Frequency Landscapes

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Evolution of Regulation

- Gene interaction networks
- Topologies reflect adaptation to their environment - biological computation and problem solving
- Mechanisms for long-term evolution of these control networks
- Control networks coupled to Metabolism
- Out-of-equilibrium adapting in the landscape

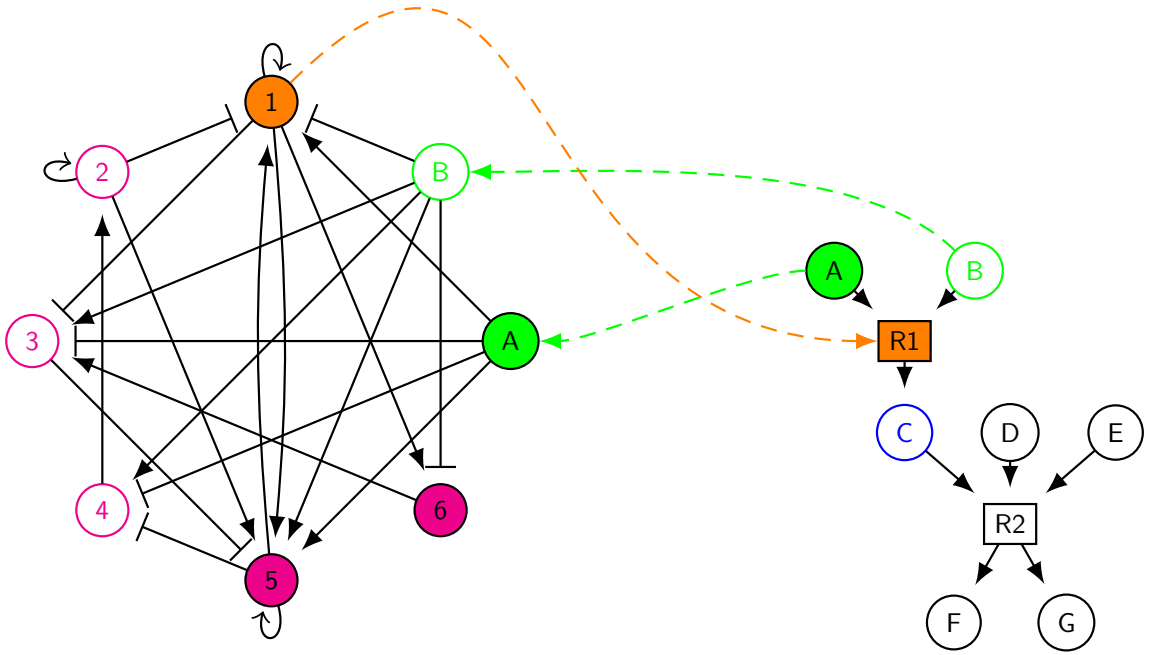
Boolean Networks

- Boolean Networks as Models for gene interaction networks
- Several boolean functions can be used, we focus only on threshold functions
- Every node i has a state σ_i^t at time t and they are synchronously updated according to the Heaviside function

$$\sigma_i^{t+1} = \Theta(\sum_j \omega_{ji}\sigma_j^t - \theta_i) \tag{1}$$

Coupling two Networks

- Two different directions: Signalling and Catalysis
- Gene regulatory network senses metabolites present in the environment and respond to them

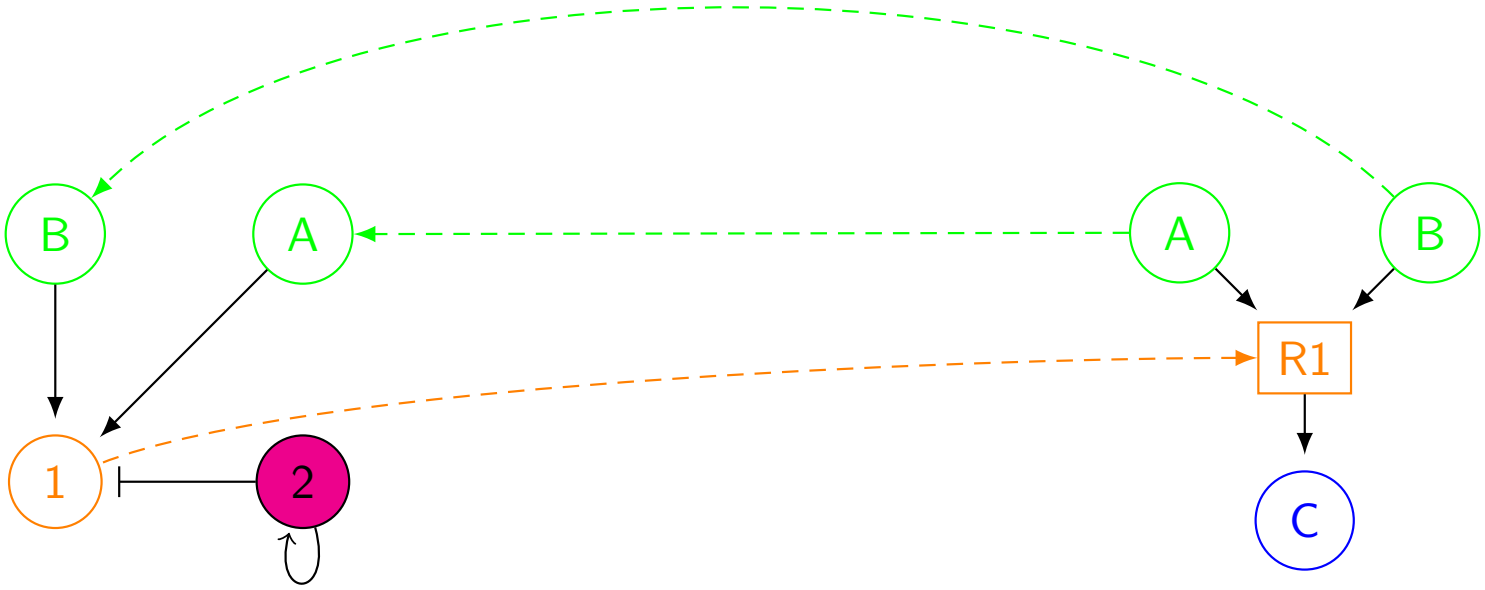


Population Dynamics

- Population dynamics and Evolution
- Biomass accumulation, enzyme fraction penalty and division threshold
- Fitness is implicitly defined

Learning AND function

- In this setting, the selective pressure to learn depends on the environment
- Oscillating environment forces population to learn AND function



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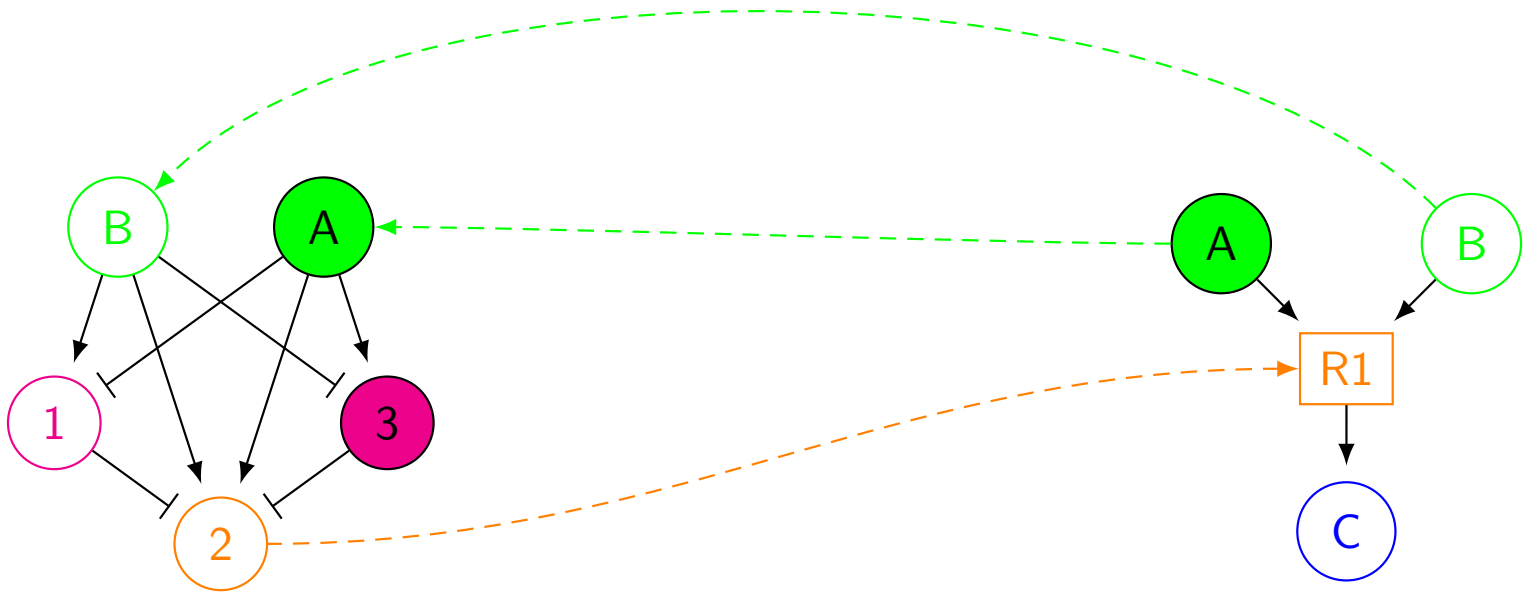

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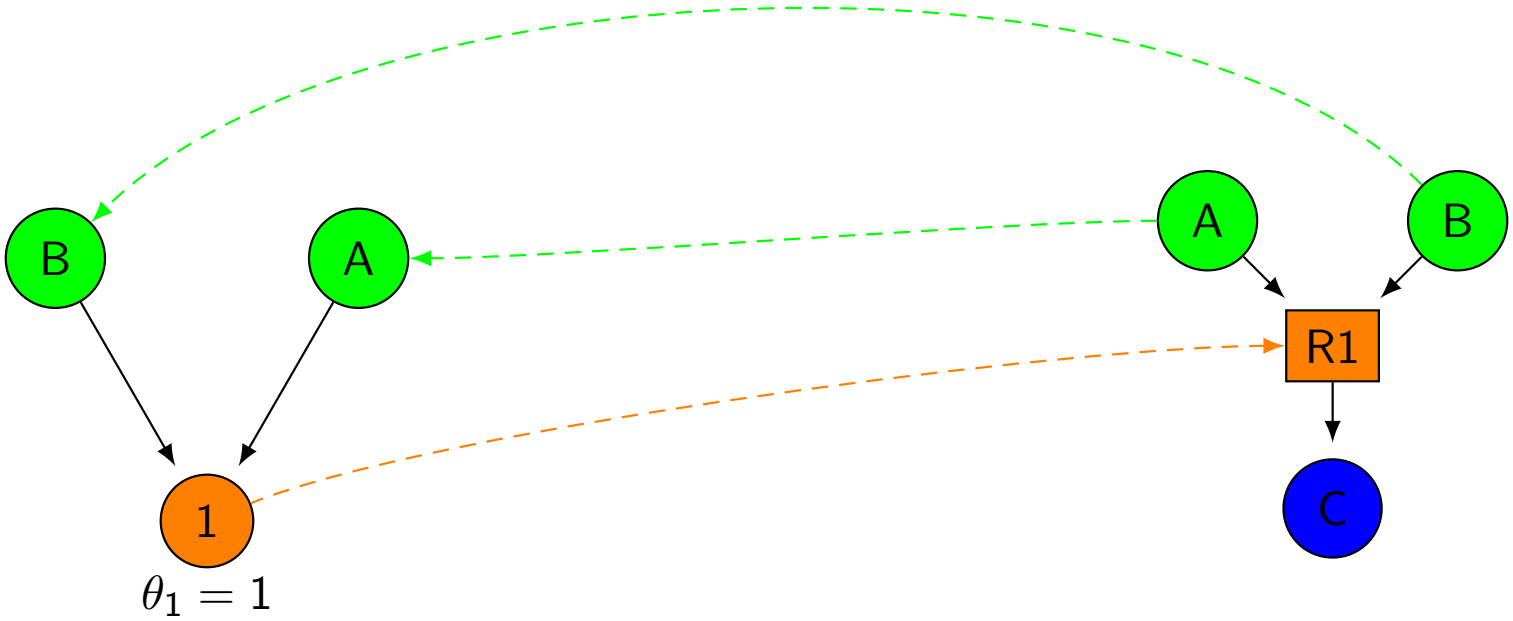
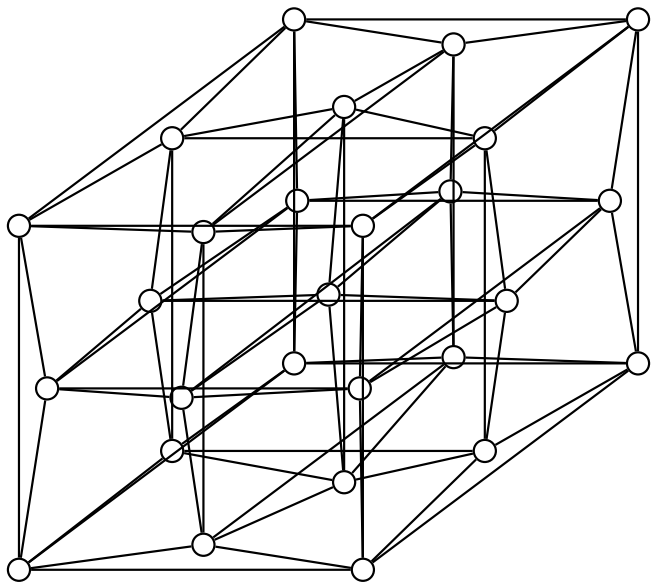


Landscape

- The landscape topology is defined, but the fitness of each genotype depends on the environment
- For an oscillatory environment, the best solution will be the AND function
- The topology is a cartesian product between a Hamming graph and a path graph



Genotype to Phenotype Mapping

- Mapping also depends on environment - timescales
- For the oscillatory environment, 270 different genotypes produce only 8 different phenotype categories