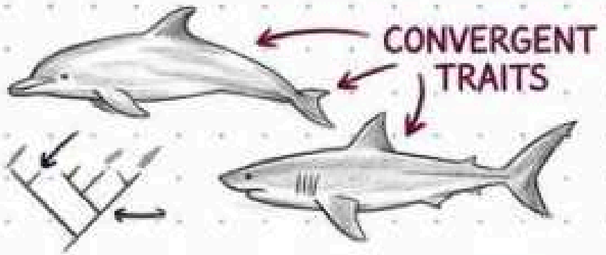
Testing claims of adaptation requires moving from plausible stories to rigorous predictions.

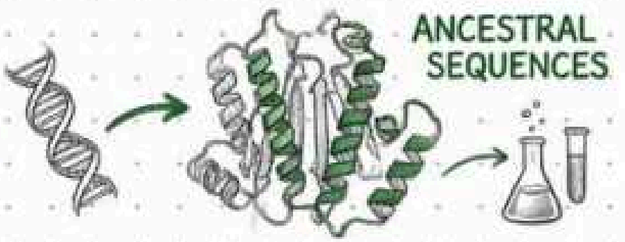
¶6.1

ANCESTRAL PLAUSIBILITY

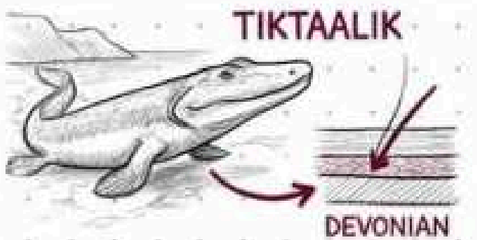
The Comparative Method & Convergent Evolution

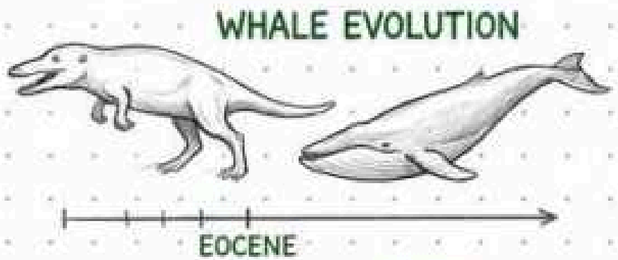


Reconstructing Ancient Proteins



Risky Predictions (Tiktaalik & Whales)

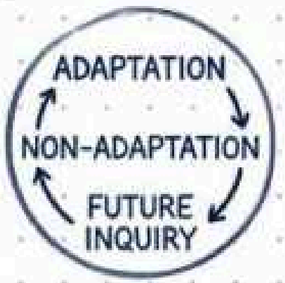




The Limits of Inference & Course Summary

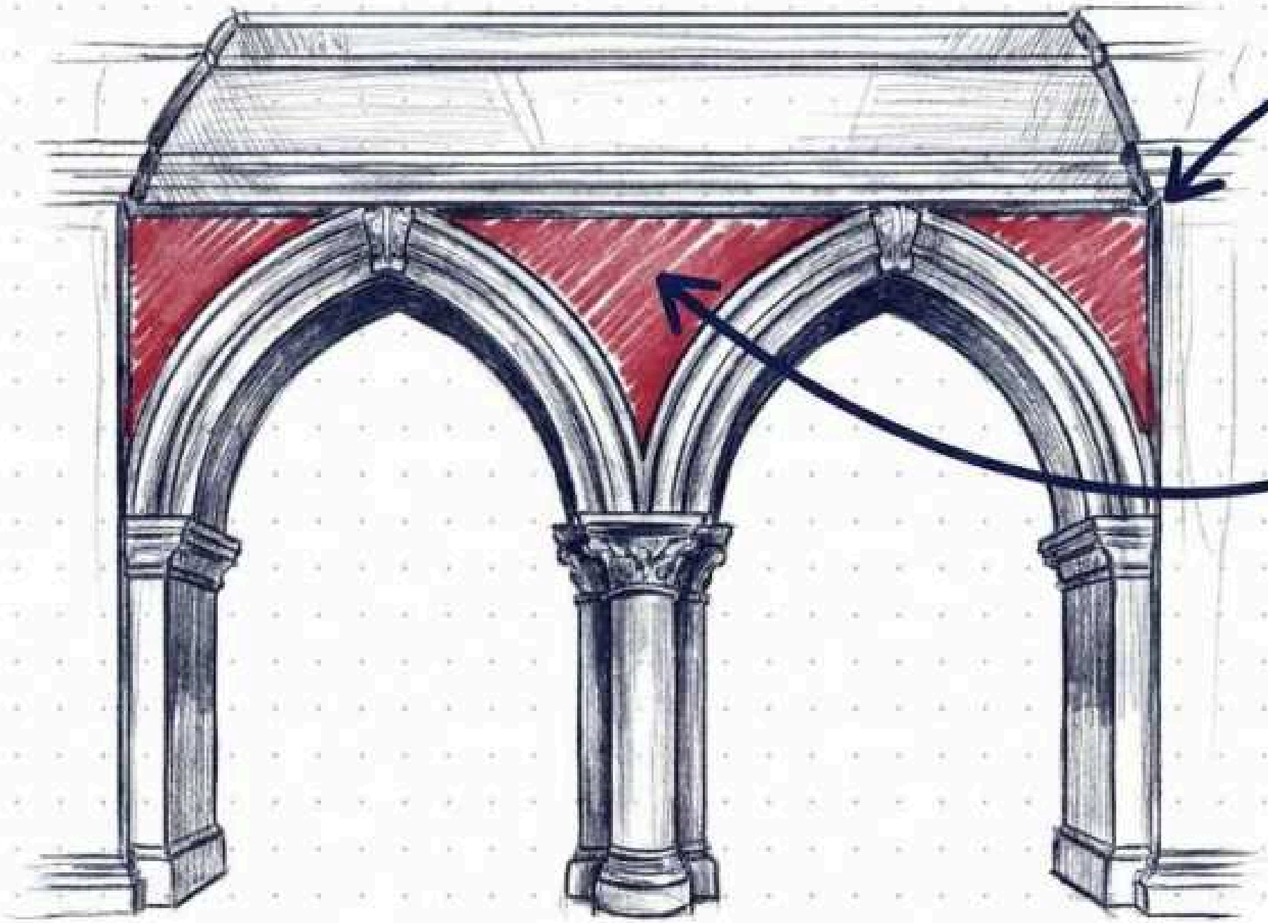






The Panglossian Paradigm assumes every trait exists for a specific adaptive purpose.

¶ 6.2



The Critique: In 1979, Stephen Jay Gould and Richard Lewontin challenged the creation of **just-so so stories** in biology.

The Spandrel Fallacy: Spandrels exist as a structural byproduct of arches. They were decorated later, but decoration was not their original purpose.

Takeaway: An invented function is not proof of adaptation.

¶ 6.3

Claims of adaptation must be weighed against four distinct alternative mechanisms.

1. Structural Byproduct:

A trait exists as a secondary consequence of another selected trait.

2. Genetic Drift:

Random fluctuations in allele frequencies, rather than selection, drive the trait.

3. Developmental Constraint:

The organism's fundamental developmental pathways limit or dictate physical forms.

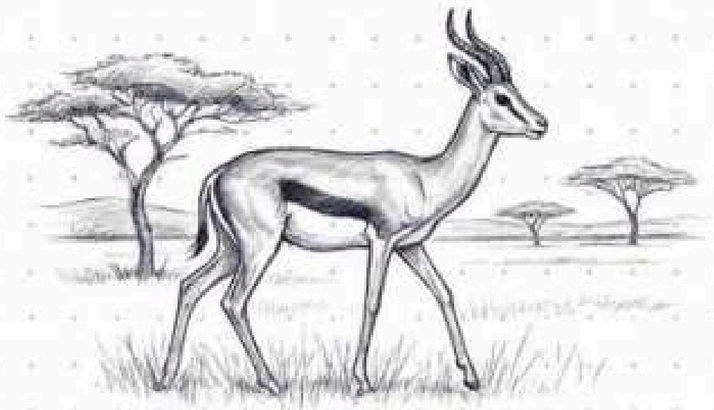
4. Ancestral Inheritance:

A trait was inherited from an ancestor where it originally served an **entirely** different function.

Today, adaptation requires empirical evidence, not merely a plausible narrative.

The comparative method tests adaptation by linking specific traits to environmental challenges.

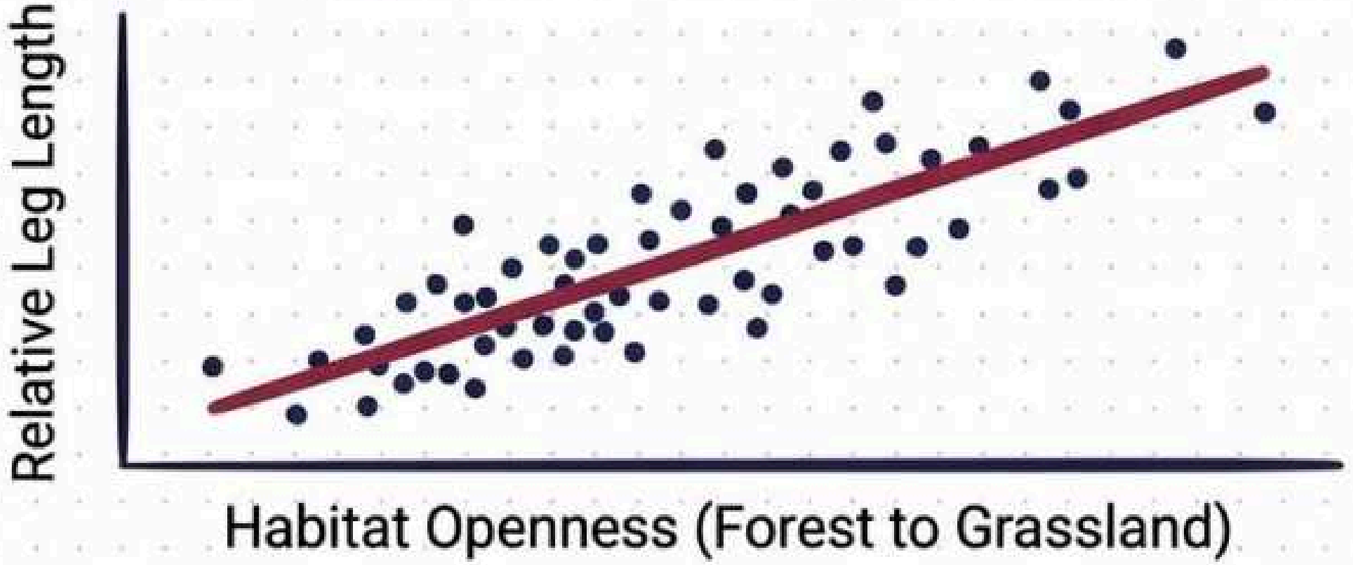
¶ 6.4



Grassland Environment



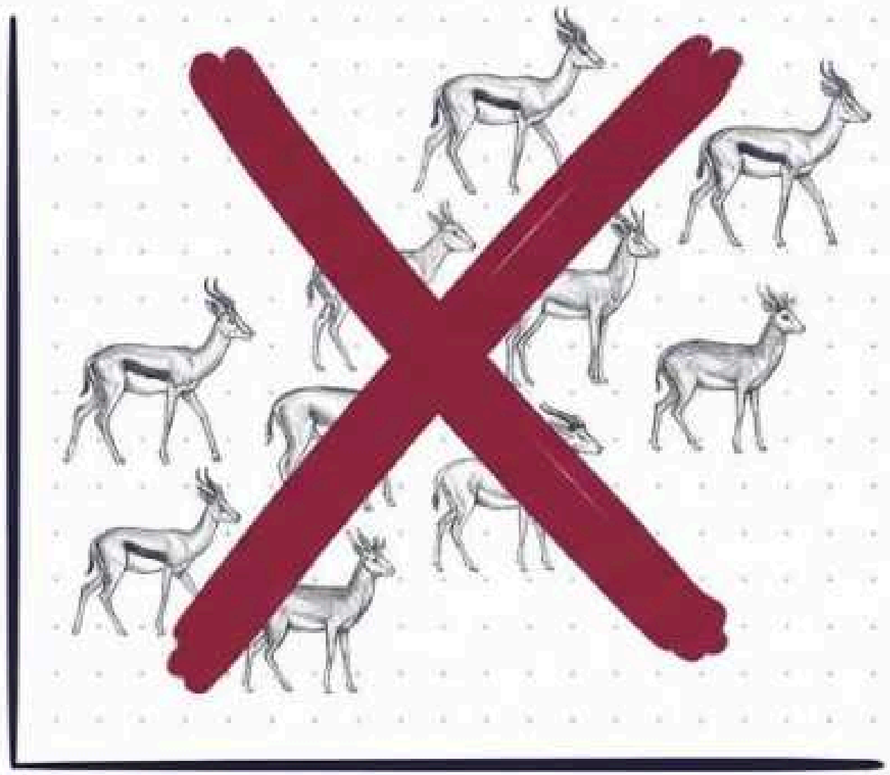
Forest Environment



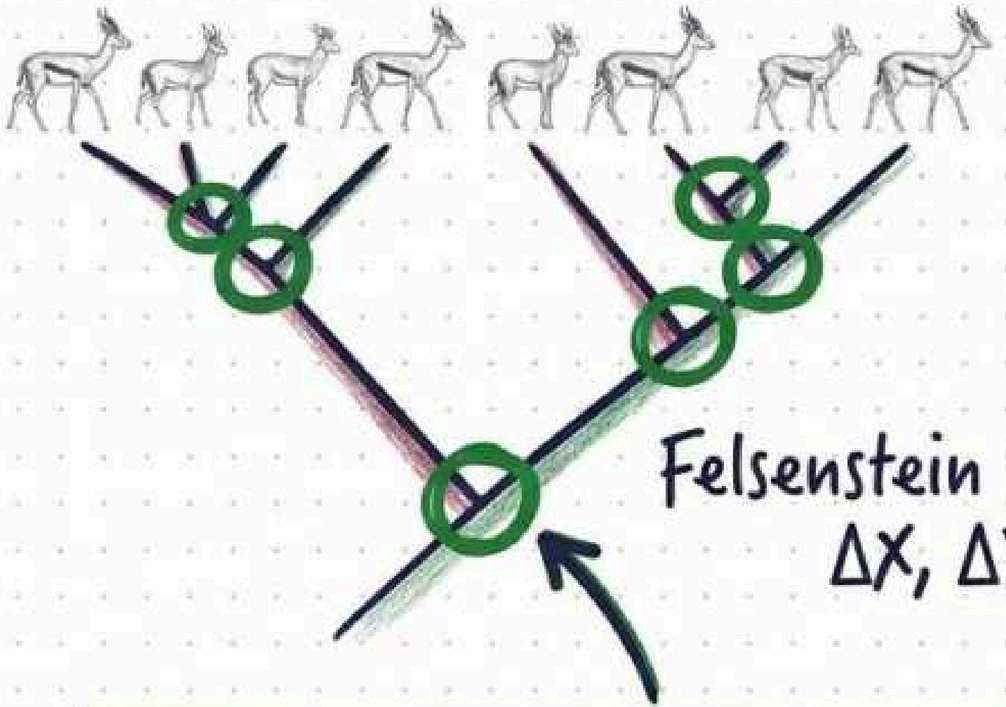
If a trait is an adaptation, species in that environment should exhibit the trait more frequently than chance allows.

Shared ancestry invalidates raw data correlation by inflating independent data points.

¶ 6.5



Species are not independent data points.

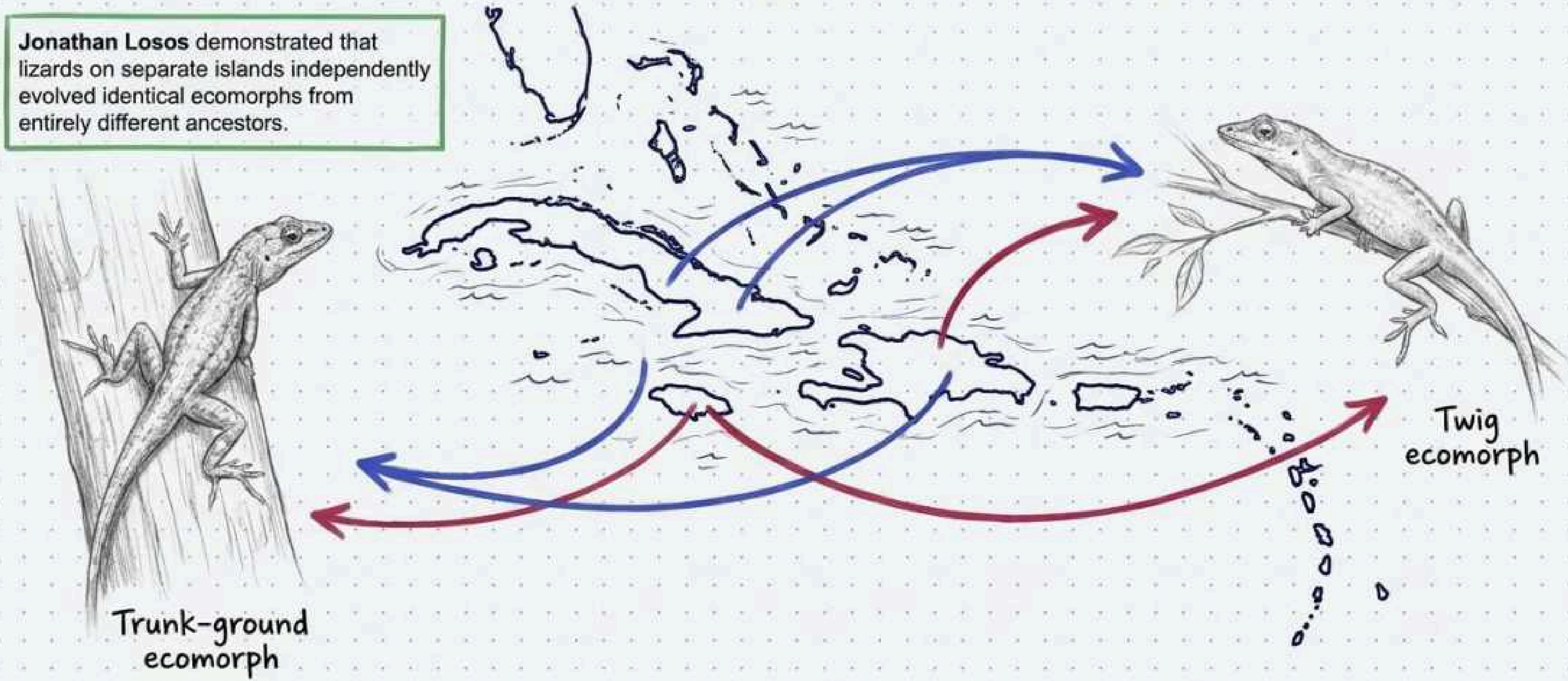


Phylogenetically Independent Contrasts: Compare changes only at the branching points to ensure each evolutionary event is counted exactly once.

Convergent evolution repeatedly **solves** the **same environmental challenges** from different origins.

¶ 6.6

Jonathan Losos demonstrated that lizards on separate islands independently evolved identical ecomorphs from entirely different ancestors.

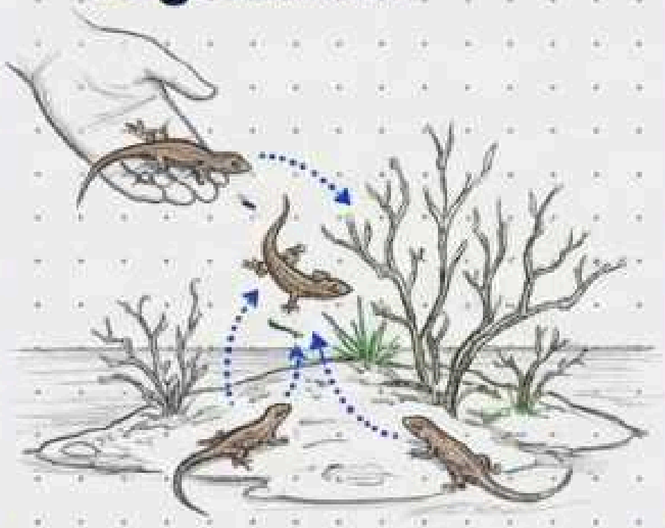


When the same trait evolves independently multiple times, chance becomes statistically improbable.

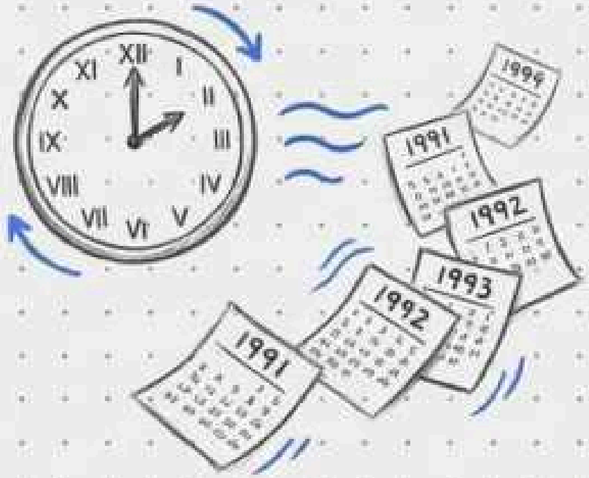
Experimental evolution directly tests adaptive hypotheses through manipulation in nature.

¶ 6.7

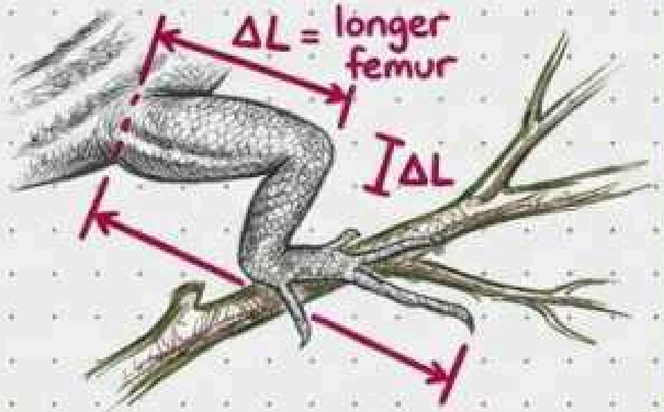
1. Introduction to new vegetation.



2. Incubation:
A few years pass.



3. Rapid Adaptation:
Leg lengths shift to match available perches.

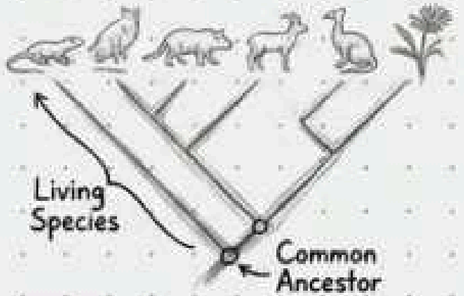


Combining cross-species comparison with active environmental manipulation provides definitive proof of adaptive change.

Reconstructing ancient proteins allows researchers to test **historical evolutionary functions** in the lab.

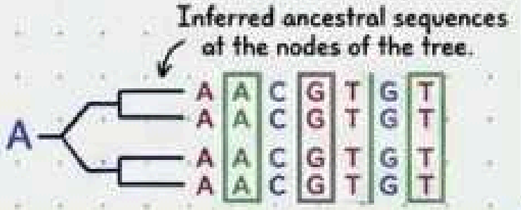
¶ 6.8

1. Build the Tree

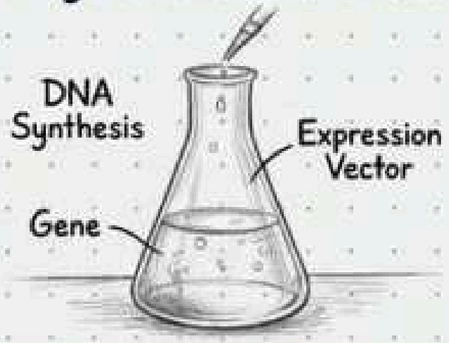


2. Infer Sequence

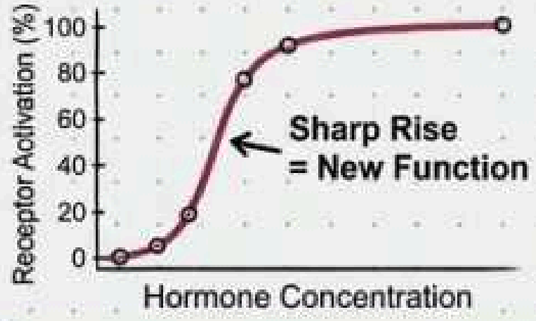
$\mathcal{P}(S|T,\theta) \Rightarrow$ **Maximum Likelihood**



3. Synthesize Gene



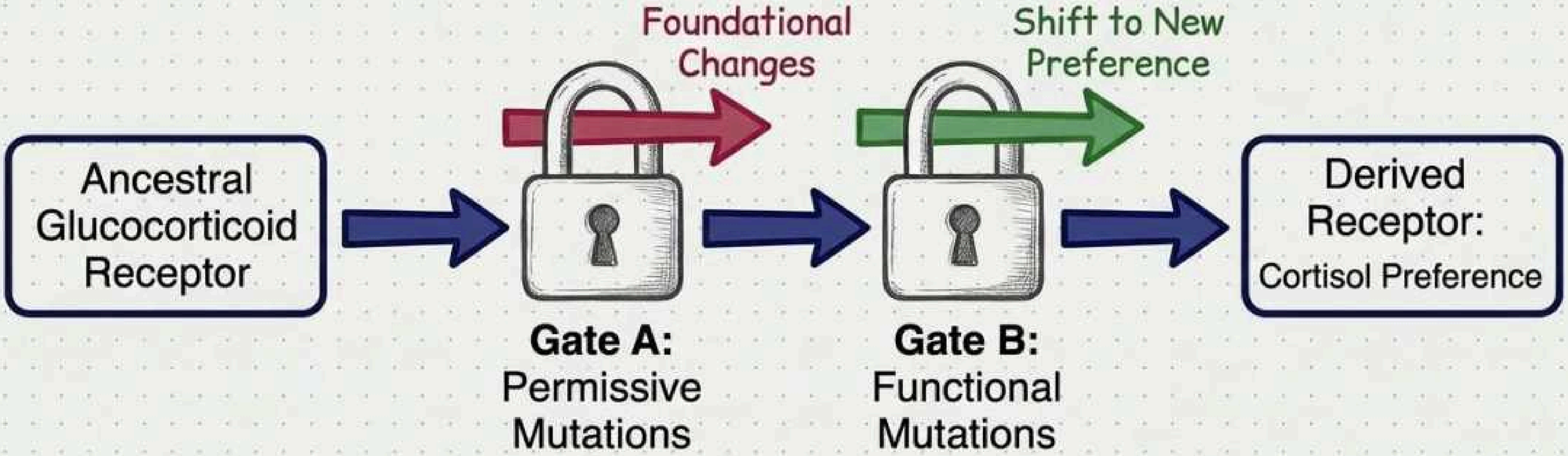
4. Test Properties



Joe Thornton's team pioneered this approach to study the evolution of new functions in hormone receptors.

¶6.9

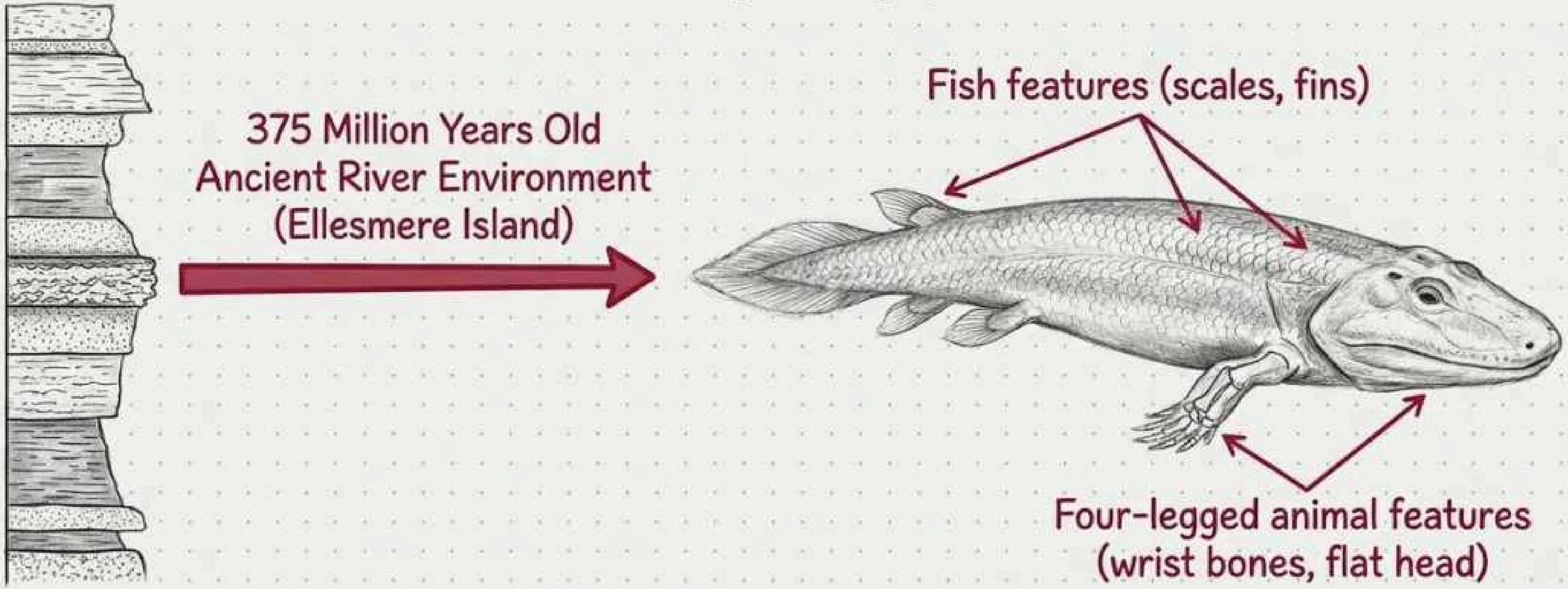
Evolutionary pathways are strictly constrained by historical sequence dependencies.



Thornton's 2007 reconstruction proved that history matters: certain genetic changes are physically impossible without specific prerequisite mutations paving the way.

¶ 6.10

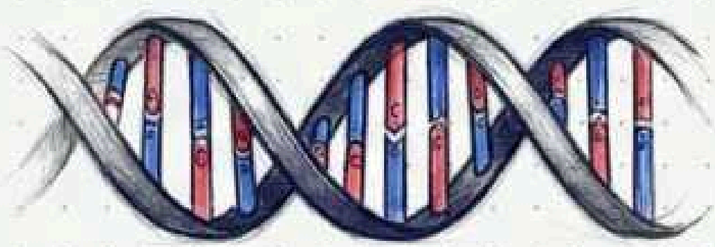
A hallmark of rigorous science is the ability to make and **verify risky predictions.**



In 2004, Shubin, Daeschler, and Jenkins predicted exactly where and when this transitional fossil should exist—and found it.

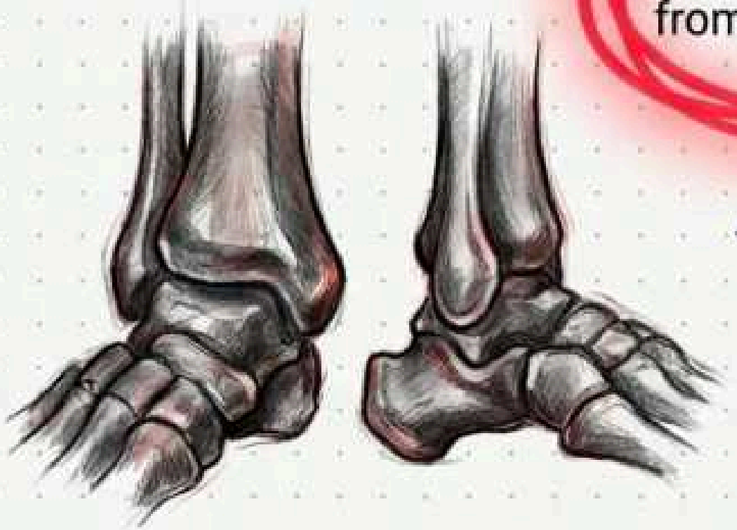
Consilience occurs when entirely independent lines of evidence converge on a single truth.

¶ 6.11



Molecular Data: Okada's 1990s research on mobile DNA element insertions links whales to hippopotamuses (even-toed hoofed mammals).

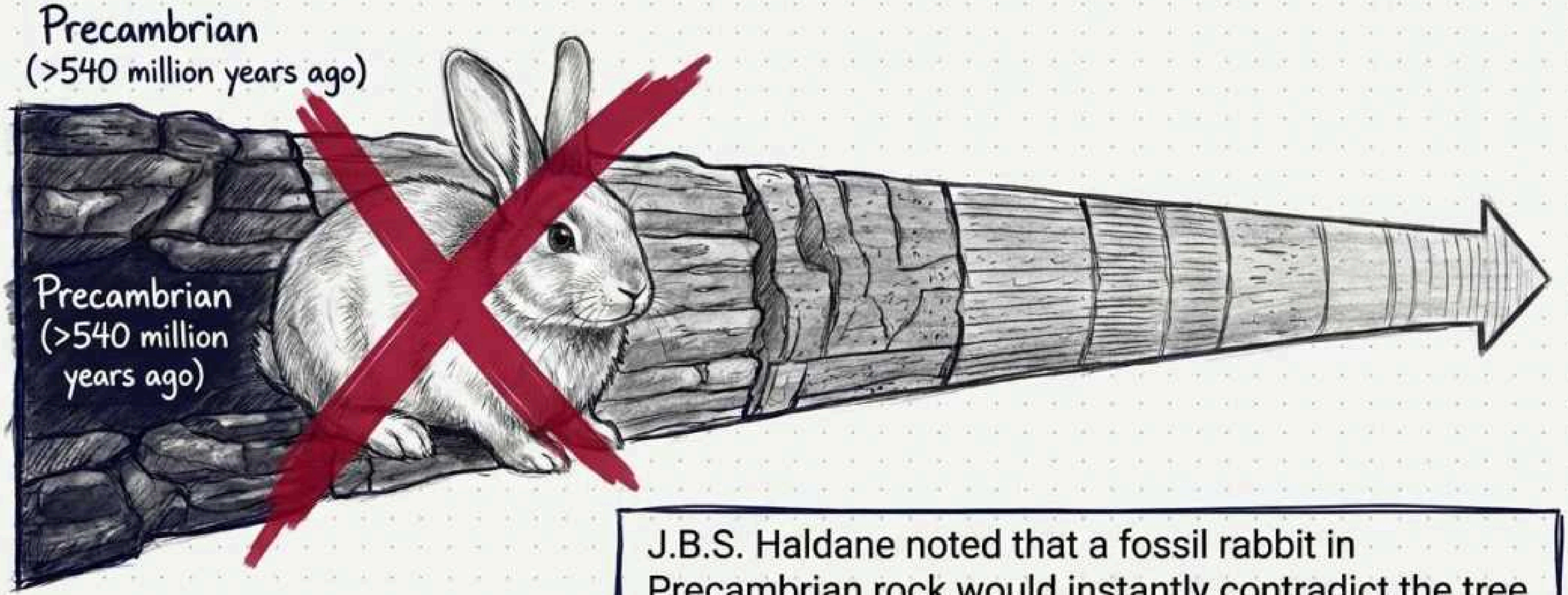
Consilience:
The transition from land to sea



Fossil Data: 50-million-year-old Pakicetus and Ambulocetus display distinct even-toed ankle structures.

Evolutionary theory remains highly falsifiable, yet no anomalous evidence has broken it.

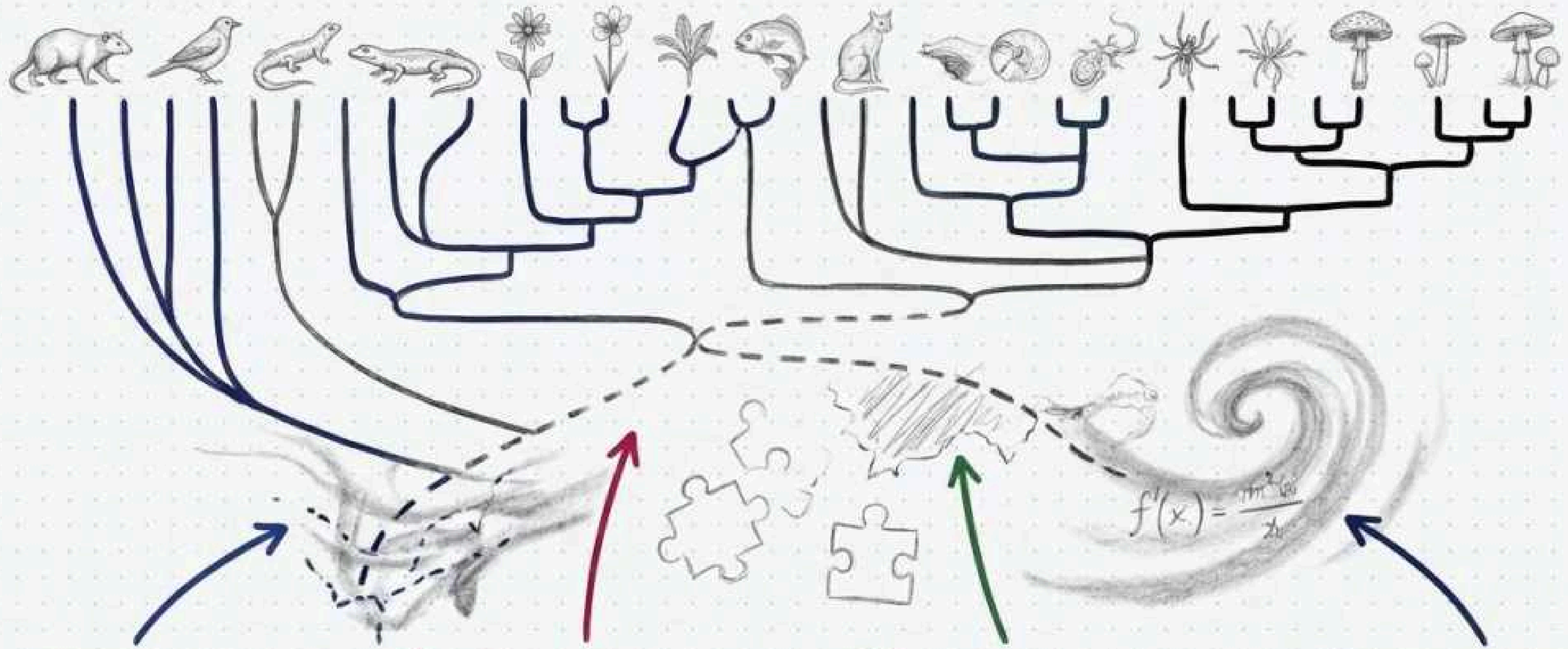
¶ 6.12



J.B.S. Haldane noted that a fossil rabbit in Precambrian rock would instantly contradict the tree of life. Among millions of unearthed fossils, no such temporal anomaly has ever been found.

Honest science clearly distinguishes well-supported conclusions from open questions.

¶ 6.13



① **Deep Origins:**
Traces of the origin of life and the first eukaryotic cells remain highly uncertain.

② **Preservation Bias:**
Soft-bodied organisms are exceptionally rare in the fossil record.

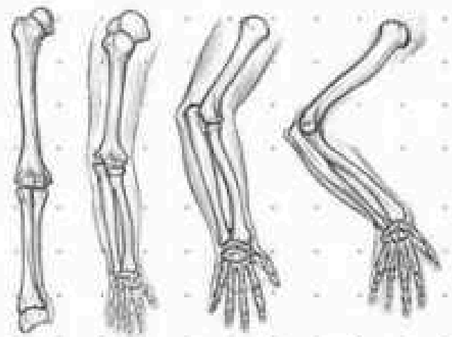
③ **Behavioral Void:**
Past mating and communication behaviors cannot be fully inferred from bones.

④ **Model Simplification:**
All analytical methods rely on models that inherently simplify complex realities.

Course Review (Part I): Establishing the foundational logic of biological inference

¶ 6.14

Lecture 1



Homology



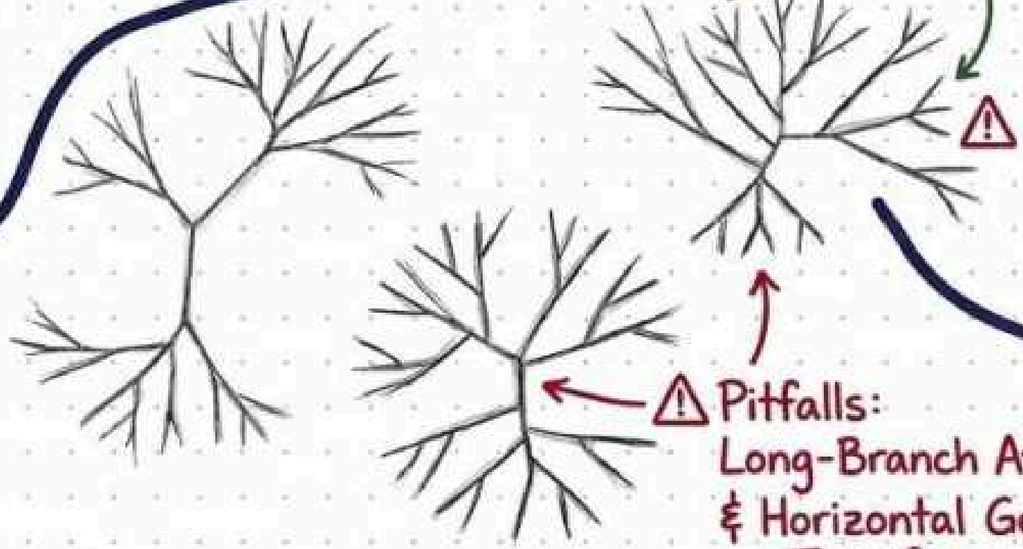
Nested Hierarchies



Inference to the Best Explanation

Lecture 2

Parsimony, Distance, Likelihood, Bayesian methods



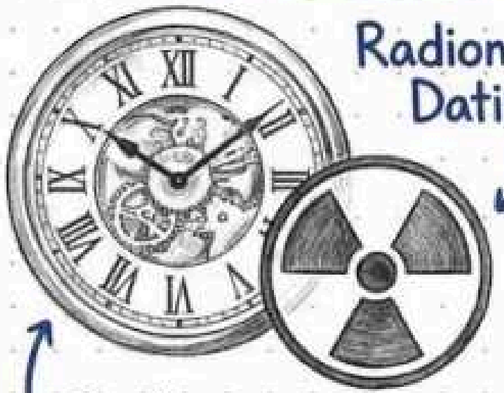
⚠ Pitfalls: Long-Branch Attraction & Horizontal Gene Transfer

Course Review (Part II): Applying the toolkit to genetics, history, and human origins.

¶ 6.15

Lecture 3

Radiometric Dating



Radiometric Dating

Molecular Clocks

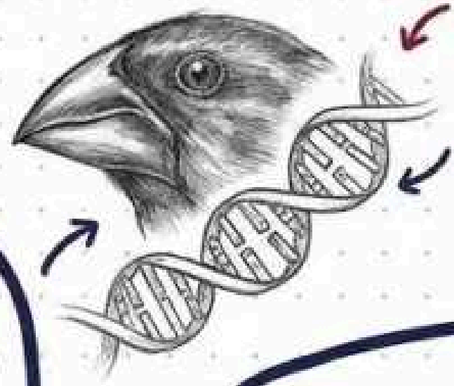


Lecture 4

Selection

Lactase Persistence

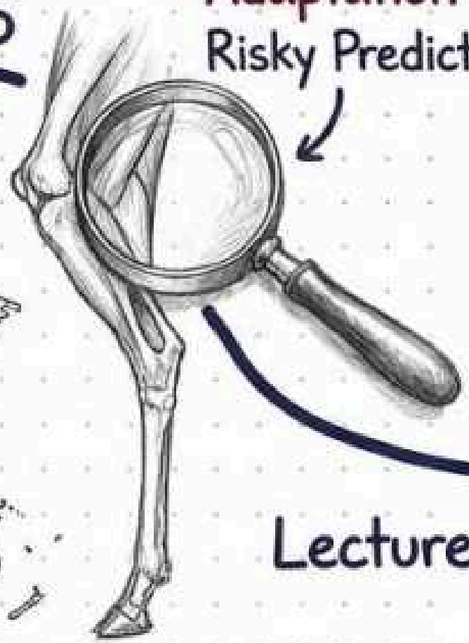
Altitude Adaptation



Lecture 5

Adaptation

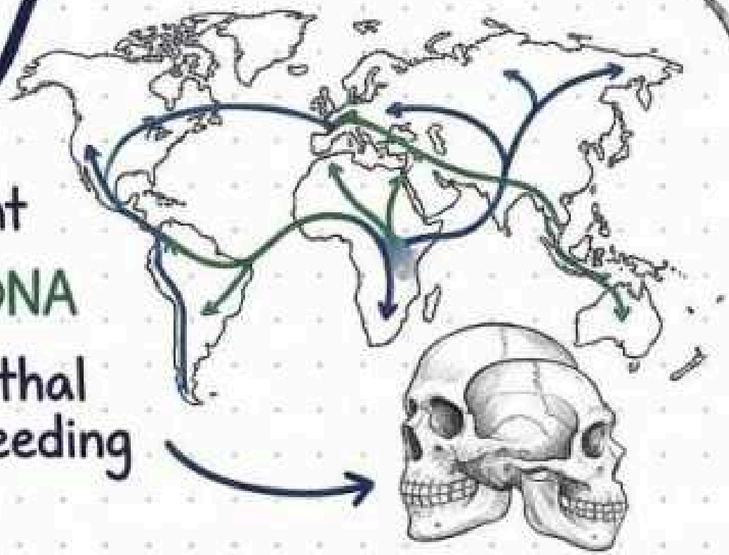
Risky Predictions



Coalescent

Ancient DNA

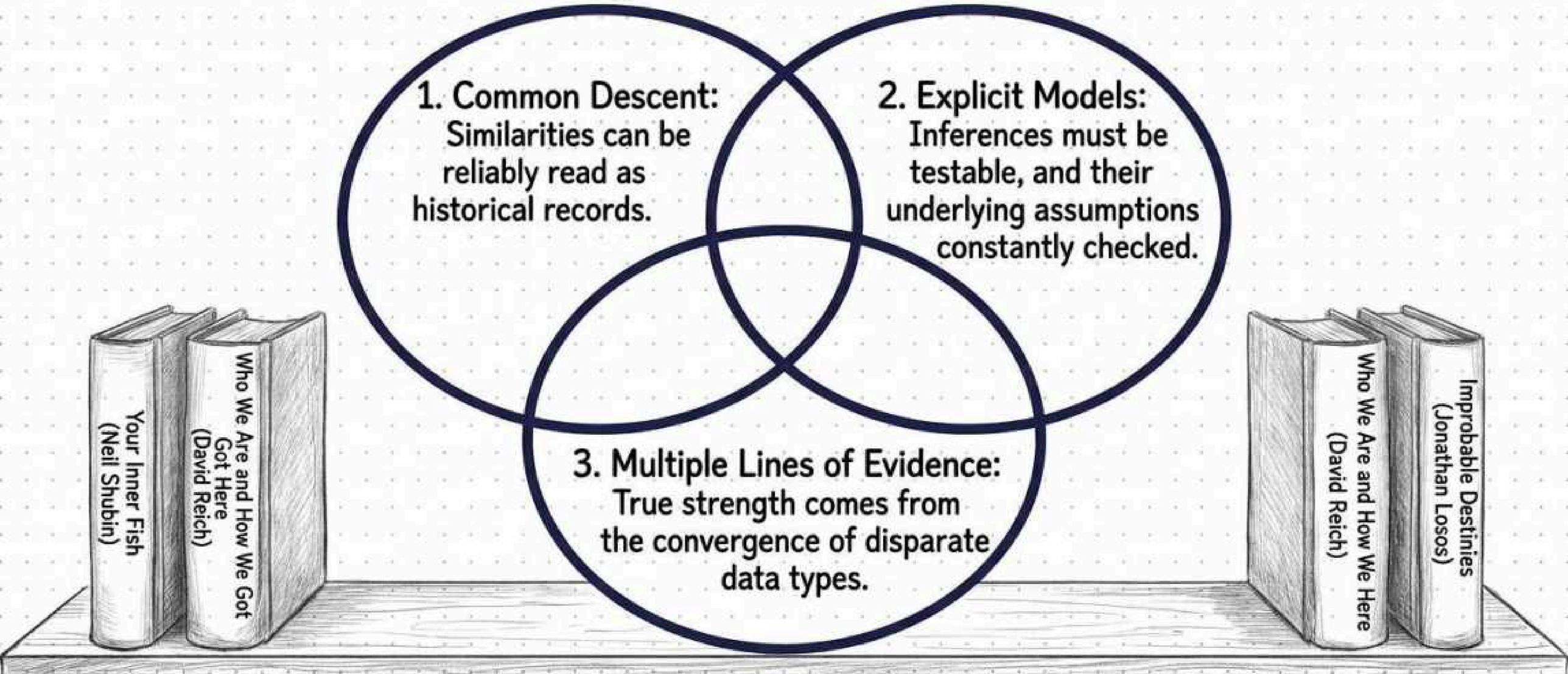
Neanderthal Interbreeding



Lecture 6

Three big ideas tie the framework of modern evolutionary biology together.

¶ 6.16



Closing Exercise: Apply the comparative method to a trait of your choosing.

¶ 6.17

Step 1: Choose a Trait (e.g., giraffe's long neck, human color vision).

Step 2: Propose an Adaptive Hypothesis (What specific function did natural selection favor?).

Step 3: Name an Alternative (Could it be a byproduct, drift, constraint, or ancestral?).

Step 4: Propose Two Lines of Evidence (Describe disparate data types that could test between your hypothesis and the alternative).

Thank you for studying Biology 340 B with Anderson Academy. Quizzes, final exams, and tripos questions follow.

A final reminder for those taking this course for free.

¶6.18

Be of service to humanity.

The only requested compensation is to pay it forward.
Tell us how you did it and what you learned.

- ☑ Email: garyanderson@mail.grokbot.com
- 𝕏 X handle: @garyanderson