EVOLUTION 101

WEEK 4

Video Resources:

- Human Evolution
- Animation of human evolution
- How does new gene evolve?
- Genetic evolution
- How evolution works?
- Evolutionary medicine
- Classical and evolutionary medicine
- Cladograms and phylogenetic trees
- Phylogenetics
- Phylogeny and the Tree of life
- Building phylogenetic trees
- Basics of Phylogenetic trees
- Building phylogenetic trees
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Human Evolution

Human evolution is the long process by which modern humans (Homo sapiens) developed from primates over millions of years. It involves a series of changes in anatomy, behavior, and genetics, driven by natural selection, adaptation, and migration.

Let's trace human evolution beginning from Ramapithecus, one of the earliest known ancestors in the human lineage.

1. **Ramapithecus**
Time: ~14 to 8 million years ago
Significance:

- Once believed to be the first direct ancestor of humans.
- Fossils show a short face, parabolic dental arcade (like humans), and reduced canine teeth.

- Now considered closely related to modern orangutans, but important as an early Miocene ape showing some human-like traits.

2. **Australopithecus**
Time: ~4 to 2 million years ago
Significance:
- Fully bipedal (walked upright), but still had long arms for climbing.
- Small brain (400–500 cc), large face, and strong jaws.
- Teeth show a transition from ape-like to human-like.

3. **Homo habilis ("Handy Man")**
Time: ~2.4 to 1.4 million years ago
Significance:
- First to use stone tools.
- Larger brain (~600–700 cc).
- Considered the earliest species of the genus Homo.
- Likely capable of basic speech and planning.

4. **Homo erectus ("Upright Man")**
Time: ~1.9 million to 110,000 years ago
Significance:
- First to use fire, cook food, and migrate out of Africa.
- Taller, with modern limb proportions and brain size up to 1100 cc.
- Tools more advanced (Acheulean hand axes).
- May have used basic clothing and built simple shelters.

5. **Homo neanderthalensis** (Neanderthals)
Time: ~400,000 to 40,000 years ago
Significance:
- Stocky build, adapted to cold climates.
- Brain size similar or larger than modern humans (~1200–1750 cc).
- Used complex tools, buried their dead, and possibly used language.
- Interbred with early Homo sapiens.

6**. Homo sapiens (Modern Humans)**
Time: ~300,000 years ago – present
Significance:
- Highly developed brain (~1350 cc), abstract thinking, language, art, and culture.
- Created cave paintings, jewelry, and musical instruments.
- Mastered agriculture ~10,000 years ago → led to civilization.
- Rapid global migration and adaptation.

Introduction to Hominin Lineage:

The hominin lineage includes modern humans and all extinct species more closely related to us than to chimpanzees. This group evolved after our split from the last common ancestor with chimpanzees, showing key changes in brain size, posture, and behavior over millions of years.

Early Hominins:
Around 6–7 million years ago, early species like Sahelanthropus tchadensis and Orrorin tugenensis appeared in Africa. They had small brains but showed signs of walking upright, suggesting bipedalism came before major brain development.

Australopithecus and Adaptations:
Australopithecus species, such as the famous "Lucy," lived about 4 million years ago. They walked on two legs but still climbed trees. Their brains were slightly larger, and they may have used simple tools.

Genus Homo and Human Traits:
The genus Homo began with Homo habilis around 2.4 million years ago, known for using tools. Homo erectus followed with larger brains and human-like bodies, spreading out of Africa and possibly using fire and language.

Modern Humans and Neanderthals:
Later species include Homo neanderthalensis and Homo sapiens, who emerged around 300,000 years ago. Modern humans developed advanced tools, culture, and language, eventually becoming the only surviving hominin species.

Conclusion:
The hominin lineage shows a gradual evolution from ape-like ancestors to modern humans, marked by walking upright, increasing brain size, and complex behavior.

Genetic Evolution:
Genetic evolution is the change in a population’s genetic makeup over generations.It occurs through natural selection, mutations, genetic drift, and gene flow.
Examples : Evolution of bipedalism, increase in brain size, or lactose tolerance in some human populations.

Genetic evolution is slow and biological, passed from parent to child. It shaped our physical features and abilities based on environmental pressures.

Cultural Evolution
Cultural evolution is the transfer and development of behaviors, knowledge, and skills through learning, not genes. Unlike genetic changes, cultural evolution can happen within a single generation.
Examples: Tool-making, language, art, religion, agriculture, and modern technology.

Cultural traits are learned and passed on socially—through teaching, imitation, and communication—allowing rapid adaptation and progress.

Key Differences

- Genetic evolution is inherited biologically and slow.
- Cultural evolution is passed socially and fast.
- Genetic evolution affects biology; cultural evolution affects behavior, society, and technology.

Interaction Between Genetic and Cultural Evolution:

These two forms of evolution often interact. For instance:

- Agriculture (a cultural innovation) changed human diets, influencing genes like those for lactose digestion.
- Living in large groups increased disease spread, selecting for stronger immune system genes.

Thus, human evolution is not just biological—it's also deeply shaped by how we live and learn.

<u>Introduction to Applied Evolution</u>

Applied evolution refers to the use of evolutionary principles to understand and address real-world problems in medicine, agriculture, and conservation. Evolution is not just a historical process—it's ongoing and visible in everyday situations, such as how bacteria become resistant to drugs or how pests adapt to chemicals. By studying and applying these principles, scientists and policymakers can develop better strategies to manage resistance, preserve species, and improve sustainability.

1) **Antibiotic Resistance**

Antibiotic resistance is the ability of bacteria to survive and multiply despite the presence of drugs meant to kill them.When antibiotics are used, most bacteria die, but some may survive due to random mutations. These survivors reproduce, passing on their resistant genes. Over time, the entire bacterial population can become resistant.

Real-world Impact: Diseases like tuberculosis and gonorrhea have become harder to treat due to resistance. Overuse and misuse of antibiotics in medicine and agriculture accelerate this evolution.

2) **Pesticide Resistance:**

Pesticide resistance is the evolutionary adaptation of pests (insects, weeds, etc.) to survive chemicals designed to kill them.

Just like with antibiotics, pests that happen to carry resistance traits survive pesticide exposure. These individuals reproduce, and resistance spreads rapidly, especially with repeated chemical use.

Real world impact: Farmers need stronger or alternative chemicals, increasing costs and environmental harm. This also threatens food security as pests continue to damage crops.

3) **Conservation Genetics**
Conservation genetics is the use of genetic knowledge to protect endangered species and maintain biodiversity.It involves studying genetic variation in populations to manage inbreeding, loss of diversity, and genetic drift. Low genetic diversity can make species more vulnerable to diseases and environmental changes.

Real world impact:
It helps design breeding programs, select individuals for reintroduction, and maintain healthy populations in the wild or captivity (e.g., pandas, cheetahs, tigers).

Evolutionary Medicine:
Evolutionary medicine is the study of how evolutionary principles help us understand health, disease, and the functioning of the human body.

Core Idea:
Our bodies and immune systems evolved over millions of years under natural environments. However, rapid changes in modern lifestyles, diets, and environments can cause mismatches that lead to new or worsened health problems.

Key Concepts:
Mismatch Theory:
Many modern diseases arise because our evolved biology doesn't fit well with current lifestyles. For example, our ancestors were physically active and ate natural foods, while modern sedentary life and processed diets contribute to obesity, diabetes, and heart disease.

Pathogen Evolution:
Just as humans evolve, so do pathogens. Viruses and bacteria rapidly adapt to treatments, making diseases harder to control. Understanding their evolution helps in developing long-lasting treatments and vaccines.

Fever and Symptoms as Defenses:
Some symptoms like fever or inflammation may not be flaws but evolved defense mechanisms. Evolutionary medicine helps us understand when it's better to let the body respond naturally versus when to intervene.

Genetic Trade-offs:
Some genetic traits that were advantageous in the past may be harmful today. For example, genes that helped store fat during food scarcity now increase obesity risk.

Applications:
- Designing better public health policies
- Developing more effective vaccines and treatments

- Understanding mental health and autoimmune diseases from an evolutionary perspective.

Resources for Project
https://youtu.be/HcjR99SPNNM?feature=shared
https://youtu.be/PoycwO8vuc0?feature=shared
https://youtu.be/DAbtTZbYiXA?feature=shared

Project problem statement:

Title: Comparative Phylogenetic Analysis of Species Using Genetic Distances

Objective:
To analyze genetic relationships between selected species by calculating genetic distances and constructing a phylogenetic tree based on DNA sequence data obtained using BLAST.

Steps:

1. **DNA Sequence Collection:**
    - Use BLAST (Basic Local Alignment Search Tool) to retrieve DNA sequences of 8 specific species of interest.
    - Save the retrieved sequences in a standard FASTA file format for further analysis.
2. **Genetic Distance Calculation:**
    - Compute the genetic distance matrix using appropriate bioinformatics tools or algorithms.
    - Measure pairwise genetic differences among the selected species based on their DNA sequences.
3. **Species Clustering:**
    - Group the species into clusters according to their genetic distances.
    - Use clustering methods such as UPGMA (Unweighted Pair Group Method with Arithmetic Mean) or neighbor-joining to identify closely related species.

4. **Phylogenetic Tree Construction:**
    - Generate a phylogenetic tree to visually represent the evolutionary relationships among the species.
    - Utilize software tools like MEGA, PhyloTree, or a programming library such as Biopython to build and visualize the tree.

Expected submission:

1.FASTA File Containing Input Sequences
2.Python Code for Computing Genetic Distances and generating phylogenetic tree
3.Phylogenetic Tree in PNG Format(make it more vibrant like using colours using biopython)

For reference:

https://drive.google.com/file/d/1RCmbItOmJ4mn3L2ZTxBomoCpF_mTiNM-/view?usp=drive_link
Phylogenetic tree reference
https://drive.google.com/file/d/11Jqwll6hCuRweNSIERgQ-tmPOjdhsCeS/view?usp=sharing
.fasta file reference