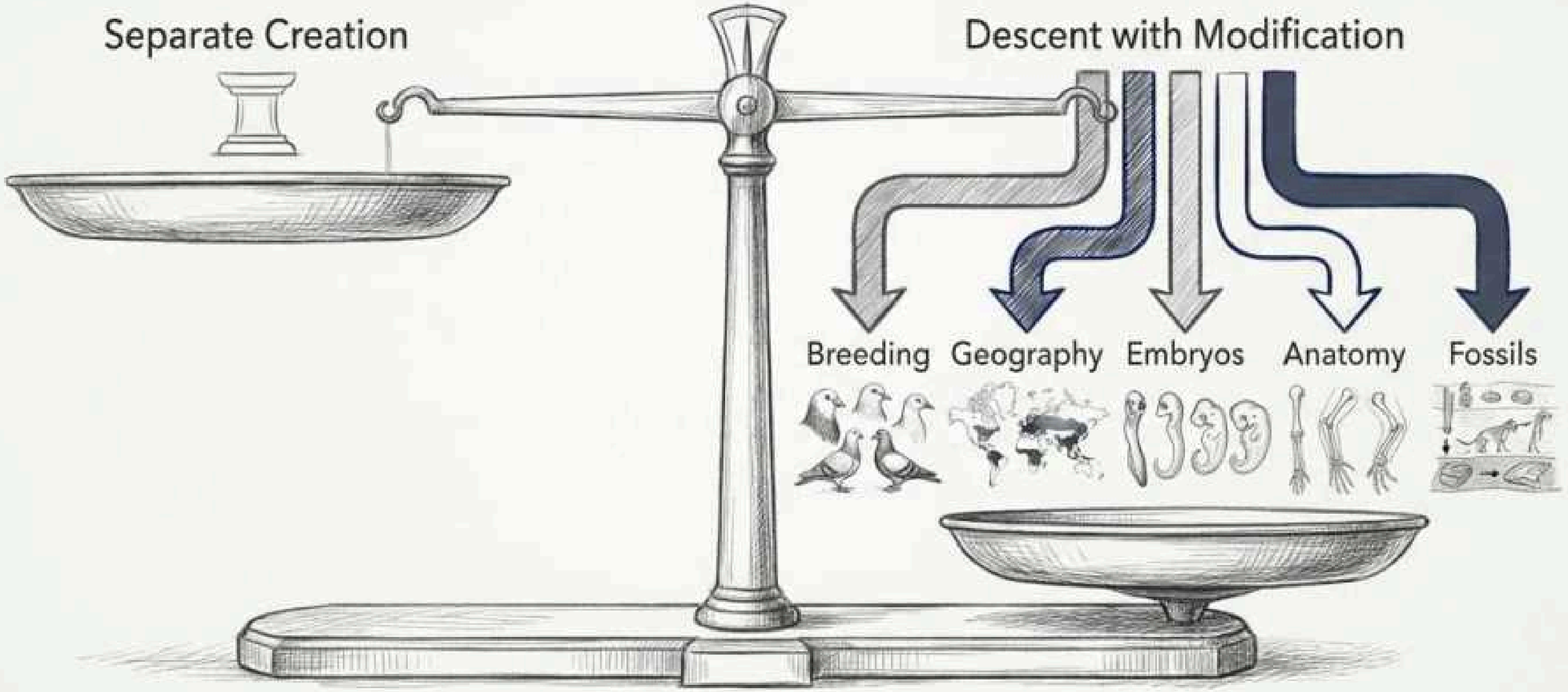
[¶ 1.1]

The Origin of Species: One Long Argument

Darwin lacked knowledge of genes and could not watch one species turn into another.



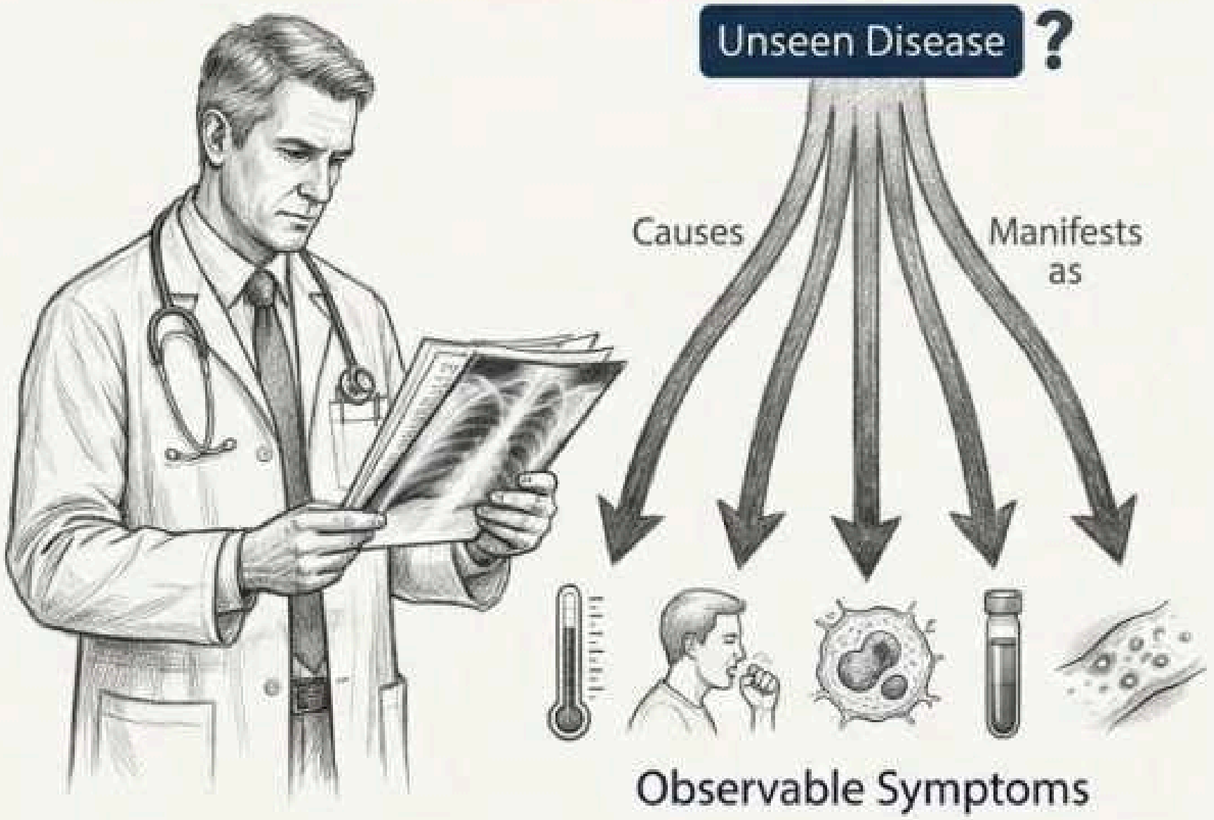
Descent with modification explains all gathered evidence better than the alternative.

[¶1.2]

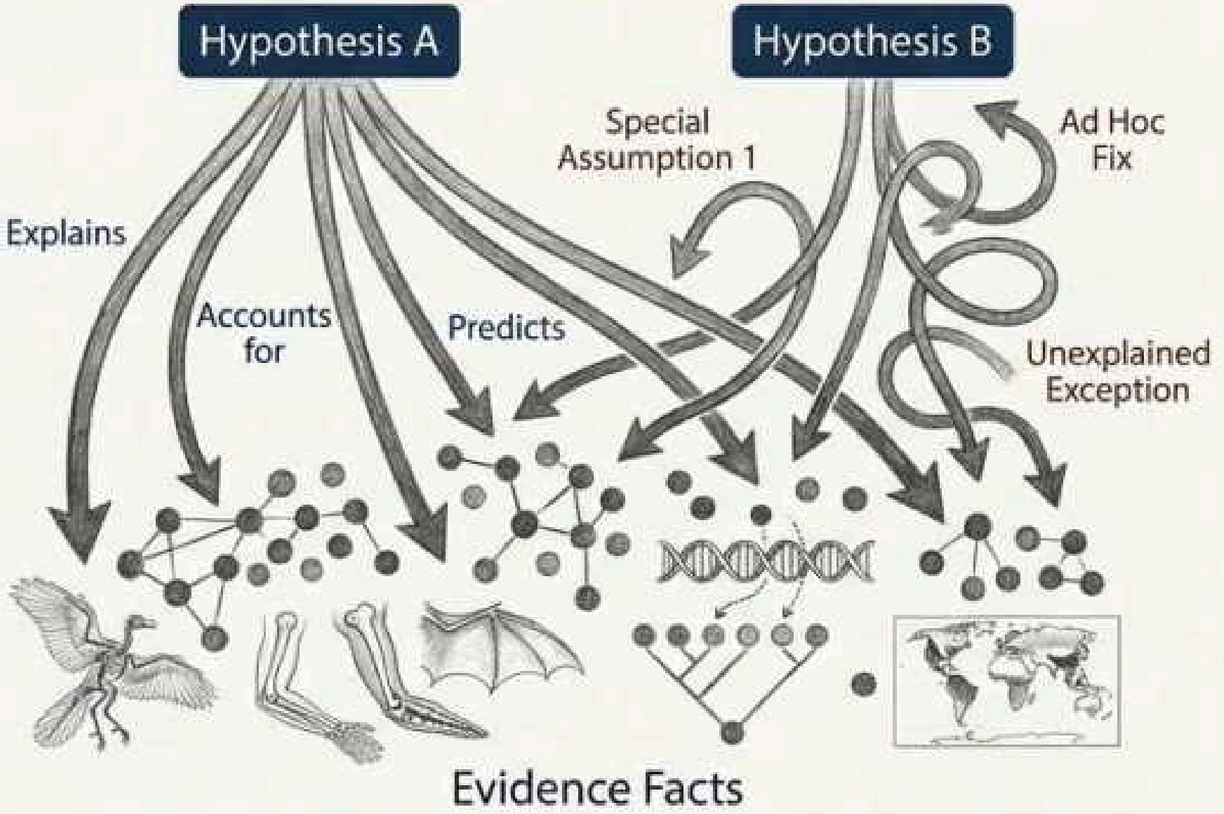
Inference to the Best Explanation

Comparing rival hypotheses to see which accounts for the **evidence** by **explaining more facts** with **fewer special assumptions.**

Medical Analogy

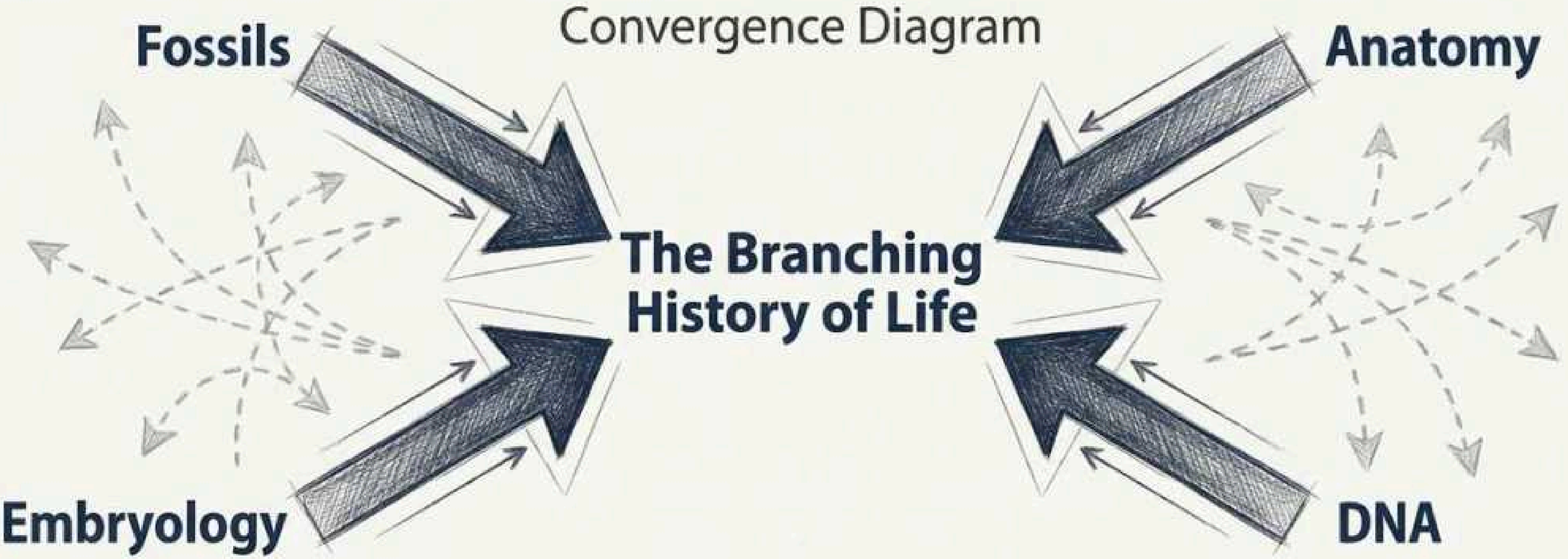


Evolutionary Reality



Consilience: The Backbone of Inference [¶1.3]

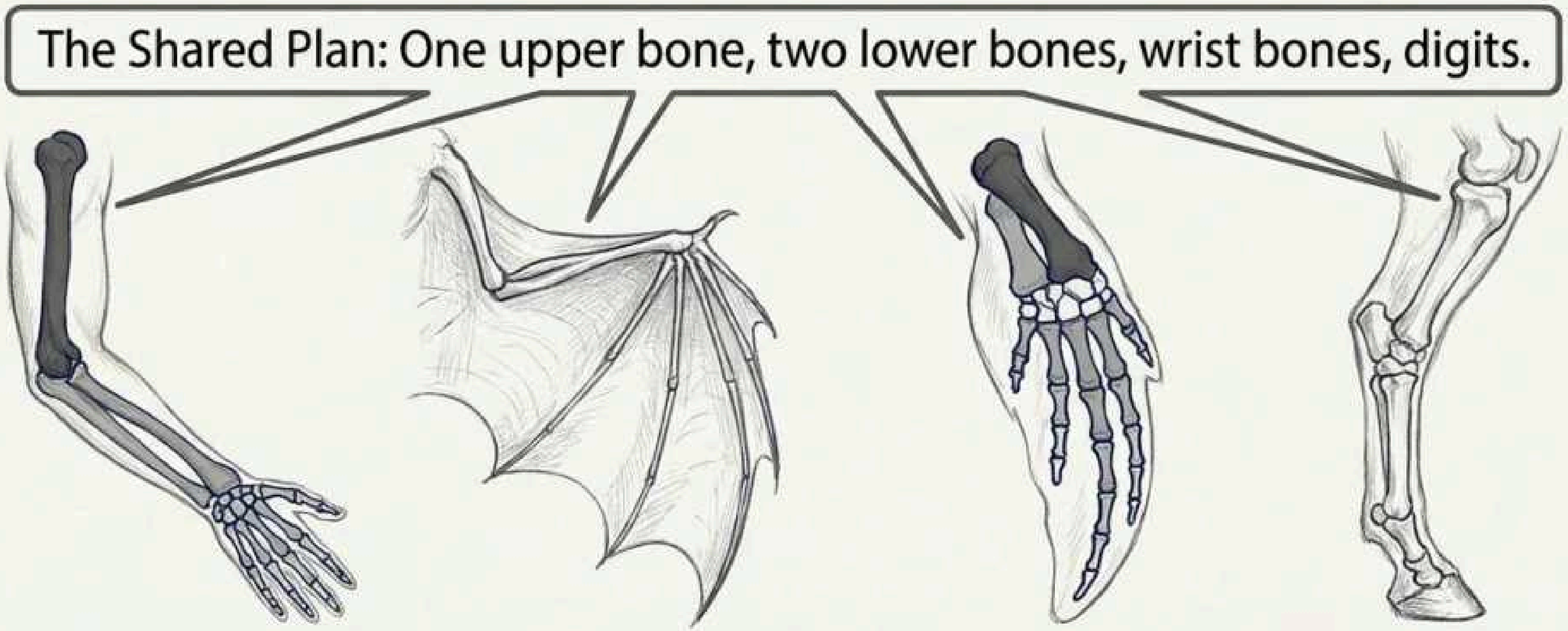
Consilience is the agreement of independent lines of evidence.



It would be an extraordinary coincidence if all these disparate data types agreed by chance. When independent data point the same way, confidence grows sharply.

Homology: Similarity Due to Shared Ancestry [¶1.4]

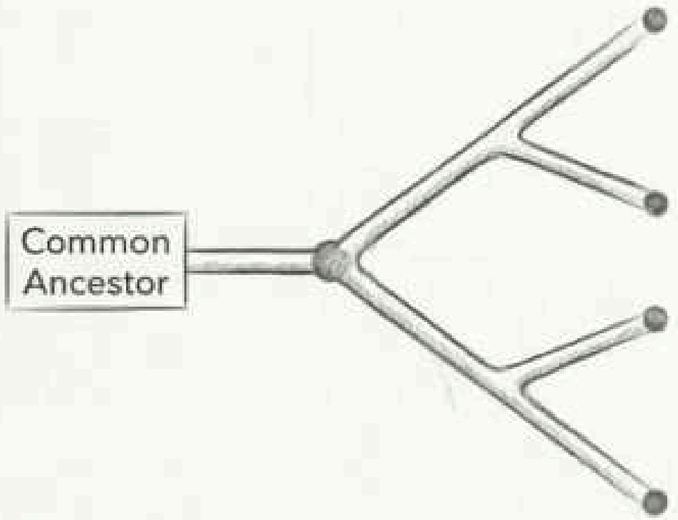
Functions differ greatly (grasping, flying, swimming, running).



Inference: The shared plan is not explained by function;
it is inherited from a common ancestor.

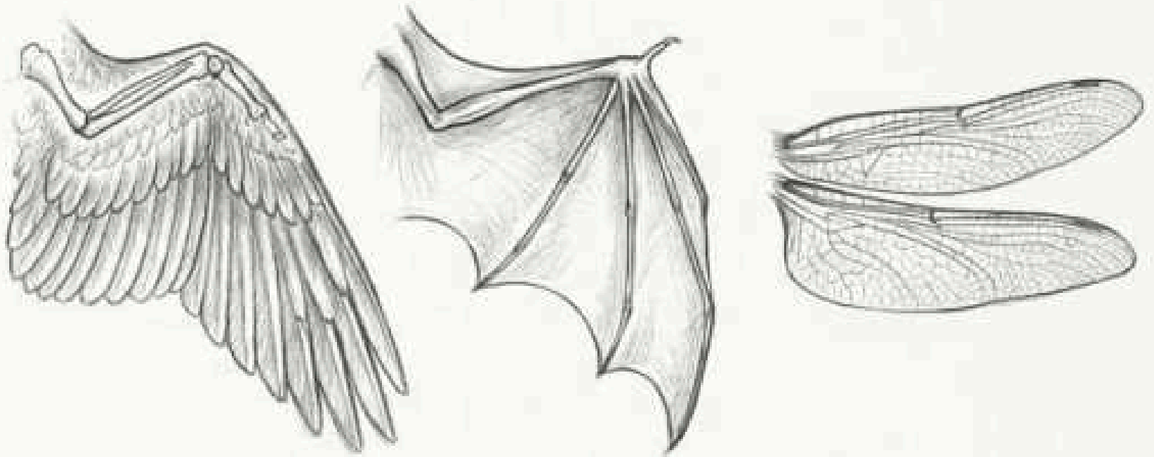
Distinguishing Homology from Convergence

Homology (Ancestry)



Shared Ancestry → Same Plan → Different Function

Convergence / Analogy (Independent)

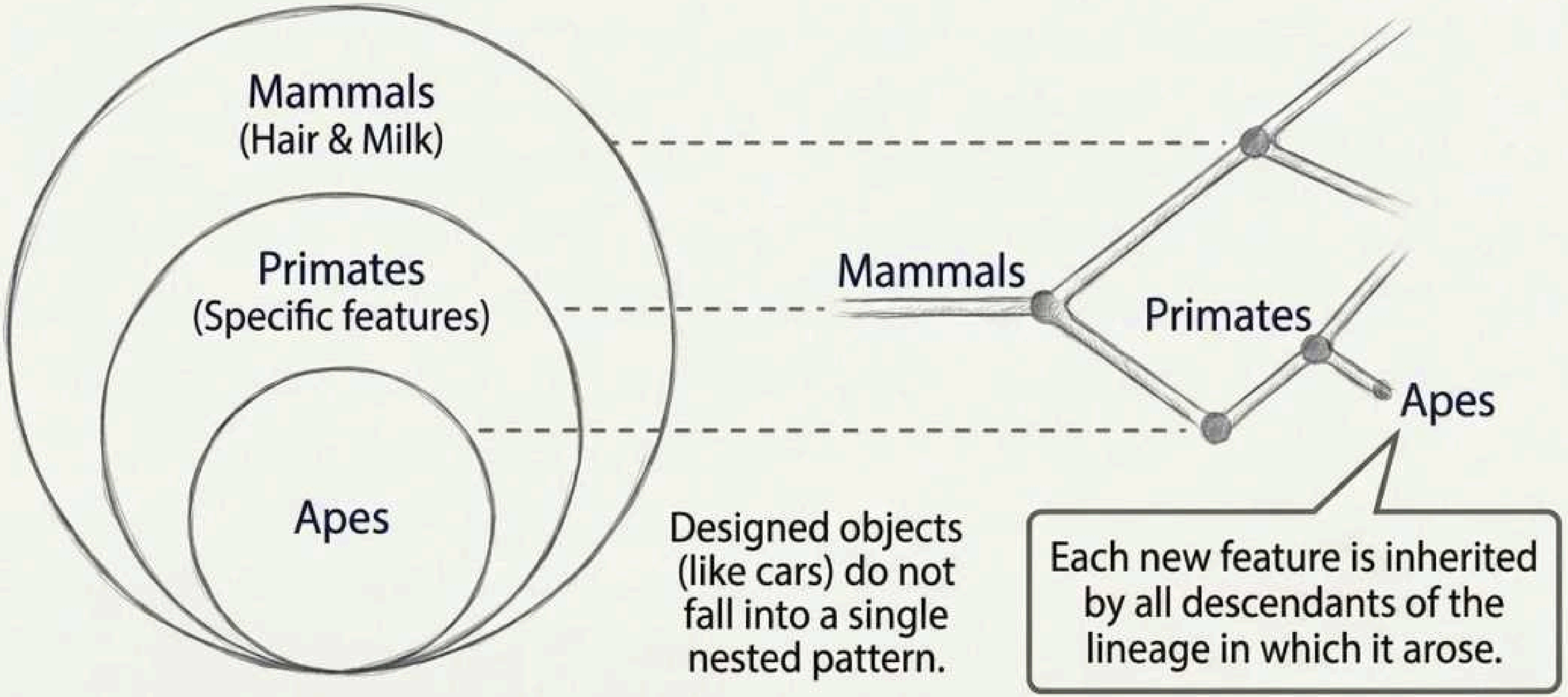


Independent Evolution → Different Plan → Same Function

Convergence can mislead us into grouping unrelated organisms together.
Distinguishing these two is a central task of evolutionary inference.

The Nested Hierarchy of Life

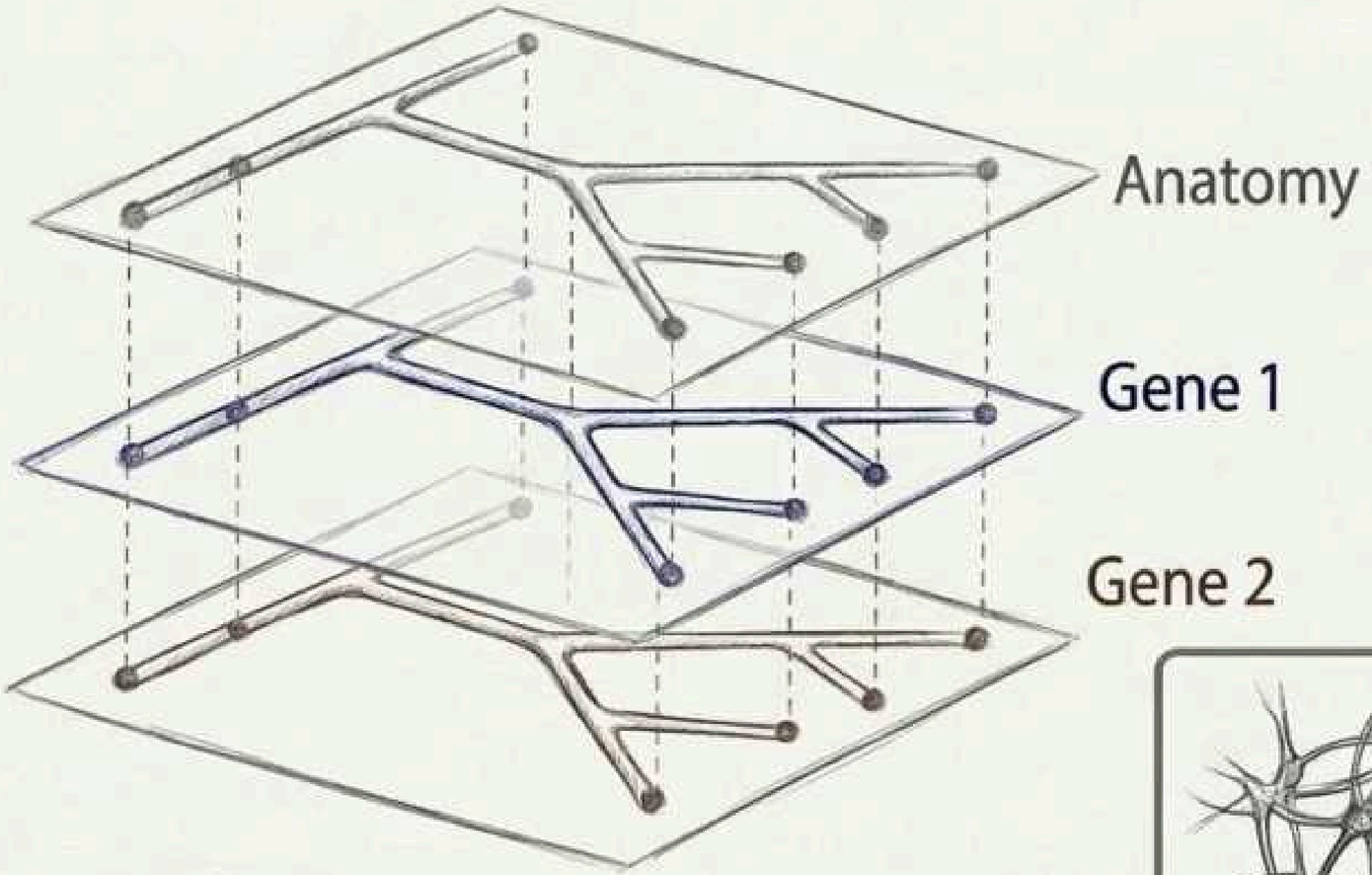
[¶1.6]



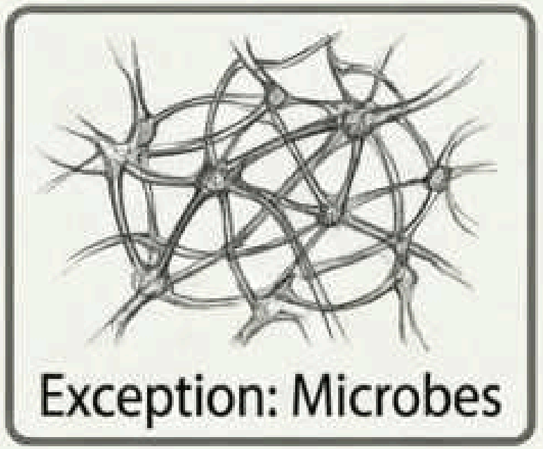
[¶1.7]

Testing the Hierarchy

If life forms a single tree, independent trees built from from different characters (anatomy vs. distinct genes) must agree.

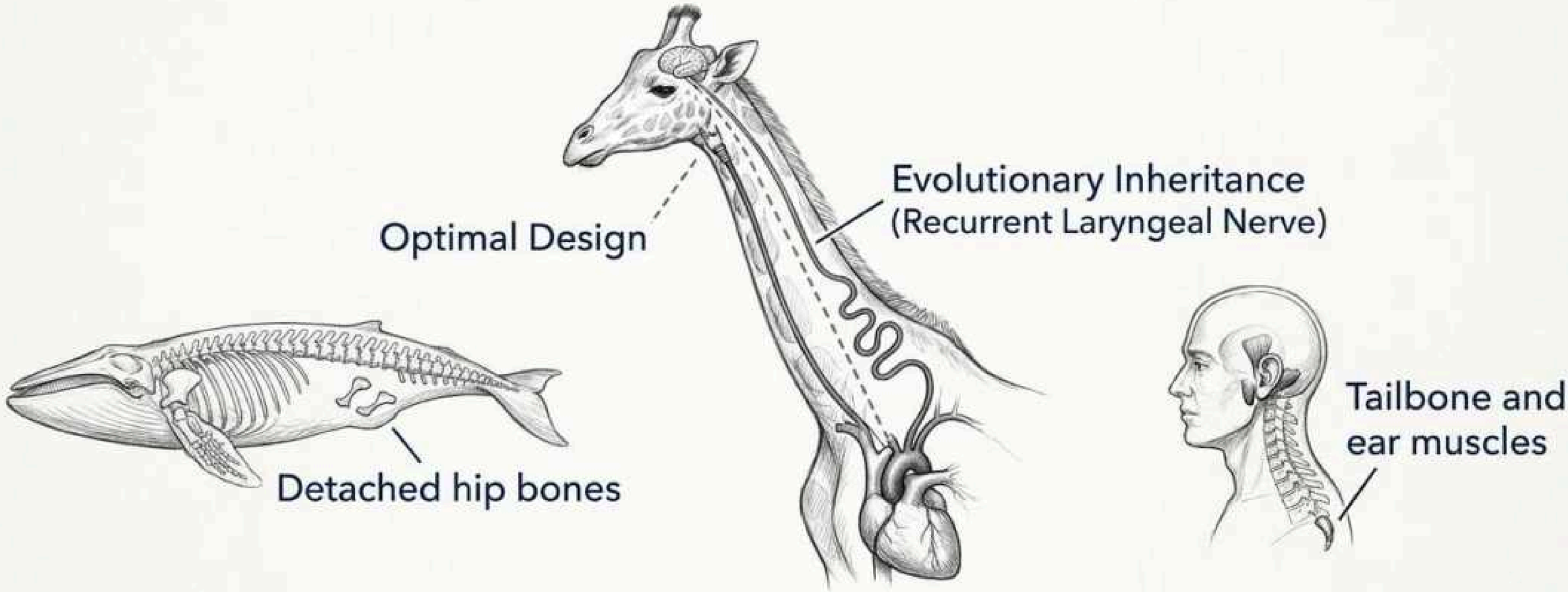


Strong agreement for most groups validates the hierarchy prediction.



Imperfections and Vestiges

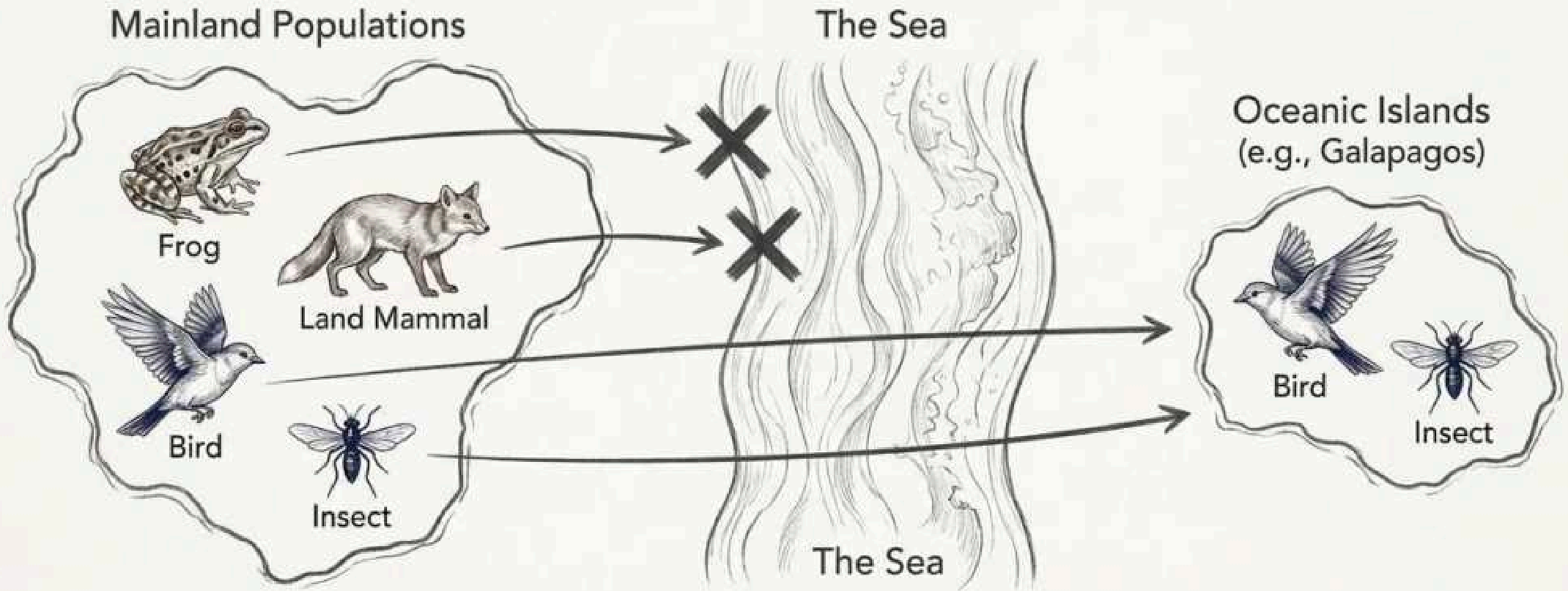
[¶ 1.8]



Such features make sense only as inheritances from ancestors with different body plans, not as optimal designs.

[¶ 1.9]

Biogeography: The Footprints of Colonists

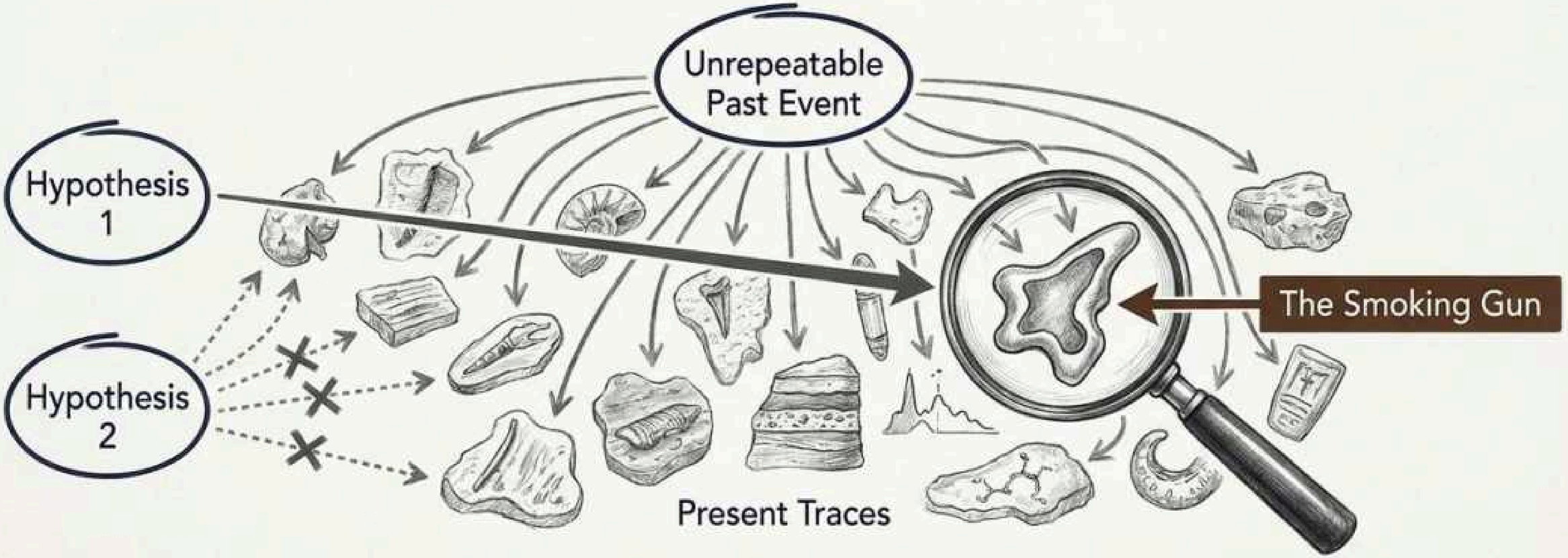


Island species resemble those on the nearest mainland, not those in similar climates elsewhere.

Descent from capable colonists explains these patterns; independent creation suited to climate does not.

Historical Science and the Smoking Gun

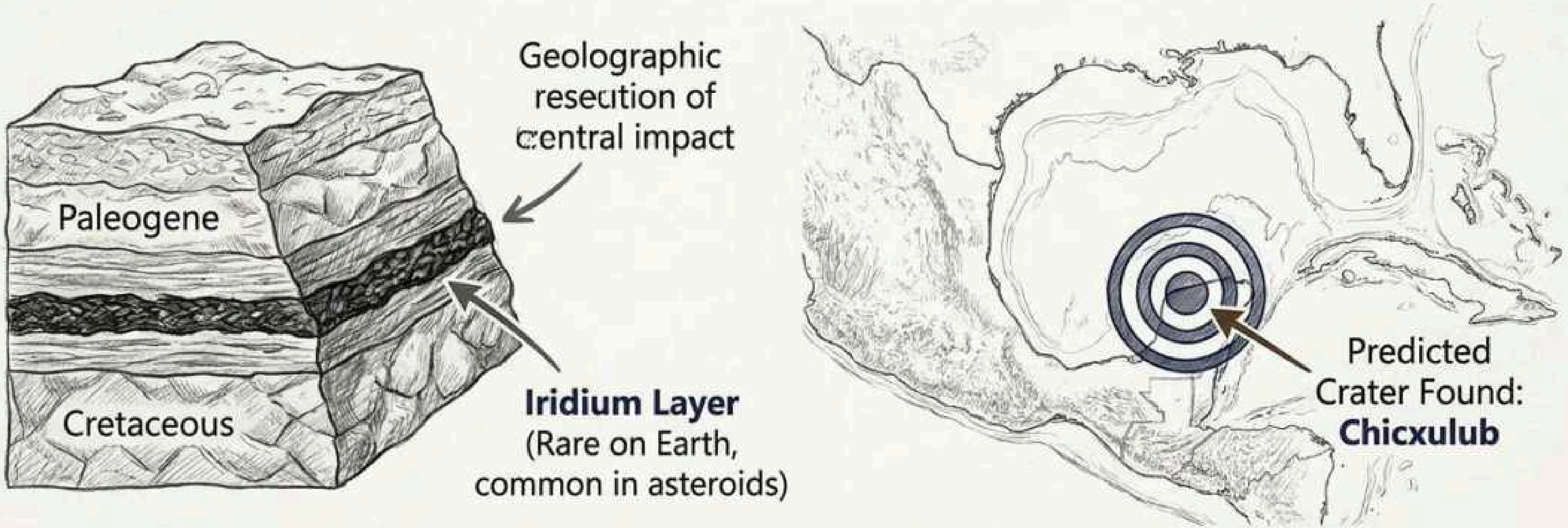
Historical sciences have a valid method distinct from repeatable experiments.



Because past events leave many traces, hypotheses are tested by finding a smoking gun—a trace predicted by one hypothesis but not its rivals.

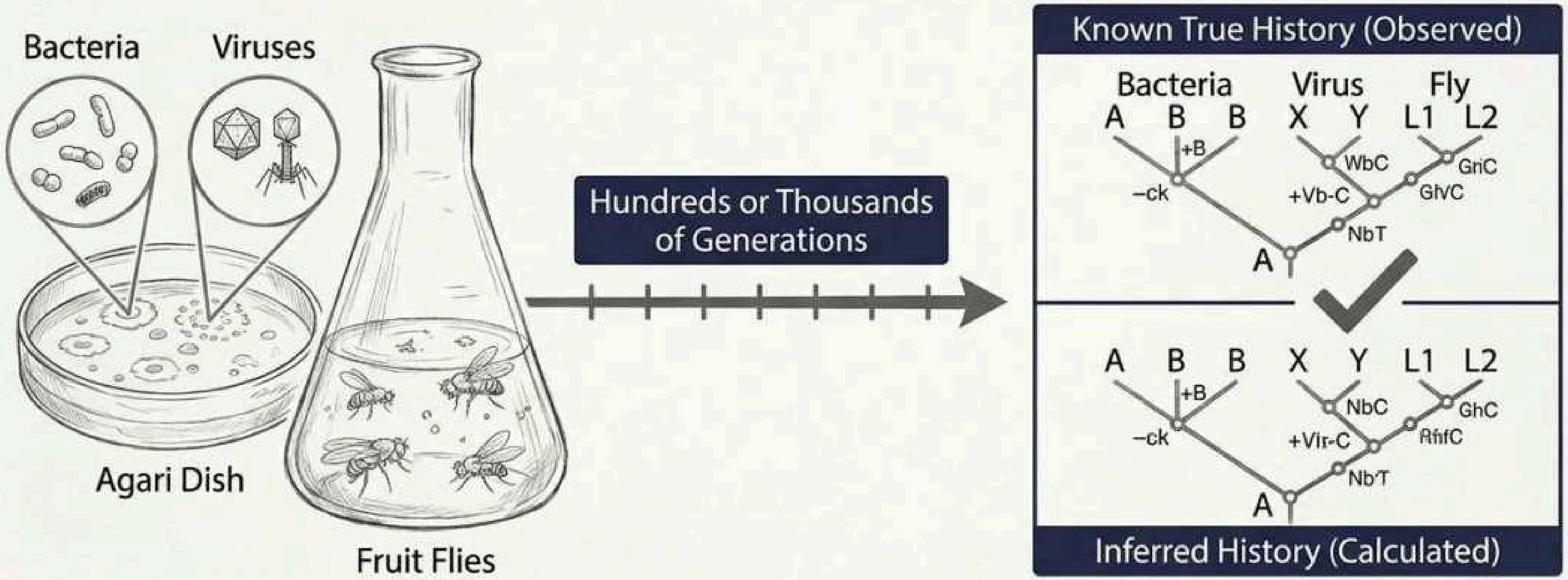
The Smoking Gun in Action

Asteroid impact extinction of dinosaurs (Luis & Walter Alvarez, 1980).



The unique chemical trace required a large crater of the exact right age, which was subsequently located.

Experimental Evolution in the Lab



Experiments show evolutionary processes directly under controlled conditions.

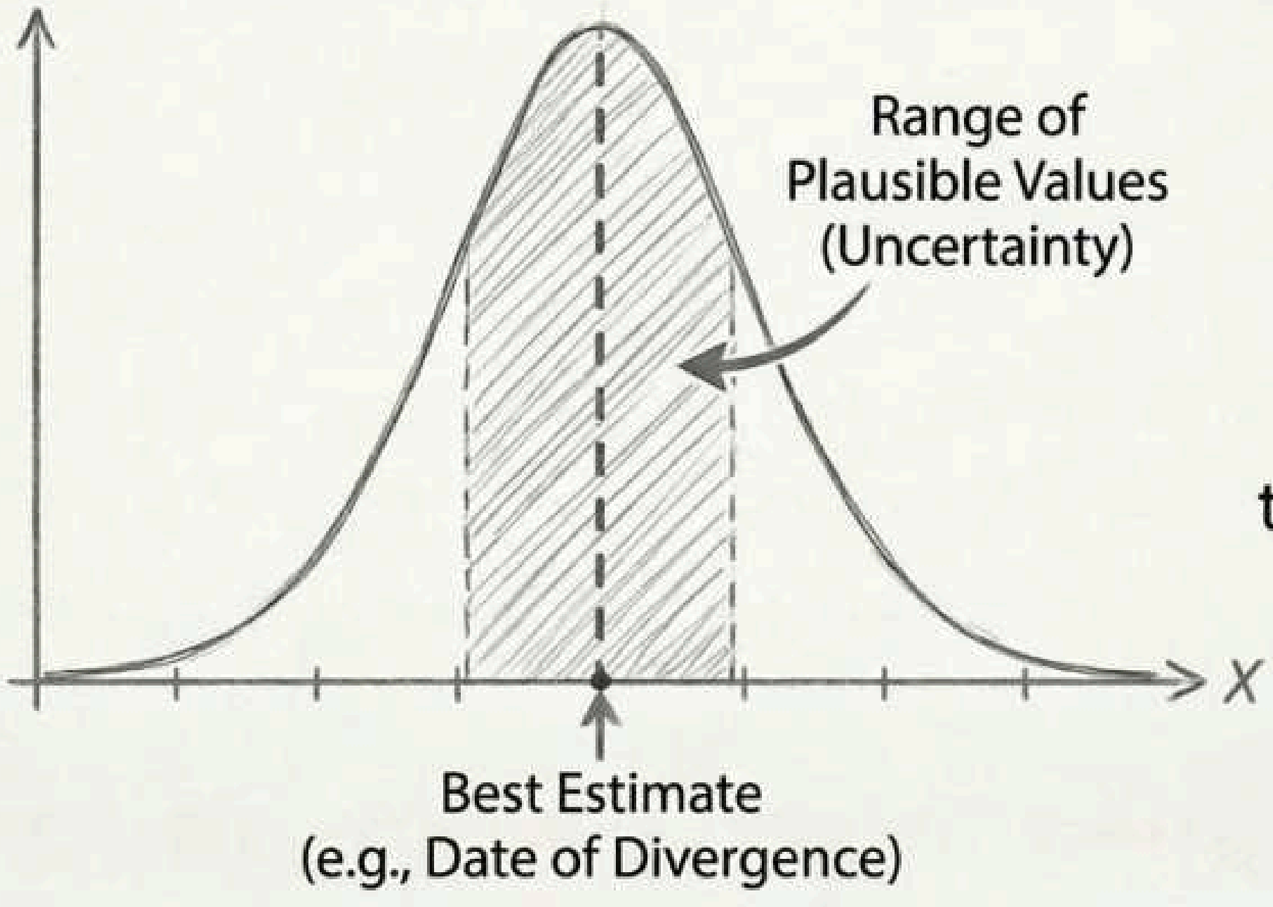
By knowing the true history in the lab, researchers can verify if their inference methods successfully recover it.

[¶ 1.13]

Modern Inference is Statistical

$$P(Tree \mid Data) \propto P(Data \mid Tree) \times P(Tree)$$

We no longer ask which tree is right, but how probable are the data given the hypothesis and model of change.



Careful papers report both a best estimate and measure the uncertainty.

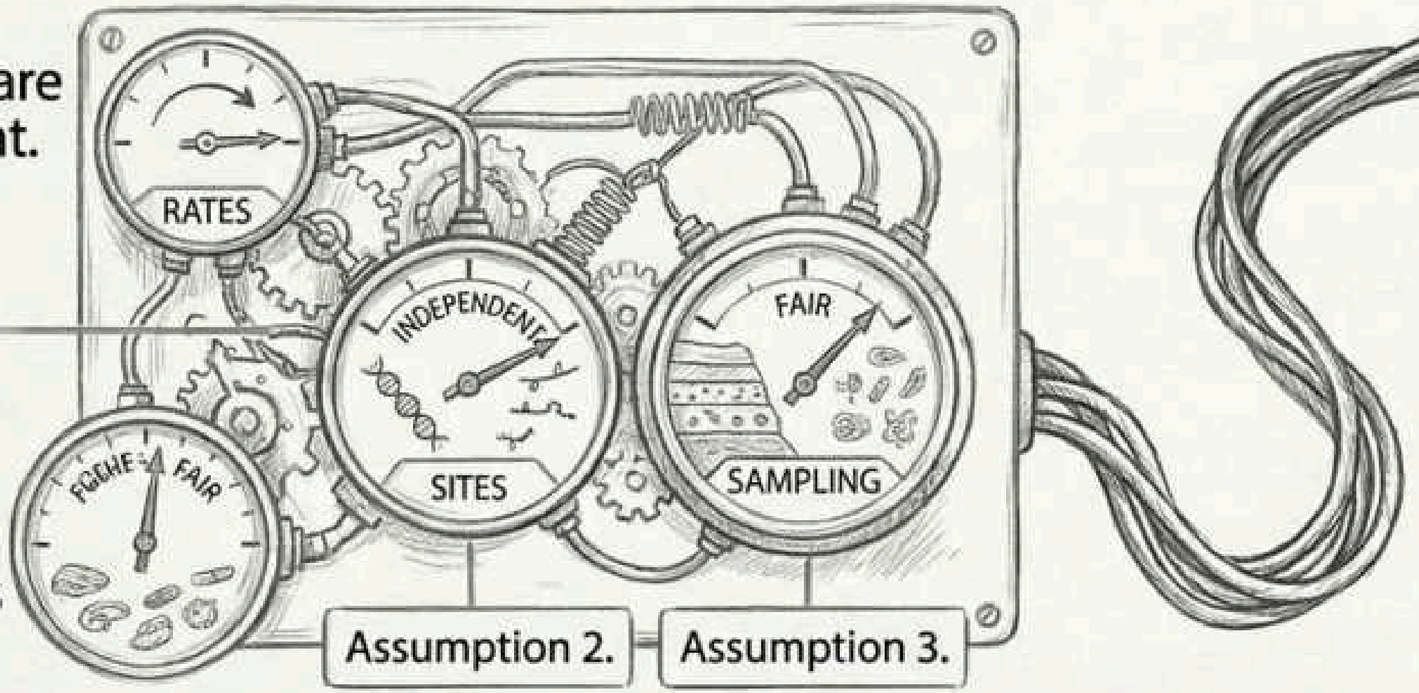
The Crucial Role of Assumptions

Every inference rests on assumptions.

Rates of change are roughly constant.

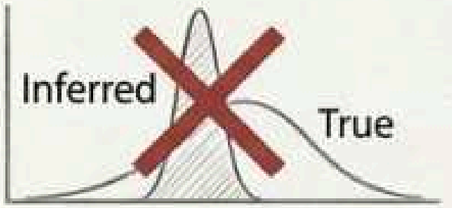
Sites in a gene evolve independently.

Fossil record samples groups fairly.





If assumptions fail → Confident but WRONG answers.



Top scientists continually test their assumptions and check results against independent evidence.

[¶ 1.15]

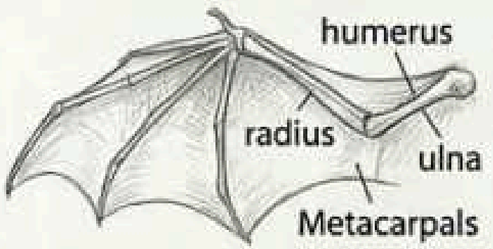
Summary: The Logic of Evolutionary Inference

Evolutionary inference reasons from present traces to unrepeatable past events.

Philosophy:
Inference & Consilience

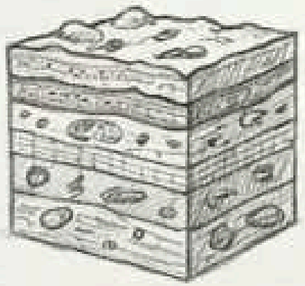


Biological Evidence:
Homology, Hierarchies, Vestiges

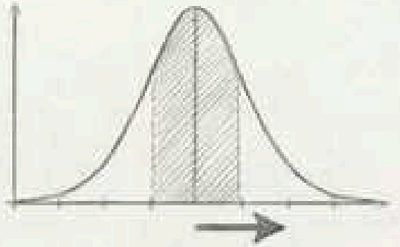


The Evolutionary Tree

Historical Traces:
Smoking Guns



Modern Math:
Statistical Models
& Lab Experiments



Next, we learn to build and read these evolutionary trees.