Means Evolution

Evolution is change in the heritable characteristics of biological populations over successive generations, evolutionary processes give rise to biodiversity at every level of biological organization, including the levels of species, individual organisms, and molecules.

Also Evolution means change in the form and behavior of organisms between generations, the forms of organisms at all levels start from DNA sequences to macroscopic morphology and social behavior, can be modified from those of their ancestors during evolution.

Evolutionary biologists work with materials as diverse as naked chemicals in test tubes, animal behavior in the jungle and fossils collected from barren and inhospitable rocks.

Evolutionary biology is a large science and is growing larger cross bonding with some sciences like as molecular genetics, morphology and embryology that have accumulated their discoveries at a more stately speed over a much longer period.

In the mid-19th century Darwin defined evolution as “descent with modification” and the word “descent” refers to the way evolutionary modification takes place in a series of populations that are descended from one another and formulated the scientific theory of evolution by natural selection.

Evolution by natural selection is a process demonstrated by the observation that more offspring are produced than can possibly survive, along with **three facts about populations:**

1. Traits vary among individuals with respect to morphology, physiology, and behavior (phenotypic variation).
2. Different traits confer different rates of survival and reproduction (differential fitness).
3. Traits can be passed from generation to generation (heritability of fitness).

Recently, Harrison (2001) defined evolution as “change over time via descent with modification”.

Evolution of life cycles

All multicellular plants have a life cycle comprising two generations or phases, one is termed the gametophyte, has a single set of chromosomes (denoted 1N) and produces gametes (sperm and eggs), the other is termed the sporophyte, has paired chromosomes (denoted 2N), and produces spores. The gametophyte and sporophyte may appear identical – homomorphy – or may be very different – heteromorphy.

The pattern in plant evolution has been a shift from homomorphy to heteromorphy. The algal ancestors of land plants were almost certainly haplobiontic, being haploid for all their life cycles, with a unicellular zygote providing the 2N stage. All land plants (i.e. embryophytes) are diplobiontic that is both the haploid and diploid stages are multicellular.

Two trends are apparent: bryophytes (liverworts, mosses and hornworts) have developed the gametophyte, with the sporophyte becoming almost entirely dependent on it, vascular plants have developed the sporophyte with the gametophyte being particularly reduced in the seed plants.

It has been proposed that the basis for the emergence of the diploid phase of the life cycle as the dominant phase is that diploidy allows masking of the expression of deleterious mutations through genetic complementation.

Thus if one of the parental genomes in the diploid cells contains mutations leading to defects in one or more gene products, these deficiencies could be compensated for by the other parental genome (which nevertheless may have its own defects in other genes).

As the diploid phase was becoming predominant, the masking effect likely allowed genome size and hence information content to increase without the constraint of having to improve accuracy of replication.

The opportunity to increase information content at low cost is advantageous because it permits new adaptations to be encoded. This view has been challenged, with evidence showing that selection is no more effective in the haploid than in the diploid phases of the lifecycle of mosses and angiosperms.

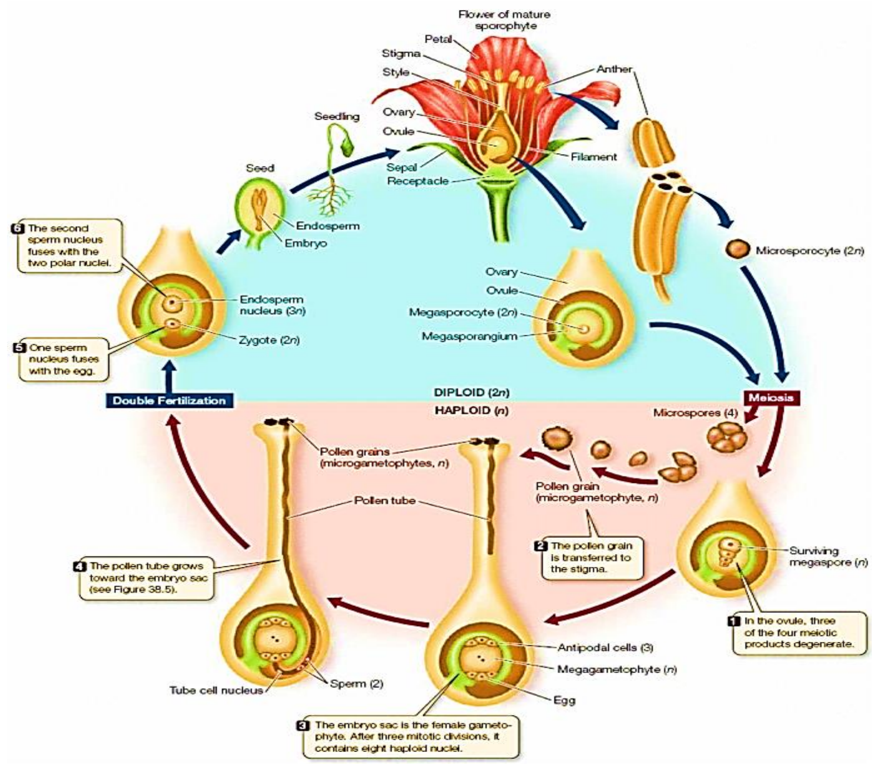


Fig 4: life cycle of plants.

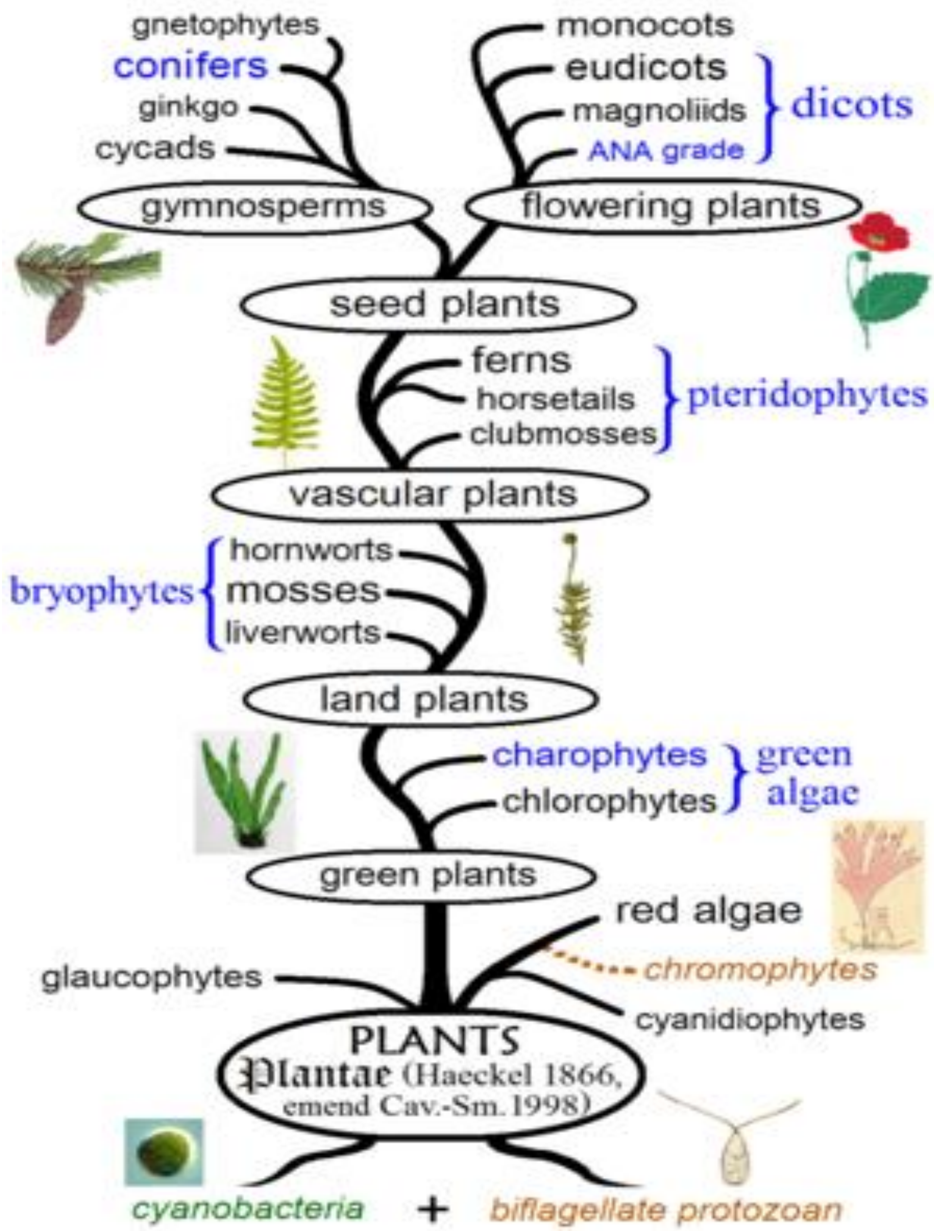


Fig. 1: Phylogenetic plant tree showing the major clades and traditional groups. Monophyletic groups are in black and paraphyletics in blue. Diagram according to symbiogenetic origin of plant cells and phylogeny of algae, bryophytes, vascular plants and flowering plants.

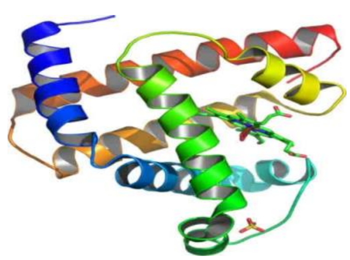
Diagram of the life cycle

5 billion years ago the Earth coalesced under the influence of gravity

It cold and heat

During that two billion years the amino acids, nucleotides and a range of other organic molecules built up in the boiling oceans.

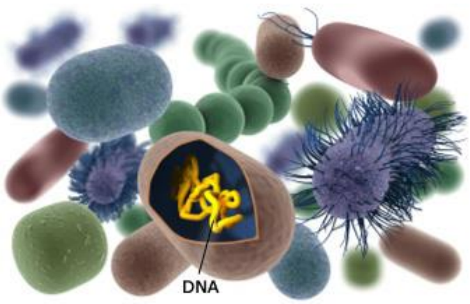
The proteins and molecules grouped together



The important jump was the incorporation of a replicable RNA/DNA molecule into the structure to become an organizing focus and provide stability and the ability to reproduce.

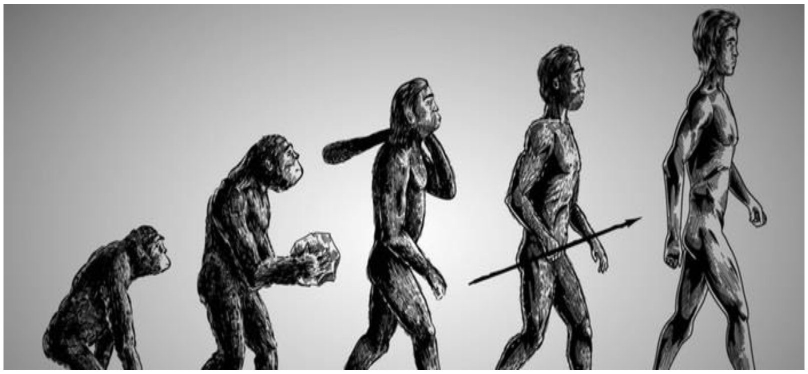
Create a tiny species of protein scum

The first life was a single cell with a single strand RNA. DNA followed and the double helix was our mother.
All life came from this one amazing instance.



The single cells began to group into colonies. The colonies formed loose organisms like sponges.
The sponges gave rise to multi-celled organisms – first flatworms, true worms and then arthropods and molluscs.
The vertebrates.
The fish gave rise to amphibians then reptiles who gave rise to the birds and mammals.

The mammals started and evolved out of monkeys that gave rise to apes. We are apes closely related to chimps. We share 99% of our genes with the chimps.



Colonization of land

Land plants evolved from a group of green algae, perhaps as early as 510 million years ago, some molecular estimates place their origin even earlier, as much as 630 million years ago.

Their closest living relatives are the Charophytes, specifically Charales, assuming that the Charales habit has changed little since the divergence of lineages, this means that the land plants evolved from a branched, filamentous alga home in shallow freshwater, perhaps at the edge of seasonally desiccating pools.

The alga would have a haplontic life cycle: it would pair chromosomes (the diploid condition) when the egg and sperm first fused to form a zygote, this would have immediately divided by meiosis to produce cells with half the number of unpaired chromosomes (the haploid condition).

Co-operative interactions with fungi may have helped early plants adapt to the stresses of the terrestrial realm.

Plants were not the first photosynthesizes on land; weathering rates suggest that photosynthetic organisms were already living on the land 1,200 million years ago and microbial fossils have been found in freshwater lake deposits from 1,000 million years ago, but the carbon isotope record suggests that they were too scarce to impact the atmospheric composition until around 850 million years ago.

These organisms, although phylogenetically diverse, were probably small and simple, forming little more than an "algal scum".

The first evidence of plants on land comes from spores of mid-Ordovician age (early Llanvirn, 470 million years ago).

These spores, known as cryptospores, were produced either singly (monads), in pairs (dyads) or groups of four (tetrads), and their microstructure resembles that of modern liverwort spores, suggesting they share an equivalent grade of organization.

Their walls contain sporopollenin further evidence of an embryophytic affinity. It could be that atmospheric 'poisoning' prevented eukaryotes from colonizing the land prior to this or it could simply have taken a great time for the necessary complexity to evolve.

Trilete spores similar to those of vascular plants appear soon afterwards, in Upper Ordovician rocks.

Depending exactly when the tetrad splits, each of the four spores may bear a "trilete mark", a Y-shape, reflecting the points at which each cell squashed up against its neighbors.

However, this requires that the spore walls be sturdy and resistant at an early stage. This resistance is closely associated with having a desiccation-resistant outer wall a trait only of use when spores must survive out of water. Indeed, even those embryophytes that have returned to the water lack a resistant wall, thus don't bear trilete marks.

A close examination of algal spores shows that none have trilete spores, either because their walls are not resistant enough, or in those rare cases where it is, the spores disperse before they are squashed enough to develop the mark, or don't fit into a tetrahedral tetrad.

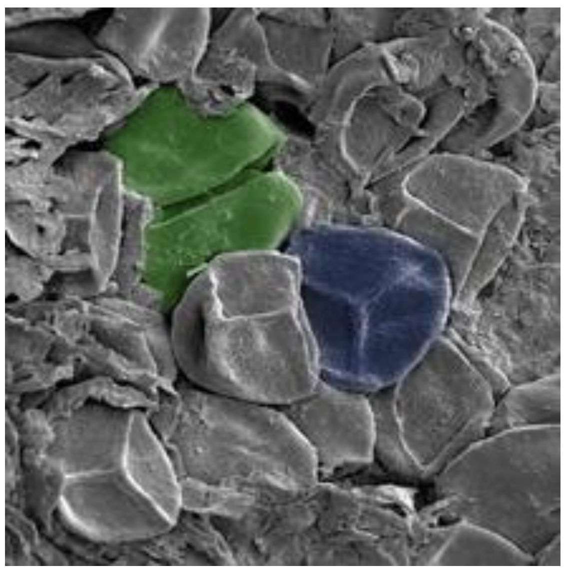


Fig 3: Trilete spores (*Trilobosporites laevigatus)*

The earliest megafossils of land plants were thalloid organisms, which live in fluvial wetlands and are found to have covered most of an early Silurian flood plain, they could only survive when the land was waterlogged and there were also microbial mats.

Once plants had reached the land, there were two approaches to dealing with desiccation. The bryophytes avoid it or give in to it, restricting their ranges to moist settings, or drying out and putting their metabolism "on hold" until more water arrives.

Tracheophytes resist desiccation: They all bear a waterproof outer cuticle layer wherever they are exposed to air (as do some bryophytes), to reduce water loss, but since a total covering would cut them off from CO_2 in the atmosphere they rapidly evolved stomata, small openings to allow and control the rate of gas exchange.

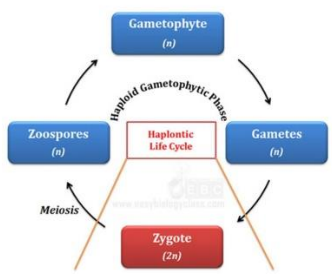
Tracheophytes also developed vascular tissue to aid in the movement of water within the organisms and moved away from a gametophyte dominated life cycle, Vascular tissue also facilitated upright growth without the support of water and paved the way for the evolution of larger plants on land.

Colonization of land

Land plants evolved from a group of green algae as 510 million years ago

Their closest living relatives are the Charophytes, specifically Charales,

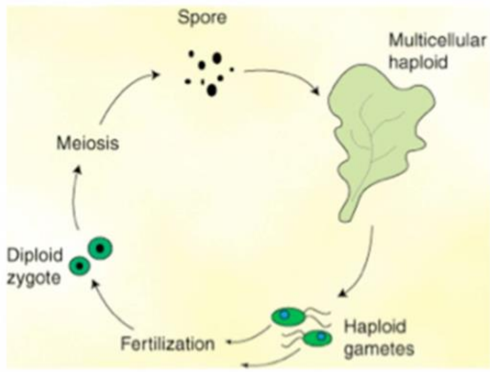
The alga would have a haplontic life cycle



Haplontic Life Cycle

it would pair chromosomes (the diploid condition) when the egg and sperm first fused to form a zygote, this would have immediately divided by meiosis to produce cells with half the number of unpaired chromosomes (the haploid condition).

A.



The first evidence of plants on land comes from spores of mid-Ordovician age (470 million years ago). eukaryotes appear in the land

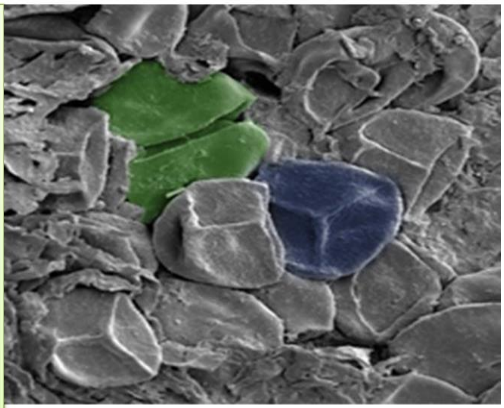
the spore walls be strong and resistant at an early stage. This resistance is closely associated with having a dry-resistant outer wall to survive out of water.


SPORES
• Spores are reproductive structures that can grow into new plants.
• Ferns are one type of plant that reproduces using spores. They have leaves called FRONDS. Each frond has smaller leaves.


Seedless Vascular plants
• Have tubes but still reproduce with spores


Seedless Plants
• Question: Do all plants reproduce from seeds?
• Some plants reproduce by spores.

The evidence of presence the algal spores some of it not have trilete mark because their walls are not resistant enough or in those rare cases where it is the spores disperse before they are squashed enough to develop the mark, or don't fit into formation tetrad of cells. Some of algae have this trilete spores, which divide via meiosis to form a tetrad of cells, first appeared in the late Late Ordovician and form a rare geographically isolated component in cryptospore grouping. Although spores are known from older rocks, cryptospore and trilete spores are thought to be the direct ancestors of land plants because of their size.



Trilete spores
(*Trilobosporites laevigatus*)

after that appeared the Tracheophytes resistant to drying and bear a waterproof outer cuticle layer to reduce water loss also appeared the stomata, small openings to allow and control the rate of gas exchange.

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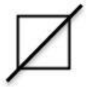
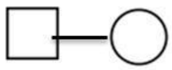
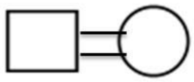
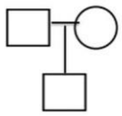
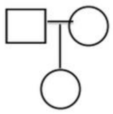
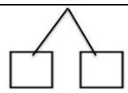
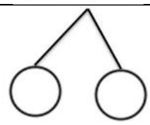
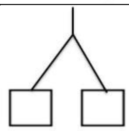
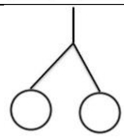
Evolution signs and symbols:

signs and symbols	Meaning
♂	Mars symbol , the symbol for a male organism or man.
♀	Venus symbol, the symbol for a female organism or woman.
☿	Mercury symbol, This symbol is used to indicate a virgin female (for example, in genetic analysis). Also used in botany to indicate flower with both male and female reproductive organs. It can even be used as a unisex symbol.
⚥	Hermaphrodite
ϴ	egg
∞	Infinity, numerous, polyhybrid.
♁ _ ♀	Monoecious
♁ : ♀	dioecious
♁ ♀ ♁	Polygamous
◊	Sex unknown
□	Square symbol, the symbol for a male family.
○	Circle symbol, the symbol for a female family.
⊘	Death of female

	Death of male
	Mating
	Consanguineous
	Mating, with male offspring.
	Mating, with female offspring.
	Dizygotic male twins.
	Dizygotic female twins.
	Monozygotic male twins
	Monozygotic female twins
⊙	Biennial
⊙ ⊙	Biennial
℄	Clone
	Northern hemisphere
	Southern hemisphere
	Old world
	New world

تقسيم التاريخ البايولوجي للارض:

1. عصر اللاحياة Azoic and Proterozoic

في هذا العصر لم يعثر الجيولوجيين على ما يدل وجود بقايا عضوية في صخور هذا الزمن وهم يعتقدون ان سطح الارض لايزال حارا وملتهبا ولم يسمح لظهور الحياة بعد ويتفق هذا الزمن مع ما يطلق عليه جيولوجياً بالزمن ما قبل الكامبيري pre-camberian .

2. العصر القديم Palaeozoic

يتفق امتداده مع الزمن الجيولوجي الاول وهو زمن طويل شمل ستة عصور وهي :

- **العصر الكامبيري Cambrian period:**

وهو العصر الذي تدل حفرياته على وجود الاعشاب البحرية Algae ومن امثلته *Epiphyton* وقد عثر عليها في القارة الجنوبية، وكان لبعض هذه الاعشاب هيكل جيري او مرجاني ساعد على ضغطها وانطباعها الحفري في الصخور.

- **العصر الاوردفيشي Ordovician period:**

تنوعت فيه الاعشاب فظهر منها الاخضر والاحمر والاشنات المتنوعة.

- **العصر السيلوري Silurian period:**

انتشر فيه المرجان والاسفنج في البحار الدافئة كما زخرت البحار الضحلة العمق بالاعشاب البحرية ذات الهيكل الجيري.

وتميزت العصور الثلاثة السابقة بظهور النباتات البسيطة الاحادية الخلية او المتعددة الخلايا ويطلق عليها من الناحية البايولوجية بعصر المشريات Age of thallophyta

- **العصر الديفوني Devonian period:**

وهو عصر بايولوجي متقدم وهو عصر زحف النبات نحو اليابسة وبداية تكيفه للحياة، حيث ان الحوادث الجيولوجية التي حدثت في اواخر العصر السيلوري اثر في اضطراب القوى الباطنية فتكونت سلاسل جبلية جديدة وتغير سطح اليابسة والماء في بعض الجهات وانحسرت ألسنة من البحار الداخلية الى المحيطات فبدأت بعض النباتات التي كانت تمتد على طول خط المد والجزر حيث يلتقي اليابسة والماء في الظهور والانتشار بصورة تدريجية نحو اليابسة ولذلك هذا العصر يسمى بعصر التطور الكبير حيث تعلم النبات تسلق صخور اليابسة وتنفس الهواء الطلق بعد ان كانت تتنفس الهواء المذاب في الماء وصفات النبات في هذا العصر هو انه املس او شوكي *Psilophyton*

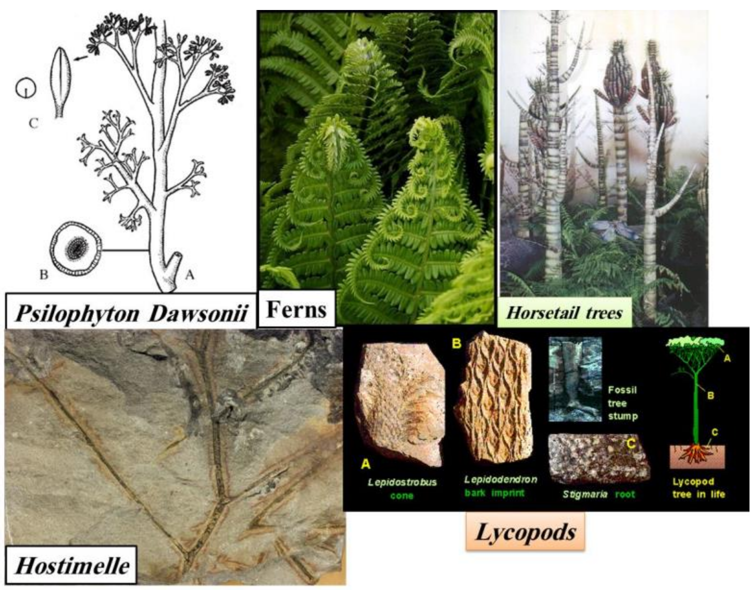
او ذو اوراق تشبه الشوكيات *Hostimelle* ولم يكن لها اوراق او جذور بل الياف يحيط بعضها بالبعض الاخر ويصل ارتفاع البعض منها الى 7-8 اقدام وهي تعتبر اسلاف المملكة النباتية ماعدا الطحالب في الماء.

العصر الكاربوني Carboniferous period:

في هذا العصر ظهرت مجموعات اخرى من النباتات والاعشاب سميت بالسرخسيات Ferns وبعضهم تضخم الى اشجار كبيرة وصل ارتفاع البعض منها الى 130 قدم.

تعتبر الغابات السرخسية القديمة الاساس في تكوين طبقات الفحم الحجري ومن اشهر اشجارها الرصن *Lycopods* حيث تكون هذه الاشجار اسطوانية الساق ذات جذور متشعبة وقد يبلغ ارتفاعها الى 100 قدم واشجار ذيل الحصان *Horsetail trees* التي يصل ارتفاعها الى 30 قدم وقطرها اكثر من قدم.

في نهاية العصر الفحمي ظهرت اسلاف الصنوبريات التي وصل ارتفاع بعضها الى 40-60 قدم مثل اشجار *Gordmite*.



العصر البيرمي Permian period:

على اثر تكوين جبال الابلاش Appalachian Mountains والاورال Ural Mountains وتراجع المياه الداخلية وجفاف المستنقعات وهبوط درجة الحرارة ظهرت الاشجار الصنوبرية ذات السيقان الصلبة لتحل محل السرخسيات الضخمة وقد عثر في قارة جندوانا القديمة على نبات الـ

Glossoptery والذي يعتقد انه سرخس بذري في الاصل ذو اوراق رفيعة تشبه اللسان كما عثر على حفرياته في امريكا الجنوبية وجنوب افريقيا والهند واستراليا وحتى القارة القطبية الجنوبية.

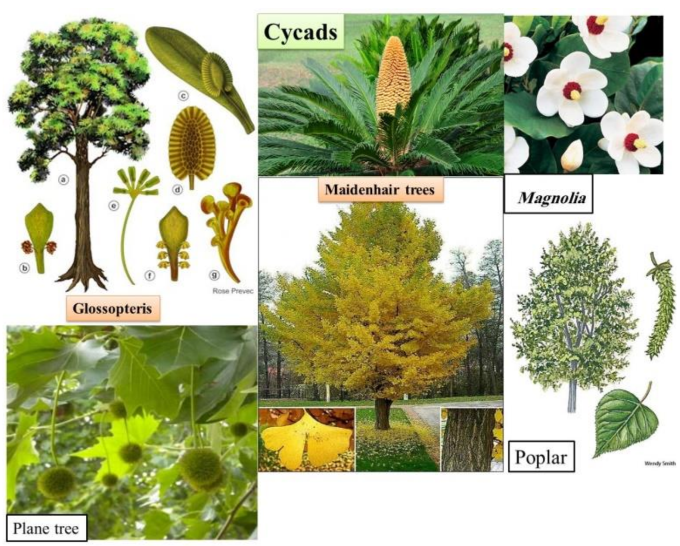
تميزت العصور الثلاثة الاخيرة بأنها عصر خفيات النباتات الوعائية Age of Pteridophytes وبنهايتها انتهى زمن الحياة القديمة.

3. عصر الحياة الوسطى Mesozoic

تميز هذا العصر بثلاثة عصور مهمة هي العصر الترياسي Triassic والعصر الجوراسي Jurassic والعصر الكرتياسي Cretaceous وتميز العصر الترياسي Triassic والعصر الجوراسي Jurassic بأنخفاض شديد في درجات الحرارة وبظهور اشجار الصنوبر الحقيقية في اواخر الترياسي والجوراسي وظهور اشجار النخيل القديم Cycads ايضاً.

دلت الحفريات على وجود انواع من السرخسيات البذرية في قارة كندوانالند حتى نهاية العصر الترياسي وفي العصر الجوراسي تنوعت الحياة النباتية وازدهرت الصنوبريات والنخيل القديم والسرخسيات واشجار كزبرة الماء Maidenhair trees وكانت واسعة الانتشار ولم يبق من سلالتها الا نوع واحد ينمو الان في اليابان والصين ويسمى هذا العصر بعصر النخيل القديم Age of Cycads وعصري الترياسي والجوراسي يمثلان عصر عاريات البذور Age of Gymnosperms .

العصر الاخير في هذا الزمن هو العصر الكرتياسي Cretaceous وهو يمثل بداية تاريخية هامة ففي منتصفه ظهرت النباتات البذرية Angiosperms ومع انتهائه انتهى زمن الحياة الوسطى وبدأت تظهر الغطاءات النباتية في الانواع الحديثة في معظم جهات العالم منها الشجيرات والاشجار النفضية التي تشبه الى حد ما اشجار المكنوليا *Magnolia* والحور Poplar والدلب Plane .



4. عصر الحياة الحديثة Caenozoic (الحقبة الاولى):

وهو عصر النباتات الزهرية (نباتات البذرة المستترة) او مغلفات البذور Age of Angiosperms وانتشرت النباتات الزهرية والاشجار النفضية واصبحت هي السائدة الى جانب وجود الصنوبريات والسرخسيات.

تضمن هذا العصر فترتين الفترة الاولى تضمنت ثلاثة عصور وهي عصور تكوين السلسة البيرينية Pyrenees وهي:

- **عصر الباليوسين Paleocene period**:

وهو العصر الاول لهذا الزمن، تكونت فيه سلسلة جبال Pyrenees.

- **عصر الايوسين Eocene period:**

هو عصر النباتات السائدة في قارة اوربا خلال هذا العصر واواخره تشبه النباتات السودانية الى حد كبير وانتشرت نباتات الاقاليم المعتدلة المناخ في المناطق التي تعتبر الان قطبية او شبه قطبية وعثر فيه على حفريات لاوراق النخيل وبعض النباتات المدارية الدائمة الخضرة في رواسب حوض الوم Alum bay و Bournemouth كما عثر على اثار لنباتات مدارية منها نخيل النيبا Nipa وهي لاتزال تنمة في مستنقعات الملايو. وفي جزيرة كرينلاند عثر على حفريات في صخور الايوسين لاشجار عريضة الاوراق وصنوبريات نفضية مثل اشجار Metasequoia .

- **عصر الاولجيسين Oligocene period :**

في هذا العصر كانت اوربا متصلة مؤقتاً بأسيا واسيا لاتزال متصلة بأمريكا الشمالية وبدأت جبال الالب بالظهور ومن حيث المناخ كانت حالات الدفء والاعتدال سائدة ولكن بعض الجهات تعرضت لمناخ بارد وتوزيع النباتات والحيوانات التي تعتمد على شتاء معتدل كالنخيل والتماسيح قد اصبح توزيعاً محدوداً. اتسع فيه ايضا نطاق الاعشاب وتضاءلت الغابات وفي بعض الجهات كألمانيا ازدهرت المستنقعات الغابية والتي كونت فيما بعد رواسب الفحم البني AL-Lignite وانتشرت اشجار النخيل على بحر كتش القديم .

الفترة الثانية تضمنت عصرين وتميزت بتكوين سلاسل جبال الالب Alpes والهملايا Himalaya .

- **عصر الميوسين Miocene period:**

تكونت فيه جبال الالب والهملايا وتقلصت مساحة بحر كتش واقتصرت على مايعرف بالبحر الابيض المتوسط الان.

انتشرت فيه النباتات الاعتدالية محل النباتات الدون مدارية وتقلص حجم الغابات بشكل عام وازدهرت مساحات السهول والاعشاب الجافة وظهرت الصحاري وقد عثر بالقرب من اونجن في سويسرا في قاع بحيرة قديمة على بقايا نباتات تعود لهذا العصر في رواسب الطين الطباشيري وتشمل انواع من الاشجار النفضية كالزان Beech trees والحور Poplar trees والاسفندان Maple trees وهي تدل على ظروف مناخية معتدلة رطبة.

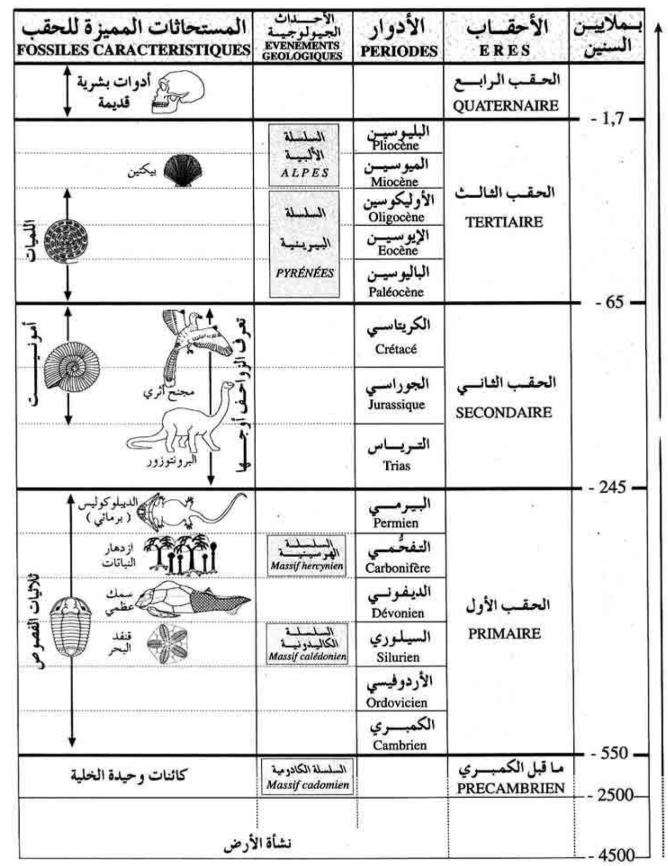
- **عصر البليوسين Pliocene period :**

وهو اخر عصر للزمن الجيولجي الثالث وفيه استمرت حركات تكوين الجبال وهبطت بعض الجبال تحت سطح الماء وبدأت القارات والمحيطات تأخذ شكلها الحالي تدريجياً وقد حلت البحيرات الكبرى مثل البحر الاسود وبحر قزوين وبحر آرال محل البحر المغلق الذي كان يمتد في عصر الميوسين شمال الالب وبحر حوض الدانوب الى جنوب روسيا، انتشرت مناطق الغابات الرطبة والسهول الجافة ولم تظهر الغطاءات الجليدية في المناطق القطبية وشبه القطبية الا نهاية هذا العصر ومن ناحية النباتات في اوائل البليوسين شملت النباتات الطبيعية في اوربا انواعاً كثيرة انحسرت الان في الصين وامريكا الشمالية وبقت شجرة كزبرة البئر تنمو في المانيا حتى نهاية البليوسين عندما اختفت تماماً من قارة اوربا.

5. زمن الحياة الحديثة (الحقبة الثانية) Caenozoic:

ويشمل عصر البليوستوسين Plioctocin period والعصر الحديث ففي عصر البليوستوسين ظهر العصر الجليدي الكبير حيث غطى الجليد معظم اوربا الشمالية والقارة القطبية الجنوبية ومناطق الجبال المرتفعة في الالب والهملايا ويقابل كل عصر جليدي عصر مطير في المناطق المدارية ويعقب كل عصر جليدي ومطير عصر دافئ واخر جاف.

من ناحية اخرى كان شريط عريض من التندرا يحف بهذه الغطاءات الجليدية ثم انتشرت الغابات في اوائل فترة الدفء الاخيرة في اوربا حيث كان الجليد سائداً وبسبب اشتداد البرودة زحف عدد كبير من انواع النباتات التي تعود الى عصر البليوسين جنوباً ويعتبر امتداد لكل من البحر المتوسط وسلاسل جبال الالب العرضية وقد عرقل هذا الزحف بصورة كبيرة وهذه الظاهرة تفسر قلة عدد الانواع النباتية الحالية شمال ووسط اوربا.



المستحاثات المميزة للحقب FOSSILES CARACTERISTIQUES	الأحداث الجيولوجية EVENEMENTS GEOLOGIQUES	الأدوار PERIODES	الأحقاب ERES	بملايين السنين
أدوات بشرية قديمة			الحقب الرابع QUATERNAIRE	
	السلسلة الألبية ALPES	البليوسين Pliocène	الحقب الثالث TERTIAIRE	- 1,7
بيكتين		الميوسين Miocène		
النميات	السلسلة البيرينية PYRÉNÉES	الأوليكوسين Oligocène		
		الإيوسين Eocène		
		الباليوسين Paléocène		
أمونيت; مجنح أثري; تعرف الزواحف أوجها		الكريتاسي Crétacé	الحقب الثاني SECONDAIRE	- 65
البرونتوزور		الجوراسي Jurassique		
		الترياس Trias		
الديلوكوليس (برمائي)		البيرمي Permien	الحقب الأول PRIMAIRE	- 245
ازدهار النباتات	السلسلة الهرسينية Massif hercynien	التفحمي Carbonifère		
سمك عظمي; ثلاثيات الفصوص		الديفوني Dévonien		
قنفد البحر	السلسلة الكاليدونية Massif calédonien	السيلوري Silurien		
		الأردوفيسي Ordovicien		
		الكمبري Cambrien		
كائنات وحيدة الخلية	السلسلة الكادومية Massif cadomien		ما قبل الكمبري PRECAMBRIEN	- 550
نشأة الأرض				- 2500
				- 4500

اهمية التاريخ الجيولوجي في توزيع النباتات:

لقد كشف التاريخ الجيولوجي ان الحياة النباتية نشأت في البحار وقد تطورت النباتات بطريقة نحو التعديل والتكيف واكتساب الصفات الجديدة المعقدة والتي ساعدتها على الانتشار فوق اليابسة ان هذا التغير في الخصائص حولها من اعشاب بحرية الى نماذج النباتات الزهرية.

ليس هناك اتفاق تام حول تاريخ ومدى هذه التغيرات واتساعها او انكماشها واهم هذه الحقائق في هذا المجال هي:

1. وجود قارة جنوبية في الزمن الاول كانت تشمل معظم الهند واستراليا وجزيرة مدغشقر وافريقيا الجنوبية وقد امتازت بنمو نبات Glossopteris ثم تقطعت هذه القارة خلال الزمن الجيولوجي الثاني، وكان لانعزال مدغشقر واستراليا اثر كبير في احتفاظ كل منهما بمجموعات نباتية وكذلك حيوانية قديمة ومتوطنة.
2. كان لتكوين قارتي اوراسيا وامريكا الشمالية بشكل لايختلف كثيرا عن الشكل الحالي ومن ثم وجود كتلة من اليابسة شبه متصلة تحيط بالقطب اثر واضح في انتشار مجموعات نباتية متشابهة الى حد كبير في العروض القطبية والمعتدلة الشمالية.
3. اثناء الزمن الجيولوجي الثالث كان توزيع القارات والمحيطات يشبه التوزيع الحالي لدرجة كبيرة فكانت قارات العالم القديم وحدة متماسكة مفتوحة المسالك ام انتشار الانواع النباتية من مكان لاخر.
4. استراليا كانت منعزلة يفصلها البحر عن اوراسيا وكذلك امريكا الجنوبية منفصلة عن امريكا الشمالية وان كانت تتصل بها بواسطة مضيق بنما من حين لاخر وكان المحيط الاطلسي الجنوبي يفصلها عن افريقيا والمحيط الهادي يفصلها عن اوراسيا وكانت العزلة الجغرافية عاملاً مهماً في مايعرف بالتطور المتوازي.

ان معرفة توزيع اليابسة والماء والتغيرات المناخية غير كافية في تفسير التوزيع الجغرافي للنبات اذ ان حوادث التوازن البركاني والالتواء والانكسار والحركات التكتونية قد سبتت اندثار كثير من الحفريات التي قد تساعد في تفسير توزيع النباتات.

ان اعتقاد العلماء بنظرية النسب الواحد في اصل الانواع النباتية يحتم علينا ان نعتقد ان حدوث النوع يظهر اولاً او فرد واحد او عدد قليل من الافراد فقط بعدها يتكاثر ويعطي خلفاً وبذلك يمر النوع بمراحل يطلق عليها نظرية الدورات الحياتية وهذه المراحل هي :

1. مرحلة الحداثة Modernity stage : وخلالها يحاول النوع النباتي ان يوطن نفسه ويوسع مدى انتشاره بالتدريج الى الحد الذي تسمح به الظروف البيئية.

2. مرحلة النضوج Maturity stage: وخلالها ينشط تسلسل النوع النباتي من الاصل الواحد الى اقصى حد فتظهر عدة اشكال جديدة مختلفة وبذلك يتكون ما يعرف بالمدى الابوي Parental range ويضم عدداً وفيراً من النسل والخلف.
3. مرحلة الخمول Idle stage : وفيها يصاب النوع النباتي بالعقم فلا ينتج انواعاً جديدة بل يفسح المجال لجيل اخر احدث وانشط.

4. مرحلة الاختفاء Disappearances stage: وفيها يختفي النوع النباتي نهائياً وينقرض فينكمش مداه الى نقطة التلاشي وقبل الانقراض تماماً يكون مداه مماثلاً الى حد كبير لمدى النوع الجديد في المرحلة الاولى من تكوينه.

التوطن Endemicity:

ويعني في جغرافية النبات التوزيع المحدد لبعض الانواع او الاجناس او العائلات في مناطق محدودة ومكان واحد او اقليم واحد. التوطن مصطلح نسبي فمثلاً يصبح اعتبار العائلات التي لا توجد في قارة واحدة عائلات غير متوطنة لان معدل توزيع هذه العائلة يفوق هذا المدى، لذلك لايصلح ان نطلق مصطلح التوطن الا على العوائل النباتية التي يقل توزيعها عن المعدل الشائع لهذه الوحدة النباتية.

التوطن اساس هام في التمييز بين الاقاليم النباتية المختلفة فيلاحظ ان جزء من اقليم كبير يحتوي على نسبة عالية من التوطن بينما يلاحظ ان الجزء الاخر من الاقليم او اقليم مجاور يحتوي نسبة قليلة من النباتات المتوطنة لذلك تظهر نسبة التوطن كعامل هام في التميز بين اقليمين ويفيد ايضاً في معرفة درجة او كثافة الفلورا الخاصة بمكان معين.

مثال على ذلك ثلاث مجموعات من الجزر هي :

. (Galapagos island -Hawaii - Juan Fernandez)

Galapagos island تحتوي على انواع متوطنة وهي معظمها تعود الى نماذج القارة الجنوبية.

وتقع جوان فرناندز بالقرب من شيلي ولكنها تحتوي على فلورا خاصة بها اي لا تتشابه نماذج اي قارة اخرى.

اما جزر هواي في المحيط الهادي فهي منعزلة الى حد كبير وتحتوي على فلورا هائلة تفوق القارتين السابقتين اضافة الى ذلك فأنها تحتوي على نسبة عالية من التوطن فنحو 90% من انواعها النباتية تنحصر في توزيعها هناك.

ويفسر التوطن من الناحية التطورية على ان هذه النباتات تمر اما في مرحلة الحداثة او الانقراض وتفسر عادة بأنها في مرحلة الانقراض بالنسبة للذين يؤمنون بنظرية الانتخاب الطبيعي اما المؤمنين بالطفرة فيفسرون توطنها لحداثتها مثل Willis .

الانقطاع Interruptions:

ان الانقطاع هو عدم الاتصال او وجود انواع نباتية في اقليمين او اكثر ومنفصلة عن بعضها البعض، وهي ظاهرة نباتية ليست نادرة والانقطاع هو مصطلح نسبي مثل التوطن فلا يطلق الا حين يحدث الانقطاع في منطقتين او اكثر على مقياس كبير وقد يكون الانقطاع بمدى واسع ولمسافة كبيرة تصل الى الاف الاميال وقد تكون قصيرة جداً.

ويرتبط الانقطاع كالتوطن بموضوع وحدة او تعدد النسب النباتي فهو لايكون ظاهرة ذات قيمة ومهمة في حالة تعدد النسب الى انه يبرز كمشكلة علمية معقدة في حالة الاعتقاد بنظرية النسب الواحد.

ان تعدد نسب النوع النباتي تسهل تفسير الانقطاع حيث يعزى الى نشأته في كل منطقة من هذه المناطق نشأة مستقلة عن الاخرى اما في حالة النسب الواحد وهو ما يعتقده جميع العلماء فلابد من معرفة العوامل التي سببت هذا الانقطاع وهل حصل نتيجة انقطاع مكاني او انفصال اراضي. يرتبط الانقطاع ايضاً بنظرية الدورة الحياتية ومراحلها الاربعة (حداثة، نضوج، خمول و اختفاء) وهو بذلك ظاهرة طبيعية تحصل في مرحلة الخمول والتي تحصل تحت تأثير عدد كبير من العوامل البيئية المعقدة.

Natural selection

It is important to recognize that "natural selection" is not synonymous with "evolution." Evolution can occur by processes other than natural selection, especially genetic drift. Many definitions of natural selection have been proposed, for our purposes, we will define natural selection as <u>any consistent difference in fitness among phenotypically different classes of biological entities</u>.

Is the differential survival and reproduction of individuals due to differences in phenotype and it's a key mechanism of evolution and the change in heritable traits of a population over time.

When we speak of natural selection among genotypes of organisms, the components of fitness generally consist of:

(1) The probability of survival to the various reproductive ages.

(2) The average number of offspring (e.g., eggs, seeds) produced via female function.

(3) The average number of offspring produced via male function. “Reproductive success”.

Charles Darwin popularized the term "natural selection", and compared it with artificial selection and can define it as (Artificial selection is the intentional breeding of plants or animals. It means the same thing as selective breeding).

In other words, natural selection is a key process in the evolution of a population.

Natural selection can be contrasted with artificial selection in which humans intentionally choose specific traits, whereas in natural selection there is no intentional choice.

Evolution by means of natural selection:

A precondition for natural selection are 1. Adaptive evolution 2. Novel traits and 3. Speciation from heritable genetic.

Genetic variation is the result of mutations, genetic recombinations and alterations in the karyotype (the number, shape, size and internal arrangement of the chromosomes) any of these changes might have an effect that is highly advantageous or highly disadvantageous but large effects are rare.

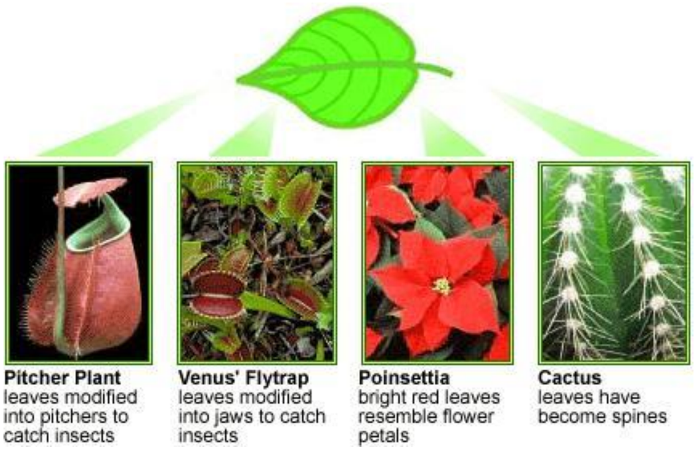
Examples of Plants Natural Selection:

1. Some plants, such as the Venus Fly Trap, are carnivorous. Usually plants obtain nitrogen, a chemical element vital to a plant’s survival, from the soil through their roots. These plants, however, usually grow in areas where soil is lacking in nitrogen. They cannot get enough nitrogen just by taking it out of the ground. In order to thrive in such an environment, these carnivorous plants capture insects in trap-like leaves. These insects become an alternative source of nitrogen for the plant allowing it to survive in a nitrogen-poor habitat (Figure 1).

(Figure 1): Venus Fly Trap.

2. Pitcher plants: evolution leaves to catch insects
3. Cactus plant leaves are like spines whereas poinsettia leaves are like flower petals and developed a trichomes to protect her from the hard environment.
4. The Venus flytrap leaves petals are like jaws that close to catch insects to add the protein in the body.
5. Poinsettias are part of the Euphorbiaceae or Spurge family. Botanically, the plant is known as *Euphorbia pulcherrima*.

   Many plants in the Euphorbiaceae family ooze a milky sap. Some people with latex allergies have had a skin reaction (most likely to the sap) after touching the leaves. For pets, the poinsettia sap may cause mild irritation or nausea. Probably best to keep pets away from the plant, especially puppies and kittens.



(Figure 2)

Speciation and Natural Selection:

Mimulus lewisii (A) and *Mimulus cardinalis* (C) are two wildflowers of the American west coast that share a recent common ancestor.

M. lewisii is specialized for bee pollination, its flowers are colored to attract bees and they have a nice landing pad.

M. cardinalis specializes in hummingbird pollination, it has no landing pad and is colored red, which is easier for birds to see.

It's thought that their ancestor was pollinated mostly by insects but occasionally mutants with extra red coloration or more tubular flowers would attract hummingbirds. Plants that were pollinated mostly by hummingbirds typically shared pollen with others with the same pollinator so they preferentially bred with each other and not with the bee-pollinated ones, eventually concentrating hummingbird-attracting genes into populations that became distinct enough to be a new species.

This hypothesis was tested experimentally when the researchers generated hybrids of the two *Mimulus* species (B, and D-L) and tested their fitness in the field, the hybrids were worse at reproducing than the parents, probably drove the evolution for pollinator specialization and speciation of the two modern species (Figure 6).

(Figure 6)

Rapid speciation in a polluted world:

Sometimes speciation occurs very quickly (over the course of hundreds or thousands of years versus millions+ years):

A population of *Anthoxanthum* (a grass) that grows in zinc-polluted soils near an ancient mine site in Wales has recently (i.e. during the time that humans were in the area) evolved to flower earlier and to tolerate high levels of zinc.

Since this newer population flowers so much earlier it no longer breeds much with other populations of *Anthoxanthum* in the area, thus you could consider it a different species, this probably happened due to natural selection.

Anthoxanthum plants that already had relatively high zinc tolerance and/or that flowered earlier were more likely to survive and reproduce than their brethren when growing on the polluted site.

Researchers have replicated this hypothetical by testing heavy metal tolerance of various populations of *Anthoxanthum* sure enough the occasional individual of the normal population had genes for zinc tolerance and earlier flowering.

Those genes got concentrated in the population growing on polluted soil to the point that the mine population nowadays is biologically isolated and radically different from the nearby populations even though the nearest population is only about 20 meters away!

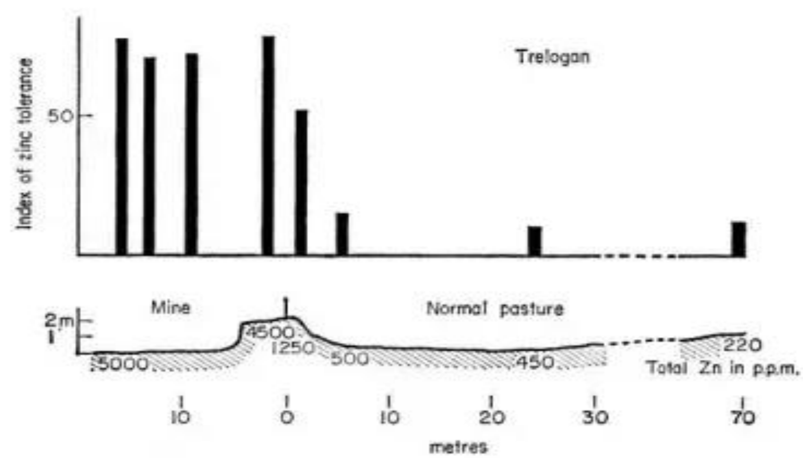


FIGURE 2.11. The zinc tolerance of populations of *Anthoxanthum odoratum* at the boundary of Trelogan mine (from Putwain, in Jain & Bradshaw 1966).

Artificial selection:

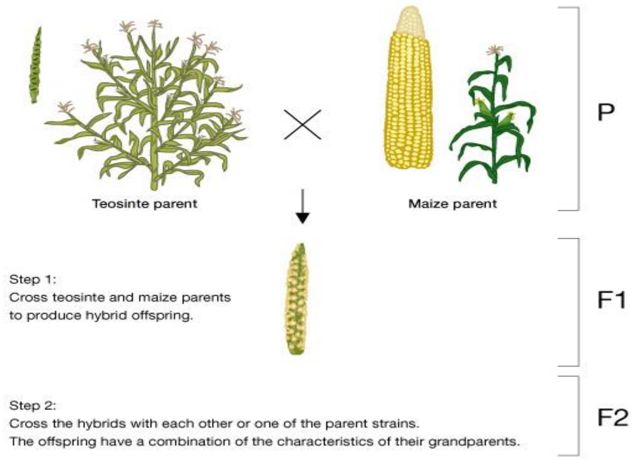
Artificial Selection is a form of selection in which humans actively choose which traits should be passed onto offspring.

Humans have used selective breeding long before Darwin's Postulates and the discovery of genetics when the humans have, over millennia, selected seeds with modified organ shape from wild mustard also breeding many common vegetables that seem distinct from the same parent wild species.

Examples of Plants Artificial Selection:

1. Maize was bred from an unfamiliar tall grass-like plant called <u>Teosinte (Noun a Mexican grass that is grown as fodder and is considered to be one of the parent plants of modern corn</u>).
   Larger and fuller kernels were selected for in order to allow the crop to be a more effective food source.
   About 10,00 years ago, ancient farmers in what is now Mexico took the first steps in domesticating corn when they simply chose which kernels (seeds) to plant. These farmers noticed that not all plants were the same.
   Some plants may have grown larger than others, or maybe some kernels tasted better or were easier to grind. The farmers saved kernels from plants with desirable characteristics and planted them for the next season's harvest. This process is an example of selective

breeding. Corn cobs became larger over time, with more rows of kernels, eventually taking on the form of modern corn (Figure 3).



(Figure 3)

2. Clearly one of the major traits early strawberry growers selected for was bigger fruits. But even in this case, the major changes at the genome:

   Left wild Strawberries have two copies genome duplications, during domestication each of the cells in the domestic strawberries on the right contain eight copies of each chromosome.

   The modern commercial strawberry is derived from hybridization of the Virginia strawberry and the beach strawberry (Figure 4).

(Figure 4): Wild strawberry (left) and domesticated strawberry (right).

3. The species Cabbage, broccoli, cauliflower, Brussels sprouts, collards, and kale are all members of the same species, *Brassica oleracea* (Figure 5).

(Figure 5)

4. Also examples of crops that have been genetically modified are:
   Corn - insect resistance
   Soybeans - herbicide tolerance
   Rice - vitamin enrichment (beta-carotene aka vitamin A)
   Potatoes - virus resistance

Convergent Evolution:

Convergent evolution occurs when organisms from different evolutionary lineages evolve similar adaptations to similar environmental conditions.

This can happen even when the organisms are widely separated geographically.

For example of convergent evolution occurred with *Cactaceae*, the cactus family of the Americas and with the *euphorbs* or *Euphorbiaceae* the spurge family of South Africa both of which have evolved succulent (water storing) stems in response to desert conditions.

The most primitive cacti are vine like tropical plants of the genus *Pereskia*, these cacti which grow on the islands of the West Indies and in Tropical Central and South America have somewhat woody stems and broad flat leaves as deserts developed in North and South America members of the cactus family began to undergo selection for features that were adaptive to hotter and dryer conditions, the stems became greatly enlarged and succulent as extensive water storage tissues formed in the pith or cortex the leaves became much reduced.

In some cactus species such as the common prickly pear (*Opuntia*) the leaves are small, cylindrical pegs that shrivel and fall off after a month or so of growth.

In most cacti, only the leaf base forms and remains as a small hump of tissue associated with an axillary bud.

In some cacti this hump is enlarged and is known as a tubercle.

Axillary buds in cacti are highly specialized and are known as areoles, the leaves of an areole are reduced to one or more spines particularly in columnar cacti the areoles are arranged in longitudinal rows along a multiple-ridged stem.

With the possible exception of the genus *Rhipsalis* which has one species reported to occur naturally in Africa and all cacti are native to the Americas, as deserts formed in Africa, Eurasia and Australia, different plant families evolved adaptations similar to those in cacti.

The most notable examples are the *candelabra euphorbs* of South Africa, desert dwelling members of the Euphorbiaceae frequently have succulent, ridged, cylindrical stems resembling those of cacti and the leaves are typically reduced in size and present only during the rainy season also they are arranged in rows along each of several ridges of the stem associated with each leaf are one or two spines as a result when the leaves shrivel and fall off during the dry season a spiny cactus like stem remains.

Other plant families that show convergence with the cacti in having succulent stems or leaves are the stem succulents of the Asclepiadaceae (milkweed family), Asteridaceae (sunflower family), Crassulaceae (stonecrop family), Portulacaceae (purslane family), Vitaceae (grape family), the ice plant family Aizoaceae (leaf succulents), Amaryllidaceae (daffodil family), Bromeliaceae (pineapple family), Geraniaceae (geraniumfamily) and Liliaceae (lily family).

cactaceae of the Americas

euphorbiaceae of africa

Divergent Evolution:

Galápagos Cactaceae

Divergent evolution is the accumulation of differences between groups, leading to the formation of new species. The term can also be applied in molecular evolution, such as to proteins that derive from homologous genes. Both orthologous genes (resulting from a speciation] event) and paralogous genes (resulting from gene duplication) can illustrate divergent evolution. Through gene duplication, it is possible for divergent evolution to occur between two genes within a species.

Similarities between species that have diverged are due to their common origin, so such similarities are homologies. In contrast, convergent evolution arises when an adaptation has arisen independently, creating analogous structures such as the wings of birds and of insects.

Some of the most famous examples of divergent evolution have occurred in the Galápagos Islands. The Galápagos comprise fourteen volcanic islands located about 600 miles west of South America.

A total of 543 species of vascular plants are found on the islands, 231 of which are endemic, found nowhere else on earth.

Seeds of various species arrived on the islands by floating in the air or on the water or being carried by birds or humans.

With few competitors and many different open habitats variant forms of each species could adapt to specific conditions a process known as adaptive radiation. Those forms of a species best suited to each particular habitat were continually selected for and produced progeny in that habitat.

Over time, this natural selection resulted in multiple new species sharing the same ancestor.

The best examples of divergent evolution in the Galápagos have occurred in the *Cactaceae* and *Euphorbiaceae*.

Eighteen species and variety of cacti are found on the islands and all are endemic.
Of the twenty-seven species and varieties of Euphorbs, twenty are endemic.

An interesting example of the outcome of divergent evolution can be seen in the artificial selection of different cultivars (cultivated varieties) in the genus Brassica.

Galápagos Euphorbiaceae

Evolution of morphology

One of the most important parts of plants that have passed through the different ages is the process of evolution:

1. **Tree form**

The early Devonian landscape was taller without the evolution of a strong vascular system, however there was constant evolutionary pressure to attain greater height. The most obvious advantage is the harvesting of more sunlight for photosynthesis. early plants had to develop woody tissue that provided support and water transport and the stele of plants undergoing "secondary growth" is surrounded by the vascular cambium, a ring of cells which produces more xylem (on the inside) and phloem (on the outside). The Late Devonian Archaeopteris, a precursor to gymnosperms which evolved from the trimerophytes, reached 30 m in height.

The dominant groups today are the gymnosperms, which include the coniferous trees and the angiosperms, which contain all fruiting and flowering trees. It was long thought that the angiosperms arise from within the gymnosperms, but recent molecular evidence suggests that their living representatives from two distinct groups.

The angiosperms and their ancestors played a very small role until they diversified during the Cretaceous. They started out as small to become the dominant member of non-boreal forests today.

2. **Roots**:

Roots are important to plants for two main reasons: Firstly, they provide anchorage to the substrate more importantly they provide a source of water and nutrients from the soil. Roots allowed plants to grow taller and faster.

But, how and when did roots evolve in the first place? While there are mark of root-like impressions in fossil soils in the Late Silurian, body fossils show the earliest plants to be devoid of roots. Many had tendrils that sprawled along or beneath the ground, with upright axes or thalli[1] dotted here and

[1] a plant body that is not differentiated into stem and leaves and lacks true roots and a vascular system. Thalli are typical of algae, fungi, lichens, and some liverworts.

there and some even had non-photosynthetic subterranean branches which lacked stomata.

The evidence to grow and evolve the root:

1. In Siluron Devonian plants such as Rhynia and Horneophyton have the physiological equivalent of roots.

2. Roots are appearing in the fossil record.

3. Rhizoids small structures performing the same role as roots, usually a cell in diameter probably evolved very early, perhaps even before plants colonised the land, they are recognised in the Characeae, an algal sister group to land plants.

4. Roots and root-like structures became increasingly more common and deeper during the Devonian, with *lycopod* trees forming roots around 20 cm long.

5. Today roots became larger, they could support larger trees, and the soil was weathered to a greater depth.

3. **Leaves**:

Leaves today are in almost all instances an adaptation to increase the amount of sunlight that can be captured for photosynthesis. Leaves certainly evolved more than once and probably originated as spiny outgrowths to protect early plants from herbivory.

Evolve the leaves took about 50 m.g. in the vascular plants.

Stomata on plant leaves take in carbon dioxide from the air to supply the photosynthesis that goes on inside the leaf spaces. Because they are open, stomata can lose water from the plant in the form of water steam by transpiration process.

Carbon dioxide levels were globally high in mid-Paleozoic times, so any protoleaves would have needed few stomata to take in all the carbon dioxide they would have needed. As a result, proto-leaves would not have been evaporating much water.

Evaporation cools a surface if fluid is evaporating from it. A slow rate of evaporation would not cool a leaf very much.

Early vascular plants would have fried or burn if they had evolved leaves, the added solar radiation shining on the leaf combined with the lack of evaporative cooling would have resulted in "lethal overheating”.

Then 50 million years later, carbon dioxide levels and global temperatures dropped in the Late Devonian, making it finally possible for leaves to evolve without frying themselves. Leaves would now need many stomata to take in the carbon dioxide they needed, so they would have generated much more evaporative cooling.

Why Did Leaves Evolve?

Leaves do more than photosynthesize. Essentially, they are expansions of the plant epidermis, increasing its surface area many times. Furthermore, they are typically studded with stomata, thus the leaves exchange gases with the atmosphere. The gases of most interest are carbon dioxide, oxygen, and water vapor.

Stomata encourage transpiration, where water vapor evaporates from the plant.

But there is another aspect of transpiration, one that may be much more significant for the origin of leaves. Transpiration from stomata high on the plant sets up a pressure gradient, a pump that produces upward flow in the xylem of the plant.

Fluid in the xylem flows upward from the roots to the leaves to carrying essential nutrients with it.

The most important point is that the addition of leaves by itself will not accomplish much. Leaves in higher plants are part of a system that's mean the origin of leaves would have evolved side by side with increased capacity of xylem and phloem, to accommodate the increased reciprocal flow of nutrient-bearing fluids up and down the plant and evolving roots to bear the weight of the added leaves and their support branches.

So what we see as the "evolution of leaves" is just a part of the evolution of an integrated yet differentiated higher plant, with increasingly different functions operating in increasingly different anatomical regions.

The next level of question is evolutionary and ecological

The first vascular plants were small (low to the ground) and apparently lived in tropical swamps. In such environments, evapotranspiration doesn't work very well in plants, slow evapotranspiration means low pressure gradients in the vascular system, low nutrient flow, and overall a small energy budget. Plants cannot grow high, and sophisticated transport systems are not needed, so don't evolve: and that includes size, strength, and complexity of phloem and xylem; size, strength and complexity of roots; and leaves.

4. **Vascular tissue system of root, stem and leaves:**

To photosynthesis, plants must absorb CO2 from the atmosphere while stomata are open to allow CO2 to enter, water can evaporate.

Water is lost much faster than CO2 is absorbed, so plants need to replace it and have developed systems to transport water from the wet soil to the site of photosynthesis.

Early plants transported water within the porous walls of their cells, later, they evolved the ability to control water loss (and CO2 gain) through the use of a waterproof cuticle perforated by stomata that could open and close to regulate evapotranspiration.

Specialized water transport tissues evolved first in the form of hydroids[2] than tracheids and secondary xylem followed by vessels in flowering plants.

The high CO2 levels of Silurian-Devonian times when plants were first colonizing land mean that the need for water was low but when began gain more CO2 from the atmosphere, more water was lost from her body therefor transport mechanisms evolved gradually.

As water transport mechanisms and waterproof cuticles evolved plants could survive without being continually covered by a film of water.

Plants then needed a strong internal structure that contained long narrow channels for transporting water from the soil to all the different parts of the above soil plant especially to the parts where photosynthesis occurred.

[2] Hydroids: is a type of vascular cell that occurs in certain bryophytes. In some mosses such as members of the Polytrichaceae family, hydroids from the innermost layer of cells in the stem.

However, the transport vessels and the cohesion-adhesion mechanism can transport water a few cm, therefore the plants developed a waterproof cuticle.

That's mean plants needed a more efficient water transport system and development these systems as:

1. Cohesion-adhesion mechanism.

2. Transpiration.

3. Osmotic pressure

Plants continue to create new ways of reducing the resistance to flow within their cells thereby increasing the efficiency of their water transport by appeared the thickened bands on the walls of tubes in the early Silurian to ease the flow of water, as well as tubes with pitted ornamentation on their walls were lignified are referred to as tracheids.

These the "next generation" of transport cell design, have a more rigid structure that hydroids, preventing their collapse at higher levels of water tension, also water transport requires regulation and dynamic control is provided by stomata through transpiration.

Once plants had evolved this level of controlled water transport they were truly able to extract water from their environment through root-like organs rather than relying on a film of surface wet enabling them to grow and alive.

5. Flowers

The pollen bearing organs of the early "flower" *Crossotheca*

Flowers are modified leaves possessed only by the angiosperms, which are relatively late to appear in the fossil record. The group originated and diversified during the Early Cretaceous and became ecologically significant thereafter.

Flower-like structures first appear in the fossil records some ~130 mya, in the Cretaceous. Colorful and pungent[3] structures surround the cones of plants such as cycads and Gnetales, making a strict definition of the term "flower"

The main function of a flower is reproduction, which, before the evolution of the flower and angiosperms, was the job of microsporophylls and megasporophylls. A flower can be considered a powerful evolutionary innovation because its presence allowed the plant world to access new means and mechanisms for reproduction.

The flowering plants have long been assumed to have evolved from within the gymnosperms, according to the traditional morphological view, they are closely allied to the Gnetales.

However, recent molecular evidence is at odds with this hypothesis and further suggests that Gnetales are more closely related to some gymnosperm groups than angiosperms and that extant gymnosperms form a distinct clade to the angiosperms, the two clades diverging some 300 million years ago.

The relationship of stem groups to the angiosperms is important in determining the evolution of flowers.

In the fossil record, there are three irregular groups which bore flower-like structures.

The first is the Permian pteridosperm Glossopteris, which already bore recurved leaves resembling carpels. The Mesozoic Caytonia is more flower-like still, with enclosed ovules – but only a single integument. Further, details of their pollen and stamens set them apart from true flowering plants.

Second Bennettitales bore remarkably flower-like organs, protected by whorls of bracts which may have played a similar role to the petals and sepals of true flowers.

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[3] Having a sharp strong taste or smell.

Third these flower-like structures evolved independently, as the Bennettitales are more closely related to cycads and ginkgos than to the angiosperms.

By the end of the Cretaceous 66 million years ago, over 50% of today's angiosperm orders had evolved and the clade accounted for 70% of global species. It was around this time that flowering trees became dominant over conifers.

The inflorescences of the Bennettitales are strikingly similar to flowers

6. **Seeds**:

The fossil seed *Trigonocarpus*

Early land plants reproduced in the fashion of ferns: spores germinated into small gametophytes, which produced eggs and/or sperm. These sperm would swim across moist soils to find the female organs (archegonia) on the same or another gametophyte, where they would fuse with an egg to produce an embryo, which would germinate into a sporophyte.

Heterosporic plants bear spores of two sizes – microspores and megaspores. These would germinate to form microgametophytes and megagametophytes, respectively. This system paved the way for ovules and seeds: taken to the extreme, the megasporangia could bear only a single megaspore tetrad and to complete the transition to true ovules, three of the megaspores in the original tetrad could be aborted, leaving one megaspore per megasporangium.

The transition to ovules continued with this megaspore being "boxed in" to its sporangium while it germinates. Then, the megagametophyte is contained within a waterproof integument (ovule wall), which forms the bulk of the seed.

The microgametophyte – a pollen grain which has germinated from a microspore.

The seed plants have been identified in the earliest seed plants about 20 million years in Middle Devonian, they are small and radially symmetrical and surrounded by integumented.

The first spermatophytes "seed plants" that is the first plants to bear true seeds are called pteridosperms "seed ferns" so called because their foliage consisted of fern-like fronds, although they were not closely related to ferns.

The oldest fossil evidence of seed plants is of Late Devonian age and they appear to have evolved out of an earlier group known as the progymnosperms.

These early seed plants ranged from trees to small, rambling shrubs like most early progymnosperms, they were woody plants with fern-like foliage. They all bore ovules, but no cones, fruit or similar.

This seed model is shared by basically all gymnosperms “naked seeds" most of which encase their seeds in a woody cone or fleshy aril (the yew[4], for example), but none of which fully enclose their seeds. The angiosperms "vessel seeds" are the only group to fully enclose the seed, in a carpel.

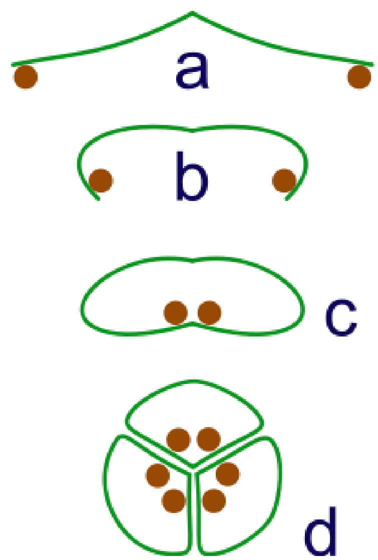
Fully enclosed seeds opened up a new pathway for plants to follow that of seed dormancy. The embryo, completely isolated from the external atmosphere and hence protected from drying, could survive some years of drought before germinating.

Gymnosperm seeds from the Late Carboniferous have been found to contain embryos, suggesting a lengthy gap between fertilization and germination and

[4] a coniferous tree that has red berrylike fruits, and most parts of which are highly poisonous. Yews are linked with folklore and superstition and can live to a great age; the timber is used in cabinetmaking and (formerly) to make longbows.

this period is associated with the entry into a greenhouse earth period, with an associated increase in aridity. This suggests that dormancy arose as a response to drier climatic conditions, where it became advantageous to wait for a moist period before germinating.

This evolutionary breakthrough appears to have opened a more areas, such as dry mountain slopes and covered by trees and the seeds success to fertilized gametophytes and contain the embryo, the seeds could germinate rapidly in inhospitable environments, reaching a size where it could protect itself more quickly.



The evolution of syncarps. a: sporangia borne at tips of leaf b: Leaf curls up to protect sporangia
c: leaf curls to form enclosed roll d: grouping of three rolls into a syncarp.

Plant Systematics and Evolution

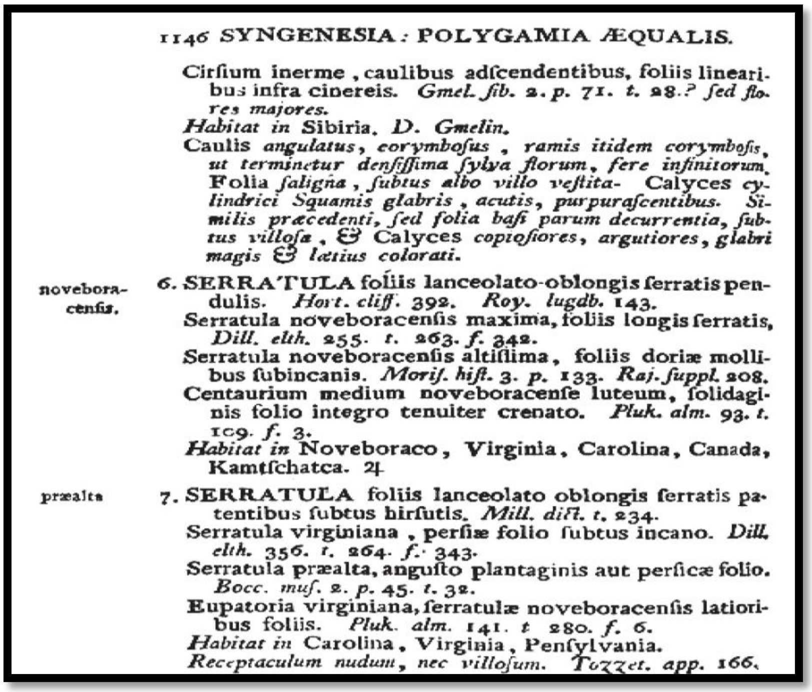
Plant systematics is the branch of botany that is concerned with the naming, identification, evolution, and classification (arrangement into groups with common characteristics) of plants.
The simplest form of classification is a system based on need and use; early humans classified plants into edible, poisonous and medicinal categories.

EARLY HISTORY OF CLASSIFICATION

1. The earliest known formal classification was proposed by the Greek naturalist Theophrastus (370–285 B.C.), who was a student of Aristotle. In his botanical writings (*Enquiries into Plants* and *The Causes of Plants*), he described and classified approximately 500 species of plants into herbs, undershrubs, shrubs, and trees, because his influence extended through the Middle Ages, he is regarded as the Father of Botany.
2. Two Roman naturalists who also had long-lasting impacts on plant taxonomy were Pliny the Elder (A.D. 23–79) and Dioscorides (first century A.D.). Both described medicinal plants in their writings and Dioscorides's *Materia Medica* remained the standard medical reference for 1,500 years. From this period through the Middle Ages, little new botanical knowledge was added.
3. The invention of the printing press in the middle of the fifteenth century allowed botanical works to be more easily produced than ever before. These richly illustrated books, known as **herbals,** dealt largely with medicinal plants and their identification, collection, and preparation.
4. The renewal of interest in taxonomy can be traced to the work of several herbalists; in fact, this period of botanical history from the fifteenth through the seventeenth centuries is known as the Age of Herbals. Another factor in the revival of taxonomy was the global exploration by the Europeans during this period, which led to the discoveries of thousands of new plant species.
5. In less than 100 years more plants were introduced to Europe than in the previous 2,000 years.

Carolus Linnaeus

By the beginning of the eighteenth century, it was common to name plants using a polynomial, which included a single word name for the plant (today called the genus name), followed by a lengthy list of descriptive terms, all in Latin. This system had flaws. It was not standardized; different polynomials existed for the same plant and longer polynomials, which could be a paragraph in length. This was the state of taxonomy during the time of Linnaeus (figure 1).


1146 SYNGENESIA: POLYGAMIA ÆQUALIS.

Cirſium inerme, caulibus adſcendentibus, foliis linearibus infra cinereis. *Gmel. ſib. 2. p. 71. t. 28.? ſed flores majores.*
Habitat in Sibiria. *D. Gmelin.*
Caulis *angulatus, corymboſus, ramis itidem corymboſis, ut terminetur denſiſſima ſylva florum, fere infinitorum.* Folia *ſaligna, ſubtus albo villo veſtita.* Calyces *cylindrici Squamis glabris, acutis, purpuraſcentibus. Similis præcedenti, ſed folia baſi parum decurrentia, ſubtus villoſa, & Calyces copioſiores, argutiores, glabri magis & lætius colorati.*

noveboracenſis. 6. SERRATULA foliis lanceolato-oblongis ſerratis pendulis. *Hort. cliff.* 392. *Roy. lugdb.* 143.
Serratula noveboracenſis maxima, foliis longis ſerratis, *Dill. elth.* 255. *t.* 263. *f.* 342.
Serratula noveboracenſis altiſſima, foliis doriæ mollibus ſubincanis. *Moriſ. hiſt.* 3. *p.* 133. *Raj. ſuppl.* 208.
Centaurium medium noveboracenſe luteum, ſolidaginis folio integro tenuiter crenato. *Pluk. alm.* 93. *t.* 109. *f.* 3.
Habitat in Noveboraco, Virginia, Carolina, Canada, Kamtſchatca. ♃

præalta 7. SERRATULA foliis lanceolato oblongis ſerratis patentibus ſubtus hirſutis. *Mill. dict. t.* 234.
Serratula virginiana, perſicæ folio ſubtus incano. *Dill. elth.* 356. *t.* 264. *f.* 343.
Serratula præalta, anguſto plantaginis aut perſicæ folio. *Bocc. muſ.* 2. *p.* 45. *t.* 32.
Eupatoria virginiana, ſerratulæ noveboracenſis latioribus foliis. *Pluk. alm.* 141. *t* 280. *f.* 6.
Habitat in Carolina, Virginia, Penſylvania.
Receptaculum nudum, nec villoſum. Tozzet. app. 166.

Figure 1. A photograph from Species *Plantarum* illustrates the beginning of the binomial system. Note the trivial names in the margin next to the polynomial description for each species. The trivial name was later designated as the species epithet, which, together with the generic, forms the binomial.

HOW PLANTS ARE NAMED

Names are useful because they impart some information about a plant; it may be related to flower color, leaf shape, flavor, medicinal value, the season of blooming, or location. Names are necessary for communication; "if you know not the name, knowledge of things is wasted." This lecture begins with a look at common names, or what plants are called locally, and follows with an examination of internationally recognized scientific names.

Common Names

A close look at common names often reveals a keen sense of observation, a fanciful imagination, or even a sense of humor for example: trout lily, milkweed, Dutchman's pipe, Texas bluebonnet, ragged sailor, and old maid's nightcap.

Names have evolved over centuries but are sometimes only used in a limited geographical area. Even short distances away, other common names may be used for the same plant. Consider, for example, the many names for the tree that many people call osage orange (*Maclura pomifera*) bodeck, bodoch, bois d'arc, bow-wood, osage apple tree, hedge, hedge apple, hedge osage, hedge-plant osage, horse apple, mock orange, orange-like maclura, osage apple, and wild orange.

On the other hand, different plants may share the same common name. Although mock orange is one of the common names for osage orange, the name mock orange is usually associated with a completely unrelated group of flowering shrubs (*Philadelphus* spp.). These examples point out the difficulties with common names; one plant may be known by several different names, and the same name may apply to several different plants. The need to have one universally accepted name is fulfilled with scientific names.

Scientific Names

Each kind of organism is known as a species and similar species form a group called a genus (pl., genera). Each species has a scientific name in Latin that consists of two elements; the first is the genus and the second is the specific nickname, we can define the scientific name as ((the recognized Latin name given to an organism, consisting of a genus and species, according to a taxonomy, also called binomial name))

Such a name is a binomial, literally two names and is always italicized or underlined; for example, *Maclura pomifera* is the scientific name for osage orange. in the binomial, the first name is a noun and is capitalized; the second, written in lower case, is usually an adjective. After the first mention of a binomial, the genus name can be abbreviated to its first letter, as in *M. pomifera*, but the specific nickname can never be used alone, the genus name, however, can be used alone, especially when referring to several species within a genus; for example, *Philadelphus* refers to over 50 species of mock orange.

The specific nickname can be replaced by an abbreviation for species, "sp." (or "spp." plural), when the name of the species is unknown or unnecessary for the discussion, in the previous example, *Philadelphus* sp. refers to one species of mock orange whereas *Philadelphus* spp. refers to more than one species.

Scientific names may be just as descriptive as common names and translation of the Latin (or latinized Greek) is informative, sometimes either the genus name or the specific nickname is commemorative, derived from the name of a botanist or other scientist, some specific epithets are frequently used with more than one genus and knowledge of their meanings will provide some insight into scientific names encountered later in this text, for example Rosemary (in English) *Rosemarinus officinalis* (in Latin)

A complete scientific name also includes the name or names of the author or authors (often abbreviated) who first described the species or placed it in a particular genus. For example, the complete scientific name for corn is *Zea mays* L.; the "L" indicates that Linnaeus named this species.

On the other hand, the complete name for osage orange is *Maclura pomifera* (Raf.) Schneid. This author citation indicates that Rafinesque-Schmaltz first described the species, giving it the specific epithet *pomifera*, but Schneider later put it in the genus *Maclura*. In this text, the author citations are omitted for simplicity.

Examples:

- (Plant) *Amaranthus retroflexus* L. – "L." is the standard abbreviation for "Linnaeus"; the absence of parentheses shows that this is his original name.
- (Plant) *Hyacinthoides italica* (L.) Rothm. – Linnaeus first named the Italian bluebell *Scilla italica*; Rothmaler transferred it to the genus *Hyacinthoides*.

TAXONOMIC HIERARCHY

In addition to genus and species, other taxonomic categories exist to conveniently group related organisms. As pointed out, Linnaeus used an artificial system; however, today scientists use a phylogenetic system to group plants. In a phylogenetic system, information is gathered from morphology, anatomy, cell structure, biochemistry, genetics, and the fossil record to determine evolutionary relationships and, therefore, natural groupings among plants.

Taxonomic Hierarchy is the placing of known plants into groups or categories to show some relationship and the scientific classification follows a system of rules that standardize the results, and groups successive categories into a hierarchy. For example, the family to which the lilies belong is classified as follows:

- Kingdom: Plantae
- Division: Magnoliophyta
- Class: Liliopsida
- Series: Liliales
- Family: Liliaceae
- Genus: *Lilium*
- Species: *Lilium columbianum*

Higher Taxa

Species that have many characteristics in common are grouped into a genus, one of the oldest concepts in taxonomy. In almost every society, the concept of genus has developed in colloquial language; in English the words *oak, maple, pine, lily,* and *rose* represent distinct genera, these groupings reflect natural relationships based on shared vegetative and reproductive characteristics.

Many of the scientific names of genera are directly taken from the ancient Greek and Roman common names for these genera (*Quercus,* old Latin word for oak).

The next higher category, or **taxon** (pl., **taxa)**, above the rank of genus is the **family,** families are composed of related genera that again (as in a genus) share combinations of morphological traits, in the angiosperms, floral and fruit features are often used to characterize a family, the family represents a natural group with a common evolutionary lineage; some families may be very small while others are very large, but still cohesive, groups.

According to the *International Code of Botanical Nomenclature*, each family is assigned one name, which is always capitalized and ends in the suffix -aceae.

Families are grouped into orders, orders into classes, classes into divisions (phyla) and divisions into kingdoms. A domain is above the kingdom level and is the most inclusive taxonomic category.

In addition to the categories already described, biologists also recognize intermediate categories with the "sub" for any rank; for example, divisions may be divided into subdivisions, and species may be divided into subspecies (varieties and forms are also categories below the rank of species).

What Is a Species?

As indicated previously, each kind of organism is known as a species, although this intuitive definition, based on morphological similarities, scientists have given much thought to the biological basis of a species, the first proposed by Ernst Mayr in 1942, which defines a species as "a group of interbreeding populations reproductively isolated from any other such group of populations."

This definition presents problems when defining plant species, many closely related plant species that are distinct morphologically are in fact, able to interbreed; this is true for many species of oaks and sycamores. By contrast, a single plant species may have diploid and polyploid (more than the diploid number of chromosomes) individuals that may be reproductively isolated from each other. It is estimated that as many as 40% of flowering plants may be polyploids, with the evening primrose group a thoroughly studied example; an even higher percentage of polyploid species occurs in ferns.

Table 1: Traditional and Standardized Names for Some Common Families

Family Name	Traditional Name	Standardized Name
Sunflower	Compositae	Asteraceae
Mustard	Cruciferae	Brassicaceae
Grass	Gramineae	Poaceae
Pea	Leguminosae	Fabaceae

Palm	Palmae	Arecaceae
Carrot	Umbelliferae	Apiaceae

Table 2: The Taxonomic Hierarchy and Standard Endings

Rank	**Standard Ending**	**Example**
Division (Phylum)	-phyta	Magnoliophyta
Class	-opsida	Liliopsida
Order	-ales	Liliales
Family	-aceae	Liliaceae
Genus		*Lilium*
Species		*Lilium superbum L.*