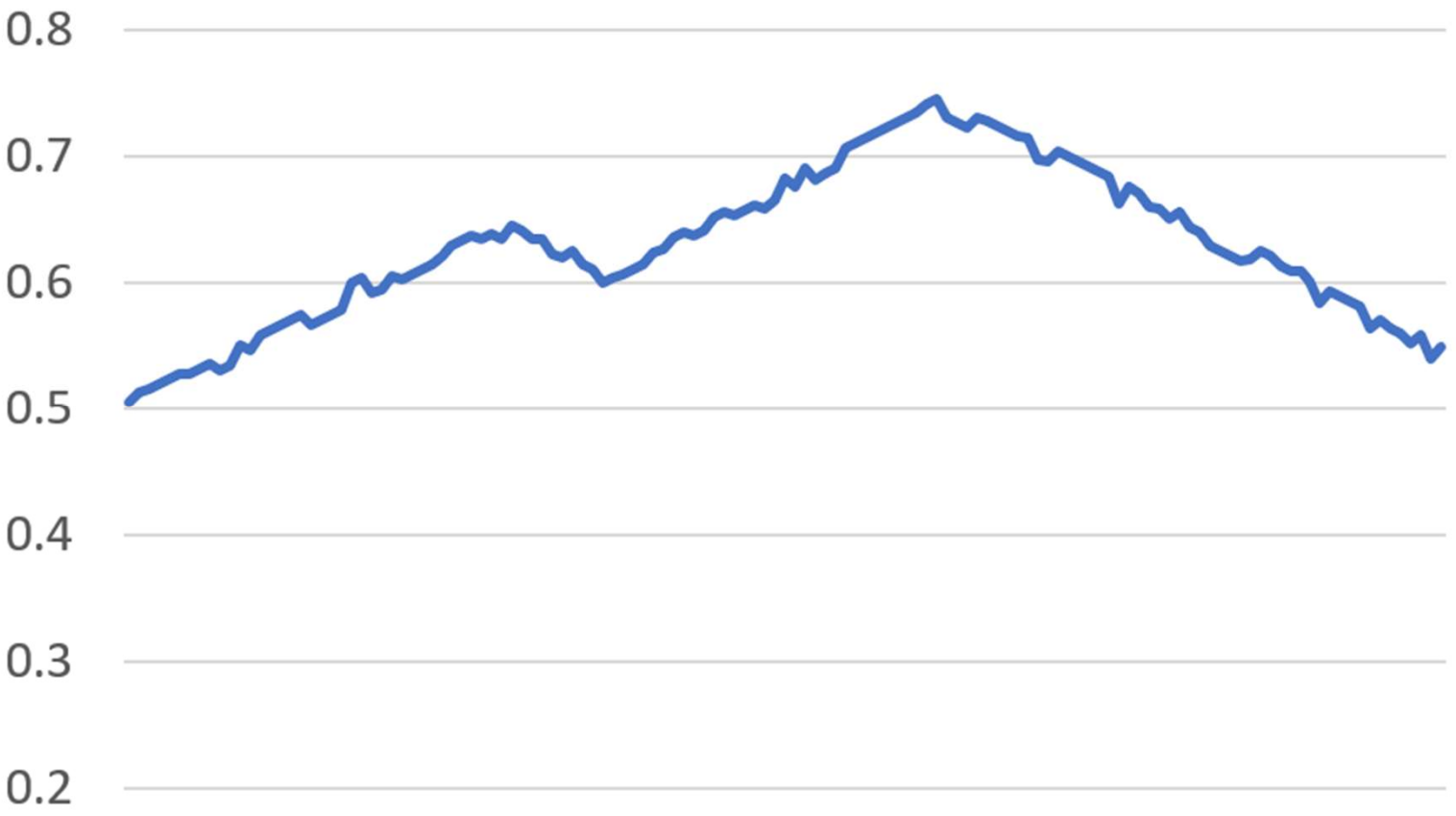
Multimodal?

- Many basins of attraction for many optima.
- But isn't this landscape still bimodal really?
  - Depends on the algorithm…



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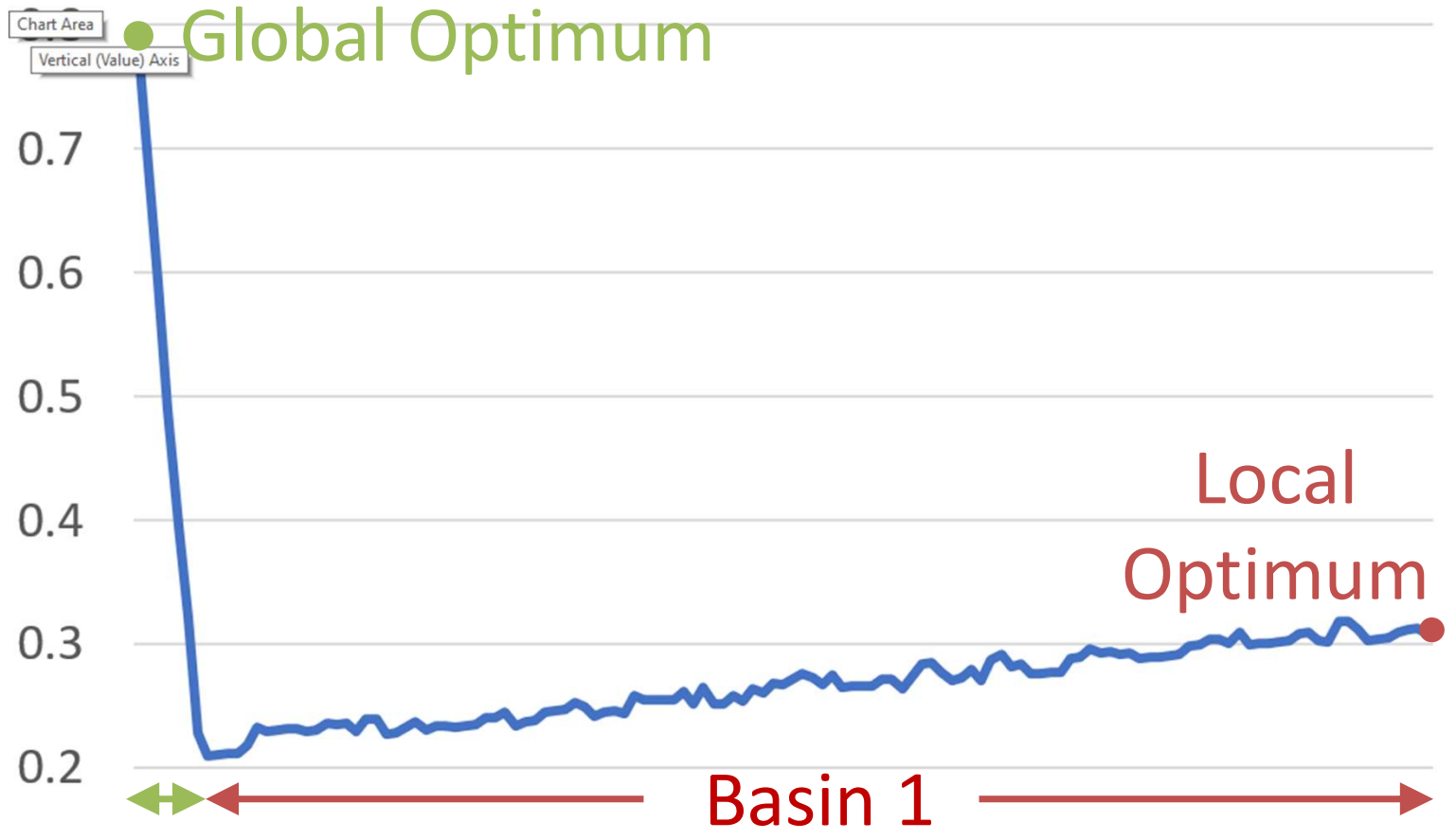
Deception

For a deceptive landscape:

- The best optima have small basins.
- Consequently, global optima are hard to find



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Example Questions

- What size is the search space if genotypes each have G genes and each gene can be one of A alleles? *[1 mark]*
- Consider the search landscape drawn below. Which of the following properties does it have *[1 mark each]*
  - Neutral, Global, Deceptive, Unimodal, Rugged, Coevolutionary
- Tom's GA keeps getting stuck on local optima. He thinks that doubling the mutation rate might be a good idea. Is it? Explain your answer. *[5 marks]*

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Thank you!