Abiogenesis, Genetic Drift, Neutral Theory, and Molecular Clocks
The history of evolutionary thought

- Charles Darwin and the Origin of Species (1859)
  - Georges Cuvier (Catastrophism)
  - Thomas Malthus (Density Dependence)
  - The Struggle for Existence
  - Survival of the *Fittest*
  - Selection of Traits Associated with *Fitness*
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- A side note on Alfred Wallace
  - Wallace independently derived the idea of evolution from biogeography.
  - Biogeography is the study of how organisms are geographic distributed.
  - Geographic speciation (covered next week) is easier to study in the fossil record.
The history of evolutionary thought

- The Darwinian model of evolution was met with disbelief
  - The general public was skeptical of the whole thing
  - The scientific community did not accept natural selection
Early alternatives to Darwin

- Saltationism

- Hugo Dervries and Mendel
  - Chromosome – the blueprints necessary for building an individual
  - Pangene – the subset of a chromosome that controls a particular trait.
Early alternatives to Darwin

- Saltationism
  - Richard Goldschmidt and the hopeful and hopeless monsters.
  - Proposed that mutations in “rate genes” were the principle driver of speciation.
Early alternatives to Darwin

- **Mutationism**
  - Thomas Hunt Morgan realized that mutations – of the type DeVries was describing – did not necessarily create a new species.
  - Morgan bred thousands of fruit flies, and tried to create mutants using x-rays, acids, and other toxic substances.
  - Interestingly, it was in one of the control groups that he observed his first mutation, a change from red eyes to white yes.
  - He later learned that he could breed these white-eyed flies back in with the red-eyed flies.
Early alternatives to Darwin

- **Mutationism**
  - Morgan still believed that mutation was the primary force behind evolution, and that natural selection is merely a sieve to save advantageous mutations and eliminate deleterious mutations.
  - Instead of giant leaps though, he believed in continuous small-scale mutation.
  - The problem with this was that most observed mutations are deleterious, which made people doubt that mutation alone could lead to advantageous changes.
  - Neutral Mutation – “If the new mutant is neither more advantageous than the old character, nor less so, it may or may not replace the old character, depending partly on chance: but if the same mutation recurs again and again, it will most probably replace the original character.”
Early alternatives to natural selection

- Senescence
- John Christopher Willis
- Age-Area Hypothesis
Early alternatives to natural selection

![Graph showing the relationship between geographic range size and time (myr). The graph illustrates how different species, represented by colored lines, progress in terms of geographic range size over time. Each line corresponds to a different species or group, with the x-axis representing time in million years (myr) and the y-axis representing geographic range size. The colors and labels indicate the oldest and youngest species or groups, with the oldest on the right and the youngest on the left.](image-url)
Early Alternatives to Darwin

Directionalism

Edward Drinker Cope’s Law of the Unspecialized – The primitive form comes before the more advanced form.
Early alternatives to natural selection

- Directionalism
  - Jean-Baptiste Lamarck
  - Even Darwin believed in a weak form of Lamarckism
Modern evolutionary synthesis

- Wright, Haldane, Fisher
  - Haldane – Originator of primordial soup model
  - Fisher – The most influential scientist of the 20th century.
  - Wright – Created the adaptive landscape model.

- Population genetics
  - The size of a population affects the probability a gene will “fix”
Genetic drift

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<th>Fitness</th>
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</tr>
<tr>
<td>bb</td>
<td><img src="image" alt="Black Head" /></td>
<td>.8</td>
</tr>
</tbody>
</table>

![Graph showing population fitness over allele frequency](image)
Genetic drift can push the small-beaked population off of its local peak in the adaptive landscape if its population is sufficiently small and the fitness difference between medium and small beak is not too great.
Modern evolutionary synthesis

- The modern evolutionary synthesis
  - Recognizes several mechanisms of evolution in addition to natural selection – e.g., genetic drift.
  - Characteristics (traits/genes) are inherited. Variation within a population is due to the presence of multiple versions of a single gene (an allele).
  - It postulates that speciation is generally due to the gradual accumulation of small genetic changes (allele substitutions).
The modern synthesis is over-stated

- The Modern view of Lamarckism
  - Trofim Lysenko pushed a unique form of Lamarckism following World War II
  - Vernalization – The exposure of seed to extreme conditions to increase their flowering potential.
  - Scientists that disagreed were executed or sent to labor camps.
  - Genetics research was banned.
  - Crop yields declined.
The modern synthesis is over-stated

Modern View of Senescence

- Species continuously expand their geographic extent.

- After some time the species will fragment like a broken plate into new species.

- These species will have smaller range sizes and be more specialized than the original parent species – in accord with Cope’s law.

- These new daughter species, with their smaller ranges and “overspecialized” forms will be more susceptible to extinction.

- The entire clade (group of species) will go extinct.

Age-Area

Cope’s Law
The modern synthesis is over-stated

- Modern View of Recapitulation
  - Evolutionary Developmental Biology
  - Evo-Devo is NOT the same as recapitulation.
  - However, we do see elements of a taxon’s evolutionary history in its ontogenetic development at the Embryonic stage.
  - Goldshmidt’s explanation for hopeful monsters – i.e., mutations in genes that control developmental rates – is basically the basis of evo-devo.
  - Allometry – a change in the rate of growth of a dimension or feature relative to other features
The modern synthesis is over-stated

- Modern View of Mutationism
  - Genetic Neutral Theory
    - A neutral (silent or synonymous) mutation occurs when the change of a single DNA nucleotide (A, T, C, G) within a gene does not affect the sequence of amino acids that make up the gene’s protein.
    - In other word’s most allele substitutions and polymorphisms do not affect an organisms' fitness.
The modern synthesis is over-stated

- Modern View of Mutationism
  - Genetic Neutral Theory Gives us the molecular clock and molecular phylogeny

![Diagram showing evolutionary sequence with sequences from modern lineages and common ancestor.](image)
The modern synthesis is over-stated

- Nearly-Neutral Theory and Neo-Mutationism
The modern synthesis is over-stated

- Nearly-Neutral Theory and Neo-Mutationism
The modern synthesis is over-stated

- It allows us to think of natural selection as intermittent state changes as opposed to a continuous process.
The modern synthesis is over-stated

- Modern view of Catastrophism
  - “Sloshing Bucket” model – The degree of evolutionary innovation is roughly proportional to the degree of severity of extinction.
  - Two end-member states of extinction that we know well from empirical observation.
    - Local Extirpation from short-term catastrophes: wildfires, volcanoes, floods.
    - Mass extinctions from dramatic global catastrophes: extraterrestrial bolides, mass volcanism, mass cooling.
  - We can therefore interpolate that most extinctions are driven by intermediate-level catastrophes between these two extremes.
The great war that paleontologists fight

- Environmental perturbations (state changes) are more important drivers of evolution than biological interactions.

- This is a very different picture of evolution than what is generally presented to the public.

- Do paleontologists believe this because we are biased by the nature of the geological record?