Lecture 3 Botany 21st Century
Plant Names and Classification/cells and Meristems chp 3
Chapter 16
Outline

- Development of Binomial Nomenclature
- International Code of Botanical Nomenclature
- Development of the Kingdom Concept
  - Classification of Major Groups
- Cladistics

Development of Binomial Nomenclature

- Theophrastus first attempted to organize and classify plants in the 4th century B.C.
  - Classified nearly 500 plants on the basis of leaf characteristics.
    - By the beginning of the 18th century, details of fruit and flower structure, in addition to form and habit, were used in classification schemes.

Development of Binomial Nomenclature

- Customary to use descriptive Latin phrase names.
  - All organisms were grouped into genera with the first word of the Latin phrase indicating the particular genus to which the organisms belonged.

Development of Binomial Nomenclature

- Linnaeus set out to classify all known plants and animals according to their genera.
  - Also changed the Latin phrases to reflect relationships, placing one to many kinds of organisms, species, in each genus.
    - Limited each Latin phrase to a maximum of 12 words.
      - Abbreviated names to two parts (binomials).

Development of Binomial Nomenclature

- Binomial System of Nomenclature
  - All species or organisms are named according to this system, which includes the authority for the name.
    - Spearmint: *Mentha spicata L.*
      - Linnaeus organized all known plants into 24 classes which were based mainly on the number of stamens in flowers.

International Code of Botanical Nomenclature

- Single book with a common index to English, French, and German translations of the various rules and recommendations.
  - Requires two steps to officially recognize a new plant species.
    - Latin description of the plant must be published in a journal or other public publication.
    - Annotated herbarium specimen must be deposited in an herbarium.

Development of the Kingdom Concept

- Early classification schemes naturally classified all living organisms as either plants or animals.
  - The distinction works well for complex animals, but not for simpler organisms.
    - Hogg and Haeckel proposed a third Kingdom in the 1860's.
      - All organisms that did not develop complex tissues were placed in Protoctista.

- ***Hypoglossum subsImplex*** Wynne sp. nov.
- *Fasciculus lamina rum simplicium aut subsimplicium erectarum delicatarum e base disciformi orientium; ranNflcatio tantum ad unum* ***ordinem; laminae tantum usque 6 mm*** *altae;* ***margins*** *laminae laeves; costa corticata destituta; omnes cellulae serierum cellularum secundi ordinis series cellularum tertii ordinis procreant; tetrasporangia tantum in una lamina procreant, cellulis ambo serierum secundi ordinis et tertii ordinis abscissa, vicina costa laminae, sic laterales cellulas pericentrales includentibus; sorus tetrasporangiorum non discretus in longitudino sed ad aliquot distanciam currens; sori spermatangiorum plerumque in turmis diagonaliter aut irregulariter dispositi, parvi et sejuneti aut confluentes; uno aut duo cystocarpiae in quoque femina lamina, in costa locatae.*
- **Diagnosis:** A cluster of simple or subsimple erect, delicate blades arising from a discoid base; branching to one order only; blades only up to 6 mm tall; margins of blade smooth; corticated midrib lacking; all second-order row cells producing third-order rows; tetrasporangia produced in only the primary layer, cut off by cells of both second- and third-order rows in vicinity of midline of blade, thus including lateral pericentral cells; tetrasporangial sorus not discrete in length but running continuously for some distance; spermatangial sori arranged usually in diagonal or irregular groups, small and isolated or becoming confluent; I or 2 cystocarps per female blade, located on the midline.
- **Holotype:** Wynne 9959 (slide in MICH), on *Halimeda tuna*, collected by M. D. Hanisak, 19 June 1994, Content Keys, lee side of Florida Keys, Florida, U.S.A. **Isotypes:** slides deposited in MEL, PC, UC, US.

Cellular Tree of Life

Development of the Kingdom Concept

- In 1938, Copeland proposed all single-celled organisms with prokaryotic cells be separated into the Monera Kingdom.
  - In 1969, Whittaker split Fungi off from the Protista Kingdom.
    - In the 1990s, Woese argued Monera should be split into Archaea and Bacteria.
      - Currently have six Kingdoms:
        - » Archae - Bacteria - Protista - Fungi - Plantae - Animalia

- Genes encoding
- ribulose-l,5-bisphosphate carboxylase/oxygenase (Rubisco) were cloned from dinoflagellate symbionts (*Symbiodinium* spp) of the giant clam *Tridacna gigas* and characterized. Strikingly, *Symbiodinium* Rubisco is completely different from other eukaryotic (form I)
- Rubiscos: it is a form II enzyme that is ~65% identical to Rubisco from *Rhodospirillum rubrum* (Rubisco forms I and II are ~25 to 30% identical

Classification of Major Groups

- Genera are now grouped into Families.
  - Families are grouped into Orders.
    - Orders are grouped into Classes.
      - Classes are grouped into Phyla.
        - » Phyla are grouped into Kingdoms.
- Depending on the classification system, there are between 12 and 30 recognized plant phyla.

Classification of Major Groups

- Various in-between categories such as subphylum, subclass, and suborders have been used, and species are sometimes further divided into subspecies, varieties and forms.
  - Taxonomists specialize in identifying, naming, and classifying organisms.

- Systematists incorporate evolutionary processes in their distinctions.

Classification of Major Groups

- Dichotomous Keys are used to help identify and classify organisms.
  - Works by examining an organism and choosing from paired statements that most closely apply to the organism in question.
    - Not always practical due to different life stages.

Cladistics

- Cladistics is a method of examining natural relationships among organisms, based on shared features.
  - Relationships are portrayed in straight line diagrams.
    - The value or form of a feature is referred to as a character state.
- **Cladistics** is an approach to classification in which items are grouped together based on whether or not they have one or more shared unique characteristics that come from the group's common ancestor and are not present in more distant ancestors.
- Therefore,
- members of the
- same group are
- thought to share
- a common history
- and are considered to be
- more closely related

Cladistics

- In trying to choose the best cladograms, taxonomists use the principle of parsimony.
  - Occam's Razor
    - "One should not make more assumptions than the minimum needed to explain anything"
- The best cladogram is interpreted as that which requires the fewest evolutionary changes in the taxa involved.
- **. Binomial means Two Names (Genus & specific epithet). Snidely Whiplash is an example of a binomial name!**
- **The binomial system of identifying organisms with binomial names was formally developed by Linnaeus.**
- **This has become the "universal" method used in Science Worldwide.**

Examples

Genus of maple trees is *Acer*

It has many species including:

| Common name | Scientific name |
|---|---|
| "Red maple" | *Acer rubrum* |
| "Sugar maple" | *Acer saccharum* |
| "Black maple" | *Acer nigrum* |

.

**Coconut Palm (niu) = *Cocos nucifera***
**Taro (kalo) = *Colocasia esculenta***
**Sugarcane (ko) = *Saccharum officinarum***

**. Latin was adopted as the official language for identifying plants because it was**

- **widely known by educated Europeans**
- **unlikely to change because it was not in common parlance. Conversation; discourse; talk;**
- **the spelling (and meaning) of Latin words and phrases would not change over time.**

**.I did not fully appreciate this until I had to use a copy of the Japanese Journal of Phycology. The text was in Japanese (surprise, surprise) and was incomprehensible to me. However, each species was identified by its *Latin name* which I could recognize or look up.**

- **. Scientific names are *italicized* or underlined.**
- **Each binomial is accompanied by an "Authority" which identifies the person who applied a name to a particular organism.**
- **. This is abbreviated when the authority is well known, like Linnaeus. An L. after a binomial indicates that Linnaeus was the authority.**
- **This is important when scientists want to repeat the work of others, or track down the names which have been used to designate a species.**
- **As you can imagine, individual species have been given different names by people working in different parts of the world, over a long time-span.**
- **The authority is not generally used except in cases like Scientific Papers and Herbarium specimens where this is essential.**

.Species

- **The Species is the basic unit of Taxonomy.**
- **Taxonomy is the formal science which attempts to classify species and show their interrelationships.**
- **The word Taxon can be used to designate a group of related organisms without being specific about their taxonomic level.**
- **This is a convenient term!**

**. The literal meaning of the word Species is kind. This is a general concept and could refer to different types of lava or different types of palms.**
**Plants can be grouped based on qualitative & quantitative traits like stature, leaf shape & flower color. These are said to be Morphological or Anatomical traits.**

**.Floral characteristics have been extremely important for the classification of plants, but other morphological and anatomical features are also significant.**
**Classical genetics and molecular genetics bring us to the genome where species traits become more certain.**

**. It has been possible to extract DNA from fossils and compare it with the DNA of living species to see the genetic similarities or differences. *This is truly AMAZING!!!!***
**The Species Concept is clear for most Animals because different species can't reproduce sexually.**
**Humans constitute a single species despite the Morphological differences between our "races".**

**. Kingdom Protista (Algae)**
**Divisions/Phylum**
**Rhodophyta**
**(Red Algae)**
**Phaeophyta**
**(Brown Algae)**
**Chlorophyta**
**(Green Algae)**

**. Kingdom Plantae (Terrestrial Plants)**
**Divisions/Phylum**
**Bryophyta**
**(Liverworts & Moss)**
**Psilophyta**
**(Wisk Ferns)**
**Lycophyta**
**(Clubmoss)**

**. Sphenophyta**
**(Horesetails)**

**Ptreophya (Ferns)**

. **KingdomPlantae (Terrestrial Plants cont.)Divisions/Phylum**
**Cycadopyta**
**(Cycads)**

**Coniferophyta**
**(Conifers)**

**Anthophyta**
**(Flowering Plants)**
Which group has the largest # organisms?
**Kingdom:**

- **Cell types**
- **Prokaryotes**
- **Eukaryotes**
- **Cell number**
- **Nutrition**
- **Structures**

Plant Kingdom
Division is now replaced by Phylum
PLANT SYSTEMATICS

- Common names
  - Have evolved over centuries in a multitude of languages
  - Sometimes used only in a limited geographical area
  - Problem with common names:
    - One plant may be known by several names in different regions, and the same name may be used for several different plants…

Scientific names

Similar plant species form a group called a genus (plural: genera)…
Genera are grouped into families…
Families into orders, classes, divisions(phyla) and kingdoms

Kingdom-Division-Class-Order-Family-Genus-Species

"King David Came Over For Great Spaghetti"
"King David Conquered Our Fifty Great States"

Species name

Each species has a single correct scientific name in Latin called a binomial (two names) – it is always *italicized* or underlined.

First name is **genus** name.
Second name is **species** name

Human: *Homo sapiens*
Cat: *Felis catus*
Dog: *Canis familiaris* Wolf: *Canis lupus*

- Through the lens of a high-powered microscope, Karen Steidinger of the Florida Fish and Wildlife Conservation Commission stares down at her nemesis of the past 43 years. *Karenia brevis, as a* Danish colleague renamed this plantlike speck of algae in tribute to Steidinger's groundbreaking contributions toward unraveling the mysteries of it cloverleafshaped body, twin tails and – under normal circumstances –laid-back lifestyle in the warm Gulf waters off western Florida.

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Review

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Cells
Chapter 3
Outline

- History
- Modern Microscopes
- Eukaryotic and Prokaryotic Cells
- Cell Structure
  - Cell Components
- Cell Reproduction
  - Interphase
  - Mitosis

History

- Cells discovered in 1665 by Robert Hooke.
- Cell Theory was generally developed around 1838 by Schleiden and Schwann.
  - All living organisms are composed of cells and cells form a unifying structural basis of organization.
- 1858 - Virchow argued there is no spontaneous generation of cells.
  - Pasteur experimentally disproved spontaneous generation in 1862.

Modern Microscopes

- Light Microscopes - Increase magnification as light passes through a series of transparent lenses made of glass or calcium fluoride crystals.
  - Compound Microscopes (1500x)
    - In general can distinguish organelles 2 micrometers or larger in diameter.
  - Dissecting Microscopes (30x)
    - Stereomicroscopes

Modern Microscopes

- Electron Microscopes - Use a beam of electrons produced when high-voltage electricity is passed through a wire.
  - Transmission Electron Microscopes - Can produce magnification up to 200,000x, but material must be sliced extremely thin.
  - Scanning Electron Microscopes - Offer magnification up to 10,000x but surface detail can be observed on thick objects.

Fig. 3.2a
Fig. 3.2b

Modern Microscopes

  - Scanning Tunneling Microscope - Uses a probe that tunnels electrons under a sample.
    - Reproduces an image with atomic resolution.

Eukaryotic versus Prokaryotic Cells

- Prokaryotic - Cells lacking a nucleus.
- Eukrayotic - Cells containing a nucleus.
  - Organelles - Membrane-bound bodies found within eukaryotic cells.

Cell Structure

- Cell Wall surrounds protoplasm (contains all living cell components).
  - Bound by a plasma membrane.
    - Cytoplasm consist of all cellular components between the plasma membrane and the nucleus.
      - Cytosol - Fluid within cytoplasm containing organelles.

Cell Size

- Cells of higher plants generally vary in length between 10 and 100 micrometers.
- Increase in surface area of a spherical cell is equal to the square of its increase in diameter, but its increase in volume is equal to the cube of its increase in diameter.
  - Smaller cells have relatively large surface to volume ratios enabling faster and more efficient cellular communication.

Cell Wall

- Main structural component of cell walls is cellulose.
  - Also contain matrix of hemicellulose, pectin, and glycoproteins.
- Middle lamella is first produced when new cell walls are formed.
- Secondary walls are derived from primary walls by thickening and inclusion of lignin.

**. The Sweater is outside of your body, just as the Cell Wall is outside of the Protoplast.**
**Back in the 50's college students tried to see how many people could cram into a telephone booth. Imagine that they are all wearing body sweaters (this was another craze in the 50's). Even though all of their bodies were pressed together their skins did not actually touch one another (they also wore gloves).**

**. However, their sweaters did touch. Their sweaters would constitute the major part of the Apoplast. Even though their bodies are extremely close together, there are some air spaces between them. These air spaces are also part of the Apoplast**
**Their bodies are each Protoplasts. All of their protoplasts would constitute the Symplast of the phone booth.**

**. What would happen if a prankster opened the top of the telephone booth and started pouring colored water onto the sweaters of those on top?**
**The water would pass through the Sweaters (Apoplast) but would be repelled by the skin (Plasmalemmas) of the Symplast.**

**. A typical plant cell has an external Wall, Cytoplasm and a Vacuole. The Plasmalemma is the boundary that separates the Cytoplasm and the Wall. The Tonoplast (Vacuole Membrane) is the boundary between the Vacuole and the Cytoplasm.**

**. If all of the Protoplasts are destroyed, the Apoplast remains like a honey-comb. The Apoplast consists of the Cell Walls and Intercellular Spaces.**

**This image shows the thick and sturdy cell walls found in the Velamen of Orchids. The Protoplasts are gone and the Apoplast is all that remains. The Velamen is the white part of exposed orchid roots.**

**. When the Cell Wall is removed, the Protoplast is directly exposed to the outside emvironment. The Protoplast is the Plasmalemma and everything in side of it.**

**. If all of the Cell Walls were removed and the cells touched one another they would constitute a Symplast (Sym means together).**

**. Cells are interconnedcted by Plasmodesmata. The interconnected Protoplasts constitute the Symplast.**

**. Plasmodesmata are narrow channels in the cell wall. There is continuity between the Cytoplasm and Plasma Membranes of adjacent cells. Consequently, the Protoplasts of each cell are in direct communion, and constitute the Symplast.**
**Molecules can pass from one cell to another via Plasmodesmata (Symplast).**

**Molecules can also move through the Apoplast but they must cross the *Plasmalemma* to enter the *Symplast*.**
**The movement of Molecules in the Apoplast is governed by the rules of Chemistry and Physics.**
**The Movement of Molecules in the Symplast is also governed by the rules above plus the rules of Biology.**

- **. Cell Wall Composition**
- **Polysaccharides (Polymers made from Sugars) constitute most of the cell wall.**
- **Cellulose is a Polymer of Glucose**
**Hemicellulose has Glucose as one of its principal components.**
**Pectins are principally composed of acidic sugars like galacturonic acid.**
- **Phenolic Compounds like Lignin may be present.**
- **. Proteins constitute a small fraction of the wall.**
- **Structural Proteins are frequently present.**
- **Elastin is a protein which appears to function in Wall Loosening.**
- **Extensin adds Rigidity to the wall.**
- **Enzymes may be present.**

**. The Principal Functions of the Cell Wall are to regulate Cell**
**VOLUME, SHAPE &**
**STRUCTURAL PROPERTIES.**
**Ecological Importance**

- **Cell Walls constitute the Major Component of Carbon Flow through Ecosystems**
- **Dead cell Walls help determine Soil Structure**

**. Functional Overview**
**The Cell Wall is a Cellular Exoskeleton (External) & thus provides Structural Support.**
**It is Necessary for the development of Specialized Cell Shapes. Otherwise, all cells would be spherical.**
**It is Required for Water Relations (Turgor Pressure would not develop without a Cell Wall).**

Communication Between Cells

- Fluids and dissolved substances can pass through primary walls of adjacent cells via plasmodesmota.
  - Cytoplasmic strands extending between cells.

Cellular Components

- Plasma Membrane
  - Composed of phospholipids arranged in two layers, with proteins interspersed throughout.
    - Some proteins extend across the entire width, while others and embedded to the outer surface.

Nucleus

- Nucleus is bound by two membranes, which together constitute the nuclear envelope.
  - Structurally complex pores occupy up to one-third of the total surface area.

- Contains fluid nucleoplasm packed with short fibers, and contain larger bodies.
  - Nucleoi composed primarily of RNA.
  - Chromatin Strands - Coil and become chromosomes.

Endoplasmic Reticulum

- Endoplasmic Reticulum facilitates cellular communication and materials channeling.
  - Enclosed space consisting of a network of flattened sacs and tubes forming channels throughout the cytoplasm.
    - Ribosomes may be distributed on outer surface (Rough ER).
      - Associated with protein synthesis.
    - Smooth ER is devoid of ribosomes and is associated with lipid secretion.

Ribosomes

- Ribosomes are composed of two subunits composed of RNA and proteins.
  - Ribosomal subunits are assembled within the nucleolus, released, and in association with special RNA molecules, initiate protein synthesis.
    - Have no bounding membranes.

Dictysomes

- Dictysomes (Golgi Bodies in animals) are often bound by branching tubules that originate from the ER.
  - Involved in the modification of carbohydrates attached to proteins synthesized and packaged in the ER.
    - Polysaccharides are assembled within dictysomes, and collect in small vesicles.
      - Migrate to plasma membrane and secrete contents to the outside.

Plastids

- Chloroplasts are the most conspicuous plastids.
  - Each bound by double membrane.
    - Contain stroma - Enzyme-filled matrix.
    - Contain grana made up of thylakoids.
      - Thylakoid membranes contain chlorophyll.
- Chromoplasts and Leucoplasts
- are additional plastids found
- in many plants.

Mitochondria

- Mitochondria release energy produced from cellular respiration.
  - Inward membrane forms numerous folds (cristae).
    - Increase surface area available to enzymes in the matrix fluid.

Microbodies

- Microbodies are small, spherical bodies with a single membrane, distributed throughout the cytoplasm which contain specialized enzymes.
  - Perixosomes - Serve in photorespiration.
  - Glyoxisomes - Aid in converting fat to carbohydrates.

Vacuoles

- In mature cells, 90% of volume may be taken up by central vacuoles bounded by vacuolar membranes (tonoplasts).
  - Filled with cell sap which helps maintain pressure within the cell.
  - Also frequently contains water-soluble pigments.

Cytoskeleton

- Cytoskeleton is an intricate network of microtubules and microfilaments.
  - Microtubules control the addition of cellulose to the cell wall.
  - Microfilaments play a major role in the contraction and movement of cells in multicellular animals.
    - Appear to play a role in cytoplasmic streaming.

Cellular Reproduction

- Cell division process referred to as cell cycle.
  - Divided into interphase and mitosis.
- Interphase
  - Period when cells are not dividing.
    - $G_1$ - Cell increases in size.
    - S - DNA replication takes place.
    - $G_2$- Mitochondria divide, and microtubules produced.

Mitosis

- Mitosis refers to the process of cellular division that produces two daughter cells with equal amounts of DNA and other substances duplicated during interphase.
  - Each daughter cell is an exact copy of the parent cell.
    - Mitosis occurs in meristems

.

Fig. 3.17cd

Prophase

- Chromosomes condense.
  - Strands of chromatin coil and tighten with centromeres holding each pair of chromatids together.
- Nuclear envelope fragments.
  - Kinetochore is located on the outer surface of each centromere.
    - Spindle fibers develop and become attached to the kinetochore.

Metaphase

- Chromosomes align at the cell's equator.
  - Spindle fibers collectively referred to as the spindle.
  - At the end of metaphase, the centromeres holding each sister chromatid separate lengthwise.

Anaphase

- Sister chromatids separate and are pulled to opposite poles.
  - Spindle fibers gradually shorten as material is continuously removed from the polar ends.

Fig. 3.17ab

Fig. 3.17cd

Telophase

- Each group of daughter chromosomes become

surrounded by a nuclear envelope.

- Daughter chromosomes become indistinguishable.
- Nucleoli reappear
- Spindle fibers disintegrate
- Cell plate forms.

Review

- History
- Modern Microscopes
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  - Cell Components
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Tissues
Chapter 4
Outline

- Meristematic Tissues
  - Apical Meristems
  - Lateral Meristems
  - Intercalary Meristems
- Simple Tissues
- Complex Tissues

Meristematic Tissues

- Meristems - Permanent regions of active cell division.
  - Apical Meristems - Found at the tips of roots and shoots.
    - Increase in length as the apical meristems produce new cells (primary growth).
      - Primary Meristems
        - » Protoderm
        - » Ground Meristem
        - » Procambium

Fig. 4.1
Meristematic Tissues

  - Lateral Meristems - Produce tissues that increase the girth of roots and stems.
    - Secondary Growth
      - Vascular Cambium - Produces secondary tissues that function primarily in support and conduction.
        - » Thin cylindrical cells.
      - Cork Cambium - Lies outside vascular cambium just inside the outer bark.

Meristematic Tissues

- Grasses and related plants do not have vascular cambium or cork cambium, but do have apical meristems in the vicinity of the nodes.
  - Intercalary meristems
    - Develop at intervals along stems where they add to stem length.

Tissues Produced By Meristems

- Simple Tissues
  - Parenchyma - Composed of parenchyma cells. Tend to have large vacuoles and many contain various secretions.
    - Aerenchyma - Parenchyma tissue with extensive connected air spaces.
    - Chlorenchyma - Parenchyma cells containing chloroplasts.

Simple Tissues

  - Collenchyma - Contain living cytoplasm and may live an extended time.
    - Provide flexible support for organs.
  - Sclerenchyma - Cells with thick, tough, secondary walls, normally impregnated with lignin.
    - Sclerids - Stone Cells
    - Fibers - Contain Lumen

Complex Tissues

- Complex tissues are made up of two or more cell types.
  - Xylem - Chief conducting tissue for water and minerals absorbed by the roots.
    - Vessels - Made of vessel elements.
      - Long tubes open at each end.
    - Tracheids - Tapered at the ends with pits that allow water passage between cells.
    - Rays - Lateral conduction.

Complex Tissues

  - Phloem - Conducts dissolved food materials produced by photosynthesis throughout the plant.
    - Sieve Tube Members - Large, cylindrical
      - Sieve Plates - Porous region
    - Companion Cells - Narrow, tapered

Complex Tissues

  - Epidermis - Outermost layer of cells.
    - One cell thick
      - Most secrete fatty substance, cutin, on the surface of the outer walls.
        - » Forms cuticle.
    - Root epidermal cells produce root hairs.
    - Leaves have stomata bordered by pairs of guard cells.

**. The Epidermis is the interface between the plant and its environment. Consequently, many adaptations have evolved to foster existence in terrestrial ecosystems.**

**. There are four important Epidermal structures in this image. A= Typical Epidermal cell with wavy walls; B=Guard Cells; C= stalk of secretory Trichome; D=Secretory Cells of the Trichome.**

**. <u>Agave</u> is a plant which lives in dry (Xeric) ecosystems. Its Epidermis contains several important adaptations that aid in water retention and light reflection.**

**. This _white Agave reflects much of the solar radiation that reaches it. This helps to prevent overheating.The reflectance is largely due to Epidermal Wax.**
**. This plant has an excellent cuticle!!! The cuticle stains orange in this specimen**

**. The cuticle forms an impervious boundary between the cells in the leaf and the environment. The cuticle keeps water in & pathogens out. Plants that grow in extremely dry environments usually have thick cuticle layers.**

Complex Tissues

  - Periderm - Constitutes outer bark.

- Primarily composed of cork cells.
  - Cytoplasm of corks cells secretes suberin into the walls.
- Some parts of cork cambium form loosely arranged pockets of parenchyma cells that protrude through the surface of the periderm.
  - Lenticels

Complex Tissues

- Secretory Cells and Tissue
  - Secretory cells may function individually or as part of a secretory tissue.
    - Flower nectar
    - Citrus oils
    - Glandular hair mucilage
    - Latex

Review

- Meristematic Tissues
  - Apical Meristems
  - Lateral Meristems
  - Intercalary Meristems
- Simple Tissues
- Complex Tissues

Fig. 4.6
Fig. 4.7
Fig. 4.8
Fig. 4.9

. **Control of the Cell Division Plane**

**Interphase**

**Microtubules have a uniform distribution in the cortical (peripheral) Cytoplasm.**

**Preprophase Band**

**Prior to Prophase, Microtubules accumulate and form a band around the circumference of the cell. This is called the Preprophase Band.**

**Microtubules then depolymerize and reassemble as the Spindle Fibers during Mitosis.**

***Banana is another Example!***

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