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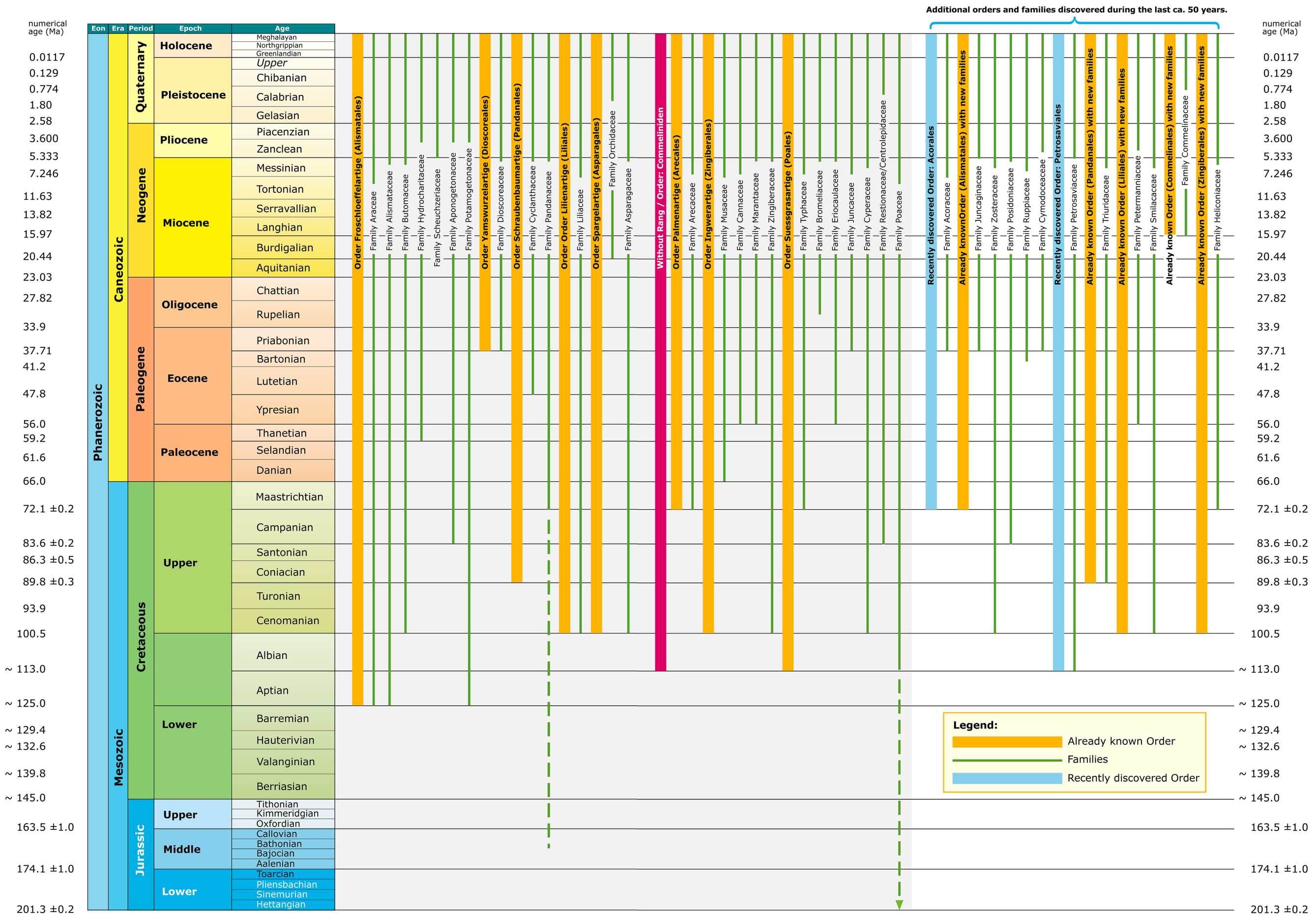
On the Inordinate Amount of "Living Fossils" in the Flowering Plants (Angiospermae)

Or how Darwin's "abominable mystery" has become even more "abominable" and "mysterious" during the last 150 years than ever before

Just a few flowers of some of the more than 300,000 morphological species of flowering plants[1]

[1] Photographs by W.-E. L. – "Just a few flowers" is continued on the last pages of this document (see 102 – 110).

Abstract



Fossil record of the monocot families. On the left (shaded gray) the families known around 1971. **Right: The additional orders and families detected during the last ca. 50 years** of paleontological research (details in the text below).
Figure by Roland Slowik (Dietzenbach), 19 October 2021.[2] Geologic time scale according to ChronostratChart2021-05.pdf

As illustrated for the monocots (virtually the same situation in the dicots[3]), the figure above shows that Darwin's "abominable mystery" has become even more "abominable" and "mysterious" during the last 50 (not to speak of the last 150) years than ever before.

All orders and families of the angiosperms appear abruptly in the fossil record (same for most lower systematic categories).

The statement of distinguished paleontologist Otto H. Schindewolf (University of Tübingen) of 1965 has definitely been further corroborated also in paleobotany and is all the more true in 2021 (see also Eldedge et al. 2005 and discussion in Lönnig 2018, 2019[4]; see also Bechly 2021[5]).

> "According to the Darwinian concept, minor racial differences are to be gradually increased to become species traits, and then, by adding more and more small alterations, become generic, family differences, etc. The variety of forms would then increase towards the end of the individual phyla, and there would be the greatest abundance of orders, families and genera, that is to say, differences of a higher degree. **The opposite is the case**.
>
> A new Bauplan (body plan) of the systematic range of a class or order ***usually appears absolutely abruptly*** in the fossil record, without long rows/successions of links that would show us a gradual formation from another order forming its root."[6]

And, what is more, Living Fossils are not the exception – as they are usually portrayed in the biological literature – but **the rule for a large part of plant and animal families**: We are literally surrounded by Living Fossils: Angiosperms, mammals, birds and many other organisms. Moreover: "Living fossils are something of ***an embarrassment to the expectation that evolutionary change is inevitable as time goes by***" (Niles Eldredge; emphasis added/reference below).

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[2] Incidentally, M. E. Collinson, M. C. Boulter and P. L. Homes – did not include any figures in their otherwise valuable contribution about the "Magnoliophyta ('Angiospermae')" pp. 809-841 in *The Fossil Record 2* (Edited by M. J. Benton), Chapman and Hall, London 1993 – in contrast to the other 86 authors, and in my view for not very convincing reasons. – As for some questions on the millions of years, *cf.* http://www.weloennig.de/HumanEvolution.pdf pp. 27/28

[3] See sample of a series of dicot families below.

[4] *Cf.* references in the text of this article.

[5] https://evolutionnews.org/2021/11/the-discontinuous-fossil-record-refutes-darwinian-gradualism/

[6] http://www.weloennig.de/AesIV5.html

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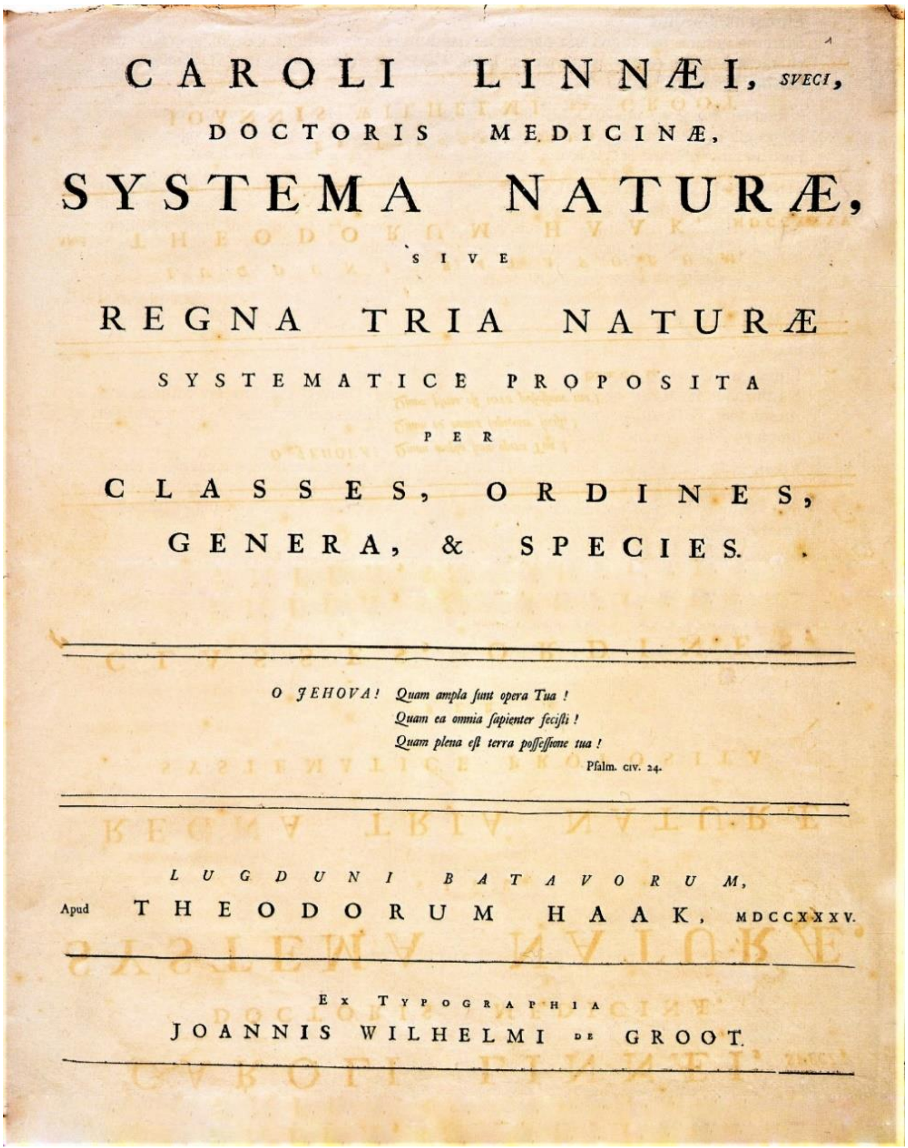
“Also, the "father of modern binomial nomenclature" Carl von Linné (1707-1778) studied and published some notes about plant fossils hosted in the cabinets of curiosities of Swedish noblemen.”[8] As for plant names in the following article – I would like to add this brief reminder: Many of these still valid names were coined by **Carolus Linnaeus (1707 – 1778)**: “**The Father of Modern Taxonomy**”[9]:


CAROLI LINNÆI, SVECI,
DOCTORIS MEDICINÆ,
SYSTEMA NATURÆ,
SIVE
REGNA TRIA NATURÆ
SYSTEMATICE PROPOSITA
PER
CLASSES, ORDINES,
GENERA, & SPECIES.

O JEHOVA! *Quam ampla sunt opera Tua!*
Quam ea omnia sapienter fecisti!
Quam plena est terra possessione tua!
Psalm. civ. 24.

LUGDUNI BATAVORUM,
Apud THEODORUM HAAK, MDCCXXXV.

Ex Typographia
JOANNIS WILHELMI DE GROOT.

See more on Linné, for example, in Lönnig (2020): *Plant Galls and Evolution* (III), pp. 12-15: *Cf.* please the article at http://www.weloennig.de/PlantGalls.III.2020.pdf

[7]Because of the copyright question, I have to refer the reader to the relevant textbooks and many papers on fossil plants showing a large amount of photographs and figures of angiosperm fossils.
[8] https://blogs.scientificamerican.com/history-of-geology/plant-paleoart-through-the-ages/
[9]https://de.wikipedia.org/wiki/Carl_von_Linn%C3%A9 and https://commons.wikimedia.org/wiki/File:Systema_naturae.jpg

How Are "Flowering Plants" (Angiosperms) Defined?

Merriam-Webster (2021): "Definition of *angiosperm:* any of a class (Angiospermae) or division (Magnoliophyta) of vascular plants (such as magnolias, grasses, oaks, roses, and daisies) that have the ovules and seeds enclosed in an ovary, form the embryo and endosperm by double fertilization, and typically have each flower surrounded by a perianth composed of two sets of floral envelopes comprising the calyx and corolla — called also flowering plant."[10]

Encyclopedia Britannica (2021): "**angiosperm**, also called **flowering plant**, any of about 300,000 species of flowering plants, the largest and most diverse group within the kingdom Plantae. Angiosperms represent approximately 80 percent of all the known green plants now living. The angiosperms are vascular seed plants in which the ovule (egg) is fertilized and develops into a seed in an enclosed hollow ovary. The ovary itself is usually enclosed in a flower, that part of the angiospermous plant that contains the male or female reproductive organs or both. Fruits are derived from the maturing floral organs of the angiospermous plant and are therefore characteristic of angiosperms. By contrast, in gymnosperms (e.g., conifers and cycads), the other large group of vascular seed plants, the seeds do not develop enclosed within an ovary but are usually borne exposed on the surfaces of reproductive structures, such as cones."[11]

For an extensive discussion of the many further basic structures usually identifying angiosperms, see please, the Britannica article just cited (however, for the explanation of several details the text starts from an implicit – but unproven – strictly evolutionary viewpoint, which could and has been rationally be questioned[12]).

What Are "Living Fossils" and Why Are They Problematic for Neo-Darwinism?

Merriam-Webster (2021): "Definition of *living fossil*: ***an organism*** (such as a horseshoe crab or a ginkgo tree) ***that has remained essentially unchanged from earlier geologic times*** and whose close relatives are usually extinct."[13]

As the following article on the *Inordinate Amount of "Living Fossils" in the Flowering Plants* (*Angiosperms*) I am going to show that the first part of the definition ("an organism…that has remained essentially unchanged from earlier geologic times") is entirely correct. However, their close relatives are ***not*** "usually extinct".

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[10] https://www.merriam-webster.com/dictionary/angiosperm
[11] https://www.britannica.com/plant/angiosperm
[12] As for the contradictions between the "*Hofmeistersche Serie*" and the paleobotanical record, see Lönnig Staatsexamensarbeit 1971, pp. 85 – 102: http://www.weloennig.de/Staatsexamensarbeit.pdf. In the interim of the last 50 years, most of these contradictions between the evolutionary interpretations and paleontology have been further substantiated (except for some Devonian mosses, which, however, still appear much too late and thus do not solve the basic problems). Also, several other problems have been added, which would necessitate a chapter of its own.
[13] https://www.merriam-webster.com/dictionary/living%20fossil

Definition of living fossils in Dictionary.com/Collins (2021): "An organism that is a living example of an otherwise extinct group and ***that has remained virtually unchanged in structure and function over a long period of time***, as the coelacanth and the horseshoe crab."[14]

Again: As the paleontological facts on stasis have demonstrated, "the group" is not necessarily extinct, but the fact should be emphasized that the living examples have "remained virtually unchanged in structure and function over a long period of time". Examples like the coelacanth, the horseshoe crab and the ginkgo tree are fine but only a tiny minority of the literary thousands of living fossils detected in the paleontological record and still thriving today.

Renowned evolutionary biologist/paleontologist N. Eldredge[15] (keyword "punctuated equilibrium") expounds in his book *Life Pulse*, 1989, p. 108: ***"...living fossils are simply species alive today that display relatively close anatomical similarity to ancestral species living way back near their group's inception***."

A problem with this definition is that we usually know evolutionarily nothing exactly of the time and mode of a group's postulated evolutionary inception – the differences between its first detection in the fossil record and their inception can be enormous[16]. Nevertheless, the first part of the definition appears to be correct and I would like suggesting to modify it as follows: "...living fossils are simply species alive today ***that display relatively close anatomical similarity to ancestral species living way back in the past*** (say from the Pliocene[17], i. e. from 2.58 Ma to more than 541 Ma[18] ago – including microoganisms even up to some 3.8 billion years)."

In his well-known textbook (several editions) Monroe W. Strickberger defines the term as follows (Evolution, 1990, p. 525 and 2005, p. 647[19]): "***An existing species whose similarity to ancient ancestral species indicates that very few morphological changes have occurred over a long period of geological time***."

Strickberger's definition appears to be the most inclusive one and appropriately does away with all the narrow definitions of living fossils, which are starkly distracting from their wide distribution and numerous occurrences in almost the entire world of organisms. I have to add, however, that the author himself does not apply his characterization consistently to extent life forms also known from fossil

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[14] https://www.dictionary.com/browse/living-fossil and https://www.collinsdictionary.com/de/worterbuch/englisch/living-fossil

[15] "Punctuated equilibrium" together with S. J. Gould. Concerning Eldredge, see https://en.wikipedia.org/wiki/Niles_Eldredge ("He has published more than 160 scientific articles, books, and reviews, including *Reinventing Darwin*")

[16] *Cf.* http://www.weloennig.de/GenesisPalaeontologie.pdf

[17] Niles Eldredge and Steven M. Stanley have this to say – in contrast to the often repeated phrase/definition that living fossils must have existed "over long periods of evolutionary time" (Mather et al. 2013) or "remained recognizable in the fossil record over an unusually long time span" (https://en.wikipedia.org/wiki/Living_fossil) – "But, as in Vrba's (this volume) impalas, as a species may be a living fossil even if its lineage arose as recently as, say, the **Miocene**" [ending 5.3 Ma ago] (1984, p. 3 in: N. Eldredge and S. M. Stanley (Eds.): ***Living Fossils***. Springer-Verlag, New York. (31 Contributors, 34 Chapters, 291 pp.). Elisabeth S. Vrba states (p. 75) "the impala, eland, aardvark, and others, provide the "living fossils" of [p.74: **Miocene**-Recent] African mammal evolution". In her "*Fig. 1.* Durations and cladogram of species" (p. 65), all the 8 species are even **less than 2 Ma old**.

[18] Start of the Cambrian explosion. *Cf.* the International Chronostratigraphic Chart 2021.

[19] The textbook has been called "…the most broadly based textbook on evolution" by the succeeding textbook authors of EVOLUTION Brian K. Hall and Benedict Hallgrimsson (2008, p. XI). They, however, define (2008, p. 58): "Living fossils. Interestingly, ***some ancient lineages have persisted with minimal morphological changes to the present day***", then applying the term again in its restricted sense: "Occasionally, species are discovered that are so remarkable similar to organisms believed to have become extinct many ages ago that they are called living fossils. Sturgeons, lungfish, horseshoe craps, *Lingula* (a brachiopod) and ginkgo trees are living fossils." ***Well, not only "occasionally" but regularly and not only "some ancient lineages*** have persisted with minimal morphological changes to the present day, ***but many thousands*** – see the article below. (As for Hall and Hallgrimsson,
see https://books.google.de/books/about/Strickberger_s_Evolution.html?id=jrDD3cyA09kC&redir_esc=y)

record the but restricts it in its more conservative sense (Coelacanths, Dipnoans, *Ginkgo*, *Limulus* etc.), writing 1990, p. 49 (very similar in Hall and Hallgrimsson 2008/2013; *cf*. footnote below): "Interestingly, ***ancient organisms may persist to modern times without further evolving morphologically***. Such living fossils include opossums, alligators, sturgeons, lungfish, horseshoe craps, *Lingula*, brachiopods, and ginkgo trees. Occasionally, biologists discover species remarkably similar to organisms believed to have become extinct many ages ago." Well, as pointed out in the footnote "***not only occasionally" but regularly*** etc. For a broad application of the term, see the book on *Living Fossils*, edited by Eldredge and Stanley (as mentioned in the longer footnote on the previous page).

The more narrow/restricted/limiting definition is also applied in the Wikipedia 2021[20]. For many specific and in part also aberrant definitions and discussions, see Bennett et al. 2018/2019[21] – even to the point of questioning not only the term itself but also the very concept of morphological and anatomical stasis involved in the phenomenon, *cf*. zoologist Matthias Glaubrecht 1995/1998 ("On the death of living fossils"[22]), in part also Mathers et al. (2013) and Lidgard and Love (2018)[23], and perhaps also in some of the further literature cited in the Wikipedia article of 2021. In many cases the deeper reason behind all the fuss about living fossils is the annoyance/offense/trouble and irritation ***of the evolutionarily totally unexpected stasis of the overwhelming majority of life forms*** in their history throughout geological ages up to now. This fact – to repeat: stasis of the overwhelming majority of life forms – is largely obscured by the usual focus on a relatively few selected examples as if that were the end of the subject instead of its beginnings.

During the last decades I have addressed the topic of living fossils time and again in discussions – in writing and verbally – with evolutionists in general and neo-Darwinians in particular: Although many of them earnestly tried to do so, up to now none of my interlocutors has been able to solve the basic problems involved in the

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[20] https://en.wikipedia.org/wiki/Living_fossil (retrieved 26 August 2021). Nevertheless, the article already shows a larger range of living fossils even in its restricted sense. **See also discussion by Lönnig (2004) in** http://www.weloennig.de/DynamicGenomes.html

[21] https://palaeo-electronica.org/content/2018/2194-quantifying-the-living-fossil: "The living fossil concept is, however, controversial and **viewed unfavourably by many evolutionary biologists and palaeontologists**. Much of the difficulty surrounding the term, however, stems from its multiple and often vague definitions, which causes different authors to classify different sets of organisms as living fossils (Schopf, 1984). Some authors place increased focus on living fossils constituting "evolutionary relicts" (Nagalingum et al., 2011), others focus on "little change through time" (Eldredge, 1984; Fisher, 1990), and others still interpret the term to mean Lazarus taxa (Smith, 1939). More recently, **there have been efforts to reject the living fossil term entirely** as it is thought to recall Haeckel's scala naturae and is a product of bad 'tree-thinking' (Casane and Laurenti, 2013; Grandcolas et al., 2014; Minelli and Baedke, 2014). It is argued that the term living fossil is a form of 'progressivist' language that can promote a false interpretation of evolution where life is organised into 'higher' and 'lower' ranks (Rigato and Minelli, 2013). Under a progressivist scheme, these 'lower' ranked organisms are then able to subvert post-Darwinian evolutionary thinking by remaining unchanged for millions of years - an impossibility even in the hypothetical circumstance of an absence of selective pressure (Casane and Laurenti, 2013).

Additionally, doubts over the concept are compounded all the more by new evidence. Some groups that were once thought to be species-poor have since been found to be species-rich (Monoplacophora [Kano et al., 2012] and Notostraca [Mathers et al., 2013]); others have been shown to have more genetic diversity than previously thought (Limulidae [Obst et al., 2012]); some show great morphological diversity in the past (Crocodilia [Buckley et al., 2000], Sphenodon [Meloro and Jones, 2012] and Latimeria [Casane and Laurenti, 2013]), and other groups that were thought to consist of ancient lineages have, in fact, experienced most of their diversification relatively recently (Cycadophyta [Nagalingum et al., 2011]).

[22] Evolutionary biologist Matthias Glaubrecht, Direktor des Centrums für Naturkunde in Hamburg, in his book (1995/1998): Der lange Atem der Schöpfung. Was Darwin gern gewußt hätte. Rasch und Röhring Verlag, Hamburg. Pp. 125 ff: "**Vom Tod der „lebenden Fossilien"**" [Chapter: "**On the death of living fossils**". Concerning the zoologist M. Glaubrecht see: https://de.wikipedia.org/wiki/Matthias_Glaubrecht.

[23] Thomas C Mathers , Robert L Hammond, Ronald A Jenner, Bernd Hänfling, Africa Gómez (2013): Multiple global radiations in tadpole shrimps challenge the concept of 'living fossils': https://pubmed.ncbi.nlm.nih.gov/23638400/

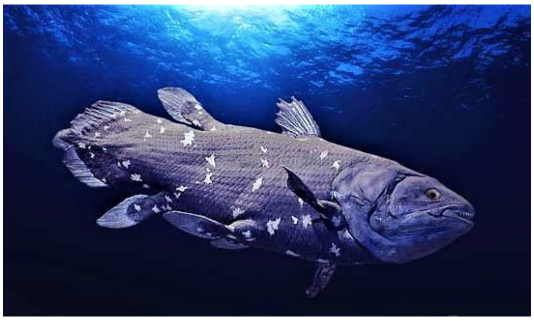
Scott Lidgard and Alan C Love (2018): Rethinking Living Fossils: https://pubmed.ncbi.nlm.nih.gov/30385890 /

- **Insert to illustrate several points of the previous page – main text is continued on the next page.**

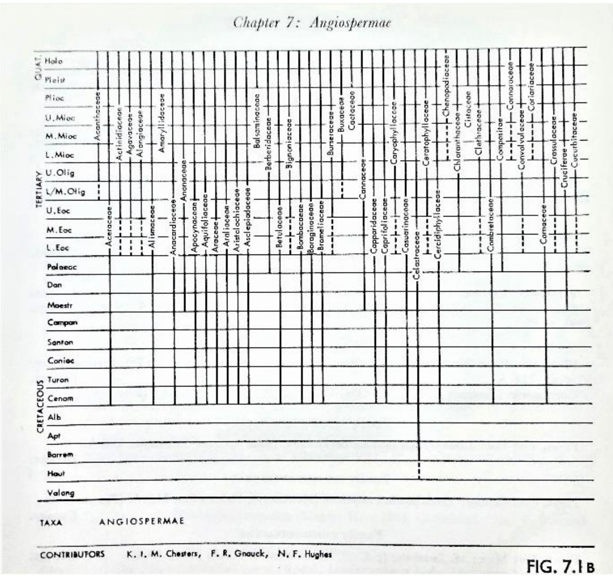
Usually only relatively few life forms are addressed as Living Fossils. However, taking the definition of Strickberger and others, as quoted above, **the overwhelming majority of life forms - plants as well as animals - reveals constancy/stasis throughout their geological strata up to now**. This fact is largely obscured by the usual focus on a relatively few selected examples as if that were the end of the topic of Living Fossils instead of its beginnings in reality comprising thousands of species and families.







First row, left: Fossil leaves of *Gingkoites huttoni*[24] dated to be ca. **170 Ma** (photo/author: Ghedoghedo 2010). Middle: *Ginkgo biloba* leaves (photo James Feld 2008): Both from https://en.wikipedia.org/wiki/Living_fossil. Right: Cinnamon fern *Osmundastrum cinnamomeum*, Syn.: *Osmunda cinnamomea* L.first **75 Ma**, now up to **180 Ma** (Antepenultimate 2014): https://de.wikipedia.org/wiki/Zimtfarn.
Second row: Left: Horse shoe crap (*Tachypleus tridentatus*) **450 Ma**: https://it.wikipedia.org/wiki/Fossile_vivente.
Right: *Latimeria chalumnae* (Zoo Firma 2013): https://fr.wikipedia.org/wiki/Esp%C3%A8ce_panchronique



If any plants are mentioned at all for the topic of Living Fossils, usually the ginkgo (*Ginkgo biloba*) and sometimes the cinnamon fern (*Osmundastrum cinnamomeum*, Syn.: *Osmunda cinnamomea* L.) and the pine *Wollemia nobilis* are mentioned, but in the majority the authors refer only to several animal species (as cited on the previous page). Fact is, however, that ***we are literally surrounded by living fossils*** – plants and animals. As for the **angiosperms**, see, for example, the figure (left) by Chesters, Gnauck and Hughes in Harland et al. (eds) on the first serious the angiosperm families presented in alphabetical order (1967, p. 271) (many of them ca. **100.5 Ma**). For the very similar but even more pronounced situation in 2021, I would like to invite the reader to carefully check the data of the present paper.

[24] My comment on the name: One may doubt whether a new genus and species name were really necessary. “Nur die Namen haben sich entwickelt” (”only the names have evolved“) H. Nilsson on a postulated phase of the evolution of the horse.

[now text continued] essential/inherent/intrinsic constancy of the living fossils during geological eons of time within any materialistic theory of evolution, so that they all gave up – i. e. discontinuing/breaking off the dialogues due to their total lack of any convincing counter arguments.

Since all these main arguments and facts against Darwinism[25] and evolution have been clearly and unmistakably stated in the written exchanges referred to above, I would like to come back directly to these conversations/dialogues/ discourses citing them at length, inviting (especially) my critical readers to check them carefully and, if possible, to refute and evolutionarily solve these phenomenal organismic constancies, raising obviously unsurmountable problems for any phylogenetic theory stating that "all is in flux, nothing stands still" or "everything flows and nothing stays" ("*panta rhei* – πάντα ῥεῖ, Heraclitus).

First, an excerpt of my discussion with an evolutionary geologist seemingly fully/entirely/totally convinced of neo-Darwinism (see, please, pp. 19 - 21 in http://www.weloennig.de/ExplosiveOrigins.pdf – 2018)[26]:

Ernst Mayr (2001, p. 195): "The complete standstill or stasis of an evolutionary lineage for scores, if not hundreds, of millions of years **is very puzzling**."

Donald R. Prothero (2007, p. 81): Evolution: what the fossils say and why it matters. "Some biologists tried to explain away stasis with mechanisms such as stabilizing selection (selection against the extremes of a population, reinforcing the mean tendency), **but this does not explain how some fossil populations persist unchanged through millions of years of well-documented climatic change (surely a strong selection pressure)**, as documented by Prothero and Heaton (1996) and Prothero (1999). As Gould (1980a, 2002) pointed out, ***the persistance of fossil species through millions of years of intense selection pressure suggests that they are not infinitely malleable by selection, but instead have an integrety of some sort of internal homeostatic mechanism that resist most external selection***." Prothero betont weiter, dass diese These "still hotly controversial" ist und dass sie von Seiten der Vertreter der Synthetischen Evolutionstheorie zumeist nicht akzeptiert wird ("…many biologists are unconvinced that the fossil record can't be explained by some Neo-Darwinian mechanism (see chapter 4))."

Steven M. Stanley (1981, p. XV): "The record now reveals that **species typically survive for a hundred thousand generations, or even a million or more, without evolving very much**. … After their origins, most species undergo little evolution before becoming extinct."

Stephen Jay Gould (2002, p. 749) "[T]he tale [of the correspondence between Darwin and Falconer] itself illustrates the central fact of the fossil record so well – **geologically abrupt origin and subsequent extended stasis of most species**. …Most importantly, this tale exemplifies what may be called the **cardinal and dominant fact of the fossil record**…: the great majority of species appear with **geological abruptness in the fossil record and then persist in stasis until their extinction**. Anatomy may fluctuate through time, but the last remnants of a species look pretty much like the first representatives. In proposing punctuated equilibrium, Eldredge and I did not discover, or even rediscover, this fundamental fact of the fossil record. Paleontologists have always recognized the longterm stability of most species, but we had become more than a bit ashamed by this strong and literal signal, ***for the dominant theory of our scientific culture told us to look for the opposite result of gradualism as the primary empirical expression of every biologist's favorite subjec***t – evolution itself." (P. 755:) "[...] George Gaylord Simpson, the greatest and most biologically astute paleontologist of the 20th century (and a strong opponent of punctuated equilibrium) **acknowledged the literal appearance of stasis and geologically abrupt origin as the outstanding general fact of the fossil record** and as a pattern which would "pose one of the most important theoretical problems in the whole history of life" if Darwin's argument for artifactual status failed." "...stasis is data... Say it ten times before breakfast every day for a week, and the argument will surely seep in by osmosis: "stasis is data; stasis is data"..." (p. 759.)

Niles Eldredge (1998, p. 157): "**It is a simple ineluctable truth that virtually all members of a biota remain basically stable, with minor fluctuations, throughout their duration**.. (Remember that by "biota" we mean the commonly preserved plants and animals of a particular geological interval…)"

Once again: Donald R. Prothero (1992, p. 41): "Eldredge and Gould not only showed that paleontologists had been out-of-step with biologists for decades, but also that **they had unconsciously trying to force the fossil record into the gradualistic mode**. The few supposed examples of gradual evolution were featured in the journals and textbooks, but paleontologists had long been silent about their "dirty little trade secret": **most species appear suddenly in the fossil record and show no appreciable change for millions of years until their extinction**. http://chaos.swarthmore.edu/courses/SOC26/PunctEquil.pdf

Tom S. Kemp (1985, pp. 66-67): "As is now well known, most fossil species appear instantaneously in the record, persist for some millions of years virtually unchanged, only to disappear abruptly - the 'punctuated equilibrium' pattern of Eldredge and Gould."

[25] Darwinism" is (again) an abbreviation used here (and by many further authors) synonymously with "neo-Darwinism", or "The Modern Synthesis" and the "Synthetic Theory of Evolution" with its main focus on "omnipotent" natural selection.
See also: http://www.weloennig.de/PlantGalls.pdf (footnote p. 1)
For some reasons regarding terms, see please http://www.weloennig.de/BegriffNeodarwinismus.html

[26] The following documentation is also shown in http://www.weloennig.de/Hunderassen.Bilder.Word97.pdf and http://www.weloennig.de/Utricularia2011Buch.pdf. Siehe weiter http://www.weloennig.de/KutscheraPortner.pdf pp. 43/44 (2019). Also: No reply!

Beforehand: In the following dialogue (2018) I am playing the student – and my interlocutor is the great evolutionary master, explaining to his uninformed student the conundrums of evolution including the living fossils – which, however, he never did – so absolutely no ***factual*** evolutionary explanation was given for the living fossils.

Last not least, some additional words on **living fossils**. You have told your student that: "Living fossils, such as the six-gills sharks, the coelacanths, the crocodiles, and other species, have remained almost unchanged for hundreds of millions of years. The answer is quite obvious: they do not need to change in their ecological system in which they live."

You probably remember that in my last very short mail I had quoted paleontologist Niles Eldredge that your hypothesis: [This]"…doesn't explain why still other groups do change even though they share the same supposedly constant environment."

Now, please, explain to your student why such change has been assumed to be possible in the same supposedly constant environment?

And why do leading evolutionary biologists have problems with living fossils (discussing them to this very day) and my teacher does not?

Additionally, your student has detected the following comments on living fossils:

"Moreover, as to the general idea of Darwinism concerning evolution due to adaptation to the environment: If the answer to the origin and formation of plants and animals, including the important question of how such forms can be constant (within the limits of genera and families) over enormous periods of time and even under strongly changing environments, were adaptation, ***we would expect everything except living fossils***, i. e. life forms that remain constant in contrast to all major (and minor) environmental changes, even over hundreds of millions of years!"

"The sudden appearance and the constancy of the classes, orders and the multiplicity of living fossils (practically all today living animal and plant species and genera are "living fossils"!) clearly prove that these questions cannot be answered by 'adaptations to the environment' (at least not scientifically convincingly and sufficiently). ***Usually the constancy of form is demonstrably/verifiably independent of adaptations to the geo-historically and geographically continuously changing environment***."

"The theory of evolution, which has tried to explain the emergence of all forms of life as adaptation phenomena (especially Darwinism and now the synthetic evolutionary theory) is thus demonstrably wrong. However, much of this has already become clear from the previous remarks: ***The living fossils show an "inner" constancy that makes them largely independent of the changing environmental conditions of geological time periods and geographical distances***. But this fact of inner constancy of forms was neither predicted nor can it exist according to the theory of neo-Darwinian evolution. The theory is false."

Now, please, my teacher and instructor, explain to your student this ***inner constancy*** as described by so many paleontologists independently of each other as quoted above."[27]

No answer on this topic in the following three years until now.

In the ensuing dialogue with a zoologist (Dr. A.) from the Zoological Garden in Berlin-West (1995) (in the interim he has become its "Zoologischer Leiter") several further definitions of living fossils are cited and analyzed[28]. He never tried to refute the argumentation.[29] Check, please, carefully the facts and arguments presented in the ensuing text and ask yourself whether you can agree with me ***that they are all the more***

[27] http://www.weloennig.de/ExplosiveOrigins.pdf

[28] See also http://www.weloennig.de/mendel20.htm

[29] Note of 22 Sept. 2021, 10:30: I just became aware of the fact that the perhaps most famous French zoologist of the 20th century, **Pierre-Paul Grassé argued similarly in several points as I have done**. See please https://fr.wikipedia.org/wiki/Esp%C3%A8ce_panchronique and https://fr.wikipedia.org/wiki/Pierre-Paul_Grass%C3%A9 As for a counter argument presented by some authors, I would like to point out that much more is involved here than just "l'apparente stabilité morphologique des espèces". Also, as to "l'apparente" morphological stability: **the stability is real – not only "apparente"** (see present paper and Lönnig 1997 https://www.sciencedirect.com/science/article/abs/pii/S0378111997003971 and 2015 https://onlinelibrary.wiley.com/doi/abs/10.1002/9780470015902.a0026265. (Main point in both papers "the hierarchy of gene redundancies"). See, also, for example, Bomfleur et al. (2014/2015): https://www.biorxiv.org/content/10.1101/005777v1.full for 'morphologie interne'**. Concerning species concepts, see please http://www.weloennig.de/Artbegriff.html**

up-to-date in 2021 (translated by Professor Granville Sewell of the University of Texas, El Paso; 1 November 2021. The original German text of the discussion is presented subsequently):

Some quotations occur twice – since *repetitio est mater studiorum*, these may perhaps be looked at as a good way to further internalise these quotes.

"Everything changes, nothing is constant, nothing proves eternal" one evolutionist wrote me recently (Dr. A from Berlin) as an objection to the popular science book *Life, how did it get here? By evolution or by creation*? (1985; 29.4 million copies in 27 languages published—this book was by the way also critically reviewed/commented by Prof. Heinz Haber and others.)

The phenomenon of living fossils mentioned there is very easy to explain, Dr. A. believes.

After some quotes on the constancy of several life forms (insects, fossil leaves of several trees and shrubs and the King Crab), as well as from Stanley's book *The New Evolutionary Timetable* "As is seen, many species have populated the Earth for millions of years without further development worth mentioning…from their appearance to the time of their extinction, these species experience only a trivial development," Dr. A remarked as follows:

"When a life form is adapted to the environment, and the environment does not significantly change, the life form remains unchanged for long periods. What is hard to understand about that?"

In his letter of 9-15-1995 he wrote, regarding the fundamental principle of natural science (and as an objection to constant creations): "Everything changes, nothing is constant, nothing proves eternal."

If however e v e r y t h i n g really changes, and n o t h i n g is proven to be e t e r n al, how does it happen that certain life forms exist not only 40 or 200 million years (as quoted above) but even 570 million years, until the present day?! (Compare this last point to the detailed quotation in my discussion with Mr. R. W. Kaplan, pages 14 and 24ff. The body plans of the animal kingdom have been constant for over 500 million years!

And further (page 14 of quote) "…since approximately 400 million years" there have arisen "no new classes within these animal branches. All of today's classes arose together with others which have not survived to the present day." Thus: all of today's living classes have been constant for over 400 million years. (I write "over 400" because some of the animal classes are much older, only the youngest classes are 400 million years old.)

"The construction of new orders stopped around the end of the Mesozoic era, about 60 million years ago." Thus, all of today's living orders have been constant for at least 60 million years! http://www.weloennig.de/NeoB.Vobe.html

One could object that this constancy is still not eternal!

(Since, as quoted above, Dr. A says "Everything changes, nothing is constant, nothing proves eternal.")

To this I would suggest that something which has been constant for more than 500 million years, and continues to the present day, and according to natural science premises should continue to exist for billions of years (even a nuclear conflict would probably only threaten a portion of the body plans), could indeed be described as "eternal."

In addition, Hans Krause in his book *The Cell—Its Cause* (Stuttgart 1995) lists many examples of fossil microorganisms (bacteria, blue algae) whose ages can be dated up to 3.5 billion years, and which have survived to the present day essentially unchanged. ("A high proportion of the nearly 300 prokaryotic taxa of Proterozoic microbial species are comparable in morphological detail to specific, modern, microorganisms." "Also, the fossilized remains of different species of the cyanobacterium *Oscillatoria* have been found at Warrawoona, N.W. Australia. They are 3.3-3.5 billion years old." Krause, p 76 and 83, where further examples are found). That could be called "eternal."
http://www.hanskrause.de/HKHPE/index_HKHPE_01_00.htm

But even if Dr. A predicts a different future (that would be in my view an unfounded question of belief), if he for example should assume, for reasons unknown to me, that tomorrow or in the near future all life forms should become extinct, one could still be able to call the body plans of the animal and plant kingdoms which have existed for such enormous time spans, "constant and unchanging."

One can (*sensu lato*) describe those life forms, which are almost unchanged over great time spans, as "living fossils." M. W. Strickberger defined this term as follows (*Evolution*, 1990, p. 525): "An existing species whose similarity to ancient ancestral species indicates that very few morphological changes have occurred over a long period of geological time."

(Other authors define the term more narrowly: "They must today exhibit primitive morphological characters, having undergone little evolutionary change since dwindling to low diversity at some time in the past" Stanley 1979, p. 123. "…living fossils are simply species alive today that display relatively close anatomical similarity to ancestral species living way back near the group's inception." Eldredge 1979, p. 108.) I use in the following the broader definition of Strickberger.

Regarding the earlier quote from Dr. A: "When a life form is adapted to the environment, and the environment does not significantly change, the life form remains unchanged for long periods. What is hard to understand about that?" There are now indeed some points that are hard to understand:

What environment for a fly population, for example, remained constant for 40 million years (essentially unchanged)?

And that the environment of our planet has remained constant for more than 500 million years, or just 200 million years, would surely not be claimed by any serious geologist today: numerous meteorite impacts, earthquakes, volcanos, major changes in the Earth's crust (Deccan-Plateau), continental drifts, mountain formation, land sinkings, floods, tsunamis, typhoons and hurricanes, erosions and avalanches, temperature spikes, ice ages and heat waves. Dr. A's statement that "Everything changes, nothing is constant, nothing proves eternal" is indeed fully valid---for the multi-million year geological history at least.

(I would make an exception for the physical constants and chemical elements and the laws governing their chemical combinations, which form the basis for geological history. H_2O was according to my understanding still H_2O five billion years ago, etc.)

Back to the geological and geographical differences on the basis of the physical constants: even over short time periods and small geographical distances we observe continual small and large changes. For example:

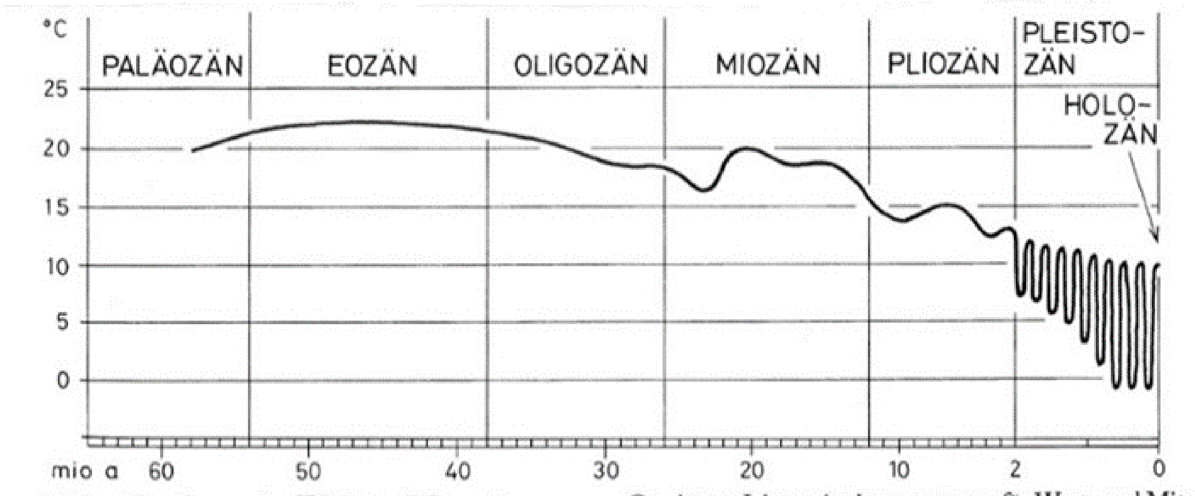
Relative to climate variations, we read in Bertelsmann's Universallexikon 1993 (Fig 9, p.347): "…approximately periodic or irregular, in contrast to the short-term variations to the general climate in a region, longer lasting climate shifts would be described as sacular" (https://en.wikipedia.org/wiki/Secular_(disambiguation) . For climate shifts, natural causes are suspected, such as changes in the dust content in the stratosphere (for example, through large volcano eruptions whose ashes have a cooling effect, in that they reflect back a portion of the solar radiation), changes in the ocean currents, ice break-ups in the Artic and Antartic. Today we especially include human-caused factors and their effect on the atmosphere. (This last point was further discussed there.)

Over the last 2.3 million years of European history, the paleobotanist G. Lang summarizes as follows [*Quarternary European Vegetation History*, Stuttgart 1994, p. 320]: "The, for the Quarternary characteristic, multiple repeated climate changes, primarily resulted in tremendous area changes of the plant and animal species." Examples followed. With such over 2.3 million year persistent climate shifts (that is, repeated strong environmental changes) with the accompanying enormous area changes of the living organisms, one should expect corresponding major evolutionary developments in the plant and animal kingdoms! (According to the rule that environmental stability leads to species stability, environmental changes lead to evolution! Thus 2.3 million years of repeated climate changes should lead to 2.3 million years of accelerated evolution.)

But that is precisely what we do not find. Lang [1994, p320] writes:

"The Quarternary…is a period of a relatively slow evolution rate. According to the paleological discoveries, at the end of the Tertiary era the groups [Sippen] in the world of organisms predominantly fit into today's genera, in large part even into today's species. That is true for the European flora as well as the fauna. Jentys-Szaferova (1958) could show, for example, through anatomical investigations of fossil fruits from *Carpinus* in Poland, that the characteristics of *C. betulus* from the Pliocene to the interglacial era to the present day remain unchanged. In addition to the majority of plant fossils, nearly all beetle fossils are identical to recent species [Coope 1979], likewise most mammals, as far as they are not extinct [Kurten 1968]. The method commonly used in Quaternary palaeontology, based on the actualistic principle of transferring the current ecological indicator value of organisms to the past, is established on this obviously extensive constancy of the groups down to the species. "

Figure: climate variations according to Lang [1994, p11]:



Klimaschwankungen im Tertiär und Quartär. Geschätzte Jahresmitteltemperaturen für West- und Mitteleuropa. Aus Darstellungsgründen ist der Zeitmaßstab für das Pleistozän und das Holozän gedehnt und die Zahl der Kalt- und Warmzeiten geringer als tatsächlich. Nach WOLDSTEDT (1961) und NILSSON (1983).

Sketch of the climate variations in the Tertiary and Quarternary: "Estimated yearly average temperatures for West and Middle Europe. For presentation reasons, the lengths of the Pleistocene and Holocene are changed, and the number of cold and warm cycles are reduced. G. Lang 1994, according to Woldstedt 1961 and Nilsson 1983.

About half of all genera of the flowering plants, which appear in geological formations dated as 37 million years old, can already be identified with living genera (Stanley: *Earth and Life through Time*, 1986, p. 530]. And it should be remembered that the fossil material has not yet been completely worked through and the identification process is not yet finished. Of the overall paleobotanical finds of all flowering plant genera, perhaps 50-75% have so far been found and identified. Thus, many more modern genera may be expected to be found in "old" layers. We are virtually surrounded by living fossils!

Let's take another known plant group: Moss. Prof S.N. Agashe remarked (*Paleobotany*: 1995 p88):

"Members of both the major groups of bryophytes, i.e., Hepaticopsida (liverworts) and Bryopsida (mosses), are well represented in the known fossils. However, a detailed comparative study with modern bryophytes indicated that the group has remained almost unchanged since the Paleozoic time. Hence the fossil bryophytes do not help us much in understanding evolution except for the fact that they formed a prominent part of the vegetation from the Paleozoic onwards."

The oldest mosses are thus "almost unchanged" for around 400 million years. One can document similar statements for numerous other plant- and animal groups. We are indeed surrounded by living fossils.

Let's return to environmental differences. As far as even relatively small geographical distances are concerned, we also find almost perpetual large and small (also being often not constant over longer periods of time) environmental differences down to the microclimate, "the climate of small spaces, e.g. a depression [Senke], determined by layers of air close to the ground, of slopes, fields or gardens" (Bertelsmann Universallexikon 1993, Vol. 9, p. 340). Almost everywhere we should expect progress through mutation and natural selection, at least over large time spans.

If with regard to the development of life forms and the possible question, to what extent can forms be constant, we answer "adaptation to the environment", then we would expect anything...anything but living fossils, that is, forms that in spite of all the large (and small) environmental change remain constant up to hundreds of millions of years! The occasional sudden arrival (see hint in the Creation book mentioned above) and the constancy of body plans and classes and orders and the many living fossils (practically all living animal and plant genera are "living fossils"!) clearly show, that this question cannot be answered with "adaptation to the environment"! The constancy of life forms can be shown to be independent of the (**steadily** changing historically and geographically) environment. The evolutionary teaching (of Darwinism and the synthetic theory of evolution in particular) that the arrival of life forms can be explained through adaptation to the environment, is thus demonstrably false.

By the way, Darwin himself hinted at the problem living fossils posed for his theory when he wrote "When I see that species even in a state of nature do vary little and seeing how much they vary when domesticated, I look with astonishment at a species which has existed since one of the earlier Tertiary periods...This fixity of character is marvellous." (Darwin 1852, quoted by D. Ospovat 1995, p 201).

And, what is more, according to Darwin and his supporters, the assumed evolution should continually progress even without environmental change. The cause of this is supposed to be the "eternal" intra- and inter-species competition ("Struggle for Existence" and "Survival of the Fittest"). The continual arrival and selection of new and further developed variants — variants that in turn produce further progressed variants to offer to selection, etc., that means, evolution never stands still. Nothing remains constant. Everything changes continually. Everything evolves further and higher, and becomes continually better and more complex. "All is in flux" (Heraclitus) in agreement with the Victorian belief in progress. This fundamental idea of evolutionary theory is also clearly and dramatically contradicted by "living fossils." (Thus, the commentary in *The Globe and Mail* regarding the discovery of a fossil fly: "In their 40 million years of continual struggle to climb the evolutionary ladder they have shown almost no recognizable progress." (See Creation book, p. 63).

Darwin himself had recognized the problem and attempted to solve it with the hypothesis: living fossils can perhaps be explained by assuming the selection pressure in certain regions was lower than in others and thus development stagnated. However, since we are surrounded by living fossils in all areas of the world, the selection pressure should logically have decreased also all over the world and there should have been no evolution of new species and forms at all for hundreds of millions of years.

Moreover, it is hard to understand that numerous species and forms should have continued to evolve uninterruptedly in the same biotopes (occupied together with the living fossils), while the living fossils, in competition with these continuously improving species, live much longer than each of the species that replaced each other in the history of the earth and evolution, which (because they evolved further) displaced the respective preceding species. If it is possible for evolution to continually replace species with further evolved ones through new and ever better forms, and thus to make evolutionary progress - why then are the primitive living fossils not also, and from the beginning, replaced?

Living fossils are a difficult problem for evolutionary theory: All species and life forms should over long time periods evolve further and higher because of 1) the constantly changing environments; 2) the continual perfection through adaptation (according to Darwin also through use and disuse of organs); 3) the continual production of new improved variants (mutations); 4) the continual selection through intra- and interspecies competition; and 5) the continual replacement of less evolved species by higher evolved ones. Living fossils should not exist at all!

The fact is, however: Living fossils exist in great numbers. And they are constant over great time spans: Continual environmental change, competition with members of their own and other species, millions of mutation events (gene-, chromosome, genome-mutations) and all other evolutionary ideas and biological realities have not changed that.

Living fossils thus bring several pillars of the general evolutionary theory into question: 1) Do mutations really create "progressive variations" for the genetic/plasmatic construction of new species and life forms? 2) Does selection run into limits because it perhaps does not have the status that that synthetic evolutionary theory claims for it? Is selection either a) not so strict as previously assumed or b) limited, because the construction of improved variants is not unlimited, or c) do the fittest not necessarily survive? (Or 2 or 3 of these all simultaneously.) Further discussion points: 3) Interspecies competition does not necessarily lead to the replacement of more "primitive" forms with more complex ones; 4) adaptation is not equivalent to higher development.

(Regarding this last point I have copied pp. 118-120 from the Artbegriffsarbeit [http://www.weloennig.de/Artbegriff.html] to Dr. A., with the invitation and request, to constructively/critically study carefully this exposition also. It shows clearly, in my opinion, that adaptation and higher development are not equivalent. By the way, this section is in large part from my first Master's thesis (Staatsexamenarbeit), which was given the highest marks by an evolutionary theorist.

The points 1 and 2 a,b,c raised as questions above can be answered as follows: 1. Mutations create no new species (and I have offered to supply Dr. A with extensive material to support this claim). 2. Selection runs into genetic, physiological, anatomical and morphological limits, especially regarding "higher development," and all three points a,b,c play a role.

Incidentally, the problem of living fossils for the theory of evolution is also recognized by many leading contemporary evolutionists. The zoology professors V. Storch and U. Welsch (Evolution; 1989, p. 107) state on this subject: "The derivation of an evolutionary stop or a slow pace is currently only possible to a limited degree. An explanation is still lacking for the evolutionary stop of many living fossils. "

Regarding Dr. A's explanation of living fossils through adaptation and minor environmental changes, these authors write, among other things:

"The oceans depths have also often been seen as a region of stable environmental conditions and little competition. According to recent research, however, the populations of the depths, even with regard to the microfauna on the ocean bottom, is not so low as had been assumed given the limited nourishment possibilities. The competition factor is thus not small, though the chemical-physical factors of this environment are in general less variable than near the surface or in lakes. Living fossils are found here only in isolated cases, such as the Ursnail *Neopilina*, in 2000-3000m depths."

So where, according to evolutionary premises, living fossils should be expected to be most common, they are rare. But where one would not expect them, they are frequent:

"A large number of primitive forms live, however, in areas where an "environmental protection" is not apparent. The Protarthropods with *Peripatus* and others live on the ground layers of the tropics, the *Lepisosteus* fish and *Amia* in commonplace North American waters, the primitive marsupials (Didelphidae) in South America (which was full of higher mammals especially in the Tertiary), and *Limulus* and *Lingula* live in shallow seas."

This is followed by the above quoted sentences:

"The derivation of an evolutionary stop or a slow pace is currently only possible to a limited degree. An explanation is still lacking for the evolutionary stop of many living fossils."

Professor Osche in his Springer text *Biology* agrees with Dr. A's environmental explanation of the long living genera, or "living fossils", but adds (1976, p810)

"Although no doubt the stability of the environmental conditions (and thus of the selection conditions) represents an important factor for the stagnation in the evolution of living fossils, there remain many open questions." What those questions are is clear from the above discussion (not to mention that the environmental conditions are not stable over geological time spans even for the ocean depths, and the inter- and intraspecies competition has been ignored, see above). Anyway, it is conceded that many questions remain open for evolutionary theory, that is, the theory cannot answer these questions. (In later editions Osche has dropped the reference to "open questions"—without having answered the open questions. That's what I call evolutionary progress.)

Professor Niles Eldredge, likewise an evolutionist, even writes (*Life Pulse*, 1989, p108) "Living fossils are something of an embarrassment to the expectation that evolutionary change is inevitable as time goes by."

After presenting several attempts at an evolutionary explanation, he comments on the environmental stability hypothesis (which he favors): "…yet it doesn't explain why still other groups do change even though they share the same supposedly constant environment." Here is this quote in a larger context (numbering by me):

"There have been a number of theories advanced to explain the seeming incongruities posed by these "living fossils". (1) Some paleontologists have been content merely to shrug the problem away, as if to say, "Well, some groups evolve quickly, the vast majority exhibit a moderate rate of evolutionary change, while a very few others have simply inherited the low end of the spectrum of rates of change." Such an attitude hardly explains why some groups evolve more quickly than certain others. (2) Paleontologists have sought the explanation in genetic material: perhaps some groups, such as lungfishes and coelacanths, simply lack the requisite genetic variation that would allow them to escape the straightjacket of their ancient anatomical design. (3) Still others have speculated that such resistance to change merely reflect a constancy of the environment: natural selection simply keeps animals and plants looking the same as long as their environments remain recognizably constant. This last notion is, to my mind, more on the right track - yet it doesn't explain why still other groups do change even though they share the same supposedly constant environment."

All three explanations are insufficient. (1) and (3) we have already treated in detail, and for hypothesis (2) there are meanwhile numerous studies on the genetic variability of living fossils, that show no significant differences to other forms. (When in the above quotation it is stated that the other forms vary and evolve further, that is by the way only an evolutionary interpretation of the fact that further forms appear abruptly.)

Eldredge himself offers a fourth hypothesis: "The condition of being an ecological generalist automatically decreases the rate of speciation in a lineage; and low rates of speciation ensure low rates of anatomical change" p110. This explanation brings up now three new problems:

1) Why are there many ecological specialists among the living fossils?

(Other authors have argued exactly the opposite: living fossils are ecological specialists and thus experience little anatomical variation or remain practically constant. That is the fifth untenable explanation! Then precisely the specialists should, according to evolutionary assumptions, in long geological time spans under continually changing abiotic and biotic environmental conditions, either go extinct or develop further!)

2) On the other hand, why should, according to evolutionary theory, so many ecological generalists nevertheless have continually evolved further and higher?

3) ”Low rates of anatomical change” still do not explain why over hundreds of millions of years living fossils underwent virtually no anatomical change. Over such time spans even small anatomical rates should accumulate to large differences.

To some evolutionists the living fossils are such a nuisance that they have tried to flatly deny the existence of such life forms.

It would surely be very interesting to discuss *sensu stricto* in detail the individual living fossils presented in many works: to document what gigantic environmental change many living fossils have survived in the millions of years leading up to today, their sudden appearance and their morphological and genetic variability (today) and present further examples, to show that adaptation is not equivalent to higher evolution. But I would have to invest several weeks, which at the moment is not possible.

This much should already be clear from the material so far presented: living fossils show an “inner” constancy, that makes them quite independent from the changing environmental conditions across geological time spans and geographical distances. However, according to evolutionary theory this inner constancy of the forms should not exist at all! (By the way, Marxist ideology rests on this alleged non-existence [of inner constancy]).

According to the theory, all is in flux and nothing is constant. In Darwin’s theory, the "law of the conditions of existence" (environmental conditions) is fully embraced by natural selection - as a strategy of adaptation to inorganic and organic living conditions. Compared to the unity of the type, it is the "higher law" (Darwin literally). The postulate of perfection and further development on the basis of uninterrupted variation and intraspecific selection even without changes in the inorganic milieu is already contained in the "law of the conditions of existence". The inner constancy over millions of years (and in the case of prokaryotes over billions of years) of living fossils—the constancy of the body plans and types, down to the genera and species—is on evolutionary grounds fully unexpected and remains in the end, in spite of all explanatory attempts, inexplicable for evolutionary theory. And this is also conceded by outstanding evolutionary theorists (see quotations above).

Biblical creation teaching [creation days as long periods; not to be confused with creationism with its literal 24 hour creation days], on the other hand, expects and predicts living fossils. The Genesis-text says 10 times that God created plants and animals “according to their kind.” Within the “kind” there is a large variability (*cf*. human, pigeon and dog races, but the respective kind remains constant (“a dog a cat will never evolve into a cat”). Living forms are so created that on the one hand they dispose of a great variability and adaptability, but on the other hand their respective “kind” remains constant. And this is confirmed by Earth’s history as well as the geographical distribution of many life forms.

According to the Biblical creation account, the great constancy and resistance of living forms to environmental change points to a wisdom and power behind a creation plan for the maintenance of the stability of the kind or type. Intelligence, wisdom, mind and God are an adequate cause for the coding of the ingeniously complex constancy programs, and not (chance) mutations, selection and/or symbioses (the latter assumes the preexistence of complex life forms and itself forms a part of the constancy-program.)

For evolutionary theory the phenomenon of living fossils is inexplicable, because it contradicts its basic assumptions (“all is in flux”, nothing is constant). For an intelligent design theory living fossils are further evidence of the correctness of its assumptions and fundamental claims.

So much for the constancy of body plans and living fossils. I should by the way mention that D. A has not yet commented on any of these points.

Now, for comparison, the original German text of the discussion:

"Alles verändert sich, niemals wurde etwas Beständiges, also Ewiges nachgewiesen", schrieb mir kürzlich ein Evolutionstheoretiker (Dr. A. aus Berlin) als Einwand zum populärwissenschaftlichen Buch *Das Leben - Wie ist es entstanden? Durch Evolution oder durch Schöpfung*? (1985, Auflage 29,4 Millionen Exemplare in 27 Sprachen - das Buch wurde übrigens auch von [Prof.] Heinz Haber und anderen kritisch rezensiert/kommentiert).

Das dort erwähnte Phänomen der lebenden Fossilien glaubte Herr Dr. A. sehr einfach erklären zu können.

[Nach einigen Zitaten zur Konstanz mehrerer Lebensformen (Insekten, fossile Blätter mehrerer Bäume und Sträucher und der Königskrabbe) sowie aus dem Buch von Stanley *The New Evolutionary Timetable* "Wie sich zeigt, haben zahllose Arten die Erde Jahrmillionen lang ohne nennenswerte Weiterentwicklung bevölkert...Von ihrer Entstehung bis zur Zeit ihres Aussterbens machen die Arten nur eine geringfügige Entwicklung durch." - bemerkte Herr Dr. A. dazu das Folgende:]

"Wenn das Lebewesen sich an die Umgebung angepasst hat, und die Umgebung sich nicht wesentlich verändert, bleibt das Lebewesen lange Zeit unveränderlich. Was ist da unverständlich?"

In seinem Brief vom 15. 9. 1995 schrieb er zu den Grundprinzipien der Naturwissenschaften (und als Einwand zu konstanten Schöpfungen, s.o.): "Alles verändert sich, niemals wurde etwas Beständiges, also Ewiges nachgewiesen."

Wenn sich aber tatsächlich a l l e s verändert und n i e m a l s etwas Beständiges nachgewiesen wurde, wie kommt es dann, daß bestimmte Lebensformen nicht nur über 40 Millionen und 200 Millionen Jahre (wie oben zitiert), sondern sogar über 570 Millionen Jahre bis auf den heutigen Tag existieren?!

(Vergleichen Sie zum letzteren Punkt das ausführliche Zitat in meiner Diskussion mit Herrn R.W.Kaplan S. 14 und S. 24ff.[30]). Die Baupläne (Stämme) des Tierreichs sind seit über 500 Millionen Jahre konstant!

Und weiter (Zitat von S. 14):"...seit ungefähr 400 Millionen Jahren" treten "keine neuen Klassen innerhalb dieser Tierstämme auf. Alle heutigen Klassen kamen zusammen mit anderen vor, die nicht bis zur Gegenwart überlebt haben." Ergo: Alle heute lebenden Klassen sind seit mehr als 400 Millionen Jahren konstant! (Ich schreibe "mehr als" weil ein Teil der Tierklassen weit älter ist, nur die jüngsten Klassen sind etwa 400 Millionen Jahre alt).

"Die Bildung neuer Ordnungen hörte gegen Ende des Mesozoikums auf, vor ungefähr 60 Millionen Jahren." Folglich sind alle heute lebenden Ordnungen mindestens 60 Millionen Jahre konstant!

Man könnte vielleicht einwenden, dass das noch nichts Ewiges sei!

(Denn, wie oben schon zitiert, meint Herr Dr. A.: "Alles verändert sich, niemals wurde etwas Beständiges, also Ewiges nachgewiesen.")

Dazu würde ich zu bedenken geben, dass etwas, was mehr als 500 Millionen Jahre konstant gewesen ist, was bis in die Gegenwart fortdauert und was allein nach naturwissenschaftlichen Prämissen noch Milliarden Jahre existieren wird (selbst eine atomare Auseinandersetzung würde wohl nur einen Teil der Baupläne bedrohen) tatsächlich auch als "Ewiges" zu bezeichnen ist.

Darüber hinaus hat Hans Krause in seinem Buch *The Cell - Its Cause* (Stuttgart 1995) zahlreiche Beispiele von fossilen Mikroorganismen (Bakterien, Blaualgen) zusammengestellt, deren Alter auf bis zu 3,5 Milliarden Jahre datiert wird und die diese Zeit im Wesentlichen unverändert bis auf den heutigen Tag überlebt haben. ("A high proportion of the nearly 300 prokaryotic taxa of Proterozoic microbial species are comparable in morphological detail to specific, modern, microorganisms." "Also the fossilized remains of different species of the cyanobacterium Oscillatoria have been found at Warrawoona, N.W. Australia. They are 3.3-3.5 billion years old." Krause, S. 76 und S. 83, dort weitere Beispiele). Das darf man wohl eine "Ewigkeit" nennen!

Aber selbst wenn Herr Dr. A. die Zukunft anders einschätzen sollte (das wäre jedoch aus meiner Sicht eine nicht begründbare Glaubensfrage), - wenn er z. B. aus mir noch unbekannten Gründen annehmen würde, dass morgen oder in naher Zukunft alle Lebensformen ausstürben, selbst dann wird man die so lange existierenden Baupläne des Tier- und Pflanzenreichs für ungeheure Zeiträume als "beständig und unveränderlich" bezeichnen können.

Man kann solche über große Zeiträume fast unveränderten Lebensformen auch als "lebende Fossilien" *sensu lato* bezeichnen. M.W.Strickberger definiert den Begriff wie folgt (Evolution, 1990, S. 525):"An existing species whose similarity to ancient ancestral species indicates that very few morphological changes have occurred over a long period of geological time."

(Andere Autoren fassen den Begriff enger:"They must today exhibit primitive morphological characters, having undergone little evolutionary change since dwindling to low diversity at some time in the past" Stanley 1979, S. 123. "...living fossils are simply species alive today that display relatively close anatomical similarity to ancestral species living way back near their group's inception" Eldredge 1989, S. 108.) Ich gebrauche im folgenden den weiter gefassten Begriff nach Strickberger.

Zu den anfangs zitierten lebenden Fossilien: Dr.A's Erklärung und Frage lauteten ja: "Wenn das Lebewesen sich an die Umgebung angepaßt hat, und die Umgebung sich nicht wesentlich verändert, bleibt das Lebewesen lange Zeit unveränderlich. Was ist da unverständlich?"

Da sind nun tatsächlich einige Punkte unverständlich:

Welche Umwelt bleibt denn z. B. für eine Fliegenpopulation 40 Millionen Jahre lang konstant (im wesentlichen unverändert)?

Und daß die Umwelten unseres Planeten gar über 200 Millionen oder mehr als 500 Millionen Jahre konstant geblieben sind, wird wohl heutzutage von keinem ernsthaften Geologen mehr vertreten: zahlreiche Meteoriteneinschläge, Erdbeben, Vulkanismus, Umwälzungen in der Erdrinde gigantischen Ausmaßes (Dekkan-Plateau), Verschiebungen der Kontinente, Gebirgsbildung (Orogenese), Landsenkungen, Überschwemmungen, Tsunamis, Taifune und Hurricans, Erosionen und Lawinen, Temperaturstürze, Eiszeiten und Hitzewellen - für die Geologiegeschichte über Millionen von Jahren hat Dr.A's Aussage nun tatsächlich ihre volle Gültigkeit: "Alles verändert sich, niemals wurde etwas Beständiges, also Ewiges nachgewiesen."

(Davon würde ich allerdings die physikalischen Konstanten und chemischen Elemente und die Gesetzmäßigkeiten der Bildung ihrer Verbindungen ausnehmen, die ja die Grundlage der Geologiegeschichte bilden. H20 war nach meinem jetzigen Kenntnisstand auch schon vor 5 Milliarden Jahren H20 etc.)

Zurück zu den geologischen und geographischen Unterschieden auf der Basis der physikalischen Konstanten: Selbst über kürzere Zeiträume und geringe geographische Entfernungen stellen wir ununterbrochen kleinere und größere Veränderungen fest. Einige Beispiele:

Zum Thema Klimaschwankungen lesen wir im Bertelsmann Universallexikon 1993, Bd.9, S. 347: "...annähernd periodische oder unregelmäßige, im Gegensatz zu den Klimaänderungen der Erdgeschichte kurzfristige Änderungen des allgemeinen Klimas in einem Gebiet. Länger andauernde Klimaschwankungen werden als säkulär bezeichnet. Für Klimaschwankungen werden einerseits natürliche Ursachen vermutet, wie Änderungen des Staubgehaltes in der Stratosphäre (z.B. durch große Vulkanausbrüche, deren Aschenmassen einen abkühlenden Effekt haben, indem sie einen Teil der Sonnenstrahlung zurückstreuen), des weiteren Änderungen der Meeresströmungen, Eisausbrüche in Arktis und Antarktis. Heute werden insbesondere auch die vom Menschen verursachten Faktoren und deren Auswirkungen auf die Atmosphäre diskutiert." (Worauf letzterer Punkt weiter behandelt wird.)

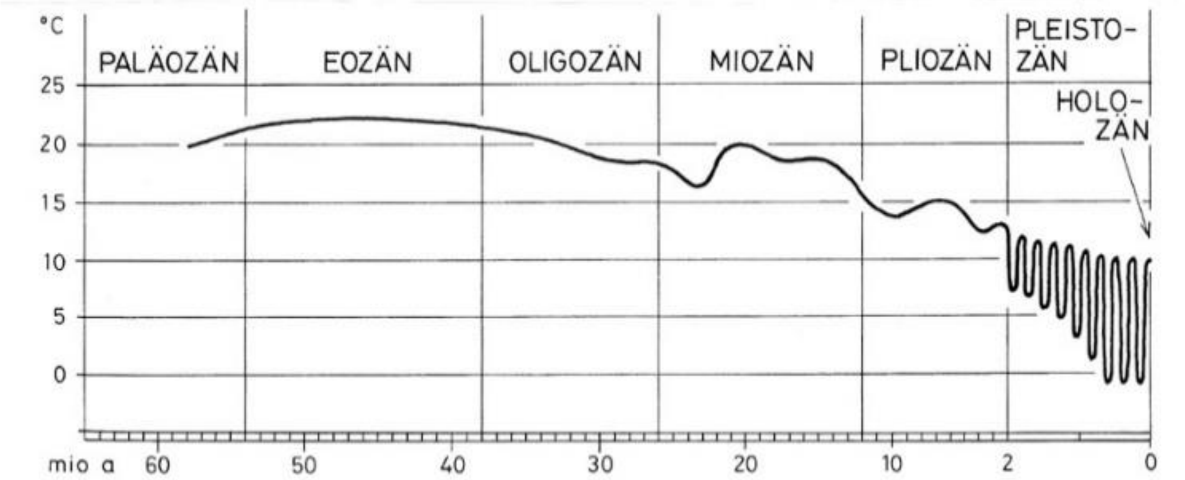
Über die letzten 2,3 Millionen Jahre der europäischen Geschichte schreibt der Paläobotaniker G. Lang zusammenfassend folgendes (Quartäre Vegetationsgeschichte Europas, Stuttgart 1994, S. 320): "Die für das Quartär charakteristischen, sich vielfach wiederholenden Klimawechsel hatten in erster Linie gewaltige Arealveränderungen der Pflanzen- und Tierarten zur Folge." - Worauf Beispiele folgen. Bei solchen über mehr als 2,3 Millionen Jahre anhaltenden Klimawechseln (d.h. wiederholt starken Umweltveränderungen) mit einhergehenden gewaltigen Arealveränderungen der Lebewesen dürfte man ja auch entsprechend gewaltige evolutionäre Entwicklungen in der Pflanzen- und Tierwelt erwarten! (Nach der Regel: Umweltkonstanz führt zu Artkonstanz, Umweltwechsel zu Evolution! Also 2,3 Millionen Jahre mit sich vielfach wiederholenden Klimawechseln ergeben 2,3 Millionen Jahre mit beschleunigter Evolution.)

Aber genau das finden wir nicht! Lang schreibt 1994, S. 320:

[30] http://www.weloennig.de/NeoB.Vobe.html

"Das Quartär...ist ein Abschnitt mit vergleichsweise geringer Evolutionsrate. Nach dem Ausweis der paläontologischen Befunde bestand die Organismenwelt am Ende des Tertiärs aus Sippen, die bereits ganz überwiegend heutigen Gattungen, zum großen Teil sogar heutigen Arten zugeordnet werden können. Das trifft sowohl für die europäische Flora wie für die Fauna zu. Jentys-Szaferova (1958) konnte beispielsweise durch anatomische Untersuchungen fossiler Früchte von Carpinus in Polen zeigen, dass die Merkmale von C. betulus vom Pliozän über die Interglaziale bis zur Gegenwart unverändert blieben. Neben den meisten Pflanzenfossilien sind auch nahezu alle fossilen Käferfamilien mit rezenten Arten identisch (Coope 1979), ebenso wie die meisten Säugetiere, soweit sie nicht ausgestorben sind (Kurtén 1968). Auf diese offensichtlich weitgehende Konstanz der Sippen bis hinunter zur Art, gründet sich die in der Quartärpaläontologie allgemein übliche Methode, nach dem aktualistischen Prinzip den heutigen ökologischen Zeigerwert von Organismen auf die Vergangenheit zu übertragen."

Skizze: Klimaschwankungen nach Lang 1994, S. 11:



Klimaschwankungen im Tertiär und Quartär. Geschätzte Jahresmitteltemperaturen für West- und Mitteleuropa. Aus Darstellungsgründen ist der Zeitmaßstab für das Pleistozän und das Holozän gedehnt und die Zahl der Kalt- und Warmzeiten geringer als tatsächlich. Nach WOLDSTEDT (1961) und NILSSON (1983).

Skizze der Klimaschwankungen im Tertiär und Quartär: "Geschätzte Jahresmitteltemperaturen für West- und Mitteleuropa. Aus Darstellungsgründen ist das Zeitmaß für das Pleistozän und das Holozän gedehnt und die Zahl der Kalt- und Warmzeiten geringer als tatsächlich." G.Lang 1994 nach Woldstedt 1961 und Nilsson 1983.

Etwa die Hälfte aller Gattungen der Blütenpflanzen, die in auf 37 Millionen Jahre datierten geologischen Formationen nachgewiesen wurden, konnten bereits mit heute lebenden Gattungen identifiziert werden (Stanley: Earth and Life through Time; 1986, S. 530). Und dabei ist zu bedenken, daß der Fossilbericht noch nicht vollständig durchgearbeitet ist und die Identifikationen noch nicht abgeschlossen sind. Von der paläobotanischen Gesamtüberlieferung aller Gattungen der Blütenpflanzen sind bisher vielleicht erst 50-70 Prozent gefunden und identifiziert worden. So sind noch zahlreiche weitere moderne Gattungen in 'alten' Schichten zu erwarten. Wir sind geradezu von lebenden Fossilien umgeben!

Nehmen wir eine weitere bekannte Pflanzengruppe - die Moose: Prof. S.N. Agashe bemerkt (Paleobotany; 1995, S. 88):

"Members of both the major groups of bryophytes, i.e. Hepaticopsida (liverworts) and Bryopsida (mosses), are well represented in the known fossils. However, a detailed comparative study with modern bryophytes indicated that the group has remained almost unchanged since the Paleozoic time. Hence the fossil bryophytes do not help us much in understanding evolution except for the fact that they formed a prominent part of the vegetation from the Paleozoic onwards."

Die ältesten Moose sind damit "almost unchanged" um die 400 Millionen Jahre alt. Man könnte ähnliche Aussagen für zahlreiche weitere Pflanzen- und Tiergruppen dokumentieren. Wir sind tatsächlich von lebenden Fossilien umgeben!

Kommen wir zu den Umweltunterschieden zurück. Was selbst relativ geringe geographische Entfernungen anlangt, so finden wir hier ebenfalls fast ununterbrochen große und kleinere (ebenfalls häufig nicht über größere Zeiträume konstante) Umwelt-Unterschiede bis hin zum Mikroklima, "das durch bodennahe Luftschichten bestimmte Klima kleiner Räume, z.B. einer Senke, eines Hanges, Feldes oder Gartens" (Bertelsmann Universallexikon 1993, Bd. 9, S. 340). Fast überall sollte die Evolution durch Mutation und Selektion fortschreiten, zumindest über größere Zeiträume.

Wenn wir die Bildung der Lebensformen und die eventuelle Frage, inwieweit Formen konstant sein können, mit der 'Anpassung an die Umgebung' beantworten, dann würden wir alles erwarten, - nur keine lebenden Fossilien, d. h. Formen, die allen Umweltunterschieden zum Trotz, ja im schärfsten Gegensatz zu sämtlichen größeren (und kleineren) Umweltveränderungen sogar über Hunderte von Jahrmillionen hinweg konstant bleiben! Das jeweils plötzliche Auftreten (siehe Zitate im Schöpfungsbuch oben) und die Konstanz der Baupläne, der Klassen, Ordnungen und die Vielzahl lebender Fossilien (praktisch alle heute lebenden Tier- und Pflanzengattungen sind "lebende Fossilen"!) beweisen eindeutig, dass diese Fragen nicht mit der 'Anpassung an die Umgebung' (wissenschaftlich überzeugend und hinreichend) zu beantworten sind! Die Formenkonstanz besteht nachweislich unabhängig von der Anpassung an die (erdgeschichtlich und geographisch ununterbrochen wechselnde) Umgebung. Die Evolutionslehre, die die Entstehung aller Lebensformen als Anpassungserscheinungen erklären wollte (insbesondere Darwinismus und Synthetische Evolutionstheorie) ist damit nachweislich falsch.

Im übrigen hat Darwin selbst die Problematik der lebenden Fossilen für seine Theorie angedeutet, wenn er schreibt: "When I see that species even in a state of nature do vary little & and seeing how much they vary when domesticated, I look with astonishment at a species which has existed since one of the earlier Tertiary periods...This fixity of character is marvellous" (Darwin 1852, zitiert nach D. Ospovat 1995, S. 201)

Außerdem soll gemäß Darwin und seinen Nachfolgern die angenommene Evolution als Vervollkommnungsprozess auch ohne Veränderungen der Umwelt ununterbrochen weiterlaufen ! Und die Ursache dafür soll die "ewige" intra- und interspezifische Konkurrenz sein ('Struggle for Existence' und 'Survival of the Fittest'): Die andauernde Entstehung und Selektion von neuen und weiterentwickelten Varianten, - Varianten, die ihrerseits wieder fortschrittlichere Varianten hervorbringen und der Selektion anbieten usw. usf.: D. h. die Evolution bleibt niemals stehen. Nichts bleibt konstant. Alles wandelt und verändert sich ununterbrochen. Alles entwickelt sich weiter und höher, wird immer besser und komplexer. "Alles fließt" (Heraklit) in Kombination mit dem viktorianischen Fortschrittsglauben. Auch diesem Grundgedanken der Evolutionstheorie widersprechen die 'lebenden Fossilien' deutlich und drastisch. (Deshalb der Kommentar in The Globe and Mail zum Fund einer fossilen Fliege: "In ihrem 40 Millionen Jahre dauernden Kampf beim Erklettern der evolutionären Leiter haben sie fast keinen erkennbaren Fortschritt erzielt", - siehe Schöpfungsbuch, S. 63.)

Darwin hatte seinerzeit das Problem für seine Theorie schon erkannt und versuchte es mit einer Hilfshypothese zu lösen: Lebende Fossilien können vielleicht damit erklärt werden, dass der Selektionsdruck in bestimmten Gebieten geringer war als in anderen und daher die Entwicklung stagnierte. Da wir aber in allen Gebieten der Erde von lebenden Fossilien umgeben sind, müsste logischerweise der Selektionsdruck auf der ganzen Erde nachgelassen haben und es dürfte seit Hunderten von Millionen von Jahren überhaupt keine Evolution neuer Arten und Formen mehr geben.

Darüber hinaus ist nicht einzusehen, dass sich an denselben (mit den lebenden Fossilien gemeinsam besetzten) Biotopen zahlreiche Arten und Formen ununterbrochen weiterentwickelt haben sollen, während die lebenden Fossilen in Konkurrenz mit diesen sich dauernd verbessernden Arten wesentlich länger leben als jede einzelne der in der Erd- und Evolutionsgeschichte einander ablösenden Arten, die (weil weiterentwickelt) die jeweils vorhergehenden Arten verdrängten. Wenn es möglich war, die in der Evolution laufend entstandenen weiterentwickelten Arten durch immer neue und noch bessere Formen zu verdrängen und damit die Evolution weiterzuführen, - warum dann nicht auch und vor allem erst einmal die primitiven lebenden Fossilien?!

Die lebenden Fossilien sind ein schweres Problem für die Evolutionstheorie: Alle Arten und Formen sollen sich über längere Zeiträume wegen 1. der sich ständig ändernden Umweltverhältnisse, 2. der ununterbrochenen Vervollkommnung durch Anpassung (nach Darwin auch durch Gebrauch und Nichtgebrauch von Organen), 3. der immerwährenden Erzeugung neuer vorteilhafter Varianten (Mutationen) 4. der dauernden Selektion durch die intra- und interspezifische Konkurrenz und 5. der damit einhergehenden fortwährenden Verdrängung von weniger entwickelten Arten durch höher entwickelte ununterbrochen verändern, weiter- und höherentwickeln. Lebende Fossilien dürfte es demnach überhaupt nicht geben!

Tatsache ist jedoch: Lebende Fossilien gibt es in großer Zahl. Und sie sind über große geologische Zeiträume hinweg konstant: Ständige Umweltveränderungen, Konkurrenz mit Angehörigen der eigenen sowie anderer Arten, Millionen von Mutationsereignissen (Gen-, Chromosomen, Genommutationen) und alle weiteren evolutionistischen Ideen und biologischen Realitäten haben daran nichts geändert.

Die lebenden Fossilien stellen damit gleich mehrere Grundpfeiler der allgemeinen Evolutionstheorie in Frage: 1. Schaffen die Mutationen tatsächlich 'fortschrittliche Varianten' für die Bildung genetisch-plasmatisch neuer Arten und Formen? 2. Stößt die Selektion auf ihre Grenzen, weil sie vielleicht nicht den Stellenwert hat, der ihr von der Synthetischen Evolutionstheorie beigemessen wird? Ist die Selektion a) entweder allgemein nicht "so streng" wie bisher angenommen oder b) ist sie begrenzt, weil die Bildung fortschrittlicher Varianten nicht "unendlich" ist, oder c) überleben nicht notwendigerweise die Besten? (- Oder 2 oder alle 3 dieser letzteren Punkte treffen gleichzeitig zu.) - Weitere Diskussionspunkte: 3. Interspezifische Konkurrenz führt nicht notwendigerweise zur Verdrängung "primitiver" Formen durch komplexere. 4. Anpassung ist nicht mit Höherentwicklung gleichzusetzen.

(Zum letzteren Punkt habe ich Herrn Dr. A. die Seiten 118-120 aus der Artbegriffsarbeit kopiert, mit der Einladung und Bitte, auch diese Ausführungen gründlich und konstruktiv-kritisch zu studieren. Sie zeigen meiner Auffassung nach eindeutig, dass Anpassung und Höherentwicklung tatsächlich nicht gleichzusetzen sind. - Im Übrigen ist dieser Abschnitt zum größten Teil aus meiner ersten Staatsexamensarbeit, die von einem Evolutionstheoretiker mit der bestmöglichen Beurteilung bewertet wurde.)

Die oben in Frageform aufgeführten Punkte 1. und 2. a) b) c) sind wie folgt zu beantworten: 1. Mutationen schaffen keine neuen Arten (dazu habe ich Herrn Dr.A. angeboten, Ihm umfangreiches Material für die Richtigkeit dieser Behauptung auf Wunsch zukommen zu lassen). 2. Die Selektion stößt insbesondere zur Frage nach der 'Höherentwicklung' auf genetische, physiologische, anatomische und morphologische Grenzen, wobei alle drei Punkte a), b) und c) eine Rolle spielen können.

Die Problematik der lebenden Fossilien für die Evolutionstheorie wird übrigens auch von vielen führenden zeitgenössischen Evolutionisten anerkannt. So schreiben die Zoologieprofessoren V. Storch und U. Welsch (Evolution; 1989, S. 107) zu diesem Thema: "Die Ableitung eines Evolutionsstops oder eines langsamen Tempos ist zurzeit nur in einem beschränkten Bereich möglich. Eine Erklärung fehlt auch noch für den Evolutionsstop vieler lebender Fossilien."

Zu Herrn Dr.A.'s Erklärung der lebenden Fossilien durch Anpassung und unwesentliche Umweltveränderungen schreiben die Autoren unter anderem:

"Auch die Tiefen des Meeres hat man vielfach als konkurrenzarmes Gebiet mit stabilen Umweltbedingungen angesehen. Allerdings ist nach neueren Untersuchungen die Besiedlung der Tiefen, auch in Bezug auf die Mikrofauna des Meeresbodens nicht so gering, wie man zunächst aufgrund der vermuteten Ernährungsmöglichkeiten angenommen hatte. Der Konkurrenzfaktor ist also nicht klein, aber die chemisch-physikalischen Faktoren der Umwelt sind im Allgemeinen weniger wechselnd als in der Flachsee und in Seen. Es kommen hier lebende Fossilien nur vereinzelt vor, z.B. die Urschnecke *Neopilina* in 2000-3000m Tiefe."

Also dort, wo man lebende Fossilien nach evolutionistischen Prämissen am häufigsten erwarten sollte, kommen sie nur selten vor. Wo man sie aber nicht erwartet hatte, da sind sie häufig:

"Eine große Zahl von Primitivformen lebt aber in Räumen, für die ein solcher >Umweltschutz< nicht sichtbar ist. Die Protarthropoden mit *Peripatus* und anderen leben in der Bodenschicht der Tropen, die Fische *Lepisosteus* und Amia in normalen Gewässern Nordamerikas, die primitiven Beuteltiere (Didelphidae) in Südamerika (das eine Fülle höherer Säugetiere hat und besonders im Tertiär hatte), und *Limulus* und *Lingula* leben in Flachmeeren."

Worauf die oben schon zitierten Sätze folgen:

"Die Ableitung eines Evolutionsstops oder eines langsamen Tempos ist zurzeit nur in einem beschränkten Bereich möglich. Eine Erklärung fehlt auch noch für den Evolutionsstop vieler lebender Fossilien."

Professor Osche favorisiert im Springer-Lehrbuch Biologie Dr.A.'s Umwelterklärung zu den Dauergattungen oder "lebenden Fossilien", fügt dann jedoch hinzu (1976, S. 810): "Wenn auch zweifellos die Stabilität der Umweltverhältnisse (und damit der Selektionsbedingungen) ein wesentlicher Faktor für das Sistieren der Evolution der lebenden Fossilien darstellt, bleiben doch noch viele Fragen offen." Welche Fragen das sind, geht aus den obigen Abschnitten schon hervor (abgesehen davon, daß eine Umweltstabilität über geologische Zeiträume nicht einmal für die 'Tiefen des Meeres' gilt und die inter- und intraspezifische Konkurrenz vergessen wird usw. siehe oben). Immerhin wird eingeräumt, dass für die Evolutionstheorie noch viele Fragen offen bleiben, d. h. dass die Theorie die Probleme nicht beantworten kann. (In späteren Auflagen hat Osche den Hinweis auf 'viele offene Fragen' fallengelassen - ohne jedoch die offenen Fragen beantwortet zu haben - das nenne ich "evolutionären Fortschritt").

Professor Niles Eldredge, ebenfalls Evolutionist, schreibt sogar (Life Pulse; 1989, S. 108): "Living fossils are something of an embarrassment to the expectation that evolutionary change is inevitable as time goes by."

Nach Aufführung mehrerer evolutionistischer Erklärungsversuche bemerkt er zur Hypothese von der Umweltstabilität (die auch er nicht ungern sieht): "...yet it doesn't explain why still other groups do change even though they share the same supposedly constant environment." Hier das Zitat noch einmal im größeren Zusammenhang (Numerierung von mir):

"There have been a number of theories advanced to explain the seeming incongruities posed by these "living fossils". (1) Some paleontologists have been content merely to shrug the problem away, as if to say, "Well, some groups evolve quickly, the vast majority exhibit a moderate rate of evolutionary change, while a very few others have simply inherited the low end of the spectrum of rates of change." Such an attitude hardly explains why some groups evolve more quickly than certain others. (2) Paleontologists have sought the explanation in genetic material: perhaps some groups, such as lungfishes and coelacanths, simply lack the requisite genetic variation that would allow them to escape the straightjacket of their ancient anatomical design. (3) Still others have speculated that such resistance to change merely reflect a constancy of the environment: natural selection simply keeps animals and plants looking the same as long as their environments remain recognizably constant. This last notion is, to my mind, more on the right track - yet it doesn't explain why still other groups do change even though they share the same supposedly constant environment."

Alle drei Erklärungen sind unzureichend. (1) und (3) haben wir schon ausführlich behandelt und zur Hypothese (2) gibt es inzwischen zahlreiche Studien zur genetischen Variabilität an lebenden Fossilien, die keinen nennenswerten Unterschied zu den anderen Formen ergeben haben. (Wenn in den obigen Zitaten davon die Rede ist, dass die anderen Formen sich verändern und weiterentwickeln, dann ist das nebenbeibemerkt auch nur eine evolutionistische Interpretation der Tatsache, dass weitere Formen sprunghaft in Erscheinung treten.)

Eldredge selbst wartet mit einer 4. Hypothese auf: Die lebenden Fossilien seien ökologische Generalisten und das würde die Speziationsrate in der Linie herabsetzen. ("The condition of being an ecological generalist automatically decreases the rate of speciation in a lineage; and low rates of speciation ensure low rates of anatomical change", p. 110). Dieser Erklärungsversuch wirft nun gleich drei neue Probleme auf:

1) Warum gibt es dann unter den lebenden Fossilien auch zahlreiche ökologische Spezialisten?

(Andere Autoren haben genau umgekehrt argumentiert: Die lebenden Fossilien seien ökologische Spezialisten und wären deswegen sowenig anatomisch verändert oder praktisch konstant geblieben. Das ist die fünfte unhaltbare evolutionistische Erklärung! Denn gerade die Spezialisten sollten - nach evolutionstheoretischen Voraussetzungen - bei den in geologischen Zeiträumen sich laufend verändernden abiotischen und biotischen Umweltbedingungen entweder aussterben oder sich weiterentwickeln!)

2) Warum sollen sich nach der Evolutionstheorie dann auf der anderen Seite so viele ökologische Generalisten trotzdem ununterbrochen weiter- und höherentwickelt haben?

3) "Low rates of anatomical change" erklären immer noch nicht, warum sich in Hunderten von Jahrmillionen viele lebende Fossilien praktisch gar nicht anatomisch verändert haben. In solchen Zeiträumen müssten sich doch auch geringe anatomische Veränderungsraten zu größeren Unterschieden addieren!

Für einige Evolutionstheoretiker sind die lebenden Fossilen ein solches Ärgernis, dass sie versucht haben, die Existenz solcher Lebensformen rundweg zu leugnen.

Es wäre sicher noch hochinteressant, die einzelnen in vielen Arbeiten aufgeführten lebenden Fossilien *sensu stricto* im Detail zu diskutieren: Welche gigantischen Umweltveränderungen viele lebende Fossilien in Jahrmillionen bis auf den heutigen Tag überstanden haben, ihr jeweils plötzliches erstes Auftreten und ihre morphologische und (heutige) genetische Variabilität zu dokumentieren und weitere Beispiele dafür aufzuführen, dass Anpassung nicht mit Höherentwicklung gleichzusetzen ist. Aber dazu müsste ich einige Wochen investieren, was mir zur Zeit nicht möglich ist.

Soviel dürfte jedoch schon an Hand der bisherigen Ausführungen deutlich und klar geworden sein: Die lebenden Fossilien zeigen eine "innere" Konstanz, die sie weitgehend unabhängig von den wechselnden Umweltbedingungen geologischer Zeiträume und geographischer Distanzen macht. Diese innere Konstanz der Formen aber dürfte nach der Evolutionstheorie überhaupt nicht existieren! (Auf dieser behaupteten Nichtexistenz beruht(e) übrigens die marxistische Ideologie).

Nach der Theorie ist alles im Fluß und nichts konstant. Das "Gesetz der Daseinsbedingungen" (Umweltbedingungen) wird nach Darwin von der natürlichen Zuchtwahl - als Strategie der Anpassung an die anorganischen und organischen Lebensbedingungen - voll umfasst. Es ist im Vergleich zur Einheit des Typus das "höhere Gesetz" (Darwin wörtlich). Auch das Postulat der Vervollkommnung und Weiterentwicklung aufgrund von ununterbrochener Variation und innerartlicher Selektion selbst ohne Veränderungen des anorganischen Milieus ist im "Gesetz der Daseinsbedingungen" schon enthalten. Die über Jahrmillionen (und im Falle von Prokaryonten sogar über Jahrmilliarden) gehende innere Konstanz lebender Fossilien - die Konstanz der Baupläne und Typen z.T. bis hinunter zu systematischen Gattungen und Arten - ist auf evolutionistischer Grundlage völlig unerwartet und bleibt trotz aller Deutungsversuche für die Evolutionstheorie letztlich unverständlich. Und das ist auch von hervorragenden Evolutionstheoretikern zugegeben worden (siehe die Zitate oben).

Die Schöpfungslehre hingegen hat das Phänomen der lebenden Fossilien geradezu erwartet und vorausgesagt. Sagt doch der Genesis-Text immerhin 10mal, dass Gott die jeweiligen Pflanzen und Tiere 'nach ihrer Art' erschuf. Innerhalb der 'Arten' gibt es eine große Variabilität (vgl. Menschen-, Tauben-, Hunderassen), aber die Typen des Lebens bleiben konstant ("aus einem Hund wird niemals eine Katze"). Die Lebensformen sind so erschaffen, daß sie auf der einen Seite über eine große Variabilität und Anpassungsfähigkeit verfügen, dass auf der anderen Seite jedoch der jeweilige Typus konstant bleibt. Und das bestätigen sowohl die Erdgeschichte als auch die geographische Verbreitung vieler Lebensformen.

Nach der Schöpfungstheorie beruht die weitgehende Konstanz und Resistenz der Lebensformen gegen Umweltveränderungen auf einem von Weisheit und Macht zeugenden Schöpfungsprogramm zur Erhaltung der Art- oder Typusstabilität. Intelligenz, Weisheit, Geist und Gott sind für die Kodierung solch genial-komplexer Konstanz-Programme die adäquate Ursache, nicht aber (Zufalls-)Mutationen, Selektion und/oder Symbiosen (welch letztere ja schon komplexe Lebewesen voraussetzen und die selbst einen Teil der Konstanz-Programme bilden).

Für die Evolutionstheorie ist das Phänomen der lebenden Fossilien letztlich nicht erklärbar, weil es ihren grundsätzlichen Voraussetzungen und Annahmen widerspricht ("alles fließt", nichts ist konstant). Für die Schöpfungstheorie sind die lebenden Fossilien ein Beweis mehr für die Richtigkeit ihres Ansatzes und ihrer grundlegenden Aussagen.

Soviel zur Konstanz der Baupläne und der lebenden Fossilien. Ich sollte nebenbei schon einmal erwähnen, dass Herr Dr .A. zu keinem dieser Punkte im weiteren Verlauf der Diskussion Stellung bezogen hat.

Altogether, in the written dialogues these notes have been presented either as a link, or in part or entirely to: an evolutionary zoologist (Dr. A.), a group of three evolutionists (*cf. Die Evolution der karnivoren Pflanzen*[31]), a totalitarian Darwinian professor of biology[32], and an evolutionary geologist (see above): No qualified answers! Moreover, a discussion group addressed the article just cited: likewise no evolutionarily convincing solutions. Result: ***The biological facts deny the ruling paradigms of evolution***.

Incidentally, this overall inference is in agreement with Steven M. Stanley's comment in *The New Evolutionary Timetable* (1981, p. 85 – an observation, which has also been proven to be all the more up-to-date by new evidence in 2021)[33]:

> "***Living fossils have represented a thorny puzzle in the traditional, gradualistic scheme of evolution***. If natural selection is constantly reshaping species in significant ways, why have some species been almost immune to the process? Darwin, who seems to have coined the phrase "living fossils" in the first edition of the *Origin* (p. 107) suggested that "they have endured to the present day, from having inhabited a confined area, and from having thus been exposed to less severe competition." On the contrary, we can now see that ***many species of living fossils are not narrowly distributed***. Delamare-Deboutteville and Botosanéanu, who recently published a book on living fossils, described them as creatures "that have stopped participating in the great adventure of life," being confined by their **narrow adaptations**. **Exactly the opposite explanation** has been offered by George Gaylord Simpson, who has considered living fossils to have stagnated **because of their unusually broad adaptations**; according to his view, a typical living fossil species has tolerated such a wide variety of conditions that it has not been subjected to strong, specific pressures of natural selection.
>
> These ***conflicting conjectures on ecological breadth illustrate the dilemma in which gradualism has been trapped by living fossils***. In truth, some living fossils are narrowly distributed and others are broadly distributed. Some are narrowly adapted and others are broadly adapted. Many, like the American alligator and snapping turtle, are quite abundant, or were prior to human interference. ***Living fossils share no obvious adaptive feature that can explain why natural selection should have largely ignored them for millions of years while working enormous changes on other well-established forms of life***."

The problem is not new. On Thomas Henry Huxley's *Address to the Geological Society of London* in 1870, Stanley remarks that "… **he was simply confounded by the existence of "persistent types"**, or body plans which changed little through the ages:

> "The significance of persistent types, and of the small amount of change which has taken place even in those forms which can be shown to have been modified, becomes greater and greater in my eyes, the longer I occupy myself with the biology of the past.""

[31] http://www.weloennig.de/Utricularia2011Buch.pdf
[32] http://www.weloennig.de/KutscheraPortner.pdf
[33] Steven M. Stanley (1981): *The New Evolutionary Timetable*. Basic Books. Inc. (For Stanley's clear, appropriate and fully valid criticism cited above, two points may also be considered: (1) It was made at a time when the relatively new theory of punctuated equilibrium was at a height of its popularity and its near general recognition as a scientific alternative to neo-Darwinism and thus researchers felt free to criticize old gradualism and its problems as plainly/distinctly/definitely as possible. It was also a time when young Olivier Rieppel could publish refreshing books like *Kladismus oder die Legende vom Stammbaum* (1984). As for the history how punk eek largely ended, see Meyer 2013/2014, pp. 136-152 in his book *Darwin's Doubt* and Lönnig (2019, pp. 5/6) in http://www.weloennig.de/ElephantEvolution.pdf. (2) Stanley has obviously corrected his restrictive/narrow definition of living fossils (especially expounded in *Macroevolution* 1979, p.123) in the book edited with Eldredge on *Living Fossils* 1984 (see above). However, the veracity of the statement quoted above is independent of his former definitions.

Summary according to my article in the *THE CORSINI ENCYCLOPEDIA OF PSYCHOLOGY & BEHAVIORAL SCIENCE* (Vol. 3, 3rd Edition, pages 1008-1016)[34]:

NATURAL SELECTION AND LIVING FOSSILS

"Living fossils have been totally unexpected for a theory according to which everything is in a state of permanent flux and evolution (Lönnig, 1999b). In the wording of Eldredge (1989, p. 108), "Living fossils are something of ***an embarrassment to the expectation that evolutionary change is inevitable as time goes by***." Darwin admitted, "When I see that species even in a state of nature do vary little and seeing how much they vary when domesticated, I look with astonishment at a species which has existed since one of the earlier Tertiary periods. ...***This fixity of character is marvellous***" (Darwin, 1852, quoted in Ospovat, 1995, p. 201). The general explanation by neo-Darwinians is that certain species are fixed because they are adapted to non-changing environments. This explanation is doubtful for the following reasons: (a) **There are hardly any constant environments over longer geologic time periods**; (b) **Most living fossils are found in permanently changing environments with high competition factors** (Storch & Welsch, 1989); and (c) According to the modern synthesis, **even in constant environments** the endless generation of new advantageous mutations plus selection pressures within the species should lead to the permanent substitution of primitive structures and species by more advanced ones. ***So, in spite of billions of mutations in the long history of living fossils and in defiance of natural selection during millions of years, species did not diverge*** (see definition of natural selection at the beginning of the article). Therefore, the rich array of living fossils constitutes another serious problem for the neo-Darwinian school."

What was Darwin's "Abominable Mystery" Concerning the Origin of the Angiosperms?

Richard J. A. Buggs of the Royal Botanic Gardens, Kew, Richmond, Surrey, UK and School of Biological and Chemical Sciences, Queen Mary University of London, comments (2021, p. 22) in his paper on *The origin of Darwin's "abominable mystery"* "that Darwin was referring to the origin only of a subset of what are today called angiosperms: a (now obsolete) group equivalent to the "dicotyledons" of the Hooker and Bentham system", but Buggs continues to point out that "developments in plant systematics and paleobotany *after 1879 meant that Darwin's letter was widely understood to be referring to the abrupt appearance of all angiosperms when it was published in 1903, a meaning that has been attached to it ever since*. (Italics added.) Buggs specifies his understandings in the subsequent paragraphs (pp. 22/23):

> The much-repeated term "Darwin's abominable mystery" is derived from a private letter written in 1879 by Charles Darwin to his friend Joseph Hooker, Director of the Royal Botanic Gardens Kew. In his letter, Darwin stated: "the rapid development as far as we can judge ***of all the higher plants within recent geological times is an abominable mystery***" (Darwin, 2019, pp. 336–337). When the letter was first published in 1903, the volume's editors Francis Darwin and Albert Seward placed it under a page header "Evolution of Angiosperms" (Darwin and Seward, 1903, p. 21). "*Darwin's abominable mystery" has ever since been a commonly used appellation in the scientific literature for a range of unanswered questions about the origin and diversification of this group*

[34] http://www.weloennig.de/NaturalSelection.html (2001 – updated 2016)

(e.g., Axelrod, 1952; Stebbins, 1965; Crepet, 2000; Frohlich and Parker, 2000; Davies et al., 2004; Berendse and Scheffer, 2009; Friedman, 2009). ***The scope of the mystery has been seen to encompass all aspects of the ancestry, age, environment, character, diversity, and diversification rate of the early angiosperms***. Whether all these aspects address Darwin's mystery is questionable (Friedman, 2009), and Bateman (2020) argues that some recent approaches are misguided. But over the past century, paleobotanists, palynologists, anatomists, molecular phylogeneticists, developmental biologists, paleoecologists, and genome biologists have all seen themselves as tackling the "abominable mystery" when they have researched angiosperm origins and diversification. ***Despite much progress in these areas, there is general agreement that Darwin's "abominable mystery" remains intact, and the origin and diversification of the angiosperms remains one of the greatest open questions of the history of life***.[35]

Incidentally, as for the dicotyledons, "the name refers to one of the typical characteristics of the group, namely that the seed has two embryonic leaves or cotyledons. There are around 200,000 species within this group."[36] However, in the interim – starting around 1990 – the group itself has been divided in subgroups (the eudicots comprising about 190,000 species or three quarters of the entire group of angiosperms[37]). So even in Darwin's original "subset"-meaning it would address the majority of the altogether some 300,000 angiosperm species.

Although **"**Darwin's "abominable mystery" was to him in 1879 ["only" , I would add in quotation marks] the sudden appearance of angiospermous dicotyledonous fossils in great diversity in the Cretaceous**"** (Buggs 2021, p. 34), now/today – if he knew of the additional discoveries of the past 150 years (and had not given up his doubtful/questionable/unconfirmed/unproven theory being in stark contradiction to 'endless forms most beautiful'), – would he not apply the term's meaning in agreement with the researchers just quoted above addressing "all the higher plants within recent geological times" (also "this great division", see below Darwin 1875)? Probably so, especially considering the fact that – as just cited – "*there is general agreement that Darwin's "abominable mystery" remains intact, and* ***the origin and diversification of the angiosperms remains one of the greatest open questions of the history of life***."

A Word on Wikipedia

Wikipedia has been criticized for various reasons: see, for example, the following discussion in the Wikipedia itself[38]. Some criticisms are undoubtedly true/correct/appropriate[39]. However, ***for the present paper, the Wikipedia that has proven to be extremely valuable to me***: Most of the **photographs** of representative species of the different plant families shown and discussed here are taken from the Wikipedia[40] – hardly anyone has a collection of photos from all living plant families and to write to hundreds of authors/photographers to ask for permissions would have been so extremely time consuming that I would probably have given up early to get them all.

As for the question of accuracy, – I have checked time and again many points in the scientific literature and I must say that – on the whole – the authors have taken great care to be successfully up to date. So, almost all of the often anonymous authors are to be recommended for their efforts.

Also, I have *consistently set the links to the articles and authors/ photographers cited wherever possible* (often their witty pseudonyms they themselves have proposed and used).

[35] https://bsapubs.onlinelibrary.wiley.com/doi/epdf/10.1002/ajb2.1592 (Emphasis again added as also in most of the following quotations.) See also https://evolutionnews.org/2021/02/botany-journal-revisits-darwins-abominable-mystery/
[36] https://en.wikipedia.org/wiki/Dicotyledon (retrieved 20 July 2021).
[37] https://www.sciencedirect.com/topics/biochemistry-genetics-and-molecular-biology/eudicot
[38] https://thecritic.co.uk/the-left-wing-bias-of-wikipedia/ see further https://www.vice.com/en/article/bnppw4/wikipedias-co-founder-is-wikipedias-biggest-critic-511 https://www.technologyreview.com/2013/10/22/175674/the-decline-of-wikipedia/ https://computing.dcu.ie/~humphrys/wikipedia.html
[39] https://evolutionnews.org/2017/10/wikipedia-erases-paleontologist-gunter-bechly/ https://cei.org/blog/american-spectators-tom-bethel-writes-about-my-views-on-wikipedia/ (There many more of such stories, but this is not the topic of may present paper.)
[40] Because I had to miniaturize many of the photographs ***I have sharpened and added color to several of them*** so that they can be more clearly be identified. So, I would like to suggest to my readers to take the original Wikipedia photographs in case somebody wants to make any further use of them.

The Fossil Record of the Angiosperms in 1971 as compared to 50 Years Later in 2021

Fully fifty years ago, I focused in Chapter VII of my MSc thesis[41] on the topic of the FOSSIL RECORD AND THE ORIGIN OF THE ANGIOSPERMS (1971, pp. 57-73[42]), presenting an overview of the abrupt appearance of the flowering plants in the fossil record so far known at that time. Now let's compare the state of the art of 1971 with our present knowledge of 2021 centering our attention on the question to what extent the enormous progress of paleontology during the last fifty years has either alleviated/reduced or amplified/reinforced/increased the depth of the "abominable mystery" for the present evolutionary theories, especially neo-Darwinism and punctuated equilibrium, and whether, and if so, to what extent the intelligent-design-theory (ID) could be a scientifically well-grounded, sound and valid alternative for the evolutionary theories on the origin and diversification of the angiosperms.

So, let's begin with an overview of the knowledge of the angiosperm fossil record of 2021 in comparison with the most important discoveries up to 1971 (paleobotany began with J. J. Scheuchzer 1709 (*Herbarium diluvianum*)[43] and more comprehensively with A.-T. Brongniart 1822 (*Classification*)[44], thus presently ***involving the paleobotanic work/research of altogether more than 300 years***):

In 1971 (so, after more than 250 years of paleobotany), I started that Chapter VII mentioned above with a quotation of professor Karl Mägdefrau of the University of Tübingen (his "main research areas were paleobotany and the ecology of mosses"[45]):

> Nowhere in the whole history of the earth is the difference in vegetation character so enormous as between E a r l y and L a t e C r e t a c e o u s. In the Wealden Group[46] and Neokom[47] there still lived a flora of pure Jurassic character, without a trace of angiosperms. And in the Upper Cretaceous the latter have already become the dominant component.
> ...First, we are struck by the fact that the angiosperms appear so 'suddenly', without any precursors. Why? We do not know. That the Bennettitines were not the immediate precursors, we have already learned.[48]

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[41] Title: Ursprung und Entwicklung des Pflanzenreichs im Spiegel älterer und moderner Auffassungen. Kritische Betrachtung unter Auswahl geeigneter Beispiele.
"[42] The original German title of Chapter VII was "FOSSILE ÜBERLIEFERUNG UND HERKUNFT DER ANGIOSPERMEN". See, please: http://www.weloennig.de/Staatsexamensarbeit.pdf
[43] See https://en.wikipedia.org/wiki/Johann_Jakob_Scheuchzer
[44] Cf. https://en.wikipedia.org/wiki/Adolphe-Th%C3%A9odore_Brongniart "Brongniart's pioneering work on the relationships between extinct and existing plants has earned him the title of father of paleobotany." (Retrieved 26 July 2021). A fine summary of the history of paleobotany is given in Goathan/Weyland (Lehrbuch der Paläobotanik; BLV) 1973, pp. 18-24). P. 18: "**Das älteste wirklich paläobotanische Werk ist das "*Herbariumn diluvianum*" von J. J. Scheuchzer (1709, 2. Auflage 1723)**, der wie weitere gleichzeitige Autoren die Fossilien als durch die biblische Sintflut verschüttete Lebewesen ansah…Auch ein englisches Werk von Lhwyd (**1699**, Luidius) enthält bereits zahlreiche Abbildungen fossiler Pflanzen." (By the way, Scheuchzer's often quoted error of the *Homo diluvii testis* was corrected by another "creationist"– the famous Georges Cuvier.) And also p. 18: „Als eigentlicher Vater der wissenschaftlichen Botanik muß aber A. **Brogniart** gelten, dessen Hauptwerk „*Histoire des végétaux fossiles*" (1828-1838) er bereits früher eine „***Classification*" (1822)** und einen „*Prodrome*" (1828) vorausgeschickt hatte."
[45] https://de.wikipedia.org/wiki/Karl_M%C3%A4gdefrau (retrieved 24 July 2021).
[46] Early/Lower Cretaceous https://en.wikipedia.org/wiki/Wealden_Group: "Berriasian to Aptian age" [145.0 ± 4.0 Ma and 139.8 ± 3.0 Ma]
[47] Outdated term. My old Encyclopaedia Britannica defines (1982, p. 253; Micropaedia, Vol VII): "The Neocomian includes the four lower stages of the Lower Cretaceous Series: from oldest to youngest, these are the Berriasian, Valanginian, Hauterivian, and Barremian stages. In effect, the Neocomian is a superstage, and the name is sometimes used in a time sense only, without any implication of rock sequence, so that lack of precision limits its utility. In the Macropaedia, vol. 5, p. 247 (Table), the Berriasian, Valanginian, Hauterivian, and Barremian are likewise listed for the Neocomian. (Incidentally, the Micropaedia and Macropaedia of 1982 note that "the [entire] Cretaceous Period began about **136,000,000** years ago and lasted about **71,000,000** million years". Today (2021) the following dates are given: "The Cretaceous … is a geological period that lasted from about **145 to 66 million years ago** (Mya). It is the third and final period of the Mesozoic era, as well as the longest. At nearly 80 million years, it is the longest geological period of the entire Phanerozoic." https://en.wikipedia.org/wiki/Cretaceous (Subdivision of the Cretaceous according to the ICS [International Commission on Stratigraphy], as of **2021**). (Retrieved 24 July 2021). In only 39 literal years (**from 1982 to 2021) the Cretaceous Period started 9,000,000 million years sooner/earlier than before** (so about equal to a time period in which humans are asserted to later have evolved from extinct "apes") – just progress or how sure are these dates really? See also Lönnig **2019, pp. 27/28** of http://www.weloennig.de/HumanEvolution.pdf. As for the "Néocomien", the French Encyclopaedia Universalis of 1985 (Thesaurus Index, vol. 2, p. 2084) notes, among other points: „Terme créé par Thurmann pour l'ensemble Valangien-Hauterivien-Urgonien (Barrémien actuel) de type jurassien pour la serié du Crétacé inférieur de Neufchatel. Le Néocomien a été interprété de facon **très differente** suivant les auteurs. Et d'Orbigny lui-même en a change l'accepation en plusieurs années." Charles River Editions (2020): "…the boundary between the Barremian and Aptian ages is a matter of debate and **estimates vary by as much as nine million years**. As of 2019, the most recent data suggest a date of 121-122 Mya." However, the 2021 Int. Chron. Chart shows 125 Ma.
[48] Original German text: „Nirgends in der ganzen Erdgeschichte ist der Unterschied im Vegetationscharakter ein so gewaltiger wie zwischen U n t e r s t e r und O b e r e r K r e i d e. Im Wealden und Neokom lebte noch eine Flora von rein jurassischem Gepräge, ohne eine Spur von Angiospermen. Und in der Oberkreide sind letztere schon zum herrschenden Bestandteil geworden.

And I continued as follows (1971, p 57): “Thus K. Mägdefrau (1942, pp. 285/286; 1953, pp. 300/301) describes the "angiosperm problem". From 1956 on, the question *Why* is followed by reference to the hypotheses of Axelrod and later also of Tompson, who both hold the opinion that the angiosperms had developed in ablation areas where no fossils could be preserved (1956, p. 293; 1968, p. 356). If we disregard such in principle unprovable and therefore rather worthless hypotheses, the "angiosperm problem", counting from Darwin's sigh of the "abominable mystery" (1879), can now soon celebrate its centenary, if until then the hypothesis of a continuous evolution should still be maintained.”[49]

Well, in the absence of any convincing materialistic alternative, the already long doubtful belief in Darwin’s “extremely gradual evolution”[50] has been maintained up to the present day by most evolutionists in order to uphold, preserve and perpetuate a naturalistic theory of the origin of species. As for the idea “of ablation areas where no fossils could be preserved” I should now add that Darwin himself favored a somewhat similar answer. He wrote to Oswald Heer, Professor of Botany at the University of Zürich, Switzerland (1875; cited according to Buggs 2021, p. 27):

> “The sudden appearance of so many Dicotyledons in the Upper Chalk appears to me a most perplexing phenomenon to all who believe in any form of evolution, especially those who believe in extremely gradual evolution, to which view I know you are strongly opposed. The presence of even one true Angiosperm in the Lower Chalk makes me inclined to conjecture ***that plants of this great division must have been largely developed in some isolated area***, whence owing to geographical changes, they at last succeeded in escaping and spread quickly over the world. But I fully admit that this case is a great difficulty in the views which I hold. (Darwin, 2015, p. 96)”

Reminds me somewhat of the evolution of the *Bau und Leben der Rhinogradentia* on an isolated island group (“The Hi-Iay Islands”) as envisioned by German zoologist Gerolf Steiner[51]. In case the reader now gets some thought connections/associations to

…Zunächst fällt uns auf, dass die Angiospermen so ‚plötzlich‘ auftauchen, ohne irgendwelche Vorläufer. Warum? Wir wissen es nicht. Dass die Bennettitinen nicht die unmittelbaren Vorläufer waren, haben wir schon erfahren.“

[49] Original German text (Lönnig 1971, p.57): So beschreibt K. Mägdefrau (1942, pp. 285/286; 1953, pp. 300/301) das „Angiospermenproblem“. Ab 1956 folgt auf die Frage nach dem Warum der Hinweis auf die Hypothesen Axelrods und später auch Tompsons, die beide die Meinung vertreten, die Angiospermen hätten sich in Abtragungsgebieten entwickelt, in denen sich keine Fossilien erhalten konnten (1956, p. 293; 1968, p. 356). Wenn wir einmal von solchen prinzipiell unbeweisbaren und damit ziemlich wertlosen Hypothesen absehen, kann das „Angiospermenproblem“, von Darwins Stoßseufzer vom „abominable mystery“ (1879) an gerechnet, nun bald sein hundertjähriges Jubiläum feiern, falls bis dahin die Hypothese einer kontinuierlichen Entwicklung noch vertreten werden sollte.

[50] As I have repeatedly pointed out (as for example 2019, p. 3 in http://www.weloennig.de/HumanEvolution.pdf): Darwin from 1859 onwards up to the protagonists of the Modern Synthesis (neo-Darwinism) of the present day have unanimously proclaimed for the origin of all life forms and taught worldwide – by omnipotent natural selection of mutations “with slight or even invisible effects on the phenotype” (Mayr) or in Darwin’s formulations, of: “...innumerable slight variations”, “extremely slight variations” and “infinitesimally small inherited variations”. He also spoke of “infinitesimally small changes”, “infinitesimally slight variations” and “slow degrees” and hence imagined “steps not greater than those separating fine varieties”,”insensibly fine steps” and “insensibly fine gradations”, “for natural selection can act only by taking advantage of slight successive variations; **she can never take a leap**, but must advance by the shortest and slowest steps” or “the transition [between species] could, according to my theory, be effected only by numberless small gradations [emphasis added].” Also, he repeatedly cited his belief that “natura non facit saltum” (“nature makes no leaps”) in his *Origin* and elsewhere.

[51] Alias „Harald Stümpke” https://en.wikipedia.org/wiki/Rhinogradentia (to give an ‘impressive’ example: "*Tyrannonasus imperator* is particularly remarkable for two reasons: The animal is, like all polyrrhine species, not particularly fast to nose, but at least a more rapid strider than the nasobemoids. Since all polyrrhine species, due to their intranasal pneumatic apparatus, make a whistling hissing sound during walking, which can be heard from far away, *Tyrannonasus imperator* cannot sneak up on its victims, but must first silently lie in wait for them - since they are already fleeing from a distance - and then stride after them. In this escape and pursuit process, which at first makes a comical impression on the observer because of the noisy effort and yet so modest speed, *Tyrannonasus* often has to pursue the intended victim for hours to catch up with it, since *Nasobema* also uses its lasso tail for escape by raising it up, curling it around branches, and thus letting it swing away over ditches or small bodies of water. Even when the predator has moved up close to the pursued animal, so that it can no longer escape by ordinary flight to nose, *Nasobema* often still uses this last means successfully by swinging its tail close to the ground in circles or in wide pendulum swings, **until the predator finally becomes dizzy and vomits during its constant attempts to snatch the prey**. At this moment of the predator's disorientation, the *nasobema* then often escapes." – As Translated with www.DeepL.com/Translator (free version).

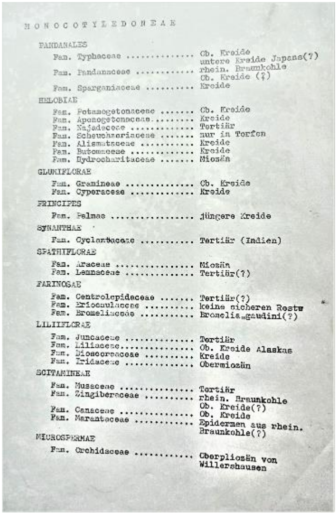
Reminds me of a discussion I had with a student at the University of Mainz (Wintersemester 1968/69). He was totally convinced of the modern synthesis of evolution and - when I mentioned some objections - wildly gestured raising his voice so strongly that some fellow student who came along on that street leading to the University’s library knocked on his shoulders and told him that he was wrong (without knowing what the fuss was all about). I then advised him to go directly further along the road to the library and **read the *Rhinogradentia* book – which, in fact, he did**. **Afterwards he told me that he had believed/accepted/endorsed everything until he had come to that very passage just quoted about *Tyrannonasus* and *Nasobema*** – at that moment a light bulb went on and he was realizing that all this was just a fantastic joke. He continued to tell me that from now on he won’t believe anything at all anymore. Well, I hope it helped him to become more critical in his further biological research and analysis.

the Galapagos Islands I would like to refer him/her to the seven posts of 2020 at https://evolutionnews.org/tag/galapagos-finches-series/

My MSc paper then goes on to present the facts shown in the TEXTBOOK OF PALEOBOTANY by Walther Gothan[52] and Hermann Weyland[53] of 1964 (Akademie-Verlag Berlin, 594 pp. with 339 Fig.)[54], being the best known and most up-to-date textbook on the topic in the German-speaking world of this time:

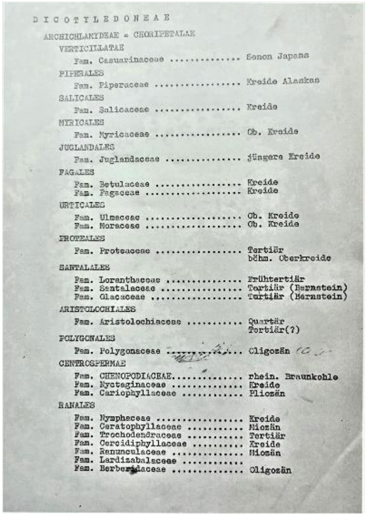
> "According to this textbook (1964), we count for the occurrence of the angiosperms only in the Upper Cretaceous 30 of the 41 orders listed by Gothan/Weyland, i.e. **more than 2/3 or 72 %**. Now the number of orders fluctuates somewhat, depending on the points of view according to which the different systematists operate. However, the following table quickly shows that this, as will be explained in more detail, is of little importance for the percentage ratio."[55]

Subsequently the following pages were composed (here strongly miniaturized; the PDF can, of course, be magnified at your computer screen or viewed directly in the original paper at http://www.weloennig.de/Staatsexamensarbeit.pdf, pp. 58 ff.



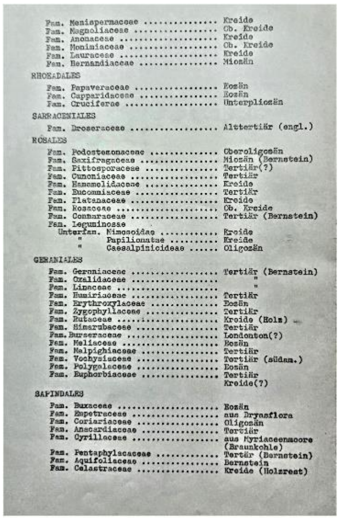
M O N O C O T Y L E D O N E A E

PANDANALES
Fam. Typhaceae .... Ob. Kreide / untere Kreide Japans(?)
Fam. Pandanaceae .... rhein. Braunkohle / Ob. Kreide (?)
Fam. Sparganiaceae .... Kreide
HELOBIAE
Fam. Potamogetonaceae .... Ob. Kreide
Fam. Aponogetonaceae .... Kreide
Fam. Najadaceae .... Tertiär
Fam. Scheuchzeriaceae .... nur in Torfen
Fam. Alismataceae .... Kreide
Fam. Butomaceae .... Kreide
Fam. Hydrocharitaceae .... Miozän
GLUMIFLORAE
Fam. Gramineae .... Ob. Kreide
Fam. Cyperaceae .... Kreide
PRINCIPES
Fam. Palmae .... jüngere Kreide
SYNANTHAE
Fam. Cyclanthaceae .... Tertiär (Indien)
SPATHIFLORAE
Fam. Araceae .... Miozän
Fam. Lemnaceae .... Tertiär(?)
FARINOSAE
Fam. Centrolepidaceae .... Tertiär(?)
Fam. Eriocaulaceae .... keine sicheren Reste
Fam. Bromeliaceae .... Bromelia„gaudini(?)
LILIIFLORAE
Fam. Juncaceae .... Tertiär
Fam. Liliaceae .... Ob. Kreide Alaskas
Fam. Dioscoreaceae .... Kreide
Fam. Iridaceae .... Obermiozän
SCITAMINEAE
Fam. Musaceae .... Tertiär
Fam. Zingiberaceae .... rhein. Braunkohle / Ob. Kreide(?)
Fam. Canaceae .... Ob. Kreide
Fam. Marantaceae .... Epidermen aus rhein. Braunkohle(?)
MICROSPERMAE
Fam. Orchidaceae .... Oberpliozän von Willershausen

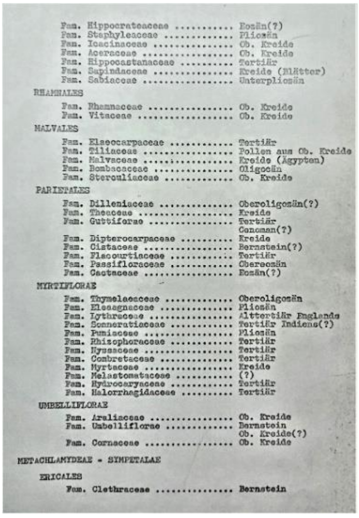


D I C O T Y L E D O N E A E

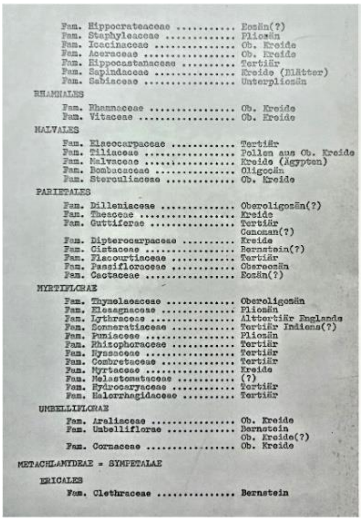
ARCHICHLAMYDEAE = CHORIPETALAE
VERTICILLATAE
Fam. Casuarinaceae .... Senon Japans
PIPERALES
Fam. Piperaceae .... Kreide Alaskas
SALICALES
Fam. Salicaceae .... Kreide
MYRICALES
Fam. Myricaceae .... Ob. Kreide
JUGLANDALES
Fam. Juglandaceae .... jüngere Kreide
FAGALES
Fam. Betulaceae .... Kreide
Fam. Fagaceae .... Kreide
URTICALES
Fam. Ulmaceae .... Ob. Kreide
Fam. Moraceae .... Ob. Kreide
PROTEALES
Fam. Proteaceae .... Tertiär / böhm. Oberkreide
SANTALALES
Fam. Loranthaceae .... Frühtertiär
Fam. Santalaceae .... Tertiär (Bernstein)
Fam. Olacaceae .... Tertiär (Bernstein)
ARISTOLOCHIALES
Fam. Aristolochiaceae .... Quartär / Tertiär(?)
POLYGONALES
Fam. Polygonaceae .... Oligozän
CENTROSPERMAE
Fam. CHENOPODIACEAE.............. rhein. Braunkohle
Fam. Nyctaginaceae .... Kreide
Fam. Cariophyllaceae .... Pliozän
RANALES
Fam. Nymphaceae .... Kreide
Fam. Ceratophyllaceae .... Miozän
Fam. Trochodendraceae .... Tertiär
Fam. Cercidiphyllaceae .... Kreide
Fam. Ranunculaceae .... Miozän
Fam. Lardizabalaceae ....
Fam. Berberidaceae .... Oligozän



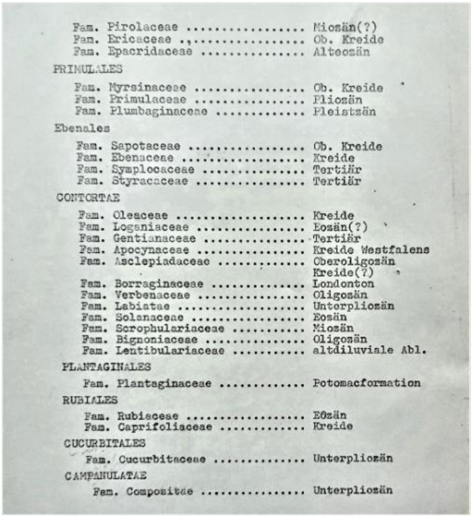
Fam. Menispermaceae .... Kreide
Fam. Magnoliaceae .... Ob. Kreide
Fam. Anonaceae .... Kreide
Fam. Monimiaceae .... Ob. Kreide
Fam. Lauraceae .... Kreide
Fam. Hernandiaceae .... Miozän
RHOEADALES
Fam. Papaveraceae .... Eozän
Fam. Capparidaceae .... Eozän
Fam. Cruciferae .... Unterpliozän
SARRACENIALES
Fam. Droseraceae .... Alttertiär (engl.)
ROSALES
Fam. Podostemonaceae .... Oberoligozän
Fam. Saxifragaceae .... Miozän (Bernstein)
Fam. Pittosporaceae .... Tertiär(?)
Fam. Cunoniaceae .... Tertiär
Fam. Hamamelidaceae .... Kreide
Fam. Eucommiaceae .... Tertiär
Fam. Platanaceae .... Kreide
Fam. Rosaceae .... Ob. Kreide
Fam. Connaraceae .... Tertiär (Bernstein)
Fam. Leguminosae
Unterfam. Mimosoidae .... Kreide
" Papilionatae .... Kreide
" Caesalpinioideae .... Oligozän
GERANIALES
Fam. Geraniaceae .... Tertiär (Bernstein)
Fam. Oxalidaceae .... "
Fam. Linaceae .... "
Fam. Humiriaceae .... Tertiär
Fam. Erythroxylaceae .... Eozän
Fam. Zygophyllaceae .... Tertiär
Fam. Rutaceae .... Kreide (Holz)
Fam. Simarubaceae .... Tertiär
Fam. Burseraceae .... Londonton(?)
Fam. Meliaceae .... Eozän
Fam. Malpighiaceae .... Tertiär
Fam. Vochysiaceae .... Tertiär (südam.)
Fam. Polygalaceae .... Eozän
Fam. Euphorbiaceae .... Tertiär / Kreide(?)
SAPINDALES
Fam. Buxaceae .... Eozän
Fam. Empetraceae .... aus Dryasflora
Fam. Coriariaceae .... Oligozän
Fam. Anacardiaceae .... Tertiär
Fam. Cyrillaceae .... aus Myriaceenmoore (Braunkohle)
Fam. Pentaphylacaceae .... Tertär (Bernstein)
Fam. Aquifoliaceae .... Bernstein
Fam. Celastraceae .... Kreide (Holzrest)



Fam. Hippocrateaceae .... Eozän(?)
Fam. Staphyleaceae .... Pliozän
Fam. Icacinaceae .... Ob. Kreide
Fam. Aceraceae .... Ob. Kreide
Fam. Hippocastanaceae .... Tertiär
Fam. Sapindaceae .... Kreide (Blätter)
Fam. Sabiaceae .... Unterpliozän
RHAMNALES
Fam. Rhamnaceae .... Ob. Kreide
Fam. Vitaceae .... Ob. Kreide
MALVALES
Fam. Elaeocarpaceae .... Tertiär
Fam. Tiliaceae .... Pollen aus Ob. Kreide
Fam. Malvaceae .... Kreide (Ägypten)
Fam. Bombacaceae .... Oligozän
Fam. Sterculiaceae .... Ob. Kreide
PARIETALES
Fam. Dilleniaceae .... Oberoligozän(?)
Fam. Theaceae .... Kreide
Fam. Guttiferae .... Tertiär / Cenoman(?)
Fam. Dipterocarpaceae .... Kreide
Fam. Cistaceae .... Bernstein(?)
Fam. Flacourtiaceae .... Tertiär
Fam. Passifloraceae .... Obereozän
Fam. Cactaceae .... Eozän(?)
MYRTIFLORAE
Fam. Thymelaeaceae .... Oberoligozän
Fam. Elaeagnaceae .... Pliozän
Fam. Lythraceae .... Alttertiär Englands
Fam. Sonneratiaceae .... Tertiär Indiens(?)
Fam. Puniaceae .... Pliozän
Fam. Rhizophoraceae .... Tertiär
Fam. Nyssaceae .... Tertiär
Fam. Combretaceae .... Tertiär
Fam. Myrtaceae .... Kreide
Fam. Melastomataceae .... (?)
Fam. Hydrocaryaceae .... Tertiär
Fam. Halorrhagidaceae .... Tertiär
UMBELLIFLORAE
Fam. Araliaceae .... Ob. Kreide
Fam. Umbelliflorae .... Bernstein / Ob. Kreide(?)
Fam. Cornaceae .... Ob. Kreide
METACHLAMYDEAE - SYMPETALAE
ERICALES
Fam. Clethraceae .... Bernstein



Fam. Hippocrateaceae .... Eozän(?)
Fam. Staphyleaceae .... Pliozän
Fam. Icacinaceae .... Ob. Kreide
Fam. Aceraceae .... Ob. Kreide
Fam. Hippocastanaceae .... Tertiär
Fam. Sapindaceae .... Kreide (Blätter)
Fam. Sabiaceae .... Unterpliozän
RHAMNALES
Fam. Rhamnaceae .... Ob. Kreide
Fam. Vitaceae .... Ob. Kreide
MALVALES
Fam. Elaeocarpaceae .... Tertiär
Fam. Tiliaceae .... Pollen aus Ob. Kreide
Fam. Malvaceae .... Kreide (Ägypten)
Fam. Bombacaceae .... Oligozän
Fam. Sterculiaceae .... Ob. Kreide
PARIETALES
Fam. Dilleniaceae .... Oberoligozän(?)
Fam. Theaceae .... Kreide
Fam. Guttiferae .... Tertiär / Cenoman(?)
Fam. Dipterocarpaceae .... Kreide
Fam. Cistaceae .... Bernstein(?)
Fam. Flacourtiaceae .... Tertiär
Fam. Passifloraceae .... Obereozän
Fam. Cactaceae .... Eozän(?)
MYRTIFLORAE
Fam. Thymelaeaceae .... Oberoligozän
Fam. Elaeagnaceae .... Pliozän
Fam. Lythraceae .... Alttertiär Englands
Fam. Sonneratiaceae .... Tertiär Indiens(?)
Fam. Puniaceae .... Pliozän
Fam. Rhizophoraceae .... Tertiär
Fam. Nyssaceae .... Tertiär
Fam. Combretaceae .... Tertiär
Fam. Myrtaceae .... Kreide
Fam. Melastomataceae .... (?)
Fam. Hydrocaryaceae .... Tertiär
Fam. Halorrhagidaceae .... Tertiär
UMBELLIFLORAE
Fam. Araliaceae .... Ob. Kreide
Fam. Umbelliflorae .... Bernstein / Ob. Kreide(?)
Fam. Cornaceae .... Ob. Kreide
METACHLAMYDEAE - SYMPETALAE
ERICALES
Fam. Clethraceae .... Bernstein



Fam. Pirolaceae .... Miozän(?)
Fam. Ericaceae .... Ob. Kreide
Fam. Epacridaceae .... Alteozän
PRIMULALES
Fam. Myrsinaceae .... Ob. Kreide
Fam. Primulaceae .... Pliozän
Fam. Plumbaginaceae .... Pleistzän
Ebenales
Fam. Sapotaceae .... Ob. Kreide
Fam. Ebenaceae .... Kreide
Fam. Symplocaceae .... Tertiär
Fam. Styracaceae .... Tertiär
CONTORTAE
Fam. Oleaceae .... Kreide
Fam. Loganiaceae .... Eozän(?)
Fam. Gentianaceae .... Tertiär
Fam. Apocynaceae .... Kreide Westfalens
Fam. Asclepiadaceae .... Oberoligozän / Kreide(?)
Fam. Borraginaceae .... Londonton
Fam. Verbenaceae .... Oligozän
Fam. Labiatae .... Unterpliozän
Fam. Solanaceae .... Eozän
Fam. Scrophulariaceae .... Miozän
Fam. Bignoniaceae .... Oligozän
Fam. Lentibulariaceae .... altdiluviale Abl.
PLANTAGINALES
Fam. Plantaginaceae .... Potomacformation
RUBIALES
Fam. Rubiaceae .... Eozän
Fam. Caprifoliaceae .... Kreide
CUCURBITALES
Fam. Cucurbitaceae .... Unterpliozän
CAMPANULATAE
Fam. Compositae .... Unterpliozän

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https://www.amazon.de/Bau-Leben-Rhinogradentia-Harald-St%C3%BCmpke/dp/3827411963?asin=3827411963&revisionId=&format=4&depth=1

[52] https://de.wikipedia.org/wiki/Walther_Gothan: Professor at the University of Berlin, author of **more than 300 scientific papers on paleobotany**.

[53] Hermann Weyland was Professor of Geologie and Paläontologie at the *Universität zu Köln*. https://de.wikipedia.org/wiki/Hermann_Weyland

[54] Incidentally, when preparing my *MSc* text, I obviously had missed *The Fossil Record* edited by Harland et al. (1967): Angiospermae: **20** pp., however in G/W: Angiospermae pp. **388-487**. Otherwise, I would have cited it (see Eckardt p. 149 in http://www.weloennig.de/Staatsexamensarbeit.pdf)

[55] Original German text: „So zählen wir nach diesem Lehrbuch (1964) allein für das Vorkommen der Angiospermen in der Ob. Kreide 30 der 41 nach Gothan/Weyland aufgeführten Ordnungen, d.h. mehr als 2/3 oder 72 %. Nun schwankt die Zahl der Ordnungen etwas, je nach den Gesichtspunkten, nach welchen kaum ins Gewicht fällt."

The text continued:

> "As mentioned above, the number of orders varies according to the points of view according to which the different systematists operate. The same applies to the families listed here. As far as the orders are concerned, I counted (in) Strasburger (1962) 46 orders; Eckardt (1964, p. 500) gives the figure 62, Soo (1961) 50 orders, Pulle (1952) 69 orders, etc. However, these differences in the number of orders are of little importance, since most systematists include the families listed here in the systematic category of orders, but some of these families have also been found in Cretaceous formations."[56]

Now let's turn to the updated paleontological record of the angiosperm families and orders as presented for 2021. First: This will be done in detail for the monocots and for a sample of the dicots, following the Tables composed according to Gothan/Weyland (G/W) (Lönnig 1971, pp. 58 – 62) comparing the orders and families[57] presented there to the fossil record of 2021 given in the data bases of:

(1) https://palaeobotany.org/
(2) https://paleobiodb.org/classic/beginTaxonInfo
(3) http://fossilworks.org/?a=collectionSearchForm&type=view
(4) As well as additional information from recent paleobotanic volumes
and on the internet (especially including photographs available in the Wikipedia).

Instructive/informative/revealing quotes **from still fully valid comments** are additionally given for example by Collinson, M. C. Boulter and P. L. Holmes (C/B/H) from *The Fossil Record 2* of 1993).

A) Monocotyledoneae

Encyclopedia.com (Oxford University Press 2019):

"**Monocotyledoneae** One of the two classes of flowering plants (see Anthophyta), distinguished by having one seed leaf (cotyledon) within the seed. The monocotyledons generally have parallel leaf veins, scattered vascular bundles within the stems, and flower parts in threes or multiples of three. Monocotyledon species include some crop plants (e.g. cereals, onions, fodder grasses), ornamentals (e.g. tulips, orchids, lilies), and a very limited number of trees (e.g. the palms)."[58]

Britannica 2021:

"**Monocotyledon**, byname monocot, one of the two great groups of flowering plants, or angiosperms, the other being the eudicotyledons (eudicots). There are approximately 60,000 species of monocots, including the most economically important of all plant families, Poaceae (true grasses), and the largest of all plant families, Orchidaceae (orchids). Other prominent monocot families include Liliaceae (lilies), Arecaceae (palms), and Iridaceae (irises). Most of them are distinguished by the presence of only one seed leaf, or cotyledon, in the embryo contained in the seed. Eudicotyledons, in contrast, ordinarily have two cotyledons."

And after some ecolutionary presuppositions ("it is widely ***believed***", "***Given*** that the various physical features of monocots ***are regarded as derived*** characteristics within the angiosperms" … "Molecular clock studies (which employ differences in DNA to estimate when a group split from its ancestors) ***suggest*** that monocots may have originated as early as 140 million years ago."), the text continues: "Evolutionary diversification among the monocotyledons appears to have been constrained by a number of fundamental features of the group, most notably the absence of a typical vascular cambium and the parallel-veined rather than net-veined leaves. Within these constraints, the monocots show a wide range of diversity of structure and habitat. They are cosmopolitan in their distribution on land. They also grow in lakes, ponds, and rivers, sometimes free-floating but more often rooted to the bottom. Some of them grow in the intertidal zone along the seashore, and a few are submerged marine plants rooted to the bottom in fairly shallow water along the shore.

[56] Original German text: "Wie oben schon erwähnt, schwankt die Anzahl der Ordnungen je nach den Gesichtspunkten, nach denen die verschiedenen Systematiker operieren. Dasselbe trifft auf die hier aufgeführten Familien zu. Was die Ordnungen anlangt, habe ich (im) Strasburger (1962) 46 Ordnungen gezählt; Eckardt (1964, p. 500) gibt die Zahl 62 an, Soo (1961) 50 Ordnungen, Pulle (1952) 69 Ordnungen usw. Diese unterschiedlichen Angaben der Ordnungen fallen jedoch kaum ins Gewicht, da die meisten Systematiker hier aufgezählte Familien zu der systematischen Kategorie von Ordnungen rechnen, diese Familien zum Teil aber ebenfalls schon in Kreideformationen gefunden worden sind."

[57] Why families as the basic unit in G/W, C/B/H and many others? "For an answer, see (again) **http://www.weloennig.de/Artbegriff.html** (for example **http://www.weloennig.de/AesIITaEnHu.html**, **http://www.weloennig.de/AesIIMe.html**, **http://www.weloennig.de/AesIV3.html** etc.). See perhaps also C/B/H, p. 11 on the validity of families: "There is no counter-argument other than practicality." However, G. Ledyard Stebbins once commented correctly: "**If genera, families, and other higher categories are relatively old**, and if many intermediate forms have become extinct [or without neo-Darwinian presuppositions: "and if there are/were no series of intermediates or any intermediates at all, which is generally true also for the angiosperm families" - comment by W.-E.L.], they **are well marked and can be delimited in a reasonably objective fashion**." (Process of Organic Evolution. Second Edition 1972. Third edition 1977, Prentice Hall, Inc. (German edition 1980). *Cf.* https://archive.org/stream/B-001-015-433/B-001-015-433_djvu.txt. So, that seems to be essentially the reason why they show practicality. As for the botanist and geneticist George Ledyard Stebbins (1906-2000), "widely regarded as one of the leading evolutionary biologists of the 20th century" (he was also involved on the establishment of botany within the "modern synthesis"). See more https://en.wikipedia.org/wiki/G._Ledyard_Stebbins

[58] https://www.encyclopedia.com/plants-and-animals/botany/botany-general/monocotyledoneae

Physical characteristics Monocot plants are marked by seeds with a single cotyledon, parallel-veined leaves, scattered vascular bundles in the stem, the absence of a typical cambium, and an adventitious root system. Flower parts typically come in multiples of three, and the pollen grains characteristically feature a single aperture (or furrow).” See more on the roots and flowers of monocots in this article.[59]

As for the origin of the monocots, there are many contradictory evolutionary hypotheses: See, for example, the short contribution of Shashank Goswami: *Origin of Monocots: 7 Hypotheses*.[60] However, there are no convincing paleontological data for any of the evolutionary hypotheses: “The monocots form a monophyletic group arising early in the history of the flowering plants, but the fossil record is meagre.”[61] Virtually all monocot families discovered so far are distinguished by abrupt appearance and stasis in the fossil record – in utmost contradiction to their generally postulated evolution by omnipotent natural selection[62] of mutations “with slight or even invisible effects on the phenotype” (Mayr) or in Darwin’s formulations, of: “...innumerable slight variations”, “extremely slight variations” and “infinitesimally small inherited variations” (see longer footnote above).

Moreover, let us apply the following questions, which may be even more relevant for dicot families, also to the monocots: “Let's just consider the variety of leaf shapes: What [selective] advantage should a plant with entire leaves have over one with toothed ones, or a plant with serrated leaves over one with doubly serrated leaves, etc.”?[63] One may add “or a plant with parallel leaf veins over those with net-veined (see below Araceae: “The leaves commonly have netveins.”) or “The leaves [of Dioscoreaceae] are spiral, opposite, **or** whorled, petiolate (typically with a pulvinus at proximal and distal ends), **simple to palmate**, **undivided to palmately lobed**, **stipulate or not**, with parallel **or** often net (reticulate) venation, the primary veins arising from the leaf base” etc.
In a vanishing minority, adaptations appear possible, in the overwhelming majority not (see also J. C. Willis as quoted in Lönnig 2012, pp. 31-33: http://www.weloennig.de/Utricularia2011Buch.pdf).

Order PANDANALES (also APG 2021[64])

G/W 1964, p. 392/1973, p. 428: Fam. Typhaceae Upper Cretaceous (same as 1971, except that the time scale has been extended – see below).



Left: *Typha latifolia*. https://es.wikipedia.org/wiki/Typhaceae (Otto Wilhelm Thomé). Middle: *Typha latifolia* (photo Petri Tapola) (both retrieved 31 July 2021). Right: Same species: “Cross section of plant’s pseudostem, formed of overlapping leaf bases” (photo Bj. Schoenmakers) https://en.wikipedia.org/wiki/Typha_latifolia (3 August 2021)

Comment by **C/B/H** (**1993, p. 836**): “Fruits and seeds like those of **modern *Typha* are widespread in the Upper Cretaceous** onwards in Europe…” [References].

PBDB (2021) and *fossilworks* (2021): “Late/Upper Maastrichtian (**70.6 - 66.0 Ma**) Overview in https://paleobiodb.org/classic/beginTaxonInfo: “Late/Upper Maastrichtian (70.6 - 66.0 Ma)”. May even be somewhat older according to INTERNATIONAL CHRONOSTRATIGRAPHIC CHART of 2021: **72.1 +/-0.2 – 66.0 Ma**.

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[59] https://www.britannica.com/plant/monoco
[60] https://www.biologydiscussion.com/angiosperms/origin-of-monocots-7-hypotheses/30543
[61] https://en.wikipedia.org/wiki/Monocotyledon
[62] http://www.weloennig.de/OmnipotentImpotentNaturalSelection.pdf
[63] Original German text: „Betrachten wir nur einmal die Vielfalt der Blattformen: Welchen Vorteil sollte eine Pflanze mit ganzrandigen Blättern gegenüber einer mit gezähnten oder eine Pflanze mit gezähnten gegenüber einer mit gesägten oder doppelt gesägten Blättern usw. haben?“ Lönnig 1971, p. 37. See further discussion in Lönnig 2012, p. 23: http://www.weloennig.de/Utricularia2011Buch.pdf Concerning natural selection, see also http://www.weloennig.de/CorCat.html
[64] http://www.mobot.org/MOBOT/research/APweb/

Family Typhaceae and Genus *Typha*: Constancy/stasis for some 72 Ma: Living Fossils. Age range extended from 70.6 to 72.1 Ma.

G/W 1964, p. 392/1973, p. 428/429: Fam. Pandanaceae[65]

"Rheinische Braunkohle; Ob. Kreide?" ("Upper Cretaceous?"). **Cretaceous** seems to be corroborated: "Daghlian (1981) indicated that good fossil evidence of members of the Pandanaceae, Arecaceae (Palmae), Potamogetonaceae, Araceae, and several other possible families occurs in the **Cretaceous**,…" (T. N. Taylor, E. L. Taylor, M. Krings (2009): Paleobotany)[66]. So, another **Living fossil**.



Left: *Pandanus heterocarpus*. (photo B. Navez 2006). Middle: *Pandanus humilis*. Plate by F. M. Blanco (between 1880/83) Right: Fruit of *Pandanus montanus*. (photo B. Navez 2006). See https://de.wikipedia.org/wiki/Schraubenbaumgew%C3%A4chse

Some additional instructive details/points: Thomas N. Taylor, Edith L. Taylor and Michael Krings (2009) "Strap-shaped leaves with parallel veins and marginal spines are placed in Pandanites (J. Kvaček and Herman, 2004). They are M-shaped in transverse section and have tetracytic stomata arranged in two bands. They appear to have been a common component of coal forming wetlands during the Cretaceous and may be used as evidence to support the hypothesis that monocots originated in wetland habitats (Les and Schneider, 1995)."

David M. Jarzen (1983, p. 163): "The fossil record of pollen comparable to the family Pandanaceae and ***sometimes directly comparable with the extant genus Pandanus*** extends back to **the latest Upper Cretaceous**. The family which once had a wide geographic distribution on all continents except Australia, has, since the mid-Tertiary, become restricted to the Old World tropics and subtropics." (P. 169/170:) Stone (1976) and Muller (1981), accept palynological reports of Maestrichtian Pandanaceae pollen. From the descriptions and illustrations of the six published reports of "pandanaceous" pollen from the **Maestrichtian/ Palaeocene interval** of the western interior of North America it appears that at least two species of the family Pandanaceae once occurred in North America 65-63 million years ago…. Other angiosperm pollen recovered from the Morgan Creek sediments could be compared with extant families including the Juglandaceae, Myrtaceae, Buxaceae, Cercidiphyllaceae, Gunneraceae, and all found together today only in Southeast Asia-Indomalaysia."[67]

Martin W. Callmander et al. (2003): "Pandanaceae are an ancient family of dioecious monocots **dating from the early to mid-Cretaceous**, ["early": 145.0 "to mid-": Cenomanian–Turonian: 100.5 to 89.8 Ma] comprising three extant genera *Sararanga*, *Freycinetia* and *Pandanus*."[68]

Interestingly, **C/B/H** mention "*Pandanocarpum oolithicum* (Carruthers) Zigno, 1873. Fruit. **Jurassic**, UK, England: Kingsthorpe near Northampton. *Podocarya bucklandi* Goeppert. In Bronn, 1848, p. 1023, 1836 (post-30 May). Fruit. **Jurassic**, UK, England: Dorset: Charmouth." If correctly determined, according to the standard geologic time table the (living fossil) family Pandanaceae would even be older/earlier than so far imagined: Jurassic (Kingsthorpe: Middle Jurassic 168.3 –

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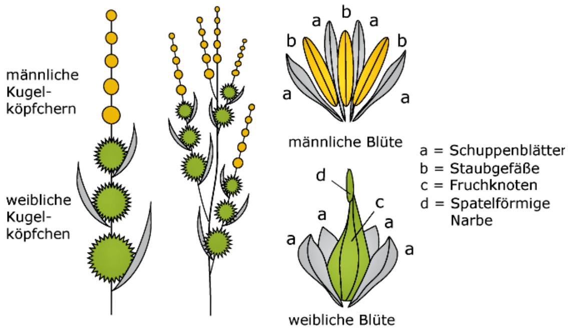
[65] In G/W's textbook the Pandanaceae are listed directly after the Typhaceae. However, in the interim the third family in G/W's list, Sparganiaceae (see below) have lost their family status ("Taxonomy is very much a matter of personal opinion" - H. K. Airy Shaw) and *Sparganium* is now classified as a genus of the Typhaceae.
"Sparganiaceae is a family of flowering plants. Such a family was previously recognized by most taxonomists.
The APG II system, of 2003 (unchanged from the APG system, 1998), also recognizes this family, and assigns it to the order Poales in the clade commelinids, in the monocots. The family consists of only one genus *Sparganium* of fewer than two dozen species, perennial plants of wet habitats. By the APG III system of 2009, *Sparganium* had been found to be fairly closely related to *Typha*, and so was placed with that genus in family Typhaceae.
The Cronquist system, of 1981, also recognized such a family and placed it in the order Typhales in the subclass Commelinidae in class Liliopsida in division Magnoliophyta.
The Wettstein system, last updated in 1935, placed the family in order Pandanales." https://en.wikipedia.org/wiki/Sparganiaceae (Retrieved 3 August 2021)
[66] Thomas N. Taylor, Edith L. Taylor and Michael Krings (2009): Paleobotany. The Biology and Evolution of Fossil Plants. Academic Press. Elsevier Kindle-Version.
[67] https://www.nparks.gov.sg/sbg/research/publications/gardens-bulletin-singapore/-/media/sbg/gardens-bulletin/4-4-36-2-01-y1983-v36p2-gbs-pg-163.pdf
[68] *Cf.* https://www.jstor.org/stable/3647349 and https://www.sciencedirect.com/science/article/abs/pii/S1464343X10000920

166.2 Ma). However, if C. A. Arnold was correct with Raritan: “Only” more than 93.9 Ma.[69] Charmouth: Jurassic “…dating from approximately 190-185 million years ago.”[70] Whatever may be correct: The status of living fossils cannot be denied.

Family Pandanaceae: Constancy/stasis for some 72 Ma: Living Fossils. Age range extended from 70.6 to 72.1 Ma.

G/W 1964, p. 393/1973, p. 429: Fam. Sparganiaceae (Pandanales)

Again: **Upper Cretaceous** (same as 1973, however, as already mentioned, the time scale has been extended: So, from its first evidence/counted from the first discoveries so far: constancy more than 66 Ma: **Living fossils**. As pointed out in the footnote on the previous page, in the interim/at present the third family in G/W’s list, the Sparganiaceae, has lost its family status and *Sparganium* is now classified as a genus of the Typhaceae.



Left: *Sparganium erectum* (Wilhelm Thomé 1885). Middle: Same species (photo Christian Fischer 2011) Right: “Schematic representation of individual flowers and inflorescence of *Sparganium* (Alfred 2007). All from https://de.wikipedia.org/wiki/Igelkolben (retrieved 3 August 2021

Sparganium**:** “The earliest fossil record of ***Sparganium*** L. (the other genus of Typhaceae) is from the **late Maastrichtian** [ca. **70 Ma**] in Alberta, Canada.” (Zou et al.: *Nature* article 2018).[71] Genus: Thus, also a **Living Fossil**.

Quotation of Zou et al (2018) in context**:** “*Typha* is a relatively ancient genus. The earliest ***Typha*** fossil records that have been found were seeds assigned to *T. ochreaceae* Knobloch and Mai and *T. protogaea* Knobloch and Mai from the **Late Cretaceous** (**Maastrichtian**) period in Eisleben, Germany. The earliest fossil record of ***Sparganium*** L. (the other genus of Typhaceae) is from the **late Maastrichtian** in Alberta, Canada. In China, the earliest record of pollen grains assigned to Typhaceae was from the **uppermost Maastrichtian** (**Senonian**) to Paleocene sediments. Both ***Typha*** and ***Sparganium*** have extensive and distinctive fossil records dating back to the Paleogene.”

Chester A. Arnold (1947/2007/2013): “More than 25 families of monocotyledons have been recognized in the Cretaceous and Cenozoic deposits of North America. The largest groups are the Gramineae, which includes the grasses, and the Palmaceae, or the palm family. … A number of aquatic monocotyledons find their way into the accumulating sediments of swamps and bogs. Chief among these is ***Typha***, the common cattail. ***Typha*** has been reported from the Magothy and Raritan (**lower Upper Cretaceous**), and from most succeeding formations up to the Recent.”[72]

Family Sparganiaceae and Genus *Sparganium*: Constancy/stasis for some 70 Ma: Living Fossils. Age range extended.

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[69] Chester A. Arnold (1947/2007/2013): An Introduction to Paleobotany. Read Books Ltd. Kindle-Version. Miller Press. https://en.wikipedia.org/wiki/Chester_A._Arnold (Magothyand Raritan: https://www.researchgate.net/figure/Lithologic-subdivisions-of-the-Raritan-and-Magothy-Formations-and-hydrogeoloqic-units_tbl1_284157250 - Arnold: “…lower Upper Cretaceous”: Raritan: Upper Cenomanian: More than 93.9 Ma https://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=NJKr%3B1 Cf. https://stratigraphy.org/ICSchart/ChronostratChart2021-07.pdf

[70] http://www.discoveringfossils.co.uk/charmouth-dorset/

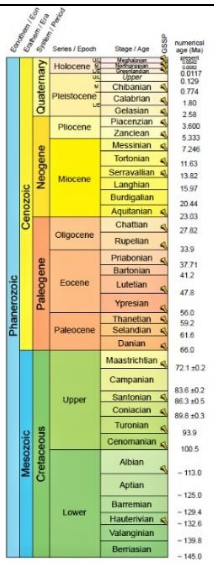
[71] Beibei Zhou, Tieyao Tu, Fanjiao Kong, Jun Wen and Xinwei Xu (2018): Revised phylogeny and historical biogeography of the cosmopolitan aquatic plant genus *Typha* (Typhaceae): https://www.nature.com/articles/s41598-018-27279-3

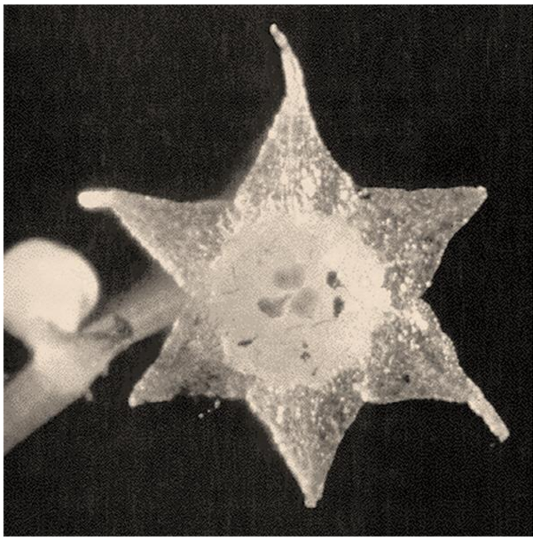
[72] Chester A. Arnold (1947/2007/2013): An Introduction to Paleobotany. Read Books Ltd. Kindle-Version. Miller Press. See also: https://en.wikipedia.org/wiki/Chester_A._Arnold (Magothyand Raritan: https://www.researchgate.net/figure/Lithologic-subdivisions-of-the-Raritan-and-Magothy-Formations-and-hydrogeoloqic-units_tbl1_284157250 - Arnold: “…**lower Upper Cretaceous**”: Raritan: **Upper Cenomanian: More than 93.9 Ma** https://mrdata.usgs.gov/geology/state/sgmc-unit.php?unit=NJKr%3B1 Cf. https://stratigraphy.org/ICSchart/ChronostratChart2021-07.pdf

Now (2021) in addition to G/W (1964/1973) and C/B/H (1993):

Fam. Triuridaceae (likewise Order Pandanales) Also **Upper Cretaceous.** T. N. Taylor, E. L. Taylor, M. Krings (2009): Paleobotany[73]: "*Mabelia* is a small, unisexual flower with six tepals (FIG. 22.95) from the Upper Cretaceous (**Turonian**) [up to **93.9 Ma**] of New Jersey (USA) (Gandolfo et al., 2002). … Trimerous, staminate flowers have been reported from the Upper Cretaceous (**Santonian**) [up to **86.3 Ma**] that may also be included in the family (Herendeen et al., 1999)."

Thus, another **Living Fossil**.

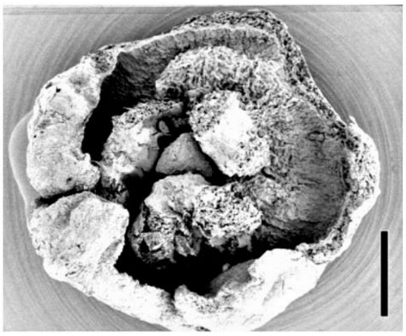


Left: Part of https://stratigraphy.org/ICSchart/ChronostratChart2021-07.pdf Middle: *Sciaphila secundiflora* https://commons.wikimedia.org/wiki/File:Lacandonia.PNG Middle: Author Kui-Chu Yueh (2015). Right: *Lacandonia schismatica*. (2009). Also same Wikipedia article.

Context of the comment of Thomas N. Taylor, Edith L. Taylor and Michael Krings (2009): "The nine genera of this family are ***achlorophyllous herbs with scalelike leaves*** that today occupy tropical and subtropical habitats. The plants form ***symbiotic relationships with fungi***. Flowers are unisexual and borne in racemose inflorescences, each flower characterized by elongate tepal-like structures that are thought to mimic fungal structures that attract insects (Leake, 1994; Rudall, 2003).

Mabelia is a small, unisexual flower with six tepals (FIG. 22.95) from the **Upper Cretaceous (Turonian)** of New Jersey (USA) (Gandolfo et al., 2002). Anthers are dithecal with in situ pollen that is prolate and monosulcate, with a reticulate tectate structure. *Nuhliantha* is another triurid flower from the same deposit (FIG. 22.96), which also has six tepals and monosulcate pollen. Trimerous, staminate flowers **have been reported from the Upper Cretaceous (Santonian)** that may also be included in the family (Herendeen et al., 1999)."

Photographs in Thomas N. Taylor, Edith L. Taylor and Michael Krings (2009): Paleobotany. Left: "Figure 22.95. Lateral view of *Mabelia archaia* showing valvate tepals (Cretaceous). Bar = 450 µm. (Courtesy K. Nixon.)" Right: "Figure 22.96. Top view of *Nuhliantha nyanzaiana* flower showing remains of perianth surrounding three stamens and central pistilloide (Cretaceous). Bar = 450 µm. Courtesy K. Nixon.)" Kindle-Version, position 21239. See **further excellent photographs/figures** of *Mabelia archaia* by Gandolfo et al. (2002) here: https://www.researchgate.net/figure/23-Mabelia-archaia-Gandolfo-Nixon-et-Crepet-18-Overall-lateral-view-of-a_fig1_51212014 and also of *Nuhliantha nyanzaiana* here: https://bsapubs.onlinelibrary.wiley.com/doi/pdf/10.3732/ajb.89.12.1940 (full paper).

[73] Thomas N. Taylor, Edith L. Taylor and Michael Krings (2009): Paleobotany. The Biology and Evolution of Fossil Plants. Academic Press. Elsevier Kindle-Version, position. 21239

There is also the following enlightening comment on this family in https://de.wikipedia.org/wiki/Triuridaceae:

> "Fossil findings of pollen and flowers of the (extinct) genera *Mabelia* and *Nuhliantha* from 1998 and 2002, respectively, ***with their age of about 90 million years*** are among the oldest known fossils of monocotyledons ever. Phylogenetic studies placed the genera in the tribus of Triurideae and ***justify the assumption that they, too, already possessed a mycotrophic way of life***."[74]

So, probably both – family Triuridaceae as well as their fungi: Age range/constancy/stasis for some 90 Ma: Living Fossils.

Although the ensuing family is treated under "Synanthae" in G/W (according to Engler), I have subsumed it here in the Pandanales. Others raised it to an order of itself: Cyclanthales (Cronquist; Takhtajan). In http://www.mobot.org/MOBOT/research/APweb/ (2017/2021) it is placed within the Pandanales.

C/W 1964, p. 400/1973, p. 438: Fam. Cyclanthaceae (Pandanales): Tertiary (Deccan: ca. 44 Ma.).

C/B/H 1993, p. 818: Same as C/W above.

Smith et al (2008) state: "The first known fossil fruits and seeds of Cyclanthaceae are described here. *Cyclanthus messelensis* sp. nov., from the **Middle Eocene** of Messel, Germany, has discoidal fruiting cycles up to 6 cm in diameter, with a central hole, radiating fiber strands, a thickened outer rim, and paratetracytic stomata. In situ seeds are up to 2 mm long, with an elongate micropylar end, a chalazal neck, and adpressed bands. ***The Messel fruits and seeds are nearly identical to those of Cyclanthus, differing in minor details of cuticular structure and seeds***."[75] – Middle Eocene of Messel: "…plateau age of **47.8 ± 0.2 Ma**"[76]

Left: *Cyclanthus biparticus* (E. F. Poeppig 1838): https://commons.wikimedia.org/wiki/File:Cyclanthus_bipartitus_NG.png
Middle: Fruit of *Cyclanthus bipartitus* (photo Dick Culbert 2008): https://commons.wikimedia.org/wiki/File:Cyclanthus_bipartitus,_fruit_pods._(9729039846).jpg
Right: Leaf of *Carludovica rotundifolia*: https://commons.wikimedia.org/wiki/File:Carludovica_rotundifolia_2.jpg (Author/photo: Franz Xaver 1998). (Retrieved 7 August 2021) Uses: "*Carludovica* leaves are made into Panama hats" http://www1.biologie.uni-hamburg.de/b-online/delta/angio/www/cyclanth.htm (8 August 2021)

Family Cyclanthaceae: Age range/constancy/stasis up to 47 Ma: Living Fossils. Age range extended.

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[74] Original German Text: "Fossile Funde von Pollen und Blüten der (ausgestorbenen) Gattungen Mabelia bzw. Nuhliantha von 1998 und 2002 zählen mit ihrem Alter von rund 90 Millionen Jahren zu den ältesten bekannten Fossilien der Einkeimblättrigen überhaupt. Phylogenetische Untersuchungen platzierten die Gattungen in der Tribus der Triurideae und begründen die Annahme, dass auch sie bereits eine mykotrophe Lebensweise besaßen.[2]" https://de.wikipedia.org/wiki/Triuridaceae (retrieved 4 August 2021)

[75] https://bsapubs.onlinelibrary.wiley.com/doi/full/10.3732/ajb.2007390 (retrieved 6 August 2021). "The fossil fruits from Messel, Germany and seeds from Messel and the UK are virtually identical to Cyclanthus in general fruit shape, fruit cuticular features, and seed shape and sculpturing. ***Minor differences, such as size and cuticular features, as well as the taphonomic alteration of seeds (or possibly incomplete development of seed coat), prevent us from placing these fossils within the modern species Cyclanthus bipartitus***." (The authors have presented 27 excellent Figures of the fossils found.)
See also: Collinson et al. (2012): "A survey of the extensive fruit and seed collections from the Middle Eocene (Paleogene, Tertiary) oil shale of the Messel Formation, at Messel Pit Fossil Site, a UNESCO World Heritage Site at Messel near Darmstadt, Germany, ***reveals at least 140 genera, representing more than 36 families***. The flora includes occasional conifer remains (Doliostrobus scales) and numerous angiosperm remains. The following angiosperm families are represented (of which ten denoted "*" are new records for Messel): Alangiaceae (*), Altingiaceae (*), Anacardiaceae (4 genera), Apocynaceae, Arecaceae, Bignoniaceae, Burseraceae (*) (2 genera), Cannabaceae (*), Cyclanthaceae, Cyperaceae, Elaeocarpaceae (*), Euphorbiaceae, Hamamelidaceae (2 genera), Icacinaceae (6 genera), Juglandaceae (3 genera), Lauraceae (c. 4 morphotypes), Leguminosae (c. 5 morphotypes), Lythraceae, Magnoliaceae, Mastixiaceae (5 morphotypes), Menispermaceae (17 morphotypes), Myristicaceae (*), ?Nymphaeales, Nyssaceae, Pentaphylacaceae, Rhamnaceae (*), Rutaceae (5 morphotypes), Sabiaceae (*), Sapotaceae, Simaroubaceae, Tapisciaceae (*), Theaceae, Toricelliaceae (*), Ulmaceae, Vitaceae (7 morphotypes), plus 65 morphotypes of unknown familial affinity. **The [modern] genera Berchemia, Mytilaria and Pleiogynium are here recorded for the first time from the Paleogene**."
For more information´, see please: https://www.schweizerbart.de/publications/detail/isbn/9783510614004/Fossil_Fruits_and_Seeds_of_the_Middle_Eocene_Messe&af=featured

[76] https://www.researchgate.net/publication/281579713_A_numerical_age_for_the_Messel_fossil_deposit_UNESCO_World_Heritage_Site_derived_from_40Ar39Ar_dating_on_a_basaltic_rock_fragment

G/W: "Reihe Helobiae"[77] [Helobiales[78]] Now: Alismatales[79]

G/W (1964, pp. 392-394/1973, pp, 429-432): Fam. Potamogetonaceae Upper Cretaceous. **C/B/H (1993, pp. 830/-31)** Leaf: Lower Cretaceous.

PBDB (2021) and *fossilworks* (2021): *Potamogeton middendorfensis*. "Where: South Carolina (34.6° N, 80.1° W: paleocoordinates 35.2° N, 51.1° W). When: Black Creek Formation, Campanian (**84.9 - 70.6 Ma**)"[80]. *Potamogeton jeholensis* ("Where: Liaoning, China (41.2° N, 119.3° E: paleocoordinates 44.3° N, 119.4° E). When: Yixian Formation (Jehol Group), **Aptian (125.5 - 112.6 Ma)**", i.e. Lower Cretaceous)[81]: **Living Fossil**.





First row left: *Potamogeton natans* and *Potamogeton pectinatus* (C. A. M. Lindman, 1905/1917/1926): https://it.wikipedia.org/wiki/Potamogetonaceae#/media/File:Potamogeton_natans-pectinatus_nf.jpg
First row middle: *Potamogeton crispus* (O. W. Thomé 1885): https://pl.wikipedia.org/wiki/Rdestnicowate
Potamogeton perfoliatus (photo Christian Fischer 2008): https://es.wikipedia.org/wiki/Potamogetonaceae#/media/Archivo:PotamogetonPerfoliatus2.jpg
Potamogeton lucens (photo Christian Fischer 2006): https://commons.wikimedia.org/wiki/File:PotamogetonLucens.jpg
https://commons.wikimedia.org/wiki/File:Potamogeton_natans3_ies.jpg
Inflorescence of *Potamogeton natans* (photo Frank Vincentz 2007): /https://de.wikipedia.org/wiki/Laichkr%C3%A4uter#/media/Datei:Potamogeton_natans3_ies.jpg

Family Potamogetonaceae: Age range/constancy/stasis up to 125 Ma: Living Fossils. Age range extended.

[77] "Helobiae is a botanical name, and is no longer valid. It was used in the Engler and Wettsteins systems of plant taxonomy for an order of flowering plants; in the latter system it had this circumscription: order Helobiae: family Alismataceae, family Butomaceae, family Hydrocharitaceae, family Scheuchzeriaceae, family Aponogetonaceae, family Potamogetonaceae, family Najadaceae. The Cronquist system placed quite a few of the plants involved in order Alismatales, as does the APG II system, although it assumes a much expanded circumscription of the order." https://en.wikipedia.org/wiki/Helobiae
[78] *Cf.* https://books.google.de/books?id=S7H_CFO0G48C&pg=PA231&lpg=PA231&dq=Helobiales#v=onepage&q=Helobiales&f=false (1909)
[79] https://en.wikipedia.org/wiki/APG_IV_system (retrieved 4 August 2021) Presently the Alismatales comprise the following families: Araceae, Tofieldiaceae, Alismataceae, Butomaceae, Hydrocharitaceae, Scheuchzeriaceae, Aponogetonaceae, Juncaginaceae, Maundiaceae, Zosteraceae, Potamogetonaceae, Posidoniaceae, Ruppiaceae, Cymodoceaceae.
[80] http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=83632&max_interval=Cretaceous&country=United%20States&state=South%20Carolina&is_real_user=1&basic=yes&type=view&match_subgenera=1 See some photographs of fossil *Potamogeton* spec.: https://www.mineralienatlas.de/lexikon/index.php/FossilData?fossil=Potamogeton
[81] http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=83632&max_interval=Cretaceous&country=China&is_real_user=1&basic=yes&type=view&match_subgenera=1

G/W (1964, p. 395/1973, p. 432): Fam. Aponogetonaceae (Order Alismatales) "Von Selling aus der Kreide Südamerikas genannt" ("Mentioned by Selling from the Cretaceous of South America"). **C/B/H (1993, p. 812)**: "Zhilin (1974a,b, 1989) and Pneva (1988) have described **leaves like those of modern *Aponogeton*** from the Oligocene of former USSR. Pollen: No record."

(2021): However, in the interim, see Grímsson et al. 2014, pp. 161/162/167: Paper on "*Aponogeton* pollen from the Cretaceous and Paleogene of North America and West Greenland: Implications for the origin and palaeobiogeography of the genus." P. 161: "*Aponogeton* pollen is highly diagnostic and when studied with light microscopy (LM) and scanning electron microscopy (SEM) ***it cannot be confused with any other pollen types***. … The oldest pollen type is from the **early Campanian** Eagle Formation of the Elk Basin in Wyoming, north-western USA.
… *Age*: **Late Cretaceous** (Lower Campanian), **82-81 Ma** (Hicks, 1983)."[82]
According to INTERNATIONAL CHRONOSTRATIGRAPHIC CHART of 2021: **Lower Campanian 83,6 +/-0.2 Ma.** (So, Selling cited in G/W has probably been right.)

Fam. Aponogetonaceae: Age range/constancy/stasis up to ca. 83 Ma: Living Fossils. Age range extended.

Left: *Aponogeton distachyos* (photo Hedwig Storch 2008): https://commons.wikimedia.org/wiki/File:Monte_(Funchal)_IMG_2045.JPG
Middle: Flower again of cape pondweed *Aponogeton distachyos* (photo JMK 2015): https://en.wikipedia.org/wiki/Aponogeton
Right: *Aponogeton madagascariensis* (Sir William Jackson Hooker 1856): https://de.wikipedia.org/wiki/Wasser%C3%A4hren

By the way: "The family consists of only one genus, *Aponogeton*, with 56 known species (Christenhusz & Byng 2016) of aquatic plants, most of which have been included in a molecular phylogeny by Chen et al. (2015). The name was published in Supplementum Plantarum 32: 214 (1782) and is derived from a geographic location neighboring (geton) the Apono tribal district of coastal Gabon."[83]

G/W 1964 p. 395/1973, pp. 429: Fam. Najadaceae (Order Alismatales)

"The genus of water-nymphs (*Najas*) is a plant genus within the Hydrocharitaceae. All species of this genus live exclusively in water. The up to 40 species are distributed almost worldwide."[84]

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[82] https://www.sciencedirect.com/science/article/pii/S0034666713001462
[83] https://en.wikipedia.org/wiki/Aponogeton
[84] https://de.wikipedia.org/wiki/Nixenkr%C3%A4uter

"*Najas*, the water-nymphs or naiads, is a genus of aquatic plants. It is cosmopolitan in distribution, first described for modern science by Linnaeus in 1753. Until 1997, it was rarely placed in the Hydrocharitaceae, and was often taken as constituting (by itself) the family Najadaceae."

"The APG II system, of 2003 (unchanged from the APG system, of 1998), places the genus in family Hydrocharitaceae, in the order Alismatales of the monocots." (https://en.wikipedia.org/wiki/Najas) Seems to be the same in APG IV[85] (2017) last updated 21 May 2021.

See also: https://www.delta-intkey.com/angio/www/najadace.htm (9 August 2021)."

Upper row left: *Najas major, Najas minor, Najas flexilis* (Gilg and Schumann ca. 1900): Middle: *Najas major* (Otto Wilhelm Thomé 1885). Right: *Najas guadalupensis* (photo Robert H. Mohlenbrock 1992). Second row left: *Najas gracillima* (photo Show_ryu 2010). Right: Part of that photograph (Show_ryu 2010). All from: https://de.wikipedia.org/wiki/Nixenkr%C3%A4uter

Fossil Record: **G/W (1964, p. 395/1973, p. 432):** "Öhninger Tertiärschichten" (**13 Ma**)[86]. **C/B/H (1993, p. 827):** NAJADACEAE: "*Cymodoceites parisiensis* (Brongniart) Bureau, 25 January – 30 January 1886. Tertiary: Eocene, France: Loire-Inférieure, Arton. Comments: Seeds like those of modern *Najas* are common from the Oligocene [up to **33.9 Ma**] onwards in Europe (Mai 1985a; Collinson 1988a)."

Eocene, France Loire-Inférieure, Arton**: Lutecian[87]: 47.8 – 41.2 Ma.** But according to ***fossilworks***: "When: **Ypresian (55.8-48.6 Ma)**"[88]. Yet, still different dates are presented by mindat.org: **Paleocene: 66.0 – 56.0 Ma**[89].

Fam. Najadaceae: Age range/constancy/stasis ca. 33 Ma, possibly up to 66 Ma. Age range extended. Whatever the final age determination will be, the family thus belongs to the Living Fossils

[85] http://www.mobot.org/MOBOT/research/APweb/
[86] https://ethz.ch/content/dam/ethz/special-interest/erdw/erdwissenschaftliche-sammlungen/documents/Ohningen_DE.pdf
[87] https://science.mnhn.fr/institution/mnhn/collection/f/item/40074.?lang=en_US
[88] http://fossilworks.org/bridge.pl?a=collectionSearch&collection_no=125597: under the names: Hydrocharitaceae - Alismatidae "*Posidonia parisiensis*" = *Amphitoites parisiensis*"
[89] https://www.mindat.org/taxon-P214532.html "Primary Reference: E. Bureau. 1866. Etudes sur une plante phanerogame (Cymodoceites parisiensis) de l'order des Naiadees, qui vivait dans les mers de l'epoque eocene. Comptes Rendus des Seances de l'Academie des Sciences 102(4):191-193." All articles/links up to this page retrieved 11 August 2021.

Fam. Scheuchzeriaceae (Order Alismatales) "*Scheuchzeria palustris* (Rannoch-rush, or pod grass), is a flowering plant in the family Scheuchzeriaceae, in which there is ***only one species and Scheuchzeria is the only genus***. In the APG II system it is placed in the order Alismatales of the monocots."[90] Same in APG IV of 2021[91]. Up to some 5 Ma: **Living Fossil**.

Left: *Scheuchzeria palustris* (Otto Wilhelm Thomé 1885): https://fr.wikipedia.org/wiki/Scheuchzeria_palustris. Middle: *Scheuzeria palustris*. (Part of photograph by Christian Fischer 2009): https://en.wikipedia.org/wiki/Scheuchzeria. Right: Stem with seed capsules (Atlas flory Polski/Bagnicowate): https://de.wikipedia.org/wiki/Blumenbinse

Fossil record: **G/W (1964, p. 395/1973, p. 434):** "*Scheuchzeria* relics occur frequently in peat (*Scheuchzeria*-peat). In contrast, the occurrence of the family in older strata cannot be clearly substantiated by fossil finds."[92] **C/B/H (1993, p. 833):** "Chesters et al. (1967) cite a **Pliocene record [5.33 – 2.58 Ma]**. We know of no well-substantiated megafossil record for this family. Pollen: No record." In contrast, Chesters et al. state: "First, Tert Plioc: *Scheuchzeria palustris* L., U. Plioc, Neudorf, Czechoslovakia (Rudorph 1935[93])." Seems to be pollen record[94]. Correspondingly they include it on p. 282 (text) and in their figure p. 283: Scheuchzeriaceae Plioc.

Now in **2021**: Same situation. However, in K. Bremer's phylogenetic reconstruction (PNAS of 2000, p. 4708)[95], *Scheuchzeria* is assumed to have been evolved before 65 Ma. Nevertheless, there is no corresponding fossil record so far.

Fam. Scheuchzeriaceae: Including Chesters et al. (1967) as being sure, **constancy/stasis some 5 Ma: Living Fossils** (although 'only' up to some 5 Ma old).

Prediction: Considering the wide, circumpolar range of the species from polar to temperate[96], Megafossils and pollen will probably be found by future research, either in a fossil pit or a museum collection. However, the probability to detect fossils of a plant family consisting of *just one genus and only one species* is, of course, much lower then in a family with many genera and many species – as, for example, in the next one:

Fam. Alismataceae (Order Alismatales) "The water-plantains (Alismataceae) are a family of flowering plants, comprising 19 genera (17 extant & 02 fossils) and between 85 and 95 species. The family has a cosmopolitan distribution, with the greatest

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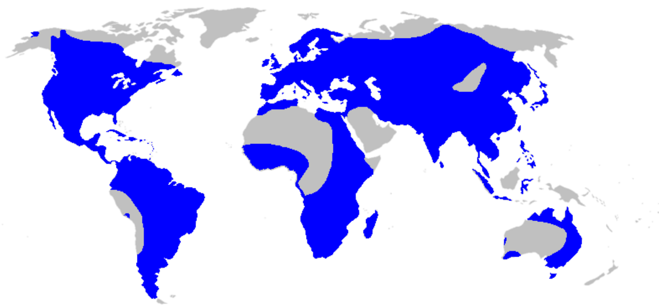
[90] https://en.wikipedia.org/wiki/Scheuchzeria
[91] http://www.mobot.org/MOBOT/research/APweb/ (Last updated 05/21/2021 21:25:52)
[92] Original German text: „Scheuchzeria-Reste treten in Torfen (Scheuczeria-Torf) nicht selten auf. Dagegen ist das Vorkommen der Familie in älteren Schichten durch Fossilfunde nicht eindeutig zu belegen."
[93] Wolfgang R. Müller-Stoll (1950) nennt Rudorph einen „verläßlichen und kritischen Beobachter": https://www.jstor.org/stable/23358054
[94] Could not check the original paper so far.
[95] https://www.pnas.org/content/pnas/97/9/4707.full.pdf
[96] *Cf.* See details in https://de.wikipedia.org/wiki/Blumenbinse

number of species in temperate regions of the Northern Hemisphere. Most of the species are herbaceous aquatic plants growing in marshes and ponds."[97]




First row left: *Alima plantago-aquatica* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Froschl%C3%B6ffelgew%C3%A4chse
Middle: Photograph of *Alima plantago-aquatica* (Rasbak 2005): https://da.wikipedia.org/wiki/Skeblad-familien
Right: *Sagittaria latifolia* (Source: Bouba 2004): https://en.wikipedia.org/wiki/Alismataceae
Below left: Plant family distribution map (Wlodzimierz 2006): Also https://en.wikipedia.org/wiki/Alismataceae
Below left: Flower and part of the inflorescence of *Echinodorus floribundus* (photo Rolf Engstrand 2012): https://de.wikipedia.org/wiki/Froschl%C3%B6ffelgew%C3%A4chse

Fossil record: **G/W (1964, p. 395/1973, p. 434):** Probably Cretaceous. C/B/H (1993, p. 811): "*Alismaphyllum victor-masoni* (Ward) E. W. Berry, 1911. Leaf?[98] **Lower Cretaceous** [Potomac: Aptian-Turonian: up to **125 Ma**], USA, Virginia, White House Bluff. **Comments:** Erwin and Stockey (1989) assigned a permineralized petiole from the **Middle Eocene** of Canada to the family. Collinson (1983) documented fruits from the uppermost Eocene/Lower Oligocene of England, UK, but the majority of the records are Oligocene or younger (Mai 1985a; Collinson, 1988a; Erwin and Stockey, 1989)."

2021: ***fossilworks***[99]: "Age range: **66.043 to 5.332 Ma**

Distribution:

- Miocene of Denmark (2 collections), Germany (1), the Russian Federation (6)
- Oligocene of the Russian Federation (3)
- Eocene of United States (6: Wyoming)
- Paleocene of United States (2: Wyoming)
- Tertiary of the Russian Federation (1)

Total: **21 collections including 22 occurrences**" **(PBDB speaks of 28 collections including 30 occurrences)"**[100]

Family Alismataceae: Constancy/stasis 66 or even 125 Ma: Living Fossils

[97] https://en.wikipedia.org/wiki/Alismataceae
[98] https://www.zobodat.at/pdf/Botanisches-Centralblatt_120_0529-0560.pdf
[99] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55790#
[100] https://training.paleobiodb.org/classic/basicTaxonInfo?taxon_no=55790

Fam. Butomaceae (Order Alismatales) '*Butomus umbellatus* is the only plant species in the monotypic genus *Butomus* and the monogeneric family Butomaceae. It thrives as a marsh plant on water banks and in wetlands.'[101]

Left: *Butomus umbellatus* (Otto Wilhelm Thomé 1885). Middle: Same species (Part of the photo by Christian Fischer 2011 shown in the Wikipedia). Right: *Butomus umbellatus* flower (photo Christian Fischer 2010). All from https://de.wikipedia.org/wiki/Schwanenblume (Retrieved 15 August 2021)

Fossil record: **G/W (1964, p. 396/1973, p. 434):** "Leaf and rhizome fragments from the Bohemian Cretaceous [**Cenomanian: up to 100.5 Ma**] are given as *Butomites* VEL., the genus *Botumus* TOURN. itself from the Tertiary of Öhningen [**13 Ma**]. The remains, however, are not perfectly determinable."[102] Well, not perfectly determinable? Velenovsky (1889) – a skilled botanist[103] – determined it as *Butomites cretaceous*[104]. As long as there are not convincing reasons to question his paleobotanical work, I accept *Butomites cretaceous* as correctly determined.

C/B/H (1993, p. 811): "*Butomites cretaceous*, 1889. Leaf. Upper Cretaceous". Yet, they assert that "we know of no well-supported leaf fossils", but go on to state that "**seeds like that of modern *Butomus*** occur in the Oligocene [up to **33.9 Ma**] onwards in Europe (Mai, 1985a)."

2021: PBDB and *Mineralienatlas – Fossilienatlas* mention *Butomites cretaceous*[105].

Fam. Butomaceae: Age range/constancy/stasis ca. 100 Ma: Living Fossils (even if *Butomites* were invalid – in that case constancy/stasis of 'only' ca. 34 Ma).

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[101] *Cf.* https://de.wikipedia.org/wiki/Schwanenblume

[102] Original German text: "Als *Butomites* VEL. werden und Blatt- und Rhizombruchstücke aus der böhmischen Kreide, die Gattung *Botumus* TOURN. selbst aus dem Öhninger Tertiär angegeben. Die Reste sind aber nicht einwandfrei bestimmbar."

[103] "He was a research investigator and professor in the Botanical Institute of the University of Prague, alternating with his colleague Ladislav Josef Čelakovský. He was also professor of botany at Charles University, where he concentrated in the study of mycology in final half of his life. Velenovský collected innumerable material, particularly in new central Bohemia, and described at least 2000 species of fungi.[1] Many of his type specimens and other collections are located in the herbarium of the Národní Museum of Prague.[2]" Also "**Flora Cretacea Bohemiae I–IV, 1926–1931**": https://de.wikipedia.org/wiki/Josef_Velenovsk%C3%BD (As for his often doubtful philosophical ideas, one should clearly distinguish them from his skilled work as a botanist.) https://en.wikipedia.org/wiki/Josef_Velenovsk%C3%BD

[104] https://www.mineralatlas.eu/lexikon/index.php/FossilData?lang=de&fossil=Butomites%20cretaceus

[105] https://www.mineralatlas.eu/lexikon/index.php/FossilData?lang=de&fossil=Butomites%20cretaceus

Fam. Hydrocharitaceae (Order Alismatales)

G/W (1964, p. 396/1973, p. 434): Genus *Hydrocharis*: Upper Oligocene: 27.82 Ma. **C/B/H (1993, p. 823):** Seeds of *Stratiotes*: Upper Paleocene: up to **59.2 Ma** – "Hydrocharitaceae is a flowering plant family including 16 known genera with a total of ca 135 known species (Christenhusz & Byng 2016), that including a number of species of aquatic plant, for instance the tape-grasses, the wellknown Canadian waterweed [*Elodea canadensis*] and frogbit *Hydrocharis morsus-ranae*.

The family includes both fresh water and marine aquatics. They are ***found throughout the world*** in a *wide variety of habitats*, but are primarily tropical."[106] It is, in fact, a family with surprisingly many diverse forms including strongly diverging habitat-adaptations being all within the same basic *bauplan*[107] – just a few examples:

Upper row, left*: Hydrocharis morsus-ranae* (Otto Wilhelm Thomé 1885). Middle: Same species (photo Christian Fischer 2006): https://commons.wikimedia.org/wiki/File:HydrocharisMorsus-ranae2.jpg. Right: *Stratiotes aloides* (Otto Wilhelm Thomé 1885) https://de.wikipedia.org/wiki/Froschbissgew%C3%A4chse. **Second row**, left: *Stratiotes aloides* (photo Velela 2006): https://de.wikipedia.org/wiki/Krebsschere. Middle: *Elodea densa* (Ernst Schütte 2004): https://es.wikipedia.org/wiki/Hydrocharitaceae. Right: *Halophila ovalis* (Hemprich & Ehrenberg 1900): https://de.wikipedia.org/wiki/Froschbissgew%C3%A4chse

Fossil record 2021: "Total: 67 collections including 75 occurrences"[108]. Among them: "**Eocene** of Germany (1), the United Kingdom (8), United States (2: Florida)." Germany: "When: MP 13 zone, Eifel Formation, MP 13 (**48.6 - 40.4**

[106] https://en.wikipedia.org/wiki/Hydrocharitaceae

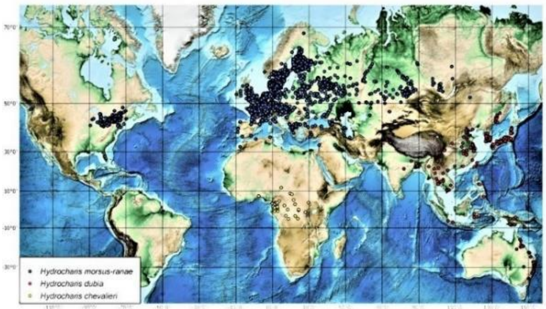
[107] See the descriptions in Wikipedia and other encyclopedias like https://www.britannica.com/plant/Hydrocharitaceae (see, however family Najadaceae above; *cf.* also the examples and discussion in http://www.weloennig.de/Utricularia2011Buch.pdf, pp. 27- 35 (2012).

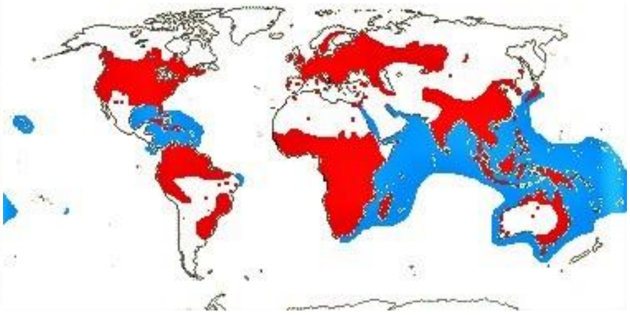
[108] Family: https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55791. Clade: Hydrocharitaceae de Jussieu 1789: "Total: 245 collections including 434 occurrences: http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=214067

Ma)[109]. Middle Eocene UK[110] and USA[111]: Bartonian: up to **41.2 Ma**. According to ***fossilworks***. However, in this case C/B/H seem to be correct: **59.2 Ma**.[112]

Just two further examples of the many diverse forms of this family:







Above, left: *Ottelia alismoides* (photo J. M. Garg 2009): https://en.wikipedia.org/wiki/Hydrocharitaceae.
Above, right: *Vallisneria americana* (Fredlyfish4 2016): https://de.wikipedia.org/wiki/Vallisneria (there also an illustration of its anatomy)
Now back to *Hydrocharis*: Below, left: World distribution of the species of *Hydrocharis* L. by Andrey Efremov, Veronika Grishina, Dmitry E. Kislov, Attila Mesterhazy (2020): **The genus *Hydrocharis* L. (Hydrocharitaceae): distribution features and conservation status**. *Botanica Pacifica* **9**: 83-94.
Full article: https://www.researchgate.net/publication/346888624_The_genus_Hydrocharis_L_Hydrocharitaceae_distribution_features_and_conservation_status
P. 87: "During the Eocene-Holocene *H. morsus-ranae* had a European-Siberian boreal distribution,…" See Table 1, p. 88: Paleontological findings of the genus *Hydrocharis.*
Below, right: **Geographical distribution of the family**: "World-wide (map: blue, marine Hydrocharitaceae; red, freshwater members - see Hultén 1961; Hultén & Fries 1986; *Fl. N. Am.* 22: 2000; FloraBase 2005; Fl. Austral. 39: 2011; *Trop. Afr. Fl. Pl. Ecol. Distr.* 7. 2012: van Steenis & van Balgooy 1966; but commonly introduced and original distributions unclear; den Hartog 1970 for marine taxa). From http://www.mobot.org/mobot/research/apweb/orders/alismatalesweb.htm#Hydrocharitaceae

Family Hydrocharitaceae: Age range/constancy/stasis 59 Ma: Living Fossils.

Problem: In comparison to G/W and many further authors, at present (2021) the following families have been additionally included in the Order Alismatales[113]:

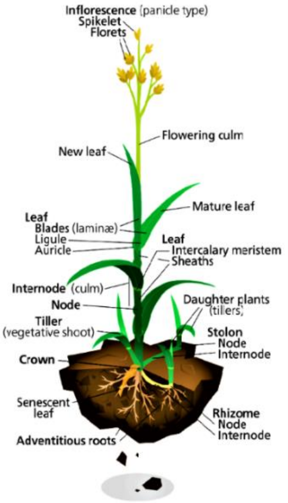
Araceae	G/W: record p. 439	C/B/H (1993, p. 812): record
Cymodoceaceae	G/W: P. 429/430 no record?[114]	C/B/H (1993, p. 818): record
Juncaginaceae	G/W: no record	C/B/H (1993, p. 823): record
Maundiaceae[115]	G/W: no record	C/B/H (1993): Not mentioned; no record
Posidoniaceae	G/W: no record ?	C/B/H (1993, p. 830): no record??
Ruppiaceae	G/W: no record	C/B/H (1993, p. 832): record
Tofieldiaceae	G/W: no record	C/B/H (1993, p. 835): no record
Zosteraceae	G/W: no record	C/B/H (1993, p. 835): no record?

According to and in agreement with G/W, the Araceae will be discussed under the topic "Reihe Spathiflorae" (in order to continue to emphasize the comparison with the status quo of the angiosperm fossil record in 1971), the "rest" also below. Incidentally, C/B/H list(s) the plant families only strictly alphabetically anyway.

[109]https://paleobiodb.org/classic/displayCollResults?taxon_no=55791&max_interval=Eocene&country=Germany&is_real_user=1&basic=yes&type=view&match_subgenera=1
[110] https://wessexcoastgeology.soton.ac.uk/Hengistbury-Head-Geology-Revised.htm
[111]https://paleobiodb.org/classic/displayCollResults?taxon_no=55791&max_interval=Eocene&country=United%20States&state=Florida&is_real_user=1&basic=yes&type=view&match_subgenera=1https://paleobiodb.org/classic/displayCollResults?taxon_no=55791&max_interval=Eocene&country=United%20States&state=Florida&is_real_user=1&basic=yes&type=view&match_subgenera=1
[112] "The oldest fossil of Hydrocharitacae **(genus *Stratiotes*) is from the Late Paleocene**." https://bmcecolevol.biomedcentral.com/articles/10.1186/1471-2148-12-30
[113] https://en.wikipedia.org/wiki/Alismatales on the basis of APG IV http://www.mobot.org/MOBOT/research/APweb/ (2016/ Page last updated: 05/21/2021 21:25:52)
[114] ***Cymodocea*** is mentioned on p. 429 in connection with "Reihe Helobiae" and "Fam. Potamogetonaceae" as is also ***Posidonia*** and ***Zostera***.
[115] *Maundia* was formerly included in the family Juncaginaceae but is now considered to form a family of its own under the name Maundiaceae.[4][5][6] https://en.wikipedia.org/wiki/Maundia

G/W: “Reihe Glumiflorae”
Now: Order Poales

Fam. Gramineae/Poaceae (Order Poales) “**Poaceae** (/poʊˈeɪsiaɪ/) or **Gramineae** (/grəˈmɪniaɪ/) is a large and nearly ubiquitous family of monocotyledonous flowering plants known as **grasses**. It includes the cereal grasses, bamboos and the grasses of natural grassland and species cultivated in lawns and pasture. The latter are commonly referred to collectively as **grass**. With [12 subfamilies,] around 780 genera and around 12,000 species,[4] the Poaceae is the fifth-largest plant family, following the Asteraceae, Orchidaceae, Fabaceae and Rubiaceae.”[116]



Left: “Diagram of a typical lawn grass plant” (Kelvinsong 2013): https://en.wikipedia.org/wiki/Poaceae. Right: “Oglala National Grassland, Nebraska, USA, near Toadstool Geologic Park” (Brian Kell 2005): https://de.wikipedia.org/wiki/S%C3%BC%C3%9Fgr%C3%A4ser

Now for a change directly first some data of 2021 on the fossil record: “Total: 224 collections including 252 occurrences”[117], among them **Cretaceous** of China (2), Senegal (2), United States (3: Georgia, South Carolina) and **Carboniferous** of Canada (1: Nova Scotia: Westphalian: **318.1 - 314.6 Ma**[118]).

Early Cretaceous Aptian (ca. **125.0 – 113.0 Ma**)

Poales – Poaceae: *Eragrostis changii* n. gen. n. sp. Cao et a. 1998
Poales – Cyperaceae: *Liaoxia chenii* n. gen. n. sp. Cao et a. 1998[119]

And **Early Cretaceous** Early Albian/Middle Albian (ca. **113.0 – 100.5 Ma**)

Poales – Poaceae indet.

Concerning *Eragrostis changii* and *Liaoxia chenii*, see Y. Wu, H.-L. You, and X.-Q. Li. (2018): ***Dinosaur-associated Poaceae epidermis and phytoliths*** from the Early Cretaceous of China. *National Science Review* **5**:721-727 [M. Carrano/M. Carrano][120]

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[116] https://en.wikipedia.org/wiki/Poaceae
[117] Family: https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55791. Clade: Hydrocharitaceae de Jussieu 1789: “Total: **245 collections including 434 occurrences**: http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=214067
[118] https://paleobiodb.org/classic/displayCollResults?taxon_no=228919&max_interval=Carboniferous&country=Canada&state=Nova%20Scotia&is_real_user=1&basic=yes&type=view&match_subgenera=1
[119] https://training.paleobiodb.org/classic/displayCollResults?a=basicCollectionSearch&collection_no=31541
[120] https://training.paleobiodb.org/classic/displayReference?reference_no=68330/ https://training.paleobiodb.org/classic/basicCollectionSearch?collection_no=45413

G/W (1964, p. 396/1973, p. 434): *Poacites*: Cretaceous.

C/B/H (1993, p. 830): "**PFR** [Plant Fossil Record] **First**: ***Yorkia gramineoides*** **L. F. Ward, 1900. Leaf. Triassic [ca. 252-201 Ma**[121]**]**, York Haven, York County, Pennsylvania, USA."

"**Comments**: Whole plants including spikelets and inflorescences have been recorded recently from the Paleocene/Eocene boundary in North America (Creper and Feldman, 1991). These represent the earliest unequivocal grasses." One may put a question mark behind the latter sentence.

Encyclopedia.com: "*Phragmites cliffwoodensis* [Berry 1903]: An early representative of the reed-grasses (*Phragmites*), recorded from the mid-Cretaceous of New Jersey, USA, that has rather uncertain affinities but if accepted would be the first of the family Gramineae."[122] Comment by **Chesters et al.** (in Harland et al. 1967, p. 275): "Uncertain *Phragmites cliffwoodensis* Berry 1903, Cret Coniac, Magothy Fm, New Jersey, USA."







First row above: 1. *Phragmites australis* Delta del Danubio, Rumanía (part – focusing on reeds – of the middle part of photo by Diego Delso 2016): https://de.wikipedia.org/wiki/Datei:Ca%C3%B1as_(Phragmites_australis),_Delta_del_Danubio,_Ruman%C3%ADa,_2016-05-28,_DD_17.jpg
2. *Phragmites australis* (part of photo by Darkone 2004): https://de.wikipedia.org/wiki/Schilfrohr
Second row, from left to right: 1. *Phragmites australis* (Otto Wilhelm Thomé 1885): https://fr.wikipedia.org/wiki/Phragmites
2. *Phragmites australis* (photo Elizabeth Banda/NASA 2019): https://en.wikipedia.org/wiki/Phragmites_australis
3. Bambus forest: possibly *Phyllostachys edulis* syn. *Phyllostachys pubescens* at Kamakura (Author? 2005): https://de.wikipedia.org/wiki/S%C3%BC%C3%9Fgr%C3%A4ser 4. *Triticum aestivum* (wheat) (photo by Eugen Staab 2005):
5. *Zea mays* (Köhler's Medizinalpflanzen (1897): https://en.wikipedia.org/wiki/Poaceae


Left: Rice (*Oryza sativa*): Rice diversity (International Rice Research Institute (IRRI), 2010): https://de.wikipedia.org/wiki/Reis.
Right: *Ammophila arenaria* Grenen, Denmark: (photo by Malene Thyssen 2004): https://es.wikipedia.org/wiki/Poaceae

[121] According to The International Chronostratigraphic Chart (2021): 251.902 - 201.3 201.3 ±0.2 Ma.
[122] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/phragmites-cliffwoodensis-0

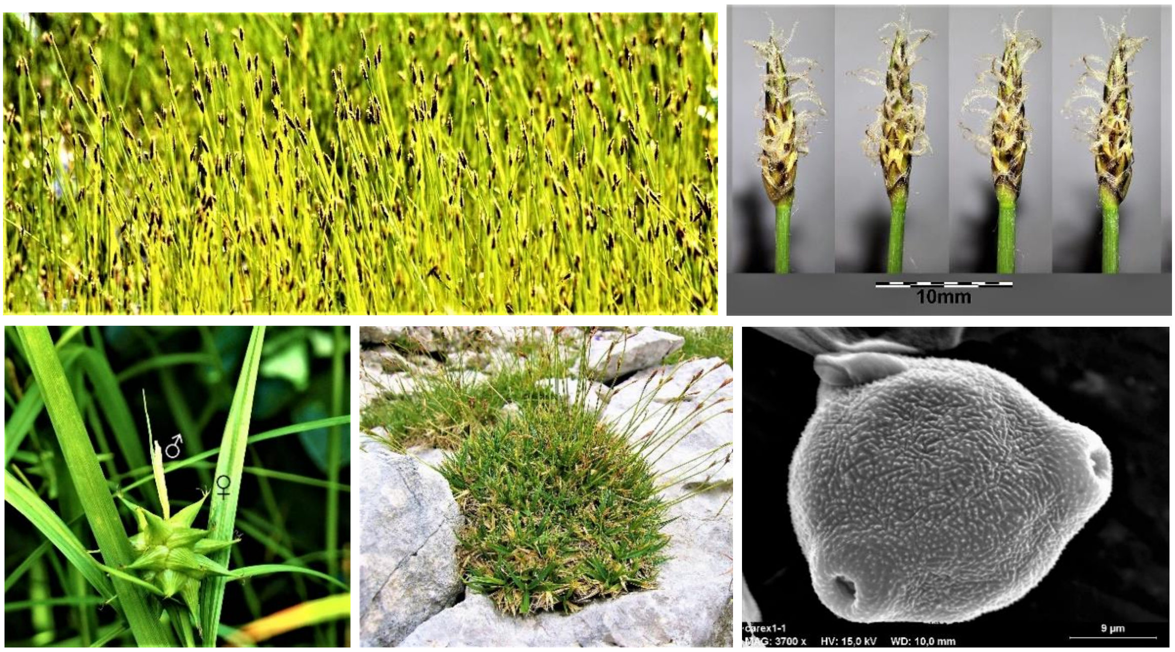
Now again 2021: Gramineae: According to ***fossilworks***: At least "**Age range : 84.9 to 0.0 Ma**"[123] (Obviously the paper of Cao et a. 1998 and Wu et al. (2018) not yet included; if *Yorkia gramineoides* were correct: more than **201.3 Ma**[124]). For "Family Poaceae Barnhart 1895" ***fossilworks*** mentions: "Age range: **112.6 to 0.0 Ma**" – so seemingly including the Chinese papers[125].

In comparison to G/W 1964, p. 396/1973, p. 434, and 1967 (Harland et al.) the ***age range has become larger*** (even without *Yorkia* and the Carb. Poaceae find).

Whatever the final age determination will be (PBDB: Carboniferous: *Poacites* (?)[126]):

Family Poaceae: Constancy/stasis 112 Ma (or including *Yorkia gramineoides* and the Carb. *Poacites*: up to 314 Ma): Living Fossils.

Fam. Cyperaeae (Order Poales) G/W (1964, p. 396/1973, p. 435): Upper Cretaceous (?). **C/G/H** in **Harland et al.**: Upper Cretaceous: Coniacian (up to **83,6 Ma**). C/B/H: *Caricopsis laxa* V. A. Samylina, March 1960. Leaf. "**L Cretaceous [Albian: ca. 113.0 – 100.5 Ma]**, former USSR: north-east Siberia: Kolyma Basin."



Upper row: Left: Cyperaceae: Eleocharis uniglumis (part of photo by Christian Fischer 2005): Right: Spikelets of Eleocharis uniglumis (part of photo by Stefan.lefnaer 2018): Both from: https://de.wikipedia.org/wiki/Einspelzige_Sumpfbinse
Second row: Left: Another species of Cyperaceae: *Carex grayi* ('Aha' 2007).Middle: *Carex firma* ('Tigerente' 2006). Right: *Carex* pollen (Rasterelektronenmikroskop; work by Marie Marauja 2007): https://de.wikipedia.org/wiki/Seggen
As for a series of photos of the family Cyperaceae , *cf.* https://de.wikipedia.org/wiki/Sauergrasgew%C3%A4chse

"The Cyperaceae are a family of graminoid (grass-like), monocotyledonous flowering plants known as sedges. The family is large, with some 5,500 known species described in about 90 genera, the largest being the "true sedges" genus ***Carex* with over 2,000 species**. These species are widely distributed, with the centers of diversity for the group occurring in tropical Asia and tropical South America. While sedges may be found ***in almost all environments*** [*so*

[123] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55515
[124] I would like to add that both, Lester Frank **Ward** (for *Yorkia gramineoides*: Triassic) as well as Edward Wilber **Berry** (for *Phragmites cliffwoodensis*: mid-Cretaceous of New Jersey, USA) were excellent paleobotanists and their identifications of fossils should not be easily dismissed. *Cf.* for example their work cited in Frank Hall Knowlton (1919): A Catalogue of the Mesozoic and Cenozoic Plants of North America. https://archive.org/details/acataloguemesoz00knowgoog as well as their own publications including books.
[125] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=53543# and http://fossilworks.org/bridge.pl?a=referenceInfo&reference_no=8508
[126] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=53546 Carboniferous of Canada (1: Nova Scotia) see also: https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=228919

enormous adaptations within the same constant bauplan], many are associated with wetlands, or with poor soils. Ecological communities dominated by sedges are known as sedgelands or sedge meadows."[127] "To distinguish them from Gramineae, the following applies: Their more or less triangular stems are medullated and have no raised nodes."[128]

PDBD (2021): Genus ***Carex***: "Total: 121 collections including 278 occurrences"[129]. "**Campanian 83.6 - 72.1** [Ma] USA (South Carolina) *C. clarkii* (210092)"[130] **Living fossil**. Cyperaceae: *Caricopsis laxa* (see above): **Lower Cretaceous**[131] – **so more than 100.5 Ma** [as just mentioned above**: Albian: ca. 113.0 – 100.5 Ma**].

Compared to G/W and C/G/H in Harland et al.: Age range extended.

Family Cyperaceae: Age range/constancy/stasis >100.5 Ma: Living Fossils. And age range extended.

Interim Results for the First 13 Families

So far, we have discussed the first 13 of the 28 monocotyledon families of G/W (including Cyclanthaceae (moved up), plus Triuridaceae (new)). Result so far: The living fossil status of all thirteen has been further substantiated[132]. Also, most of them: age range extended) and ***one has been added***. In fact, this is already an inordinate amount of "living fossils" in the few flowering plants just addressed.

Now, the additional 15 Monocot Families Treated by G/W (1964 cited in Lö 1971) as Compared to the Current State of Paleobotany (2021)

G/W: "Reihe Principes"
Now: Order Arecales

Family Arecaceae/Palmae: "The Arecaceae is a family of perennial flowering plants in the monocot order Arecales. Their growth form can be climbers, shrubs, tree-like and stemless plants, all commonly known as **palms**. Those having a tree-like form are called palm trees. Currently 181 genera with around 2,600 species are known, most of them restricted to tropical and subtropical climates. … However, palms exhibit an enormous diversity in physical characteristics and inhabit nearly every type of habitat within their range, from rainforests to deserts."[133]

G/W (1964, p. 398/1973, p. 435): Fam. Palmae (Order Arecales): Upper Cretaceous.

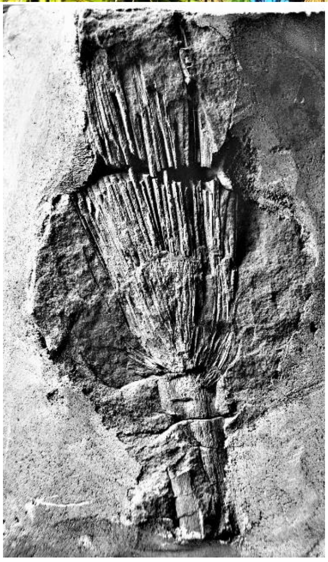
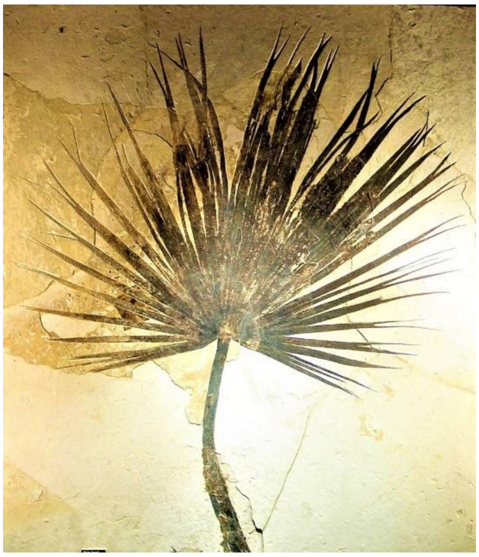
C/B/H (1993, p. 830): Arecaceae (Palmae): "PFR [Plant Fossil Record] first *Eolirion primigenium* Schenk, June, 1869. Leaf. [**Lower**] **Cretaceous**, **Urgonian,** Austria. (Barremian "overlaps the lower part of the Urgonian stage"[134]). **Barremian: 129.4 – 125.0 Ma.**

[127] https://en.wikipedia.org/wiki/Cyperaceae
[128] https://de.wikipedia.org/wiki/Sauergrasgew%C3%A4chse „Zur Unterscheidung von den Süßgräsern gilt: Ihre mehr oder weniger dreikantigen Stängel sind markhaltig und besitzen keine erhabenen Knoten."
[129] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=424190
[130] https://training.paleobiodb.org/classic/checkTaxonInfo?taxon_no=424190&is_real_user=1
[131] See also Index of Generic Names of Fossil Plants, 1820-1965: https://digital.library.unt.edu/ark:/67531/metadc1114957/m2/1/high_res_d/report.pdf
[132] Although one of them only weakly.
[133] https://en.wikipedia.org/wiki/Arecaceae
[134] https://en.wikipedia.org/wiki/Barremian, see also: https://www.infona.pl/resource/bwmeta1.element.elsevier-5826bb0d-ddf1-35cd-9c9c-bba6b61bcb6b







Upper row, left: *Archontophoenix alexandrae* (Kahuroa 2008): https://de.wikipedia.org/wiki/Archontophoenix. Middle: *Brahea brandegeei* (syn. *Erythea*) (author/photo: Megan Hansen 2011): https://en.wikipedia.org/wiki/Brahea. Right: *Nypa fruticans* (Luis Argerich 2006): https://fr.wikipedia.org/wiki/Nypa_fruticans. **Middle row**, left: *Oraniopsis appendiculata* (author/photo: Tanetahi 2007): https://en.wikipedia.org/wiki/Oraniopsis. Middle: *Thrinax parviflora* (Kyle Wicomb 2010). Left: *Thrinax excelsa* (Guettarda 2009): Both the latter from https://en.wikipedia.org/wiki/Thrinax. **Last row**, left: *Elaeis guineensis* (Köhlers Medizinalpflanzen 1897): https://fr.wikipedia.org/wiki/Arecaceae. Same source: Middle: "Palnier fossile" (photo Eugéne Trutat. (1840 – 1910) Collection: Museum de Toulouse). Right: *Palmites* (file lacks information). Green River Basin, Eocene (**53.5–48.5 Ma**)[135]

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https://www.zobodat.at/pdf/Ber-Inst-Erdwiss-Univ-Graz_9_0250-0254.pdf "…'Urgonian platform' known from the interval Late Barremian-Albian. … The allodapic limestones of Kaltenleutgeben, however, are of Hauterivian age and thus, older than the first records of the Urgonian platform known so far as Late Barremian (HAGN 1982)." See perhaps also https://opac.geologie.ac.at/wwwopacx/wwwopac.ashx?command=getcontent&server=images&value=MO0003_145_A.pdf

[135] https://en.wikipedia.org/wiki/Green_River_Formation: "…**leaves of palms, ferns and sycamores** … were covered with fine-grained sediment and preserved. …**The earliest known bats** (*Icaronycteris index* and *Onychonycteris finneyi*), **already full-developed for flight**, are found here. … **Millions of fish fossils** have been collected from the area,…"

Already three of genera of the family Arecaceae/Palmae shown above (*Erythea* [synonym: *Brahea*], *Nypa*, and *Thrinax*) belong to the living fossils[136].

Further data on the Fossil record:

PBDB (2021): Fam. Arecaceae (Palmae): "GeoDeepDive matched this taxon in 500 documents from 207 journals/publications."[137] "Maximum range based only on fossils: base of the Valanginian to the top of the Holocene or 139.80000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): **132.9 Ma**[138].

***fossilworks* (2021)**: "Age range: **140.2 to 0.0 Ma**"
"**Cretaceous** of Argentina (1), Canada (1: Alberta), Japan (1), Mexico (1), Mongolia (1), South Sudan (16), Spain (1), United States (2: New Mexico, South Dakota). Total: 244 collections including 276 occurrences." [139] "There are 297 matches - here are the first 30 rows" (see document)[140].

Family Arecaceae/Palmae – including several genera like *Erythea*, *Nypa* and *Thrinax* – Age range/constancy/stasis up to 140 Ma: Living Fossils.[141]

And there ***are even more* '*Living Fossil' genera in this family***:

Serenoa: "Eocene of the United Kingdom (1) Total: 2 collections including 3 occurrences When: London Clay Formation, Ypresian (56.0 - 47.8 Ma)."[142] *Sabal*: "Cretaceous of United States (2: New Mexico, Texas)": 100.5 - 66.0 Ma.[143] *Corypha*: "(London Clay Formation), Ypresian (56.0 - 47.8 Ma)."[144] *Chamaerops*: "When: London Clay Formation, Ypresian (56.0 - 47.8 Ma)."[145] *Phoenix*: "Paleocene of France"[146] (66 to 56 Ma). *Hyphaene*: Miocene to Pliocene[147]: (23.0 - 2.6 Ma)[148]. *Calamus*: Eocene[149]: Ypresian (56 Ma). *Livistona*: Ypresian: 56.0 - 47.8 Ma[150]. Note: There are also quite a number of extinct genera existing over several geologic formations.[151]

From left to right: (1) *Sabal* Palm Trees (William Bumgarner [en.wp: Zsinj] 2006). (2) Fossil: *Sabal major* (Hectonichus 2017): https://en.wikipedia.org/wiki/Sabal. See also this photo of a fossil: "Blatt einer Fächerpalme": http://objekte.nhm-wien.ac.at/objekt/th33/ob32 (3) *Corypha umbraculifera* (flowering) (PraweenP 2009): https://en.wikipedia.org/wiki/Corypha. (4) *Chamaerops humilis* (Tato Grasso 2006): https://de.wikipedia.org/wiki/Zwergpalme. (5) *Livistona nitida* (Cgoodwin 2010): https://en.wikipedia.org/wiki/Livistona

[136] *Archontophoenix*: Pleistocene https://paleobiodb.org/classic When: Pleistocene (2.6 - 0.0 Ma) *Erythea*: Miocene: fossilworks.org/bridge.pl *Nypa*: Thanetian: Upper Paleocene: fossilworks.org/bridge.pl *Oraniopsis*: Pleistocene *Thrinax*: Middle Eocene.
[137] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=53807&is_real_user=1
[138] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=53807&is_real_user=1
[139] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=53807
[140] http://fossilworks.org/bridge.pl
[141] See perhaps also: https://www.zobodat.at/pdf/MGSL_139_0343-0352.pdf
[142] https://paleobiodb.org/classic/basicTaxonInfo?a=basicTaxonInfo&taxon_name=Serenoa
[143] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=338231 Total: 53 collections including 60 occurrences. Total: 53 collections including 60 occurrences [including Paleocene Records]
[144] https://training.paleobiodb.org/classic/basicCollectionSearch?collection_no=178051
[145] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=424388
[146] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=424393
[147] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=424387
[148] https://paleobiodb.org/classic/basicCollectionSearch?collection_no=22390
[149] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=319893
[150] https://paleobiodb.org/classic/basicCollectionSearch?collection_no=2281
[151] It would be a special task to document them and represent them in a graphic like those in Harland et al and Benton (ed.): However, there is no corresponding figure there for them.

Recently the family Dasypogonaceae has been added to the Arecaceae/Palmae. However: “Such a family has not been commonly recognized by taxonomists:…”[152] No fossils known so far.

As for the Synanthae with the family Cyclanthaceae, see please above.[153]

G/W: “Reihe Spathiflorae”

Now: Order Alismatales (acc. to APG IV 2017/2021)

Fam. Araceae “A major family of monocotyledons (Monocotyledoneae), comprising tiny to giant herbs and many bole climbers, which produce sap with irritant crystals. The leaves commonly have netveins. Flowers are borne in a spike (spadix) subtended by an often colourful spathe; they are small, usually unisexual, the male apical (see RACEME), and usually lack a perianth. The fruit is a berry. There are 106 genera, and about 2950 species, with pantropical distribution (especially America), with temperate outliers.”[154]

“The arum family (Araceae) comprises 114 genera and about 3,750 species of flowering plants. The flowers are characteristically borne on a distinctive inflorescence known as a spadix and are usually surrounded by a single leaflike bract known as a spathe. Several species are important in the floral industry, and a number are common houseplants.”[155]

Upper row: Left: *Hapaline brownie* (Curtis's Botanical Magazine v.119 [ser.3:v.49] (1893), Enzo 2010. Middle: *Xanthosoma sagittifolium* (Eric Guinther on Maui, Hawai'I 2003). Right: Fossil of extinct *Orontium wolfei* (Kevmin 2009. “48.5 million years old, Klondike Mountain Formation, Ferry County, Washington, USA.” **Second row** (from left to right): (1) *Ulearum sagittatum* (Das Pflanzenreich 1920. Drawing: Pohl and Engler; Enzo 2010). (2) *Arisaema engleri* (H. Zell 2009) (3) *Eminium spiculatum* (Author אורן אוריה 2011). So far all from https://de.wikipedia.org/wiki/Aronstabgew%C3%A4chse – there even more excellent photographs and text. (4) *Arum maculatum* (photo: Sannse 2004). (5) *Dracunculus vulgaris* (Marek Ślusarczyk 2013). (4) and (5) from https://en.wikipedia.org/wiki/Araceae. (6) *Calla palustris* (Otto Wilhelm Thomé 1885). See also Kurt Stüber: http://www.biolib.de/ (2005).

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[152] https://simple.wikipedia.org/wiki/Dasypogonaceae
[153] Incidentally: Until here: all the links were set between 19 July 2021 and 31 August 2021 (in several cases above I have also mentioned the exact dates).
[154] Michael Allaby: https://www.encyclopedia.com/plants-and-animals/botany/botany-general/araceae (2018/2019) Oxford University Press.
[155] https://www.britannica.com/topic/list-of-plants-in-the-family-Araceae-2075376 (One may note, of course, the differences in the species and genera numbers given by different authorities.)

Fossil record of Araceae:

G/W (1964, p. 400/1973, p. 439): "Cockerell mentions an inflorescence of *Orontium* L. from the **Miocene** of Colorado…" Also: "Weyland (1957) has also described two epiderms from the rhenish lignite (rheinischen Braunkohle[156]), one of which *Anthurriophyllum spectabile* resembles the recent *Anthurium scherzerianum* to a high degree according to the composition of the thick-walled cells, the stomata, and the glandular spots. Characteristic of the Araceae are stomata located in the center of the glandular spots (Drüsenflecke)." **25 - 30 Ma**: That would belong to the **Oligocene**.

C/B/H (1993, p. 812): "PFR first: *Limnophyllum primaevum* Hosius and Marck 1880. Leaf. **Cretaceous**, Senonian [up to **89 Ma**], Germany, Westfalen.

Comments: Fruits and seeds occur in the Middle Eocene of North America … an Upper Paleocene seed form was listed by Collinson (1986a). Leaves are recorded from the Middle Eocene of Europe (Wilde, 1989) and Lower and Middle Miocene of North America (Taylor, 1990)."

Now some data up to 2021:

Cleal and Barry (2019, p. 204): "There are Cenozoic fossils from the USA that are closely comparable to extant members of the Araceae, such as leaves included in *Philodendron* and florets similar to those in *Acorus*."[157]

T. N. Taylor, E. Taylor and M. Krings (2009): "(Hesse and Zetter (2007) indicated that some *Ephedripites* grains are similar to pollen of *Spathiphyllum*, an extant pantropical member of the Araceae.

…Characterization of leaf venation and foliar morphology in extant Araceae has provided a framework to deal with fossil leaves of this type (Wilde et al., 2005). Based on these features four fossil leaf morphogenera are delimited: *Araceophyllum*, *Araciphyllites*, *Caladiosoma*, and *Nitophyllites*.

…*Araceites* is another genus used for fossil spadices thought to belong to the Araceae (Fritel, 1910). Numerous aroid seeds have been described from the upper Eocene, but the largest number are known from the Oligocene (Madison and Tiffney, 1976).

…The dispersed ***pollen record*** of the Araceae is scanty; ***it begins in the late Early Cretaceous***, and peaks in the Paleocene–Eocene. It includes three distinct pollen types (Hesse and Zetter, 2007): a zona-aperturate pollen of the *Monstera* or *Gonatopus* type, which is very similar to *Proxapertites operculatus*; an ulcerate-spiny type typical for *Limnobiophyllum*; and a polyplicate, omniaperturate pollen type, *Mayoa portugallica* (FIG. 22.88) (an ephedroid pollen morphology with non-gnetalean affinities), which was reported from late ***Lower Cretaceous*** deposits in Portugal (Friis et al., 2004). The fossil *Mayoa* grains are most similar to extant pollen of *Holochlamys*, a modern member of the family that is today restricted to New Guinea.[158]

APG IV 2017/2021: "Age. Crown-group Araceae have been dated to **(132-)122(-112) Ma** by Nauheimer et al. (2012b); **other dates include 98-89 Ma** (Wikström et al. 2001), ca **128 Ma** (Janssen & Bremer 2004) and (114-)89, 79(-55) Ma (Bell et al. 2010).

Distinctive pollen assigned to Pothoideae-Monstereae has been found in **Early Cretaceous** deposits of the late Barremian-early Aptian of some **120-110 Ma** [Intern. Cronostrat. Chart of 2021: ca. **125 Ma**] old in Portugal (Friis et al. 2004); other pollen types that may also be Araceae were found at the same place (see also Hesse & Zetter 2007). However, *Mayoa portugallica*, one fossil involved, may be an individual of *Laganella*, an euglenid alga... (Hoffmann & Zetter 2010)."[159]

Distribution from Quaternary to Cretaceous: "Cretaceous to Paleogene of Argentina (1)/Cretaceous of Argentina (1), Canada (2: Alberta) Total: 96 collections including 180 occurrences."[160]

Hence, during the last 50 years the fossil record of the Araceae has been greatly extended – from some 30 Ma to more than 100 Ma.

Family Araceae: Age range/constancy/stasis up to ca. 125 Ma. Thus, it belongs to the Living Fossils.

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[156] Up to 30 Ma according to https://www.mineralienatlas.de/lexikon/index.php/Deutschland/Nordrhein-Westfalen/Rheinisches%20Braunkohlerevier. Dirk Jansen (2017, p. 4) mentions in https://www.bund-nrw.de/fileadmin/nrw/dokumente/braunkohle/2018_03__Braunkohle_im_Rheinland_-_Garzweiler_II.pdf 25 Ma ("im Laufe der letzten 25 Millionen Jahre entstand so das heute für den Aufbau der Niederrheinischen Bucht typische Bild einer Abfolge von Braunkohlenflözen, Lockersedimenten und Tonen.")

[157] Christopher Cleal and Barry A. Thomas (2019: Introduction to Plant Fossils. Cambridge University Press. Kindle-Version

[158] T. N. Taylor, E. Taylor and M. Krings (2009): Paleobotany. The Biology and Evolution of Fossil Plants. Academic Press. Elsevier Kindle-Version

[159] http://www.mobot.org/MOBOT/research/APweb/

[160] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55277

Fam. Lemnaceae (now subfamily Lemnoidea of the Araceae Order Alismatales).

"DUCKWEED, the common botanical name for species of *Lemna* which form a green coating on fresh-water ponds and ditches. The plants are of extremely simple structure and are the smallest and least differentiated of flowering plants. They consist of a so-called "frond"—a flattened green more or less oval structure which emits branches similar to itself from lateral pockets at or near the base. From the under surface a root with a well-developed sheath grows downwards into the water. … The inflorescence is a very simple one, consisting of one or two male flowers each comprising a single stamen, and a female flower comprising a flask-shaped pistil."[161]

"Reproduction is mostly by asexual budding (vegetative reproduction), which occurs from a meristem enclosed at the base of the frond. Occasionally, three tiny "flowers" consisting of two stamens and a pistil are produced, by which sexual reproduction occurs … The flower of the duckweed genus *Wolffia* is the smallest known, measuring merely 0.3 mm long. The fruit produced through this occasional reproduction is a utricle, and a seed is produced in a bag containing air that facilitates flotation."[162]

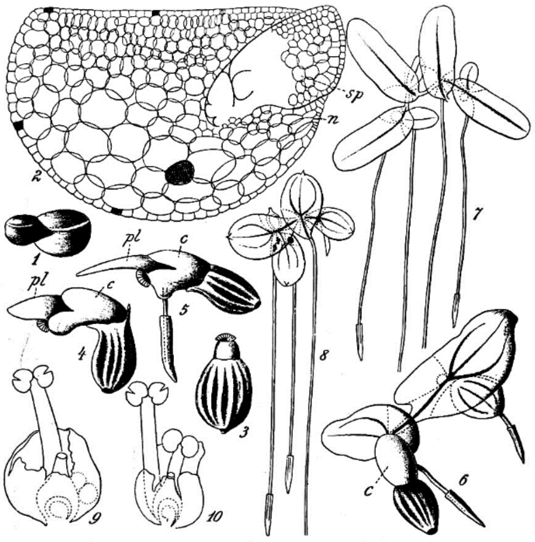


Abb. 649. *Lemnaceae.* — Fig. 1. *Wolffia arrhiza*, ganze Pfl. — Fig. 2. *W. brasiliensis*, Längsschn., *n* Narbe nach dem Abfallen vom Muttergliede, *sp* Tochterglied. — Fig. 3 bis 6. Keimung von *Lemna trisulca*; *c* Kotyledo, *pl* erstes Glied. — Fig. 7. *Lemna valdiviana*, ganze Pfl. — Fig. 8. *L. angolensis*, ganze Pfl. — Fig. 9 u. 10. Blütenstände von *L. trisulca.* Fig. 1, 7 u. 8 etwa 10fach, 3–6 etwa 20fach, 2, 9, 10 stärker vergr. — Nach Hegelmaier.

Left: Lemnaceae: aus Richard Wettstein (1924): Handbuch der Systematischen Botanik. Einscannen und Bearbeitung von Frank Al-Dabbagh, Mai, 2003. See Kurt Stüber: http://www.biolib.de/ (2005). Right: Part of "Wasserlinsengesellschaft: *Spirodela polyrhiza*, *Lemna minor*, *Wolffia arrhizal/* Close-up of different duckweeds on the surface of a pond: *Spirodela polyrhiza* (large "leaves"), *Lemna minor* (medium), and *Wolffia arrhiza* (very small). (Christian Fischer 2009): https://de.wikipedia.org/wiki/Wasserlinsengew%C3%A4chse
As for the question of natural selection of several different species of the same genus in one and the same environment, see http://www.weloennig.de/Utricularia2011Buch.pdf, pp. 20-24

Fossil record of Lemnoidea: G/W (1964, p. 401/1973, p. 439):

"Fam. Lemnaceae. The genus *Lemna* L. probably occurs in fossil form in the European and North American Tertiary."[163] That's all in this textbook.

C/B/H (1993, p. 824): Seeds like those of modern *Lemna* are recorded by Dorofeev (1988), Mai (1985a), and Mai and Walther (1978) from the Oligocene [up to **33.9 Ma**] onwards in Europe and Asia. … Leaves assigned to modern *Spirodela* are reported from the Paleocene [up to **66 Ma**] and Eocene [up to **56 Ma**] of Canada (Taylor, 1990)."

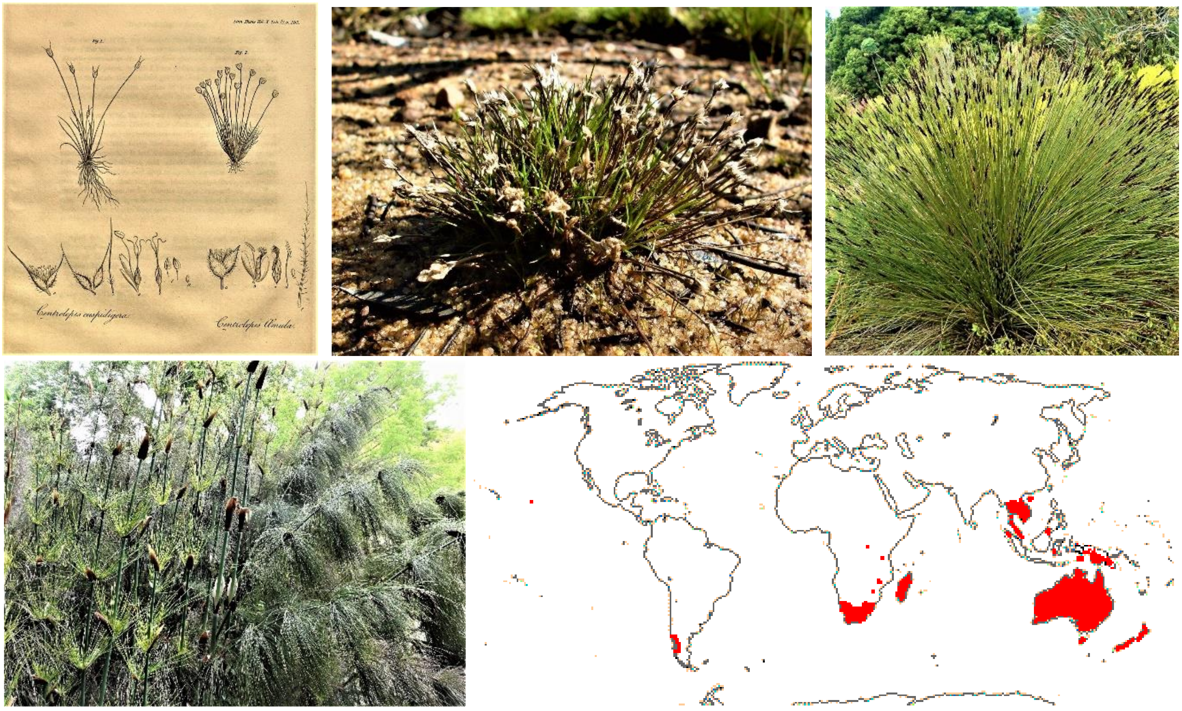
PBDB (2021): *Lemna*: "Alismatales - Araceae *Lemna tertiaria*: Rupelian" [**33.9 – 27.82 Ma**].[164] Lemnaceae: "Cretaceous of Canada (1: Alberta), United States (4: North Dakota, South Dakota)": Modern genus *Spirodela*: Maastrichtian (**72.1 – 66 MA**).[165]

[161] https://en.wikisource.org/wiki/1911_Encyclop%C3%A6dia_Britannica/Duckweed
[162] https://en.wikipedia.org/wiki/Lemnoideae (retrieved 2 September 2021)
[163] Original German text: "Fam. Lemnaceae. Die Gattung *Lemna* L. kommt fossil wahrscheinlich im europäischen und nordamerikanischen Tertiär vor."
[164] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=319856
[165] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=53867Fossilworks

Family Lemnaceae, now subfamily Lemnoidea: Age range/ constancy/ stasis up to ca. 72 Ma.: Living Fossils.

G/W: “Reihe Farinosae” (now esp. Bromeliales)[166]

Fam. Centrolepidaceae: “A family of tufted or cushion-like herbs … that have bristle-like leaves, similar to grasses, rushes, or mosses. They may be annual or perennial.”[167] “Centrolepidaceae are a family of flowering plants now included in **Restionaceae** following APG IV (2016).”[168] “*Centrolepis* is a genus of small herbaceous plants in the family Restionaceae known as thorn grass scales, with about 25 species native to Australia, New Zealand, New Guinea, and south-east Asia as far north as Hainan Dao.”



Upper row, from left to right: Left: *Centrolepis cuspidigera* and *C. aemula* (1911 https://www.biodiversitylibrary.org/item/13720#page/301/mode/1up)
Middle: *Centrolepis fascicularus* (part of the photo by John Tann 2009): https://de.wikipedia.org/wiki/Centrolepidaceae
Right: *Elegia tectorum* (Restionaceae) (part of the photo by User:BotBln 2010)
Second row: Left Now Restionaceae: *Elegia capensis* (part of the photo by Andy king50, 2011): https://en.wikipedia.org/wiki/Restionaceae.
Right: Geographical distribution of Restionaceae: http://www.mobot.org/MOBOT/research/APweb/ (2017/2021)

G/W (1964/1973): Only doubtful specimen. Similarly in C/B/H (1993).

Fossil Record of Restionaceae: Oldest: **Cretaceous** of South Sudan (1)[169] (“When: Zarga-Ghazal Formation (Darfur Group), Campanian to Campanian (**83.6 - 66.0 Ma**)).” Restionaceae: According to http://www.mobot.org/MOBOT/research/APweb/ (2017/2021): “Age. The age of this node is ca 96 or 97 Ma, depending on relationships (Janssen

[166] Farinosae [from Late Latin farinosus = farinaceous], in older systematics an order (or series) roughly comprising the present orders Bromeliales (pineapple-like) and Commelinales. The name refers to the often starchy endosperm. Original German text: Farinosae [von spätlatein. farinosus = mehlig], in der älteren Systematik eine Ordnung (bzw. Reihe), die in etwa die heutigen Ordnungen *Bromeliales* (Ananasartige) und *Commelinales* umfaßt. Die Bezeichnung bezieht sich auf das häufig stärkereiche Endosperm. https://www.spektrum.de/lexikon/biologie/farinosae/23743
[167] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/centrolepidaceae
[168] https://en.wikipedia.org/wiki/Centrolepidaceae
[169] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55812

& Bremer 2004), ca 80 Ma (Litsios et al. 2014: "root" age for Restionaceae, Centrolepis, etc., not included), or about 75.9 Ma (Magallón et al. 2015).The 27.7 Ma fossil *Restiocarpum latericum* was assigned to this node (Iles et al. 2015)."

Family Restionaceae: Age range/constancy/stasis up to ca. 83 Ma. hence belonging to the Living Fossils.

Next: Fam. Eriocaulaceae "The Eriocaulaceae are a family of monocotyledonous flowering plants in the order Poales, commonly known as the pipewort family. The family is large, with about 1207 known species described in seven genera. They are widely distributed, with the centers of diversity for the group occurring in tropical regions, particularly the Americas. Very few species extend to temperate regions, with only 16 species in the United States, mostly in the southern states from California to Florida, only two species in Canada, and only one species (*Eriocaulon aquaticum*) in Europe."[170]

G/W (1964/1973, p. 439): Fam. Eriocaulaceae: No sure record.

C/B/H (1993, p. 820): Although "Chesters *et. al.* (1967) cited a North American Paleocene record of *Erioncaulon*", the authors say "No record" because "this was not listed by Taylor (1990)". Hardly enough reason not to mention it. Chesters et al. note (1967, p. 274): "First, Tert Paleoc [>**56 Ma**]: *Eriocaulon porosum* Lesquereux, Denver Fm, Colorado, U.S.A. (Knowlton 1930)." Edited posthumously by E. W. Berry[171] – thus, it had already been cited by an accomplished paleobotanist with a series of excellent publications.

PBDB (2021): "Quaternary of Australia (5 collections): Age range: base of the Late/Upper Pleistocene to the top of the Holocene or 0.12600 to 0.00000 Ma."[172] Knowlton[173] unfortunately not considered.

From left to right: (1) *Eriocaulon heterolepis* (photo J. M. Garg 2008). (2) *Eriocaulon madayiparense* type specimen (photo Malabarica 2012). (3) *Eriocaulon scariosum* (Macleay Grass Man/Harry rose 2009). (4) *Eriocaulon nudicuspe* in Wetland, Japan (Alpsdake 2012). All from https://en.wikipedia.org/wiki/Eriocaulon. More excellent photographs here: https://de.wikipedia.org/wiki/Eriocaulaceae

Family Eriocaulaceae: Assuming that F. H. Knowlton was correct (no counterevidence so far): Constancy/stasis over 56 Ma.: Living Fossils.

[170] https://en.wikipedia.org/wiki/Eriocaulaceae
[171] https://en.wikipedia.org/wiki/Edward_W._Berry
[172] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=319891 https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=319891&is_real_user=1
[173] https://en.wikipedia.org/wiki/Frank_Hall_Knowlton ("Born in Vermont, he joined the Geological Survey and took an interest in fossil plants in the local lignite, later becoming **a specialist in paleobotany**.")

Followed in G/W by Fam. Bromeliaceae

Encyclopedia.com (Oxford University Press 2019): "Bromeliaceae: A distinctive family of monocotyledons (Monocotyledoneae) with no close relatives, most of which are herbs and epiphytes, a few being terrestrial. Most have leaves crowded together with an amplexicaul (see STIPULE) base forming a tank from which water is absorbed. The inflorescence is terminal, sometimes with showy bracts. The flowers are regular and trimerous. The fruit is a berry or capsule. There are 46 genera, with about 2110 species, entirely confined to the New World, except for one in W. Africa, and mostly tropical."[174]

Britannica (2021) speaks of the **pineapple family** of flowering plants (order Poales] "with more than 3,000 species across 56 genera" (for such number differences see perhaps Lönnig on *Species Concepts*: http://www.weloennig.de/Artbegriff.html) and mentions that "Spanish moss (*Tillandsia usneoides*) and the edible fruit of the **pineapple (*Ananas comosus*)** are the major economic products of the family… Members of Bromeliaceae are herbaceous evergreen perennials with simple spirally arranged leaves. Many bromeliads are short-stemmed epiphytes that live in trees or on cacti, though a number are terrestrial. The flowers have three parts, like lilies but with contrasting sepals and petals, and are often borne in long spikes with distinctive coloured bracts. Most have fleshy fruit, but some produce dry capsules." See more here (including "tank bromeliads" of which at least three (*Brocchinia reducta*, *B. hectioides*, and *Catopsis berteroniana*) are known to be carnivorous")[175].

Upper row, from left to right: (1) *Aechmea tillandsioides* (Carl Friedrich Philipp von Martius (1794-1868), August Wilhelm Eichler (1839-1887), Ignaz Urban (1848-1931), between 1898 and 1902). (2) "Geographic distribution of Bromeliaceae. Map adapted from Bromeliaceae: Profile of an Adaptive Radiation by David H. Benzing of same." (3) *Neoregelia concentrica* var. *plutonis* (Hanson59 2004). So far, the first three figures from https://de.wikipedia.org/wiki/Bromeliengew%C3%A4chse. (4) Ananas sauvage/wild Ananas (Author: de: Benutzer:Esskay 2004): https://fr.wikipedia.org/wiki/Bromeliaceae. **Middle row** (1) "Pineapple in the starting stage" (Ramesh NG 2011). (2) "A young pineapple in flower" (Supportstorm 2011). (3) "Pineapple, whole and in longitudinal section" (fir0002 flagstaffotos [at] gmail.com, 2009). All from https://en.wikipedia.org/wiki/Pineapple. **Below**: Fossil: *Puya gaudini* (Rama 2005): https://de.wikipedia.org/wiki/Bromeliengew%C3%A4chse

[174] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/bromeliaceae
[175] https://www.britannica.com/plant/Bromeliaceae

G/W (1964, p. 401/1973, p. 440): Fam. Bromeliaceae: Possibly *Bromelia gaudini* Heer. However not sure, could also be *Puya*[176]. **No age suggested.**

C/B/H (1993, p. 814): "PFR [Plant Fossil Record] First: *Bromelites dolinskii* J. Schmalhausen, 1883. Stem. Tertiary, Eocene [>**33.9 Ma**], former USSR near Kiew." Also, "Graham (1987) lists pollen of *Tillandsia* type from the Upper Eocene [Priabonian **37.9** to **33.9 Ma**] of Central America." Yet, without giving any further reasons, C/B/H consider the records unconfirmed.

PBDB (2021) and *fossilworks* (2021): A fossil named *Bromelianthus heuflerianus* is mentioned, however: "No collection or age range data are available"[177]. Same for *Bromeliaceophyllum renanum*, Weyland (1957) and there is neither anything on *Karatophyllum*, D. Gómez (1972)[178] nor on *Puya gaudini*.

Wikipedia with reference (2021): "There are only a few fossil finds from the Bromeliaceae family. The most secure is *Karatophyllum bromelioides* L. D. Gómez, a **30 million** year old[179] fossil from Middle Tertiary sediments in Costa Rica described by Luis Diego Gómez Pignataro in 1972."[180]

Family Bromeliaceae: Age range/constancy/stasis probably >30 Ma. (according to evolutionary presuppositions/derivations: "stasis of 100 million years" – see footnote): Living Fossils.

G/W: "Reihe Liliiflorae" (Now: Order Liliales)

Fam. Juncaceae

"Juncaceae is a family of flowering plants, commonly known as the rush family [Binsengewächse]. It consists of 8 genera and about 464 known species of slow-growing, rhizomatous, herbaceous monocotyledonous plants that may superficially resemble grasses and sedges. They often grow on infertile soils in a wide range of moisture conditions. The best-known and largest genus is *Juncus.* Most of the *Juncus* species grow exclusively in wetland habitats. A few rushes, such as *Juncus bufonius* are annuals, but most are perennials."[181]

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[176] Belongs to the Bromeliaceae, too: https://en.wikipedia.org/wiki/Puya_(plant) – more extensive and detailed here: https://de.wikipedia.org/wiki/Puya

[177] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=405997&is_real_user=1

[178] https://www.mineralienatlas.de/lexikon/index.php/FossilData?fossil=Karatophyllum

[179] Baresch et al. (2011) confirm "a close affinity with the extant bromeliad *Aechmea magdalenae* (André) André ex Baker. Leaf thickness (1.6 mm at maximum) suggests that *K. bromelioides* L. D. Gómez performed CAM photosynthesis" but they also suggest that there are "uncertainties surroundíng its age". They claim it would be younger: "It seems more probable that K. *bromelioides* was collected from similar Late Pleistocene to Holocene travertine deposits (Pérez and Laurito, 2003) rather than Middle Cenozoic. However, I would add that an "It seems more probable…" is not really/entirely convincing. They continue: "Despite uncertainty over its provenance and age, we consider that the fossil is convincingly assignable to Bromeliaceae on morphological grounds (leaf dimensions, cuticular imprint, and marginal spines). Although he chose to assign the specimen to a novel genus, Gómez (1972) noted the **possible affinities of this fossil with *Aechmea* and *Bromelia***, which are represented by 17 species and 3 species, respectively, in the modern flora of Costa Rica (Morales, 2003)." https://www.researchgate.net/publication/51752101_Karatophyllum_bromelioides_LD_Gomez_revisited_A_probable_fossil_CAM_bromeliad

[180] Original German text: "Es gibt nur wenige Fossilfunde aus der Verwandtschaft der Bromeliaceae. Am gesichertsten ist *Karatophyllum bromelioides* L. D. Gómez, ein von Luis Diego Gómez Pignataro 1972 beschriebenes 30 Millionen Jahre altes Fossil aus Sedimenten des Mittleren Tertiärs in Costa Rica": *Karatophyllum bromelioides* L.D.Gómez (Bromeliaceae), nov. gen. et sp., del Terciario Medio de Costa Rica. In: *Revista de Biología Tropical*. Volume **20**, Issue 2, 1972, pp. 221–229. (*Karatophyllum bromelioides* L.D. Gómez (Bromeliaceae), nov. gen. et sp., del Terciario Medio de Costa Rica./ *Karatophyllum bromelioides* L.D. Gómez (Bromeliaceae), nov. gen. et sp., from the Middle Tertiary of Costa Rica.). Kessous et al. (2021) cite circumstantial/inconclusive/weak evidence for a Pleistocene date: hence, also not sure (https://onlinelibrary.wiley.com/doi/full/10.1002/fedr.202000035). They also mention that "Benzing (2000) suggested the **possible existence of palynological records of *Tillandsia* L. from the Eocene** of Panama (Graham, personal communication with Benzing); however, no expert has confirmed this placement so far." Yet, this may come later. They also suggest that "after an apparent **evolutionary stasis of 100 million years**, they [the Bromeliaceae] have undergone a high diversification starting it the Miocene." Gomez himself states (p. 224): "HOLOT1FO: Ejemplar No.16399, Museo Nacional de Costa Rica, procedente del **Terciario Medio** de la región de San Ramón, Provincía de Alajuela. https://1library.co/document/z3dw1omy-karatophyllum-bromelioides-gomez-bromeliaceae-terciario-medio-costa-rica.html. Baresch et al. on the outcrop where the fossil was found: "We visited this outcrop, but unfortunately **the entire outcrop has disappeared because the travertine has been quarried for ornamental stone**." – Thus, the real evidence, which could eventually/finally decide the question, has been destroyed.

[181] https://en.wikipedia.org/wiki/Juncaceae

Upper row, left: *Juncus effusus* (photo Christian Fischer 2007): https://de.wikipedia.org/wiki/Binsengew%C3%A4chse. Middle: Inflorescence of *Juncus effusus* (photo Frank Vincentz 2007): https://de.wikipedia.org/wiki/Binsen. Right: *Luzula pilosa* (Otto Wilhelm Thomé 1885): https://nl.wikipedia.org/wiki/Russenfamilie Lower Row, left: *Luzula alpinopilosa* (part of a photo by Jerzy Opioła 2006). https://de.wikipedia.org/wiki/Hainsimsen. Same source for the photo in the middle: *Luzula hawaiiensis* (Forest & Kim Starr 2004). Also for the following one on the right: *Luzula echinata* (Katja Schulz from Washington, D. C., USA).

G/W (1964, p. 401/1973, p. 440): Fam. Juncaceae: "Very well preserved inflorescences of a *Luzula* (*L. rottensis* WLD.) are recorded in the Upper Oligocene [**27.82 – 23.03 Ma**] from Rott in the Siebengebirge."[182]

C/B/H (1993, p. 814): "Seeds like those of modern *Juncus* are recorded in the Upper Eocene/Lower Oligocene [up to **37.01 Ma**] of England, UK (Collinson, 1983) and from the Miocene onwards elsewhere in Europe (Mai 1985a)."

PBDB (2021) and *fossilworks* (2021): "Total: 4 collections each including a single occurrence." Most ancient so far: "Eocene of United States (1: Colorado). … When: Chadronian (**37.2 - 33.9 Ma**)."[183]

Family Juncaceae: Constancy/stasis up to 37 Ma.: Living Fossils

[182] Original German Text: "Sehr gut erhaltene Blütenstände einer *Luzula* (*L. rottensis* WLD.) stammen aus dem Oberoligozän von Rott im Siebengebirge."

[183] https://paleobiodb.org/classic/basicTaxonInfo?a=basicTaxonInfo&taxon_name=Juncaceae and https://paleobiodb.org/classic?a=basicCollectionSearch&collection_no=24209

Fam. Liliaceae (Order Liliales)

Britannica (2021)**:** "**Liliaceae**, the lily family of the flowering plant order Liliales, with 16 genera and 635 species of herbs and shrubs, native primarily to temperate and subtropical regions. Members of the family usually have six-segmented flowers and three-chambered capsular fruits; occasionally the fruits are berries. The leaves usually have parallel veins and are clustered at the base of the plant but may alternate along the stem or be arranged in whorls. Most species have an underground storage structure, such as a bulb.

The family is important for its many garden ornamentals and houseplants, especially *Erythronium*, fritillary (*Fritillaria*), lily (*Lilium*), and tulip (*Tulipa*)."[184]

Encyclopedia.com (Oxford University Press 2019**):** "**Liliaceae** A large family of monocotyledons, most of which are herbs (lilies, onions, etc.) with elongated leaves springing from rhizomes, corms, or bulbs, but some are shrubs or trees. … The inflorescence is a raceme or umbel, the flowers mostly regular and trimerous, with 2 usually similar whorls of petaloid perianth segments. There are usually 6 stamens, the ovary is superior and normally 3-celled. The fruits are capsules or berries. Many (e.g. *Lilium* and *Tulipa*) are cultivated for their flowers, others as vegetables or for flavouring (e.g. *Allium*, onions and garlic). There are 294 genera, comprising about 4500 species, with a cosmopolitan distribution."[185]

All photographs (but one) from https://en.wikipedia.org/wiki/Liliaceae. **First row**, left: *Lilium* "Zanlophator' [longiflorum type x Oriental type[186]] (photo Ulf Eliasson 2006). Middle: *Fritillaria meleagris* (photo H. Zell 2009):https://de.wikipedia.org/wiki/Liliengew%C3%A4chse. Right: *Tricyrtis* flower with patterned tepals (Wildfeuer 2006): Again https://en.wikipedia.org/wiki/Liliaceae – also the following ones. **Second row**, left: Dehiscence of anthers in *Lilium* cultivar 'Peach butterflies' (Nadiatalent 2010): Middle: *Lilium* anthers in cross section (Luis Fernández García 2007). Right: *Lilium auratum* pollen with typical single-grooved (monosulcate) pattern (Denis Barthel 2004). **Third row**, left: Tulips in April (part of a photo by Terry Korte 2006). Middle: Stamens and pistel of *Tulipa aucheriana* (Bernd Haynold 2008). Right: "A selection of seeds for species belong to Liliaceae" (Hardyplants).

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[184] https://www.britannica.com/plant/Liliaceae
[185] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/liliaceae
As for the different numbers of genera and species given in these encyclopedias, see please again http://www.weloennig.de/Artbegriff.html However, see also: "Früher wurden bis zu 3.500 Arten zu den Liliengewächsen gezählt":. https://de.wikipedia.org/wiki/Liliengew%C3%A4chse and further details in https://www.wikiwand.com/en/Taxonomy_of_Liliaceae
[186]https://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?taxonid=272965&isprofile=0&

G/W (1964, pp. 401-402/1973, pp. 440-441): Fam. Liliaceae: The authors included in this family the genera *Dracaena* (now family Asparagaceae)[187] from the Eocene and *Smilax* from the Upper Cretaceous of Alaska[188] (now family Smilaceae[189] – however, as stated/claimed by **PBDB** and ***fossilworks*** this is just a synonym for "Family Liliaceae"[190]). Hence, Liliaceae according to G/W: Upper Cretaceous (Maastrichtian **72.1** to **66 Ma**).

C/B/H (1993, p. 814): "PFR first: *Cretovarium* M. Stopes and Fujii[191], March 1910. Upper Cretaceous, Japan: Hokkaido (again Maastrichtian **72.1** to **66 Ma**)." Pollen: "*Astelia*. Mildenhall, 1980. Upper Eocene. New Zealand."

PBDB (2021) and *fossilworks* (2021): *Smilax pristina*, *Agave eoceneca*: Eocene of the United Kingdom/The London Clay Flora.[192] Both, ***fossilworks*** and **PBDB** also mention *Smilax pristina* and *Smilax* (?) *coloradensis*: The latter "Cretaceous of United States (1: Wyoming)" – "Age range: **99.7 to 7.246 Ma**".[193] The former (*fossilworks*): "Upper Frontier Formation – Lincoln County [Wyoming] (Cretaceous of the United States)". – "When: Frontier Formation, Late/Upper Cretaceous (**100.5 - 66.0 Ma**)."[194]

Family Liliaceae: Constancy/stasis up to 100.5 Ma.: Living Fossils

Fam. Dioscoreaceae (now Order: Dioscoreales)

Britannica 2021: "**Dioscoreaceae**, the yam family of the flowering plant order Dioscoreales, consisting of 4 genera and 870 species of herbaceous or woody vines and shrubs, distributed throughout tropical and warm temperate regions. Members of the family have thick, sometimes woody roots or tuber-like underground stems and net-veined, often heart-shaped leaves that sometimes are lobed. The small green or white flowers of most species are borne in clusters in the leaf axils. The fruit is a winged capsule or a berry. Several species of yams (vines of the genus *Dioscorea*) are grown for their edible tuberous roots, such as Chinese yam, or cinnamon vine (*D. batatas*); air potato (*D. bulbifera*); and yampee, or cush-cush (*D. trifida*).

A few species are cultivated as ornamentals. Black bryony (*Tamus communis*) is a European perennial vine with yellow flowers, poisonous red berries, and poisonous blackish root tubers. *Dioscorea* is a principal raw material used in the manufacture of birth-control pills."[195]

Encyclopedia.com (Oxford University Press 2019**): "Dioscoreaceae** A family of plants most of which are slender climbers. The leaves are commonly cordate. The flowers are regular, small, inconspicuous, tri- or hexamerous and the ovary is inferior. The fruit is a capsule or berry. There are 6 genera, with about 630 species, most of which are tropical, but including *Tamus communis*, the black bryony of Europe."[196]

Some more details: Science direct (Michael G. Simpson, in Plant Systematics (Second Edition), 2010: **Dioscoreaceae** "Yam family (after Dioscorides, Greek herbalist and physician of 1st century a.d.). 4 genera/800+ species. (Figure 7.27): The Dioscoreaceae consist of dioecious or hermaphroditic, perennial herbs. The stems are rhizomatous or tuberous, often with climbing aerial stems, secondary growth present in some taxa. The leaves are spiral, opposite, or whorled, petiolate (typically with a pulvinus at proximal and distal ends), simple to palmate, undivided to palmately lobed, stipulate or not, with parallel or often net (reticulate) venation, the primary veins arising from the leaf base. The inflorescence is an axillary panicle, raceme, umbel, or spike of monochasial units (reduced to single flowers),

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187 https://en.wikipedia.org/wiki/Dracaena_(plant)
188 https://pubs.er.usgs.gov/publication/pp159
The Upper Cretaceous floras of Alaska, with a description of the plant-bearing beds Professional Paper 159 By: Arthur Hollick and G. C. Martin (1930). See also: https://dggs.alaska.gov/pubs/id/3807
189 https://en.wikipedia.org/wiki/Smilax
190 https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54578
191 https://academic.oup.com/aob/article-abstract/os-24/4/679/182955
192 https://paleobiodb.org/classic/displayCollResults?taxon_no=54578&max_interval=Eocene&country=United%20Kingdom&is_real_user=1&basic=yes&type=view&match_subgenera=1
193 http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54577
194 https://paleobiodb.org/classic/displayCollResults?taxon_no=54577&max_interval=Cretaceous&country=United%20States&state=Wyoming&is_real_user=1&basic=yes&type=view&match_subgenera=1
195 https://www.britannica.com/plant/Dioscoreaceae
196 https:/www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/dioscoreaceae

with prominent involucral bracts in Tacca. The flowers are bisexual or unisexual, actinomorphic, pedicellate, bracteate or not, and epigynous. The perianth is biseriate, homochlamydeous[197], 3+3, a hypanthium[198] absent or present. The stamens are 3+3 or 3+0, whorled, diplostemonous[199] or antisepalous, distinct or monadelphous, free or epitepalous. Anthers are longitudinal and introrse or extrorse in dehiscence, tetrasporangiate, dithecal. The gynoecium is syncarpous, with an inferior ovary, 3 carpels, and 3 locules. The style(s) are 3 or 1 and terminal; stigmas are 3. Placentation is axile or parietal; ovules are 1–2 [∞] per carpel. The fruit is a capsule or berry, often winged, 1–3 locular at maturity. Seeds are exalbuminous[200]."[201]

The photographs just shown above are all from https://de.wikipedia.org/wiki/Yamswurzelgew%C3%A4chse. **Upper row**, left: *Dioscorea communis* (Otto Wilhelm Thomé 1895). Middle: Leaves and fruits of *Dioscorea communis*, Syn. *Tamus communis* Right: Leaves of *Dioscorea communis*, (Meneerke bloem 2011). **Second row**, left: *Dioscorea elephantipes* (Frank Vincentz 2007). ("It takes the name "elephant's foot" from the appearance of its large, partially buried, tuberous stem, which grows very slowly but often reaches a considerable size, often more than 3 m (10 ft) in circumference with a height of nearly 1 m (3 ft 3 in) above ground. It is rich in starch, whence the name Hottentot bread, and is covered on the outside with thick, hard, corky plates. It requires significant processing before being eaten to remove toxic compounds": https://en.wikipedia.org/wiki/Dioscorea_elephantipes)[202]. Middle: Inflorescence of wild yams (*Dioscorea villosa*) (H. Zell 2009). Right: Flower of *Trichopus zeylanicus* (Nyanatusita 2010).

Fossil Record:

G/W (1964, p. 402/1973, p. 442): Fam. Dioscoreaceae: Possibly certain *Macclintockia* leaves: Cretaceous of Greenland and Egypt. Sure is *Dioscorea*: Rhenish lignite (rheinischen Braunkohle): **25 – 30 MA**.

C/B/H (1993, p. 819): "PFR first: *Dioscoroides lyelli* (A. Watelet) P. H. Fritel, 15 October1904. Leaf. Tertiary, Eocene [Bartonian: **41.2 – 37.71 Ma**], France: Bassin de Paris: Belleu. *Prototamus paucinernis* M. Langeron, 1899. Leaf. Tertiary:

[197] "having a perianth whose inner and outer series are similar or not differentiated into calyx and corolla" https://www.merriam-webster.com/dictionary/homochlamydeous

[198] "In angiosperms, a hypanthium or floral cup is a structure where basal portions of the calyx, the corolla, and the stamens form a cup-shaped tube." https://en.wikipedia.org/wiki/Hypanthium

[199] "Definition of diplostemonous: having the stamens in two whorls each of which has the same number as the petals and usually an inner stamen opposite each petal and an outer one opposite each sepal." https://www.merriam-webster.com/dictionary/diplostemonous

[200] "Having no albumen about the embryo" (many dictionaries – for further definitions of the botanical terms cf. such dictionaries as just cited.)

[201] https://www.sciencedirect.com/topics/pharmacology-toxicology-and-pharmaceutical-science/dioscoreaceae

[202] See also the impressive photo at https://hr.wikipedia.org/wiki/Blju%C5%A1tovke#/media/Datoteka:Cactus_&_Succulents_(183440853).jpg

Eocene [Lutetian up to **47.8 Ma**], France, Sézanne[203].” However, the authors do not find any of the records of the family convincing (just “questionable”) – as if the “old” paleobotanists could not work accurately and precisely. Since only a reference to Daghlian (1981) is mentioned, but no concrete arguments presented by C/B/H, one may doubt their doubts.

PBDB (2021) and *fossilworks* (2021): “Distribution: Miocene of Colombia (1 collection), Germany (1), Kenya (4), Panama (1), Oligocene of Ethiopia, (1) Eocene of United States (1: Colorado) Dioscorea”[204] “Age range: **37.2** to 11.608 Ma. Genus *Dioscorea*: Age range as just mentioned[205]. Distribution: Miocene of Colombia (1 collection), Germany (1), Kenya (2). Oligocene of Ethiopia (1). Eocene of United States (1: Colorado).

Family Dioscoreaceae: Age range/constancy/stasis up to at least 37.2 Ma (even at the genus level with *Dioscorea*): Living Fossils.

Fam. Iridaceae (now Order Asparagales)

Britannica 2021: “Iridaceae, the iris family of flowering plants (order Asparagales), comprising 66 genera and around 2,200 species. The family is nearly worldwide in distribution, but it is most abundant and diversified in Africa. Most species are native to temperate, subtropical, and tropical regions. A few species grow in swampy locations, and a few withstand the rigours of subarctic substrates. The family contains a number of economically important ornamentals.

Plants of the family Iridaceae are mostly perennial herbs, though there are a few shrubs and evergreen herbs as well. Most have long narrow leaves, generally with parallel venation. The underground stems may be one of at least three structural types: rhizomes, bulbs, and corms. In many Iris species the stem is horizontal, robust, and ringed with leaf-scars. It is a rhizome that often grows partially exposed but is firmly rooted in the soil.” (See more in that detailed article)[206].

From **Encyclopedia.com** (Oxford University Press 2019)**: “**The flowers have perianths with 2 similar or dissimilar whorls, each of 3 segments, 3 stamens, and an inferior, 3-celled ovary. They are cosmopolitan, with some 92 genera, comprising about 1850 species. Many genera are cultivated, especially *Iris*, *Crocus*, and *Gladiolus*.”[207]

From left to right: *Iris spuria* (Franz Xaver 1992): https://de.wikipedia.org/wiki/Schwertliliengew%C3%A4chse. Middle: *Babiana sambucina* (Stan Sheps 2006) and Right: *Tigridia pavonia* (Goldi64 1982). Same Wikipedia article. See more excellent photographs in this article and in https://es.wikipedia.org/wiki/Iridaceae

203 https://www.mindat.org/loc-369119.html
204 https://paleobiodb.org/classic/displayCollResults?taxon_no=54577&max_interval=Cretaceous&country=United%20States&state=Wyoming&is_real_user=1&basic=yes&type=view&match_subgenera=1
205 http://fossilworks.org/?a=taxonInfo&taxon_no=320506
206 https://www.britannica.com/plant/Iridaceae
207 https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/iridaceae

Fossil Record:

G/W (1964, p. 402/1973, p. 442): Fam. Iridaceae: Upper Miocene of Öhningen: **13 MA**.

C/B/H (1993, p. 819): "**PFR first**: *Iritis alaskana* Lesquereux, 17 May 1888. Leaf. Lower Cretaceous [more than **100.5 Ma**], USA: Alaska, Cape Lisbourne. **Comments**: We know of no well-substantiated early megafossil record of this family, although Pleistocene seed are known from Europe and Japan (Miki, 1961; Mai, 1985a)." – I would like to repeat that also the "old" paleobotanists could and usually did work accurately, precisely/meticulously. Since no concrete arguments are presented by C/B/H, for the time being I would not only accept *Iritis alaskana* Lesquereux but also *Iridium groenlandicum* Heer 1868 Paleocene (see below).

PBDB (2021) and *fossilworks* (2021): "No occurrences of Iridaceae in the database."[208]

However, K. I. M. Chesters, F. R. Gnauck and N. F. Hughes (1967, pp. 269, 279 **in Harland et al**. have accepted "**First**, Tert Palaeoc [more than **56.0 Ma**]: *Iridium groenlandicum* Heer[209] 1868, Greenland. **Comment**: *Libertia* sp. (pollen), Plioc, New Zealand (Couper 1953, p. 58)." Incidentally, Heer was an excellent paleobotanist. Even "Charles Darwin regarded Oswald Heer [a 'creationist' like Cuvier] as an authority on fossil plants, and corresponded with him."[210]

Family Iridaceae: Age range/constancy/stasis up to at least 13 Ma (including *Iridium groenlandicum* 56.0 Ma and *Iritis alaskana* no less than 100.5 Ma): Living Fossils.

Next in G/W: "Reihe Scitamineae" (now Order Zingiberales)

Fam. Musaceae

Britannica 2021: "**Dioscoreaceae**, Musaceae, the banana family of plants (order Zingiberales), consisting of 2 genera, *Musa* and *Ensete,* with about 50 species native to Africa, Asia, and Australia. The common banana (M. sapientum) is a subspecies of the plantain (M. paradisiaca). Both are important food plants.

The slender or conical false trunk of Musaceae herbs may rise to 15 metres (50 feet). The "trunk" is formed by the leaf sheaths of the spirally arranged leaves, which form a crown at the top. The large leaves may be up to three metres long and half a metre wide. The prominent midrib of the leaf is joined at right or slightly oblique angles with parallel veins. When the plant grows in an unsheltered place, wind and rain easily tear the leaves between the veins, giving the leaves a fringed or ragged appearance. The large, leathery bracts (leaflike structures) are red to purple. The yellow flowers have five fertile stamens and are rich in nectar.

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[208] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55861

[209] https://de.wikipedia.org/wiki/Oswald Heer https://archive.org/details/florafossilisarc01heer/page/n205/mode/2up?q=Iridium Obwohl im Detail begründet etwas unsicher, bemerkt er abschließend: "Als Charakter für *Iridium* hätten wir anzugeben: Breite monocotyledone Blätter von vielen parallelen Längsnerven durchzogen, welche von dreierlei Stärke sind."

[210] https://en.wikipedia.org/wiki/Oswald_Heer: As just cited:"Charles Darwin regarded Heer as an authority on fossil plants" [and also interesting], and corresponded with him. ***The two men disagreed over evolution, but were on cordial terms***. In a letter in 1875, Heer described to Darwin in some detail a new dicotyledonous angiosperm fossil that he had identified in the lower Cretaceous in the arctic, which appeared to allow slightly more time for the evolution of dicots than Darwin had previously been aware of. Heer published a critique of Darwinism in volume 2 of his 1867 [1876] book The Primaeval World of Switzerland, concluding "**All these facts afford arguments against a slow and uniformly progressive transformation of species**, and lead to the conclusion that the transformation of organic nature took place in a period of comparatively limited duration" (p. 288). **He believed in progressive creation**: "Times of creation occurred during which was accomplished a remoulding of organic types, and there was a primaeval epoch during which the first species were brought into being. **Even if the first species were extremely simple, for them an act of creation must be admitted**, an act without example in modern times; for in our days plants and animals of decidedly low forms proceed from species already in existence" (p. 291, The Primaeval World of Switzerland).

During a great part of his career Heer was hampered by slender means and ill-health, but his services to science were acknowledged in **1874 when the Geological Society of London awarded to him the Wollaston medal**. He died at Lausanne on 27 September 1883."

See also book at Amazon by Conradin A Burga (Herausgeber) (2013): Oswald Heer (1809–1883): Paläobotaniker, Entomologe, Gründerpersönlichkeit. (512 pp.) https://www.amazon.de/Oswald-Heer-1809-1883-Pal%C3%A4obotaniker-Gr%C3%BCnderpers%C3%B6nlichkeit/dp/3038237477

Some species of wild bananas, such as *M. coccinea,* have ornamental scarlet flowers but inedible fruit. *M. textilis* from the Philippines furnishes Manila hemp, also called abaca fibre. The genus *Ensete* of Africa produces no edible bananas, but the flower stalk of one species, *E. ventricosa*, is edible after cooking. Species of *Ensete* are distinguished from those of Musa by their larger seeds. See also abaca; banana; plantain."

From **Encyclopedia.com (**Oxford University Press 2019**): "**Bananas, plantains, and their relatives are various species of plants in the family Musaceae. ….

…The flowers of bananas are finger-shaped, with three petals and sepals, and are subtended by large, fleshy, bright reddish-colored scales, which fall off as the fruit matures. The flowers are imperfect (that is, unisexual), and the plants are monoecious, meaning individual plants contain both female and male flowers. The flowers are arranged in a group, in an elongate structure known as a raceme, with male flowers occurring at the tip of the structure, and female flowers below. Only one inflorescence develops per plant. The flowering stalk develops from the underground rhizome or corm, and pushes up through the pseudostem of the plant, to emerge at the apex. The flowering stalk eventually curves downwards, under the weight of the developing fruits. The central axis of the raceme continues to elongate during development, so that older, riper fruits occur lower down, while flowers and younger fruit occur closer to the elongating tip. The same is true of the male flowers, with spent flowers occurring lower down, and pollen-producing ones at the tip of the inflorescence.

The flowers of bananas are strongly scented, and produce large quantities of nectar. These attract birds and bats, which feed on the nectar, and pollinate the flowers. The mature fruits are a type of multi-seeded berry, with a leathery outer coat known as an exocarp, and a fleshy, edible interior with numerous seeds embedded."

APG IV (2017/2021): "The inflorescence bracts are usually deciduous ["shedding its leaves annually"] and subtend fascicles of ebracteate flowers. The monosymmetric flowers have five tepals that are connate except adaxially, where there is a single, free, deeply concave tepal."

Left: "Bananengewächs", *Musa acuminata* (photo Daniela Kloth 2018): https://de.wikipedia.org/wiki/Bananengew%C3%A4chse. Middle: *Musella lasiocarpa* (photo KENPEI 2008). Right: Cross section of a banana plant's pseudostem (Frank Vincentz 2008): All from https://de.wikipedia.org/wiki/Bananengew%C3%A4chse. More

Fossil Record:

G/W (1964, p. 403/1973, p. 443): Fam. Musaceae (Order Zingiberales): In 1964 the authors stated: "Für das Vorhandensein der Familie im Tertiär sprechen verschiedene Blattreste von europäischen (*Musophyllum* UNG.) und amerikanischen Fundorten (*Musa* L., hiervon auch Samen aus Kolumbien und *Heliconia* BERRY)."

However in **1973** they asserted that according to Jain the only sure fossils of Musaceae would be a fruit of *Musa cardiosperma* Jain (1965) and a pseudostem (*Musocaulon indicum* Jain), both from India. No age suggestions were made.

C/B/H (1993, pp. 826/827): "**PFR first**: *Haastia speciosa* Ettinghausen, 1887. Leaf. Upper Cretaceous [Santonian **86.3 Ma** – Maastrichtian **66 Ma**], New Zealand: Pakawau, Nelson." And they added: "This use of the genus is nomenclaturally invalid as it is a junior homonym of *Haastia* J. D. Hooker, 1864." – *However, this does not change the species's membership to the Musaceae*.

After some critical comments on large *Musa*-like leaves, the authors state: "One record of *Musa* fruits from the Eocene of the Deccan was noted by Daghlian (1981) and

Manchester (in Knobloch and Kvacek, 1990, pp. 183-8) lists *Musa* as a component of the Middle Eocene Clarno flora ["Middle Eocene age of about **44 million years**"[211]]."

PBDB (2021) and *fossilworks* (2021): PBDB: "Distribution: Eocene of the United Kingdom (1 collection), United States (1: Wyoming). Paleocene of United States [When: Fort Union Formation, Clarkforkian (**56.8 - 55.8 Ma**)[212]](2: North Dakota, Wyoming)."[213] *Fossilworks*: "Age range: **56.8 to 37.2 Ma**. Distribution: Eocene of United States (1: Wyoming collection). Paleocene of United States (2: North Dakota, Wyoming)."[214]

Family Musaceae: Age range/constancy/stasis up to at least 58 Ma (including *Haastia speciosa* more than 66 Ma): Living Fossils. Age range extended.

Fam. Zingiberaceae (Order Zingiberales):

Britannica 2021: "**Zingiberaceae**, the ginger family of flowering plants, the largest family of the order Zingiberales, containing about 56 genera and about 1,300 species. These aromatic herbs grow in moist areas of the tropics and subtropics, including some regions that are seasonably dry.

Physical description: Members of the family are perennials that frequently have sympodial (forked) fleshy rhizomes (underground stems). They may grow to 6 metres (20 feet) in height. A few species are epiphytic — i.e., supported by other plants and having aerial roots exposed to the humid atmosphere. The rolled-up sheathing bases of the leaves sometimes form an apparent short aerial stem.

The commonly green sepals differ in texture and colour from the petals. Bracts (leaflike structures) are spirally arranged, and the flower clusters are spiral and conelike. The Zingiberaceae ***flower resembles an orchid*** because of its labellum (two or three fused stamens) joined with a pair of petal-like sterile stamens. Nectar is present in the slender flower tubes. The brightly coloured flowers may bloom for only a few hours and are thought to be pollinated by insects. One genus, *Etlingera*, exhibits an unusual growth pattern. The floral parts grow below ground except for a circle of bright red, petal-like structures that emerge from the ground, yet the leafy shoots rise to 5 metres (16.4 feet)."[215]

Encyclopedia.com (Oxford University Press 2019): "Zingiberaceae (ginger, cardamom, turmeric) The ginger family, comprising rhizomatous herbs, many of which are huge, and spicy in all their parts. The leaves have pinnate nervation and a sheathing base with a 2-ranked ligule. The aerial stems are oblique, but in Costus and its related genera spiral. Inflorescences are borne either on leafy stems or separately from the rhizome. There are 53 genera, with about 1200 species, occurring, mostly in rain forest, throughout the tropics but chiefly in Indo-Malaysia."[216]

Left: Zingiber officinale (Köhler's Medizinal-Pflanzen; between 1883 and 1914). Middle: Freshly harvested Ginger plants (Sengai Podhuvan 2012). Right: *Zingiber officinale*: Zygomorphic flower (Ogniw, derivative work Lämpel 2011).
All three figures from: https://de.wikipedia.org/wiki/Ingwer

[211] https://www.researchgate.net/publication/270051359_Fruits_and_Seeds_of_the_Middle_Eocene_Nut_Beds_Flora_Clarno_Formation_Oregon
[212] https://paleobiodb.org/classic?a=basicCollectionSearch&collection_no=11372
[213] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55819
[214] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55819 and http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=55819&max_interval=Paleocene&country=United%20States&state=North%20Dakota&is_real_user=1&basic=yes&type=view&match_subgenera=1
[215] https://www.britannica.com/plant/Zingiberaceae
[216] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/zingiberaceae





Upper row. Left: *Curcuma zedoaria* (Köhler's Medizinal-Pflanzen 1897). Right: *Curcuma* sp. (Uncleeric (talk) 2008). Both from https://commons.wikimedia.org/wiki/File:Curcuma_sp.jpg Second row: Left: *Curcuma inodora* (photo J.M.Garg 2009): also https://commons.wikimedia.org/wiki/File:Curcuma_sp.jpg. Middle: Wild tumeric, *Curcuma aromatica* (part of a photo by goldentakin 2012). Right: *Curcuma alismatifolia* (Wouter Hagens 2002): Middle and right from https://de.wikipedia.org/wiki/Curcuma

Fossil Record:

G/W (1964, pp. 403-404/1973, p. 443): Fam. Zingiberaceae (Order Zingiberales): 1964: Rhenish lignite (rheinischen Braunkohle: **25 - 30 Ma.** 1973: Miozän (up to **23.03 Ma**) ("hervorragends Material"/"excellent material"). They call *Zingeberites* Heer, Upper Cretaceous, "ambiguous" ("nicht eindeutig").

C/B/H (1993, pp. 837): "**PFR first**: *Spirematospermum wetzleri* Heer, 1925. Fruit. Tertiary, Upper Eocene, UK: England: Hordle, Hampshire. **Comments**: *Spirematospermum* is now known from the Santonian/Campanian [up to **86.3 Ma**] of North America and Maastrichtian of Europe (Goth, 1986; Knobloch and Mai, 1986; Friis, *in* Collinson, 1988c, pp. 7 – 12). This seed record is supported by leaves of *Zingiberopsis* also in the Upper Cretaceous of North America (Friis, *in* Collinson, 1988c, pp. 7 – 12; Taylor, 1990). Subsequent seed records occur throughout the Tertiary

(Friis, *in* Collinson, 1988c, pp.7-12) and leaves at least in the Middle and Upper Eocene (Wilde, 1989; Taylor, 1990). **Pollen**: No record."

PBDB (2021) and *fossilworks* (2021): PBDB: "Distribution: Pliocene of Germany (1 collection). Miocene of Germany (29), Portugal (1), the Russian Federation (10). Oligocene of Germany (13), the Russian Federation (14), the United Kingdom (1), United States (1: Oregon). Eocene of the United Kingdom (1), United States (53: North Dakota, Washington, Wyoming). Paleocene of United States (9: Wyoming). Cretaceous of United States (6: North Carolina, North Dakota). Total: **139 collections** each including a single occurrence Wyoming)."[217]

"When: When: Black Creek Formation, Late/Upper Cretaceous (**100.5 - 66.0 Ma**)"[218]

fossilworks: Most ancient/oldest: "Cretaceous of United States (5: North Dakota) Total: 68 collections each including a single occurrence." – "Age range: 70.6 to 28.4 Ma."

Family Zingiberaceae: Age range/constancy/stasis up to ca. 100 Ma: Living Fossils. Age range/constancy/stasis during the last some 50 years: extended due to further paleobotanical discoveries.

Fam. Cannaceae[219] (Order Zingiberales):

Britannica 2021: "**Canna,** (genus Canna), genus of about 10 species of flowering plants, ***the only genus of the family Cannaceae (order Zingiberales)***. The plants are distributed from southeastern North America through South America. Many are cultivated as ornamentals for their showy flowers and attractive foliage, and a number of cultivars have been developed. Edible canna, or Indian shot (*Canna indica*), and achira (*C. discolor*) have edible starchy rhizomes and are grown agriculturally in some places; the latter is sometimes listed as a synonym of C. indica.

Canna are tropical herbs and possess rhizomes (underground stems) with erect stems growing to 3 metres (10 feet) high. The tall or dwarf foliage displays spirally arranged leaves that may be green or bronze. The flowers are asymmetrical, with one half-functional stamen and a labellum, a petal-like structure rolled outward. The two to three "petals" are actually sterile stamens (staminodes); there are also three regular petals. Sometimes spotted variations of the scarlet, red-orange, or yellow flowers occur.)."[220]

Encyclopedia.com (Oxford University Press 2019): "**Canna (family Cannaceae)** A genus of rhizomatous (see RHIZOME) herbs which are cultivated for their showy inflorescences. *C. edulis* of the Andes is cultivated for its edible rhizomes (Queensland arrowroot or achira). There are 25 species, occurring in tropical and subtropical America."[221]

From left to right: (1) *Canna indica* (Francisco Manuel Blanco (O.S.A.) 1880-1883?). (2) *Canna indica* (photographs by Robert Uyeyama 2006). (3) Inflorescence of *Canna indica* (ZoomViewer 2007). (4) *Canna* x *generalis* (Forest & Kim Starr 1998). All four figures from https://de.wikipedia.org/wiki/Blumenrohr.

[217] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55284
[218] https://paleobiodb.org/classic/displayCollResults?taxon_no=55284&max_interval=Cretaceous&country=United%20States&state=North%20Carolina&is_real_user=1&basic=yes&type=view&match_subgenera=1
[219] Not to be confused with Cannabaceae https://en.wikipedia.org/wiki/Cannabaceae
[220] https://www.britannica.com/plant/Cannaceae
[221] https://www.encyclopedia.com/plants-and-animals/plants/plants/canna

Fossil Record:

G/W (1964, pp. 404/1973, p. 443): Fam. Cannaceae (Order Zingiberales): No sure records known although *Canna* has already been mentioned from the Cretaceous of North America.

C/B/H (1993, pp. 837): "**PFR First:** *Cannaites intertrappa* B. S. and C. L. Verma, 1971. Root. Tertiary: Eocene [more than **33.9 Ma**], India: Mohgaon Kalan, Chhindwara." My postscript: See also B. S. Trivedi and C. L. Verma (1970): "Silicified pseudostem of *Canna* m from Early Eocene [Ypresian up to **56 Ma**] of Deccan intertrappean beds Madhya Pradesh India."[222]

PBDB (2021) and *fossilworks* (2021): *Cannaites intertrappa* is mentioned, but no details on occurrence and age range.

Family Cannaceae: Age range/constancy/stasis up to ca. 56 Ma: Living Fossils. Again: Constancy/stasis during the last some 50 years extended due to further paleobotanical discoveries.

Fam. Marantaceae (Order Zingiberales):

Britannica 2021: "**Marantaceae**, the prayer plant or arrowroot family (order Zingiberales), composed of about 31 genera and about 550 species. Members of the family are native to moist or swampy tropical forests, particularly in the Americas but also in Africa and Asia. Several species are cultivated as ornamentals or as a source of edible starch.

Physical description: Marantaceae members are largely rhizomatous perennial herbs. They vary from plants with slender, reedlike stalks to leafy spreading or dense bushes nearly 2 metres (about 6.5 feet) high. The petioles (leaf stalks) have a sheathed base, and the simple leaves usually are arranged in two rows. The asymmetrical flowers are borne characteristically in mirror image pairs. The fruit commonly is a berry or a capsule.

Major genera and species: The genus *Maranta* has 40–50 members, which are native to Central and South America and the West Indies. The smooth white rhizomes (underground stems) of some species, such as Maranta arundinacea, furnish the starch known as arrowroot. Other members of the family are popular ornamentals, such as the prayer plant (*M. leuconeura*).

The number of species of the genus *Calathea* is contentious, with some taxonomists placing the large genus *Goeppertia* in *Calathea*. The leaves of some species are used in basket weaving and for wrapping food. Several *Calathea* species produce wax, and some have edible flowers and tubers. A number are cultivated as houseplants for their striking patterned foliage".[223]

Encyclopedia.com (Oxford University Press 2019): "**Marantaceae** A family of herbs most of which have rhizomes or tubers. The petiole base is sheathing [Die Blattstielbasis ist ummantelt], and kneed at the top, the leaves pinnately nerved. The inflorescence is subtended by a large bract. The epipetalous flowers are hermaphrodite, zygomorphic, and trimerous, with 1 stamen. The ovary is inferior, the fruit a capsule or berry. Marantaceae are related to Musaceae. There are 31 genera, with about 550 species, occurring in the tropics, mainly in America. ."[224]

From left to right: (1) *Maranta leuconeura* (Kurt Stüber 2004). (2) *Calathea roseopicta* (Forest & Kim Starr 2008). (3) *Calathea crotalifera* (Forest & Kim Starr 2008). (4) *Goeppertia majestica* (Syn.: *Calathea princeps*) (Kurt Stüber 2004). All from: https://de.wikipedia.org/wiki/Pfeilwurzgew%C3%A4chse

[222] https://eurekamag.com/research/027/386/027386196.php
[223] https://www.britannica.com/plant/Marantaceae
[224] https://www.encyclopedia.com/plants-and-animals/plants/plants/canna

Fossil Record:

G/W (1964, pp. 404/1973, p. 443): Fam. (Order Zingiberales):

"Certain epidermas from the Rhenish lignite [**25 – 30 Ma**] (*Scitamineophyllum* WEYLAND 1957) belong ... with some probability to the Marantaceae."[225] "Gewisse Epidermen aus der rheinischen Braunkohle (*Scitamineophyllum* WEYLAND 1957) gehören … mit einiger Wahrscheinlichkeit zu den Marantaceen."

C/B/H (1993, pp. 837): "**PFR First:** *Cannaites intertrappa* B. S. and C. L. Verma, 1971. Root. Tertiary: Eocene [more than **33.9 Ma**], India: Mohgaon Kalan, Chhindwara." My postscript: See also B. S. Trivedi and C. L. Verma (1970): "Silicified pseudostem of *Canna* m from Early Eocene [Ypresian up to **56 Ma**] of Deccan intertrappean beds Madhya Pradesh India."[226]

PBDB (2021) and *fossilworks* (2021): *Cannaites intertrappa* is mentioned, but no details on occurrence and age range are given.

Family Marantaceae: Age range/constancy/stasis up to ca. 56 Ma: Living Fossils. Constancy/stasis during the last some 50 years extended due to further paleobotanical discoveries.

G/W: "Reihe Microspermae" (now "currently placed in the order Asparagales"[227])

Fam. Orchidaceae

Britannica 2021: "**orchid**, (family **Orchidaceae**), any of nearly 1,000 genera and more than 25,000 species of attractively flowered plants distributed throughout the world, especially in wet tropics. Orchidaceae is a member of Asparagales, an order of monocotyledonous flowering plants that also includes the asparagus and iris families. The word orchid is derived from the Greek word (orchis) for testicle because of the shape of the root tubers in some species of the genus *Orchis*. These nonwoody perennial plants are generally terrestrial or epiphytic herbs (i.e., growing on other plants rather than rooted in soil). Those attached to other plants often are vinelike and have a spongy root covering called the velamen that absorbs water from the surrounding air. Most species manufacture their own food, but some live on dead organic material (saprophytic) or are helped to obtain nourishment by a fungus living in their roots.

… The primary characteristics that distinguish the orchids as a group are found in the flower. At the bottom of an unspecialized non-orchid flower is the stem that supports it, called the pedicel. Directly above, and at the base of the flower itself, is a whorl of green, leaflike organs called sepals. Above and inside the sepals is a second whorl of coloured petals. Together the sepals and petals are called the perianth, which constitute the nonreproductive parts of the flower. The perianth protects the flower or attracts pollinators or both. Inside (also arranged in whorls) are the sexual portions of the flower. First are the pollen-producing stamens in up to several whorls; each stamen consists of an anther on a long slender filament. In the centre of the flower is the female pistil, which consists of an enlarged inferior ovary topped by a stalklike style with a stigma at its apex. The sepals and petals are usually similar, often highly coloured, and in sets of three. One petal is developed as a landing platform for the pollinator and is called the lip (or labellum).

The sexual portions of the orchid flower are quite different from other generalized flowers, and they tend to characterize the family. The filaments, anthers, style, and stigma are reduced in number and are usually fused into a single structure called the column. The majority of the orchids retain only a single anther at the apex of the column. In the orchid the ovary is composed of three carpels fused so that the only outward evidence of their existence is the three ridges on the outside of the seed pods. The mature seed pod opens down the middle between the lines of juncture. The ovules are arranged along the ridges inside the ovary and do not develop until some time after the flower has been pollinated, thereby contributing to the long delay between pollination and the opening of a ripened pod." **See more in that excellent article**.[228]

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[225] Original German text: "Gewisse Epidermen aus der rheinischen Braunkohle (*Scitamineophyllum* WEYLAND 1957) gehören … mit einiger Wahrscheinlichkeit zu den Marantaceen."

[226] https://eurekamag.com/research/027/386/027386196.php

[227] https://en.wikipedia.org/wiki/Orchidaceae

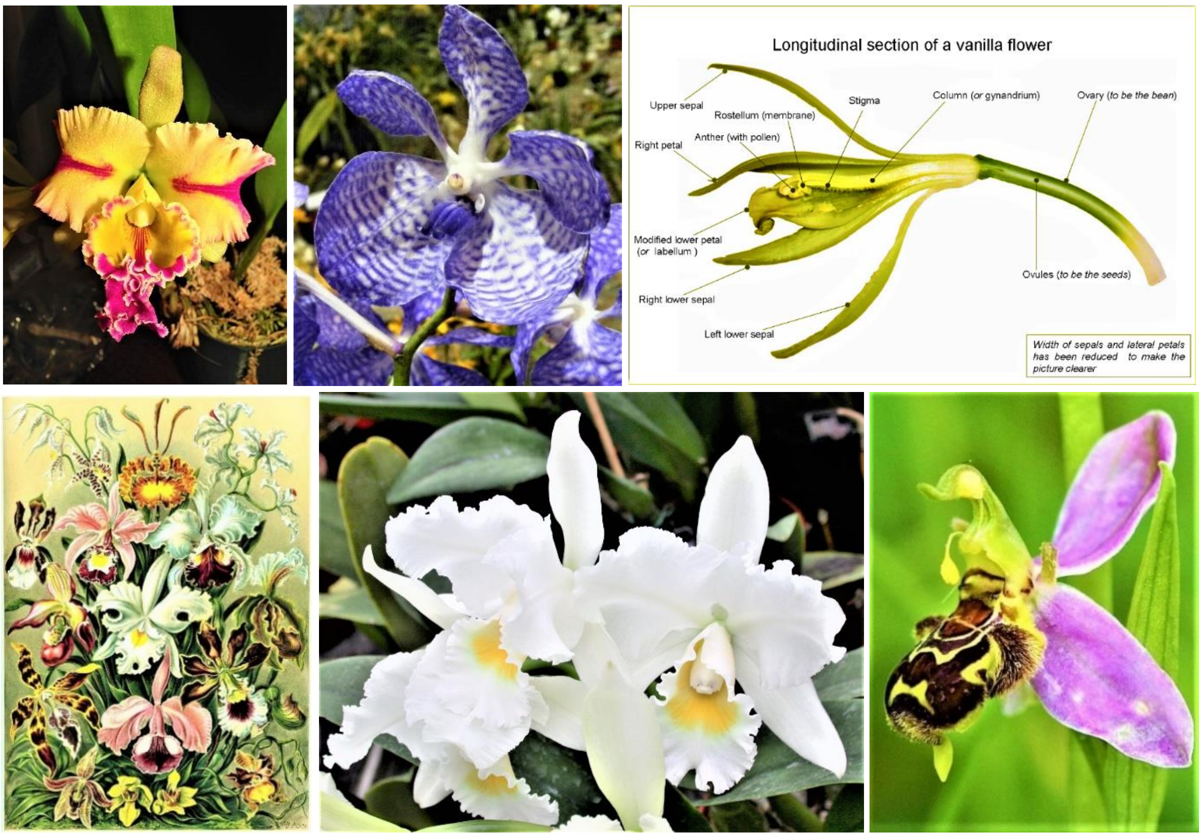
[228] https://www.britannica.com/plant/orchid/Characteristic-morphological-features

Cf. also my articles on: *The Deceptive Flowers of Orchids and Evolution by Natural Selection. Or How More than Eight Thousand Beautiful Facts are Slaying an Ugly Hypothesis: Darwinism* Part I[229] and II[230] and *Coryanthes* und *Catasetum*: Bietet die Synthetische Evolutionstheorie eine wissenschaftlich gesicherte Erklärung für den Ursprung der synorganisierten Strukturen dieser (und anderer) Orchideen?[231]

Encyclopedia.com (Oxford University Press 2019): "Orchid family (Orchidaceae)

The many species of orchids comprise one of the largest families of flowering plants, the Orchidaceae, which contains about 1,000 genera and about 20,000 species. Orchids have a worldwide distribution, and they occur in a wide variety of habitats, although their greatest diversity of species is in tropical rain forest. The most species-rich genera of orchids are Dendrobium and Bulbophyllus, each with about 1,500 species, and Pleurothallis, with 1,000 species.

Species of orchids can have very unusual morphological traits and ecological relationships, especially with their species of pollinating insects. For these reasons, along with the great beauty of their flowers, orchids hold a special place in the hearts of botanists, ecologists, and horticulturists. However, appreciation of the intrinsic value of orchids extends far beyond the scientists who work with these plants—few people fail to be enthralled by the loveliness of orchid flowers." **See also more in that further excellent article.**"[232]



Upper row: From left to right. Left A *Brassolaeliocattleya* ("BLC") Paradise Jewel 'Flame' hybrid orchid (photo by Dougie WII 2013). (2) *Vanda* cultivar (part of a photo by José Manuel López Pinto 2013). (3) Vanilla flower longitudinal section (photo & caption B.navez 2006).
Second row: 16 Orchid species by A. Giltsch (in Ernst Haeckel: Kunstformen der Natur 1899 Orchids Illustrated Plate 74). (2) *Cattleya* Queen Sirikhit Diamond Crown (Arne and Bent Larsen, Haarby, Denmark between 1990 and 2010). (3) *Ophrys apifera* flower (photo Bernd H. 2004).All photos/figures above from https://en.wikipedia.org/wiki/Orchidaceae (there and also in the corresponding Wikipedia articles in many languages many more beautiful photographs[233] and graphics. See also *Ophrys*: https://de.wikipedia.org/wiki/Ragwurzen For a series of my own photos, see please: http://www.weloennig.de/BeautifulFactsPartI.pdf pp. 50-70 an http://www.weloennig.de/BeautifulFactsPartII.pdf pp. 19-49.

Fossil Record:

G/W (1964, pp. 404/1973, p. 443): Fam. Orchidaceae (now Order Asparagales):

The authors reject the identifications/determinations of Massalongo (1858) from the Eocene of Monte Bolca, but: "Straus [1969] found unmistakable fruit stands… in

[229] http://www.weloennig.de/BeautifulFactsPartI.pdf
[230] http://www.weloennig.de/BeautifulFactsPartII.pdf
[231] http://www.weloennig.de/CorCat.html
[232] https://www.encyclopedia.com/science/encyclopedias-almanacs-transcripts-and-maps/orchid-family-orchidaceae
[233] See perhaps also my photographs in the articles mentioned above

the Upper Pliocene [up to **3.6 Ma**] of Willershausen (*Orchidacites orchidioides* und *O. wegelei*).” [234]

Incidentally, in Harland et al. (1967) the family Orchidaceae was not taken into account.

C/B/H (1993, pp. 828): “**PFR First:** *Palaeorchis rhizoma* A. Massalongo[235], post-22 August 1858. Stem, rhizome and leaf. Tertiary: Eocene, Italy: Monte Bolca[236]: Veronese. *Protorchis monorchis* A Massalongo, post-22 August 1858. Stem, rhizome and leaf. Tertiary: Eocene [Ypresian up to **56 Ma**], Italy: Monte Bolca.

Comments: Schmid and Schmid (1973) concluded that the family had no reliable fossil record, but considered a Pliocene example (Strauss[237], 1969) as most plausible. Friies (1985a) describe a lower Miocene seed which was tentatively compared with Orchidaceae.”

PBDB (2021) and *fossilworks* (2021)[238]: Both: “Miocene of the Dominican Republic (1 collection), Mexico (1).” – “Age range: **20.43 to 15.97 Ma**.

T. N. Taylor, E. Taylor and M. Krings (2009) state: “The fossil record of the family … includes only a few specimens of flowers preserved as impression – compressions, including *Protorchis*, *Palaeorchis*, and *Eoorchis* (Schmid and Schmid, 1977). *Eoorchis miocaenica*, a Miocene compression, has been described as the oldest orchid, although there is only poorly preserved specimen. It consists of a flower ~1.3 cm long (FIG. 22.93) (Mehl, 1984). The absence of fossil orchid pollen in the rock record is attributed to the lack of preservational potential and perhaps methods of recovery (Wolter and Schill, 1985). Molecular clock assumptions suggest that the family is at least 65 Ma old (Chase, 2005). Paleontological evidence suggests that the orchids extend at least to the ***Neogene based on the report of orchid-pollinating bees in amber*** (Engel, 1999). The report by Ramírez et al. (2007) of ***pollinia on a stingless bee preserved in Miocene amber*** is not only an extraordinary example of a specific plant – animal interaction, but also provides **unequivocal evidence of the Orchidaceae in the Neogene**. Morphological and molecular phylogenies suggest the Orchidaceae evolved perhaps by the mid-Cretaceous (Chase, 2001).”[239]

Chase et al. (2017, p. 12) have this comment: “Orchids evolved during the Late Cretaceous period, roughly **76 to 105** million years ago. This is much earlier than botanists once thought and makes **Orchidaceae one of the 15 oldest angiosperm families**, of which there are **416 in total**. Few orchid fossils older than 20 to 30 million years have been found, and it was thought that orchids evolved relatively recently compared to many other groups of flowering plants. That they have a poor fossil record is not surprising because most orchids are herbs, which generally do not fossilize well, and their highly modified pollinia are difficult to recognize in the fossil record.”[240]

Family Orchidaceae: Age range/constancy/stasis at least for some 20 Ma: Living Fossils. Constancy/stasis during the last some 50 years extended due to further paleobotanical discoveries.

So far, an overview of the fossil record of the 28 angiosperm monocot families as discussed in G/W (1964/1973). In the interim of the last some 50 years of paleontological research, in many cases the time range of these families has been extended and several additional families have been discovered – see below.

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[234] “Unverkennbare Fruchtstände fand Straus … im Oberpliozän [up to 3.6 Ma] von Willershausen (*Orchidacites orchidioides* und *O. wegelei*).“

[235] *Cf.* Schmid and Schmid (1973): Fossils attributed to_the orchidaceae: https://de.slideshare.net/nextorbo/fossils-attributed-totheorchidaceae

[236] https://en.wikipedia.org/wiki/Monte_Bolca

[237] Adolf Straus (1992): Die oberpliozäne Flora von Willershausen am Harz. Ber. Naturhist. Ges. Hannover ***134***: 7 - 115 (There many fine photographs of fossils: pp. 96-115.) Straus (not Strau<u>ss</u>).

[238] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55864

[239] Position 21195. Thomas N. Taylor, Edith L. Taylor and Michael Krings (2009): Paleobotany. The Biology and Evolution of Fossil Plants. Academic Press. Elsevier Kindle-Version.

[240] https://www.degruyter.com/document/doi/10.7208/9780226224664-003/html The Book of Orchids.
Mark W. Chase, Maarten J. M. Christenhusz und Tom Mirenda. University of Chicago Press.

Now APG IV (2016/2017/2021 – Page last updated: 09/03/2021 00:43:52)[241] counts 11 monocot orders (plus one group “ohne Rang” – without taxonomical rank) and 77 monocot families. So, let’s have a look on the question of **how many additional monocot families have been found (marked in blue)**.

Monocotyledoneae

Order Kalmusartige (Acorales)	**Eocene**
Family Kalmusgewächse (Acoraceae)	**Eocene**[242]
Order Froschlöffelartige (Alismatales)	X
Family Araceae	X
Family Tofieldiaceae	–
Family Alismataceae	X
Family Butomaceae	X
Family Hydrocharitaceae	X
Family Scheuchzeriaceae	X
Family Aponogetonaceae	X
Family Juncaginaceae	**Eocene**[243]
Family Maundiaceae	–[244]
Family Zosteraceae	**Cretaceous**[245]
Family Potamogetonaceae	X
Family Posidoniaceae	**Cretaceous**[246]
Family Ruppiaceae	**Eocene**[247]
Family Cymodoceaceae	**Eocene**[248]
Order Petrosaviales	**Cretaceous**
Family Petrosaviaceae	**Cretaceous**[249]
Order Yamswurzelartige (Dioscoreales)	X
Family Nartheciaceae	–[250]
Family Burmanniaceae	–[251]
Family Dioscoreaceae	X[252]
Order Schraubenbaumartige (Pandanales)	X
Family Triuridaceae (see above) X	**Cretaceous**
Family Velloziaceae	–
Family Stemonaceae	–
Family Cyclanthaceae	X
Family Pandanaceae	X
Order Lilienartige (Liliales)	X
Family Campynemataceae	–
Family Corsiaceae	–
Family Melanthiaceae	–
Family Petermanniaceae	**Eocene**[253]
Family Alstroemeriaceae	–
Family Colchicaceae	–
Family Philesiaceae	–
Family Rhipogonaceae	–
Family Smilacaceae	**Cretaceous**[254]
Family Liliaceae	X
Order Spargelartige (Asparagales)	X
Family Orchidaceae	X
Family Boryaceae	–
Family Blandfordiaceae	–
Family Asteliaceae	–

Family Lanariaceae	–[255]
Family Hypoxidaceae	–[256]
Family Doryanthaceae	–[257]
Family Ixioliriaceae	–
Family Tecophilaeaceae	–
Family Iridaceae	–
Family Xeronemataceae	–
Family Asphodelaceae	–
Family Amaryllidaceae	–
Family Asparagaceae	X
Without tax. Rank Commelinids	X
Order Palmenartige (Arecales)	X
Family Dasypogonaceae	–
Family Arecaceae	X
Order Commelinaartige (Commelinales)	**Miocene**
Family Hanguanaceae	–
Family Commelinaceae	**Miocene**[258]
Family Philydraceae	–
Family Pontederiaceae	–
Family Haemodoraceae	–
Order Ingwerartige (Zingiberales)	X
Family Strelitziaceae	–
Family Lowiaceae	–
Family Heliconiaceae	**Miocene**[259]
Family Musaceae	X
Family Cannaceae	X
Family Marantaceae	X
Family Costaceae	–
Family Zingiberaceae	X
Order Süßgrasartige (Poales)	X
Family Typhaceae	X
Family Bromeliaceae	X
Family Rapateaceae	–
Family Xyridaceae	–
Family Eriocaulaceae	X
Family Mayacaceae	–
Family Thurniaceae	–
Family Juncaceae	X
Family Cyperaceae	X
Family Restionaceae/Centrolepidaceae	X
Family Flagellariaceae	–[260]
Family Joinvilleaceae	–
Family Ecdeiocoleaceae	–
Family Poaceae	X

[241] http://www.mobot.org/MOBOT/research/APweb/ and https://de.wikipedia.org/wiki/Systematik_der_Bedecktsamer#Monokotyledonen

[242] https://www.plantfossilnames.org/name/38/ https://www.plantfossilnames.org/name/35/ (Retrieved 27 Septe2021). Also, “…the fossil record of basal monocots (Acorales and Alismatales) extends back to the Cretaceous...” and “…scattered record from the Eocene…” (Grimsson et al. 2014): Check please ‘Acorales’ and search: ‘fossil’ under https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=182974&is_real_user=1

[243] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55794 (Eocene. Age range: **37.2** to 0.012 Ma.

[244] “*Maundia* is a genus of alismatid monocots, described in 1858. *Maundia* was **formerly** included in the family **Juncaginaceae** but is now considered to form a family of its own under the name Maundiaceae. It contains only one known species, *Maundia triglochinoides*, endemic to Australia (States of Queensland and New South Wales).”The species is listed as vulnerable.” https://en.wikipedia.org/wiki/Maundia

[245] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=214576&is_real_user=1 (“Age range: base of the Late/Upper Cretaceous to the top of the Late/Upper Albian or **100.50000 to 99.60000** Ma.”

[246] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55799 (“Age range: **84.9** to 3.6 Ma”)

[247] http://fossilworks.org/?a=taxonInfo&taxon_no=55796 (“Age range: **40.4** to 5.332 Ma”)

[248] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55800 (“Age range: **37.2** to 0.012 Ma”)

[249] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=182977 “Cretaceous 238 collections including 415 occurrences Age range**: 112.6** to 0.0 Ma”

[250] According to http://www.mobot.org/MOBOT/Research/APweb/welcome.html: Family Nartheciaceae: Age. Divergence times at this node are (118-)109(-98) Ma (Merckx et al. 2010a: Burmanniaceae sister to rest); other estimates are (112-)96, 93(-87) Ma (Wikström et al. 2001), ca 115 and 127 Ma (Magallón & Castillo 2009) and (111-)92, 83(-68) Ma (Bell et al. 2010). The node is dated to ca 116 Ma by Janssen and Bremer (2004), (122.5-)104(-86.4)Ma by Couto et al. (2018) and ca 79.9 Ma by Magallón et al. (2015). The age of a clade including Afrothismia, Thismiaceae, and Trichopodaceae is some (109-)95(-79) Ma (Merckx et al. 2010a). Ages should be carefully checked here, because sampling in several studies is poor and relationships unclear.

[251] “There is no known fossil record of Burmanniaceae…or Natheciaceae” (Selena Y Smith in:Paul Wilkin and Simon J. Mayo (2013, p.41): Early Events in Monocot Evolution. Cambridge University Press.) Also: While there is no known fossil record for Stemonaceae or Velloziaceae (Collinson et al., 1993 ; Herendeen and Crane, 1995), Pandanaceae and Triuridaceae appear in the Cretaceous and Cyclanthaceae are known from the Eocene.”

[252] See also https://www.researchgate.net/publication/316248348_A_review_of_the_fossil_record_for_Dioscoreaceae

[253] http://www.mobot.org/MOBOT/Research/APweb/orders/lilialesweb.htm#Petermanniaceae (“…**early Eocene** of Australia”)

[254] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55853 Cretaceous of United States (1: Wyoming) Total: 18 collections each including a single occurrence (“age range…**100.50000** to 7.24600 Ma”).

[255] One Family with one species (“endemic to the southern coast of South Africa”): https://en.wikipedia.org/wiki/Lanaria

[256] “Fossil net-veined monocot leaves can be difficult to identify, … no fossil record …Blandfordiaceae, Boryaceae, Doryanthaceae, Hypoxidaceae, Iridaceae, Ixioliriaceae, Lanariaceae, Tecophilaeaceae or Xeronemataceae.” (see Selena Y Smith above, p. 44)

[257] “The family **Doryanthaceae,** placed in the order Asparagales of the monocots, **has only recently been recognized by taxonomists**.. formerly.. [in] Agavaceae https://en.wikipedia.org/wiki/Doryanthes
See also the **recent family** status of **Ixioliriaceae, Tecophilaeaceae, Xeronemataceae, Dasypogonaceae, Hanguanaceae, Joinvilleaceae** (1970?), **Ecdeiocoleaceae** with no fossil record so far. *Cf.* likewise the **Tofieldiaceae** (Tachtadschjan 1995), **Philesiaceae** (Watson and Dallwitz 1992), **Rhipogonaceae** (Conran and Clifford 1985), **Boryaceae** (in APG from 1998 onwards, formerly Liliaceae).

[258] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54955&is_real_user=1 http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55808 Tofieldiaceae

[259] http://www.mobot.org/MOBOT/research/APweb/ “…Kapgate (2013) reports *Heliconiaites mohgaoensis* from Deccan Intertrappean deposits **70.6-65.5** Ma; both the age and locality of this report are surprising.”

[260] Nevertheless: http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55808: Age range: **0.781 to 0.012 Ma**

(Just an insert: Until here the **links** were set between 1 and 27 September 2021 (for the links between 19 July and 31 August 2021, see please note for the Cyclanthaceae above.)

In 1964/1973 Gothan and Weyland (G/W) gave an overview on the fossil record of **28** monocot families, **5** of them were uncertain (mostly labelled with a question mark: Lemnaceae, Centrolepidaceae, Eriocaulaceae ("keine sicheren Reste") Bromeliaceae, Maranthaceae – that leaves **23** quite securely documented families.

In the interim of some 50 years, now in 2021, at least 4 of them have been further documented: (1) Lemnaceae (now in Araceae), Centrolepidaceae? (in Restionaceae), (2) Eriocaulaceae, (3) Bromeliaceae, and (4) Scheuchzeriaceae.

So, at present at least **27** of G/W's report have been found in the fossil record and additionally **12** families[261] have been detected – thus altogether **39 families** (including the Restionaceae even 40 families).[262]

From 23 documented monocot families to 39 is a growth to almost 170 % (169,57 %). ***So, for the monocot families Darwin's "abominable mystery" has become even more "abominable" and "mysterious" during the last 150 years than ever before.***

According to APG:

Including the entire research during more than 250 years of paleobotany: at least[263] **37 of 77 (48 %)** monocot families and fossils of all **11 (100 %)** orders have been found (along with the one category without taxonomical rank: also, all **12,** again **100%)** of higher systematic categories have been identified, which are currently recognized and counted according to the *Angiosperm Phylogeny Website* of the *Missouri Botanical Garden* (2021)[264], presently being the standard for botanical systematics almost worldwide (including orders, families, characters, references and more).

Conclusion regarding the APG system: All the 11 monocot orders (plus 1 group without taxonomic rank) and 37 families of them – i.e., completely all, which have been detected so far – belong to the Living Fossils, displaying constancy/stasis for eons.

Yet, although somewhat mitigated, my comment of 1971 on the incompleteness of the fossil record of the angiosperms still appears to be correct: Yes, the fossil record is incomplete. "Nevertheless, whoever assumes that the

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[261] Incidentally, **these 12 additionally detected monocot families are also 'new' as compared to the fossil documentation by Chesters, Gnauck and Hughes in Harland et al. (1967)**.

[262] In the table above (according to APG IV: 2016/2017/2021), the following families of G/W are missing: Sparganiaceae (now sunk into Typhaceae), Najadaceae (now placed in Hydrocharitaceae), Lemnaceae (now in Araceae) and Centrolepidaceae (presently in Restionaceae) – nevertheless, Typhaceae, Hydrocharitaceae, Araceae, and Restionaceae are represented in the fossil record.

Also, in APG several new families have been "created" often consisting of just one genus and one or a few species (see family Doryanthaceae etc. above), families which previously had been subsumed under other (larger) families. Appears to me **somewhat contradictory**: Systematically long recognized families (see Engler and Prantl 1887/1915 and many further authors) have been sunk into others, whereas many very small (often Australian) genera have now been risen to family rank.

[263] Consider the differences between G/W and APG. And further families will most probably be detected by addition research.

[264] See again: http://www.mobot.org/MOBOT/research/APweb/

fossil material is extremely incomplete, must necessarily also conclude ***that the number of orders [and families] and in general the diversity of forms of the angiosperms of the Cretaceous far exceeded that of today*** - which would make the "angiosperm problem" even far more problematic than it already is in the eyes of most evolutionary theorists."[265]

So far in the article I have repeatedly used the term stasis in the form of "**age range/constancy/stasis during…**" – hence, a further look at the term "stasis" may not be inappropriate. This is how ten (10!) evolutionary biologists have defined it (2005, p. 133/134) – among them the first author who, together with Stephen Jay Gould, applied the term (long used in medicine and some other subjects) to paleontology in 1972 – still being valid in 2021:

> "Stasis is generally defined as little or no net accrued species-wide morphological change during a species-lineage's existence up to millions of years — instantly begging the question of the precise meaning of ''little or no'' net evolutionary change. All well-analyzed fossil species lineages, as would be expected, display variation within and among populations, but ***the distribution of this variation typically remains much the same even in samples separated by millions of years*** (Fig. 1). This view of fossil variation has been reinforced over the past decade as paleontological studies have applied higher sampling intensities in time and space, improvements in both relative and absolute stratigraphic dating, more comprehensive use of multivariate statistical analysis, and better controls for sampling biases."[266]

See also my article on *Elephant Evolution* (2019, especially pp. 5 to 18), the discussion with an evolutionary geologist on: *Paleontology and the Explosive Origins of Plant and Animal Life* (2018), the book on the *Evolution of the Giraffe* (2011) as well as the Chapter *Dynamic genomes, morphological stasis, and the origin of irreducible complexity* in the book Dynamical Genetics of 2004.[267]

On the basis of data of paleontology, genetics, anatomy and further biological disciplines, my inference concerning the monocot families, which have not been found in the fossil record so far, is that future research will most probably

[265] http://www.weloennig.de/Staatsexamensarbeit.pdf (1971, p. 64). In this context the following observation may also be relevant: "Man fragt sich, wie überhaupt bei einem derart fragilen Material, wie es Blätter und Blüten im Vergleich zu tierischen Hartteilen sind, doch noch so viel überliefert werden konnte." ("One wonders how so much of such a fragile material, as leaves and flowers are compared to animal hard parts, could have been preserved.")

[266] Niles Eldredge, John N. Thompson, Paul M. Brakefield, Sergey Gavrilets, David Jablonski, Jeremy B. C. Jackson, Richard E. Lenski, Bruce S. Lieberman, Mark A. McPeek, and William Miller II: The dynamics of evolutionary stasis. *Paleobiology*, 31(2), 2005, pp. 133–145. See full article here:
https://www.researchgate.net/publication/228362712_The_dynamics_of_evolutionary_stasis. (See especially also their explanatory Figure 1 on p. 134.)
After the comments cited above, the authors continue (pp. 134/135): "Although it is now clear that some fossil species lineages do indeed accrue morphological change through time (Geary 1995), it is also now evident that many do not. Well-documented examples of stasis range from Paleozoic brachiopods (Lieberman et al. 1995) to late Cenozoic bivalves (Stanley and Yang 1987) and bryozoans (Jackson and Cheetham 1999). Inventories of evolutionary tempo and mode across entire clades are sparse, but Jackson and Cheetham's (1999) survey of well-documented case studies in the Neogene fossil record found **52 instances of stasis and only two instances of anagenesis** in nine benthic macroinvertebrate clades, and eight instances of stasis as opposed to 10–12 instances of anagenesis in marine microplankton. Anagenesis occurs in only eight of 88 trilobite lineages in the Ordovician of Spitsbergen, and in but one of 34 scallop lineages in the northern European Jurassic (Jablonski 2000). Studies of extant taxa with rich fossil records provide mounting evidence that ***morphologically defined species-level lineages recognized in fossil sequences often correspond to genetically defined species in the modern biota*** (Jablonski 2000)." Well, as to anagenesis: Are these really examples of anagenesis ("species formation without branching of the evolutionary line of descent" … which species "accrue morphological change through time")? Could it be that **most of their examples of anagenesis are based on much a too narrow species concept**? For, contrary to their statement, most of the "genetically defined species in the modern biota" of current systematics are, in reality, **still only morphologically defined** (see in detail the 622 pp. of my book on species concepts also available on the internet: http://www.weloennig.de/Artbegriff.html *Cf.* and perhaps also the book about the origin of dog races (*Unser Haushund: Eine Spitzmaus im Wolfspelz*? 2012/2014; 407 pp.). Applying a purely morphological definition to the **dog races**, you could "create" **a new animal family with many new genera and species**. Moreover, in the fossil record examples of continuous evolution resulting in irreducibly complex structures (Behe) are missing.

Stasis: "from Greek στάσις "a standing still": https://en.wikipedia.org/wiki/Stasis

Some interesting points may also be found in the Wikipedia article on Punctuated Equilibrium (retrieved 3 October 2021): "In evolutionary biology, punctuated equilibrium (also called punctuated equilibria) is a theory that proposes that once a species appears in the fossil record, the population will become stable, showing little evolutionary change for most of its geological history.[1] This state of little or no morphological change is called stasis. When significant evolutionary change occurs, the theory proposes that it is generally restricted to rare and geologically rapid events of branching speciation called cladogenesis. Cladogenesis is the process by which a species splits into two distinct species, rather than one species gradually transforming into another. Punctuated equilibrium is commonly contrasted against phyletic gradualism, the idea that evolution generally occurs uniformly and by the steady and gradual transformation of whole lineages (called anagenesis). In this view, evolution is seen as generally smooth and continuous." https://en.wikipedia.org/wiki/Punctuated_equilibrium

[267] You can find them all on my homepage: http://www.weloennig.de/internetlibrary.html

show that the 'rest' of the families (hopefully many more will be detected) will also conform to this pattern of abrupt appearances and constancy/stasis (Living Fossils). See also the comments by paleontologist Oskar Kuhn below.

Interestingly, this inference is to a certain extent even in agreement with the following explanation of evolutionary biologist Peter Stevens on classification ("it is the phylogeny that is central") from the *Missouri Botanical Garden* in APG IV (2017/2021) on crown and stem groups:

> "There is a useful distinction to be made between crown and stem groups. The former ***are the monophyletic groups that include the extant members of a particular clade and their immediate common ancesto***r (see the figure below), ***and also any fossils that can be placed in this part of the tree***. The groups characterized in this site are such groups. Thus, Proteaceae are crown-group Proteaceae, apomorphies like the single carpel, four-merous perianth, etc., being found in their common ancestor. Stem groups, on the other hand, include all the members of that clade below the crown group to immediately after its [W.-E. L.: macro-evolutionarily imagined] split from its sister group - and all branches (which have fossil representatives only, of course) of this part of the tree [W.-E. L.: which are usually not found because they probably never existed]. Thus, stem Proteaceae would include everything after the split from its sister group, Platanaceae, but they might well be unrecognizable as the Proteaceae of these pages. ***Obviously, most of the organisms in that part of the tree are unknown, only a few fossils being placed there***, and it is also not known when/where particular apomorphies of crown group Proteaceae evolved along this branch. In the case of the stem group of angiosperms, not only is it largely unknown and probably well over 100 m.y.o., but almost certainly most of the organisms to be placed along it will be gymnospermous."[268]

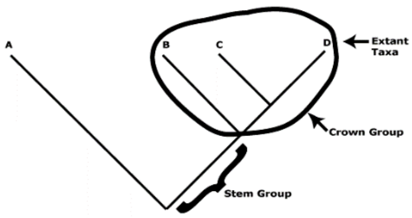

Figure by Peter Steven 2017/2021 in http://www.mobot.org/MOBOT/research/APweb/welcome.html
See his explanations in the text as quoted above. My comment: For our purposes the Crown Group corresponds to an angiosperm family with the genera B, C and D detected in the fossil record. For the postulated Stem Group the fossils are regularly missing.

Correspondingly the author has regularly formulated – above all on the basis of recent molecular data – some points under the subheading "**Age**" also for the families shown in the table above being without a fossil record so far, just to cite the first four examples shown in that table (which, incidentally, are revealing at the same time the scientific uncertainties/insecurities of such age determinations due to many contradictory phylogenetic results):

> **Tofieldiaceae**: "Age. Crown-group Tofieldiaceae are dated to ca 100 Ma (Janssen & Bremer 2004); other age estimates are 80-75 Ma (Wikström et al. 2001) and (95-)64, 61(-35) Ma (Bell et al. 2010).
>
> **Maundiaceae**: "Age. Janssen and Bremer (2004: c.f. topology; see also L.-Y. Chen et al. 2014b) suggest that the first split within this clade can be dated to ca 73 Ma, and they also give other divergence dates within it; see also Coyer et al. (2013: again, c.f. topology).
>
> **Nartheciaceae**: "Age. Crown-group Nartheciaceae are dated to ca 76 Ma (Janssen & Bremer 2004) and (92-)41(-10)Ma by Merckx et al. (2010a)."
>
> **Burmanniaceae:** "Age. Crown-group Burmanniaceae are dated to ca 93 Ma (Janssen & Bremer 2004: three genera sampled); dates in Merckx et al. (2008a), at 96.4 Ma, are similar, while Merckx et al. (2010a) suggests somewhat younger ages of (99-)75(-52) Ma.

For the additional monocot families without a fossil record so far, see please the table above and compare them with the ages provided by Stevens in his APG IV.

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[268] http://www.mobot.org/MOBOT/research/APweb/

B) Dicotyledoneae

Britannica 2021 **"Dicotyledon**, byname **dicot**, any member of the flowering plants, or angiosperms, that has a pair of leaves, or cotyledons, in the embryo of the seed. There are about 175,000 known species of dicots. Most common garden plants, shrubs and trees, and broad-leafed flowering plants such as magnolias, roses, geraniums, and hollyhocks are dicots.

Dicots typically also have flower parts (sepals, petals, stamens, and pistils) based on a plan of four or five, or multiples thereof, although there are exceptions. The ***leaves are net-veined in most***, which means the vessels that conduct water and food show a meshlike pattern. In the stems the vessels are usually arranged in a continuous ring near the stem surface. ***About 50 percent of all dicot species are woody***; they show an annual increase in stem diameter as a result of the production of **new tissue by the cambium**, a layer of cells that remain capable of division throughout the life of these plants. **Branching of stems** is common, as are taproots. The microscopic pores (stomates) on the leaf surfaces are usually scattered and are in various orientations. The pollen grains typically have three germinal furrows or pores (tricolpate condition), except in the more primitive families."[269]

Encyclopedia.com **(**Oxford University Press 2019): "Dicotyledoneae One of the two classes of flowering plants (see Anthophyta), distinguished by having two seed leaves (cotyledons) within the seed. The dicotyledons usually have leaf veins in the form of a net, a ring of vascular bundles in the stem, and flower parts in fours or fives or multiples of these. Dicotyledons include many food plants (e.g. potatoes, peas, beans), ornamentals (e.g. roses, ivies, honeysuckles), and hardwood trees (e.g. oaks, limes, beeches). Compare Monocotyledoneae. See also eudicot."

"Dicotyledoneae A former division comprising the dicotyledons. The name is no longer used."[270]

Note please the evolutionary presuppositions in the following Wikipedia article:

Wikipedia (last edited 20 Sept. 2021): The **dicotyledons**, also known as **dicots** (or more rarely **dicotyls**[2]), are one of the two groups into which all the flowering plants or angiosperms were formerly divided. The name refers to **one** of the **typical characteristics of the group**, namely that the seed has **two embryonic leaves or cotyledons**. There are around 200,000 species within this group.[3] The other group of flowering plants were called monocotyledons or monocots, typically having one cotyledon. Historically, these two groups formed the two divisions of the flowering plants.

Largely **from the 1990s onwards**, **molecular phylogenetic research** confirmed what had already been suspected, namely that dicotyledons are not a group made up of all the descendants of a common ancestor (i.e. they are not a monophyletic group) [W.-E. L.: A common ancestor has never been found – neither for the monocots nor for the dicots nor for all angiosperms.[271]] Rather, a number of lineages, such as the magnoliids and groups now

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[269] https://www.britannica.com/plant/dicotyledon
[270] https://www.britannica.com/plant/dicotyledon
[271] On this point I would like to repeat two comments of paleontologist Oskar Kuhn: "The similarity of forms was explained by evolution [and principally the same method has been applied to molecular systematics] and evolution in turn was proven by the various grades of similarities. It was hardly noticed that here one has fallen victim to **circular reasoning**; the very point that one set out to prove, namely that similarity was based on evolution, was simply assumed, and then the different degrees in the gradation of the (typical) similarities, were used as evidence for the truth of the idea of evolution. Albert Fleischmann has repeatedly pointed out the lack of logic in the above thought process. The same idea, according to him, was used interchangibly as assertion and as evidence. However, similarity can also be the result of a plan, and ...morphologists such as Louis Agassiz, one of the greatest morphologists that ever lived, attributed the similarity of forms of organisms to a creation plan, not to evolution."

Also, "The prejudice that the phylogenetic history of life could only be an accumulation of the smallest variational steps and that a more complete knowledge of the paleontological documents would prove [the assumed] gradual evolution, is deeply rooted and widely accepted.But the paleontological facts have long spoken against this prejudice! Especially German paleontologists such as Beurlen, Dacqué and Schindewolf have emphatically pointed out that in many animal groups such a rich, even overwhelming amount of fossil material exists collectively known as the basal angiosperms, diverged earlier than the monocots did; in other words monocots evolved from within the dicots as traditionally defined. The traditional dicots are thus a paraphyletic group. The eudicots are the largest clade within the dicotyledons. They are distinguished from all other flowering plants by the structure of their pollen. Other dicotyledons and monocotyledons have monosulcate pollen, or forms derived from it, whereas eudicots have tricolpate pollen, or derived forms, the pollen having three or more pores set in furrows called colpi." [272]

The first question could be whether the paleontological situation may be basically different for the dicots. Well, yes: insofar as many ***dicots appear to be much better represented in the fossil record than most monocots***[273] – as the discussion for the following 28 families (following G/W again) will show I hope (I chose the first 10 dicot families of G/W of their altogether ca. 130 (subfamilies not included). My only reason for this shortcut is this: I would need at least twelve additional months to process/work on all the dicot the families listed by G/W. However, the following sample should already be sufficient to illustrate the astonishing amount of LIVING FOSSILS in this group as well.

G/W: Reihe Verticillatae (according to APG IV now Order Fagales)

Fam. Casuarinaceae

Encyclopedia.com (Oxford University Press 2019): "**Casuarina (family Casuarinaceae)** A genus of xeromorphic trees in which the twigs are slender, cylindrical, green, and grooved with whorls of minute scale leaves at the nodes. The flowers are tiny, borne in compound spikes, and become woody in the fruit, like small cones. They are wind-pollinated. The roots have nitrogen-fixing nodules. The genus may perhaps be related to the Hamamelidaceae. There are ***4 genera and about 70 species***, occurring from the Mascarenes to Polynesia, with most species in Australia."[274]

APG IV (2017/2021): "Casuarinaceae are easily recognised, ***looking as they do rather like some kind of conifer***. The minute leaves are whorled, and the carpelate inflorescence forms a small cone. The bracteoles that gape widely at maturity to release the samaras are very distinctive.
…Age. The beginning of divergence within Casuarinaceae has been dated to (65.7-)56.2(-45.3) Ma (X.-G. Xiang et al. 2014). … **Classification**. Although the monophyly of *Causarina* s.l. has never been in doubt, ***it has been split into four genera***, themselves monophyletic.[275]

Britannica 2021: **Casuarinaceae**, the beefwood family of dicotyledonous flowering plants, with ***two genera*** (Casuarina, 30 species; Gymnostoma, 20 species) of trees and shrubs, many of which have a distinctly pinelike aspect when seen from afar. They are naturally distributed in tropical eastern Africa, the Mascarene Islands, Southeast Asia, Malaysia, Australia, and Polynesia. Some, especially the beefwood (C. equisetifolia, also

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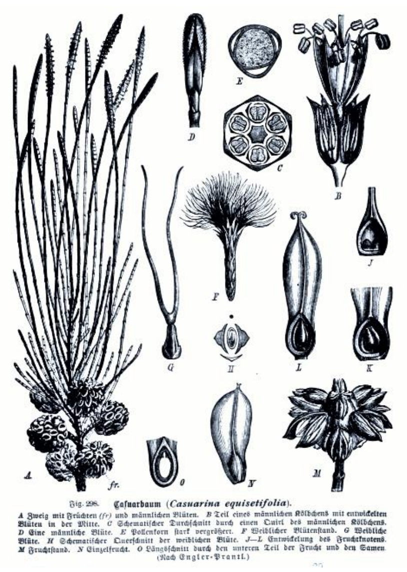
(foraminifers, corals, brachiopods, bryozoans, cephalopods, ostracods, trilobites etc.), that **the gaps between the types and subtypes must be viewed as real**". For the references see Lönnig (2011, pp. 6 and 20): The Evolution of the Long-Necked Giraffe (*Giraffa camelopardalis* L.) - What do we really know? Testing the Theories of Gradualism, Macromutation, and Intelligent Design. *Cf.* also Lönnig (2018): Paleontology and the Explosive Origins of Plant and Animal Life. A Dialogue with an Evolutionary Geologist on Gradualism and Intelligent Design. http://www.weloennig.de/internetlibrary.html - On a series of really surprising contradictions within molecular phylogenies and also between molecular and morphological phylogenies, see, for example Casey Luskin as cited in Lönnig (2014 pp. 299-301): *Unser Haushund - Eine Spitzmaus im Wolfspelz? Oder beweisen die Hunderassen, dass der Mensch von Bakterien abstammt*?
See again http://www.weloennig.de/internetlibrary.html
Cf. also Stephen C. Meyer (2013): Darwin's Doubt. The Explosive Origin of Animal Life and the Case for Intelligent Design. HarperCollin, New.York.

[272] https://en.wikipedia.org/wiki/Dicotyledon
[273] Why? May have something to do, *inter alia*, with the fact that "About 50 percent of all dicot species are woody."
[274] https://www.encyclopedia.com/plants-and-animals/botany/botany-general/casuarina
[275] http://www.mobot.org/MOBOT/Research/APweb/welcome.html

called she-oak, ironwood, Australian pine, whistling pine, or swamp oak), also are used ornamentally in warm-climate countries, where they have often escaped cultivation and become established in the wild.

The plants are characterized by slender, green, often drooping branches that are deeply grooved and that bear, at intervals, whorls of tiny, scalelike leaves. Long plant hairs that protrude from the grooves are thought to function as protective structures for the stomates (microscopic pores to the internal tissues), which are located along the side walls of the grooves. These structural features serve as adaptations to the dry conditions of the coastal strands and poor soils where these plants often grow. The structurally reduced flowers are separately male and female; both sexes may occur on the same plant (monoecious condition) or on separate plants (dioecious condition). **Male flowers** occur in elongated, slender, erect clusters (catkins or spikes), usually at branchlet tips, and each consists of a single pollen-producing stamen, together with two small, scalelike floral leaves (sepals or bracts) and two smaller scalelike structures called bracteoles. The **female flowers** occur in dense globular clusters that ***become woody and conelike at maturity***, the woody segments enclosing the seeds. Each female flower is a **petalless**, two-chambered structure (pistil) with two ovules, both in the same chamber. Two long style branches or stigmas extend from the upper end of the pistil beyond the flower cluster. Pollination is by wind.

Older classification systems held this family to be the **most primitive** of dicotyledonous plants, but the flowers and other primitive-appearing characteristics are **now considered to be reduced** rather than primitive [W.-E. L.: perhaps they are neither nor – has to be further investigated]. Several species of *Casuarina*, especially *C. equisetifolia*, are valued for their ***hard, dense, yellowish to reddish brown wood***, which is strong and reputed to be resistant to termite attack. **Beefwood and ironwood** are common names that reflect the colour and hardness of this wood."[276]






First row, left to right: *Casuarina equisetifolia* (E. Gilg and K. Schumann ca. 1900: Das Pflanzenreich, Hausschatz des Wissens, published by Kurt Stüber http://www.biolip.de): https://es.wikipedia.org/wiki/Casuarinaceae. Middle: *Casuarina suberosa* (now *Allocasuarina littoralis*) (Edward Minchen 1897): https://de.wikipedia.org/wiki/Kasuarinengew%C3%A4chse. Right: *Gymnostoma poissonianum* (Scott Zona from Miami, Florida, USA 2010): Same Wikipedia site as before.

Below: Left: *Allocasuarina distyla* cones and flowers (John Tann from Sydney, Australia 2008: "Un ejemplo de flores femeninas y seudo-conos en *Allocasuarina distyle*): https://es.wikipedia.org/wiki/Casuarinaceae. Middle: *Gymnostoma deplancheanum* (Denis.prévôt 2005): https://en.wikipedia.org/wiki/Gymnostoma. Right: *Allocasuarina decaisneana* (Cgoodwin 2004) https://en.wikipedia.org/wiki/Allocasuarina

[276] https://www.britannica.com/plant/Casuarinaceae

Fossil Record:

G/W (1964, p. 404/1973, p. 444): Fam. Casuarinaceae (Order Fagales):

"Ein Casuarinaceenholz (*Casuarinoxylon japonicum*) beschreibt Shimakura aus dem Senon Japans" ("Shimakura describes a casuarina wood (*Casuarinoxylon japonicum*) from the Senon[277] [up to **86.3 Ma**] of Japan").

C/B/H (1993, p. 816): "…there is **one Upper Triassic** [up to ca. **237 Ma**] taxon assigned tentatively to the Casuarinaceae. … Johnson and Wilson (Chapter 9, vol. 2, *in* Crane and Blackmore, 1989) who note one megafossil of *Gymnostoma* in Patagonia. This is stated (as *Casuarina*) by Romero (1986a) to be Paleocene." Pollen: "*Haloragacites* (= *Triorites*) *harrisi* (form taxon) Mildenhall, 1980. Lower Paleocene [up to **66 Ma**]. New Zealand."

PBDB (2021): "**Paleocene** of Australia (1), New Zealand (3)" of total: "90 collections including 101 occurrences" (Quaternary of Australia (46 collections) Miocene of Argentina (1), New Zealand (5), Oligocene to Miocene of Australia (4), New Zealand (1) Oligocene of Australia (3), Eocene to Oligocene of Australia (1), Eocene of Argentina (5), Australia (10), New Zealand (10)).[278]

Altough only as a form taxon): *Gymnostoma antiquum*: **Paleocene.**

***fossilworks* (2021)**: Also interesting: "Environments: crater lake (6 collections), terrestrial (4), lacustrine (3), "floodplain" (2), fluvial (1), channel lag (1), lagoonal (1), mire/swamp (1), coastal (1), fluvial-lacustrine (1), fluvial-deltaic (1), "channel" (1)"

Age range: **55.8 to 0.0 Ma**[279]

APG IV (2017/2021): "**Age**. The beginning of divergence within Casuarinaceae has been dated to **(65.7-)56.2(-45.3) Ma** (X.-G. Xiang et al. 2014)

Material from the **Eocene ca 52.2 Ma** from Patagonia has been placed in *Gymnostoma* (Zamaloa et al. 2006)." (Living Fossil genus of the Fam. Casuarinaceae.)

Postulated evolutionary node age (if there was any):

"**Age**. The age of this node is about 302-211 Ma (Forest et al. 2005: huge confidence intervals), around 76.7 Ma (Sauquet et al. 2012), about 143 or 88 Ma (Grimm & Renner 2013), or (80.3-)74.0(-66.9) Ma (X.-G. Xiang et al. 2014)."[280]

Robert S. Hill et al. (2020): "*Gymnostoma* has by far the earliest, most extensive and best preserved macrofossil record, beginning in the **Late Paleocene**."[281]

Family Casuarinaceae: Constancy/stasis at least for some 55.8 Ma: Living Fossils. However, if "Upper Triassic" is correct, the age range/constancy/stasis lasted 237 Ma.

Genus *Gymnostoma*: Late Paleocene (Thanecian) up to 59.2 Ma.

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[277] Senon: Now Santonian, Campanian and Maastrichtian.
[278] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55442
[279] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55442
[280] http://www.mobot.org/MOBOT/research/APweb/
[281] Robert S. Hill, Sung Soo Whang, Vera Korasidis, Bradley Bianco, Kathryn E. Hill, Rosemary Pauli, and Gregory R. Guerin A (2020): Fossil evidence for the evolution of the Casuarinaceae in response to low soil nutrients and a drying climate in Cenozoic Australia. *Australian Journal of Botany* **68**: 179-194: https://www.publish.csiro.au/BT/BT19126

G/W: Reihe Piperales (APG IV: Order Piperales[282])

Fam. Piperaceae

Encyclopedia.com (Oxford University Press 2019): "Piperaceae (peppers) A family of ***small trees, shrubs, and climbers***, in which the leaves are alternate, simple, and entire, with stipules, and glands containing an aromatic oil. The **petioles are winged**, and sheath the nodular, jointed stem. The stem form is a result of sympodial growth. The flowers are small, bisexual or unisexual, and held in spikes or racemes opposite the leaves. The ovary is unilocular and superior, with up to 4 fused carpels surrounded by scale-like bracts, but there is ***no calyx or corolla***. The fruit is a small, fleshy drupe with a single seed, often sunk into the stem. The vascular bundles are peculiarly arranged for a dicotyledon, often being irregularly scattered through the stem. *Piper nigrum* yields the condiment pepper, and is widely cultivated. There are 4 genera and more than 2000 species, found throughout the tropics and represented in most rain forests. ."[283]

Britannica 2021: "**Piperaceae**, the pepper family in the order Piperales, commercially important because of *Piper nigrum*, the source of black and white pepper. The family comprises about 5 genera, of which 2—Piper (about 2,000 species) and Peperomia (about 1,600 species)—are the most important. The plants grow as herbs, vines, shrubs, and trees and are widely distributed throughout the tropics and subtropics.

The leaves of Piperaceae, which have a pungent flavour, grow singly. The numerous flowers, lacking sepals and petals, are crowded in dense spikes. Piper species are mostly shrubs, woody vines, and small trees. Many are used in medicines and in food and beverages as spices and seasonings. Piper nigrum is a 9-metre (30-foot) woody climber native to southern India and to Sri Lanka; it is cultivated in most tropical regions where soil moisture is constant and temperatures are reliably warm."[284]


Left: *Piper nigrum* (Franz Eugen Köhler: Köhler's Medizinal-Pflanzen 1897): https://en.wikipedia.org/wiki/Piperaceae
Right: *Piper nigrum*: Getrocknete Früchte mit und ohne Perikarp. (Provenienz: Penja, Kamerun 2017): Same Wikipedia-Source.

Fossil Record:

G/W (1964, p. 404/1973, p. 444): Fam. Piperaceae: Cretaceous of Alaska.

C/B/H (1993, p. 816): "**PFR first**: *Piperites miquelianus* Goeppert 1854. Leaf. Tertiäry. Java: Dorfe Tandjung. **Comments**: **Seeds** like those of **modern *Peperonia*** were recorded by Dorofeev (1988) from the **Miocene** of Siberia and Tambov, former USSR."

[282] For the different systems, see https://en.wikipedia.org/wiki/Piperales
[283] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/piperaceae
[284] https://www.britannica.com/plant/Piperaceae

PBDB (2021): "Paleocene of France (1)" of "Total: 5 collections including 6 occurrences." Age range: "**58.70000** to 2.58800 Ma"[285]

fossilworks **(2021)**: Age range: **58.7 to 55.8** Ma. Distribution: found only at Petit Pâtis, Rivecourt (Paleocene of France)."[286]

APG IV (2017/2021): "Fossil evidence led Martínez et al. (2012, esp. 2014) to think that *Piper* originated in the early Cretaceous, a crown-group age of (117-)111(-109) Ma being driven by the attribution of a ***Late Cretaceous Colombian fossil*** [Maastrichtian: up to **72.1 Ma**] to the stem group of the extant *Schilleria* clade of neotropical Piper.[287]

Family Piperaceae: Age range/constancy/stasis ca. 72 Ma: Living Fossils.

G/W: Reihe Salicales (APG IV: Now Order Malpighiales[288])

Fam. Salicaceae

Encyclopedia.com (Oxford University Press 2019): "Willow family (Salicaceae). Willows are a diverse group of ***about 300 species*** of woody angiosperm plants in the genus Salix, family Salicaceae. Willows are widely dispersed and occur on all continents except Antarctica, but they are most diverse in cooler regions of the Northern Hemisphere. ***All willows are woody plants***, but the species vary greatly in size. Some species of willows are trees that can grow taller than 49 ft (15 m), while others are dwarf shrubs of the tundra that never get any taller than a few centimeters. … Willow plants are dioecious, meaning that particular individuals bear either male or female flowers but not both. Both types of ***flowers usually produce nectar so that pollination is by insects***. The flowers of willows are arranged in elongate inflorescences, known as catkins. The fruits are a capsule, containing **tiny seeds with tufted hairs** that make them aerodynamically buoyant so that they can be dispersed widely by the wind."[289]

Britannica 2021: "Salicaceae, or the willow family, contains ***55 genera and more than 1,000 species of deciduous or evergreen shrubs and trees***. The family is most common in the tropics and grows worldwide, except for New Zealand, and only a few species are found in Australia. *Salix* (willows; 450 species) is notorious for interspecific hybridization; with *Populus* (poplars; 35 species) it is the main temperate genus of the family. *Casearia* (180 species), *Homalium* (180 species), and *Xylosma* (85 species) are other large genera.

...in the European aspen (*P. tremula*), for example, as many as ***54 million seeds are produced each season on a single tree*** [W.-E. L. will really the fittest survive?[290]]. Solitary bees arrive as the small flowers of willows emerge, and other insects also pollinate these plants. Some species of Populus are wind-pollinated. In Salix and Populus the minute seeds have tufts of hair that aid in their dispersal." [291] (See more in the two articles just cited.)

Wikipedia 2021: The Salicaceae are a family, the willow family, of flowering plants. The traditional family (Salicaceae sensu stricto) included the willows, poplar, aspen, and cottonwoods. Genetic studies summarized by the Angiosperm Phylogeny Group (APG) have greatly expanded the circumscription of the family to contain ***56 genera and about 1220 species***, including the Scyphostegiaceae and many of the former Flacourtiaceae.

In the Cronquist system, the Salicaceae were assigned to their own order, Salicales, and contained three genera (Salix, Populus, and Chosenia). Recognized to be closely related to the Violaceae and Passifloraceae, the family is placed by the APG in the order Malpighiales.

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[285] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55398&is_real_user=1
[286] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55398#
[287] http://www.mobot.org/MOBOT/research/APweb/
[288] http://www.mobot.org/MOBOT/research/APweb/
[289] https://www.encyclopedia.com/social-sciences-and-law/anthropology-and-archaeology/north-american-indigenous-peoples-religion/salicaceae
[290] See Details in http://www.weloennig.de/NaturalSelection.html and several further articles here: http://www.weloennig.de/internetlibrary.html
[291] https://www.britannica.com/plant/Malpighiales/The-Salicaceae-group#ref992387

Under the new circumscription, ***all members of the family are trees or shrubs that have simple leaves with alternate arrangement*** and temperate members are usually deciduous. Most members have serrate or dentate leaf margins, and those that have such toothed margins all exhibit salicoid teeth; a salicoid tooth being one in which a vein enters the tooth, expands, and terminates at or near the apex, near which are spherical and glandular protuberances called setae. Members of the family often have flowers which are reduced and inconspicuous, and all have ovaries that are superior or half-inferior with parietal placentation."[292]

"The leaves and bark of the willow tree have been mentioned in ancient texts from Assyria, Sumer and Egypt as a remedy for aches and fever, and in Ancient Greece the physician Hippocrates wrote about its medicinal properties in the fifth century BC. … The active extract of the bark, called salicin, is metabolized into salicylic acid in the human body, and is a precursor of aspirin. In 1763, its medicinal properties were observed by the Reverend Edward Stone in England. He notified the Royal Society, which published his findings.

… **Hybrids and cultivars**: ***Willows are very cross-compatible, and numerous hybrids occur, both naturally and in cultivation***. A well-known ornamental example is the weeping willow (*Salix* × *sepulcralis*), which is a hybrid of Peking willow (*Salix babylonica*) from China and white willow (*Salix alba*) from Europe. The widely planted Chinese willow *Salix matsudana* is now considered a synonym of *S. babylonica*."[293]

First row. Left: Weeping willow (for the hybrid: see text above) (part of photo by Avraham 2005). Right: *Salix cinera* flowers ((BCB 2009): Both photographs from https://commons.wikimedia.org/wiki/File:Weeping_Willow_by_Pond.jpg
Row below. From left to right: (1) *Populus nigra* (Otto Wilhelm Thomé 1885). (2) and (3): Two photos composed to one figure: Left some poplar trees, right flying poplar fluff with enormous numbers of seeds (ca 54 million per year: see text above) (Sciencia58 2020): https://de.wikipedia.org/wiki/Pappeln. Right: *Oncoba spinosa* flower (Jeppestown 2010): https://commons.wikimedia.org/wiki/File:Oncoba_spinosa_flower_1.jpg

Fossil Record:

G/W (1964, p. 404-405/1973, p. 444-46): Fam. Salicaceae: Probably Cretaceous.

C/B/H (1993, p. 832): "**PFR first**: *Credneria integerrina* Zenker, 1833. Leaf. **Upper Cretaceous** [up to ca **72 Ma**], Germany: Blankenburg."

[292] https://en.wikipedia.org/wiki/Salicaceae
[293] https://en.wikipedia.org/wiki/Willow

And again **C/B/H (1993, p. 832)** on the same family: "**PFR first**: *Dryoxylon jenense* Schleiden, 1853. Wood. **Middle Triassic** [up to ca. **247 Ma**], Germany: near Jena. **Comments:** Well-substantiated Salicaceae occur in the uppermost Paleocene (*Populus*) and Lower Eocene (*Salix*) of North America. Middle Eocene examples of both genera are based on connected foliage and reproductive organs (Manchester *et al*. 1986)."

PBDB (2021): "Total: 297 collections including 541 occurrences" Oldest:" **Cretaceous** of Argentina (1), Canada (1: British Columbia), Spain (1), United States (37: Georgia, New Mexico, North Dakota, South Carolina, Utah, Virginia, Wyoming)"[294] Age range: "Maximum range based only on fossils: base of the Middle Albian to the top of the Holocene or **109.00000** to 0.00000 Ma. Minimum age of oldest fossil (stem group age): **100.5** Ma."[295]

***fossilworks* (2021)**: "Total: 289 collections including 509 occurrences." Age range: "**99.7 to 0.0 Ma** Ma."[296]

Surprisingly most age ranges **in APG IV (2017/2021)** are lower: "Crown Salicaceae have been dated to (50-)47, 40(-37) Ma (Wikström et al. 2001), (71-)63, 61(-55) Ma (Bell et al. 2010), **(87-)79.2(-72.8) Ma** (Xi et al. 2012b: table S7)".[297]

Family Salicaceae according to PBDB: Age range/constancy/stasis up to ca. 109 Ma. Yet, as claimed by APG IV: up to 'only' about 79 Ma. However, PFR first: 247 Ma. Whatever age determinations will finally be shown to be correct: The family belongs to the Living Fossils.

G/W: Reihe Myricales (APG IV: Now Order Fagales)

Fam. Myricaceae

Encyclopedia.com (Oxford University Press 2019): "**Myricaceae** A family of shrubs whose alternate leaves are dotted with aromatic, resinous glands. The flowers are monoecious or dioecious and borne in catkins. Male flowers have no bracteoles and 2–16 stamens, females have bracteoles and tiny, one-celled ovaries. The fruit is a nut or a drupe. There are ***3 genera, with about 50 species***, found through most of the world."[298]

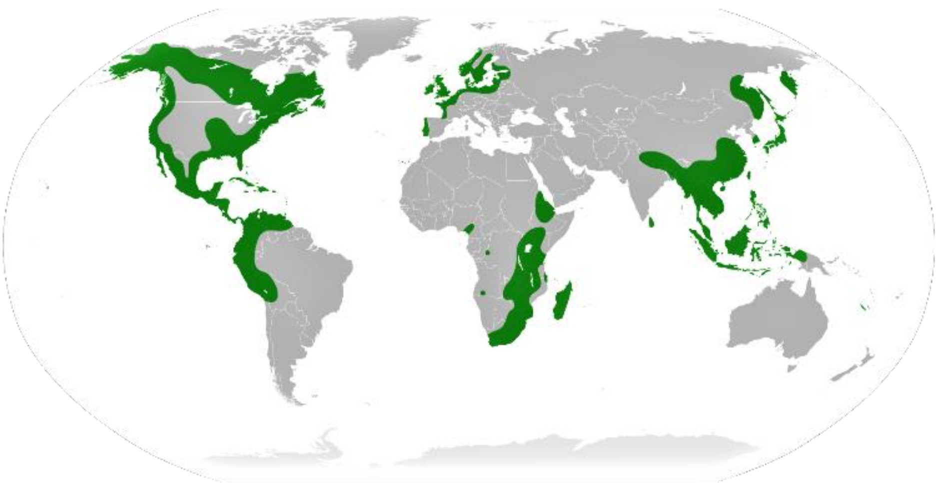
Britannica 2021: "**Myricaceae**, the wax myrtle family of dicotyledonous flowering plants, in the beech order (Fagales), found throughout the world, with three genera of trees and shrubs having aromatic leaves. Many of the species bear yellow glandular dots on the surface, from which the characteristic odour of these plants emanates, and have ***single-seeded fruits*** often covered with waxy granules, bumps, or layers. The flowers are small, greenish, and inconspicuous and usually are separately male and female on the same or different plants in clusters called catkins. Male flowers have 2 to 16 (but usually 4) stamens, or pollen-producing structures, attached just above two small scalelike bracteoles. The female flowers consist of a one-chambered ovary composed of two carpels (structural segments) that are extended on top into a two-branched style (pollen-receptive organ), the whole associated with two or four bracteoles.

[294] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54581
[295] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54581&is_real_user=1
[296] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54581
[297] http://www.mobot.org/MOBOT/research/APweb/
[298] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/myricaceae

Useful plants within the family include the sweet gale, or bog myrtle (*Myrica gale*), a shrub of wet areas with resinous leaves useful in medicines; the wax myrtle, or candleberry (*M. cerifera*), a tall shrub or small tree growing to about 11 metres (35 feet); and bayberry (*M. pennsylvanica*), which yields a wax used in candles. The sweet fern (*Comptonia peregrina*) is a small aromatic shrub of eastern North America, the leaves of which have been used in folk medicines and as a seasoning."[299] – *Myrica*: "Shrubs usually with nitrogen-fixing bacteria…"[300]

"Bacterial/Fungal Associations. Both AM and/or ECM associations have been reported from Myricaceae (e.g. Rose 1980)."[301]





Upper row. From left to right: *Myrica gale* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Gagelstrauchgew%C3%A4chse Middle: *Myrica faya* (photo by ? 2006): https://en.wikipedia.org/wiki/Myricaceae. Right: Morella cerifera (Forest & Kim Starr 2003: fruit: Location Florida, Sarasota (from Plants of Hawai): https://da.wikipedia.org/wiki/Pors-familien
Second row: Range of the Myricaceae family (Ninjatacoshell 2014 derived from http://www.mobot.org/MOBOT/research/APweb/; (but colour now green). https://en.wikipedia.org/wiki/Myricaceae

Fossil Record:

G/W (1964, p. 405-407/1973, pp. 446-448): Family Myricaceae: Upper Cretaceous [some **72 Ma**]: Evidence/proof by characteristic structures of the epidermis in *Myrica pseudoquercifolia*.

C/B/H (1993, p. 827): "**PFR first**: *Myricophyllum longepetiolatum* C. von Ettinghausen, 1893 (post-13 April). Leaf. Cretaceous, Australia: Queensland, between Warragh and Oxley." However, "This use of the genus is nomenclaturally invalid as it is a junior homonym of *Myricophyllum* G. Saporta, 1862, assigned to the Proteacea." Yet, as claimed by Blackmore 1989: Megafossils diagnostic of Myricaceae not earlier than Eocene.

[299] https://www.britannica.com/plant/Myricaceae
[300] D. J. Mabberley (1987, p. 386): The Plant Book. Cambridge University Press.
[301] http://www.mobot.org/MOBOT/research/APweb/

Pollen: Santonian [**86,3 Ma**], eastern USA ("aff. *Triatriopollenites* sp. (form genus)…)."

PBDB (2021): "Total: 180 collections including 244 occurrences." Oldest: "**Cretaceous** of Antarctica (1), United States (7: Colorado, North Dakota, South Carolina, Wyoming)."

Age range: "Maximum range based only on fossils: base of the Early/Lower Cenomanian to the top of the Holocene or **99.60000** to 0.00000 **Ma**. Minimum age of oldest fossil (stem group age): **93.5 Ma**"[302]

***fossilworks* (2021)**: Total: 177 collections including 241 occurrences. Most ancient: "**Cretaceous** of Antarctica (1), United States (5: Colorado, North Dakota, Wyoming)"

"Age range: **99.7** to 0.0 **Ma**."[303]

Incidentally: The species *Myrica torreyi* is from the Cretaceous of the Hell Creek Formation[304], dated to be **67-66 Ma**.

APG IV (2017/2021): "**Age**. An age of (81.7-)69.7(-60.4) Ma for crown-group Myricaceae is suggested by X.-G. Xiang et al. (2014).

Fossil pollen attributed to the family is Cretaceous-Cenomanian (**97.5-91 Ma**) in age (H.-L. Li et al. 2015)."[305]

Family Myricaceae: Age range/constancy/stasis up to 99.7 Ma: Living Fossils.

G/W: Reihe Juglandales (APG IV: Now Order Fagales)

Fam. Juglandaceae

Encyclopedia.com (Oxford University Press 2019): "**Juglandaceae** A family of trees in which the leaves are pinnate, with no stipules. The flowers are small, unisexual, and bracteate, and borne in spikes or catkins. They are wind-pollinated, and have an inferior ovary. The fruit is a drupe or nut, sometimes attached to a wing-like bract. The family yields several useful timbers (e.g. **walnut and hickory**) and fruits (e.g. **walnut and pecan**). There are **7 genera, with 59 species**, most of which occur in northern temperate regions, but a few of which are tropical."[306]

Britannica 2021: "**Juglandaceae**. The large and economically important Juglandaceae, or the walnut and hickory family, contains **7–10 genera and 50 species**, which are distributed mainly in the north temperate zone but extend through Central America along the Andes Mountains to Argentina and, in scattered stands, from temperate Asia to Java and New Guinea."[307]

Wikipedia 2021: "The **Juglandaceae** are a plant family known as the walnut family. They **are trees, or sometimes shrubs**, in the order Fagales. Members of this family are native to the Americas, Eurasia, and Southeast Asia. The **nine or ten genera in the family have a total of around 50 species**, and include the commercially important nut-producing trees walnut (*Juglans*), pecan (*Carya illinoinensis*), and hickory (*Carya*). The ***Persian walnut, Juglans regia***, is one of the major nut crops of the world. Walnut, hickory, and gaulin are also valuable timber trees while pecan wood is also valued as cooking fuel.

[302] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55441
and https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55441&is_real_user=1
[303] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55441
[304] https://www.mindat.org/taxon-9063691.html See also: Markus Kretschmer: https://www.dieweissensteine.de/index.php/2021/08/15/die-pflanzen-aus-der-hell-creek-formation/
[305] http://www.mobot.org/MOBOT/research/APweb/
[306] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/juglandaceae
[307] https://www.britannica.com/plant/Fagales#ref992760

Members of the walnut family have ***large, aromatic leaves*** that are usually alternate, but opposite in *Alfaroa* and *Oreomunnea*. The leaves are pinnately compound or ternate, and usually **20–100 cm** long. The trees are wind-pollinated, and the flowers are usually arranged in catkins.

The fruits of the Juglandaceae are often confused with drupes but are accessory fruit because the outer covering of the fruit is technically an involucre and thus not morphologically part of the carpel; this means it cannot be a drupe but is instead a drupe-like nut."[308]

Upper row. From left to right: *Juglans regia* (Köhler's Medizinal-Pflanzen 1897): https://it.wikipedia.org/wiki/Juglans_regia. Middle: And, from a somewhat different perspective, again *Juglans regia* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Walnussgew%C3%A4chse Right: Right: *Juglans regia* (Rasbag 2006): https://en.wikipedia.org/wiki/Juglandaceae. **Second row**. Left: Walnut (same Wikipedia article). Middle: "Fruits and leaves of *Alfaroa costaricensis*. Costa Rica, northern Cordillera de Talamanca, Savegre valley near San Gerardo, ca. 2300 m": https://en.wikipedia.org/wiki/Alfaroa. Right: *Carya cordiformis* maturing fruit. Arnold Arboretum of Harvard University, accession #22672*B.: https://en.wikipedia.org/wiki/Carya_cordiformis

Fossil Record:

G/W (1964, p. 407-408/1973, pp. 449-450): Family Juglandaceae: Cenomanian (**100.5-93.9 Ma**): "Numerous leaves, pollen, and especially unmistakable fruit remains prove that since the **Cenoman** they probably were as richly (formenreich) developed in Europe, North America and East Asia as they are today. ***The fossil genera are the same as those of today***. The species are related to the recent ones."[309]

C/B/H (1993, p. 823): "**PFR first**: *Juglandiphyllum integrifolium* W. M. Fontaine, September-December 1889. Leaf. **Lower Cretaceous**, USA: Virginia, White House Bluff." Pollen: "*Momipites fragilis* type. Nichols, *in* Muller, 1981. Lower Campanian, USA."

PBDB (2021): "Total: 532 collections including 821 occurrences." Oldest: "Cretaceous of Argentina (2), Canada (3: Alberta, Saskatchewan), China (1), Mexico (1), United States (4: Georgia, New Mexico, North Dakota, South Carolina)."

[308] https://en.wikipedia.org/wiki/Juglandaceae

[309] Original German text: "Zahlreiche Blätter, Pollen, und besonders unverkennbare Fruchtreste beweisen, dass sie in Europa seit dem Cenoman wohl ebenso formenreich entwickelt waren, wie heute in Nordamerika und Ostasien. Die fossilen Gattungen sind die gleichen wie die heutigen. Die Arten mit den rezenten verwandt."

However, PBDB and the following sources do not include the Lower Cretaceous finds. So, their age ranges are correspondingly lower: "Maximum range based only on fossils: base of the Santonian to the top of the Holocene or **86.3**0000 to 0.00000 Ma.

Minimum age of oldest fossil (stem group age): **83.6 Ma**"[310]

***fossilworks* (2021)**: "Total: 416 collections including 576 occurrences" Most ancient: "Cretaceous of Canada (1: Saskatchewan), China (1), Mexico (1), United States (3: New Mexico, North Dakota, South Carolina)

"Age range: **84.9** to 0.0 Ma ."[311]

APG IV (2017/2021): "Age. Crown-group Juglandaceae are **estimated to be around 85.8 Ma** (Sauquet et al. 2012), (96.4-)79.9-(71.2) Ma (X.-G. Xiang et al. 2014; see also J.-B. Zhang et al. 2013) or ca 81.4 Ma (Mu et al. 2020)."[312]

Family Juglandaceae: Age range/constancy/ stasis: Between 79.9 Ma and 100.5 Ma: Living Fossils. And "The fossil genera are [often] the same as those of today."

G/W: Reihe Fagales (APG IV: Order Fagales)

Fam. Betulaceae

Encyclopedia.com (Oxford University Press 2019): "**Birch family (Betulaceae)** The birch family is a group of flowering plants of tree or shrub form that includes the **birches (*Betula*), alders (*Alnus*), hornbeams (*Carpinus*), and hazels (*Corylus*)**. Members of the birch family have simple and alternate leaves that bear appendages (stipules) where they join the branch. The leaves are deciduous, generally thin, and often doubly toothed along the margin. The flowers are densely borne on elongate, spikelike structures called **catkins**. Each catkin bears flowers of only one sex, but **male and female catkins occur on the same plant**. Female catkins are stiffer and fewer-flowered than male catkins. The **flowers lack petals or sepals**, although some species have small scale-like appendages that represent reduced perianth parts. **Pollination** occurs in the spring by the **wind**. The fruit is a one-seeded nut or nutlet that is often winged and enclosed or surrounded at the base by leaf-like appendages called bracts. The family includes **six genera and about 170 species worldwide**."[313]

Britannica 2021: "**Betulaceae**, family of **six genera and about 145 species** of woody flowering plants (order Fagales). Members of the family are distributed in temperate and subarctic areas of the Northern Hemisphere, where some reach the northern limit of woody plants; in tropical mountains; and in South America through the Andes as far south as Argentina. … **Major genera and species** The family Betulaceae can be divided into two subfamilies: Betuloideae, with the genera *Betula* (birch) and *Alnus* (alder); and Coryloideae, with the genera *Carpinus* (hornbeam), *Corylus* (hazelnut), *Ostrya* (hop-hornbeam), and *Ostryopsis*. The genus *Betula*, with approximately 60 species, is the largest in the family. "[314]

Wikipedia 2021: "**Betulaceae**, the birch family, includes **six genera** of deciduous nut-bearing trees and shrubs, including the birches, alders, hazels, hornbeams, hazel-hornbeam, and hop-hornbeams numbering a total of **167 species**. They are mostly natives of the temperate Northern Hemisphere, with a few species reaching

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[310] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54584

[311] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54584

[312] http://www.mobot.org/MOBOT/research/APweb/ By the way: "There are recent reports of Engelhardtioideae (as *Alatonucula*, also pollen records) from the early Eocene of Patagonian Argentina, **far to the south of the current distribution of the subfamily**, in deposits at least 47.8 Ma (Hermsen & Gandolfo 2016). Indeed, **Several extant genera found fossil in North America and especially Europe do not grow there now (Manchester 1987)**; for the early Caenozoic fossil history **of what are now East Asian endemics**, see Manchester et al. (1987, 2009). Thus, fossil pollen of the monotypic *Rhoiptelea*, now known from southwestern China and adjacent Vietnam, is **found in eastern North America** (Fu 1992), while Cyclocarya**, now endemic to China, is known pretty much throughout the Northern Hemisphere**, the oldest fossils being from Palaeocene deposits in western North America (J.-Y. Wu et al. 2017). Friis et al. (2011) note that some fossils that are very similar to *Rhoiptelea chiliantha* have a half-inferior ovary; the ovary of *Rhoiptelea* is presumably secondarily superior."

[313] https://www.encyclopedia.com/plants-and-animals/zoology-and-veterinary-medicine/veterinary-medicine/betulaceae

[314] https://www.britannica.com/plant/Fagales#ref992760

the Southern Hemisphere in the Andes in South America. Their typical flowers are catkins and often appear before leaves.

In the past, the family was often divided into two families, Betulaceae (Alnus, Betula) and Corylaceae (the rest). Recent treatments, including the Angiosperm Phylogeny Group, have described these two groups as subfamilies within an expanded Betulaceae: Betuloideae and Coryloideae."[315]

Larger birch trees: **Seeds: ca. 30 million (30 000 000!) each** year (will really 'the best', the fittest survive, if any?[316]). Maximal age around 120 years.[317]

Upper row. Left: *Betula pendula* (Otto Wilhelm Thomé 1885). Middle: *Betula pendula*, Inari wilderness, Finnland (Percita at Flickr 2006) both from https://en.wikipedia.org/wiki/Betula_pendula Right: Stamm und Rinde einer Sandbirke (*Betula pendula*) (Rüdiger Kratz, St. Ingbert 2006): https://de.wikipedia.org/wiki/H%C3%A4nge-Birke
Second row: Left: Betula leopoldae: "A fossil leaf from the extinct *Betula leopoldae*. 48.5 million years old; Klondike Mountain Formation. Republic, Ferry County, Washington, USA. Stonerose Interpretive Center # SR 02-22-19" (Kevmin 2019): https://en.wikipedia.org/wiki/Birch
Middle: "Port d'un noisetier cultivé. Eclosion des bourgeons, à la fin du mois d'avril" (Port noisetier 2012): https://commons.wikimedia.org/wiki/File:Port_noisetier.JPG. Right: "Hazelnuts (*Corylus avellana*) - whole with kernels" (Ivar Leidus 2021): Same Wikipedia page as before.

Fossil Record:

G/W (1964, p. 409/1973, p. 451-452): Family Betulaceae: Probably already Cretaceous.

C/B/H (1993, p. 813): "Crane…recognized **modern *Alnus* and modern *Betula*** (Betuleae) as well defined by the Middle Eocene [**56-33.9 Ma**], based on multiple organ evidence. The earliest reproductive structures of *Alnus* are late Paleocene in age and foliage from Maastrichtian [**72.1-66 Ma**] onwards may represent Betuleae. Coryleae are represented in the Upper Paleocene [Thanetian: **59.2-56 Ma**] by **nuts like those of *Corylus***, and by the extinct genus *Palaeocarpinus* with associated foliage." Pollen: *Alnipollenites eminens* (form taxon),

[315] https://en.wikipedia.org/wiki/Betulaceae
[316] See, please perhaps again: http://www.weloennig.de/NaturalSelection.html and Evolution by Natural Selection – Unlimited and Omnipotent? Some ironic and factual comments on today's main evolutionary hypothesis. This and further articles at http://www.weloennig.de
[317] Rainer Flindt (2000): Biologie in Zahlen. 5. Auflage (pp. 126 and 162). Spektrum Akademischer Verlag. Heidelberg. Number of seeds per year according to several authors.

Miki 1977, Santonian, Japan. *Betulaceoipollenites* (form genus) Jarzen and Norris, 1975, Santonian, Canada." Santonian: **86.3-83.6 Ma**.

PBDB (2021): "Total: 503 collections including 898 occurrences.

Earliest: Cretaceous of Antarctica (1), Canada (4: Alberta, British Columbia), United States (1: Texas)."[318]

Age range: "Maximum range based only on fossils: base of the Early/Lower Cenomanian to the top of the Holocene or **99.6**0000 to 0.00000 Ma

Minimum age of oldest fossil (stem group age): **93.5 Ma**." [319]

fossilworks (2021): "Total: 433 collections including 820 occurrences." Earliest: "Cretaceous of Antarctica (1), Canada (3: Alberta, British Columbia), United States (1: Texas)." *Alnus perantiqua*: "When: Milk River Formation, Early/Lower Cenomanian (**99.7 - 94.3 Ma**)"[320]

According to APG IV (2017/2021): "Age. **Crown-group Betulaceae may be around 131-115 Ma** (Forest et al. 2005: large confidence intervals), about 64 Ma (Sauquet et al. 2012), about 63-43 Ma (Grimm & Renner 2013: preferred age, one estimate twice this), (72.5-)64.4(-59.4) Ma (X.-G. Xiang et al. 2014), (88.6-)85.9(-83) Ma (H.-L. Li et al. 2015: Alnus sister to the rest of the family) or (74.3-)70.5(-66.6) Ma (Z. Yang et al. 2019). A crown age of 25 Ma was suggested by Quirk et al. (2012: stem - ?what - 36 My) and (74.9-)69.5(-63.7) Ma by X.-Y. Yang et al. (2018)."[321]

Family Betulaceae: Age range/constancy/stasis up to 99.9 Ma: Living Fossils.

G/W: Fam. Fagaceae (Reihe/ Order: Fagales

Encyclopedia.com (Oxford University Press 2019): "**Fagaceae** An important family of evergreen or deciduous trees in which the leaves are simple, with stipules. The flowers are unisexual, often borne in catkins, and are apetalous, with an inferior ovary. The fruit is a nut within a cupule, the fruits held in clusters of 1–4. Many of these trees yield valuable timber. There are **7 genera**, including *Castanea* (sweet chestnut), *Castanopsis*, *Fagus* (beech), *Lithocarpus*, *Nothofagus* (southern beech), *Quercus* (oak), and *Trigonobalanus*, with about **1050 species**, concentrated in the northern hemisphere and absent from Africa."[322]

Britannica 2021: "**Fagaceae**, or the oak and beech family, contains about **1,000 species unevenly distributed among 7 or 8 genera**. The largest genus in Fagaceae is ***Quercus* (oaks), with about 400 species**, mostly limited to the warmer parts of the Northern Hemisphere. The greatest concentrations of species of oaks are in the southeastern to southwestern United States and Mexico, in eastern Asia (China and Japan), and in the area from the Mediterranean to Caucasia.

Fagus (beeches) is a genus of about 10 species in the Northern Hemisphere, with the greatest diversity in China and Japan, where about seven species are found. A single variable species, *F. grandifolia* (American beech), occurs in eastern North America and Mexico, and another, *F. sylvatica*, is found in Europe.

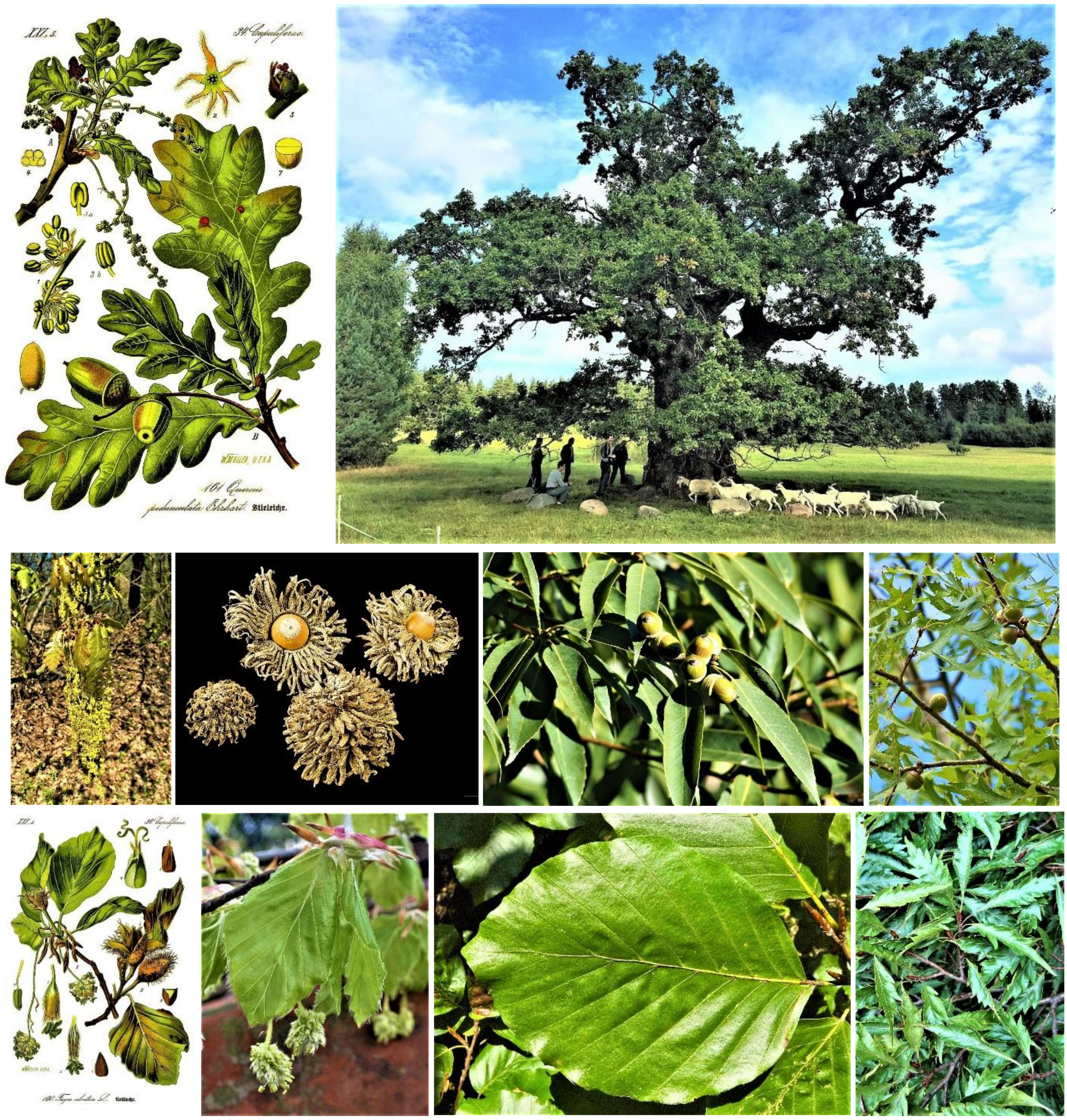
The 12 or so species of the genus *Castanea* (chestnut) also show a worldwide distribution in temperate areas of the Northern Hemisphere, again with the greatest diversity in eastern Asia. The two species of *Chrysolepis*

[318] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54589
[319] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54589&is_real_user=1
[320] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54589 and http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=54589&max_interval=Cretaceous&country=Canada&state=Alberta&is_real_user=1&basic=yes&type=view&match_subgenera=1
[321] http://www.mobot.org/MOBOT/research/APweb/
[322] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/fagaceae

(chinquapin) are confined to the western United States. The two remaining genera, *Lithocarpus* (120 species) and *Castanopsis* (about 110 species), are almost exclusively restricted to eastern and southeastern Asia."[323]

Wikipedia 2021: "Fagaceae is a family of flowering plants that includes beeches and oaks, and comprises **eight genera with about 927 species**. … The Fagaceae are often divided into five or six subfamilies and are generally accepted to include 8 (to 10) genera (listed below). Monophyly of the Fagaceae is strongly supported by both morphological (especially fruit morphology) and molecular data.

The Southern Hemisphere genus *Nothofagus*, commonly the southern beeches, was historically placed in the Fagaceae sister to the genus *Fagus*, but recent molecular evidence suggests otherwise."[324]



Upper row. Left: *Quercus robur* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Eichen. Right: Grīdnieku ancient oak in Rumbas parish, Latvia, girth 8.27m, 2015 (Spekozols 2015): https://en.wikipedia.org/wiki/Oak. **Second row**. From left to right: (1) *Quercus petraea* (Willow 2007): https://de.wikipedia.org/wiki/Eichen. Same Wikipedia source for the next three pictures: (2) *Quercus ithaburensis* ssp.*macrolepis* (Photo by Didier Descouens 2012). (3) *Quercus myrsinifolia* (Chinese evergreen oak) ('harum.koh from Kobe city, Japan' 2015). (4) Quercus palustris (Philmarin 2009). **Third row**. Left to right: (1) *Fagus sylvatica* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Rotbuche. Same Wikipedia source for the next three photos: (2) *Fagus sylvatica*: Leaf and inflorescence appearing at the same time in spring; note the silky hair in young leaves (Willow 2007). (3) Leaf of European Beech (*Fagus sylvatica*). (4) *Fagus sylvatica* forma *asplenifolia* (part of a photo by Rufus46 2008).
See fossil a series of Pliocene (3.6 Ma) leaves of different tree species in https://link.springer.com/article/10.1007/s12542-020-00538-3 (2021). Database MORPHYLL for fossil leaves from Miocene to Paleocene (up to **66 Ma**) https://palaeo-electronica.org/content/2018/2114-database-of-fossil-leaves (*cf*. PDF)

[323] https://www.britannica.com/plant/Fagales#ref594766
[324] https://en.wikipedia.org/wiki/Fagaceae

Fossil Record:

G/W (1964, p. 409-414/1973, p. 452-455): Family Fagaceae: **Numerous species known from Cretaceous** and Tertiary.

C/B/H (1993, p. 821): "Crepet … considered castaneoid and trigonobalanoid inflorescences with pollen, fruits and associated foliage in Paleocene[up to **66 Ma**]/Eocene of North America as the earliest unequivocal Fagaceae. He suggested an uppermost Cretaceous origin for the family based upon this simultaneous appearance of multiple organ fossils ***comparable with both modern tribes***. … Fossil wood, named *Notofagoxylon*, from Upper Cretaceous of South America may be the earliest megafossil of the family (noted in Hill 1991a; Romero 1986b."

Pollen: "*Nothofagidites senectus* (form taxon). Dettman and Playford, 1969, Santonian, Australia. *Tricolporopollenites* sp. (form genus). Rouse et al., 1971. Santonian/Campanian, Canada. Castanea, Zagwijn *in* Muller, 1981. Lower Campanian, Netherlands."

Santonian, Canada." Santonian: **86.3-83.6 Ma**.

PBDB (2021): "

"Total: 343 collections including 605 occurrences."

Earliest: "Cretaceous of Antarctica (1), Canada (4: Alberta, British Columbia), United States (1: Texas)."[325]

Age range: "Maximum range based only on fossils: base of the Albian to the top of the Holocene or **113.0**0000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): **100.5 Ma.**[326]

***fossilworks* (2021):** "Total: 442 collections including 706 occurrences."
Earliest: "Cretaceous of Canada (9: British Columbia, Saskatchewan), Mexico (1), Portugal (1), United States (122: Colorado, Georgia, Kansas, Montana, New Mexico, North Dakota, South Carolina, South Dakota, Wyoming)." … "Age range: **99.7 to 0.0 Ma**."[327]

According to APG IV (2017/2021):

Age. Estimates for the crown age of the family are **37-34 Ma** (Wikström et al. 2001), **77-67 Ma** (Cook & Crisp 2005), **(45-)31, 28(-16) Ma** (Bell et al. 2010), **or (103.6-)84.7, 82.3(-64.2) Ma** (Sauquet et al. 2012); see Grímsson et al. (2016: Table 2) for more suggestions. The oldest Fagaceae fossils are some **90 Ma old** (Crepet et al. 2004 for references), while Grímsson et al. (2016) discuss fossils from Wyoming assignable to stem Quercoideae and Fagoideae, as well as to an extinct clade of Fagaceae, in deposits that are dated to 81-80 Ma.

Fagus 50 Ma from British Columbia; Mindell et al. 2007; Kvacek 2008; Denk et al. 2012; Bouchal et al. 2014; Grímsson et al. 2015a: Eocene of W. Greenland).

Past ***distributions may differ from those of today***. Thus, fossils of *Lithocarpus*, now basically South East **Asian-Malesian**, are widespread in the northern hemisphere, and there have also been preliminary reports of fossils of Fagaceae from Early Eocene deposits in **Argentinian Patagonia** (M.-Q. Liu & Zhou 2006; Hermsen & Gandolfo 2016). These latter have been confirmed: ca 52 Ma fruiting fossils of *Castanopsis rothwellii*, to be included in crown-group *Castanopsis*, have recently been described from Palaeocene deposits in Argentina; leaves, probably of this species, were originally described as *Tetracera*, in Dilleniaceae (Wilf et al. 2019a). This recent description of *Castanopsis* has occasioned some interest; a number of other taxa from these Argentinian deposits are **now known only from forests in Australasia**, suggesting perhaps that *Castanopsis* itself may have moved from North to South America, thence to Australia, and finally to (Indo-)Malesia. There it and a number of other genera also known fossil from these deposits like *Ceratopetalum*, *Papuacedrus*, *Ripogonum*, *Agathis*, *Dacrycarpus*, *Eucalyptus*, *Casuarina* and *Todea*, ***all of which have since become extinct in South America***, are

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[325] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=52764&is_real_user=1
[326] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=52764
[327] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54589 and http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=54589&max_interval=Cretaceous&country=Canada&state=Alberta&is_real_user=1&basic=yes&type=view&match_subgenera=1

now to be found (Wilf et al. 2019a: biome conservatism; see also Kooyman et al. 2019 for southern elements in the **Malesian flora**).

…Fossil acorns of ***Quercus*** in particular are known from ca **44 Ma** deposits in Oregon (Manchester 1994), but ***there are probably older fossils*** (fossil pollen to ca **56 Ma**) that can be placed here - see in particular Hofmann et al. (2011b), Barrón et al (2017), also Mensing (2014: California oaks).[328]

ScienceDirect (2009): "**Fagaceae** [with several **excellent photographs of fossils**: pollen, leaves, inflorescences and stems] Evidence from pollen suggests that the Fagaceae originated ***prior to the Santonian*** **[86.3-83.6 Ma]** ***(mid-Late Cretaceous)*** (Wolfe, 1973). The family includes two subfamilies, the Castaneoideae and the Fagoideae. Castaneoid inflorescences have been described from the middle Eocene of Tennessee (Crepet and Daghlian, 1980)."[329]

Family Fagaceae: Maximal age range/constancy/ stasis 113 Ma: Living Fossils.

G/W: Reihe Urticales (APG IV: Now Order Rosales[330])

Fam. Ulmaceae

Encyclopedia.com (Oxford University Press 2019): "**Ulmaceae** A family of **trees** with simple, alternate leaves, often asymmetrical at the base, and with small, usually ***hermaphrodite flowers in dense clusters on the twigs***. The flowers have a 4–8-lobed perianth with imbricate lobes, 4–8 stamens opposite the perianth lobes, and an ovary of 2 fused carpels. They are **wind-pollinated**. The tiny, dry or fleshy **fruits are often winged**. Modern classifications recognize some **16 genera, with about 140 species**, mostly in the northern temperate zone."[331]

Britannica 2021: "**Ulmaceae**, the elm family (order Rosales), with **6–7 genera of about 45 species of trees and shrubs**, distributed primarily throughout temperate regions. Several members of the family are cultivated as ornamental plants, and some are important for their wood.

Physical description Members of the family are deciduous or evergreen and characteristically have **watery sap**. The simple **leaves** are borne alternately along the stem, usually have **toothed edges**, and often are lopsided at the base. The small flowers **lack petals** and can be bisexual or unisexual. Male and female flowers are borne together or apart on the same plant. The fruit is a samara.

Major genera and species The genus *Ulmus*, the elms, contains about **35 species** of shade and ornamental trees. Some of the six species of trees and shrubs in the Eurasian genus Zelkova are also planted as ornamentals. Members of both genera are also used as timber trees.

The planer tree, or water elm (*Planera aquatica*), of southeastern North America, produces useful timber known as false sandalwood. It is the only member of its genus.

Thorn-elm (*Hemiptelea davidii*) is the sole member of its genus and is native to Asia. Members of the genus *Holoptelea* are found in Asia and Africa and are used locally as medicinal plants.

Ampelocera and *Phyllostylon* are largely **rainforest trees** found in South and Central America"[332]

APG IV (2017/2021): "**Ulmaceae** Trees, deciduous; (growth sympodial, apex of innovation aborts); (ectomycorrhizae +); lignans +; (wood fluoresces); unicellular hairs smooth; torus-margo pits +; cystoliths usu. pegless; terminal bud of innovation aborts; **leaves** two-ranked, lamina vernation laterally (vertically) conduplicate-plicate, **secondary veins going into teeth, (margin entire), stipules extrapetiolar; flowers perfect and mixed; 4-5(-8)-merous;** P spiral, (connate); A extrorse; tapetal cells 2-3-nucleate; endothecial thickenings U-shaped; pollen 4-7-porate, exine rugulose; at least one stigma/style with 3(-5) vascular bundles; ovule (with bistomal micropyle), outer integument ca 4 cells across, inner integument ca 4 cells across, parietal tissue ca 5 cells across, nucellar cap ca 2 cells across; fruit a samara; **seeds** flattened, coat undistinguished, exotestal cells elongated, unthickened; chalazal endosperm haustorium +, (polyembryony +); x = 14, often terminal/subterminal diffuse-complex centromeres, nuclear genome [1 C] (0.014-)1.162(-39.572) pg; 69bp ndhF deletion.

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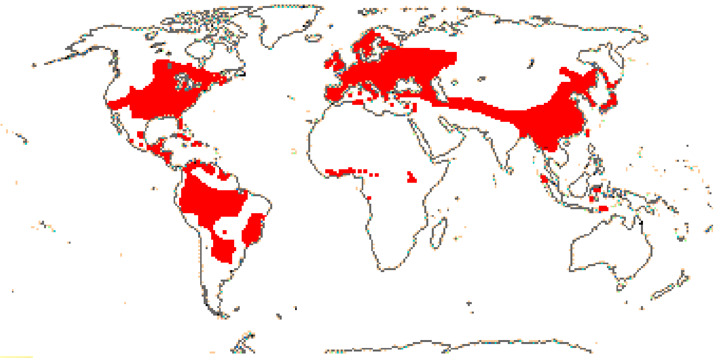
[328] http://www.mobot.org/MOBOT/research/APweb/
[329] https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/fagaceae
[330] "Urticales is an order of flowering plants. ***Before molecular phylogenetics became an important part of plant taxonomy, Urticales was recognized in many, perhaps even most, systems of plant classification, with some variations in circumscription***." https://en.wikipedia.org/wiki/Urticales
[331] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/ulmaceae
[332] https://www.britannica.com/plant/Ulmaceae

7 [list]/56: ± **Word-wide, but not Arctic**, South temperate, Madagascar, or the Antopdes and the Pacific. Map: from Soepadmo (1977), Hultén and Fries (1986), Fl. N. Am. 3 (1997), Todzia (1989, 1992) and Trop. Afr. Fl. Pl. Ecol. Distr. 5 (2010). Photos: Collection.[333]



First row. From left to right: *Ulmus carpinifolia* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Ulmengew%C3%A4chse. Middle: *Ulmus rubra* seeds (Original source: Ohio Department of Natural Resources page): https://de.wikipedia.org/wiki/Ulmen Right: *Ulmus glabra* ("Wych Elm (*Ulmus glabra*) foliage and seeds - photo 8 May 2005 by en:User:MPF. He released it under GFDL.") https://en.wikipedia.org/wiki/Elm

Second row. Left: The elm leaf beetle *Xanthogaleruca luteola* (photographer: Didier Descouensn 2014): https://en.wikipedia.org/wiki/Elm. Middle: *Ulmus* Sapporo Autumn Gold, Florence (Ptelea 2011). Also: https://en.wikipedia.org/wiki/Elm. Right: fossil leaf of *Ulmus fischeri* (Botanischen Garten Dresden): https://de.wikipedia.org/wiki/Ulmen

Fossil Record:

G/W (1964, pp. 414-415/1973, pp. 456-458): Family Ulmaceae: Tertiary and **Upper Cretaceous**. "*Ulmus* L. ist schon im Oligozän [up to sicher vorhanden gewesen und durch Blätter, in Mitteleuropa z. B. *Ulmus longifolia* UNG., *U. carpinoides* GOEPP., u. a. auf der ganzen Nordhalbkugel belegt (Abb. 331a, b, Taf. 26:7)."

C/B/H (1993, p. 821): "**PFR First**: *Celtidophyllum praeaustrale* F. Krasser, 1911. Leaf. Cretaceous, Czechoslovakia: Moravia, Kunstadt." Upper Cretaceous (Santonian-

[333] http://www.mobot.org/MOBOT/research/APweb/

Campanian). Santonian: **86.3-83.6 Ma**. Pollen: "*Triorites minutipora* (form taxon) Muller, 1968. Turonian [up to **93 Ma**], Saravak."

PBDB (2021): *Ulmus*: "Total: 97 collections including 119 occurrences." Earliest: "*Nostoceras hetonaiense* ammonoid zone, Kita-ama Formation (Izumi Group), **Early/Lower Maastrichtian** (**70.6 - 66.0 Ma**)."[334]

Ulmaceae: "Total: 390 collections including 510 occurrences." Oldest: "Cretaceous of Canada (2: British Columbia, Saskatchewan), Japan (1), Kazakhstan (1), United States (22: North Dakota, Virginia, Wyoming)."[335]

Age range: "Maximum range based only on fossils: base of the Middle Albian to the top of the Holocene *or* **109.00000 to 0.00000 Ma**. Minimum age of oldest fossil (stem group age): **100.5 Ma**.[336]

***fossilworks* (2021):** "Total: 383 collections including 498 occurrences." Earliest: "Cretaceous of Canada (2: British Columbia, Saskatchewan), Kazakhstan (1), United States (20: North Dakota)." … "Age range: **70.6 to 0.0 Ma**." [337] Rather strong difference compared to PBDB and also APG IV:

According to APG IV (2017/2021): "Age. Crown-group Ulmaceae may be **(95.2-)85.4(-76.0) Ma** (Q. Zhang et al. 2021)."…" *Ulmus* (35, species limits uncertain). North temperate, scattered in Central Asia, also Central America, scattered Western Malesia. Map: see Fragnière et al. (2021: Fig 1: d-g).

Age. The age of the crown-group temperate clade may be **(83.1-)72.59(-63.3)** Ma (Q. Zhang et al. 2021). The extant genus with the oldest known fossils is *Ulmus* itself, which has leaves and fruits in **Early Eocene** deposits in northeastern China some 50 Ma old (Q. Wang et al. 2010; see also Friis et al. 2011 for Cenozoic fossils), the age of the genus based on fossils from western North America (Manchester 1989a, b) was a little older, around **57 Ma**. This suggests an appreciably greater age for crown-group Ulmaceae as a whole." [338]

Family Ulmaceae: Minimum age range/constancy/stasis ca. 72 Ma; maximally 109 Ma: Living Fossils.

G/W: Still 'Reihe Urticales' (APG IV: Now Order Rosales[339])

Fam. Moraceae

Encyclopedia.com (Oxford University Press 2019): "**Moraceae** A family of **trees and shrubs** (**except the herb *Dorstenia***) that produce milky latex. The leaves are simple and spiral, with stipules. The flowers are unisexual, regular, small, and grouped, often on the enlarged receptacle. The fruits are often in infructescences with a fleshy receptacle or fleshy flower parts, and many are edible. There are **48 genera, with about 1200 species**, occurring mainly in the tropics and subtropics."[340]

Britannica 2021: "**Moraceae**, the mulberry family of the rose order (Rosales), with about **40 genera and some 1,000 species** of deciduous or evergreen trees and shrubs, distributed mostly in tropical and subtropical regions. Plants of the family contain a milky latex and have alternate or opposite leaves and small,

[334] *Ulmus longifolia:* https://paleobiodb.org/classic/basicTaxonInfo?a=basicTaxonInfo&taxon_name=Ulmus%20longifolia
[335] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54598
[336] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54598&is_real_user=1
[337] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54589 and http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=54589&max_interval=Cretaceous&country=Canada&state=Alberta&is_real_user=1&basic=yes&type=view&match_subgenera=1
[338] http://www.mobot.org/MOBOT/research/APweb/
[339] "Urticales is an order of flowering plants. ***Before molecular phylogenetics became an important part of plant taxonomy, Urticales was recognized in many, perhaps even most, systems of plant classification, with some variations in circumscription***." https://en.wikipedia.org/wiki/Urticales
[340] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/moraceae

petalless male or female flowers. The fruits of many species are multiple because fruits from different flowers become joined together.

Some genera produce edible fruits, such as the **mulberry** (*Morus*), **fig** (*Ficus carica*), **breadfruit and jackfruit** (*Artocarpus*), and **affon**, or African breadfruit (*Treculia*). Others, such as *Antiaris*, *Ficus*, and *Castilla*, are important for their timber and latex. The latex of the upas tree (*Antiaris toxicaria*) of Java is used as an arrow poison; the latex of the cow tree (*Brosimum utile*) of tropical America is sweet and nutritious. ***Ficus*, the largest genus in the mulberry family, contains the banyan and the India rubber tree.** The bark of the paper mulberry (*Broussonetia*) has been used for the manufacture of cloth and paper products. Among the ornamentals in the family are paper mulberry and Osage orange. "[341]

On the fig tree, *cf*. https://www.britannica.com/plant/fig [342]

APG IV (2017/2021): "**Moraceae** Largely woody; (isoflavonoids +); (cork in outer cortex); latex milky; small stalked glandular hairs +; (stomata aniso- and cyclocytic); leaves spiral, lamina vernation variable; plant dioecious (monoecious); inflorescences congested, often ± spicate [staminate] or ± globose [carpelate]; flowers 4-merous, (P 0-10); staminate flowers: bracts peltate; G (0); carpelate flowers: A 0; (G inferior), styles 1 or 2, often unequal; ovule (subapical; campylotropous), outer integument 3-4 cells across, inner integument ca 3 cells across, nucellar cap ca 5 cells across [nucellar beak]; infructescence/fruit various; exotesta ± tanniniferous; n = 12 upwards, esp. 13, 14), x = 14, chromosomes 0.5-2.7 µm long, centromeres both terminal and median, nuclear genome [1 C] (0.036-)0.833(-19.536) pg.

39 [list: to tribes]/1,137 - seven groups below. Mostly tropical to warm temperate (map: from Jalas & Suominen 1976; Wickens 1976; Frankenberg & Klaus 1980; Fl. Austral. 3. 1989; Fl. N. Am. 3. 1997; Wilmott-Dear & Brummit 2007: Asia and South America only approximate)."[343]

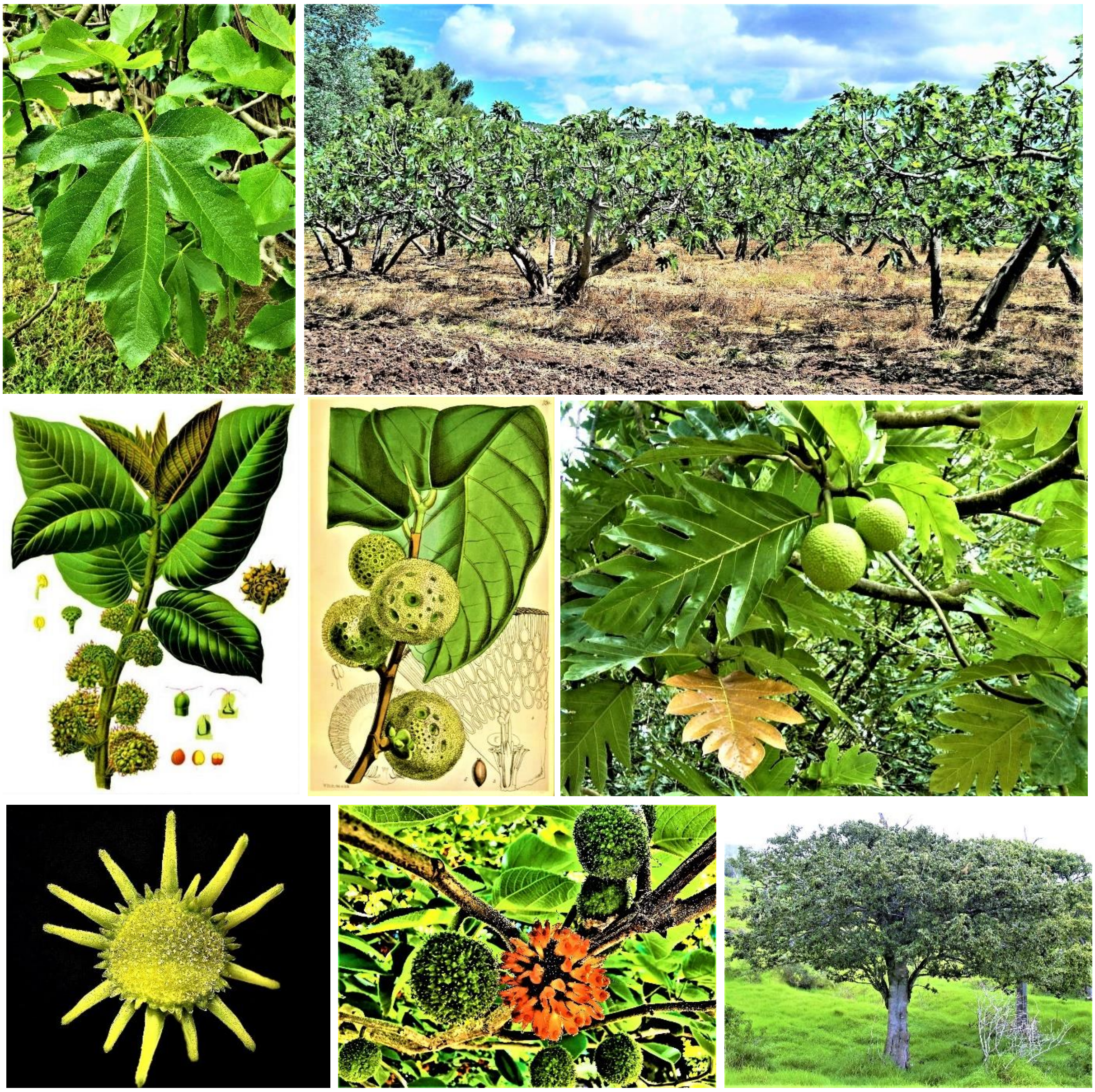
First row. Left: *Ficus carica* ("Trew, C.J., Plantae selectae quarum imagines ad exemplaria naturalia Londini, in hortis curiosorum nutrit, vol. 8: t. 73 (1771) [G.D. Ehret]"): https://en.wikipedia.org/wiki/Fig. Middle: *Ficus carica*, Brown Turkey fruit at Pali o Waipio Huelo, Maui, Hawaii (Forest and Kim 2014): https://de.wikipedia.org/wiki/Echte_Feige. Right: *Ficus carica* fruits (photo Ivar Leidus 2020): https://en.wikipedia.org/wiki/Fig

Second row. Left: *Ficus carica* fresh fruits (photo Eric Hunt 2005). Right: *Ficus carica* dried figs (taken by Deathworm 2007): https://en.wikipedia.org/wiki/Fig

[341] https://www.britannica.com/plant/Moraceae

[342] https://www.britannica.com/plant/fig For example: "The fig was one of the earliest fruit trees to be cultivated, and its cultivation spread in remote ages over all the districts around the Aegean Sea and throughout the Levant. The Greeks are said to have received it from Caria (hence the specific name); Attic figs became celebrated in the East, and special laws were made to regulate their exportation. ***The fig was one of the principal articles of sustenance among the Greeks; the Spartans especially used it at their public tables***." (And much more in this article.).

[343] http://www.mobot.org/MOBOT/research/APweb/



First row. *Ficus continued*: Left: Feuille de Figuier/Fig leaf (WAV12, 2020). Right: Fig tree orchard in the Vaucluse (part of a photograph by Marianne Casamance 2013): Both photos from https://fr.wikipedia.org/wiki/Ficus_carica
Second row. Additional genera: Left: *Castilla elastica* (Köhler's_Medizinal-Pflanzen 1897). Middle: *Treculia africana* (Joseph Dalton Hooker (1817-1911). Right: *Artocarpus altilis* (Kowloonese 2004).
Third row. *Dorstenia hildebrandtii* var. *hildebrandtii* (Frank Vincentz 2005). Middle: Paper Mulberry fruits *Broussonetia papyrifera* (Didier Descouens 2019). Right: *Streblus pendulinus*. Location: Maui/Auwahi: Hawai (Forest & Kim Starr 2004). The latter six photographs from https://de.wikipedia.org/wiki/Maulbeergew%C3%A4chse

Fossil Record:

G/W (1964, p. 416-417/1973, p. 458): Family Moraceae: (a) *Ficus* (*Ficophyllum*, *Ficoxylon*) and (b) *Artocarpus* (Blätter, Scheinfrüchte, männliche Blüten/leaves, accessory fruits, male flowers): **Upper Cretaceous** of (a) Greenland and (b) Egypt.

C/B/H (1993, p. 826): "**PFR First**: *Arthmiocarpus hesperus* (Wieland) Delevoryas, 1964. Fruit. Upper Cretaceous, USA, South Dakota, Grand River valley, slightly west of its junction with Cottonwood Creek (Wieland 1908)."

Also, same page: "**PFR First**: *Combretiphyllum acuminatum* P. Menzel, 1909. Leaf. Cretaceous Senonian, Cameroon, Balangi. Debeya serrata F. A. W. Miquel, 1853. Leaf. Upper Cretaceous: Senonian [up to **83.3 Ma**], The Netherlands: Limburg, Kunrade.

Comments: The fossil record was reviewed by Collinson (*in* Crane and Blackmore, 1989), who accepted several genera (including forms like those of modern *Ficus* and *Morus*) based on endocarps and achenes from the Lower Eocene [Ypresian up to **56 Ma**] of Eurasia." Whether all the earlier records are doubtful remained to be seen.

PBDB (2021):

Moraceae: "Total: 275 collections including 326 occurrences." Oldest: "Cretaceous of Canada (16: Alberta, British Columbia), Colombia (1), Mexico (1), the Netherlands (1), United States (40: Colorado, Georgia, Montana, New Mexico, North Dakota, South Carolina, Wyoming."[344]

Age range: "Maximum range based only on fossils: base of the **Aptian** [up to ca. **125 Ma**] to the top of the Pleistocene or **125.00000** to 0.01170 Ma.

Minimum age of oldest fossil (stem group age): 113.0 Ma."[345]

Genus *Ficus*: "Total: 189 collections including 225 occurrences." Earliest: "Cretaceous of Canada (14: Alberta, British Columbia), Colombia (1), United States (40: Colorado, Georgia, Montana, New Mexico, North Dakota, South Carolina, Wyoming)."[346]

Age range: base of the Late/Upper Albian to the top of the Early/Lower Pleistocene or **105.30000 to 0.78100 Ma**."

***fossilworks* (2021):** "Total: 251 collections including 292 occurrences".

Age range: **112.6 to 0.012 Ma**."[347]

Genus *Ficus*: Total: 182 collections including 217 occurrences.

Age range: **99.7 to 0.781 Ma**.

Earliest: Cretaceous of Canada (14: Alberta, British Columbia), Colombia (1), United States (35: Colorado, Montana, New Mexico, North Dakota, South Carolina, Wyoming)."

My comment: Despite the differences between PBDB and fossilworks, *Ficus* appeared much earlier (Late/Upper Albian **99.7 Ma**) in the fossil record than Lower Eocene (**56 Ma**, see C/B/H above).

Also, according to PBDB *Morus* seems to have been somewhat earlier: **66 Ma**: base of Paleocene[348], but definitely younger – ca. **16 Ma** – as claimed in *fossilworks*[349].

According to APG IV (2017/2021): "**Age**. Zerega et al. (2005) dated crown-group Moraceae to (110-)89.1(-72.6) Ma, while (100.6-)93.1(-85.9) Ma is the age in Gardner et al. (2017) and (84.7-)79(-73.2) Ma that in Q. Zhang et al. (2018). However, given that Misiewicz and Zerega (2012) date crown-group Dorstenia to (132.0-)112.3(-84.8) Ma, the sky - or somewhere near it - might be the limit.

Family Moraceae: Age range/constancy/stasis: up to ca. 125 Ma: Living Fossils.

Genus *Ficus*: ca. 100 Ma.

344 https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=53874
345 https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=53874&is_real_user=1
346 https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=53873
347 http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54589 and
http://fossilworks.org/bridge.pl?a=collectionSearch&taxon_no=54589&max_interval=Cretaceous&country=Canada&state=Alberta&is_real_user
https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=81716&is_real_user=1 =1&basic=yes&type=view&match_subgenera=1
348 https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=81716&is_real_user=1
349 http://fossilworks.org/?a=taxonInfo&taxon_no=39679

G/W: Still 'Reihe Urticales' (APG IV: Now Order Rosales[350])

Fam. Urticaceae

Encyclopedia.com (Oxford University Press 2019): "**Urticaceae** A family of **small trees, shrubs, or dicotyledonous** (see DICOTYLEDON) **herbs, often with stinging hairs**, with simple leaves, and only small, **usually unisexual, clustered flowers**. The flowers have a perianth of 4 or 5 segments, 4 or 5 stamens in the male flowers, and a 1-called ovary in the female. The fruits are either dry nutlets or drupes. Modern classifications recognize about **52 genera and 1050 species**, distributed widely in most regions of the world."[351]

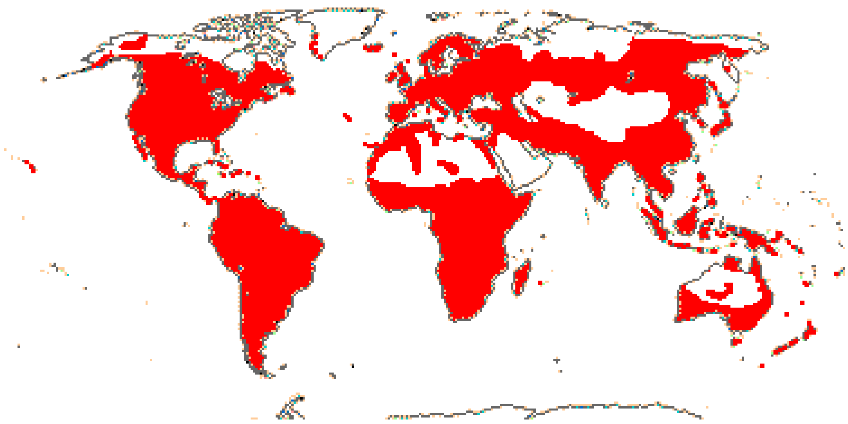
Britannica 2021: "**Urticaceae**, the nettle family (order Rosales) comprising about **54 genera and 2,625 species of herbs, shrubs, small trees, and a few vines**, distributed primarily in tropical regions. The stems and leaves of many species—especially the nettles (*Urtica)*, the wood nettles (*Laportea*), and the Australian stinging trees (*Dendrocnide*)—have ***stinging trichomes*** (plant hairs) that cause a painful rash upon contact. The long fibres in the stems of some species, such as ramie (*Boehmeria nivea*), are used in the textile industry.

Members of the family Urticaceae have varied leaves and sap that is usually watery. The **small greenish flowers** often form **clusters** in the leaf axils. Both male flowers and female flowers may be borne on the same plant, though some species are dioecious (producing male flowers on one individual and female on another). The curled stamens of the male flowers straighten quickly as the flowers open, releasing the pollen. The dry one-seeded fruit often is enclosed by the outer whorl of the flower cluster.

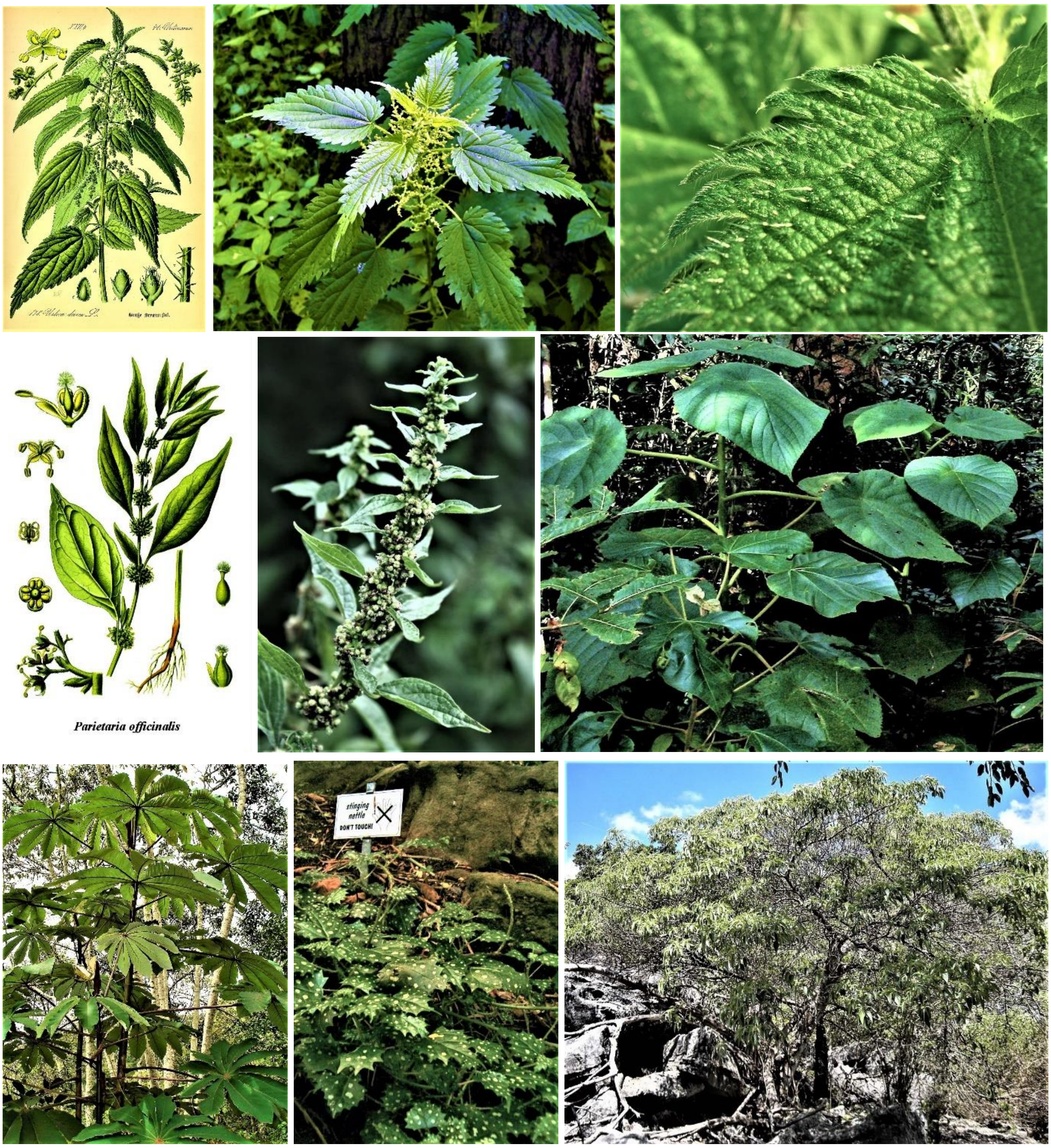
Pilea, a genus of creeping plants that includes the artillery plant (***P. microphylla***), and pellitory (***Parietaria***), a genus of wall plants, are grown as ornamentals. Baby tears (***Helxine soleiroli***), a mosslike creeping plant with round leaves, often is grown as a ground cover. The trumpet tree (***Cecropia peltata***), a tropical American species that has hollow stems inhabited by biting ants, is an extremely aggressive invasive species."[352]

APG IV (2017/2021): "**Urticaceae** Dihydroflavonols?, (furanocoumarins) +; (wood fluoresces); (wood parenchyma not lignified); laticifers (throughout the plant), latex not milky (milky); petiole bundle(s) annular or arcuate; bundle sheath extensions 0; stomata often anisocytic (paracytic, etc.); cystoliths [in lamina, stem] punctiform; lamina base often asymmetric, vernation laterally or vertically conduplicate, venation palmate, trinerved, stipules interpetiolar; P (2-)4, 5(-6); staminate flowers: anther endothecium 0; carpelate flowers: G 1; ovule basal, ± straight, both integuments often 2 cells across, (protruding into the stylar canal), (inner integument obturator, of several 1-celled thick projections in t.s.), parietal tissue 4-6 cells across, nucellar cap 2-4 cells across; fruit often a nut or achene, straight; seed coat perforated, ± crushed, but various testal/tegmic layers persisting; endosperm ± copious, (starchy), chalazal haustorium +, embryo straight; x = 7, chromosomes 0.9-1.6 µm long, protein bodies in nuclei, **nuclear genome [1 C] (0.039-)0.568(-8.35) pg**.

54 [list: to tribes]/2,625 - five groups below. World-wide, but mainly tropical. (Map: from Frankenberg & Klaus 1980; Hultén & Fries 1986; Fl. Austral. 3. 1989; Fl. N. Am. 3. 1997: ??Arabia, Central Asia). Photo: Shoot, Flower, Fruit."[353]



[350] To repeat: "Urticales is an order of flowering plants. ***Before molecular phylogenetics became an important part of plant taxonomy, Urticales was recognized in many, perhaps even most, systems of plant classification, with some variations in circumscription***." https://en.wikipedia.org/wiki/Urticales
[351] https://www.encyclopedia.com/science/dictionaries-thesauruses-pictures-and-press-releases/urticaceae
[352] https://www.britannica.com/plant/Ulmaceae
[353] http://www.mobot.org/MOBOT/research/APweb/



First row, from left to right: (1): *Urtica dioica* (Otto Wilhelm Thomé 1885): https://de.wikipedia.org/wiki/Brennnesselgew%C3%A4chse (2): Flowering *Urtica dioica* (Uwe H. Friese, Bremerhaven 2003): Same Wikipedia source as before. (3): *Urtica dioica* stinging hairs (Kószó József 2006): https://en.wikipedia.org/wiki/Urticaceae **Second row**: (1): *Parietaria officinalis* (Otto Wilhelm Thomé 1885/User: Chrizz~commonswiki/ToDo): https://de.wikipedia.org/wiki/Brennnesselgew%C3%A4chse. (2): *Parietaria officinalis* (Franz Xaver 2008): https://de.wikipedia.org/wiki/Aufrechtes_Glaskraut. (3): *Dendrocnide moroides* (Australian stinging tree) (Cgoodwin 2007): https://de.wikipedia.org/wiki/Brennnesselgew%C3%A4chse **Third row**. (1) *Cecropia glazioui* from Petropolis, Rio de Janeiro (Eurico Zimbres 2006): Same Wikipedia source as before – also the next two photos: (2): *Laportea grossa* at (Kirstenbosch National Botanical Gardens, South Africa (User:BotBln 2010). (3): *Pipturus argenteus* tree, northern Australia (Mark Marathon 2011): https://en.wikipedia.org/wiki/Urticaceae

Fossil Record:

G/W (1964, pp. 417/1973, pp. 458): Family Urticaceae: Lower Eocene (**56 Ma**).

C/B/H (1993, p. 836): No sure records prior to Upper Eocene. “Fruits like those of **modern *Pilea* and *Laportea*** occur in the **Oligocene** [Rupelian up to ca. **34 (33.9) Ma**] onwards in Europe and Asia.”

PBDB (2021): "Total: 41 collections each including a single occurrence." Earliest: "Cretaceous of United States (5: North Dakota)."[354]

"Age range: base of the Lancian to the top of the Holocene or **70.60000** to 0.00000 **Ma**."[355]

***fossilworks* (2021):** "Total: 40 collections each including a single occurrence." Earliest: "Cretaceous of United States (5: North Dakota)."

"**Age range: 66.043 to 0.0 Ma**."[356]

APG IV (2017/2021): "**Age**. The age of crown-group Urticaceae is estimated to be **(81.7-)68.7(-56.2) Ma** (Z.-Y. Wu et al. 2018) or (**104.8-)84.9(-66.3) Ma** (X. Huang et al. 2019).[357]

Family Urticaceae: Age range/constancy/stasis: up to ca. 70.6 Ma/84.9 Ma: Living Fossils.

Some Examples of Rather Recently Discovered Fossils of Dicot Families

In 1993, after some introductory notes (pp. 808-811), Collinson, Boulter and Holmes alphabetically listed and discussed 259 Angiosperm families for the "Magnoliophyta ('Angiospermae')" in Benton's *The Fossil Record 2* (pp. 811-841). However, 107 of these families noted as "PFR: No record" according the "Plant Fossil Record database version 1.0 (Holmes *et al*., 1991)", except for some fruits and pollen, which was based on Muller (1981) and occasionally Muller (1985).

In the interim additional dicot families have been detected in the fossil record, a few examples of which I'm going to mention briefly in the ensuing paragraphs (this list could be supplemented and continued through the entire alphabet)

Acanthaceae[358]

C/B/H (1993, p. 811): "PFR: No record."

PBDB (2021): "Age range. Maximum range based only on fossils: base of the Serravallian to the top of the Calabrian or **13.82000** to 0.78100 Ma. Minimum age of oldest fossil (stem group age): 11.62 Ma."[359]

***Fossilworks* (2021):** "Age range: **13.65** to 0.781 Ma."[360]

Family Acanthaceae: Age range/constancy/stasis: up to ca. 13.8 Ma Living Fossils.

[354] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55603
[355] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55603&is_real_user=1
[356] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55603
[357] http://www.mobot.org/MOBOT/research/APweb/
[358] "Acanthaceae is a family (the acanthus family) of **dicotyledonous flowering plants** containing almost 250 genera and about 2500 species." https://en.wikipedia.org/wiki/Acanthaceae
[359] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55770&is_real_user=1
[360] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55770

Akaniaceae[361]

C/B/H (1993, p. 811): "PFR: No record."

APG IV (2021): "Fossils attributed to *Akania* are known from Patagonia in deposits as old as the Palaeocene **61.7 Ma** (Iglesias et al. 2007; Gandolfo et al. 2011 and references; Wilf et al. 2011)."

PBDB (2021): "“Eocene of Argentina (6 collections), Paleocene to Eocene of Argentina (1), Paleocene of Argentina (2). Total: 9 collections including 10 occurrences."[362]

"Age range: base of the Danian to the top of the Ypresian or **66.00000** to 47.80000 **Ma**."[363]

Family Akaniaceae: Age range/constancy/stasis: up to 66 Ma: Living Fossils.

Amaranthaceae[364]

C/B/H (1993, p. 811): "PFR: No record."

PBDB (2021): "Maximum range based only on fossils: base of the Early/Lower Miocene to the top of the Calabrian or **23.03000** to 0.78100 Ma. Minimum age of oldest fossil (stem group age): 15.97 Ma."[365] (Same dates in *fossilworks*.[366])

APG IV (2021): "**Age**. A possible age for the clade is 87-47 Ma (Kadereit et al. 2012: note topology)."[367]

Family Amaranthaceae: Age range/constancy/stasis: at least up to 23 Ma: Living Fossils.

Asteraceae[368]

C/B/H (1993, p. 822): "PFR: No record." However: "Fruits like those of modern *Aesculus* are recorded in the Upper Miocene and Pliocene of Europe (Szafer, 1961) with tentative records in the Middle Miocene (Gregor 1982)."[369]

PBDB (2021): "**Cretaceous** to Paleogene of Antarctica (1). Cretaceous of Argentina (2), Canada (1: British Columbia), Mexico (1), United States (2: Montana, South Carolina). Total: 136 collections including 170 occurrences.

136 collections including 170 occurrences."[370]

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[361] Eudicots: "The Akaniaceae or turnipwood family are a family of flowering plants in the order Brassicales. It comprises two genera of trees, *Akania* and *Bretschneidera*, each with a single species. These plants are native to China, Vietnam, Taiwan, and eastern Australia." https://en.wikipedia.org/wiki/Akaniaceae
[362] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55658
[363] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55658&is_real_user=1
[364] Eudicots: "Amaranthaceae is a family of flowering plants commonly known as the amaranth family, in reference to its type genus Amaranthus. It includes the former goosefoot family Chenopodiaceae and contains about 165 genera and 2,040 species,[2][3] making it the most species-rich lineage within its parent order, Caryophyllales." https://en.wikipedia.org/wiki/Amaranthaceae
[365] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55412&is_real_user=1
[366] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55412
[367] http://www.mobot.org/MOBOT/research/APweb/
[368] https://www.britannica.com/plant/Asteraceae
[369] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54692
[370] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=183083

"Maximum range based only on fossils: base of the Santonian to the top of the Holocene or **86.30000** to 0.00000 Ma. Minimum age of oldest fossil (stem group age): **83.6 Ma**."[371]

According to ***fossilworks*** (2021): "Total: 69 collections including 88 occurrences. Cretaceous to Paleogene of Antarctica (1). Cretaceous of Argentina (2), United States (1: Montana).[372]

And the following is what **APG IV (2021)** has to say: "**Age**. Crown-group Asteraceae are dated to some **42-36 Ma** (K. J. Kim et al. 2005), (52-)**43, 40**(-31) Ma (Bell et al. 2010), or (44-)**41, 40**(-37) Ma (Wikström et al. 2001); other suggested ages are similar (Funk et al. 2009c for a summary; see also Torices 2010). However, Beaulieu et al. (2013a: 95% HPD) estimated a somewhat older crown-group age of (52-)**49**(-48) Ma, ages in Funk et al. (2014) are **47.6-47.3** m.y, in Swenson et al. (2012) they range mostly from (71.1-)**52.6, 47.4**(-45.4) Ma, in Panero and Crozier (2016) are as much as (74.4-)**64.7**(-55.1) Ma (see also Jabaily et al. 2014 for similar estimates), in C.-H. Huang et al. (2016) are ca **72.1 Ma** (or only (53-)**52.5**(-52) Ma), while ca **61.4 Ma** is the age in Denham et al. (2016), (91-)**83.5**(-64) Ma in Mandel et al. (2019) and (88-)**75**(-64) Ma (Keeley et al. 2021)... Another estimate is ca **49.6 Ma** (Ackerfield et al. 2020). On the other hand, Heads (2012) thought that the mostly Antipodean *Abrotanella*, basal Senecioneae, diverged from the rest of the tribe in the **Jurassic or Early Cretaceous**, which would imply an age for Asteraceae as a whole of around **1,500,000,000 years**, **or about a third of that age,** depending on which vicariance events you pick (Swenson et al. 2012).

Samant and Mohabey (2014) think that the **Late Cretaceous** palynomorph *Compositopollenites* from India is evidence that the family was around at this early date. Analysis of **pollen** from Antarctica dated **76-66** Ma suggests that it was from a barnadesiaceous plant, and a crown age for Asteraceae of around (91.5-)**85**.9(-82.4) Ma was suggested (Barreda et al. 2015: fig. 5, suppl.; see also discussion in *Proc. National Acad. Sci.* 113: E411, E412. 2016.), although other estimates, at (76.4-)**67.9, 55.8**(-53.6) Ma, are somewhat younger (Barreda et al. 2015: suppl.); Panero (2016) and Beaulieu and O'Meara (2018) question the placement of this fossil, which may in fact be stem [Calyceraceae + Asteraceae]." [373]

As just one example of the Asteraceae the sunflower (*Helianthus annuus*)[374]. Note the honey bee (*Apis mellifera*)[375] doing its pollination work.

Family Asteraceae: Age range/constancy/stasis: up to 86 Ma: Living Fossils. Age range strongly extended.

[371] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=183083&is_real_user=1
[372] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=183083
[373] http://www.mobot.org/MOBOT/research/APweb/
[374] Photograph by W.-E- L. See for more photos and explanations (description, mathematical model of floret arrangement, genome, history of cultivation, cultivars, heliotropism and more in https://en.wikipedia.org/wiki/Helianthus_annuus
[375] https://en.wikipedia.org/wiki/Western_honey_bee and https://en.wikipedia.org/wiki/Honey_bee ("The first Apis bees appear in the fossil record at the Eocene-Oligocene boundary (34 mya), in European deposits.")

Buxaceae[376]

C/B/H (1993, p. 811): "PFR: No record." But some pollen findings (Campanian).

PBDB (2021): "Total: 20 collections [inclusing pollen and macrofossils] each including a single occurrence." Earliest: "Cretaceous of Brazil (3), Canada (4: Alberta), South Sudan (2), United States (2: Alaska, Montana)."[377] "Maximum range based only on fossils: base of the Late/Upper Campanian to the top of the Villanyian or **83.50000** to 2.58800 **Ma**. Minimum age of oldest fossil (stem group age): **70.6 Ma**."[378]

APG IV (2021): "**Age.** *Cathiaria japonica* has been found **in rocks ca 89 Ma** from Japan and it has been placed in Buxaceae s.l. (Takahashi et al. 2017); there is a single carpel subtended by a single bract and tricolpate pollen."

Subgroup: *Didymeles*: "**Age**. Anderson et al. (2005) suggested that this node was some **111-63 Ma** old; ages in (N. Zhang et al. 2012) were ca **45 Ma** and in Wikström et al. (2001) **(107-)100, 93(-86) Ma**.

Family Buxaceae: Age range/constancy/stasis: up to ca. 89 Ma: Living Fossils

Gentianaceae

C/B/H (1993, p. 821): "PFR: No record."

PBDB (2021): "Total: 11 collections including 12 occurrences."[379] "Maximum range based only on fossils: base of the Miocene to the top of the Holocene or **23.03000** to 0.00000 Ma

Minimum age of oldest fossil (stem group age): 15.97 Ma"[380]

***Fossilworks* (2021):** Same: "Total: 11 collections including 12 occurrences." Oldest: "Oligocene to Miocene of Australia (1)."[381]

Family Gentianaceae: Age range/constancy/stasis: up to 23 Ma: Living Fossils

Geraniaceae

C/B/H (1993, p. 821): "PFR: No record."

PBDB (2021): "Total: 2 collections each including a single occurrence." "Maximum range based only on fossils: base of the Early/Lower Pleistocene to the top of the Late/Upper Pleistocene or **2.58800** to 0.01170 Ma. Minimum age of oldest fossil (stem group age): 0.781 Ma.[382]

***Fossilworks* (2021):** Same as in PBDB.[383]

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[376] Eudicots: "The Buxaceae are a small family of six genera and about 123 known species[2] of flowering plants. They are shrubs and small trees, with a cosmopolitan distribution." https://en.wikipedia.org/wiki/Buxaceae
[377] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55444
[378] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55444&is_real_user=1
[379] https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=55742
[380] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55742&is_real_user=1
[381] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55742
[382] https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55600&is_real_user=1
[383] http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=55600

APG IV (2021): "**Age.** The crown group age of Geranioideae is **estimated** at (71-)54, 48(-33) Ma (Bell et al. 2010) or some (50-)48, 37(-34) Ma (Wikström et al. 2001); Palazzesi et al. (2012) suggest an age of slightly less than 30 Ma and Park et al. (2015a) an age of ca 35 Ma, but (57-)48(-39) Ma is the figure in Sytsma et al. (2014), see also 47-38 Ma in Fiz et al. (2008), ca 39.5 Ma in Marcussen and Meseguer (2017) and (45.1-)35.8(-29.5 Ma in van de Kerke (2019), but as much as ca 67.8 Ma in Hohmann et al. (2015), similar to Sytsma et al. (2004).“[384]

Family Geraniaceae: Age range/constancy/stasis: up to 2.5 Ma: Living Fossils

Hippocastanaceae (syn. Sapindaceae)

C/B/H (1993, p. 822): "PFR: No record." However: "Fruits like those of modern *Aesculus* are recorded in the Upper Miocene and Pliocene of Europe (Szafer, 1961) with tentative records in the Middle Miocene (Gregor 1982)."[385]

PBDB (2021): "Total: 336 collections including 629 occurrences." "Maximum range based only on fossils: base of the Cenomanian to the top of the Holocene or **100.50000** to 0.00000 Ma. Minimum age of oldest fossil (stem group age): 93.9 Ma."[386]

***Fossilworks* (2021):** "Total: 179 collections including 266 occurrences." "Cretaceous to Paleogene of Antarctica (2). Cretaceous of Argentina (1), Canada (9: Alberta, British Columbia), Nigeria (1), United States (2: South Carolina, South Dakota)."

"Age range: **89.3** to 0.0 Ma."[387]

APG IV (2021): Mostly on evolutionary presuppositions, many different ages have been suggested in recent publications: "**Age.** Wikström et al. (2001) date crown-group Sapindaceae to (43-)**39, 36**(-32) Ma, Bell et al. (2010) suggested an age (53-)**42, 41**(-30) Ma, and Muellner-Riehl et al. (2016) an age of (96.9-)**87.2**(-77.4) Ma - alternatively, it is mid Cretaceous and (very approximately) **116-98** Ma (Buerki et al. 2010c). Crown and stem ages of **36 and 55 Ma** respectively were suggested by Quirk et al. (2012). **Fossils** ascribable to Sapindaceae are known from the later Cretaceous (Coetzee & Muller 1984).

Family Hippocastanaceae (syn. Sapindaceae): Fossils: Age range/ constancy/ stasis: up to ca. 100 Ma: Living Fossils. Age range strongly enlarged.

Links to some Problems of Evolutionary Plant Systematics as maintained by Peter F. Stevens in APG IV (2017/2022)

"It is the phylogeny that is central, and the names in classifications are simply names attached ***to larger or smaller branches of the phylogenetic tree*** that facilitate our discussion about larger or smaller parts of that phylogeny. A prerequisite for developing such a consensus classification is a stable phylogeny, and indeed, ***over the years family circumscriptions have*** [with some exceptions] ***been stable***." I have discussed several problems of such phylogenetic

384 http://www.mobot.org/MOBOT/research/APweb/
385 https://paleobiodb.org/classic/basicTaxonInfo?taxon_no=54692
386 https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54692&is_real_user=1
387 http://fossilworks.org/bridge.pl?a=taxonInfo&taxon_no=54692

trees, for example, in: http://www.weloennig.de/Staatsexamensarbeit.pdf (1971), http://www.weloennig.de/Artbegriff.html (1986/2002), http://www.weloennig.de/evolution/PhysalisOriginalPaper.pdf (2010), http://www.weloennig.de/ExplosiveOrigins.pdf (2018). http://www.weloennig.de/ElephantEvolution.pdf (2019), http://www.weloennig.de/HumanEvolution.pdf (2019), http://www.weloennig.de/Feduccia2020.pdf (2020).

"Imaginary forms that lived in an imaginary time in an imaginary space - that is the factual consciousness of the theory of descendance" – D. Einhorn. This applies at the very least to the origin of almost all the plant families (*cf*. Stevens above: Stem group/crown group). See also the contradictory phylogenetic reconstructions mentioned in the present article.

A Brief Note on the Origin of Angiosperms by Intelligent/ Ingenious Design

As for the scientific theory of intelligent design mentioned briefly above, I would like to refer the reader to the facts and the arguments presented in (1) Lönnig 21 August 2019, pp. 46/47 http://www.weloennig.de/HumanEvolution.pdf and (2) Lönnig 21 August 2020, pp. 50-55: http://www.weloennig.de/PlantGalls.xyz.pdf. Just to briefly repeat some of the main arguments (2020, pp. 52-53):

(1) "Intelligent design: Considering the statement (as quoted) that "even if all the data point to an intelligent designer, such a hypothesis is excluded from science because it is not naturalistic", I have noted that it virtually is a *Denkverbot* (a ban on thinking/pondering), which could also be formulated as follows: Never ask the question for a designer even in cases of the most complex and ingenious constructions ever found in nature.

Answering this dogmatic imperative, I would like to reformulate the famous aphorism ascribed to Einstein "everything should be made as simple as possible, but not simpler"[388] as follows: "Everything should be explained as naturalistically as possible, but if all the data point to an intelligent designer, we should accept it."

Could this, perhaps, be also applied to the origin of DNA? "Human DNA is like a computer program but far, far more advanced than any software ever created" – This quite rightly often cited insight of Bill Gates[389] on the complexities of DNA and its functions may shed some additional light on the origin of man (incidentally he had studied James D. Watson's "Molecular Biology of the Gene" in his twenties and was enthralled with chemistry at high school). One may consider also Gates' following comment: "[T]he mystery and the beauty of the world is overwhelmingly amazing, and there's no scientific explanation of how it came about. To say that it was generated by random numbers, that does seem, you know, sort of an uncharitable view."[390]

Now, if one is prepared to break away from the prohibition of materialistic philosophy, one could, for example, accept the following reasoning – in part according to Austrian cell physiologist Siegfried Strugger (professor of botany at the University of Münster): "The cell is the most perfect cybernetic system on earth [usually consisting of thousands of spatiotemporally precisely matched gene functions, gene interactions, cascades and pathways in a steady-state network of ingeniously complex physiological processes characterized by specified as well as (often) irreducible complexity including an abundance of information at least to the gigabyte to

[388] Ascribed to Albert Einstein: https://quoteinvestigator.com/2011/05/13/einstein-simple/ "In conclusion, Einstein may have crafted this aphorism, but there is no direct evidence in his writings."
[389] Bill Gates, The Road Ahead (London: Penguin 1996), 228. See for the context also X-Evolutionist.com: https://x-evolutionist.com/2010/04/14/dna-is-like-a-computer-program-but-far-far-more-advanced-than-any-software-ever-created-bill-gates (However, there are other positions of Gates with which I don't agree.)
[390] Bill Gates https://www.rollingstone.com/culture/culture-news/bill-gates-the-rolling-stone-interview-111915/?print=true

terabyte range]. In comparison to the cell, all automation of human technology is only a primitive beginning of man in principle to arrive at a biotechnology."[391]

Well, if [even] the first steps on the way/the path to the ingenious level of cybernetic complexities of the cell, i.e. the "primitive beginning" in Strugger's formulation, demands conscious action, imagination, perception, intelligence, wisdom, mental concepts, spirit and mind – all being already absolutely necessary for the basic start, – so how much more so does this have to apply to the origin of the thousand times more complex cybernetic systems of the life forms themselves – including all the specified and irreducibly complex structures inescapably necessary [also] for the origin of man.

P. S. As to a detailed scientific argumentation for the intelligent origin of life in its basic forms (as well as the theory of intelligent design in general), check please rigorously the books and papers by Axe, Behe, Bethell, Dembski, Denton, Eberlin, Johnson, Leisola, Lönnig, Meyer, Moreland et al. (eds.), ReMine, Sanford, Scherer, Sewell, Swift, Tour, Wells, and many others."

Methodology:

(2) "A key point of the methodology is, I would like to emphasize once again (because of its central importance), **specification** - or in Dembski's words:

"…Suppose finally that no law is able to account for the thing in question, and that any plausible probability distribution that might account for it does not render it very likely. Indeed, ***suppose that any plausible probability distribution that might account for it renders it exceedingly unlikely. In this case we bypass the first two stages of the Explanatory Filter and arrive at the third and final stage***. **It needs to be stressed that this third and final stage does not automatically yield design** - **there is still some work to do**. Vast improbability only purchases design if, in addition, the thing we are trying to explain is **specified**.

The third stage of the Explanatory Filter therefore presents us with a binary choice: attribute the thing we are trying to explain to design if it is specified; otherwise, attribute it to chance. In the first case, the thing we are trying to explain **not only has small probability, but is also specified**. In the other, it has small probability, but is unspecified. It is this category of specified things having small probability that reliably signals design. ***Unspecified things having small probability, on the other hand, are properly attributed to chance***.

The Explanatory Filter faithfully ***represents our ordinary practice of sorting through things we alternately attribute to law, chance, or design***. In particular, the filter describes

[1] how copyright and patent offices identify theft of intellectual property

[2] how insurance companies prevent themselves from getting ripped off

[3] how detectives employ circumstantial evidence to incriminate a guilty party

[4] how forensic scientists are able reliably to place individuals at the scene of a crime

[5] how skeptics debunk the claims of parapsychologists

[6] how scientists identify cases of data falsification

[7] how NASA's SETI program seeks to identify the presence of extraterrestrial life, and

[8] how statisticians and computer scientists distinguish random from non-random strings of digits.

[391] Siegfried Strugger: Botanik (Frankfurt am Main: Das Fischer Lexikon. Fischer-Taschenbuch-Verlag, 1962), 59. Comment in square brackets added. As for the question concerning comparability and identity of cybernetic systems in organisms and machines, see please http://www.weloennig.de/AuIEnt.html

…….
Why the Filter Works

The filter is a criterion for distinguishing intelligent from unintelligent causes. Here I am using the word "criterion" in its strict etymological sense as a method for deciding or judging a question. The Explanatory Filter is a criterion for deciding when something is intelligently caused and when it isn't. Does it decide this question reliably?

As with any criterion, ***we need to make sure that whatever judgments the criterion renders correspond to reality***. A criterion for judging the quality of wines is worthless if it judges the rot-gut consumed by winos superior to a fine French Bordeaux. The reality is that a fine French Bordeaux is superior to the wino's rot-gut, and any criterion for discriminating among wines better indicate as much.

...I argue that the explantory filter is a reliable criterion for detecting design. Alternatively, I argue that the Explanatory Filter successfully avoids false positives. Thus, whenever the Explanatory Filter attributes design, it does so correctly.

Let us now see why this is the case. I offer two arguments. The first is a straightforward inductive argument: in every instance where the Explanatory Filter attributes design, and where the underlying causal story is known, it turns out design actually is present; therefore, design actually is present whenever the Explanatory Filter attributes design.

My second argument for showing that the Explanatory Filter is a reliable criterion for detecting design may now be summarized as follows: the Explanatory Filter is a reliable criterion for detecting design ***because it coincides with how we recognize intelligent causation generally***. In general, to recognize intelligent causation we must observe a choice among competing possibilities, note which possibilities were not chosen, and then be able to specify the possibility that was chosen."[392]

So far these facts and inferences. The phenomena of enormous constancy/stasis of all the angiosperm Living Fossil families, often surviving eons of time under strongly different environmental conditions, including their regularly abrupt appearances in the fossil record – not speak of the ingenious complexities which characterize them all (and, of course, all the other organisms as well), – these phenomena fit seamlessly into the inference/conclusion to intelligent design, as do also the facts of mutation genetics, including the limits of variation detected[393] (and virtually so do the research results of all the other biological disciplines[394]). Complex synorganized information for specified and irreducibly complex structures arises solely by design.

I would like to suggest to the interested reader to continue applying in detail these basic insights further to the question of the origin of the angiosperms.

[392] William A. Dembski The Explanatory Filter: A three-part filter for understanding how to separate and identify cause from intelligent design An excerpt from a paper presented at the 1996 Mere Creation conference, originally titled "Redesigning Science." http://www.arn.org/docs/dembski/wd_explfilter.htm (17. März 2019).
[393] *Cf.* http://www.weloennig.de/Gesetz_Rekurrente_Variation.html, http://www.weloennig.de/Loennig-Long-Version-of-Law-of-Recurrent-Variation.pdf, http://www.weloennig.de/ShortVersionofMutationsLawof_2006.pdf, http://www.weloennig.de/Artbegriff.html
[394] And in addition to the biological and other points mentioned above: there is very much more here: From the carnivorous plants to the giraffes etc.: http://www.weloennig.de/internetlibrary.html
Note: The links in the third part of this article were set between 28 September and 24 November 2021 (*cf.* also pp. 33, 45 and 67).

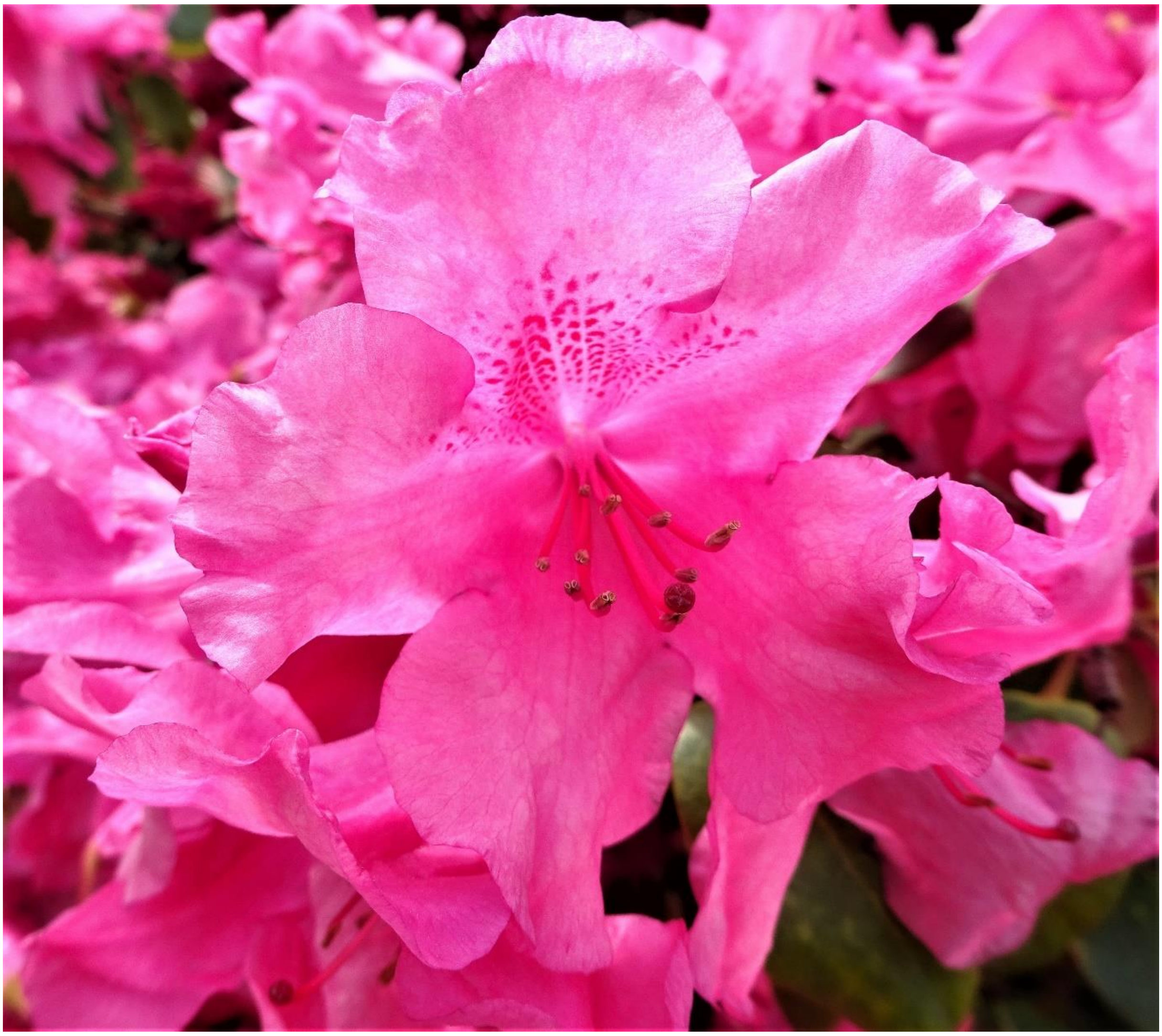
"Just a Few Flowers" continued from p. 1
(here further photos of some families and orders of fossil plants discussed above and _additionally several new families**_)**
All the following photographs by W.-E. L.

Iris sibirica L. (Fam. Iridaceae, Order Asparagales) from p. 1 above, now enlarged
Entire flower of *Iris sibirica* from different perspectives.
For the fossil record of the Fam. Iridaceae see pp. 56/57.

Flowers from *Callistemon citrinus* (Curtis/Skeels)‘splendens’ (“Flaschenputzer”)
(Fam. Myrtaceae, Order Myrtales)
Below: Individual flowers of the inflorescence can here be better recognized

Order Myrtales: “Maximum range based only on fossils: base of the Albian to the top of the Holocene or 113.00000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): 100.5 Ma”
https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54926&is_real_user=1 (24 May 2022)
See also https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54713&is_real_user=1 (24 May 2022)

Above: *Zinia elegans* L. (Fam. Asteraceae, Order Asterales)
Below: *Gazania rigens* (in different colors), Gaertn. (Fam. Asteraceae, Order Asterales)
For the fossil record of the Fam. Asteraceae see pp. 95/96 above.



Azalea spec. (possibly a *A. japonica* hybrid) (Gattung *Rhododendron* L.,
Fam. Ericaceae, Order Ericales)

Fossil record of Rhododendron: "Maximum range based only on fossils: base of the Eocene to the top of the Piacenzian or 56.00000 to 2.58800 Ma. Minimum age of oldest fossil (stem group age): 33.9 Ma"
https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=157353&is_real_user=1 (24 May 2022)

Above *Zantideschia* Spreng. (Fam. Araceae, Order Alismatales; Monocots)
For the fossil record of the Fam. Araceae see pp. 45/46 above.
Below *Phalaenopsis* (hybrid) (Orchidaceae, Order Asparagales; Monocots)
Fossil record *cf*. pp. 63-65

Above *Cattleya* Lindl., below left: *Psychopsis* Raf.;
Right *Paphiopedium* Pfitzer (all Fam. Orchidaceae, Order Asparagales; Monocots)
Fossil record *cf*. pp. 63-65

Above *Tulipa* L. (Fam. Liliaceae, Order Liliales)
Below *Vanda coerulea* Griff. ex Lindl. (Orchidaceae, Order Asparagales; Monocots)
Fossil record *cf*. pp. 63-65

Fossil record of Fam. Liliaceae: "Maximum range based only on fossils: base of the Ypresian to the top of the Holocene or 56.00000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): 47.8 Ma." https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54578&is_real_user=1 (24 May 2022)
Fossil record of Orchidaceae *cf*. again pp. 63-65

Above *Buddleja davidii* Franch. (Fam. Scrophulariaceae, Order Lamiales)
Below *Dioscorea* L. (Fam. Dioscoreaceae, Order Dioscoreales; Clade Monocots)
Fossil record of Fam. Scrophulariaceae: “Maximum range based only on fossils: base of the Oligocene to the top of the Holocene or 33.90000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): 23.03 Ma”
https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=55765&is_real_user=1 (24 May 2022)
Fossil record of **Genus *Dioscorea***: “Age range: base of the Chadronian to the top of the Late/Upper Pliocene or 37.20000 to 2.58800 Ma”
https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=320506&is_real_user=1 (24 May 2022)

Above *Mimulus* L. (of probably species) *tigrinus* (Fam. Phrymaceae, recently removed from the family Scrophulariaceae, Order Lamiales).
Below *Antirrhinum majus* L. in different colors (Fam. Plantaginaceae, Order Lamiales)

Fossil record of Order Lamiales: “Maximum range based only on fossils: base of the Late/Upper Maastrichtian to the top of the Holocene or 70.60000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): 66.0 Ma” https://paleobiodb.org/classic/checkTaxonInfo?taxon_no=54939&is_real_user=1 (24 May 2022)
Fossil record of Fam. Scrophulariaceae: “Maximum range based only on fossils: base of the Oligocene to the top of the Holocene or 33.90000 to 0.00000 Ma. Minimum age of oldest fossil (stem group age): 23.03 Ma” (24 May 2022)
Phrymaceae: “Age. The crown age may be ca 40 Ma (Nie et al. 2006: Fig. 2 - ?), ehile (43.9-)29.5(-14.6) Ma is the estimate in Tank and Olmstead (2017)” http://www.mobot.org/MOBOT/Research/APweb/orders/lamialesweb.htm#Phrymaceae (24 May 2022)

Back to Internet Library