It is interesting to contemplate a tangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent upon each other in so complex a manner, have all been

Natural Selection

“Nothing in Biology makes sense” T. Dobzhansky

Natural Selection

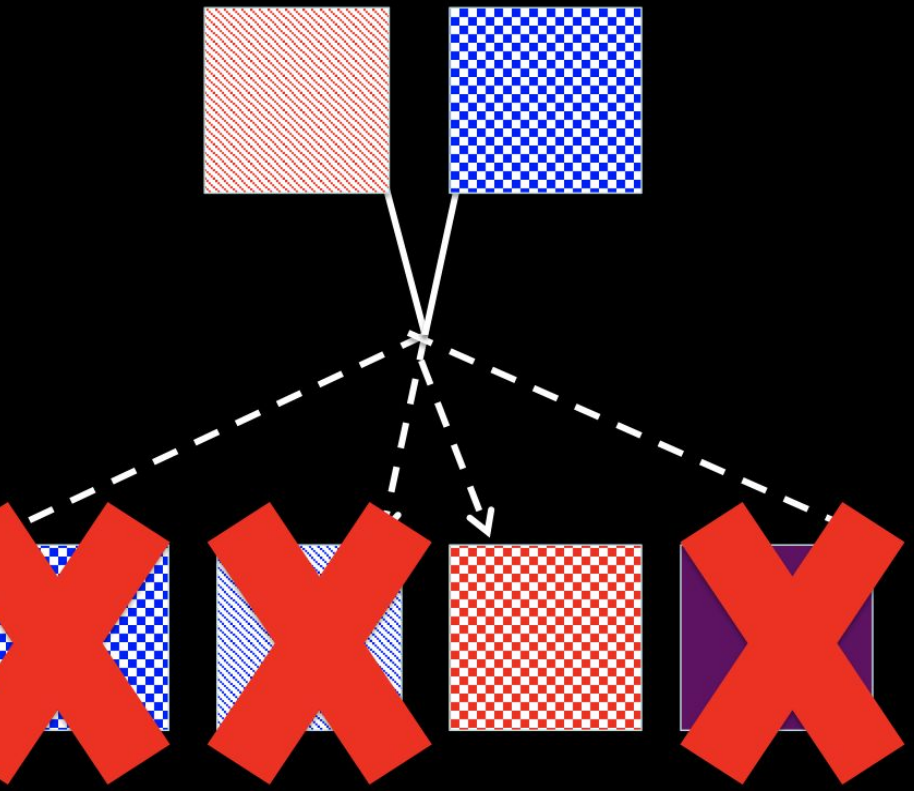
"Nothing in Biology makes sense, except in the light of evolution." T. Dobzhansky

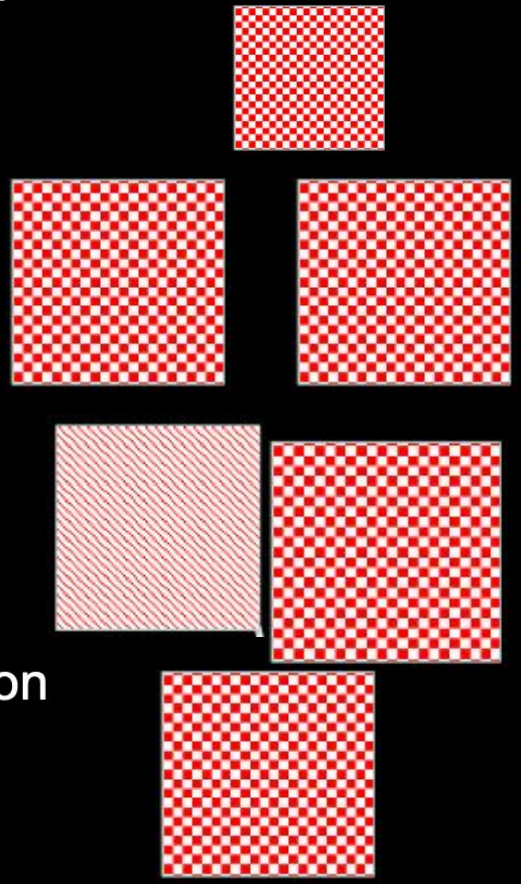
Charles Darwin, 1859, The Origin of Species

3 key ingredients for evolution by natural selection

- Exponential growth of populations
- Struggle for existence: Limited capacity for any population
- **Variable, heritable survival and reproduction**

Evolution by Natural Selection





Variation

Diversity

Inheritance

Mutation &
Recombination

Selection

Environment

Evolution: Key terms

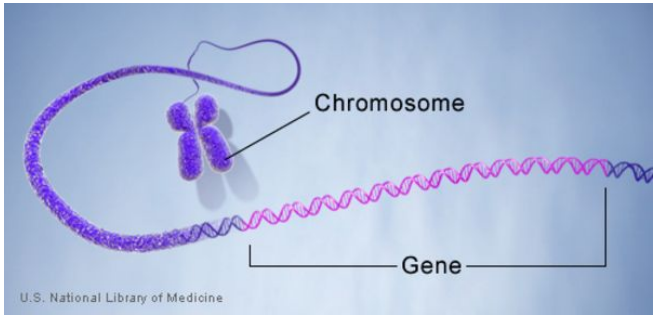
Gene: sequence of nucleotides that encodes the amino acids that form a protein

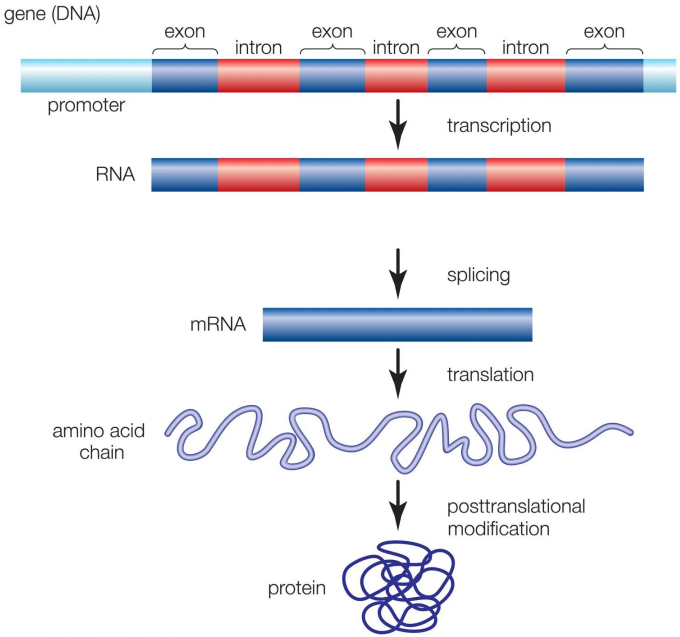
Allele: a variant or “flavor” of a gene

Evolution: change in allele frequency in a population

Evolution by **natural selection:** change due to variable survival and reproduction in an *environment*

Other forms and levels of selection?





Key terms

Gene: sequence of nucleotides that encodes the amino acids that form a protein

Allele: a variant or “flavor” of a gene

Evolution: change in allele frequency in a population

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Other forms and levels of selection?

- Artificial
- Sexual
- Group
- Cultural
- Market (?)

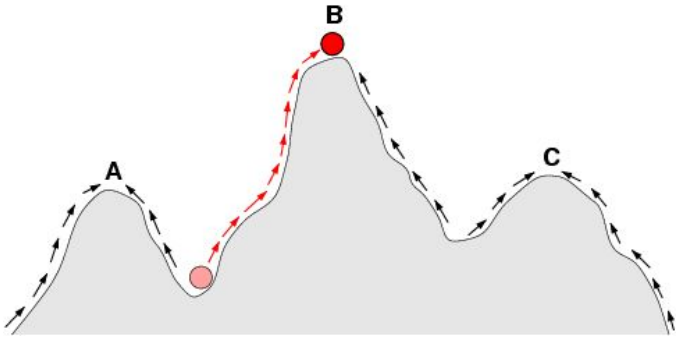
Alleles are like flavors

Is this evidence of selection?

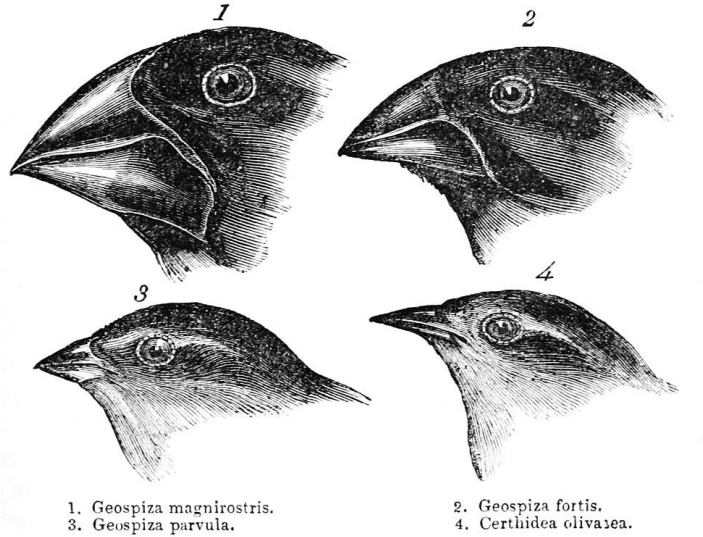
Produced by StableDiffusion

Evolution: Foundational ideas

- **The Modern Synthesis** (Mayr, Fisher, Wright, Haldane): Mathematical explanation for how observed rates of evolution arise from gene frequency
- Gene-centric view of evolution. *The Selfish Gene* and the *Blind Watchmaker* (Dawkins) How can complex things be designed without a designer?
- **Punctuated equilibrium (Gould and Eldridge) and allopatric speciation**
- Gene regulatory networks
- Evo-Devo



Fitness landscape



Punctuated equilibrium: evolution is gradual until some event (e.g. geographic isolation) causes new species to suddenly arise. What else could cause sudden speciation?

Evolution: Foundational ideas

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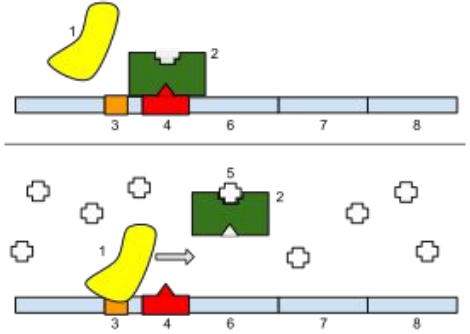
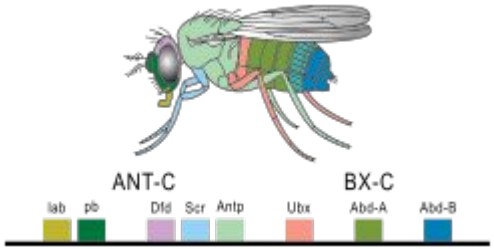
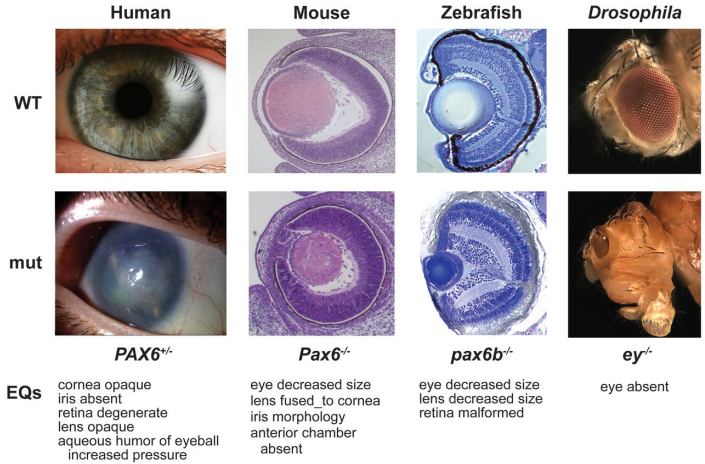


The lac operon. Top:Repressed, Bottom:Active
1: RNA Polymerase, 2: Repressor, 3: Promoter, 4: Operator, 5: Lactose, 6–8: protein-encoding genes, controlled by the switch, that cause lactose to be digested



Hox genes controls where and when genes turn on during development



Pax-6 gene controls development of eyes across animals

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

Evolution: Foundational id

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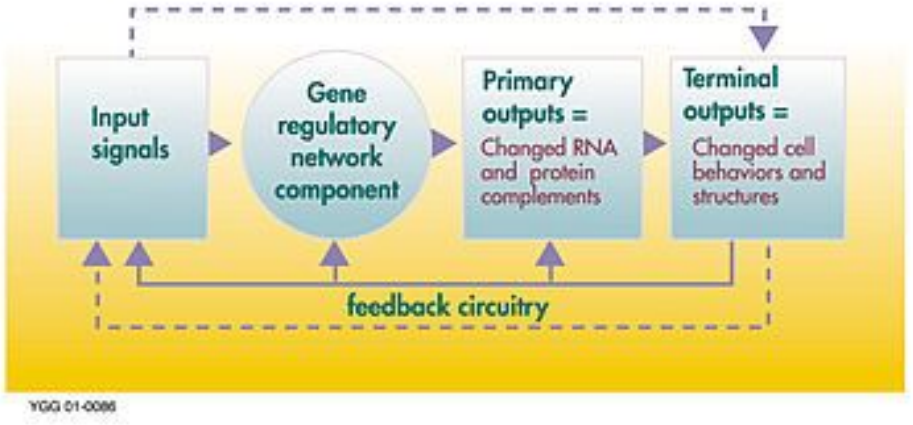
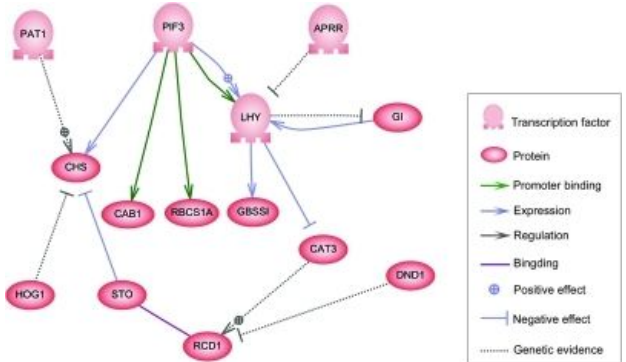
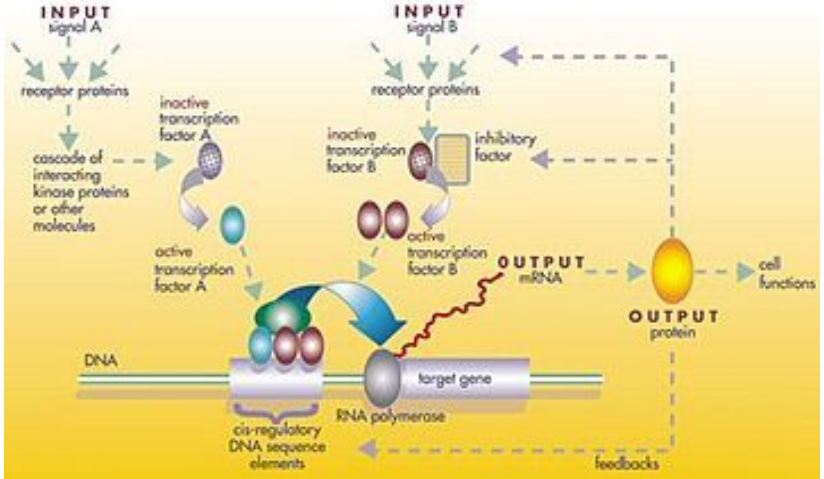






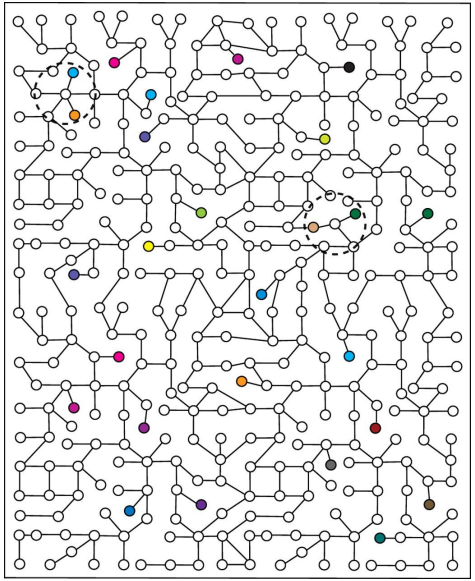
Evolution Complexified

Adjacent possible - Stuart Kauffman

“**the set of possibilities available to individuals, communities, institutions, organisms, productive processes, etc., at a given point in time during their evolution**” (Loreto 2015, p. 9).

Neutral networks **the set of genes related by single mutations that have equivalent fitness**

Fitness value of information (Donaldson-Matasci & Bergstrom)
The fitness value of information associated with a cue or signal is **the greatest fitness decrement or cost that would be favored by natural selection in exchange for the ability to detect and respond to this cue**



Connected genotype networks facilitate accessibility of diverse phenotypes.

Wagner A Proc. R. Soc. B 2012;279:1249-1258

Evolution Complexified

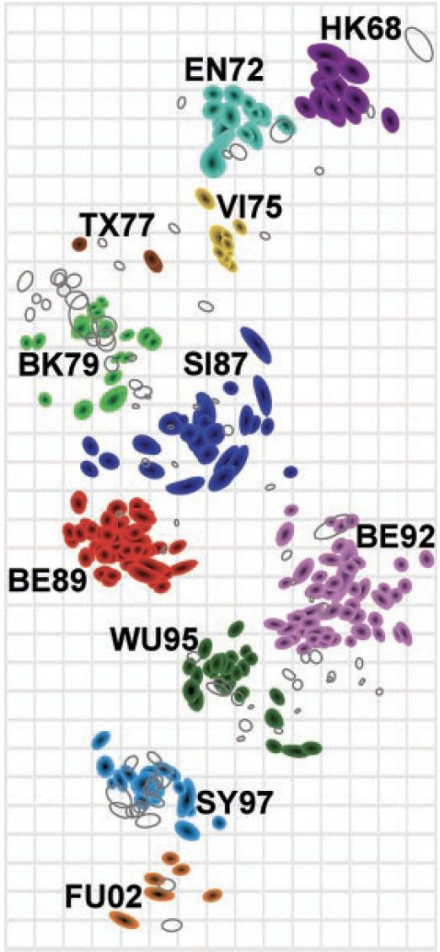
Evolution of, and in, immunity

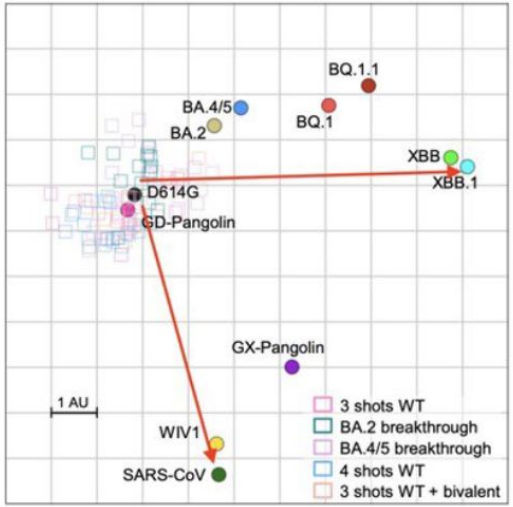
Antigenic evolution

Evolution occurs through both random and deterministic processes

How does evolution generate high complexity? Measured as effective complexity?

How does evolution process information? Who pays the cost of that information processing? Is evolution an effective parallel terraced scan?





https://www.cell.com/cell/fulltext/S0092-8674(22)01531-8

Group Quiz/Review

1. What is the best idea anyone has ever had (according to Mitchell, according to Daniel Dennet?)
   It was also an idea “in the air”
2. What is the Central Dogma?
3. What are Transcription, Translation?

4. Define fractal dimension
5. What is a “Frozen accident” (according to Gell-Mann)
6. Define Effective Complexity and Kolmogorov complexity

7. What are reasons the Central Dogma is an incomplete explanation of how genes are turned into proteins?

8. What is an antigenic map?
9. What is a neutral mutation (think about the mapping of codons to amino acids)?
10. What is a neutral network, and why is it important?

Does evolutionary theory need a rethink?

Define and explain:

- Phenotypic plasticity
- Developmental bias
- Niche construction
- Inclusive inheritance (non-genetic inheritance)

List the key points from each side

1. *Needs a rethink: Without an extended evolutionary framework, the theory neglects key processes*

2. *Existing Theory is adequate: Theory accommodates evidence through relentless synthesis*