BSCI124 Semester Notes
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Plant Diversity

Plant Systematics
- Common names (can be problem)
- Evolved over centuries/languages

Scientific Names
- **Genus:** similar plant species
- **Families:** Genera
- King David Came Over For Great Spaghetti (Taxonomic Hierarchy)
    - **Kingdom**
        - **Division**
            - **Class**
                - **Order**
                    - **Family**
                        - **Genus**
                            - **Species**

Species Name
- Single scientific name in Latin (binomal)
- Genus: first name
- Species: second name

6 Kingdoms
- Living Organisms
    - 3 Domains
        - Archaea
        - Eubacteria
        - Eurkaryota
    - 6 Kingdoms
        - Archaebacteria
        - Eubacteria (true)
        - Protists
        - Plantae
        - Fungi
        - Animalia

Plant Divisions
- There are ten
- Know four:
    - Bryophyta: mosses, liverworts
    - Pterophyta: ferns
    - Coniferophyta: conifers
    - Magnoliophyta: flowering plants

Species
- Set of individuals closely related by descent from common ancestor and can reproduce with one another, but not other species

- Groups of actually or potentially natural
- Morphological
- Biological
- Evolutionary
- Some species look very different
- Some look the same but due to **polyploidy (more than diploid # of chromosomes)** cannot interbreed

Carolus Linnaeus

- Swedish Scientist, "Father of Systematic Botany"
- Established binomal system of nomenclature
- Started sexual system of plant classification
- Risque Language

Evolution

- Genetic change in population of organisms that occurs over life time, often adapts to environment
- Must be genetically inherited, not acquired

Evolution of Evolutionary Thinking

- Lamarckism (later disproved)
    - French naturalist
    - Theory: organisms driven by some inner force toward greater complexity but thought it could pass acquired traits to offspring
- Charles Darwin
    - Publishes *On the Origin of Species by Means of Natural Selection* after trip around globe (most influential text of all time)
    - **Natural Selection**: differential survival and reproduction of individuals with inheritable characteristics (works on phenotype)
        - **Variation**
        - **Overproduction**
        - **Competition**
        - **Survival to reproduce**

Artificial Selection

- Selective breeding as practiced by humans on domesticated animals and plants (i.e. dogs; teosinte, modern corn, tomato)

Rates of Evolution

- Fossil record gives 2 interpretations about pace of evolution
    - **Gradualism** (traditional view): evolution occurs as a slow and steady accumulation of changes in organism
    - **Punctuated Equilibrium** (more support): evolution proceeds with periods of inactivity, followed by rapid evolution

Evidence for Evolution and Plant Adaptations

Evidence

- Three types of Natural Selection
    1. Directional Selection: one extreme is favored over the other and the average trait
    2. Stabilizing Selection: average trait favored over extreme traits
    3. Disruptive Selection: extreme traits favored over average trait
- Evidence for evolution in living (extant) organisms:
    1. Comparative anatomy
    2. Mimicry and Protective coloration
    3. Developmental biology
    4. Biogeography
    5. DNA; biochemistry and molecular biology
- Evidence from extinct organisms: fossils
- Adaptations; Coevolution

1. Comparative Anatomy
    - **Homologous organs**: organs similar in form in different organisms due to common evolutionary origin; may have different function (human arm, bat wing; lettuce leaves, pea tendrils)
    - **Analogous organs**: have similar look and/or function in diff organisms but don't share common evolutionary origin (insect v. bird wings; pea/grape tendrils)
    - **Convergent evolution**: process where unrelated organisms in similar environment evolve similar structures (cacti & milkweed)
    - **Vestigial organs**: organs (or parts of) that are non-functional/degenerate
2. Mimicry and Protective Coloration
    - **Mimicry**: a harmless species may resemble a dangerous species
    - **Protective coloration**: coloration that allows an organism to blend in env.
3. Developmental Biology
    - Early embryos of different animal species look very much alike—they share common features (gills, tail, etc)
4. Biogeography
    - Unequal distribution of organisms, species originated once in one place
    - **Endemic species:** occur only in particular area; usually rare (Darwin's finch)
5. Biochemistry and Molecular Biology
    - Genes provide evolutionary record
    - If we evolved from common ancestor we have same DNA

Fossil Record- Most compelling evidence for evolution

- Records for last 4 billion years; rare event and incomplete but ever growing

Adaptations- a process by which genetic changes occur during evolution

- Promote survival and reproductive success as response to environmental pressures; they are universal & without them species can become extinct
- May originate as mutations

- Plant adaptations
    - Protection: plants try to avoid predation form herbivores (thorns)
    - Coloration: different flower colors attract different pollinators
    - Morphological adaptations: strawberry grow underground
    - Leaves: adapted to many functions in different plants

Coevolution

- The long term evolutionary adjustment of one group of organisms to another
- Mutual evolutionary influence between two species; they evolve together
- Pollination: coevolution of plants and insects; flowers, insects, birds

Ways in which two organisms can interact: **symbiosis**

- **Paratism**: interaction benefits one organisms but is detrimental to another
- **Commensualism**: benefits one, but neutral to the other; epiphytes grow on top of another plant for support and position
- **Mutualism**: both organisms benefit; i.e. **lichens**: fungi and algae
    - Plant-Microorganisms Symbiosis
        - Nitrogen-fixing bacteria and legumes
        - **Mycorrhizae**: fungal growth in plants
    - Co-evolution
        - Acacia trees and ants

Viruses, Prokaryotes, Fungi

Viruses

- Non-living, cannot self replicate (so it needs a host), not a kingdom
- Virus structure:
  - Just a protein coat for protection (**capsid**) and nucleic acid (DNA/RNA) for info on how to make more copies of same virus
  - Must invade living cell to reproduce
- Virus is Cellular Parasite
  - Uses cells machinery of host to replicate and produce more viruses
  - Come in many shapes, sizes, varieties
  - Antibiotics kill bacteria, not viruses
- Viruses cause diseases (in plants, animals, bacteria, & fungi)
  - Herpes, hepatitis, rabies, flu, HPV, SARS, Norovirus (stomach flu), HPV
  - Plant viruses: TMV, rose mosaic, spots on fruit, wheat stunt

Six Kingdoms

- **Archaebacteria**: prokaryotic ancient bacteria, live in harsh environments
- **Eubacteria**: prokaryotic bacteria, have cell walls
- **Protista**: algae, slime molds, protozoa (have cell wall but not cellulose)
- **Fungi**: mold, mildew, mushrooms; rooted in ground, have cell wall
- **Plantae**: complex multicellular eukaryotes, obtain food by photosynthesis
- **Animalia**: complex multicellular eukaryotes, obtain food by ingestion

Living Organisms

- **Prokaryotic**: lack membrane-bound organelles (eubacteria, archaebacteria)
  - Small and haploid only
- **Eukaryotic:** have membrane-bound organelles (protista, plantae, fungi, animalia)

Bacteria

- Bacterial chromosome and plasmids
- Asexual reproduction; binary fusion; mutations occur
- Bacterial shapes
  - Form cocci, bacilli, spirilli
  - Some strains have flagella (whip-like appendages for swimming)
- What do they eat?
  - Most bacteria **heterotrophic**: obtain food from other organisms
  - Some are **vitotrophic**: make their own food (i.e. anabaena)
- Bacterial Pathogens
  - Typhoid, tuberculosis, Bubonic Plague, syphilis, gonorrhea, e. coli, salmonella, listeria
- Bacterial Control
  - Disinfectants
  - Antibiotics (penicillin)
  - Low temperatures (slows growth)
  - High temperatures (kills it)

    - Low oxygen
- Beneficial Bacteria
    - **Nitrogen-fixation:** convert atmospheric N into useful N
    - **Decomposition**
    - **Intestinal Bacteria:** supply vitamíns (K), lactic àcid
- Bacterial Cells
    - We have more bacterial cells in body than human cells
    - 200 species of bacteria in the mouth
    - 100 trillion in the whole body→mostly beneficial
- Commercial Uses of Bacteria
    - Yogurt, sour cream, fermentation (vinegar, cheese)
    - Genetically-engineered bacteria produce insulin and antibiotics and other important chemicals
    - Can also help clean up oil spills

Eukaryotes

- Fungi, protista, plantae, animalia
- Arose from endosymbiosis
    - **Endosymbiont Theory:** chloroplasts and mitochondria are descendents of once free-living prokaryotes that were engulfed by larger cells (symbiotic relationship)
    - Fungi cell wall=chitin; plant cell wall=cellulose

Kingdom Fungi

- Characteristics
    - Non-photosynthetic; absorb nutrients by absorption (produce digestive enzymes to break down complex molecules)
    - Reproduce sexually and asexually→successful
- Major decomposers:
    - Chytridiomycota- forms flaggelated spores
    - Zygomyota- bread mold
    - Ascomycota- formes spores in ascus
    - Basidiomycota- form mushrooms
    - Deuteromycota- only reproduce asexually
- Morphology
    - Most fungi come in hyphae (thread-like strands); other are yeasts
    - Form spores to spread with wind, air, soil (allergies)
- Structure & Reproduction
    - Basidiomycota (mushrooms): genetically compatible fuse
    - Nuclei don't fuse→heterokaryotic hyphae→mushroom (Dikaryon)
    - Underneath cap the n+n cells are called gills
    - Nuclei combine, form zygote, undergo meiosis, produce haploids
- Mycorrhizae (fungus roots) (symbiotic, mutualistic relationship)
    - Certain fungi grow into roots to supply water, P and N
    - 90% of plants need it to survive
- Fungi as Antiobiotics: Produces penicillin
- Pathogenic fungi: grow within a host, using host as food for replication
    - Athlete's foot

    - Yeast infections
    - Ring worm
    - Mycotoxins
        - Harmful, toxic chemicals accumulate in food
- Plant diseases caused by Fungi (causes majority)
    - Lawn diseases, apple scab, fire blight
- Fungi plant pathogens
    - Dutch elm disease (beetles feed on wood)
    - Irish Potato Famine (1 mill deaths, massive migration)
- Commercial Uses
    - Yeast for fermentation; breaks down sugar, produces alcohol
    - Brewing of alcoholic beverages
    - Bread making (help dough rise)
    - Cheese production (blue cheeses)
- Summary of Fungi
    - Diverse group of organisms (molds to mushrooms)
    - Composed of branched hyphase
    - Reproduce sexually or asexually, by spores
    - Fungi are absorptive, they secrete enzymes to break down stuff
    - Important decomposers
    - Cause majority of plant diseases
    - Commercially important: fermentation, food

Algae, Bryophytes, and Ferns

Kingdom Algae

- Belong to Kingdom Protista (eukaryotes), but no true organs
- More photosynthetic, like plants
- Require more moist environments bc they lack a waxy cuticle

General Features of Algae

- Can be micro or macroscopic
- Lack vascular tissues—no xylem or phloem
- Illustrate importance of photosynthesis to the Earth's ecology

Diversity

- Millions of species
    - Diatoms and Kelps
    - Dinoflagellates
    - Red and Green Algae

1. Diatoms
    - Large group of Algae (many unidentified), recently evolved
    - Live in oceans, provide basis food chain in many aquatic environments
        - Provide phytoplankton (can reproduce asexually then sexually)
    - Mostly uni cellular, silica in cell walls
2. Kelps or Brown Algae
    - Closely related to diatoms, look very different
    - Live in rocky coasts in temperate zones, open seas, cold waters
    - Multicellular; very long; holdfast, stipe, blade, air bladder/float
3. Dinoflagellates
    - Mainly uni-cellular, green or colorless, some bioluminescent
    - Unusual nucleus: chromosomes always visible
    - Mostly asexual reproduction
    - Important in food chains in warm, tropical oceans; Red Tide
4. Red Algae
    - Some of the oldest eukaryotic organisms (2 billion year old fossils)
    - Abound in tropical, warm water
    - Act as food and habitat for many marine species
    - Thin films to complex filamentous membranes
    - Why red?
        - Accessory pigments; can photosynthesize in deep water
    - Commercial uses
        - Carrageenan, lotions, toothpaste, jellies, food, agar
    4. Green Algae
    - Largest and most diverse group
    - Found in fresh water and on land; can live on rocks, trees, soil
    - Structures:
        - Single cells
        - Filaments

- Colonies
- Thalli
- Terrestrial plants arose from a green algal ancestor; have chloropyll a/b
- Commercial value
  - Oxygen and food for aquatic organisms
  - Lichens: green algae and fungi symbiosis
  - Some consumed by humans

Benefits of Algae
- Food chain, lichens, shelter, provide oxygen

Harmful Algae
- Algal blooms- sudden population explosions (clog of water, bad taste)
- Toxic to animals
- Red Tide

Kingdom Plantae
- Evolved from algae
- Algae cant survive on land (only in moist environments)
- Plants had to evolve to survive on land
- Evolutionary of tree plants, from primitive to advanced traits
- Green algae→bryophytes→ferns→gymnosperms→angiosperms

Ancestor of Plants: Green Algae
- Both have photosynthetic pigment, use starch to store, have cellulose, have alternation of generations, form cell plate during cell division

Living on Land
- Obtaining enough water
  - Evolved roots to anchor and absorb water/dissolved minerals
- Preventing water loss
  - Evolved waxy cuticle, sex organs, and resistant coat on spores
- Getting enough energy
  - Obtain sunlight for photosynthesis; grow taller or adapt to low light
- Photosynthesis/Water Dilemma
  - Plant need pores for gas exchange (photosynthesis) but stomata allow water to leave; so stomata open during day and close at night
- Multicellularity:
  - Better roots, protect gametes, grow tall, but water issue
  - Plants evolved vascular tissues, xylem and phloem
- Sexual Reproduction
  - Algae have motile gametes and single sex organs
  - Land plants developed multicellular sex organs (genetic variability)
- Life Cycle
  - Water-dependent life cycle
  - Developed dryness-resistant spores and seeds
  - Evolved to large size
  - Gametophyte→sporophyte

Plant Life Cycle: Alternation of Generations
- Plants spend part of life in 1n stage and then 2n stage (both multicellular)

Bryophytes

- Mosses, liverworts
- Non-vascular plants (no xylem, phloem)
    - Limits size and place they live
- Cuticle, mulitcellular gametangia, stomata
- Require moist environment for growth and sexual reproduction
- Alternation of generations
- Dominant gametophyte generation (1n)
- Rhizoids anchor (not true roots, but stems)

Bryophyte Reproduction

- Gametophyte plant produces multicellular sex organs
    - Archegonia: eggs
    - Antheridia: swimming sperm
- Sporophyte occurs after egg is fertilized by sperm
- Grows into archegonium of gametophyte plant (dependent on it)
    - Foot
    - Seta (stalk)
    - Capsule (spore case)
- If spore lands on suitable place, it will germinate into protonema (gametophyte generation)

Significance

- Small and inconspicuous but important part of biosphere
- Food for mammals, birds
- Important to prevent soil erosion along streams
- Commercially- peat moss (fuel, soil conditioner)

Ferns

- Important group of plants; 12,000 species
- Have developed vascular tissue
- Live in moist tropics, woodlands, stream banks
- Alternation of generations but sporophyte generation is dominant

Fern Sporophyte Generation (2n)

- Sporophyte produces spores (reproductive cell that will grow and develop into a gametophyte)

Fern Sporophyte Morphology

- Fronds (complex leaves); fiddleheads
    - Photosynthesis/reproduction
    - Under fronds, spores are produced in sporangia clusters (sori)
        - Sori are not covered, or covered by cap (indusium)
    - Meiosis occurs producing haploid spores
- Underground horizontal stem: rhizome, where true roots arise

Significance of Ferns

- Ecologically important: hold and form soil to prevent erosion
- As food: fiddleheads eaten
- As ornamental plants
- Coal formation from ancient ferns

Fern Alternation of Generations Drawing:

Gymnosperms and Angiosperms

Gymnosperms

- Means "naked seed", the seeds lack protective enclosure
- More advanced than ferns—no spores, but seeds
- Species: conifers (pine trees), cycads, ginkgo

Evolution of gymnosperms

- Evolved from fern-like ancestors, advancements over ferns:
    1. Seeds
    2. Don't depend on water for fertilization (have air-borne pollen)
    3. Have dominant sporophyte generation
    4. Have more efficient vascular system

Gymnosperm Life Cycle

- Alternation of generations
- Dominant sporophyte generation (2n); produce male and female sperms
- Gametophyte generation (1n) contained and dependent

Sporophyte Generation

- Heterosporous (produces 2 types of spores)
    - Megasporangium: undergoes meissis to produce megaspores (female)
    - Microsporangium: undergoes meiosis to produce haploid micro spores, germinate to produce male gemetophyte (pollen)

Gymnosperm Pollen

- Many use wind for pollination and pollen dispersal
- Contains male gametophyte (haploid, 1n)

Wood produced by gymnosperm sporophyte

- Woody plants, very efficient/effective vascular system
- Xylem→wood of tree, phloem→bark of tree
- Wood formed from secondary growth

Primary vs. Secondary Growth

- Primary: occurs in apical meristems of shoots & roots; increase length/height
- Secondary: derived from secondary/lateral meristems; increase in width
    - Common in trees (wood and bark)
    - Vascular cambium forms secondary xylem/phloem

Annual Rings (not in tropical trees)

- Xylem formed by vascular cambium during one growth season
- Early spring wood- vessel diameter large, xylem walls thin
- Late summer wood- vessel diameter small, thick walls

Gymnosperms

- Soil prevent soil erosions; drugs/meds, reduce greenhouse gas effect
- Conifers most important; largest and most familiar groups
    - Adapted to temperate to cold regions
    - Narrow leaves (needles) to help conserve water
    - Covered by resins for protection from predators, fire, etc
- Bear seeds in cones

- Staminate cones (male); ovulate cones (female)
- Seeds produced on open scale, don't produce flowers or fruit

Gymnosperm seed: diploid embryo, fleshy seed coat

- Mainly wood plants that include oldest living, most massive, and tallest

Angiosperms

- Means "covered seed"
- Have flowers, have fruits with seeds
- Live everywhere—dominant plants in the world, 88% of plant kingdom
- Most successful and advanced plants on earth; most important for humans

Evolution of Angiosperms

- Advancements over gymnosperms:
  - Have flowers, fruits, seeds; double fertilization of endosperm in seed

Angiosperm Life Cycle: flower has male and female sex organs

Flower Structure

- Stamens: male sex organs; composed of anther (produces pollen)
- Capel: female sex organs
- Ovary: enlarged basal portion of carpel
- Stigma: receptive portion of carpel for pollen grains to adhere
- Non-reproductive parts:
  - Sepals (green): outermost whorl of leaf-like bracts
  - Petals (colored): inner whorl of leaf-like bracts
  - Both can have various shapes/colors
  - Tepals: petals and sepals of similar shape and color

Angiosperm Life Cycle

- Heterosporous: forms two different types of spores (micro and mega, male and female)
- Male: pollen grains contain tube nucleus and generative cell (2 sperm nuclei)
- Female: gametophyte contains egg and 2 polar nuclei

Double Fertilization

- Pollen Grain germinates stigma forming pollen tube, grows down to ovary
- One sperm nucleus fertilizes haploid egg→2n zygote
- Another sperm nucleus unties with 2 polar nuclei, forms triploid endosperm

Seeds

- Fertilized egg grows into zygote, which grows into plant embryo (2n)
- Endosperm is stored food tissue (3n) for the embryo to grow
- Mature ovule becomes seed coat and/or fruit

Monocot v. Dicot

- Angiosperm divided into both
- As zygote grows into embryo, first leaves of young sporophyte develop and called cotyledons (seed leaves)
- Monocots: corn, lily, grasses
- Dicots: trees, veggies, fruit
- Endosperm is kept in dicot

FEATURE	MONOCOTS	DICOTS
Cotyledons		
Leaf venation	parallel	broad
Root system	Fibrous	Tap
Number of floral parts		In 4's or 5's
Vascular bundle position	Scattered	Arranged in a circle
Woody or herbaceous	Herbaceous	Either

- Monocot absorbs endosperm tissue during germination

Pollination

Pollination: the transfer of pollen from the male anther to the female stigma

Importance

- **Sexual reproduction** is important for evolution
  - It produces variable offspring→diversity and variation
  - Is advantageous to an organism if it happens with someone other than itself (outbreeding=good; inbreeding=bad)
  - **In animals:** easy because there are separate males/females
  - **In flowering plants**: not so easy bc most flowers have both male and female parts (**perfect flowers**)
  - Flowering plants have evolved in special ways to insure outbreeding/outcrossing and to prevent inbreeding
  - **Imperfect flowers:** either male or female only.

Function of Flower

- To attract pollinators with colorful petals, scent, nectar, and pollen
- **Complete flower**: has all four organs (sepals, petal, stamens, pistols)
- **Incomplete flower**: are missing any or 1 or more floral organs

Reproductive Organs

- Female (**carpel-pistol**); contains:
  - **Stigma**: where pollen sticks to
  - **Style**: long tube connecting stigma to ovary
  - **Ovary**: enlarged base structure where ovules are located (will become the fruit
  - **Ovule**: contains female gametophyte, becomes the seed
- Male (**stamen**); contains:
  - **Anther**: part of the stamen that produces pollen
  - **Filament**: stalk-like structure that holds anther
  - **Pollen**: immature male gametophyte

Non-reproductive Floral Organs

- **Petals**: whorl of flower organs; brightly colored to attract pollinators
- **Corolla**: whorl of petals in a flower (all petals together)
- **Sepals**: whorl of leaf-like organs outside corolla; help protect unopened flower bud
- **Calyx**: whorl of sepals in a flower

Pollination & Fertilization

- Pollen contains 2 nuclei: sperm and tube nucleus
- Sperm nucleus is protected in gametophyte tissue
- For pollen sperm to be successful there must be **pollination**: a method to get pollen from the male anther to the stigma
- Pollen sticks to stigma, starts growing pollen tube
- Fertilization occurs when tube begins to grow toward egg

Double Fertilization

- One sperm nucleus (1n) fertilizes egg, producing zygote, becomes plant embryo inside seed
- Another fuses with polar nuclei, resulting in triploid (3n) endosperm (food source for young embryo)

Strategies to Avoid Self-Pollination

- **Timing**- male/female structures mature at different times
- **Morphological**- strcutrure of male/female organs prevents self-pollination (imperfect flower)
- **Biochemical** (most efficient)- chemical on surface of pollen and stigma/style that prevent pollen tube germination on same flower (incompatible)

How do plants get pollen from one plant to another?

- Wind pollination: used by gymnosperms/flowering plants; not very efficient
- Animals: used by many flowering plants; insects, birds, mammals

Coevolution

- **Coevolution**: interactions between two different species as selective forces on each other, resulting in adaptations that increase their interdependency
- Example: animal-flowering plant interaction
    - Plants evolve method to attract animal pollinators
    - Animals evolved specialized body parts/behaviors to aid pollination

Pollen

- Shape and form of pollen is related to its method of pollination
- Insect-pollinated species have sticky or barbed pollen grains
- Wind-pollinated are lightweight, small, smooth

Palynology: the study of pollen

- Useful in many fields: petroleum geology, archaeology, anthropology, criminology, aerobiology

Animal Pollinators

- Bees: most important group of flower pollinators
    - Live on nectar and feed larvae, also eat pollen
    - Guided by sight/smell; see yellow + blue colors
    - Flowers have honey guides and bee landing platforms
- Butterflies & Moths
    - Also guided by sight and smell; can see red and orange
    - Moth-pollinated flowers are white/pale, sweet odor
- Flies & Beetles
    - Like flowers that smell like dung or rotten meat
    - Lay eggs there but die due to lack of food
    - Pollinate dull colored flowers, but strong odor
- Birds
    - Good sense of colors (yellow or red); bad sense of smell
    - Flowers provide fluid nectar more than insects, pollen large/sticky
- Mammals: Bats & Mice
    - Bats pollinate at night→flowers are white, strong odors/lots of pollen

Why do Animals Pollinate Plants?

- Food, nectar (matches their energy requirements), pollen (high in protein)
- Flowers produce: normal and sterile pollens

Plant Prostitution: Mimicry

- Some plants take advantage of insect sex drive, deceive them
- Certain orchids look like female wasps, males try to mate but just pollinate

Fruits and Seeds

Seed

- Matured ovule, containing:
  - A plant embryo
  - A food supply
  - Covered by a seed coat

Embryo

- The seed contains a well-formed multicellular young plant embryo (germ)
- Embryo is diploid and will become whole plant

Nutritive Tissue

- Seed contains food supply
- Stored food contains enough energy for the embryo to grow through the soil, when seedling is unable to photosynthesize
- Food source can be the endosperm (3n) as result of double fertilization

Seed Coat

- Thick, protective coat—outer layer of the seed
- Formed from megasporangium

Gymnosperm seeds

- Single fertilization produces the diploid embryo 2n
- Food course is the haploid megagametophyte

Flowering Plant Seed

- In angiosperms there is double fertilization
  - Produces diploid embryo and triploid endosperm
  - Endosperm is the food source

Fruit

- Fruit is mature (in flowering plants) ripened ovary that contains the seeds
- Pericarp- ovary wall
- Function of fruit: to protect the seeds and disperse them
  - Ovary: fruit; ovule: seed
- 3 fruit types
  - Simple
  - Aggregate
  - Multiple

A. Simple Fruit

- Develops from a single ovary of a single carpel
- Can be either fleshy or dry
- Simple Fleshy Fruit
  1. Berry: entire fruit wall is soft and fleshy; slimy inside
     - One of the most common
     - Grapes, tomatoes, bell peppers, bananas
  2. Hesperidium: a berry with tough, leathery rind (peel)
     - Oranges, lemons, other citrus

3. Drupe: outer part of fruit wall is soft and fleshy, inner part is hard and stony
    - Cherry, peach, plum
4. Pepo: also a fleshy fruit with a tougher, outer ring
    - Squash family, pumpkin, melons, cucumbers
5. Pome: most of the fleshy part of pomes develops from enlarged base of the perianth that has fused with ovary wall
    - Apples and pears

- Simple Dry Fruit
    i. Capsule: fruit is dry and splits open along several seams
        1. Cotton
    ii. Legumes: dry and split along two seams
        1. Pea pods, bean pods, peanuts
    iii. Ones that do not open at maturity
        1. Caryopsis: seed coat is fused to ovary wall (cereal grains, wheat, rice)
        2. Nuts: single ovary wall and seed coat remain separate, ovary wall is very hard

B. Aggregate Fruit
- Develops from one flower with many separate pistils/carpels, all ripening simultaneously
    - I.e. strawberry, raspberry, blackberry

C. Multiple Fruit
- Develops from ovaries of several flowers borne/fused together on same stalk
    - I.e. pineapple

Seed Dispersal Is Important Because...
- It spreads progeny in order to colonize new environments
- Reduces competition for resources with parents
- Reduces chances of predators destroying all of the plant's yearly seed production
- Types of seed dispersal:
    - Self
        - Forceful ejection, explosive fruits (squirting cucumber)
            - Peanut plant sews its own seeds
    - Wind
        - Special devices for this
        - Plumes catch wind currents: dandelions
        - Trees take advantage of their great heights
    - Water
        - Flotation devices to travel by water, or may have air spaces and corky floats: coconut
    - Animal
        - Most commonly used method
        - Plants coevolved with animals to accomplish seed dispersal
        - Many plants depend on animals for this; may offer nutritional reward

- Animals lern to recognize ripened fruit colors
- Fleshy fruits eaten and dispersed with feces
- Some dry fruit cling to animals
- Some are Velcro-like or sticky that cling to animal fur

Human Uses of Plants

Introduction to Agriculture

- **Agriculture**: the science, art, practice of cultivating soil, producing crops, and raising livestock
- Around 10,000 years ago: shift from foraging/hunting/gathering to farming
- Cultural evolution, began in different parts of the world
    1. The Near East: "Fertile Crescent" of Mesopotamia
    2. The Far East: Southeast Asia, along Yellow/Yangtze River
    3. New World: modern day Mexico and Peru

    ***Modern regional cuisine still reflect these early centers of agriculture

Domesticated Plants

- Genetically distinct from wild progenitors
- Wild plants: natural selection; domesticated: artificial selection
- Most domesticated plants (traits chosen for our benefit) can't survive in wild

Cultivated Plants

- From centers of origin, plants/animals dispersed to other parts of world
- Wild ancestors of domesticated plants still exist; help develop new varieties and are important for maintaining genetic diversity of crop plants

Modern Agriculture

- World: food and fiber that sustains the entire population produced on 3% land; 97% land is non-crop or non-grazing (tundra, desert, forest, mountain)

Agriculture in the U.S.

- 16% land used at crop land; 34% used for pasture and grazing
- Corn, wheat, soybeans, hay: planted on 80% of crop land
- There's been steady increase in agricultural yield per acre in U.S. crops without any significant increase in new land:
    - Improved crop varieties—higher yield
    - Improved agricultural practices
    - Improved pest control—resistant cultivars
    - Tailored fertilization of crops

Human Nutrition

Introduction

- Eat to fulfill energy needs; daily nutritional needs supplied by:
    - Macronutrients—required in large amounts
    - Micronutrients—required in small amounts

Calories

- Calorie: amount of energy required to raise 1 gram of water 1 degree C
- Food energy measured in kilo calories (kcal=1000 calories)
- Humans require 1200-3200 calories per day (avg=2000 calories)

Macronutrients

- **Carbohydrates** (C, H, O) (1:2:1 ratio)

- Monosaccharides
  - Glucose is most abundant
  - Fructose (in fruit) and galactose also important
- Disaccharides (composed of two monosaccharides)
  - Sucrose (table sugar; glucose + fructose) most common
  - Lactose (gluc + gal): milk sugar
  - Maltose: found in germinating grains (2 glucose)
  - Provide no nutritional value, just calories
- Polysaccharides (hundreds/thousands sugar units) (complex carbs)
  - Starch: long glucose chain found stored in plants (potato, wheat, rice, beans corn)
    - Broken into glucose by saliva enzymes
  - Glycogen: storage form of glucose in body; excess=fat
  - FIBER
    - Polysaccharide derived from plant cellulose
    - Not digestible, provides bulk
    - Soluble dietary fiber: oat, reduces cholest/heart risks
    - Insoluble dietary fiber: fruit, bran, veggies; absorbs water, prevents constipations, may prevent cancers

- **Proteins**
  - Introduction
    - Large complex molecules, perform many functions
    - Made from amino acids (20 different to make thousands)
    - Sources: meat, fish, cheese, milk, egg, beans, corn, whole wheat
  - Essential Amino Acids (EAA)
    - Cells in body can make 11 out of 20 amino acids
    - The 9 they can't make are EAAs: can't be stored by body so must be taken in the diet
  - Complete Proteins
    - Contain all essential amino acids
    - Proteins from animal sources are complete
    - Proteins from plant sources are incomplete
  - Protein Digestion:
    - Requires digestive enzymes (which are also proteins)
    - Some proteins can't be broken down completely
    - High quality proteins:
      - Contain all EAAs
      - Are fully digestible
      - Free their amino acids, which are absorbed readily
- **Fats**
  - Introduction (composed of C, H, O)
    - Have glycerol head (hydrophilic) and hydrophobic tail (fatty acid)
    - Serve many vital functions: energy, storage, insulation, hormones
  - Triglycerides

        - 95% of lipids come from fats and oils called triglycerides
        - Triglycerides= glycerol + 3 fatty acids
        - Fatty acid chains vary—determine characteristics of triglyc
    - Essential Fatty Acids
        - Body can make most fatty acids except three (essential)
        - Linoleic, linolenic, and arachidonic acid (found in veg oils)
    - Saturated v. Unsaturated Fatty Acids
        - Depends on Carbon-Hydrogen bonding of fatty acid chain
        - Carbon atoms joined by single bond: **saturated fatty acids**
        - Carbon-carbon double bonds: **unsaturated fatty acids**
        - **Saturated fatty acids:** solid at room temp (butter, lard)
        - **Unsaturated fatty acids:** liquid at room temp (oils)
    - Saturated (unhealthy) v. Unsaturated (healthy) Fats
        - Saturated: excess leads to obesity, heart disease, cancer
        - Unsaturated: lowers risk of heart disease, lowers cholesterol
            - Omega-3: salmon, flax, avocado, walnuts
    - Trans Fatty Acids
        - When oils are hydrogenated they change their shape
        - Very unhealthy=fried/processed foods, margarine
        - Raise bad cholesterol & harden the arteries
    - Cholesterol (subcategory of lipids called steroids)
        - Important for making cell membranes and human hormones
        - Animal products: eggs, butter, meat, cheese
        - Plant products contain unsaturated fat, lowers cholesterol
        - Good v. Bad
            - Low Density Lipoprotein (LDL) is bad: causes blockage of arteries, restricts blood flow causing heart attacks
                - Atherosclerosis: hardening of arteries
            - High Density Lipoprotein (HDL) is good: decreases LDL

Micronutrients (vitamins and minerals)

- **Vitamins**
    - Some are called coenzymes because they are essential for proper functioning of certain enzymes
    - Fat-soluble vitamins: A, D, E, K
    - Water-soluble vitamins: B-complex, C
- Vitamin A
    - Important vitamin in formation of vision pigments
    - Maintains healthy/smooth skin, bone & tooth development
    - Animal sources: liver
    - Plant sources: yellow, orange, dark green fruits and vegetables
    - Lack of causes night blindness, dry skill, infections, bad bone growth
- Vitamin B Complex
    - 8 vitamins, all water soluble
    - Most act as coenzyme, help in food breakdown and energy release
    - Deficiency: fatigue, weakness, depression, dermatitis, anemia
    - Sources: meat, fish, chicken, whole grains, seeds, nuts, legumes

    - Vitamin B12 from animal sources only
- Vitamin C (water soluble)
    - Important in collagen synthesis (connective tissue in bones, cartilage)
    - Good antioxidant and helps absorption of iron
    - Lack: scurvy (bleeding gums, skin hemorrhages, brittle bones, death)
    - Sources: citrus fruit, other fresh fruits and vegetables
- Vitamin D
    - Helps regulate calcium/phosphorous levels in normal bone dvlpmnt.
    - Can be synthesized on exposure to sunlight
    - Deficiency: bone malformation called rickets
    - Sources: egg, liver, cream, butter, milk (fortified); no plant products
- **Minerals**
    - Inorganic compounds: as free ions or part of larger molecules
    - 17 different minerals required by body (ie. calcium, iron, iodine)
- Calcium
    - Most abundant mineral in body, found in bones and teeth
    - Deficiency: osteoporosis
    - Sources: milk & dairy, dark leafy green veggies (spinach), seeds/nuts
- Iron
    - Trace mineral; component of hemoglobin (carries O in red blood cells)
    - Deficiency: anemia, too much iron can be toxic
    - Sources: liver, shellfish, fish, poultry, dark green leafy vegetables, dried fruit, legumes (bean), whole grains, breads and cereals)
- Iodine (trace mineral)
    - Required for forming of thyroid hormones (regulate cell metabolism)
    - Deficiency: goiter (swelling of thyroid gland)
    - Best source is iodized salt

Grasses, Legumes, Starchy Staples

The Grasses (Wheat, corn, rice and other grains)

- About
    - Very important plants: make up 25% of world's vegetation
    - Found in almost all environments (arctic, prairies, savannahs, tropics)
    - Monocots: herbaceous, parallel leaf venation, flower parts in 3's, scattered vascular bundles, fibrous coots
    - Member of *Poaceae* family
- Importance to Humans
    - Include the grains: single most important food group in the world
    - Edible grains of cultivated grasses are cereals (major calorie supplier)
        - Advantage: dry seeds can be stored for years
    - Grains are a concentrated food source
- Flowers of Grasses
    - Inflorescence: bunch of flowers grouped together, structure containing all the flowers

- Some have perfect flowers (bisexual): wheat/rice; some have imperfect (unisexual) flowers: corn
- Flowers are adapted to wind pollination; are small, inconspicuous
- Anthers are large/produce a lot of pollen
- Stigmas are double and large to catch pollen

- Grass Fruit
  - Grasses have simple, dry fruits that do NOT open at maturity
  - Caryopsis: seed coat is fused to the ovary wall (corn, wheat, rice)
    - Dries til 5-15% water; dry grain can withstand extreme temps
  - Grain Parts:
    - Endosperm
    - Embryo (or germ)
    - Bran
- Grain
  - Endosperm cells filled w/ starch, supply food to germinating seed
  - Embryo (germ) is the young plant (2n): rich in oils, proteins, vitamins
  - Bran consists of outer layers of old fruit wall, seed coat & **aleurone layer:** secretes enzymes that digest stored starch in endosperm; is rich in vitamins and protein
  - Whole-grain foods are more nutritious; germ & bran are still there
- Wheat (Triticum)
  - Most widely cultivated grain; adapted to cool dry climate
  - Origin: wild species in Near East crossed, forming polyploid species
  - Wheat types:
    - Durum wheat: used to make pastas
    - Bread wheat: has high gluten content, gives bread elasticity
      - CO2 bubbles trap and make bread rise
  - Wheat nutrition:
    - Great source of carbs & fibers, contains 12.9% protein
    - Nutrients concentrated in bran and germ
    - Wheat is most nutritious when eaten as whole-wheat product
    - US wheat is 3rd in world behind China and India
- Corn or Maize (*Zea mays*): Central Mexico origin
  - Features:
    - Tassel (inflorescence/group of male flowers) at stem
    - Has an ear (inflorescence of female flowers) on lateral branch. Silks coming from the ears are individual stigmas of each female flower, each attached to ovule=will become a seed
  - Modern Corn Types:
    - Popcorn: oldest type, has hard seed coat & internal moisture
    - Heating produces steam, grain explodes turning the endosperm inside out, valued by Indians-doesn't need grinding
  - Corn Types:
    - **Flour corn**: has soft endosperm, easy to grind, but easily attacked by insects

        - **Dent corn**: has soft starch in center, hard on outside (forming dent); used for animal food, corn meal, cornstarch, high fructose corn syrup, ethanol production
        - **Sweet corn**: endosperm has sugar, not starch, eaten immature
        - **Hybrid corn**: seeds come from cross of inbred lines; exhibits 'hybrid vigor', it's more pest resistant/productive
        - **Kernel colors**: come from pigments present in the pericarp (wall), aleuron layer or endosperm (blue, white, red, yellow)
        - **More than half of corn**: used for industrial or animal feed
- Rice
    - Important grain; feeds more people than any other cereal, especially in Asia; used exclusively as human food
    - Origin of rice: evolved from marsh grass in southeast Asia
    - Rice Cultivation (evidence more than 7,000 years ago)
        - Rice is adapted to survive in flooded or waterlogged soils
        - Rice has air chambers on roots & stems, allow for aeration of submerged parts
        - Rice is grown along water fern (fixes nitrogen from the air, providing rice with the nutrient; a natural fertilizer)
        - When rice is mature, paddies are drained for harvesting
        - Long grain (not sticky), medium grain, short grain (sticky)
        - Brown rice is healthiest, more vitamins, oil, fiber than white
        - A diet based on white rice only leads to beriberi: thiamine deficiency
    - Other Important Grains:
        - R____: cultivated in cold regions (east Europe) used for bread
        - Oats: highly nutritious; high protein (15%), many vitamins, minerals, oils, soluble fiber (lowers choleseterol)
        - Barley: used mostly for brewing (beer) and animal feed
        - Sorghum: important human and animal food around world
    - Forage Grasses
        - **Forage**: any vegetation eaten by domestic herbivorous animals
        - **Forage grasses**: herbaceous perennials grown for their leaves and stems
        - Leaves are digested by ruminant animals (cows), so they're extensively used for grazing
        - **Kentucky bluegrass**: one of the best, used for lawns

Legumes

- About:
    - Members of bean family; Fabacea: they are dicots
    - Legume is synonymous with pod, the fruit
    - Examples: peas, beans, soybeans, peanuts, lentils, clover, alfalfa
- Importance
    - Human nutrition: important sources of
        - Protein (bean, soybean, pea, peanut, etc)
        - Oil (soybean, peanut, etc)

    - Also legumes are major nitrogen fixers
        - Nitrogen fixing bacteria in roots, symbiotic relationship
        - Bacteria take N from air, make it usable (nitrogen cycle)
- Features
    - Mostly herbaceous, not woody
    - Usually have compound leaves
    - Mostly annuals, some perennials
    - Flowers are irregular, bilateral symmetry
    - Bees + insects pollinate them, triggers stamens
- Legume seed and fruit
    - Seeds are usually large, have 2 large cotyledon (seed leaves)- dicot
    - Cotyledons are filled with stored food, which helps seed germinate
- Legumes in nitrogen cycle:
    - Nitrogen-fixing bacteria convert atmospheric nitrogen (N2) into ammonia (NH3), which reacts with water to produce ammonium (NH4+)
    - Nitrogen-fixing bacteria live in symbiosis in roots of legumes, forming root nodules
    - Plants convert this nitrogen into proteins or other nitrogen compounds, which are then consumed by animals
    - Legumes are good for the soil! Rich in proteins
- Legume Roots
    - Legumes have a symbiotic mutualistic association with Rhizobium bacteria- form root nodules
    - Rhizobium fixes nitrogen from the air
    - Take N2 and and make it into ammonia—a usable form of nitrogen that the plant takes in
    - _____ provides nitrogen to the plant; _____ provides carbs to bacteria
- Legumes for food: beans, peas, peanut, soybean
- Legumes for forage: alfalfa, clover, vetches
- Beans
    - Bean come in hundreds species/variety: pinto, navy, black, kidney
    - Native to Mexico and Andes
    - Beans are very rich in protein (25%) and some carbs
    - Why do they give you gas?
        - Beans have complex carbohydrates that are indigestible
        - They go down into intestines, where bacteria go crazy eating these carbs and produce methane gas
        - To avoid: rinse beans well, cook long, treat w/ Beano
- Peas
    - Pisum sativum: common garden pea
    - Originated in Near East, rich in protein and carbs
    - Many varieties, including snow peas (where immature pod is eaten whole)
    - Green peas, split peas, chick peas, lentils
- Peanut (Arachis hyogaea)

    - Peanut native to S. America, cultivated by Aztecs, called ground nuts
    - Rich in oil and protein
    - Very unusual growth pattern, sow their own seeds
    - Upon fertilization, ovary grows down, buries ovules into ground, where pods mature into peanut fruit
    - Half of US peanut crop production is for peanut butter
    - Also for snack foods, candy, peanut oil, animal feed
    - Half of US peanut crop production is for peanut growth
- Soy bean (Glycine max)
    - Native to China, rich in oil and protein
    - Uses: cooking oil, salad dressing, mayo, margarine
    - Protein to make textured vegetable protein (TVP) as meat substitute, as animal feed
    - Soy sauce: fermented by soybeans and grain
    - Tofu: soy milk curds
    - Products:
        - Miso: fermented soybean and rice paste (Japan)
        - Soybean eaten as sprouts, snacks, health food—have isoflavones which lower levels of bad cholesterol
        - Oil used to make diesel fuel, plastics, paint, ink
- Legumes of the Future:
    - Winged bean: cultivated in China, all plant organs edible, high in protein and oil, easy to grow
    - Jimaca: edible, starchy tuberous root of a S. American vine, crunch and watery, slightly sweet
- Forage Legumes:
    - Some legumes are grown as pasture or forage crops
    - Alfalfa is grown extensively as animal feed
    - Trifolium species; true clovers, are also grown as pasture—some now grown with other crops to provide nitrogen and protect the soil
    - Vicia (vetches) are planted to prevent soil erosion

Starchy Staples

- Starch is most widespread storage form of energy in plant kingdom
- Starch is polysaccharide, linear polymer (chain) of glucose molecules
- Many plants have specialized organs for storing starch
- Usually modified stems and roots
- Amylase: enzyme that breaks down starch (in saliva)
- Starch Storing Stems:
    - Stolons or runners: aboveground horizontal stems that produce buds/roots at nodes (ie. strawberry)
    - Rhizome: thick horizontal underground stems that spread the plant, new shoots come out of the nodes (ie. ginger, iris)
    - Tuber: enlarged storage tips of rhizome (ie. potato, yam)
    - Bulb: short vertical underground stems with thick leaves (ie. onion, tulip, daffodil)

    - Corm: short vertical underground stem, surrounded by thin leaf-like scales (ie. taro)
    - Storage tap root: thickened main root (ie. carrot, turnip)
    - Tuberous root: thickened portion of lateral root, became enlarged with food reserve (ie. sweet potato, cassava, jimaca)
- Important Starch Crops:
    - Potato: most important starch crop
    - Origin: Andes in S. America, consumed and domesticated in Incas
    - Grows well at high elevations, can be stored for months
    - Initially not accepted by Europeans, thought to be poisonous (all of plant is except tuber) (green potatoes: highly toxic)
- Potato in Ireland
    - 1800s: population grew to 8 million in Ireland; mostly supported by potato production
    - Late blight fungus destroyed crop in 1845-49; 1 mill died, 1.5 migrate
    - Top potato producers: Russia, China, Poland
    - Production in US: in cool climate states (Idaho, Washington, Maine)
    - Commercial uses: 33% crop consumed fresh, __% processed into French fries, potato chips, instant mash potatoes, potato starch
- Potato
    - Propogation is vegetative: small potatoes or pieces of large potatoes (eyes) are planted, new ones grow; asexual (clonal) production
    - Nutrition: 25% carb, 2.5% protein
- Sweet Potato: tuberous root of a vine
    - Origin: Caribean, brought to Europe by Columbus
    - Rich in starch; orange cultivator have vitamin A, B6, C, fiber, iron, calcium; mistakenly called Yam in US
    - Requires more tropical climate than potato
- Cassava
    - Tuberous root, from Brazil/Mexico; also called Yuca, Manioc
    - Produced in tropical Africa, Asia, S. America
    - Needs to be processed to remove hydrogen cyanide (HCN, a poison), released when the root is in ground
    - Eaten baked, cooked, fried, as tapioca in US
    - Nutrition: 30% starch, very little proteins/vitamins
- Other Starchy Tropical Crops
    - Yam: a tuber; used as food and as a source of steroids and to make contraceptive pills, cotisone, other meds
    - Taro: a corm; originally from SE Asia, used mainly in food, Hawaii: poi
    - Plantain: hybrid cultivar of banana family & other species; origin in SE Asia, sweet banana selected from it. Sterile triploid, must be propagated vegitatively (asexual reproduction). Eaten, fried, baked, cooked as staple in tropical countries
    - Bananas are true fruits, (berry), unlike other starchy staples

Fibers, Herbs and Spices

Fibers

- Introduction
  - Botanical: fiber is a long, narrow tapering cell; dead and hollow at maturity with thick cell wall composed mostly of cellulose and lignin; rigid, for support, and found mainly in vascular tissue (xylem)
  - Commercial: fiber is a long, narrow, flexible material; may be animal (hair wool), mineral, synthetic (nylon) or plant in origin
  - Nutritional: fiber is a polysaccharide that comes from cellulose; indigestible material in food that may be soluble or insoluble
- Types of Plant Fibers
  - Cordage fibers: for making rope
  - Textile fibers: for making cloth
    - **Surface fibers**: grow from surface of sees, leaves, or fruit (ie. cotton, coir)
    - **Soft/bast fibers**: found in phloem of dicot stems (flax, jute hemp, ramie)
    - **Hard/leaf fibers**: found in monocot leaf vascular bundles (sisal, manila hemp, pineapple)
    - **Paper making fibers**: single cells of cotton or delignified wood
  - Origin of Cotton
    - 50% of world's textiles are cotton
    - Wild cotton harvested in ancient Peru, came to New World
    - Also used in India and Mesopotamia
  - Cotton Plant Cultivation
    - Cotton is a shrubby plant—grows best in warm climates
    - Cotton seeds have attached fibers: each seed 20,000 hairs
  - Cotton Cultivation and Processing
    - Cotton ball: fruit of the plant; splits open and dries
    - Cotton lint clings to the seeds
    - A defoliant is sprayed to the plant (all leaves fall), the boll is harvested by hand or machine
    - Cotton seed uses: cooking oil, animal feed
  - **Flax**
    - Stem fibers can be woven to make linen
    - China and USSR are important linen producers
  - Flax Plant (Bast Fiber)
    - Adapted to cool climates
    - Straight slender stems and bell-shaped flowers (white, blue)
    - Two types of flax grown: one for seed oil, one for fibers
    - Flax stem grows up to 1 meter, long fibers
    - Stems harvested by pulling root, drying bundles

        - Processing: Retting 1-2 weeks on ground/in water, removing stem; breaking, scotching, hackling, weaving
    - Other Bast Fibers, for Textiles
        - Ramie (native to China), shrub grows 6 feet high
            - Produces longest and strongest fibers
            - Fibers processed similar to flax, used for sweaters
    - Hemp
        - Comes in many varieties, native to China, processed like flax
        - Used to make canvas ropes and twines, and paper
    - Jute
        - Native to India/Bangladesh, major producers now
        - Processed like flax; makes burlap, ropes, wall coverings, carpet backing, upholstery lining, inexpensive clothing
    - Sisal: Mexico agave desert plant (rope, sacks, floor mats, garments)
    - Kapak: seed fiber, Native America, stuffing life preservers
    - Coir: seed fiber, coconut fruit, ropes and doormats
    - Rayon: "Artificial Silk"
        - Synthetic fiber comes from viscose (wood cellulose)
        - Blends well with cotton—easy to dye, comfortable
        - Cellophane is chemically identical to rayon, made into sheets
    - Paper
        - Major medium of written communication today
        - US uses 1/3 world paper supply, 1 billion trees cut/year
        - Papyrus stem fibers from Egypt
        - Wood pulp: slurry of water and separated wood fiber cells
        - Paper: thin sheet made by spreading pulp on screen, drain, dry
        - Paper Manufacturing: made from wood pulp
            - Mechanical grinding: newsprint, catalogs, paper towels
            - White Paper: sulfite/sulfate processes use strong chemicals to dissolve lignin, leave cellulose for white paper
            - Used waste chemicals & lignin=major pollution
        - Bamboo: alternative source for paper

Spices and Herbs

- General Definitions
    - Herbs: aromatic leaves or seeds of plants from temperate regions
    - Spices: other aromatic plant organs of tropical origin
        - Used for flavor and antimicrobial properties, preserve food
    - Essential oils: volatile substances that contribute to essence/flavors
        - Secondary compound: plant makes, but not essential to plant
        - Most are terpenet, C^5H^8
- History
    - Black pepper, cinnamon, ginger imported by Greeks from India
    - Age of exploration: monopolies established, import spices from East
    - Monopolies broken bye wars/smuggling of plants to new areas
    - New World spices imported to Europe by Spanish, lost importance

Spice	Origin	Part of Plant	Uses
Cinnamon	Old	Inner bark of tree	Flavor in baked goods, medicine, perfumes, scents
Black Pepper	Old	Fermented and dried berries of pepper vine	Has volatile oils, flavor
Cloves	Old	Dried, unopened flower buds of small evergreen tree	Desserts, beverages, meats, sauces, mixed w/ tobacco, medicines, disinfectant, mouthwash, toothpaste, soap, perfume, Oragel
Nutmeg/ Mace	Old	From pit inside fruit of nutmeg tree	Hallucinogenic, flavor
Ginger	Old	Fresh or dried rhizome of monocot herb	Baked goods, vegetables, meats, ginger ale; medicine
Tumeric	Old	Dried rhizome	Curry powder, prepared mustard, or yellow dye
Saffron	Old	Stigmas of Crocus sativus	Ancient yellow spice, expensive, delicate taste and color
Chili Peppers	New	Fruits of herbaceous plants; come in many pungency levels (Scoville units)	Hot compound (capsaicin) used as painkiller; good source of vitamin C
Vanilla	New	Fermented/dried fruit of vanilla bean	Flavor
Allspice	New	Dried fruits of Caribbean tree	Taste: combo of cinnamon, clove, nutmeg

Herbs (families: mint, parsley, mustard, lily)(high in antioxidants)

- Mint family (has luteolin and limonene=cancer preventors)
  - Native to Mediterranean; spearmint, peppermint, basil, thyme, oregano, rosemary (rich in camosol: may help prevent cancer), sage
  - Herbaceous plants/small shrubs; simple leaves w/ oil glands
- Parsley family
  - Native to Mediterranean; recognized by umbels (flat-topped)
  - Dill, caraway, cilantro, chervil, coriander (coriandrol: protect against liver and breast cancer, anise, cumin, celery, fennel
- Mustard family
  - Gives important vegetable crops: broccoli, cabbage, cauliflower, radish, turnip, horseradish root and wasabi (antimicrobial)
- Lily Family

- Mostly herbaceous, from Central Asia, onions, leeks, shallots, chives
- Garlic: organic sulfur inhibits bacteria/fungal/clots growth; lowers cholesterol; allicin: anti –biotic, -parasitical, -fungal, cancer fighting

Stimulating Beverages

Importance of Stimulating Plants
- The trade changes history of many nations
- Fortunes made; important as computer, defense, oil industries

Caffeine
- The active ingredient→in the most popular stimulating beverages
- Chemically related to purine bases in DNA (like guanine)
- Caffeine is an alkaloid group of secondary compounds found in plants—made to discourage grazing
- Promotes alertness and endurance
- Stimulation of central nervous system, faster heartbeat, constriction of blood vessels, increased respiration rate, suppression of appetite, dieresis
- Undesirable effects: headaches on withdrawal, infertility, birth defects, insomnia, nervousness, irritability

Coffee
- Made from seeds of Cofee Arabica; native of Ethiopia; fruits and leaves eaten for stimulation; grown in Yemen
- Most coffee is now produced in Brazil and Colombia; second to oil as traded

Growing Coffee Beans
- Small tree, grows in cool subtropical mountain habitats
- Small fruit (cherry) has two seeds (beans); hand harvested when beans ripe
- Processing: hull is removed, seeds fermented (12-24 hrs; non-alcoholic), seeds dried (1 week); coffee beans roasted (produces dark color and flavor)

Decaffeinated Coffee
- Invented by German chemist, convinced Dad died of caffeine
- Solvent is used to soak green coffee beans and removes caffeine
- Caffeine is sold for medicines, and soft drinks

Specialty Coffees: Espresso, Latte, Café Mocha, and Cappuccino

Tea
- General
  - Made from dried tip of Camellia sinensis, small tree/shrub native to Burma (Herbal teas: infusions made from other plants)
  - More people drink tea than any other stimulating beverage in the world, but international trade is less than coffee
- Origin/History
  - Originated in China (Chai tea)
  - Introduced to Japan, then to Europe (after coffee) then to America
- Tea Cultivation
  - Top two youngest leaves and stem tips harvested by hand or machine
  - Processing of tea:
    - Black tea: leaves withered, rolled, fermented, dried
    - Green tea: leaves steamed, rolled, dried (not fermented)

        - Oolong tea: teas are semifermented—leaves greenish brown
        - White tea: least processed tea

- Aromas and flavors
    - Comes from essential oils, additional taste from tannins (giving dark color and bitter taste)
    - Stimulating effect from caffeine and theophylline; caffeine levels vary and also depend on length of brewing:
        - Black tea: most caffeine
        - Oolong: intermediate
        - Green: least
- Health Effects
    - People who drink larger amounts of green tea have lower cancer rates
    - Polyphenols interfere w/ enzyme needed for cancer growth
    - Theophyllin has medicinal properties: treats asthma, weight loss
    - Black tea lowers LDL

Cocoa or cacao

- General
    - Seed of Theobroma cacao; native of South and Central America
    - Introduced to Spain by Hernan Cortes; added sugar
- Cocoa
    - Use spread to rest of Europe; not as popular as coffee or tea
    - Swiss added milk
    - 19th Century: butter processed with sugar=chocolate; first bar
    - Cocoa plantations: Singapore, Ivory Coast, Brazil
- Cocoa Cultivation
    - Fruit is size and shape of small football; born on trunk
    - Fruit harvested by hand, cut open; seeds (white pulp) are collected
- Processing:
    - Seeds are fermented (non-alcoholic) 4-7 days, develop flavor/color
    - Seeds dried, polished, roasted, cracked, de-hulled (release cotyledons)
    - Nibs (cotyledons) ground to paste: chocolate liquor (can be molded)
    - Cocoa butter can be removed, to made cocoa powder (white choc)
    - Cocoa butter: suntan lotions, soaps, cosmetics
- Chocolate Effects
    - Stimulating effect from caffeine and theobromine
    - High energy food; feeling of euphoria
    - Stearic acid (fatty acid) raises HDL; flavonoids lowers LDL
    - Dark better than milk; contains Vitamin E
- Kola
    - Cola drinks derived from Kola tree; West Africa
    - Seeds of Kola tree fermented (non-alc), dried, ground
    - High in caffeine and kolanin, heart stimulant
    - Coca cola used coca extract

Other Stimulating Plants

- Tobacco

    - Contains nicotine: powerful norepinephrine stimulant
    - Origin: Americas, introduced to France
    - Can improve memory and recall
    - Has more negative effects: reduced blood circulation, cancer, heart disease, emphysema, oral cancer, premature birth, shorter life
- Ephedra
    - Gymnosperm native to China; medicinal purposes
    - Ephedrine: CNS stimulant, bronchial dilator, increase BP, adren rush
    - Now used as dietary supplement for performance/weight loss
    - Adverse effects: hypertension, palpitations, stroke, seizures, h attacks
    - FDA issues warning at first; banned it in 2004

Medicinal, Poisonous, and Allergenic Plants

Medicinal Plants

Introduction

- Some are nutritious, poisonous, hallucinogenic, or therapeutic
- Many of the secondary compounds are for self defense

History: Hippocrates—"Father of Medicine"

Doctrine of Signature

- A belief that certain visible signatures can recognize the use of a plant, if it looks similar to something humans have.
- No scientific basis of this!

Modern Prescription Drugs

- 25% of prescriptions contain plant-derived active ingredients
- 90% of rural pop in the world still relies on herbal medicine for health care

Active Compounds in Medicinal Plants

- Plants manufacture chemical compounds called secondary plant products—to defend against herbivores and to discourage bacterial, fungal growth.
- Active compounds: alkaloids, glycosides
- Alkaloids
    - A diverse group of compounds—mostly found in herbaceous dicots
    - Contain high nitrogen (basic ph) and have a bitter taste
    - Affect nervous system of animals
    - Some are medicinally important, but others are hallucinogenic and poisonous.
    - The difference between medicinal and poisonous effect is the dosage
    - Ex. Caffeine, nicotine, cocaine, morphine, quinine, ephedrine (end in "ine")
- Glycosides (contain a sugar molecule attached to active component)
    - Three important glycosides
        - Cyanogenic—have cyanide (HCN). Cassava and pits of apricots have HCN.
        - Cardioactive—contain a steroid molecule as the active component. Have an effect on heart muscle contraction; used to treat forms of heart failure.

- Saponin—same as cardioactive

Foxglove
- Treats congestive heart failure now, originally treated dropsy (severe bloating)
- Contains cardio active glycosides in the leaves; they can be extracted
- Slows the heart rate, increasing strength of each heartbeat, improving circulation
- Excessive dose can be fatal

Willow Tree Bark: Aspirin
- Bark of willow was used by Greeks to treat pain and fever.
- Salicylic acid=aspirin. A "wonder drug" for its three class properties:
  - anti-inflammatory
  - antipyretic (fever-reducing)
  - analgesic (pain relieving)
- Also prevents heart attacks, strokes, some cancers, delays cataracts, and enhances immune system

Cinchona Tree: Malaria
- Most prevalent disease (3 million die every year)
- Endemic in tropical and subtropical countries, carried by the mosquito
- Alkaloid quinine in the cinchona tree bark is used to treat people with malaria (fever-reducing properties)

Snakeroot
- The source of the drug reserpine and other alkaloids that are used in the treatment of hypertension
- Also used as a tranquilizer to treat schizophrenia

Aloe
- Also called burn plant, native to Africa
- Treatment to various skin ailments, including rashes, burns, sunburns, wounds, etc.
- Sap of the succulent leaves contain aloin and other compounds that heal skin
- Popular in cosmetics because of moisturizing effects

Madagascar Periwinkle
- Used to treat cancer
- Alkaloids from the plant are used as chemotherapeutic agents for treating childhood leukemia

Pacific Yew
- Bark of the pacific yew is a source of taxol, an anti cancer drug
- Taxol is an alkaloid that has anti-tumor properties that may help to treat women with ovarian and breast cancer. It can be synthesized in the lab in virtually limitless amounts.

Other Medicinal Plants
- Mandrake—has been used for anesthetic properties. Doctor of signatures said it made men virile—but instead it put them to sleep!
- Belladonna—means "beautiful lady" because women would rub their eyes with it to enlarge their pupils—used by ophthalmologists to dilate pupils.
- Ipecac—an herb that contains an alkaloid that makes you throw up

- Colocynth or wild gourd—is an elaterin, purgative.
- Ginseng—considered a "cure-all" by many; root is used as sexual tonic.

Future drugs in plants: only 10% of plant species screened for therapeutic potential

Herbal Remedies

- Naturally occurring compounds in biological organisms
- Herbal medicines are classified as food rather than drugs
- Dietary supplements contain secondary component that can have physiological effects on your body, but sometimes marked without rigorous study
    - Some herbal remedies show potential, but some may interact with prescription drugs.

Commonly Used Herbal Remedies

- St. John's Wort
    - Used for treating mild depression—effectiveness has been questioned
    - Lifts spirits by raising level of serotonin
    - May induce photosensitivity, may react adversely with other drugs

Herbals

- Ginkgo: leaves have been used in China to treat asthma and bronchitis, now it is studied as a brain tonic, may halt progression in Alzheimer
    - If taken with aspirin it may cause internal bleeding
- Saw palmetto: has cherries with a substance that may help patients suffering from BPE (Benign Prostate Enlargement)
- Echinacea: a top selling herbal; stimulates body's immune system, prevents cold and flu.

Poisonous Plants

- They make poison as defense mechanisms
- Timing and place of chemicals: to manipulate animal behavior
- Some animals develop toxicity from plants (monarch butterfly)
- Some plants are poisonous to other plants—territorial competition

Types of Compounds and Plants

- Poisonous (toxic) plants have many toxic compounds)
    - Alkaloids: bitter compounds, contain Nitrogen
        - American Yew: contains taxine—causes sudden death
        - Buttercups: ranunculin—causes diarrhea and vomiting.
        - Boxwood buxene: causes convulsions and death
        - Poison Hemlock: Have coniine—causes paralysis of diaphragm, death from asphyxiation. Socrates was forced to drink hemlock...
        - Strychnine: tree seeds contain strychnine—causes convulsion, death. Used as rat poison. Cleopatra tried this on her servants while deciding method of suicide
    - Cardiac Glycosides
        - Oleander: single leaf can kill, has nerioside and oleandroside from common ornamental shrub (don't use sticks to grill)
        - Lily of the Valley: contains convallarin—which causes irregular heartbeat

- Cyanides
  - Seeds of the Rose Family—apples, apricots, peach pits, and leaves
    - Cyanide is very low in fruit, but leaves and seeds may contain high levels
  - Cassava: starchy sample eaten in many countries needs to be soaked to remove cyanide.
  - Lima Beans contain cyanide
- Other Compounds
- Castor Beans: contain ricin, a very toxic protein and is one of the most potent compounds. (1 seed can kill a child)
- Ricin: is a lectin or a toxalbumin, which causes blood cells to aggregate
- Wisteria: has wistarine which causes death (2 seeds)
- Mistletoe: contains a viscotoxin, can be fatal if eaten in large amounts
- Pokeweed: roots and berries cause respiratory depression

Milder Discouragement

- Some plants poisonous but not toxic
- Oxalic acid: occur in rhubarb—paralyze vocal chords
- Saponin: causes nausea or diarrhea
- Solanine: present in potato plant, except tubers

Allergens

- Allergenic components—poison ivy and poison oak; have urushiol, an oil that triggers your body's defenses, it gives a reaction like an infection--reddening, warming, bubbling of skin. Remember—"leaves of three let it be"

Food Allergens: compounds in certain foods produce immune reaction in some people (ie. peanut allergy)

- Hay Fever: Not caused by hay and not a fever; actually, it is allergies caused by plant pollens. More than 35 million Americans suffer from it.

Human Uses of Plant Poisons

- Natural crop defense—plants need defense against insects/disease
- Selective poisons of pests, safe insecticides
- Medicines in small doses

Important Lessons

- 99% carcinogens are present naturally
- Location, location, location—toxicity depends on what part of the plant is eaten
- Timing—whether fruit is ripe or unripe is what makes it edible vs. poisonous

Psychoactive Drugs

Psychoactive Drugs

- Psychoactive: plant compound that alters the mental state, not physical state
- Hallucinogen: non-addictive substance that cause hallucinations—perceiving or sensing things that have no reality; seeing, hearing, smelling, feeling things that aren't there; hallucinations temporary and produce
  - Changes in perception (of time, space)

- Changes in mood, in thought

Psychoactive Plants

- Same drug can be medicinal, psychoactive or toxic: depending on dosage
- Narcotic: very addictive psychoactive compounds; elicits: psychological dependence, physiological dependence, and tolerance
- Stimulant: excite & enhance mental alertness & physical activity (cocaine)
- Hallucinogen: produce changes in mood, perception (marijuana, peyote)
- Depressants: dull mental awareness, reduce physical performance, induce sleep or trance-like state (opium, morphine, heroin)

Opium Poppy

- A flower with colorful petal; ovary matures into capsule
- Milky latex inside capsule is dried and turns brown (opium)
- Opium has been eaten, drank, smoked by ancient societies to relieve pain
- Poppy seeds do not contain opium
- Opium use
  - Laudanum: mixture of opium and alcohol
  - Contains 26 different alkaloids; of these:
    - Morphine, codeine, papaverine (treats diarrhea/cramps)
    - Codeine: used as oral analgesic, 1/5 as strong as morphine

Morphine (CNS Depressant)

- 10 times stronger than opium; strongly addictive
- Valued for analgesic properties: pain relief (nothing works better)
- Used to be prescribed for diarrhea and coughing
- Administered orally first, then with hypodermic needle
- Endorphins in brain—morphine binds to receptor sites/mimics action
- Overdose=death! Suppresses respiratory center in brain

Heroin

- First introduced as cough medication, thought to be non-addictive
- 6 times more addictive than morphine—no longer used medicinally in U.S.
- Grown illegally in The Golden Triangle, The Golden Crescent
- Half million addicts in US; withdrawal symptoms are horrible
- Methadone: synthetic opiate used as gradual sub for recovering patients

Marijuana

- One of the oldest cultivated plants in the world
- Dioecious annuals: male and female flowers on separate plants
- Plants produce resin by glandular trichomes
- Brought to Jamestown in 1611; used as cash crop (rope/cordage)
- 60s and 70s: drug choice for hippies in social revolution
- Stricter/harsher sentences for users and dealers
- Active compound: THC (not an alkaloid)
  - Contains cannabinoids and THC (psychoactive component)
  - Hemp is tall erect cultivar with little THC
  - Marijuana is wild, short, busy, high in THC
- Forms of Cannibis
  - Marijuana: found on streets; dried/crushed leaves, usually smoked
  - Hashish: resin from recently fertilized flowers; smoke/drank/eat

    - Bhang, Ganja, Charas, Thia Sticks
- Psychological effects:
    - Human brain has cannabinoid receptors
    - Elicits feeling of euphoria, calmness, and well-being, lightness in the limbs, sharpened sense of sight and sound, uncontrollable laughter, distorted perception of space/time, thirst and hunger
- Health Risks
    - Doesn't result in much addiction although hashish is addictive
    - Impairs learning, short term memory, reaction time
    - Males: long term use decrease sperm production/testosterone
    - Pregnant women: damage to fetus
    - Damage to lung tissue as much as cigarettes
- Medical Uses
    - Treats glaucoma: eye disease, pressure in the eye
    - Aids cancer patients undergoing chemo; THC reduces side effects
    - AIDS patients use it to counteract weight loss
    - MS patients: reduces spastic movements

Cocaine and the Coca Plant

- Small tree or shrub, shiny evergreen leaves
- Native to Andes; sacred to Incas—leaves chewed for endurance/stamina
- Cocaine:
    - Stimulating properties; in Coca-Cola at first; MOST ADDICTIVE DRUG
    - Hamson Narcotic Act regulated its use, along w/ opium/morphine
- Recreational Use:
    - 70s and 80s: use increased dramatically
    - Clandestine labs produce pure, then adulterants added and sold as powder for snorting
    - Crack cocaine: heating cocaine with baking soda, then smoked; highly addictive
- Medical use:
    - First used for anesthetic properties
    - Now, synthetic properties: novacain and xylocane (dentists use them)
    - Cocaine constricts blood vessels, reduces blood flow during surgery
- Deadly Effects:
    - Stimulates CNS, produces short-term feeling of euphoria, burst of energy, and alertness
    - Increases heart rate, respiration, BP, body temp; dilates pupils
    - Abuse: heart attacks, cerebral hemorrhage, respiratory failure, convulsions, psychosis, schizophrenia, paranoia, hallucinations, insomnia, appetite loss

Peyote

- Dried, cut tops of Mexican cactus: buttons; consumed or soaked in water
- Mescaline is the alkaloid; gives hallucinations and visions

Kava

- Shrub related to black pepper plant; roots are used to prepare intoxicant
- Widely use in South Pacific, Hawaii, Fiji

- Lactones make people relaxed and friendly
- Primarily used as tranquilzer; can cause liver and kidney damage

Other Psychoactive Plants
- Nutmeg: cooking spice; large amounts=hallucinogenic
    - Bad effects: vomiting, nausea, headache, dizziness, irregular heartbeat
- Virola: made from Amazon tree bark; hallucinogen
- Caapi: Also from Amazon bark; harmine: powerful narcotic

War on Drugs
- Approach hasn't worked; over last 10 years hasn't dropped, but spending has increased 50%; drugs are still as available as ever
- Drugs are gotten in the black market at really high prices
- Drug violence: illegal & addicts often steal money for drugs
- Drug use in Europe (where some drugs legal) is far lower than US

Ecology and Plant Succession

Ecology- the study of the effects of:
- The environment on living organisms
- Living organisms on the environment
- Living organisms on each other

Ecological Hierarchy
- Ecology deals with studies of
    - Organisms
    - Populations
    - Communities
    - Ecosystems
    - The biosphere

Population
- Population: all the members of a single species living together
- Habitat: the location where the population is found
- Niche: the functional role an organism plays in the ecosystem

Plant Community
- Plant Community: different populations of plants living together in the same geographical area
- Dominant Species: the most influential species in the community
    - Example: Redwood Forest; they control structure and species composition of the community through
        - Physical Factors
            - Light (provide shade)
            - Wind (wind screen)
            - Humidity (higher than in open areas)
        - Chemical factors
            - Nutrients
            - pH

Ecosystem