

How do genetic algorithms relate to their biological origins?

How do they relate to human processes of design?

Why is there power in this metaphor?

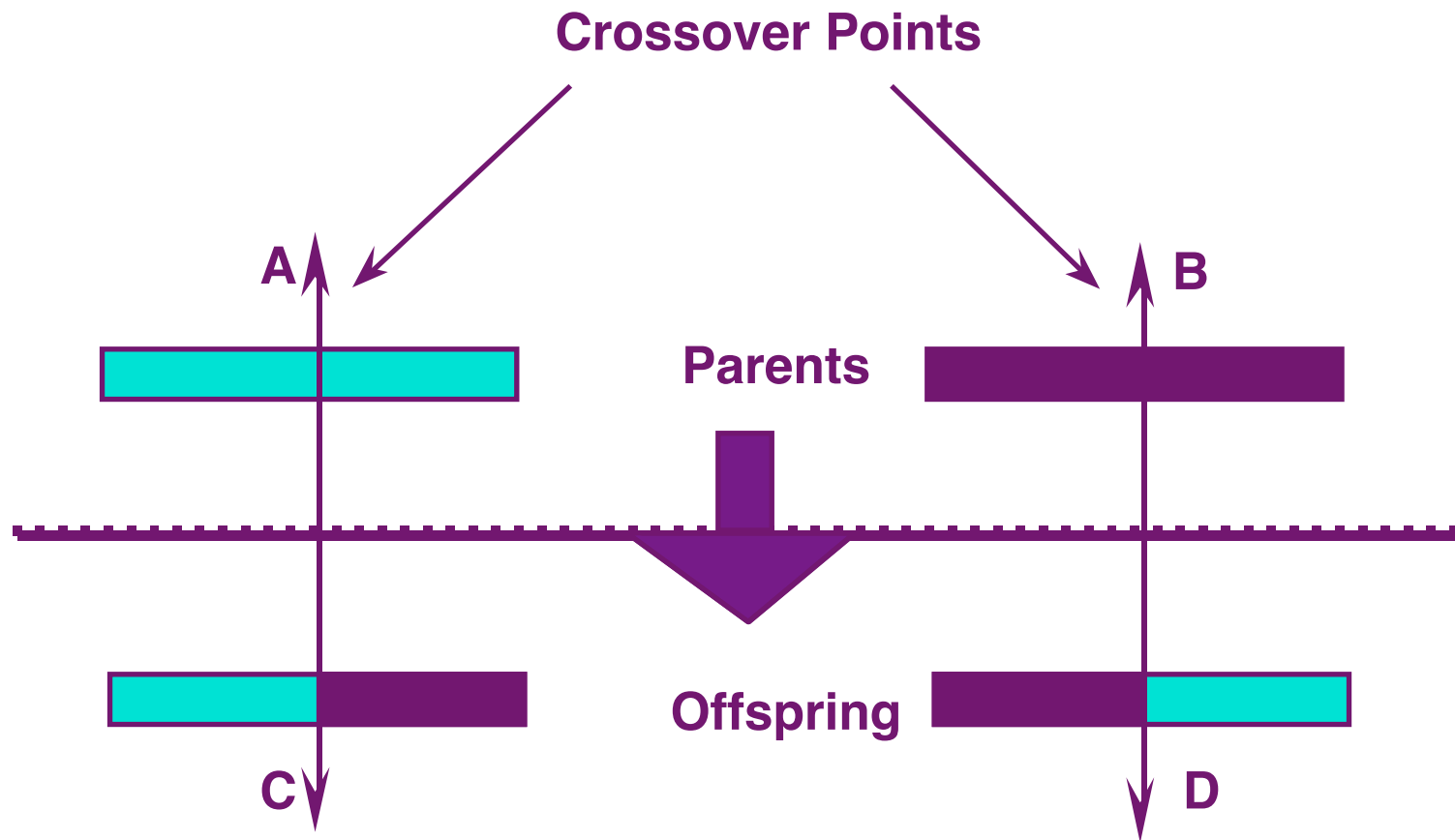
How can they be used to extend the capabilities of the designer?

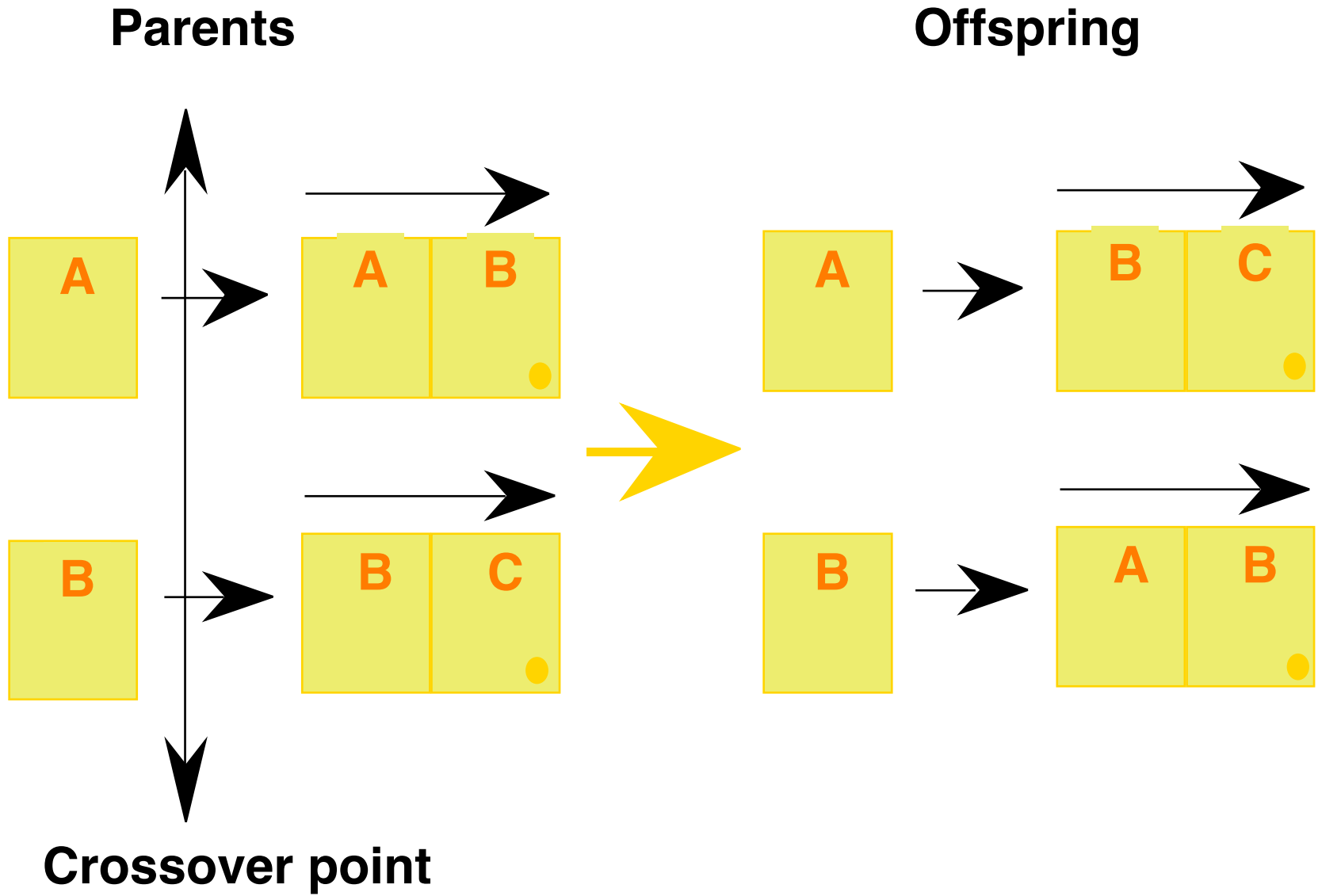
**John Gero
Professor of Design Science
University of Sydney
Visiting Professor of Design and Computation
MIT**

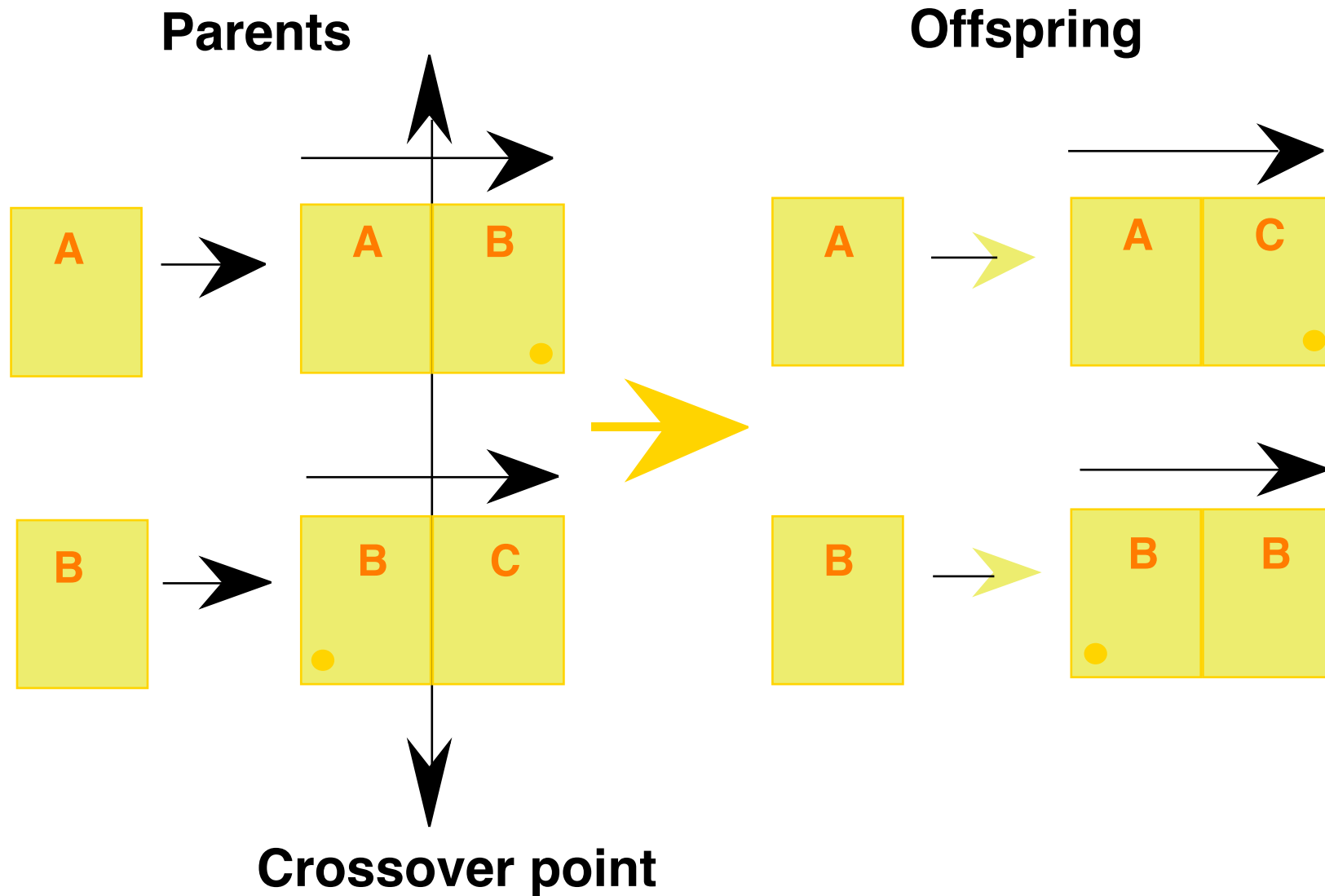
How do genetic algorithms relate to their biological origins?

- Separation of genetic material (genotype [representation]) from organism (phenotype [design])
- Expressing genotype as organism
- Organism carries genotype and reproduces genotype using 'genetic' processes of crossover and mutation
- Darwin's natural selection uses fitnesses of organisms in their environment to improve the gene pool
- GA is a simple model of this process

Genetic processes







How do they relate to human processes of design?

- Can map genetic representation onto a computational representation of a design; can map phenotype onto a interpretable view of a design
- Humans work on single or few designs at a time/ genetics works on a population of ‘designs’ in parallel
- Humans can be seen to “search” design spaces - this is one interpretation of what GAs are doing.

Why is there power in this metaphor?

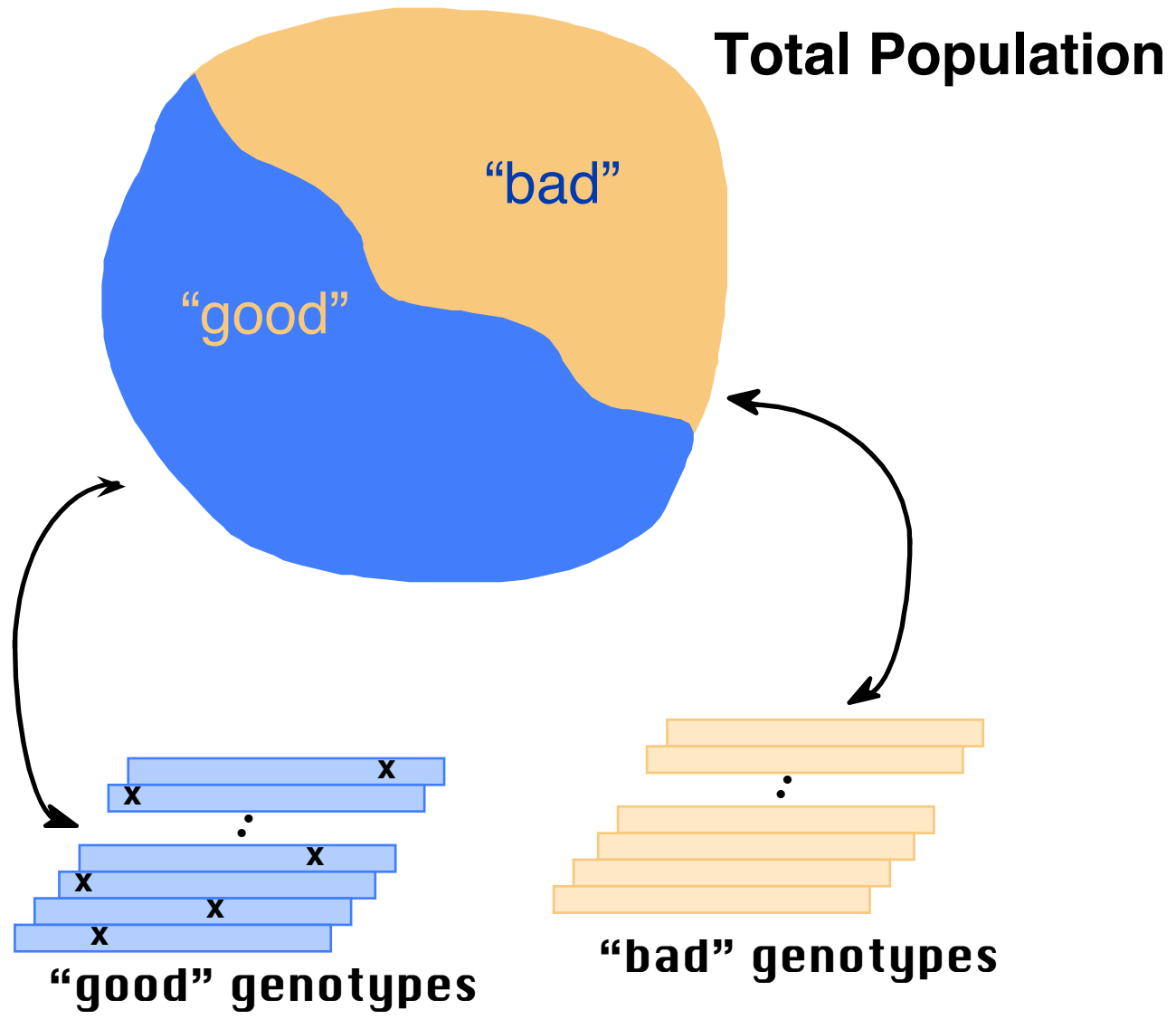
- Guaranteed improvement - Darwinian evolution
- Large scale search
- Blind search
- Fitness can be human evaluation
- Fitness can change over evolutionary time
- Can produce complexity
- Can produce unexpected results

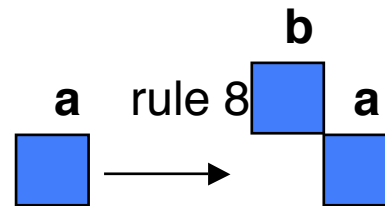
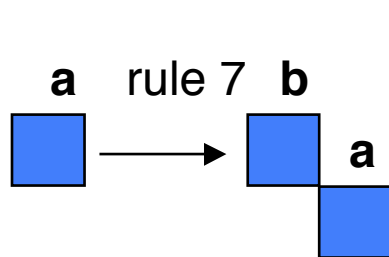
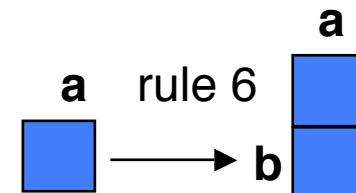
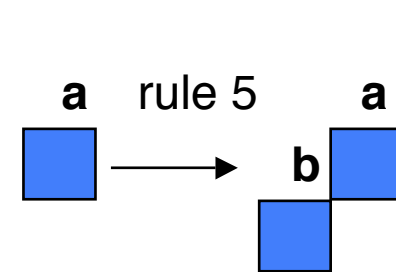
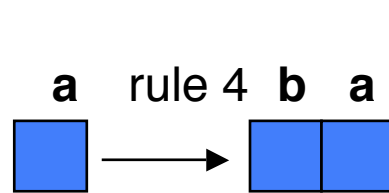
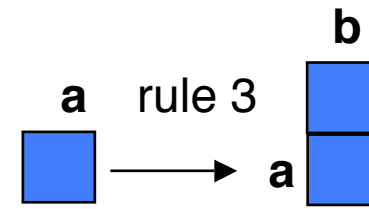
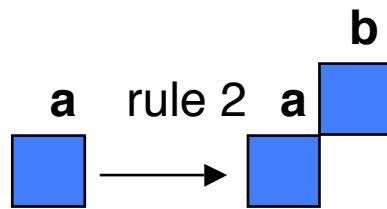
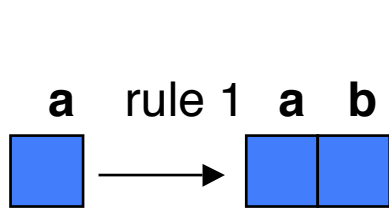
How can they be used to extend the capabilities of the designer?

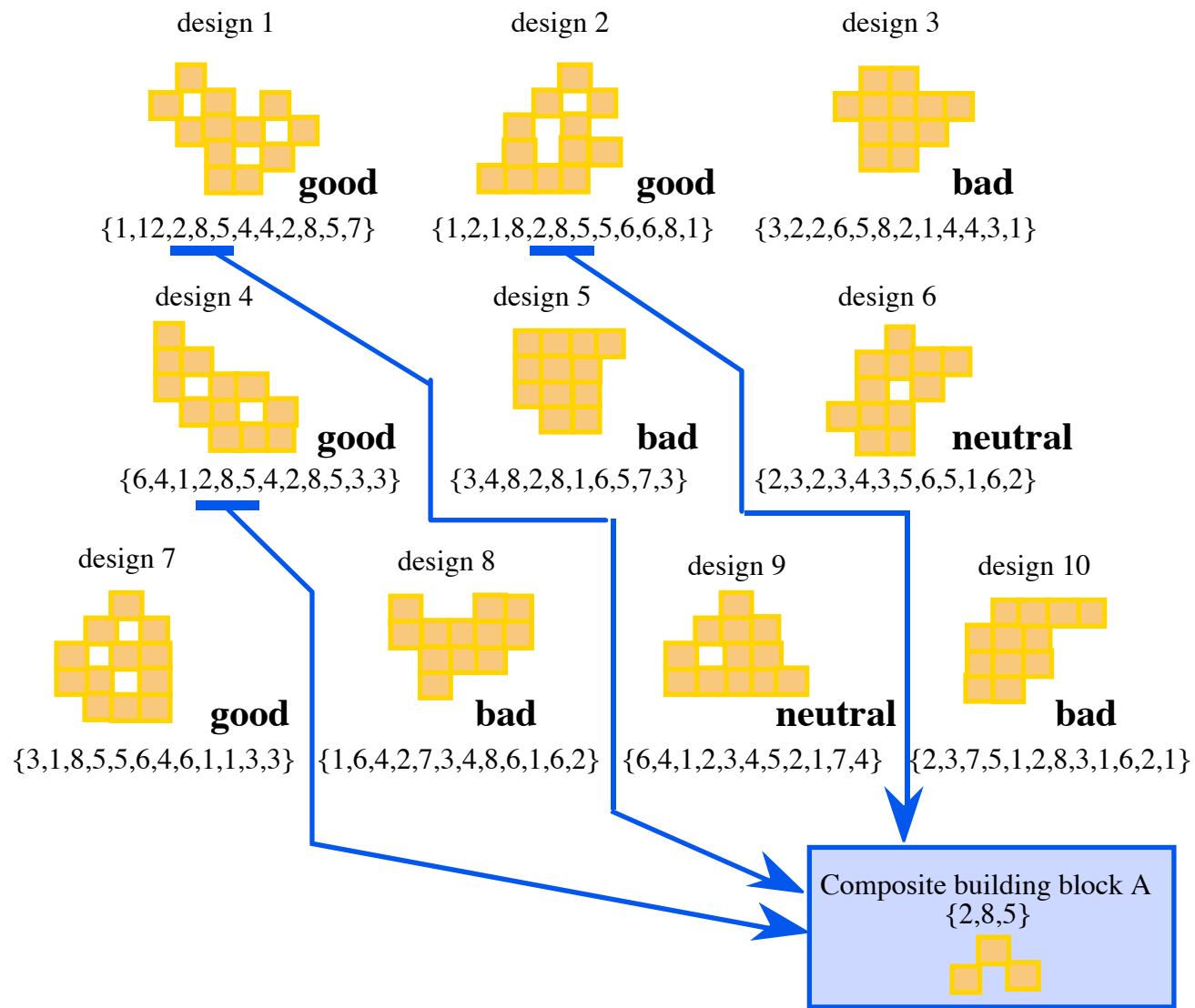
- Creativity through genetic engineering
- Novel designs through extending genetic crossover
- Novel designs through different fitnesses

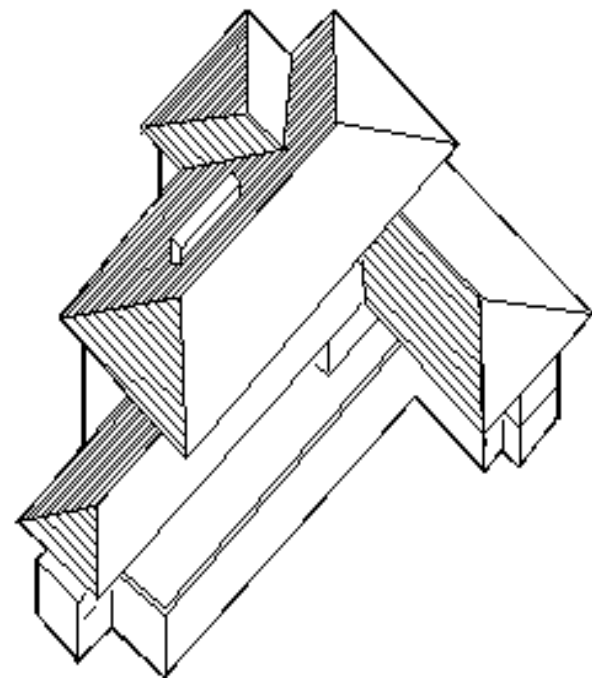
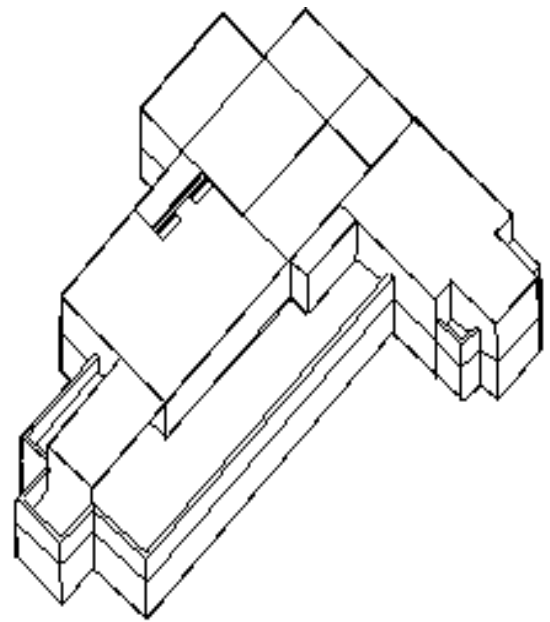
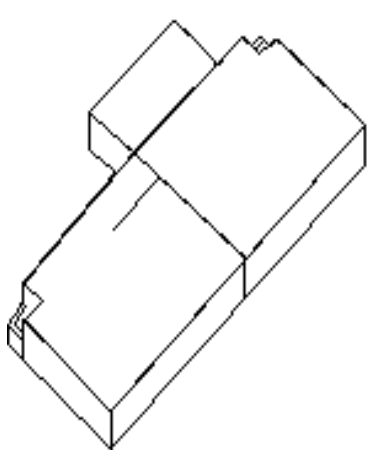
Genetic Engineering and Creative Design

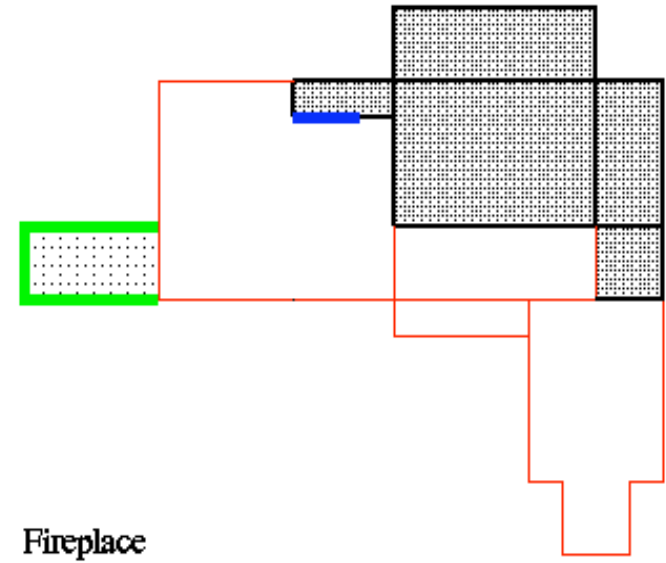
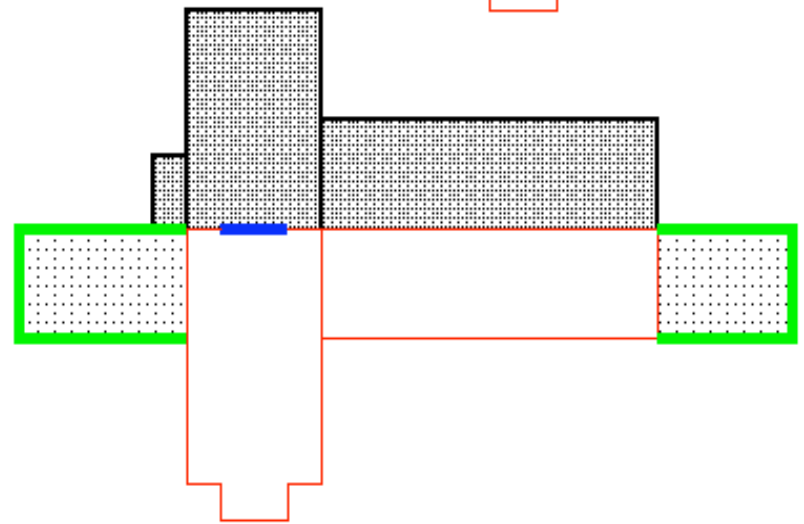
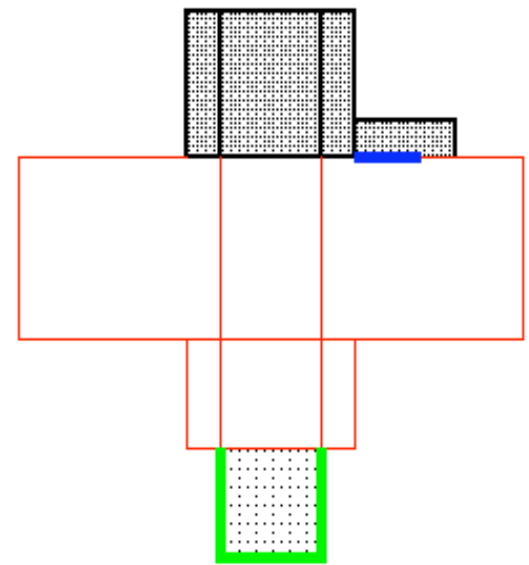
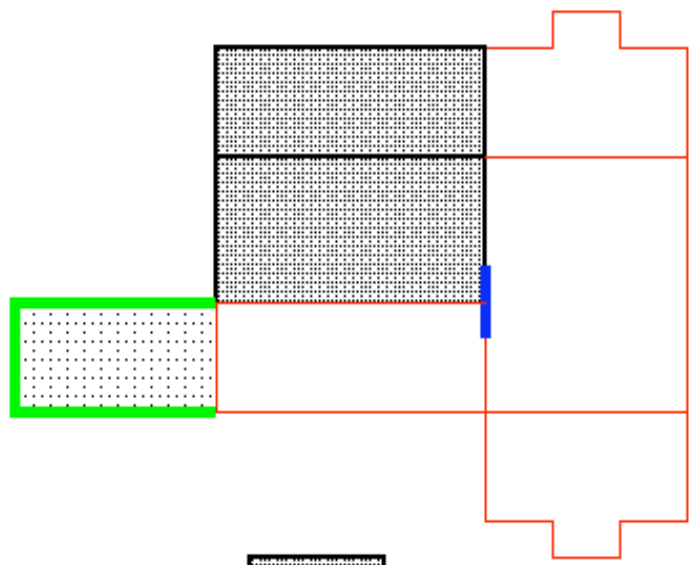
- Background
 - genes, genotype, phenotype, fitness
- Connecting genes to performance in fitness
- Emergent gene clusters \Rightarrow evolved genes



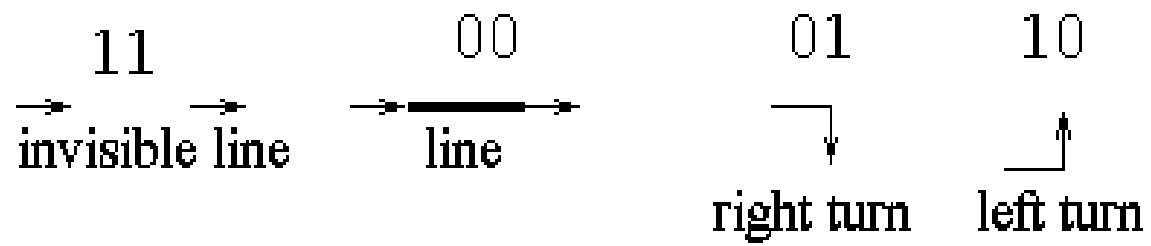


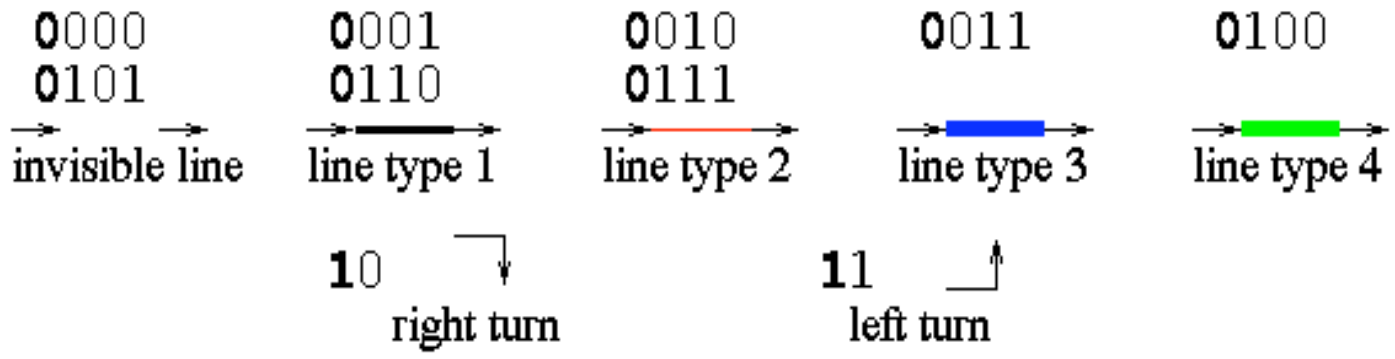


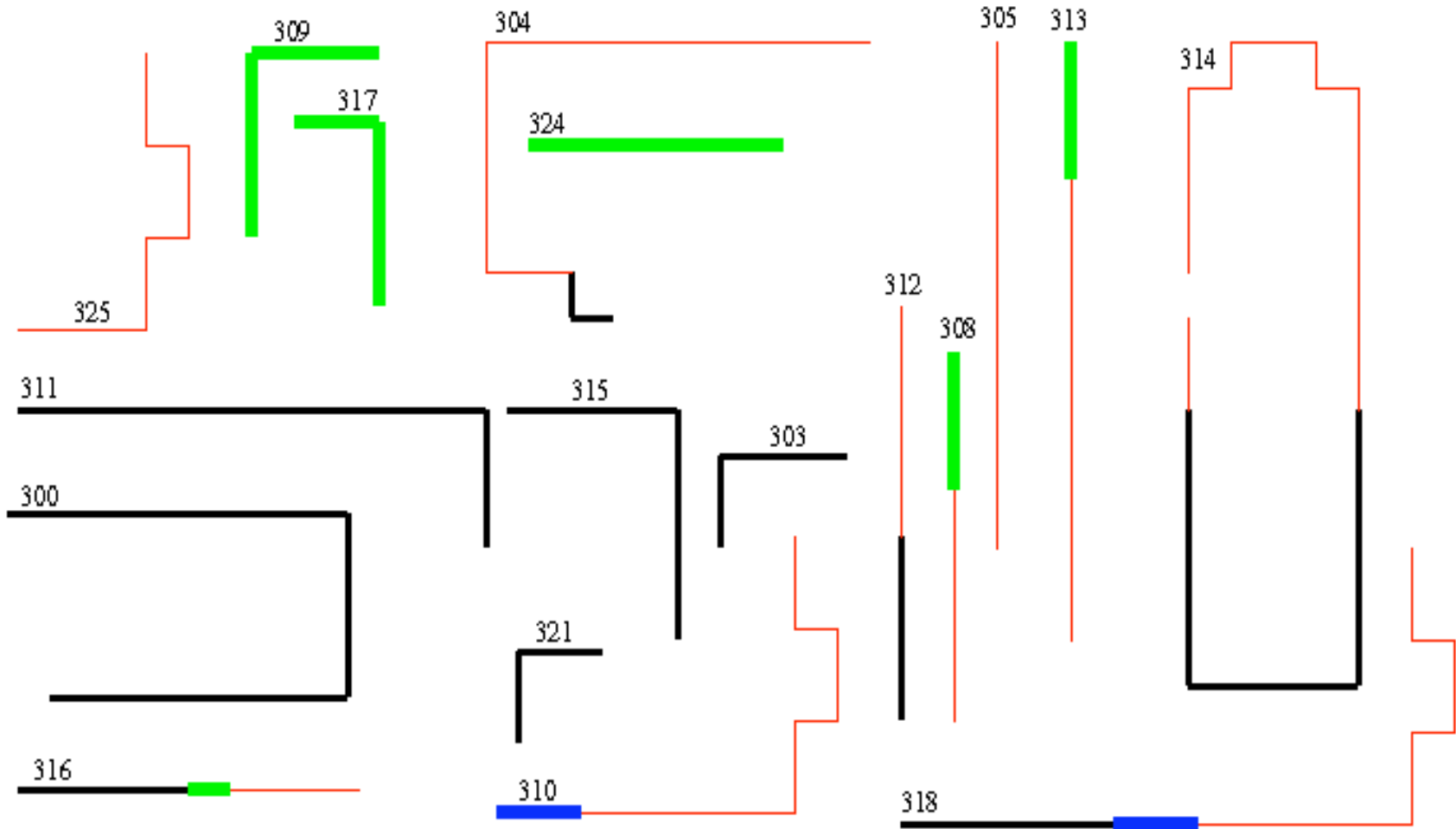


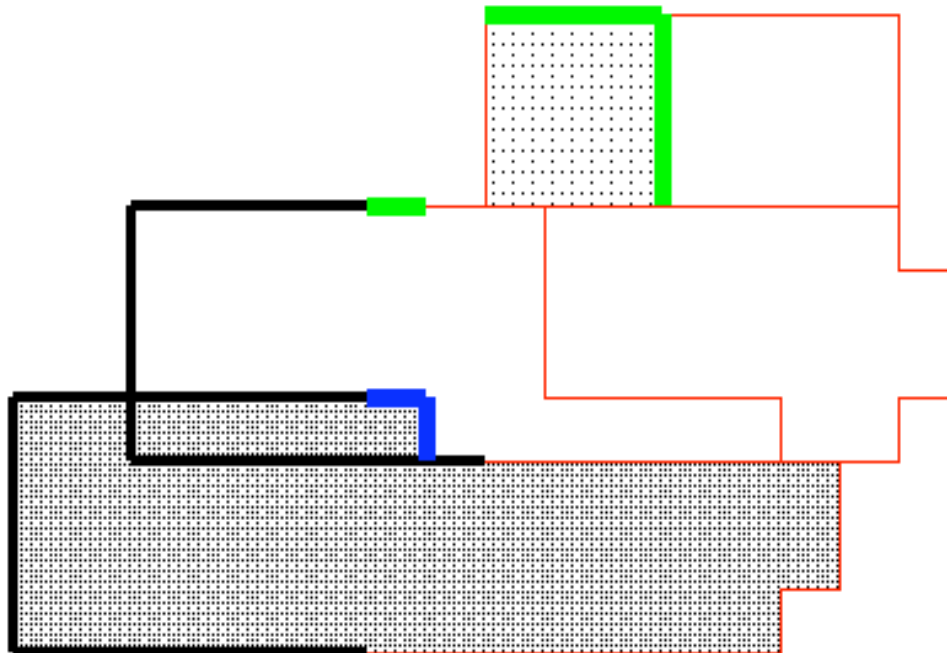


..... Porch
 Service
 Living
 Fireplace

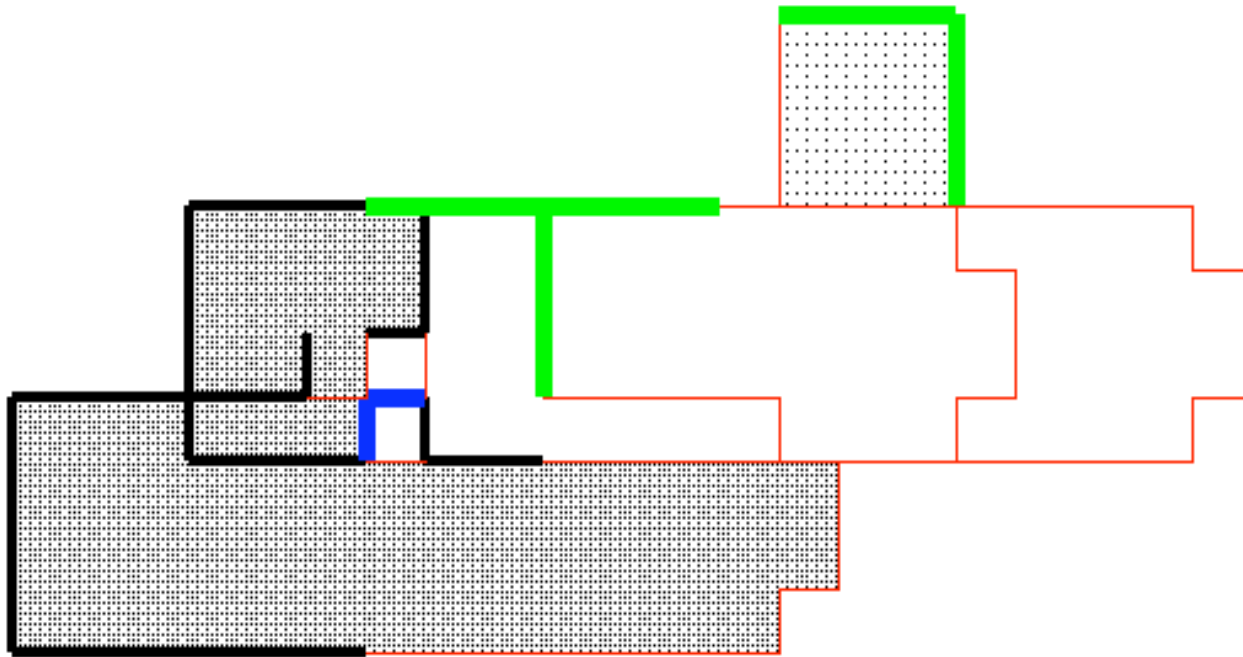


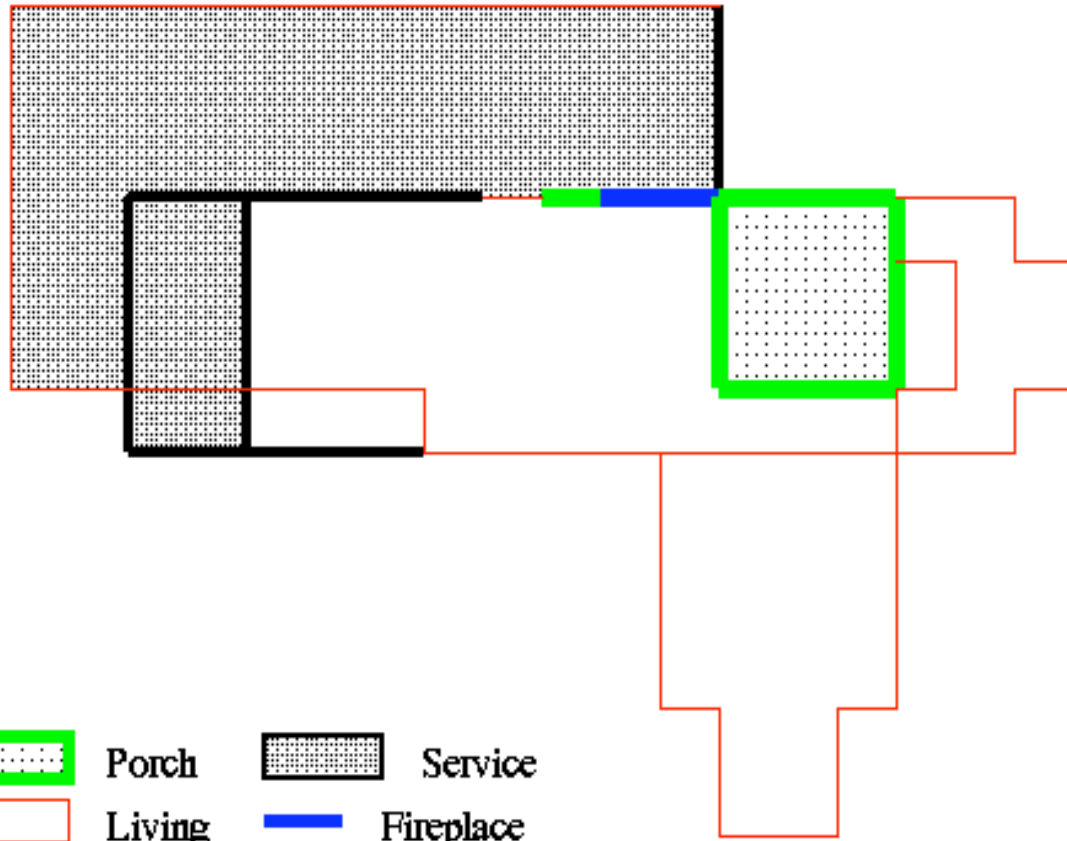




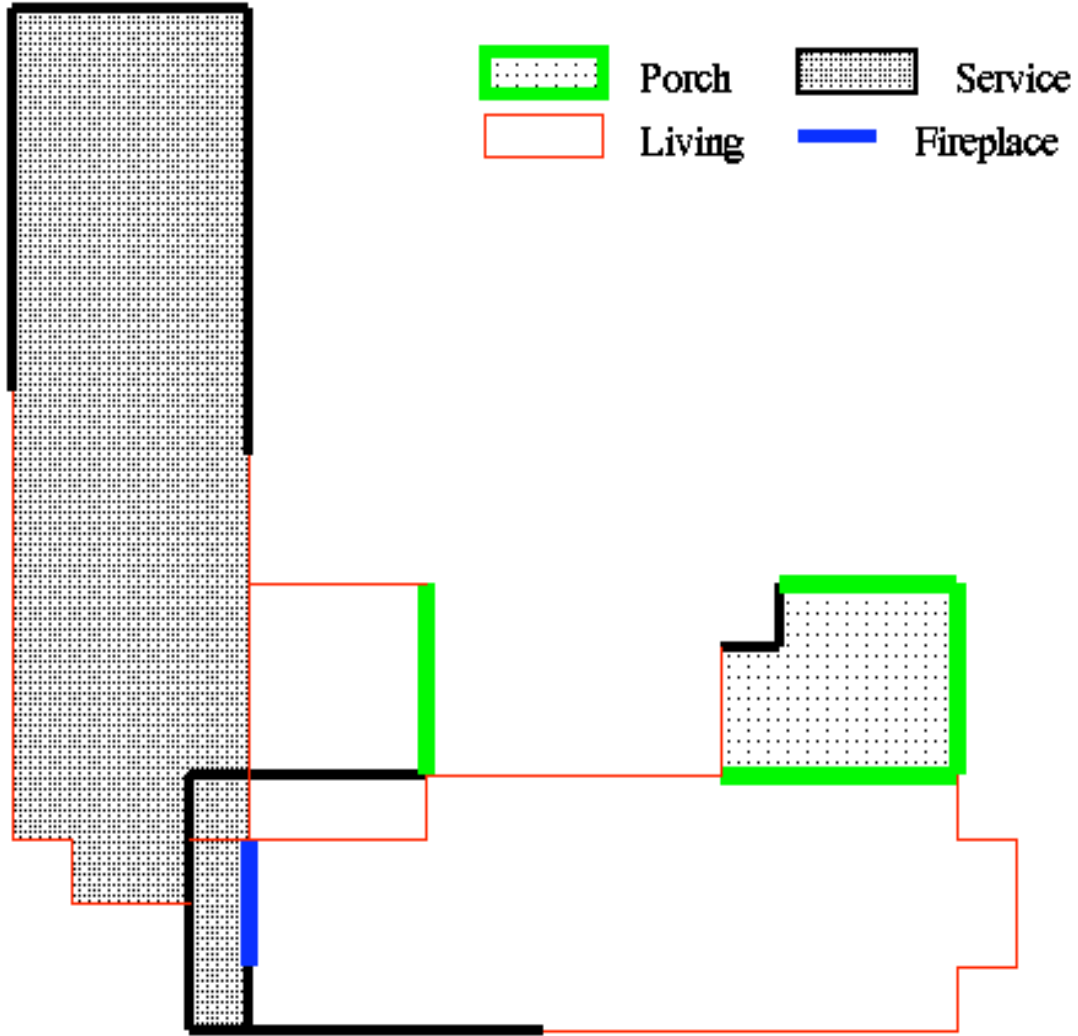


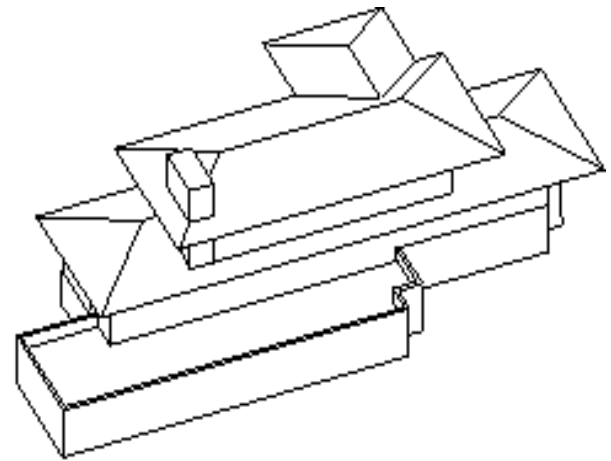
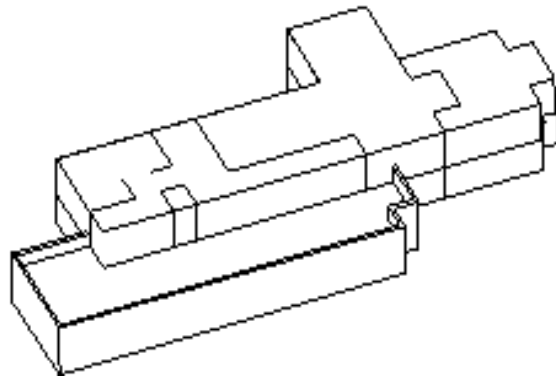
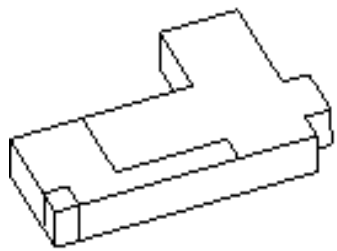
- | | | | |
|---|--------|--|-----------|
|  | Porch |  | Service |
|  | Living |  | Fireplace |

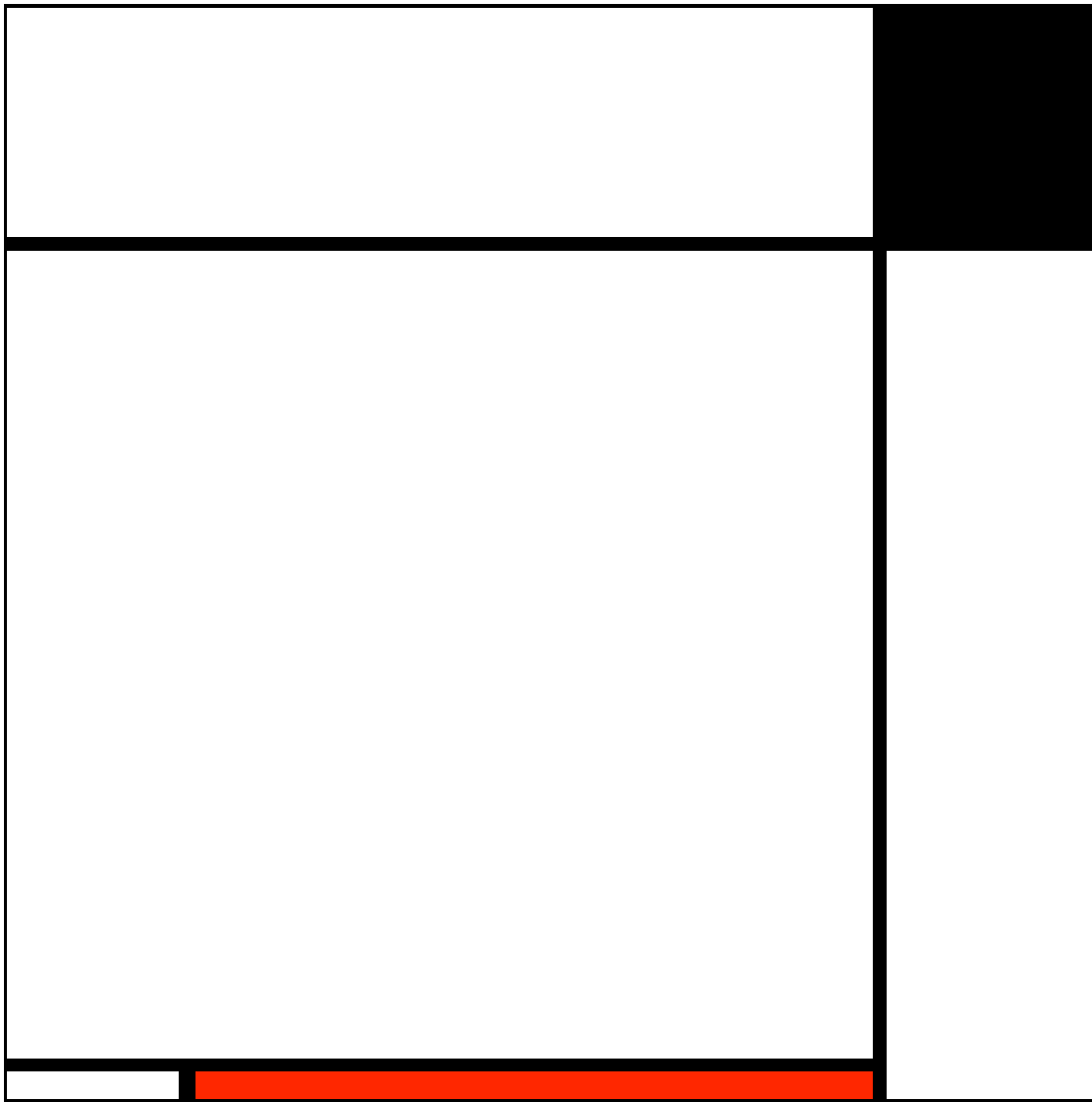




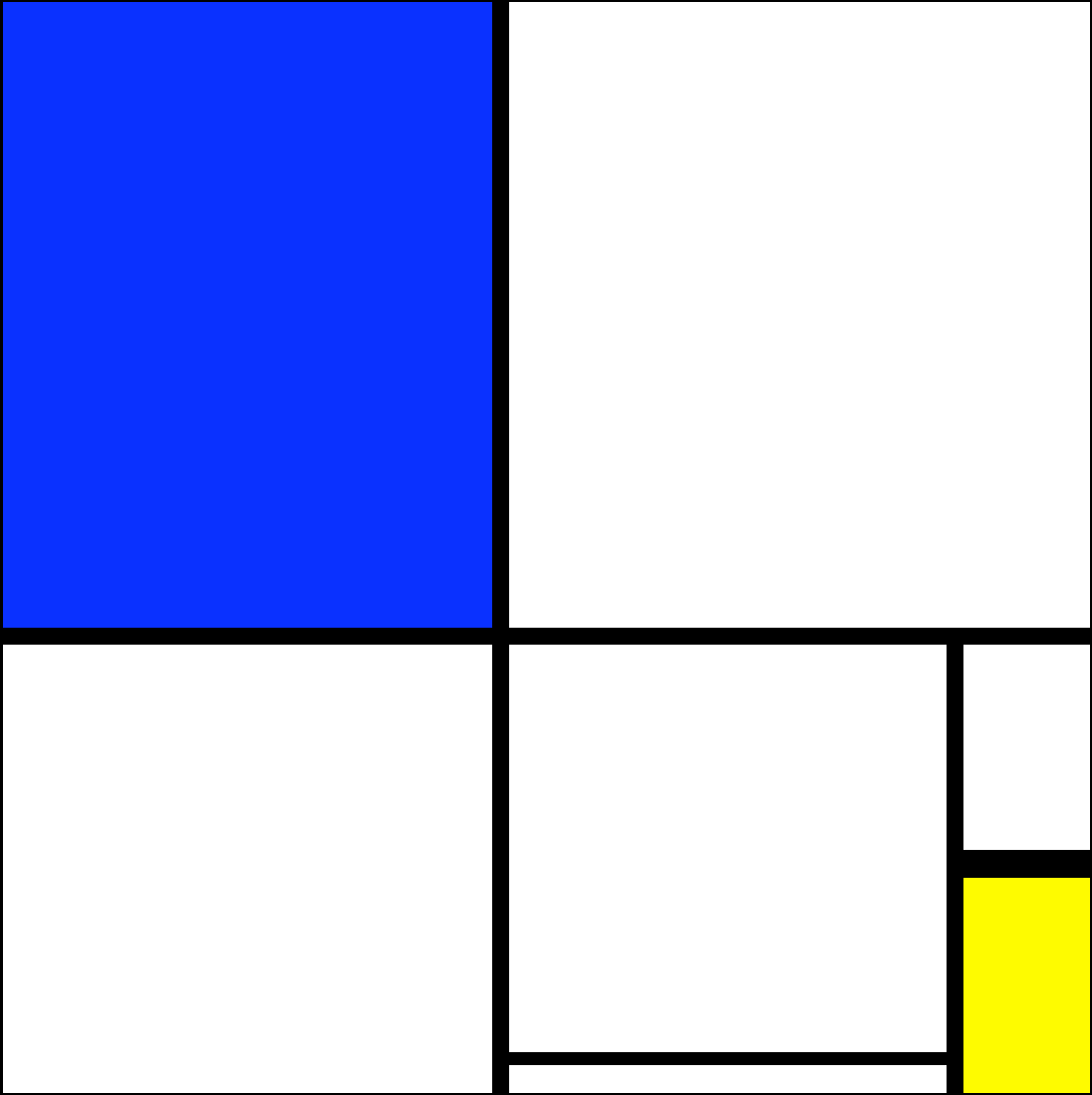
	Porch		Service
	Living		Fireplace







Mondrian

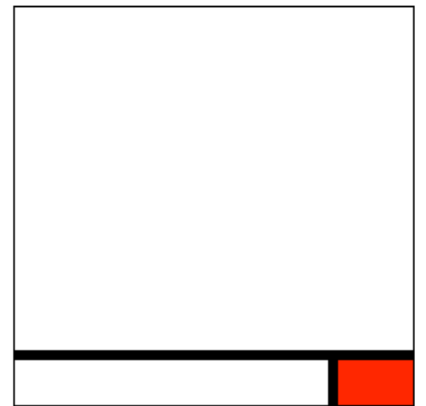
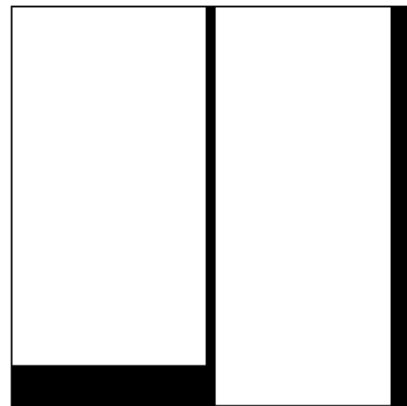
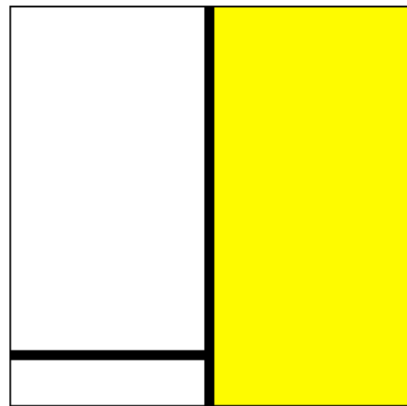
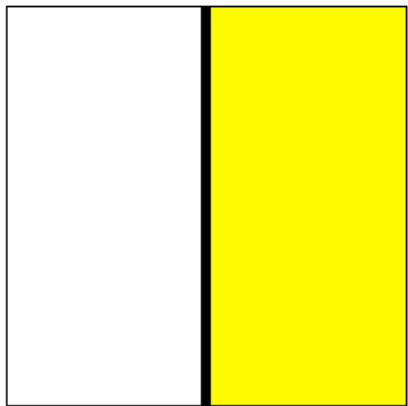
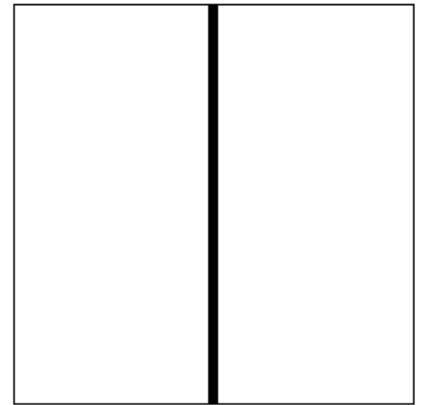
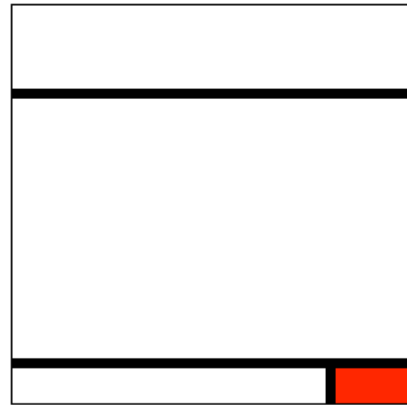
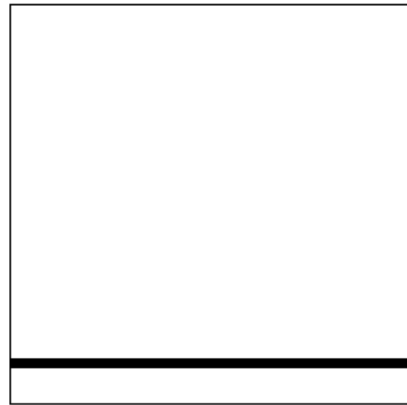
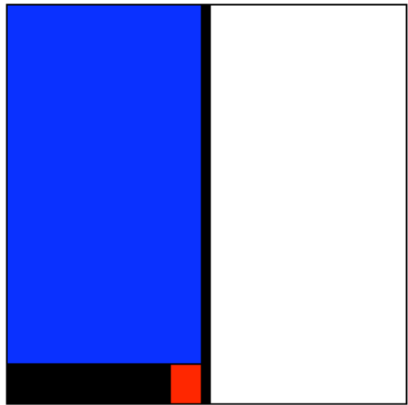
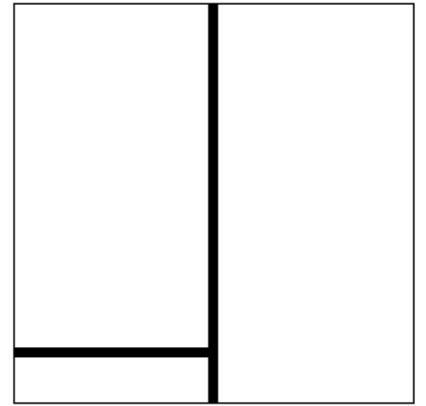
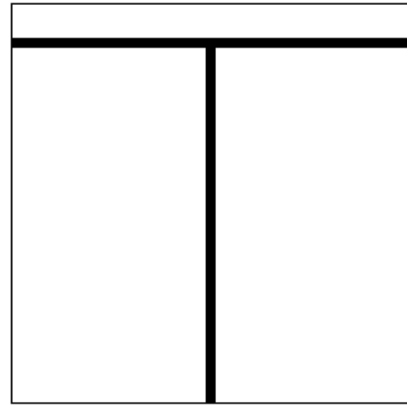
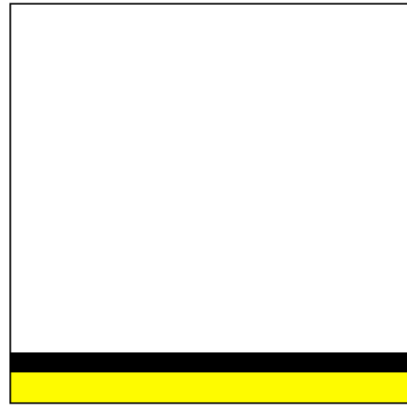
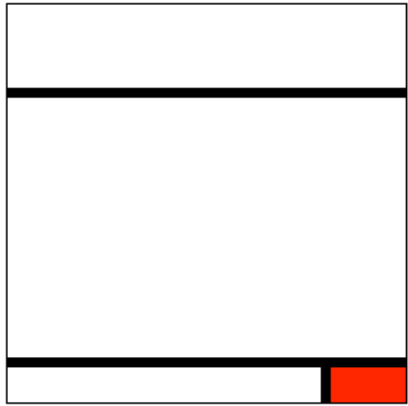


Genotype Form

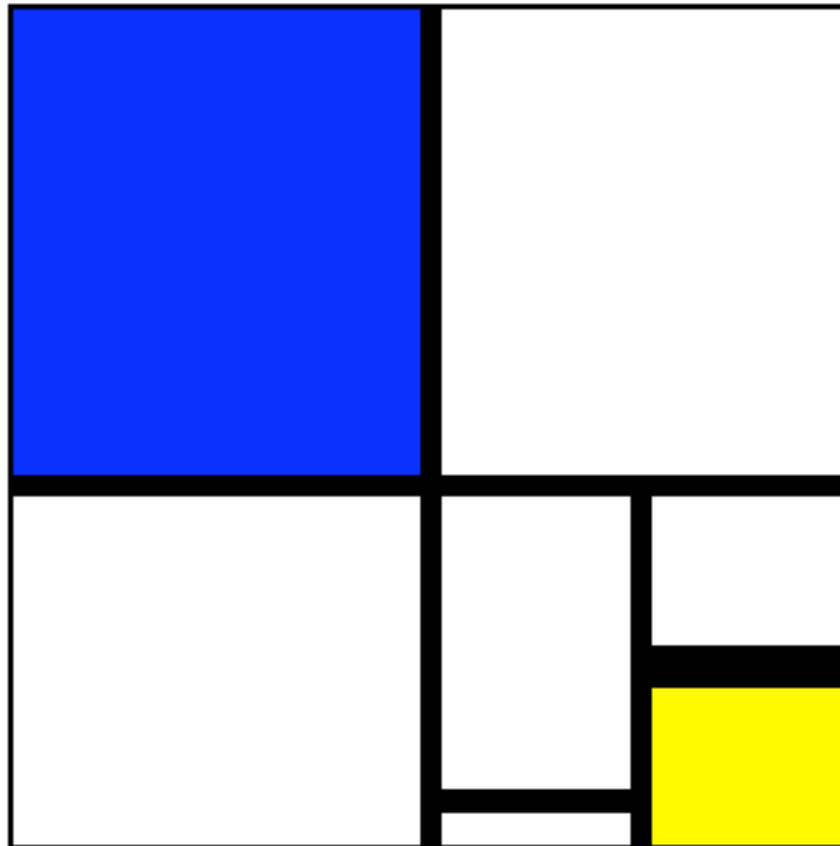
- In form of a tree
- Each node has four variables
 - direction of rectangular split (4 values)
 - fraction of the split (15 values)
 - colour of split area (10 values)
 - line width (3 values)

Fitnesses for Representation

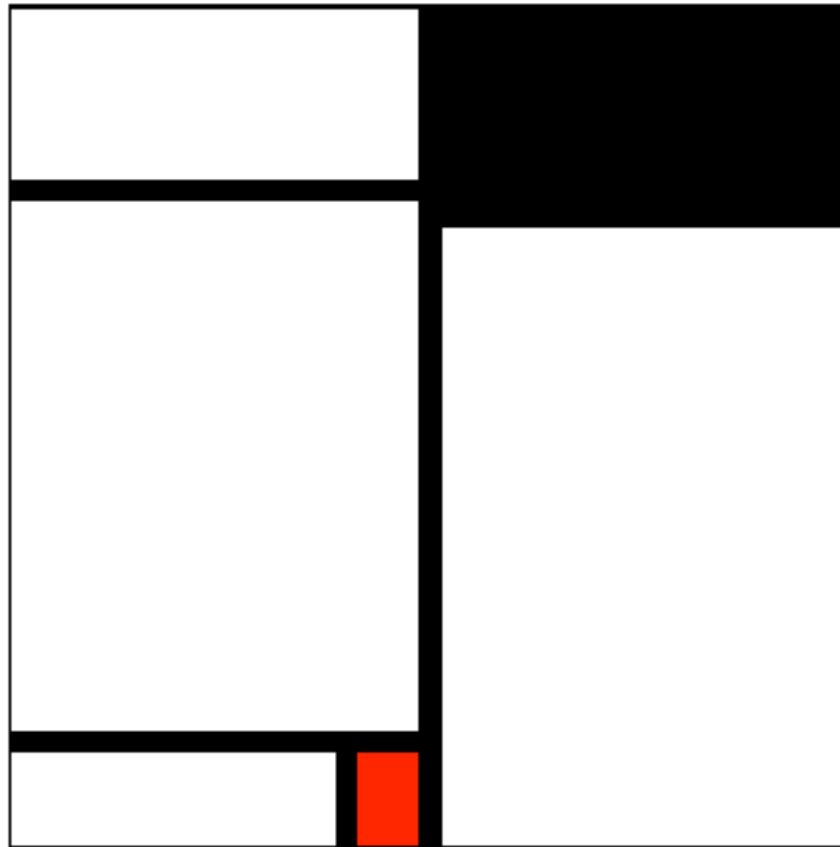
- offset between actual and required positions of dissection lines
- number of lines with correct line width, normalised
- number of correct colour panels, normalised
- number of lines assigned, normalised
- number of unassigned lines, normalised

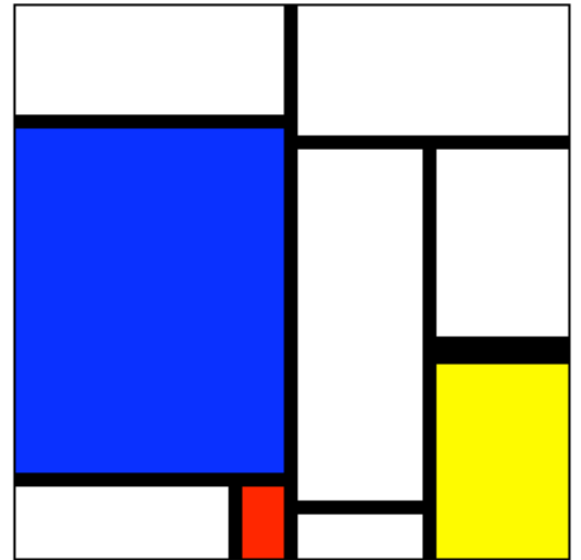
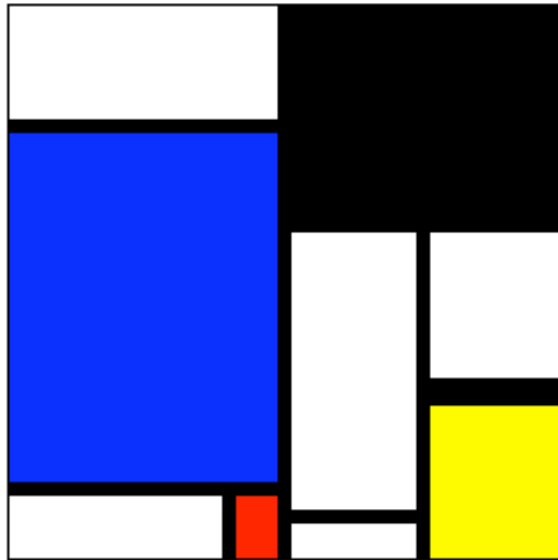
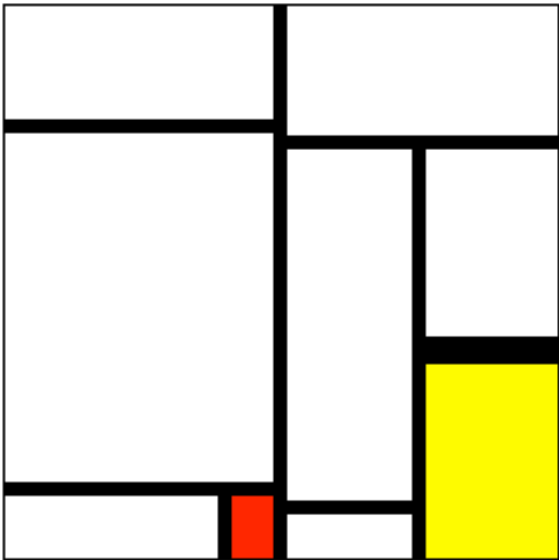
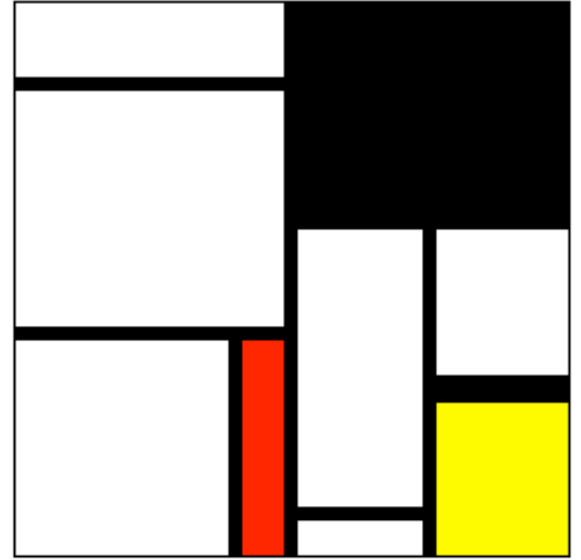
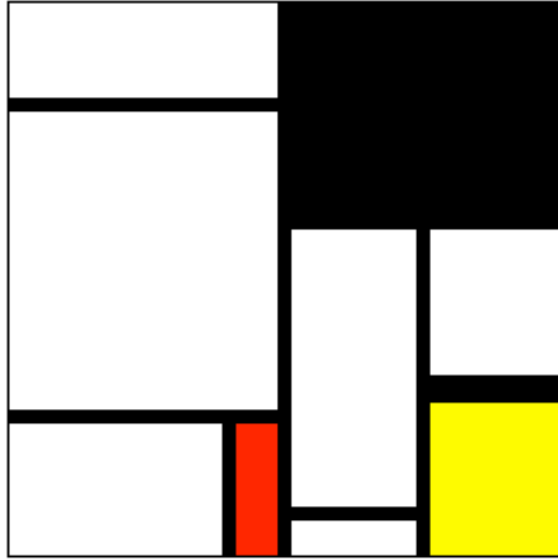
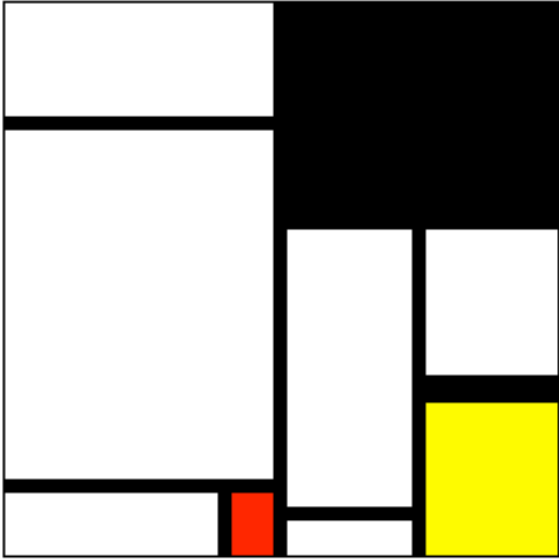


Genetically Engineered Mondrian

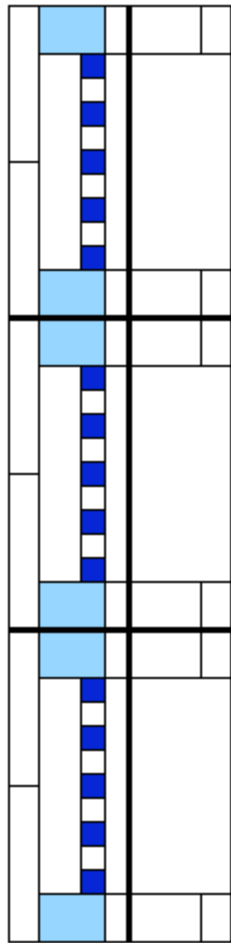


Genetically Engineered Mondrian

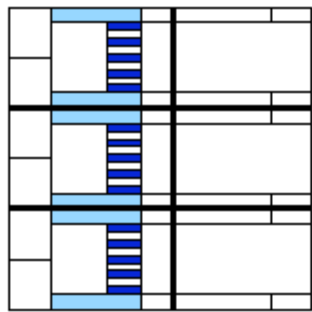




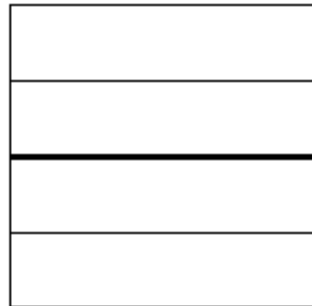
Genetically Engineered Frank Lloyd Wright Windows



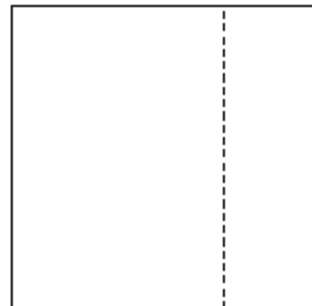
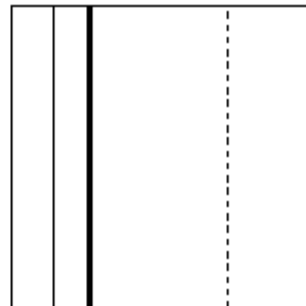
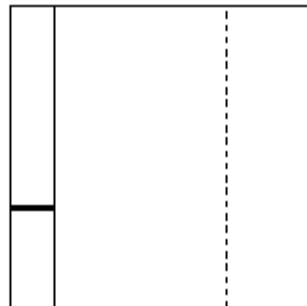
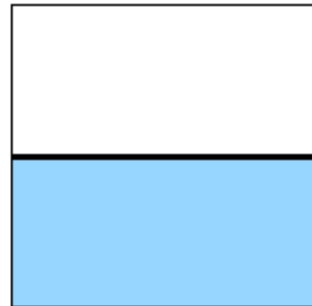
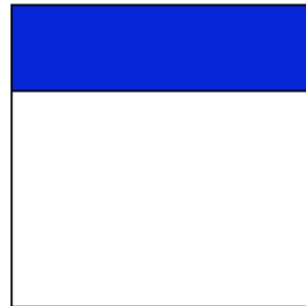
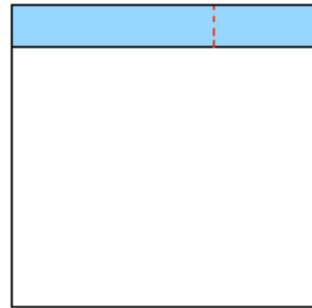
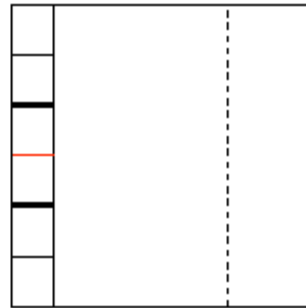
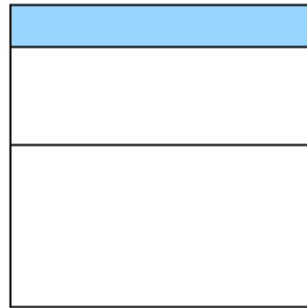
(a)



(b)

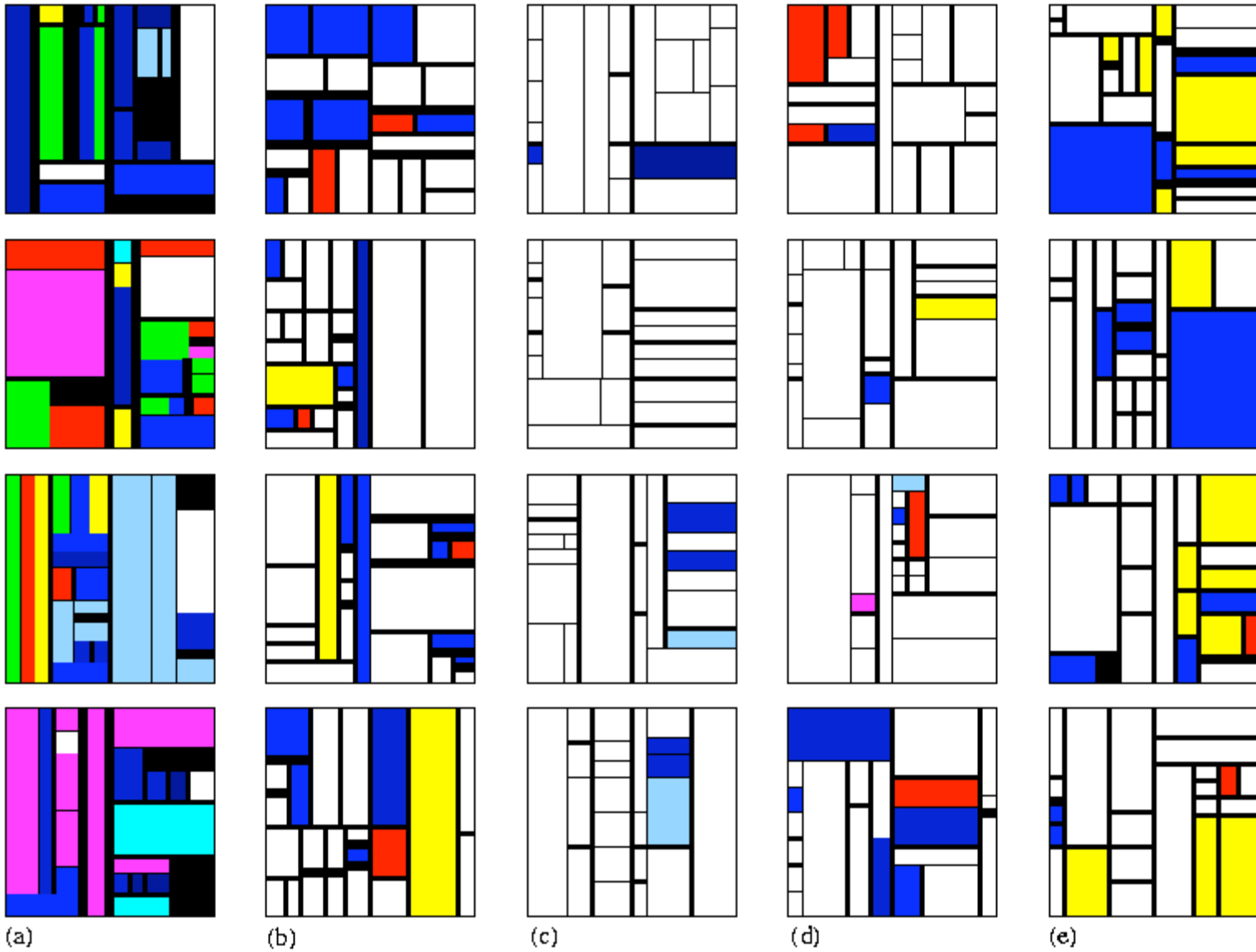


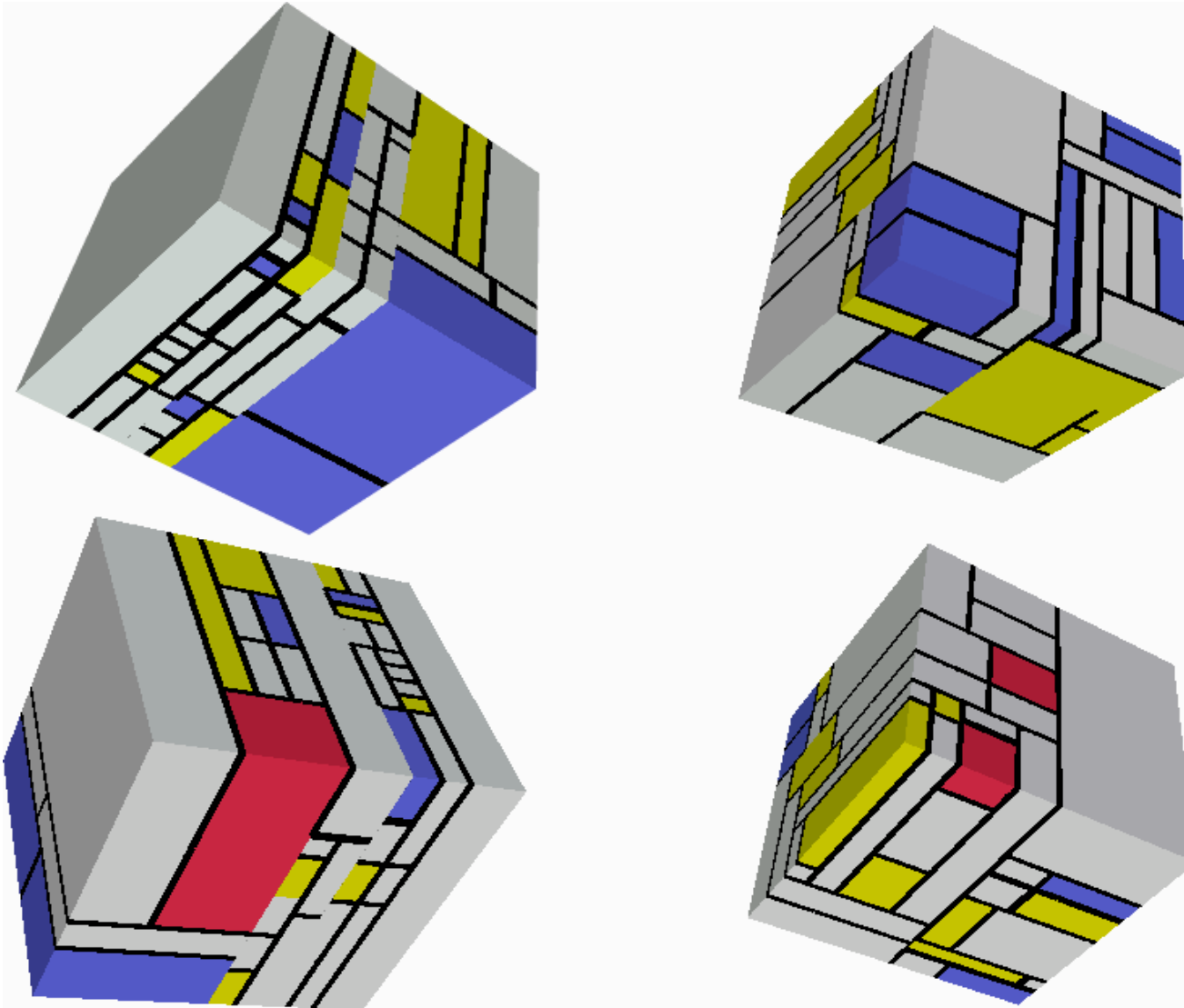
(c)



Flondrians

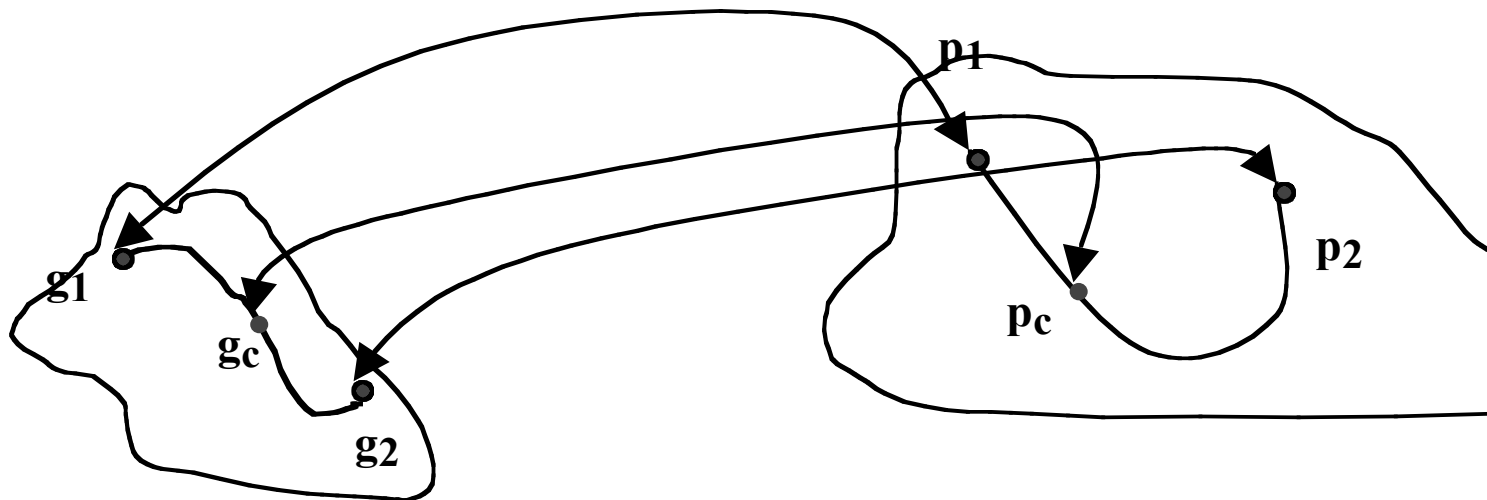
- Mondrian painting \Rightarrow genetically engineered genes: M-genes
- Frank Lloyd Wright windows \Rightarrow genetically engineered genes in same representation: F-genes
- “Flondrians” are the genetic product of mating M-genes with F-genes





How Many Designs Are There and Where Are They?

Genetic crossover as an interpolation



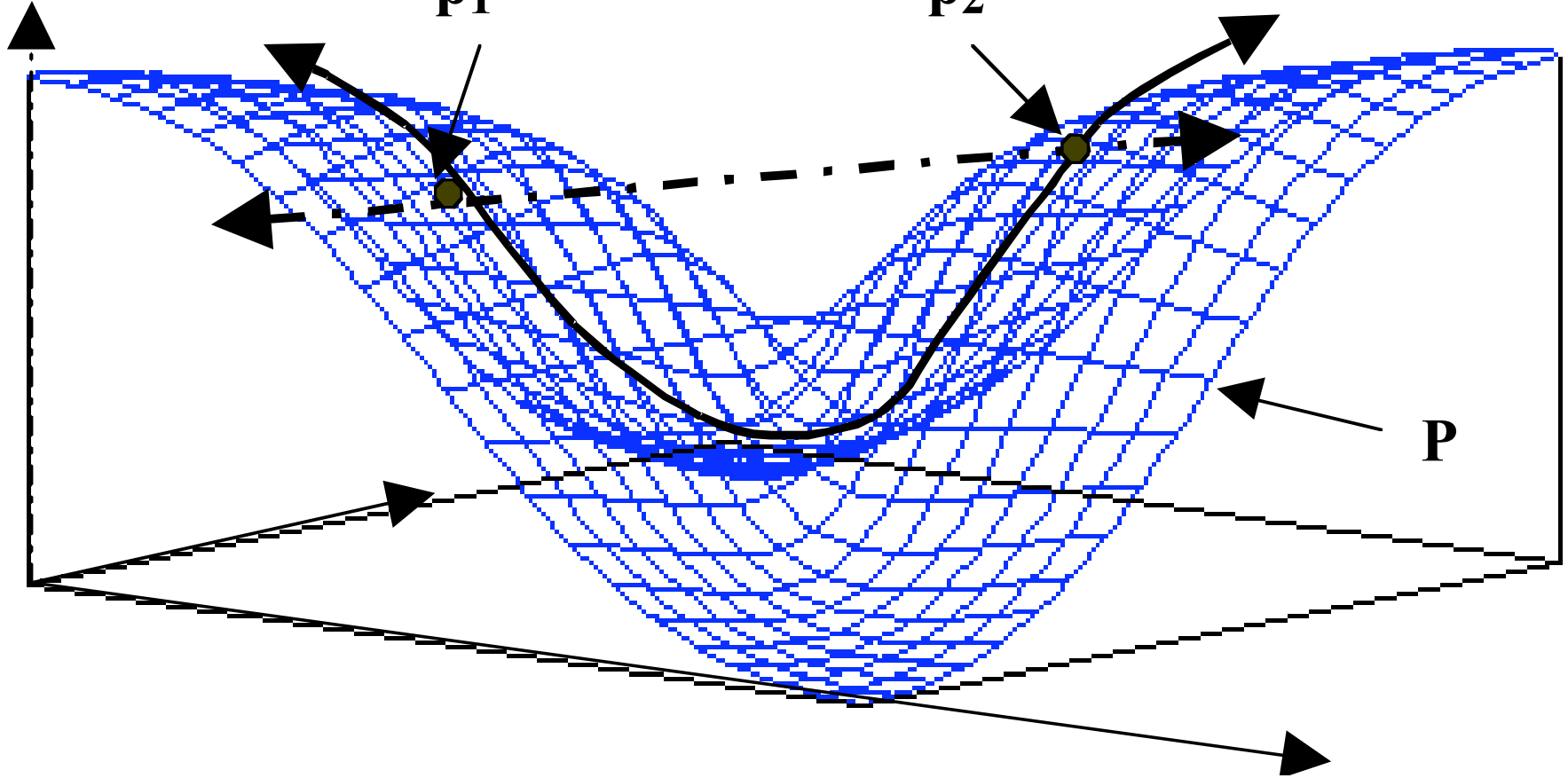
Genotypic space G

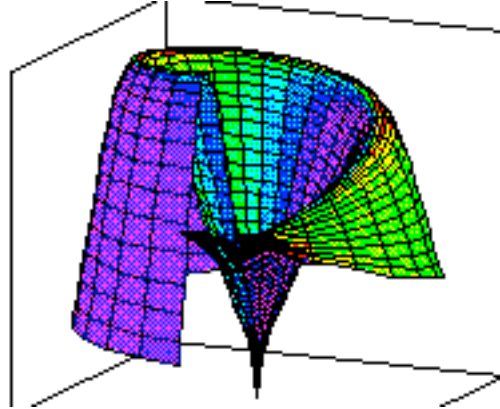
Phenotypic space P

$$C(g_1, g_2) \square g_c$$

$$C(p_1, p_2) \square p_c$$

P+



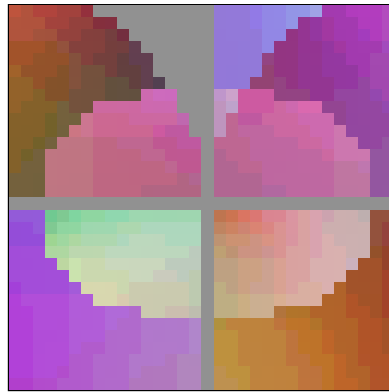


MIT Design Inquiry

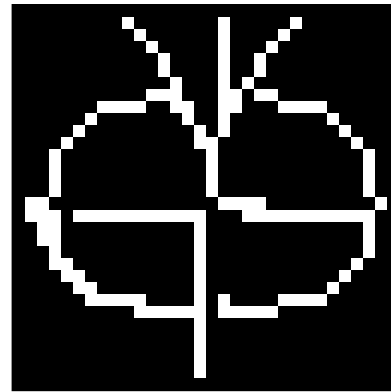
(interactive Genetic Art III)



Image detection

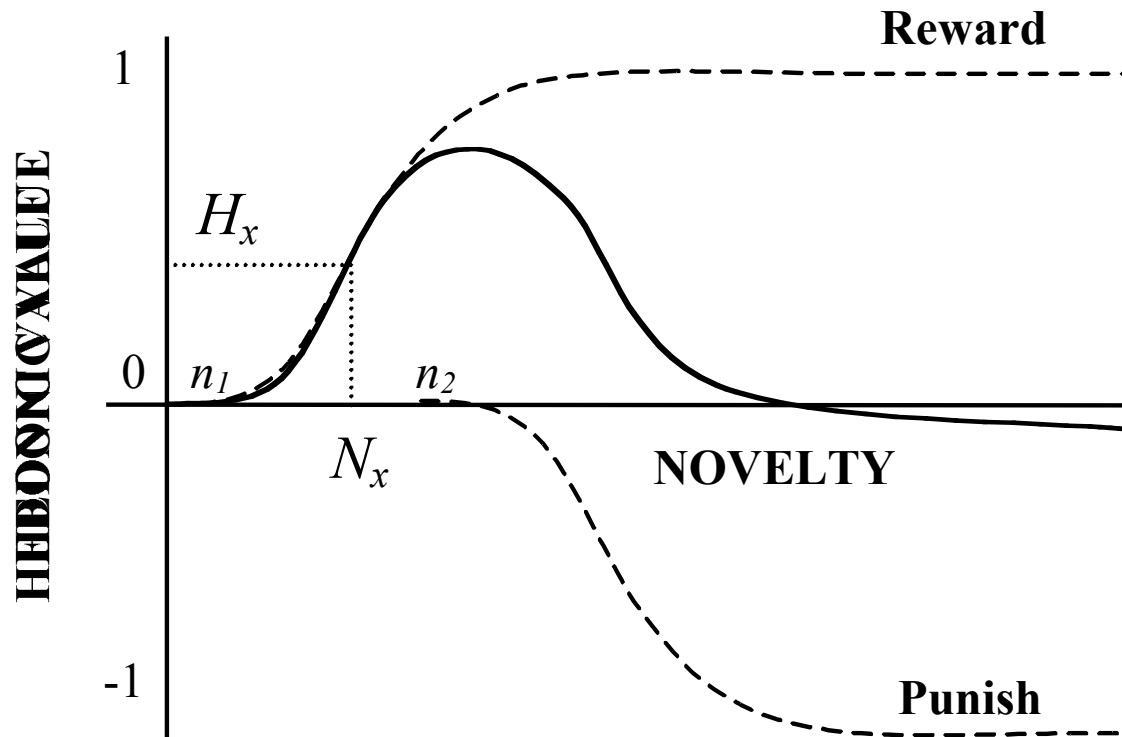


(a)



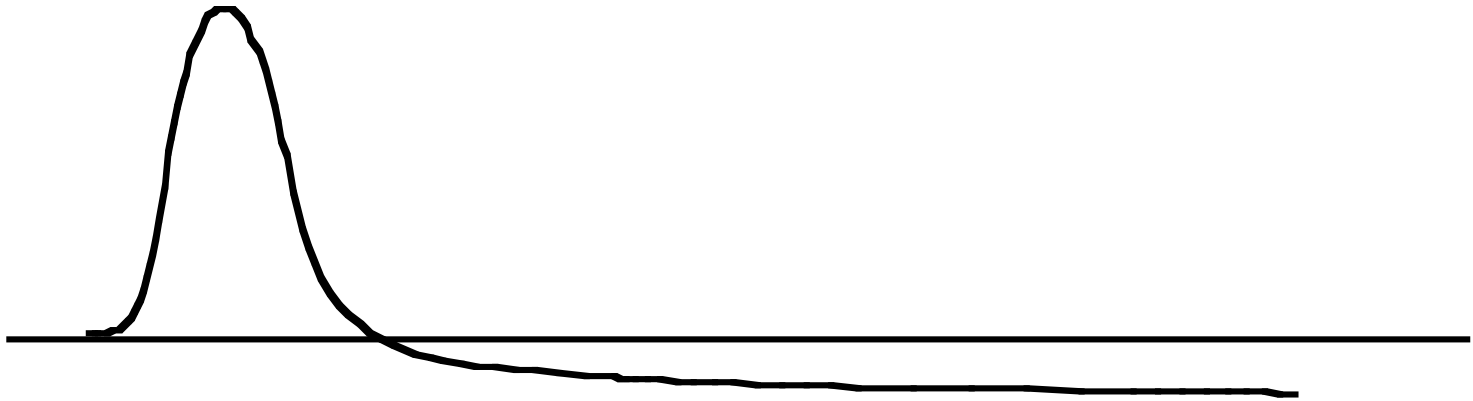
(b)

Modelling Interest



Berlyne's model of arousal based on novelty using Wundt curve

Different novelty functions



Different novelty preferences

