Phylogeny reconstruction is a major enterprise of systematic biologists. These phylogenies have obvious immediate applications to systematics, but it is not often appreciated how the theory and practice of phylogenetic inference (cladistics), developed by systematists, has transformed biology and the world we live in at large.

I. Disease Origins & Epidemiology

HIV Origins
Table 1. A comparison of the two major families of Human Immunodeficiency Virus (HIV).

<table>
<thead>
<tr>
<th>Species</th>
<th>Virulence</th>
<th>Transmissibility</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV-1</td>
<td>High</td>
<td>High</td>
<td>Global</td>
</tr>
<tr>
<td>HIV-2</td>
<td>Lower</td>
<td>Low</td>
<td>WestAfrica</td>
</tr>
</tbody>
</table>

Cladograms show HIV derived from SIV multiple times.

Cladograms reveal we’re simians (primates)

HIV Origins

Cladograms help explain why most widespread & virulent (HIV-1) came from chimp & gorilla SIV.

But how?

A Startling New Theory Attempts To Answer The Question "Was It An Act Of God Or An Act Of Man?"

It was almost thirty years ago, I think I remember, my high school in August 1982. The basketball team was going through its first day at the Walters, MSK, and I was one of the last to get there. I was talking to one of my friends, a fellow basketball player, and we were sitting on the bleachers, watching the game. Suddenly, one of the players fell off the bench and landed hard on the court. We all rushed to him, and he was bleeding profusely. I remember thinking, "This can't be happening to me."

It was a frightening moment, and it made me realize how fragile life can be. I swear I could hear the crowd cheering for me, but I was too wrapped up in my own thoughts to notice. I was thinking about all the things I wanted to do in the future, and how I was going to make them happen. It was a defining moment for me, and it changed the way I approached my life.

I remember thinking to myself, "If this can happen to me, then anything can happen. I have to be careful and take care of myself." I started to think about all the things I had planned for the future, and how I was going to make sure I followed through with them. I was determined to make my dreams a reality, and I was going to do it no matter what.

But how did I get to where I am now? It all started with that moment in August 1982. I was sitting on the bench, watching the game, and then I heard the crowd cheering for me. I looked down and saw my own reflection in the crowd, and I realized that I was different. I was special, and I was meant for something greater than just playing basketball.

I started to think about all the things I wanted to do in the future, and how I was going to make them happen. I was determined to make my dreams a reality, and I was going to do it no matter what. I was going to be the best at whatever I did, and I was going to make sure I followed through with my plans. I was going to be successful, and I was going to be happy.

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HIV Origins
But how?

Story's Release Summary: HIV-1 may have jumped into humans via OPV
- HIV likely derived from SIVcpz
- Chimps from near Kisangani (DRC) allegedly via live tissue culture, used to prepare OPV by Hilary Koprowski in the 1950's.

Story's Retraction

HIV Origins
But how?

- 7 yrs journalistic research.
- His conclusion: “Good” evidence for OPV-origin.
- www.aidsorigins.com

HIV Origins
Cladistic findings highlight the role of the bushmeat trade.

HIV Epidemiology
Ou et al. (1992) Science 256: 1165 (and others)
1990s, small Florida town:
• Young patient with no apparent risk factors comes down with and dies of AIDS.
• CDC investigates and finds other infected persons.
• Many shared dentist who was HIV positive.
• Did these infections stem from the dentist?

Which patients were infected by dentist, which were not?
II. Character Evolution

A. Homology Assessment

1. 1° homology assessment during character coding & scoring

   e.g.,
   PETAL COLOR:
   0 = red; 1 = blue
   Position 4 in rbcL
   A; G; C, or T

2. 2° homology assessment read from cladogram using optimization methods
II. Character Evolution

B. Testing Adaptational Hypotheses  
e.g., succulence

Observation: Cactaceae are succulent and grow in xeric envs.

Hypothesis: Succulence is an adaptation to xeric envs.

Test: Do nearly 1600 obs of succulence & xeric envs support this?

Answer: No. You have one occurrence of succulence evolving with a xeric habitat. 1600 species have simply inherited these traits.
II. Character Evolution

B. Testing Adaptational Hypotheses

Which cladogram(s) provides evidence for succulence as an adaptation to desert (xeric) environments?

- Left has succulence evolving with xeric 3x's rather than 1x.
- Repeated evolution of 1 trait with 1 particular selective agent provides stronger evidence (i.e. conclusion is supported by 3 natural replicates rather than just 1).

Succulence
II. Character Evolution

B. Testing Adaptational Hypotheses
e.g., origin of epiphytism in cacti

Observation 2
1. While many Cactaceae occur in deserts, some occur as epiphytes in Neotropical rainforests.
2. Epiphytism requires water-use efficiency.

Hypotheses:
Adaptation of terrestrial cacti in deserts may have allowed them to invade rainforest canopies as epiphytes.

Which cladogram(s) support this?
- Both show rainforest epiphytism evolving from a desert terrestrial habit.
What does this cladogram suggest?

- This one shows the inverse of our hyp: that desert terrestrials evolved from rainforest epiphytes.

II. Character Evolution

C. Ancestor Reconstruction

- An epiphytic plant with air roots is shown as an ancestor for its adaptations.
II. Character Evolution

C. Ancestor Reconstruction
Tetrapod origins / evolution

Observation:
Fish fossils date back more than 450 mya
Tetrapod fossils date no more than 350 mya

Hypothesis:
Tetrapod verts evolved from fish.

Conclusions:
• Best cladogram agrees with fossil record & supports hyp.
  • Whereas the most recent common ancestor of tetrapods was
certainly a tetrapod, that ancestral tetrapod evolved from fish.
II. Character Evolution

Higher resolution of the sister clades to tetrapods provide the roadmap to understanding the evolution of legs and other tetrapod traits.

III. Conservation Planning

A. Prioritizing Species

Evidence for the persistence of wild Gibbon forests: Implications for the Duke Mountains, Southeastern China
III. Conservation Planning

A. Prioritizing Species

What arguments can be made for preserving this habitat?

- Ginkgo otherwise extinct in the wild.
- Ginkgo is the most phylogenetically isolated sp.

Won & Renner (2006)

III. Conservation Planning

B. Prioritizing Areas

Scenario 1
One park to be designated, two possible locations of equal area:
Area 1: includes 100 species from lineages 4 and 5
Area 2: includes 90 species from lineages 1 and 4.

Scenario 2
One park to be designated, two possible locations of equal area:
Area 1: includes 100 species from lineages 1 and 2
Area 2: includes 100 species from lineages 3 and 5.
IV. Taxonomies

A. Revision of Existing Classification Schemes

Procedure:
1. Conduct cladistic analysis to test monophyly of existing named ingroup taxa.
2. Revise classification as necessary to ensure monophyly of ingroup taxa.

Cronquist divided the angiosperms into 2 classes.

- Magnoliophyta (angiosperms)
  - Magnoliopsida (dicots)
  - Liliopsida (monocots)

- asterids
- caryophyllids
- rosids
- monocots
  - Ranunculids
  - other primitive
eudicots
- rosids
caryophyllids
asterids
More:
Cronquist's Magnoliidae included water-lilies, magnolias, and buttercups.

Angiosperm Phylogeny Group (2009)

Chase et al. (1993)
(Or should we call it Chase et all?)
The Queen Sago cycad (Cycas circinalis) is an endangered endemic of Southern India & Sri Lanka.

2. Classification based on cladogram.

IV. Taxonomies

B. New classifications

e.g., Plowmananthus (Hardy & Faden 2004)

- Sundew spp.
- Related to Commelina (dayflower) & Tradescantia (spiderwort)
- Do they comprise a new genus or belong to an existing genus?


- Sister group relationship between these and Cochliostema
- But sampled only a single species of both genera
• Complete sampling could have revealed any of these possible topologies.
• All of these allow for the expansion of Cochliostema.
• But only one would allow for the creation of Plowmanianthus.

V. Economic Botany

A. How to target drug discovery
(e.g., Taxus, ca. 25 spp., cosmopolitan)

B. How to target breeding efforts
(e.g., Solanum, ca. 1000 spp., cosmopolitan)
VI. Speciation

A. Allopatric vs. Sympatric or Parapatric Speciation

Allopatry can come about through vicariance or dispersal.

Then what's driving speciation in west and east of Andes?
VI. Speciation

A. Allopatric vs. Sympatric or Parapatric Speciation

Terrestrial
Ter
Ter
Ter
Ter
Ephiphytic
Ter
Ter
1 plausible allopatric speciation events
2 plausible sympatric speciation events driven by adaptation to eiphytic habit

VI. Speciation

B. Key Innovation (skip)

VII. Molecular Dating

Cladogram Depicts Accumulation of Species & Clades Through Time

Present: 350 species
Past: 1 species
Converting Relative Time into Absolute Time:
An Overview

Ancestors are Represented in Phylogenetic Trees

Genetic Distance Increases with Time Since Divergence
VII. Molecular Dating

A. Age of Clades & Species

B. Tempo & Mode of Speciation
VIII. Biogeography

A. Geographic origins

Amazonian Origin

- Amazonian Ecuador
- AE
- AE
- AE
- Pacific Coastal Ecuador
- PCE
- PCE

B. Vicariance or Dispersal?

Dispersal Over Andes
Or Vicariance following Andean Uplift?

Andean Origin

Andean Orogeny
Clade age makes a difference in your interpretation

1. Divergence in allopatry
2. Trans-Andean dispersal