Discontinuities in the Fossil Record

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Natura non facit saltus

Darwin quoted this Latin sentence six times in his Origin of Species. Against Huxley’s advice, and with good reason!

Richard Dawkins (2009): “Evolution not only is a gradual process as a matter of fact; it has to be gradual if it is to do any explanatory work.”

Top-Down instead of Bottom-Up

The Neo-Darwinian theory of evolution predicts a bottom-up pattern of appearance of biological disparity: first species differences, then genus differences, then family / order / class differences, and at the end phylum level differences.

The fossil record shows the opposite: a top-down pattern, with phylum differences appearing out of nowhere in the Cambrian Explosion, then diversified on the family level in the Ordovician GOBE event, etc.

Incompleteness of the Fossil Record?

Denton 1985: 80% of all modern families of land vertebrates are represented in the fossil record!

Why Millions of Years is still Abrupt

The average longevity of an animal species is only about …:
- 5-10 my for marine invertebrates
- 3-10 my for insects
- 2.3-4.3 for mammals

Thus, a window of time of 5 million years is equivalent to a succession of just 1-3 species with only minor change!
Late Heavy Bombardment
4.1-3.8 bya (maximum at 3.9 bya)

Existing oceans would have repeatedly boiled away into steam atmospheres as a result of large collisions as late as about 4 billion years ago (Marchi et al., 2014, Nature)

The Origin of Life
3.8 bya (4.1 bya is highly controversial)

3.77 bya: Filamentous bacterial microfossils from the Nuvvuagittuq Greenstone Belt in Quebec

Right after the Late Heavy Bombardement

Origin of Photosynthesis
3.8 bya

Avalon Explosion
575-565 mya

A strange world of microbial mats with enigmatic sessile organisms ("Garden of Ediacara"): glide symmetry, fractal growth, quilted structure, no visible inner organs

Cambrian Explosion
535-515 mya

21 of 28 known bilaterian animal phyla

Recent demise of the artifact hypothesis by the discovery of Burgess-shale like deposits from the Ediacaran of Mongolia (2016) and China (2011): only algae!
Cambrian Explosion
535-515 mya

Small-Shelly-Fauna (SSF) 537-517 mya

Ediacaran-Shelly-Fauna Cloudina and Namacalathus 549-538 mya

Ediacaran “trace fossils” replicated by shaking up microbial mats in lab experiments (Mariotti et al., 2016)

Great Ordovician Biodiversification Event
485-460 mya (maximum at 470 mya)

Silurian-Devonian Terrestrial Revolution
ca. 427-393 mya

One of the two oldest known vascular land plants, Baragwanathia from the Late Silurian, already belongs to the modern group of club mosses. Bateman et al. (1998) concluded that “the Siluro-Devonian primary radiation of land biotas is the terrestrial equivalent of the much-debated Cambrian “explosion” of marine faunas”

Devonian Nekton Revolution
ca. 410-400 mya

Devonian radiation of marine nektonic animals (active swimmers like jawed fish and ammonoids) and synchronous decrease in planktonic and demersal taxa (Klug et al. 2010).
Odontode Explosion
ca. 425-415 mya
Evolution of teeth in jawed fish with earliest Chondrichthyes, Sarcopterygii and Actinopterygii all suddenly appearing within 10 million years of the Late Silurian to Early Devonian

Carboniferous Insect Explosion
325-314/307 mya

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325-314/307 mya
- Palaeodictyoptera: Delitzschala (Germany, 323-318 mya)
- Mayflies: Triplosoba (France, 303-299 mya)
- Dragonflies: Eugomphonothorac (Argentina, 323-324 mya)
- Stoneflies: Golou (China, 318-314 mya)
- Roaches: Kemperala (Germany, 318 mya) and Qilianiblatta (China, 318-314 mya)
- Orthopterans: Archaeorthoptera (Czech Rep., 324 mya)
- Thrips: Westphalothripides (France, 314-307 mya)
- Plant lice: Westphalopsocus (France, 314-307 mya)

Triassic Explosions
after End-Permian mass extinction 252 mya
No new phyla and classes, but many new families and orders of marine invertebrates (bivalves, ceratites), insects (Diptera, Coleoptera), marine reptiles, and terrestrial tetrapods.

Triassic Tetrapod Radiation
251-240 mya
- Crurotarsi: Ctenosauriscus (247 mya)
- Mammaliaformes: Haramiyida (247-245 mya)
- Dinosauria: Nyasasaurus (245-240 mya)
- Lepidosauromorpha: Paliguana (251 mya)
- Testudines: Pappochelis (240 mya)
- Testudines: Phyllochelo (France, 318-314 mya)

Peter Ward (2006: 160): „Thus, the diversity of Triassic animal plans is analogous to the diversity of marine body plans that resulted from the Cambrian Explosion. It also occurred for nearly the same reasons and, as will be shown, was as important for animal life on land as the Cambrian Explosion was for marine animal life.“
Early Triassic Marine Reptile Radiation
248-240 mya

Number of marine reptile families jumps from zero to 15 within a few million years

Aptodentatus unicus

Early Triassic Marine Reptile Radiation
248-240 mya

ichthyosaurs
placodontians
nothosaurs
pistosaurids
mystriosuchine
phytosaurids
tanystropheids
thalattosaurids
pachypleurosaurids

Mid Triassic Gliding Reptile Radiation
230-228 mya

Sharovipteryx
Longisquama
Icarosaurus

Pterosauria: Preondactylus

Upper Triassic Dinosaur Explosion
234-232 mya (Carnian Pluvial Episode / CPE)

It was an "explosive increase in dinosaurian abundance" and "it's amazing how clear cut the change from 'no dinosaurs' to 'all dinosaurs' was."

Upper Cretaceous Mosasaur Radiation
89-66 mya

38 genera, 1-17 m, parallel instead of split bronchi (like whales, unlike monitors)

Origin of Flowering Plants
130-115 mya (crown group)

Darwin's "abominable mystery": "The seemingly sudden appearance of so many angiosperm species in the Upper Chalk conflicted strongly with his gradualist perspective on evolutionary change." (Friedman 2009)

"Then, about 125 million years ago, angiosperms and their flowers sprang forth during the Cretaceous period, as fully formed as Aphrodite." (Oskin 2015)
Butterfly Radiation
55-25 mya

The different families of butterflies (Papilionoidea s.str.) appear abruptly without fossil transition in the Eocene / Oligocene of North America and Europe.

Prodryas persephone, Nymphalidae
Eocene, Florissant, 34 mya

Rapid Radiation of Modern Birds
After K-Pg-Impact: 65-55 mya

Protocoeliades kristenseni, Hesperiidae
Eocene, Moler, 55 mya

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Rapid Radiation of Placental Mammals
After K-Pg-Impact: 62-49 mya (crown group)

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Rapid Radiation of Modern Birds
After K-Pg-Impact: 65-55 mya

Penguin

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Rapid Radiation of Placental Mammals
After K-Pg-Impact: 62-49 mya (crown group)

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Big Bang of the Genus Homo
about 2 mya

"In sum, the earliest Homo remains differ significantly from australopithecines in both size and anatomical details. Insofar as we can tell, the changes were sudden and not gradual." (Hawks et al. 2000)

"New study suggests big bang theory of human evolution." (Swanbrow 2000)

Upper Paleolithic Human Revolution
60,000-37,000 years ago

Richard Klein (2000, 2002): "Recent interpretations of the African Middle Stone Age record are not conclusive; the original 'human revolution' theory remains correct: Middle Stone Age humans evolving in Africa may appear anatomically modern, but did not become cognitively modern until the Later Stone Age/Upper Paleolithic. Symbolic culture emerged some 50,000 years ago, caused by a genetic mutation that re-wired the brain."

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The Waiting Time Problem

The fossil record and population genetics combined do refute the feasibility of the Neo-Darwinian mechanism.

Geological windows of time are much too short to allow for the necessary coordinated mutations to occur and spread in a population.

No Fossils of Gradual Species Transitions

Example: Foraminifera
Globorotalia plesiotaedia — G. tumida

Evidence for abrupt speciation in a classic case of gradual evolution

No Fossils of Gradual Species Transitions

Example: Steinheim basin freshwater snails Gyraulus
Franz Hilgendorf (1866)

Hunt (2010) re-evaluated the fossil evidence for species level transformations in the light of 150 years of paleontological research since Darwin:

"The meandering and fluctuating trajectories captured in the fossil record are not inconsistent with the centrality of natural selection as an evolutionary mechanism, but they probably would not have been predicted without the benefit of an empirical fossil record"

Non-Gradualism unexplained by Neo-Darwinism

Renowned evolutionary biologist Prof. Gerd Müller at his keynote talk to the conference "New Trends in Evolutionary Biology" at the Royal Society in London in November 2016.

Inference to the Best Explanation

The accumulated conflicting evidence from the ubiquitous discontinuities in the fossil record can no longer be explained away as an artefact of undersampling of an incomplete fossil record.

The predictions of Neo-Darwinism are contradicted by the empirical evidence.

The total evidence is better explained with pulses of infusion of information from outside of the system than with an unguided mechanistic gradual bottom-up process.
Questions & Answers