ANOMALOUS (ABNORMAL) SECONDARY GROWTH IN PLANTS

This phenomenon refers to any deviation from the typical pattern of secondary thickening seen in most dicotyledonous and gymnospermous stems and roots, where a single vascular cambium forms a continuous ring and produces secondary xylem internally and secondary phloem externally in a regular manner. Anomalous secondary growth occurs in several families (e.g., Bignoniaceae, Nyctaginaceae, Amaranthaceae, Chenopodiaceae, Aristolochiaceae, and certain monocots).

Anomalous secondary growth occurs because of the following reasons;

i. Abnormal position of cambium
ii. Abnormal behaviour of cambium
iii. Accessory cambium formation
iv. Extrastellar cambium
v. Scattered vascular bundles
vi. Absence of vessels

i) Abnormal Position of Cambium

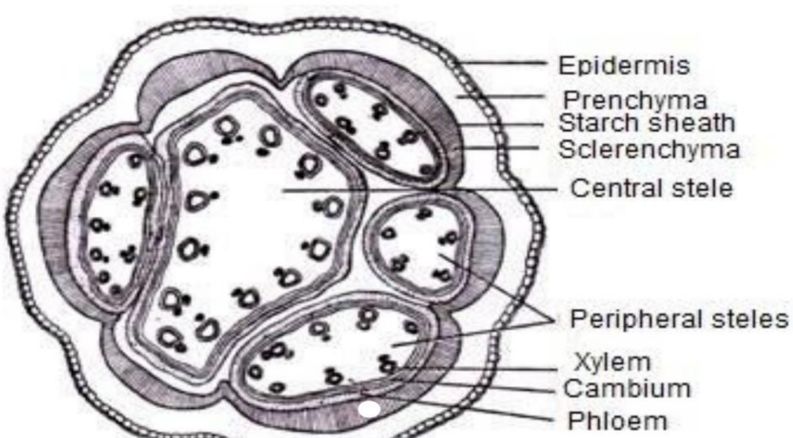
In normal secondary growth, the vascular cambium originates intrafascicularly (within vascular bundles) and interfascicularly (from interfascicular parenchyma), forming a **continuous cylindrical ring** inside the stele (intrastelar).

In anomalous cases, the cambium occupies an **abnormal position**:

Extrastelar/extrafascicular cambium arises outside the primary vascular cylinder, usually from the **pericycle** or inner cortex.

Examples: In **Boerhaavia** (Nyctaginaceae) and **Bougainvillea**, the first cambium is extrastelar, originating from pericycle cells. The cambium ring lies external to the primary vascular bundles, and its activity produces secondary vascular tissues in an atypical location.

Significance: This leads to the formation of successive concentric rings of vascular tissue embedded in conjunctive parenchyma, giving the stem a **concentric or polycyclic appearance** instead of the usual solid woody cylinder. Such positioning is often adaptive in climbing or scandent plants, allowing flexibility and rapid girth increase.



ii) Abnormal Behaviour of Cambium

Even when the cambium is in the normal (intrastelar) position, its **activity** deviates from the regular pattern (equal production of xylem inside and phloem outside).

Abnormal behaviour includes:

a. **Unequal production** of secondary tissues: Excessive secondary xylem in some sectors and more secondary phloem in others.

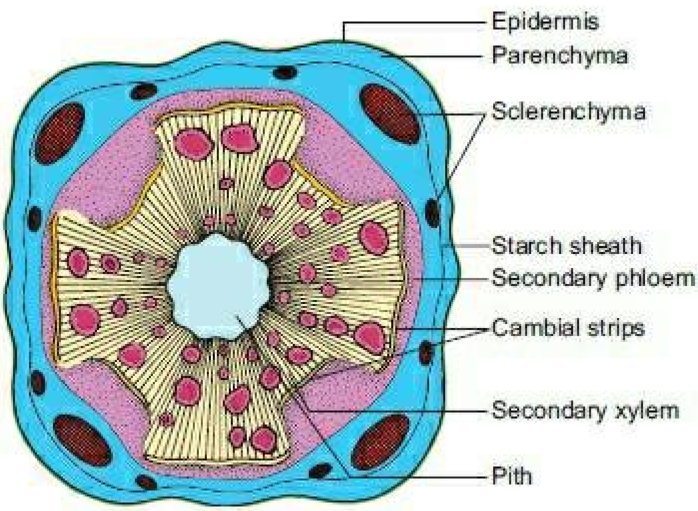
b. **Formation of phloem wedges** or **intrusions** into the secondary xylem, creating a **ridged and furrowed** (lobed) woody cylinder.

c. **Production of more parenchyma** than vascular tissue in certain regions, resulting in soft, parenchymatous zones alternating with xylem.

Examples: Bignonia (Bignoniaceae): The cambium produces wide phloem wedges that penetrate deep into the secondary xylem, giving a characteristic **four-angled** or ridged appearance in cross-section.

Aristolochia (Aristolochiaceae): The cambium produces excessive parenchyma in certain sectors, leading to a **fissured** or lobed secondary xylem.

Significance: These anomalies are often **adaptive** in lianas and climbers, allowing stem flexibility while maintaining mechanical support.



iii) Accessory Cambia Formation

Accessory (successive or supernumerary) cambia are additional cambial rings formed after the primary cambium ceases activity or in addition to it.

Process: The primary cambium functions for a short period.

New accessory cambial rings arise successively from the **secondary cortex**, **pericycle**, or **outer secondary phloem**.

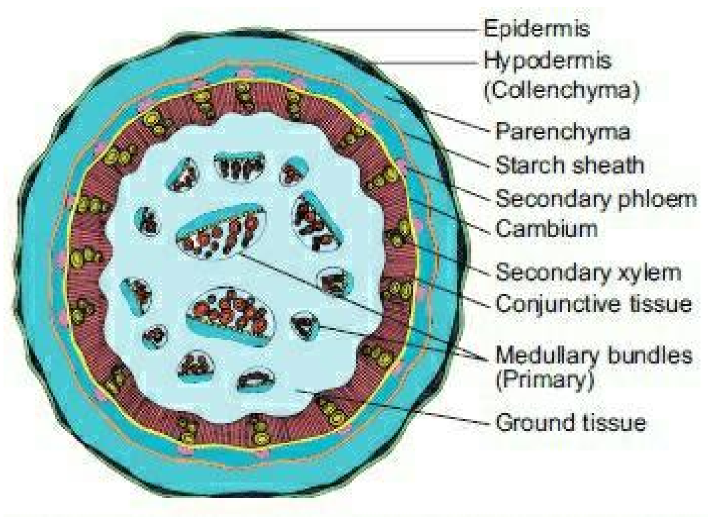
Each new cambium produces a ring of secondary xylem internally and secondary phloem externally, resulting in **concentric vascular rings** embedded in conjunctive parenchyma.

- Examples:

Boerhaavia, **Bougainvillea**, and **Mirabilis** (Nyctaginaceae): Multiple concentric rings of vascular bundles are formed.

Strychnos (Loganiaceae): Similar successive cambial activity.

Significance: This type of growth allows rapid increase in girth in scandent plants and storage organs (e.g., beetroot), providing flexibility and mechanical strength without forming a solid woody core.



iv) Extra-stelar Cambium

This refers specifically to cambium that forms **outside the primary stele** (extrastelar position), usually from the **pericycle** or inner cortex.

Process: A new cambial ring originates in the pericycle or cortical region, external to the primary vascular bundles.

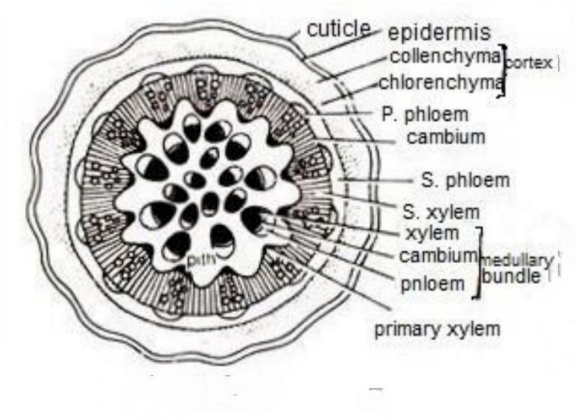
This extrastelar cambium functions normally (produces secondary xylem inside and phloem outside) but in an abnormal location.

It often gives rise to successive rings of vascular tissue.

Examples: Boerhaavia and **Bougainvillea** (Nyctaginaceae): The first cambium is extrastelar and initiates the anomalous pattern.

Amaranthus and **Achyranthes** (Amaranthaceae): Extrastelar cambium forms successive concentric rings.

Significance: Extrastelar cambium is a major cause of anomalous secondary thickening in many dicot families, especially in climbing or storage plants, enabling flexible stem expansion.



v) Scattered Vascular Bundles

In normal dicot stems, vascular bundles are arranged in a **ring** (eustele), with a continuous cambium forming between them.

In anomalous cases, vascular bundles are **scattered** throughout the ground tissue (similar to monocots), and cambial activity may occur around individual bundles.

Process: Primary vascular bundles are scattered in the cortex or pith (medullary bundles).

Cambial activity may develop around these scattered bundles, producing limited secondary growth.

Examples: Piper and **Peperomia** (Piperaceae): Scattered vascular bundles in the cortex with limited cambial activity.

Some **Nyctaginaceae** and **Amaranthaceae** species show scattered bundles along with anomalous cambium.

Significance: This pattern provides flexibility and is common in herbaceous or scandent dicots; it is considered a transitional condition between dicot and monocot vascular organization.

vi) Absence of Vessels

In typical angiosperm xylem, vessels (tracheary elements with perforated end walls) are present. In anomalous cases, the secondary xylem is **vessel-less** (tracheids only), resembling gymnospermous wood.

Process: Vessels are completely absent in the secondary xylem; only tracheids conduct water.

This is a primitive character retained in certain lineages.

Examples: **Winteraceae** (e.g., Drimys) and **Hydrilla** (aquatic plant) lack vessels in their xylem.

Some **Chloranthaceae** and **Trochodendraceae** also show vessel-less secondary xylem.

Significance: The absence of vessels is considered an evolutionary primitive feature; these plants rely on tracheids for water conduction, which is less efficient but more resistant to cavitation under stress.