The Fossil Evidence of Evolution

1. Fossils show a pattern of change through geologic time of new species appearing in the fossil record that are similar to existing species, but different in one or more key attributes.

2. Fossils reveal the pattern of evolution through time. Evolution has not proceeded smoothly and regularly. Instead, long intervals of geologic time with low levels of species formation are punctuated by relatively short intervals of extinction followed by bursts of evolution.

3. The discontinuities in the fossil record form the boundaries of the Eons, Eras, and Periods of geologic time.

4. Fossils provide information about how major transitions between different “types” (e.g. fish to tetrapods) unfolded.

Living organisms have many anatomical similarities that reveal their descent from a common ancestor. Homologies in structures with different functions don’t make sense from the perspective of design - they are the legacies of evolution.
Fossils provide a range of related species from which can be constructed a plausible sequence of transitional forms.

Evolution of the Tetrapod Limb

2006

“Lobe-fin” fish

“Fishapods”

Tetrapods (amphibian)

Tiktaalik

A ‘fishapod’ from the Devonian of Canada

From the following article:
A Devonian tetrapod-like fish and the evolution of the tetrapod body plan
Edward B. Daeschler, Neil H. Shubin and Farish A. Jenkins, Jr
Nature 440, 757-763 (6 April 2006)
Ever since Darwin published his Theory of Evolution in 1859, biologists have wondered, which group of animals are the ancestors of birds?

Darwin’s friend and defender Thomas Huxley first suggested that the newly discovered dinosauria had many skeletal features in common with birds.

Archaeopteryx lithographica
Discovered in 1861

Bird features:
• feathers
• wings
• fused clavicle (wishbone)
• hollow bones

Dinosaur features:
• three-fingered hand with claws
• reptile skull with teeth
• long, stiff tail
Archaeopteryx lithographica

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• feathers
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Skeletal homologies show that Archaeopteryx and Birds are Coelurosaurian Dinosaurs

• ascending process on astragalis
• semi-lunate carpal
Archaeopteryx and Birds are Maniraptora

- elongated middle digit on hand
- clavicles fused to form furcula (wishbone)
- elongated forelimbs
- bowed ulna

Furcula (wishbone)

Deinonychus - a North American dinosaur similar to Velociraptor

Microraptor - Early Cretaceous, China
Feathers - the latest Dinosaur - Bird homology

*Microraptor* - Early Cretaceous, China
Microraptor gui

Four-winged dinosaurs from China
Xing Xu, Zhonghe Zhou, Xiaolin Wang, Xuewen Kuang, Fucheng Zhang and Xiangke Du
Primitive Early Eocene bat from Wyoming and the evolution of flight and echolocation
Nancy B. Simmons, Kevin L. Seymour, Jörg Habersetzer & Gregg F. Gunnell
Nature 451, 818-821 (14 February 2008)

The Fossil Record of Whale Evolution
Figure based on: Walking with whales, Christian de Muizon
Nature 413, 259-260 (20 September 2001)
Adaptive Radiation

The geologically rapid (1-10’s of million years) evolution of a variety of new species from a single ancestral stock.
Adaptive Radiation

Triggered by several possible events:
• Evolution of a new organ that allows a species to invade new ecospace.

Example: the adaptive radiation of amphibians and all subsequent terrestrial vertebrates that followed the evolution of tetrapods in the Devonian Period.

Adaptive Radiation

Triggered by several possible events:
• Extinction of an existing, dominant group of organisms, vacating habitat and food sources.

Example: the adaptive radiation of mammals in the Tertiary Period following the extinction of the dinosaurs.

Adaptive Radiation

Triggered by several possible events:
• Evolution of adaptations that confer an advantage over previously existing species.

Example: the adaptive radiation of flowering plants in the Cretaceous Period, which evolved the ability to grow faster and disperse farther than other plants.
Adaptive Radiation

Minor adaptive radiations are often triggered by the colonization of newly available habitat. After arriving in the new habitat, a species can evolve into a “swarm” of new species within a few thousands of years.

Examples:
• Darwin’s finches on the Galapagos Islands.
• Fruit flies and honeycreepers (birds) on the Hawaiian Islands.
• Cichlid fish in the rift lakes of East Africa.

Extinction

• Extinction occurs when the last individual of a species dies.
• Extinction is forever. The same species never evolves more than once.

Mass Extinction
• Many species going extinct in a short interval of geologic time (less than several millions of years).
• Mass extinctions probably have many different causes, all related to the disruption of habitats.
• There have been five unusually large mass extinctions in the last 550 million years.
Analyses of the fossil record show that certain types of organisms share similar patterns of evolution and extinction through time - rising and falling as a group.

The 5 Major Mass Extinctions

- The Permo-Triassic mass extinction at 245 ma, which may have eliminated 95% of all species of marine life.
Permo-Triassic Mass Extinctions

- Terrestrial ecosystems were also depleted as most species of synapsid (“mammal-like reptiles”) go extinct.
- In the Triassic reptiles radiate into many new groups and become the dominant terrestrial animals.

Cretaceous - Tertiary Mass Extinction

- The extinction of dinosaurs, marine reptiles, flying reptiles, ammonites, and many species of plankton at 65 ma.

Pleistocene mass extinction

- The extinction of large mammals in North America at the end of the last ice age 10,000 years ago (mammoths, mastodons, camels, lions, rhinos, horses).
Holocene Mass Extinction

- The current mass extinction due to human over-hunting and destruction of habitat on a global scale.

A mass extinction must involve geologically abrupt disruption of existing habitats on a global scale.

- Climate change
- Sea level change
- Atmospheric change
- Ocean chemistry change

Bernard

*Masse Extinctions*

"Bernard went back in time this morning and killed off the dinosaurs".
Many geologists have attempted to attribute mass extinctions to rare catastrophic events

Supernova
Asteroid Impact
Flood Basalt Volcanism

There is much good evidence for a big impact event near the end of the Mesozoic.

But evidence associating impacts with other mass extinctions is vague or absent.

Flood basalt eruptions cover immense regions in layer after layer of basalt, releasing toxic and greenhouse gases into the atmosphere over tens - hundreds of thousands of years.
Most mass extinctions seem to correlate with times of major volcanic eruptions.

The Real Reason Dinosaurs Became Extinct