UNIVERSITY OF HOHENHEIM

Adaptation of plants to the Mediterranean climate

Seminar contribution to the module "Terrestrial Ecosystems" (2101-230)
Institute of Botany (210a) · University of Hohenheim · Stuttgart
presented by Marina Moser on January 16, 2019

Structure

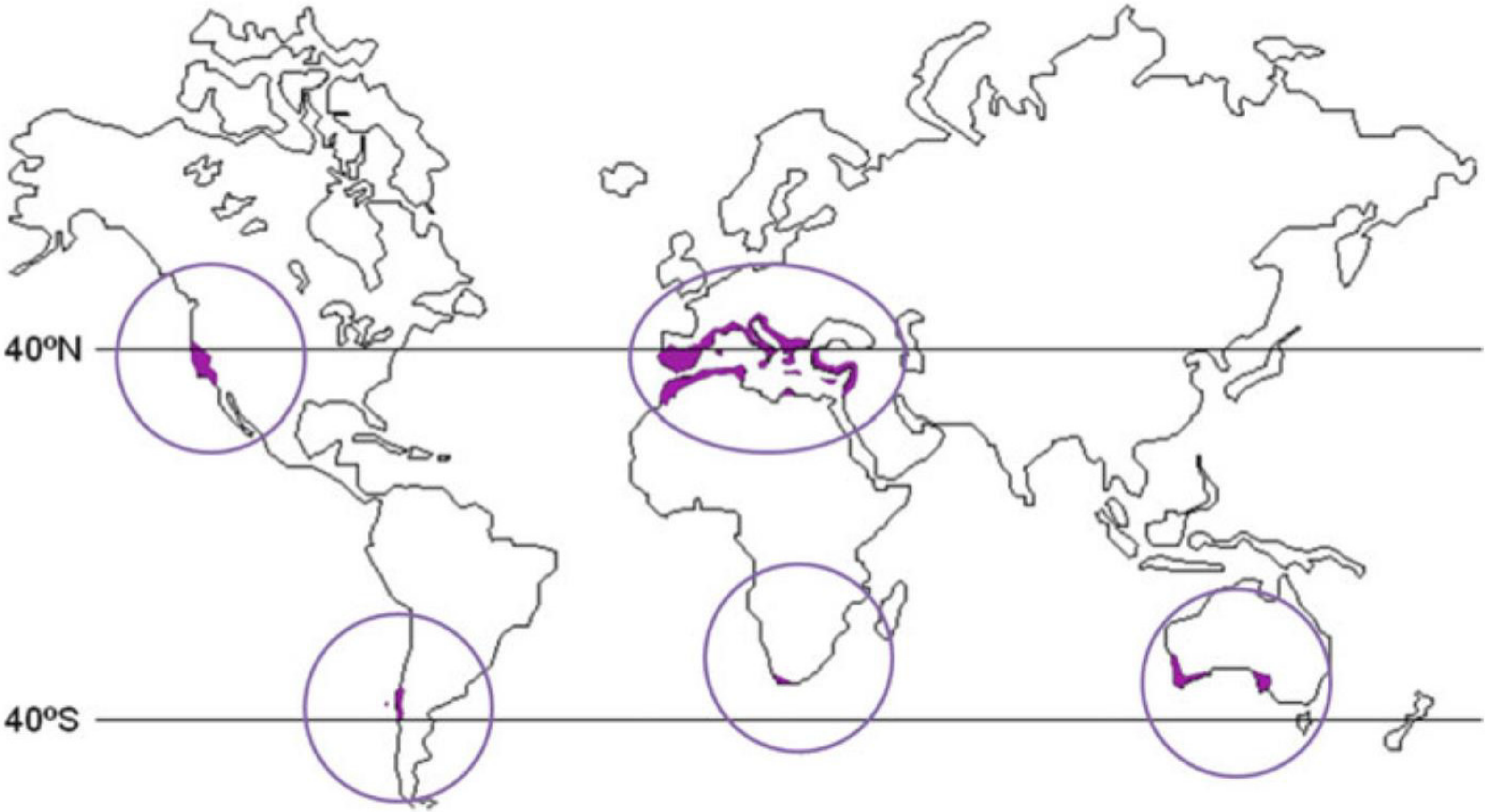
The Mediterranean climate

Challenges for the plant

Adaptations of the life forms

1. Phanerophytes
2. Chamaephytes
3. Hemicryptophytes
4. Cryptophytes
5. Therophytes

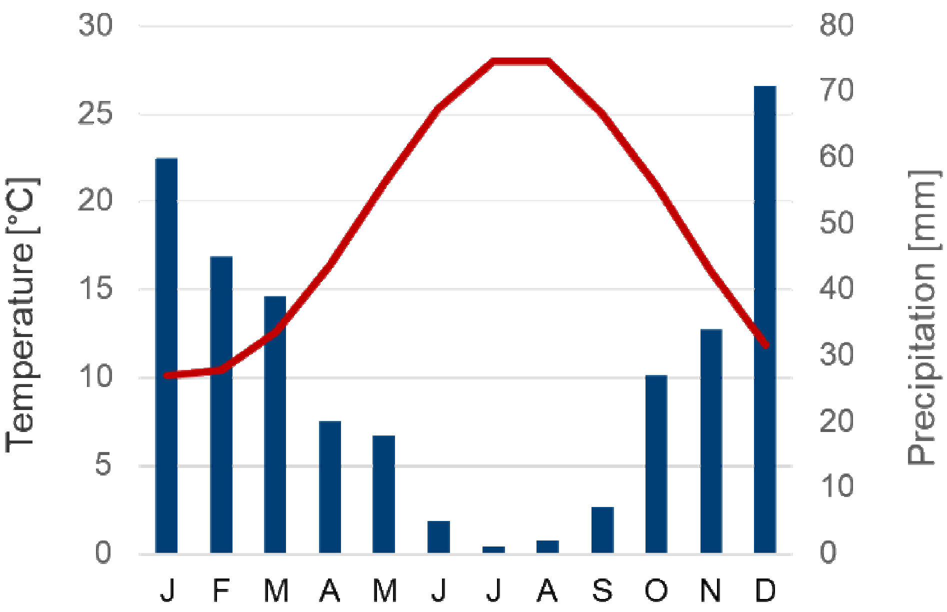
The Mediterranean climate: regions



World map with regions with Mediterranean climate highlighted [2].

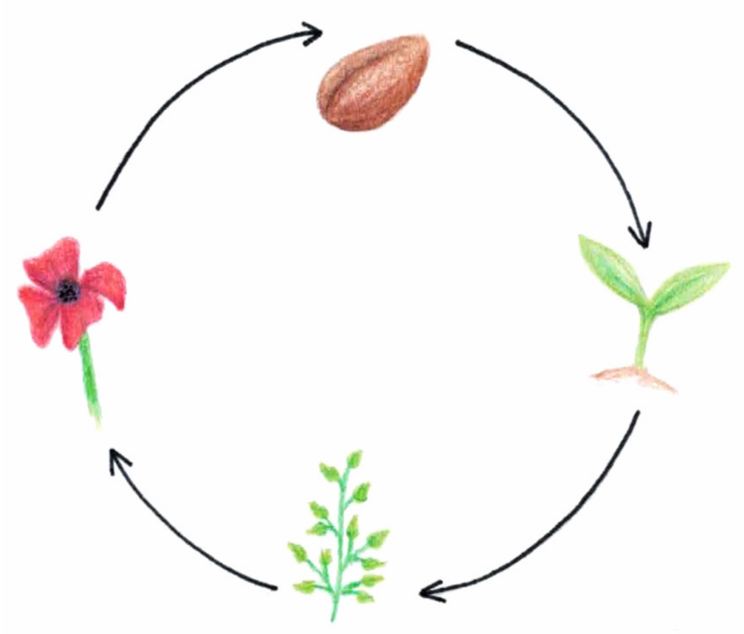
The Mediterranean climate: Characteristic features

The warm temperate Mediterranean climate is characterised by hot summers and cool winters with an average temperature of 5 - 10° C in January. Precipitation adds up to a total of 500 - 900 mm per year, which matches that of Central Europe. However, precipitation is distributed unevenly in that it is limited to the winter months and missing in summer. The climate is classified as *Csa* in the Köppen-Geiger climate classification.



Climate graph of Girne (Kyrenia) at 21 m a.s.l. with a mean temperature of 19.6 °C and 449 mm of annual precipitation [3].

Life cycle of plants

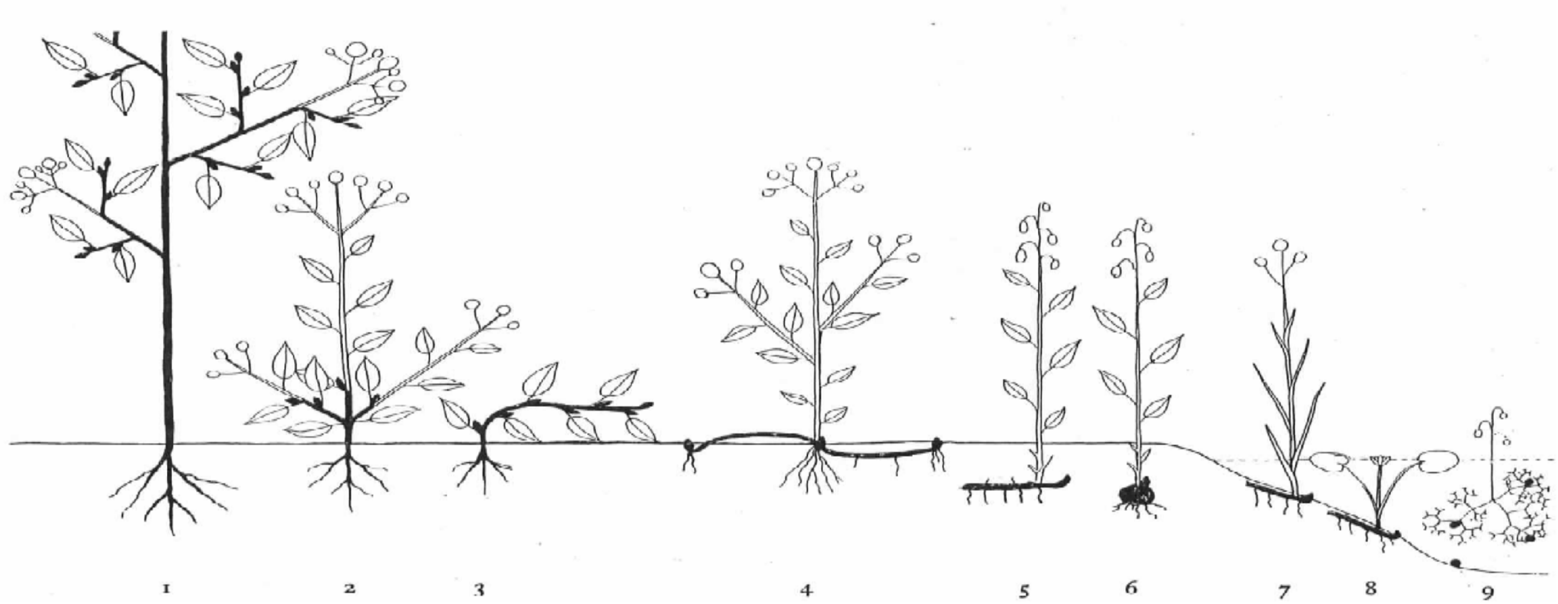


Schematic life cycle of flowering plants [4].

Generally, a flowering plant's life cycle consists of four stages. Plants start off as seeds and when conditions are favourable, they germinate. The seedlings grow into mature plants and after fertilization will eventually form seeds. At the right time, these will turn into the next generation of seedlings. However, the unequal distribution of precipitation and the intense radiation in summer in the Mediterranean ecosystem present a challenge to the plants. Therefore, they have to adapt their life cycle to the climatic conditions.

Christen Raunkiær's life forms

In 1903, Danish botanist Christen Raunkiær published a system to classify plant life forms based on their adaptation to the unfavourable season. He categorized plants according to the position of their perennating parts, i.e. buds or shoot apices.

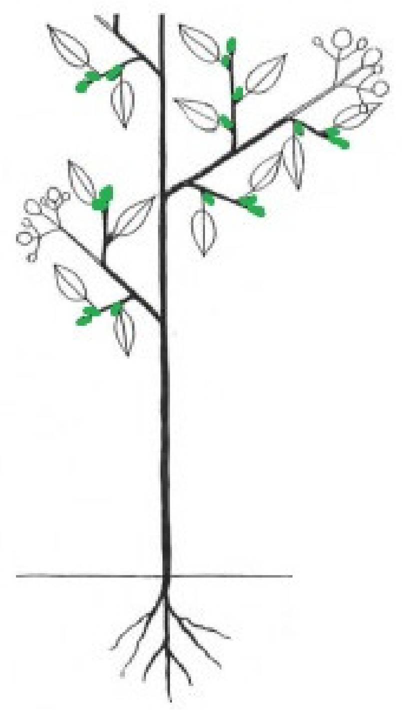


Schematic illustration of Raunkiær's life forms.
1: Phanerophyte 2,3: Chamaephytes 4: Hemicryptophyte 6-9: Cryptophytes [5].

1. Phanerophytes

Phanerophytes are plants whose buds or shoot apices are located on branches high in the air throughout the unfavourable season. Most Mediterranean phanerophytes are trees and shrubs. Raunkiær further divides this group into evergreen and deciduous phanerophytes with and without bud-covering. Smith (1913) groups phanerophytes by height, nanophanerophytes being less than two metres high up to megaphanerophytes at over 30 metres.

The most prominent phanerophytes of the Mediterranean are evergreen sclerophylls and semi-deciduous species.



Schematic Phanerophyte [6].

1. Phanerophytes: evergreen sclerophylls

Sclerophyllous phanerophytes like the Greek strawberry tree (*Arbutus andrachne* L.) bear small, leathery leaves. These are relatively costly to produce and therefore oftentimes quite persistent.

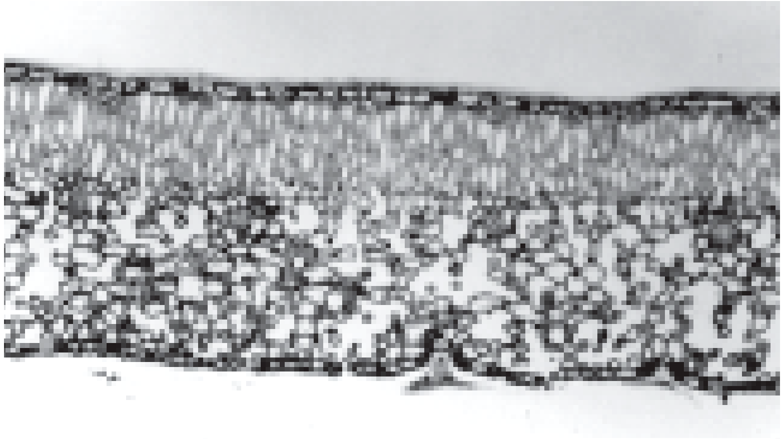
Indeciduous sclerophyll vegetation must be uniquely adapted to the dry Mediterranean summer, specifically to the water deficit and intense radiation to prevent wilting and radiation damage. Therefore, their leaves exhibit characteristic features that enable Mediterranean sclerophyll to withstand the harsh conditions in the climatically challenging summer.

Arbutus andrachne L. (Ericaceae) [7].

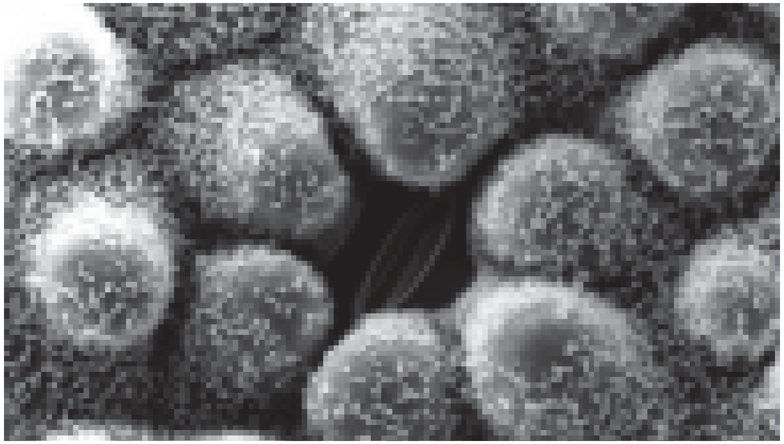
1. Phanerophytes: evergreen sclerophylls

The epidermal layer of the leaves of many Mediterranean phanerophytes have thickened cell walls in addition to a distinct cuticle to protect the inner layers from radiation. The palisade parenchyma takes up almost half the height of the leaf in cross-section.

To prevent water loss, stomata are usually sunken into the surface of the leaf, overarched by papillae or surrounded by rings of waxes.



The leaf internal structure of *Olea europaea* L. (Oleaceae). Magnification 100x [8].

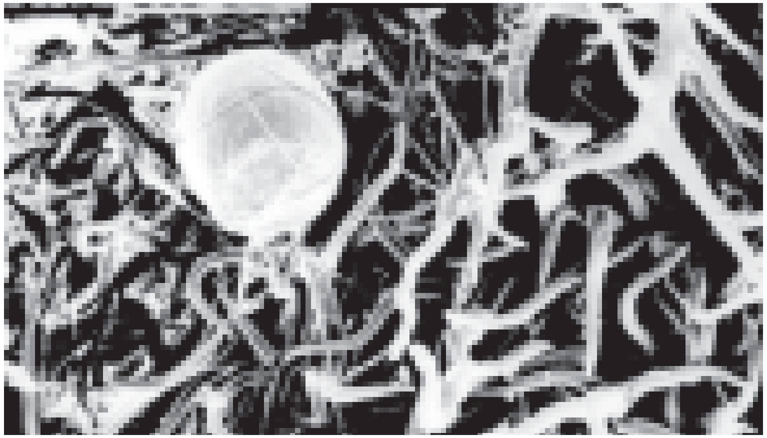


Stomata of *Euphorbia characias* L. (Euphorbiaceae). Magnification 1200x [9].

1. Phanerophytes: evergreen sclerophylls

Dense layers of trichomes increase leaf reflectance, thereby restricting light absorbance and regulate leaf temperature.

Additionally, most of the Mediterranean sclerophyll vegetation stores phenolic compounds in the vacuole and wall of epidermal cells to absorb UV light and to deter herbivores.



Hairs and trichomes of *Rosmarinus officinalis* L. (Lamiaceae). Magnification 300x [10].

R. officinalis L. (Lamiaceae) [11].

1. Phanerophytes: semi-deciduous phanerophytes

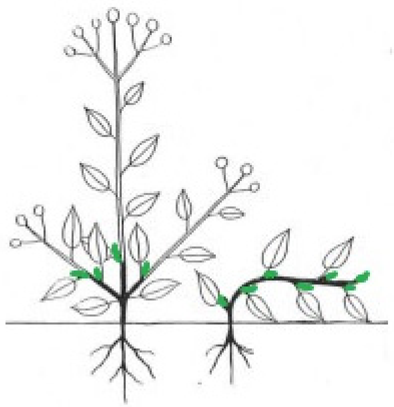
These phanerophytes avoid drought stress by casting part of their leaves at the beginning of the climatically challenging summer season.

Another adaptation of *Cistus* spec. to the excessive summer radiation is to adapt a more vertical leaf orientation in summer (> 70 °), compared to the rather horizontal (< 35°) orientation in spring. This helps prevent radiation damage as well as overheating of the leaf.

Cistus creticus L. (Cistaceae) [12].

2. Chamaephytes

In Chamaephytes, the buds or shoot apices live through the unfavourable season close to the ground. Raunkiær defined three subgroups.



Schematic Chamaephyte [13].

2a: Suffruticose chamaeophytes

These plants develop shoots in the favourable season of which the outermost parts die back in the unfavourable season. The buds are located on the surviving parts of the shoots. The portion of the shoot that dies off varies, depending on species and climatic conditions.

Zilla spinosa (L.) Prantl (Brassicaceae) [14].

2. Chamaephytes

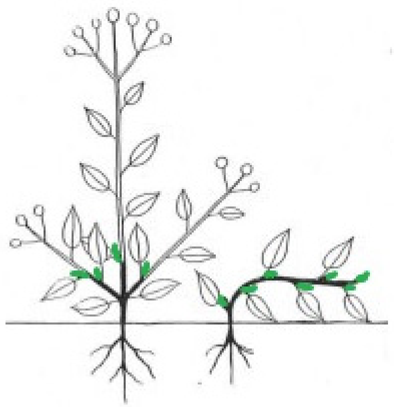
2b Active/passive chamaephytes:

The shoots of passive chamaephytes remain upright early in the unfavourable season but collapse as conditions become more challenging. Only the shoots' apices are erect.

Active chamaephytes grow transversely geotropic. They can be distinguished from the passive chamaephytes by their shoot apices, which are never bent upwards in active chamaephytes. The shoots tend to develop roots when they come into contact with damp earth.

2c Cushion plants:

The shoots of cushion plants are clustered together tightly so they do not collapse.



Schematic Chamaephyte [13].

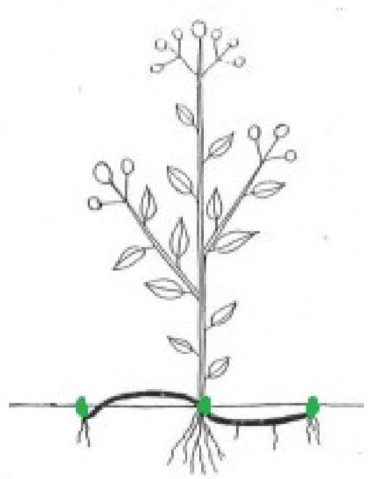
Antirrhinum majus L. (Plantaginaceae) [15].

3. Hemicryptophytes

Hemicryptophytes bear their surviving buds in the soil-surface. There, they are protected by a thin layer of soil and by remains of the plant. Aerial shots, which re-emerge from the buds the following season only last for one vegetation period.

Typically, these plants do not grow very high but spread readily through horizontal runners.

Some plants, like *Rosmarinus officinalis* grow as phanerophyte shrubs in the Mediterranean, whereas further north they have a hemicryptophyte-like appearance.



Schematic hemicryptophyte [16].

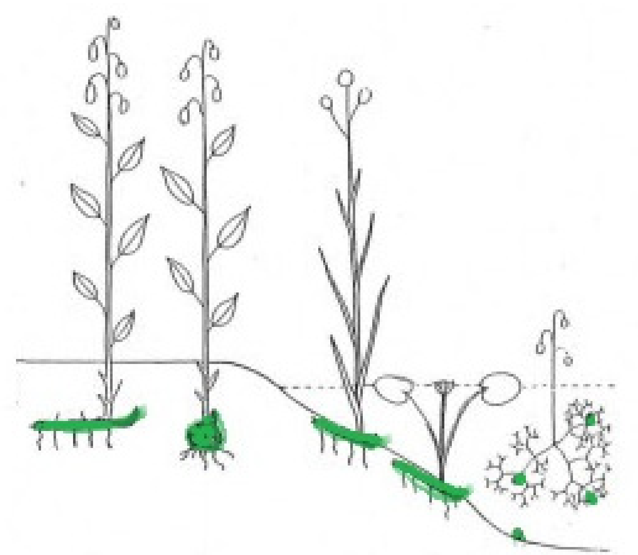
Plantago lanceolata L. (Plantaginaceae) [17].

4. Cryptophytes

Their buds, bulbs or rhizomes are situated well below the soil surface. Thus, the hibernating organs are protected excellently against desiccation and temperature fluctuations. To subcategorize further, Raunkiær (1934) introduced three groups:

1. Helophytes are cryptophytes which grow in soil saturated with water or in the water itself.

2. Hydrophytes have their buds as well at the bottom of the water. Their vegetative shoots are submerged and leaves may either be submerged or float on the surface. Only the flowers protrude into the air.



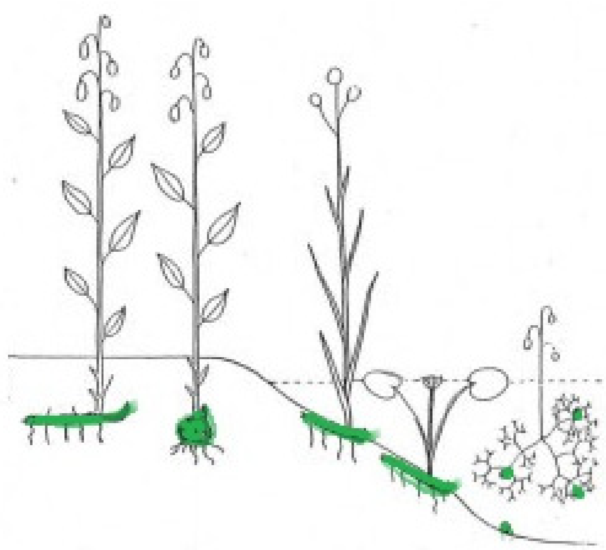
Schematic cryptophytes [18].

4. Cryptophytes

3. Geophytes include land plants that have their surviving organs deep in the soil. As this strategy provides significant protection, geophytes are found most often in very harsh environments like the desert or the northernmost latitudes. In most cases, the surviving organs are thick and bulb-shaped which allows them to store nutrients.

Storing nutrients are essential so the plant can start its development before the vegetative season begins and thus make use of the short favourable season ideally.

Anemone coronaria L. (Ranunculaceae) [19].



Schematic cryptophytes [18].

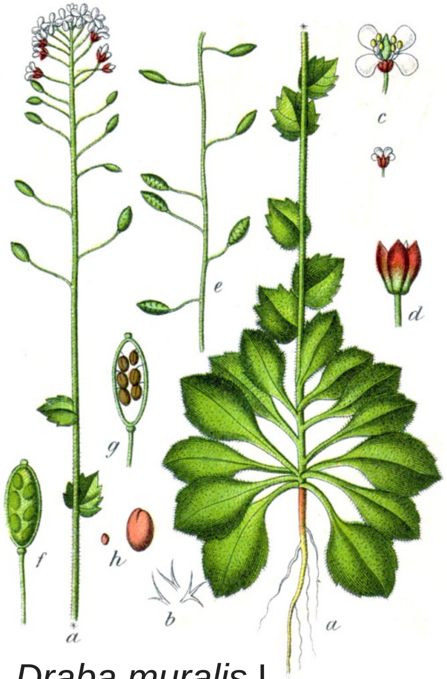
5. Therophytes

Therophytes plants are usually annual, i.e. they complete their entire life cycle in one single season. Some only take a few weeks from seed to seed. At the end of the vegetative season these plants die and only their seeds live through the unfavourable season.

Therophytes are relatively abundant in dry regions as seeds are well-adapted to aridity.

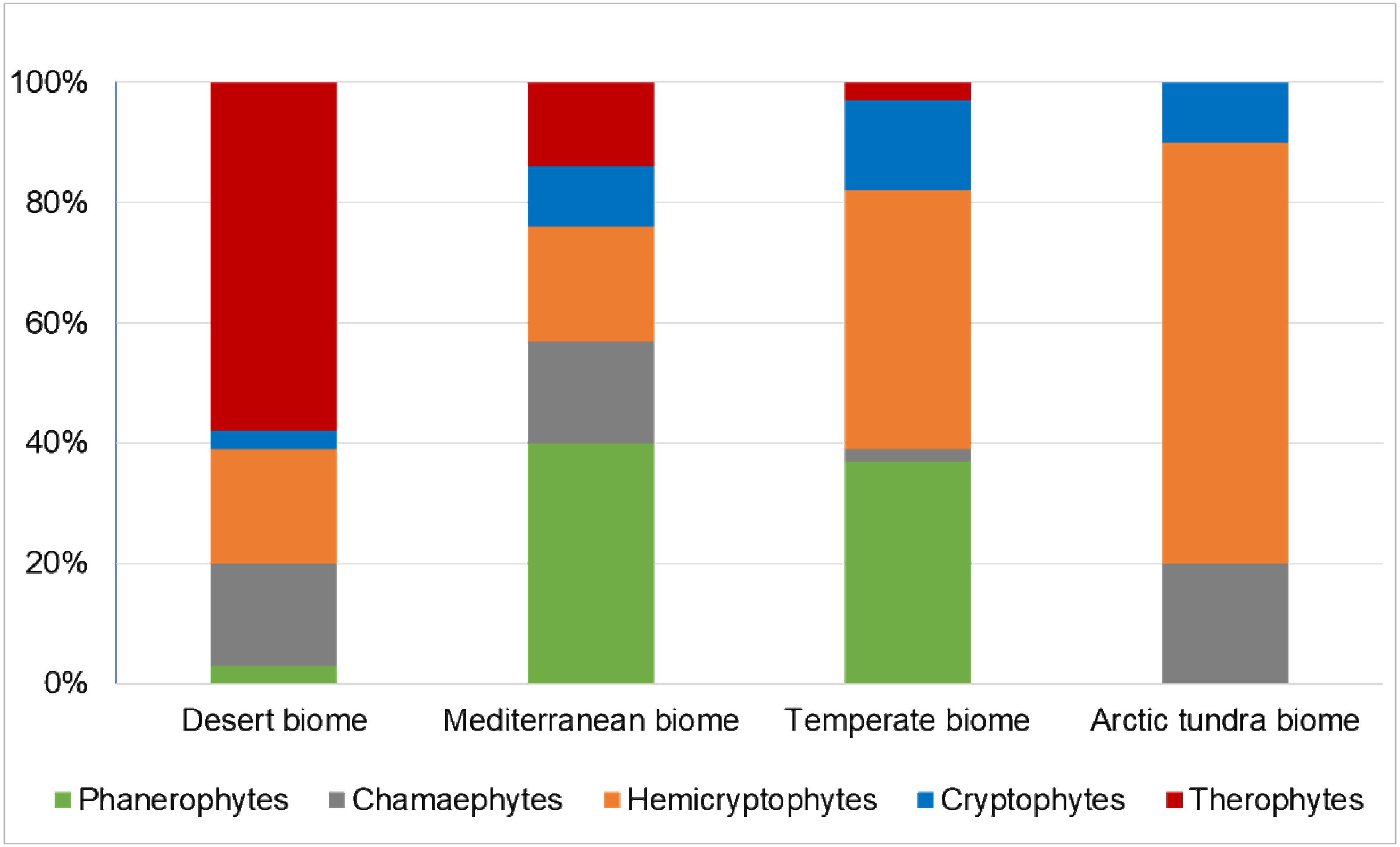
Note that biennial plants that survive the unfavourable season as rosettes are considered therophytes as well.

Arabidopsis thaliana (L.) Heynh. (Brassicaceae) [20].



Draba muralis L. Brassicaceae) [21].

Distribution of life forms per biome



Stacked column chart showing the distribution of life forms per biome type [22].

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Illustrations

[1] Marina Moser. 26-04-2014.

[2] adapted from Spano & al. (2013).

[3] adapted from https://en.climate-data.org/asia/cyprus/Nicosia/Nicosia-715118. Request 29-11-2018.

[4] Marina Moser. 14-01-2019.

[5] adapted from Raunkiær (1934).

[6], [13], [16], [18] Adapted from Raunkiær (1934).

[7] adapted from Andrew Butko. https://upload.wikimedia.org/wikipedia/commons/b/b2/Arbutus_andrachne_habit_%28Ab_plant_97%29.jpg. Request 27-01-2019

[8], [9], [10] Adapted from Rotondi & al. (2003).

[11] Marina Moser. 26-02-2018.

[12] adapted from Jörg Hempel. https://upload.wikimedia.org/wikipedia/commons/b/b3/Cistus_creticus_LC0069.jpg. Request 25-01-2019.

[13] adapted from Christian Ferrer. https://upload.wikimedia.org/wikipedia/commons/0/0a/Cistus_albidus_in_Sainte_Lucie_ Island.jpg. Request 30-12-2018.

[14] Marina Moser. 12-03-2018.

[15] adapted from Carsten Niehaus https://upload.wikimedia.org/wikipedia/commons/c/c8/Antirrhinum_majus_ssp_linkianum_b.jpg. Request 30-12-2018.

[17] adapted from Sannse Carter. https://upload.wikimedia.org/wikipedia/commons/1/17/Ribwort_600.jpg. Request 14-01-2019.

[19] Marina Moser. 03-03-2018.

[20] adapted from Marco Roepers. https://upload.wikimedia.org/wikipedia/commons/6/6f/Arabidopsis_thaliana.jpg. Request 14-01-2019.

[21] adapted from Johann Georg Sturm. https://upload.wikimedia.org/wikipedia/commons/3/35/Draba_muralis_Sturm17.jpg. Request 14-01-2019.

[22] adapted from Archibold (1995).