LIGHT WILL BE THROWN:

THE EMERGING SCIENCE OF CULTURAL EVOLUTION

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Introduction

01

Darwin's vision

02

Historical obstacles

03

The revival (1975-present)

Darwin's Prediction(1859)

1859: Darwin made a prediction

"Light will be thrown on the origin of man and his history."

Evolution will unify all sciences studying humans

Darwin's first attempts:

1871: The Descent of Man

1872: The Expression of the Emotions

The project stalled for over 100 years

Not revived until after World War II

The Obstacles (19th Century – 1975)

Social Darwinism (late 1800s)

- Herbert Spencer: "survival of the fittest"
- Used to justify social inequality

Eugenics and Nazi ideology (1900s-1940s)

- Evolution misused for racist pseudoscience
- Led to genocide

Post-WWII taboo (1945-1975)

- Applying biology to human behavior became forbidden
- Social sciences emphasized culture over nature
- Exceptions: Konrad Lorenz (1966) on aggression, Donald Campbell (1960) coined 'evolutionary epistemology'
- But largely ignored due to prevailing culture-over-nature view

The Revival (1975 – Present)

Edward O. Wilson: Sociobiology (1975)

Evolutionary basis of animal AND human social behavior

Initially controversial → accepted within a decade

What followed:

1980s: Sociobiology established

1990s: Evolutionary Psychology

2000s-present: Science of Cultural Evolution(multidisciplinary: biologists, anthropologists,psychologists, linguists, philosophers)

Darwin's vision is now becoming reality

Part 2 GENES AND CULTURE: A Two-Way Street

01

The Nature-First Problem

02

Gene-culture coevolution

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Examples

The Nature-First Problem:Gene-Culture Coevolution

Wilson's early view: "Genes hold culture on a leash" (1978)

Nature-First approach:

- Culture is embedded within biology
- Epigenetic rules constrain how culture can evolve
- Cultures that disobey biological imperatives will go extincKey
- Mechanism of Social Behavior:
    - Kin selection: Altruism towards close kin.
    - Reciprocity: "I'll scratch your back if you scratch mine".

The problem:

This underestimated culture's major role in human evolution
Culture is not subordinate to genes
Culture can ALTER the path of biological evolution

New Framework: Coevolution and Dual Inheritance

Niche construction (Laland, Odling-Smee & Feldman 2000):	Dual inheritance (Boyd & Richerson 1985):
• Environmental modification by organisms • Alters selection pressures acting on themselves • Human niche construction: • Social learning and culturally inherited practices • Extensively modified biological selection pressures	• Two transmission channels: • 1. Genetic replication (sexual reproduction) • 2. Cultural transmission (imitation and language)

This led to proposals for an 'Extended Evolutionary Synthesis' (Danchin et al. 2011) - updating Neo-Darwinism to fully incorporate cultural inheritance

How Culture Shaped Our Genes

Lactose tolerance (Durham 1991)

- ~8,000 years ago: cultural innovation of dairy farming
- Individuals with ability to digest milk had advantage
- New digestive enzyme got selected
- Cultural practice caused genetic change

other examples

- Preference for eating meat (Aiello & Wheeler 1995)
- Control of fire (Berna et al. 2012)
- Invention of cooking (Wrangham et al. 1999):Expensive-tissue hypothesis: Ancestors "swapped" excess gut tissue for larger brains through cooking.
- Without these, hominid brain expansion would not be possible

Genes altered by cultural selection pressures:

- Learning abilities, personality, intelligence, hand preference
- Dietary preferences, alcohol metabolism, hair and eye color
- FOXP2 gene facilitating language acquisition
- The list of genes altered by culture is still growing (Laland et al. 2010)

Part 3 THE HUMAN PUZZLE

01

Evidence of early culture

02

Why culture evolved

03

Why only humans?

04

Donald's three stages

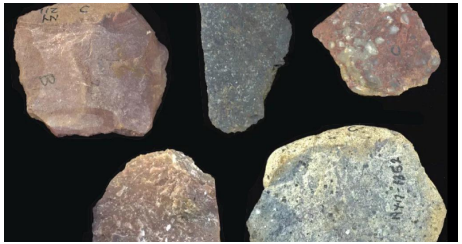
Evidence of Early Culture

El Castillo cave, Spain: Hand stencils

- More than 40,000 years old
- Oldest known examples of Paleolithic cave art
- Signs of symbolic thought
- Possibly made by Neanderthals or early humans
- ~75% of hand stencils were actually made by women.

Oldowan stone tools, East Africa

- 2.5 million years old (Homo habilis)
- Earliest tangible evidence of culture
- Culture requires accumulation of information



What Is Culture and Why Did It Evolve?

Definition

- Culture = information transmitted to next generation by non-genetic means

Why culture evolved:

- Makes behavioral repertoire more flexible
- Allows species to adapt to changing environments faster
- Cultural evolution is much faster than genetic evolution

Example: Homo sapiens

- Within 100,000 years, conquered vast range of habitats: - Deserts, frozen tundras, remote Pacific islands
- Body and mind designed for African savannah
- Culture enabled global expansion

Culture Is Common, But Cultural Evolution Is Rare

The puzzle:

If culture is so biologically advantageous, why has it not evolved in many other species?

Richerson & Boyd (2005):

"The existence of human culture is a deep evolutionary mystery,
on a par with the origins of life itself."

Key distinction:

Culture is common (many animals have culture)

But cultural evolution is rare (cumulative culture)

The Ratchet Effect: Three Conditions for Cumulative Culture

Three necessary conditions:

1. Social learning (copying others)
2. Creative invention (generating new ideas)
3. Faithful transmission (accurate replication)

→ The key difference

Birds and primates have (1) + (2) but lack (3) - they cannot prevent information loss

Tomasello's "ratchet" metaphor:

Cumulative cultural evolution requires a mechanism that prevents newly acquired information from "slipping back"

The ratchet preserves information and ensures modifications accumulate over time

Most animal species cannot overcome this threshold

Three Stages of Cultural Evolution

Stage 1: Mimetic culture (~2 million years ago, H. erectus)

- Communication through gestures and voluntary motor acts
- Knowledge shared through imitation

Stage 2: Mythic culture (~200,000 years ago, H. sapiens)

- Spoken language emerged
- Myths contained accumulated knowledge about the world
- Primary function: telling stories/narratives

Stage 3: Theoretic culture (~10,000 years ago)

- Written language (external storage systems)
- Cuneiform, hieroglyphs, symbols
- Enabled critical examination of own culture
- Led to philosophy and science
- Greatest reconfiguration of cognitive structure, but without much genetic change

Part 4 CULTURAL EVOLUTION IS DARWINIAN

01

The Darwinian Mechanism

02

Cultural phylogenies

03

The Gene-Meme Analogy

The Darwinian Mechanism of Cultural Evolution

Three essential ingredients (Richerson & Boyd 2005, Mesoudi 2011):

- Variation
- Selection
- Transmission

Combined, these create cumulative selection:

- Outputs of each stage serve as inputs for the next
- Cumulative selection is the hallmark of Darwinian evolution

Dennett (1995): Evolution is "substrate neutral"

- The process is neutral with respect to the medium
- Any system can evolve if these three ingredients are present
- Biological evolution: genetic variants
- Cultural evolution: cultural variants (ideas, skills)

Cultural Family Trees and Lineages

Cultural evolution is Darwinian — but how to prove it?

Key evidence: Darwinian evolution produces tree-like phylogenies (family trees)

Cultural traditions also form phylogenies:

- Stone tools and projectile points (O'Brien et al. 2001)
- Polynesian canoes (Rogers et al. 2009)
- Indo-European languages (Gray & Atkinson 2003)
- Italian violins (Chitwood 2014)

Darwin already noticed this in The Descent of Man (1871):

"The formation of different languages and of distinct species... are curiously parallel."

Reconstruction method: Biologists use homologies; linguists use cognates (nacht, notte, noche, nuit)

The Gene-Meme Analogy: Useful But Limited

Dawkins (1976): Cultural variants can be called "memes"

- A meme is a unit of cultural information that leaps from brain to brain

Similarities between genes and memes:

- Both are replicators that encourage their own reproduction
- Both carry information (genes → proteins; memes → culture)
- Both can be latent

But memes are not like genes (Richerson & Boyd 2005):

- Genes are discrete, particle-like bits of DNA
- Memes are often complex and fuzzy (e.g., "Asian Cuisine")
- "A Darwinian account of culture does not imply that culture must be divisible into tiny, independent gene-like bits"

Part 5

HOW CULTURE SPREADS

01

Mathematical Models of Cultural Evolution

02

Mechanisms of Transmission

03

Applications in Big Data

Mathematical Models of Cultural Evolution

Cultural evolution is a Darwinian cumulative selection process

- Therefore, researchers can use mathematical models to understand and predict outcomes
- These models use the same mathematical techniques developed in the 1920s-1930s for population genetics (Fisher, Haldane, Wright)
- showing the deep connection between biological and cultural evolution

Three key variables affect cultural evolution:

- 1. Modes of transmission
- 2. Speed of transmission
- 3. Transmission bias

By manipulating these variables in models

- researchers can analyze long-term macro-evolutionary consequences

Mechanisms of Transmission

Modes of transmission (Cavalli-Sforza & Feldman 1981):

- Vertical: parent to offspring
- Horizontal: among peers in same generation
- Oblique: older generation to younger (formal teaching)

- → Vertical transmission alone keeps cultures static; horizontal transmission enables innovation

Speed: One-to-few vs. one-to-many

- Hunter-gatherers: mainly vertical and one-to-few → slow evolution

- Modern world: internet and social media → horizontal and one-to-many → rapid evolution

Transmission biases:

- Content bias: intrinsic attractiveness of the variant

- Frequency-dependent bias: conformity (adopt common variants) vs. nonconformity (adopt rare variants)

- Prestige bias: imitate successful/famous individuals

Applications in Big Data: Predicting Cultural Evolution

Beyond academic research: cultural evolution draws attention in business

Big data companies (Google, IBM, Oracle) analyze massive information flows:

- 500 million tweets daily → predict patterns and spot trends before people notice them
- "Nowcasting"

Tools: Evolutionary algorithms and genetic programming

- These tools manage information flow and detect predictive patterns
- Evolutionary computation may solve the problem of harnessing big data

Big data research may further advance and complement the science of cultural evolution

Part 6

THE LAMARCKIAN CHALLENGE

Part 6 THE LAMARCKIAN CHALLENGE

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The Lamarckian Challenge

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Why "Lamarckian" Is Misleading

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Intentionality and Selection

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The Core: Cumulative Selection

Is Cultural Evolution Really Darwinian? The Lamarckian Challenge

The Objection

- Cultural evolution is directional and goal-directed
- Cultural variants are purposively generated and transmitted
- Therefore: "Lamarckian" not "Darwinian"

The Distinction

- Lamarckian evolution: "guided" (variants pre-adapted)
- Darwinian evolution: "blind" (variants cannot anticipate)

The Implication

- In Lamarckian evolution, wasteful selection not needed
- Variants already adjusted to needs they fulfill

Why "Lamarckian" Is Misleading (Two meanings of "Lamarckian")

1. Literal Biological Lamarckism:

- Acquired characteristics → encoded in DNA
- Changes to genome are inherited
  - Example: Exercised muscles → stronger offspring
- Nobody claims this for culture

2.Metaphorical "Lamarckism"

- Learned skills → transmitted through teaching
- Information flows intentionally (teacher → learner)
- This is simply teaching and learning
- This definition is trivial

The Real Question:
Does intentional creation eliminate the need for selection?

Why Intentionality Doesn't Make It Lamarckian

1. Not Sufficient for Success

- Being generated intentionally doesn't guarantee retention
- Intent is not even necessary: some successful variants (e.g., customs, pronunciations) "just crop up" without deliberate intent.
- Still needs selective system to determine success

2.Cultural evolution appears directed only in retrospect

- We edit out failures and dead ends
- This creates illusion of smooth, guided process
- In reality: as wasteful and laborious as biological evolution

3. Selection Remains Essential

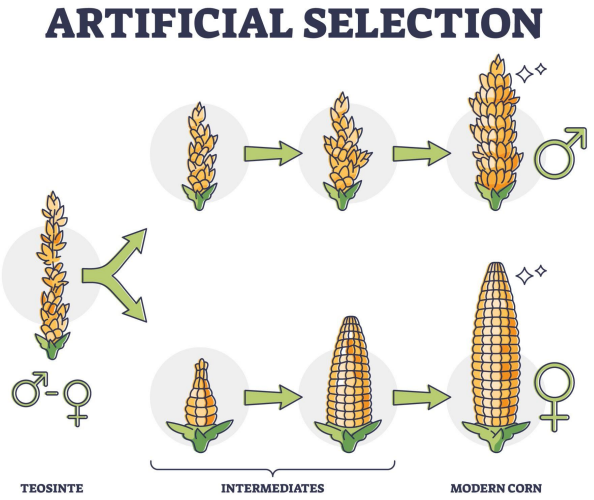
- Even "guided" variation requires hindsighted selection
- To "separate the wheat from the chaff"
- Intentionality only increases efficiency, doesn't bypass selection

Darwin's Core Definition: Cumulative Selection, Not Blind Variation

Guided Variation vs. Selection
Guided variation does not fundamentally change the process.
Intelligence increases efficiency, but selection still determines success.

Darwin's Own Example: Artificial Selection
Farmers intentionally select desirable traits
Breeders select traits with clear intent, yet it remains Darwinian evolution.
Key reason: Both are "cumulative sieving" processes.

The Defining Feature:
NOT "blind variation"
BUT "cumulative selection"
Cultural evolution fully meets this core criterion.



Cultural Evolution Is Fundamentally Darwinian

Intentionality ≠ Pre-adaptation

- Intentional creation doesn't guarantee success
- Selection still needed to winnow failures

Cumulative selection defines Darwin

- Blind vs. guided variation is secondary
- What matters: does information accumulate through selection?

Cultural evolution meets the criteria

- Exhibits variation, selection, transmission
- Results in tree-like phylogenies
- Requires hindsighted selection despite foresight

Final Point

- "Lamarckian inheritance" describes the mode of transmission
- The overall process remains fundamentally Darwinian.

Part 7
CONCLUSIONS

Conclusions & Outlook

Darwinian Nature of Culture
Cultural evolution is a cumulative selection process where information builds up through selective retention.

The Human "Ratchet" Language acts as a high-fidelity transmission medium, creating a "ratchet effect" that prevents information loss—a rarity in nature.

Gene-Culture Coevolution
Culture has its own inheritance system and can even alter the trajectory of biological-genetic evolution.

A Scientific New EraThe thriving research program(Lakatos)marks the dawn of a new era where the Darwinian paradigm reaches its full potential.

The Second Synthesis:
Unifying social sciences with a common theoretical framework, just as Neo-Darwinism unified biology in the 1930s.

THANK YOU