Demystifying Plants: Botany for Gardeners



WHEN BOTANISTS STUDY PLANTS, WHAT DO THEY STUDY?

- The way plants grow and function (plant morphology and physiology)
- How plant families are related to each other (plant taxonomy)
- How plants interact with their environment (plant ecology)
- How plants evolve and adapt to their environment (plant genetics)

HORTICULTURE = BOTANY APPLIED

- IDENTIFY USEFUL PLANTS
- GROW & PROPAGATE PLANTS
- INFLUENCE FLOWERING & FRUIT PRODUCTION
- MANAGE GROWTH & FORM
- MAINTAIN PLANT HEALTH
- MODIFY PLANT FEATURES THROUGH BREEDING AND SELECTION



HORTICULTURE IS THE STUDY OF USEFUL PLANT ODDITIES (THE WE HAVE SELECTED)



IN DISTURBED AND CODDLED LANDSCAPES





Variegated Norway maple

PLANTS DON'T LIVE IN ISOLATION

- Physical environment (soils, climate, moisture, etc.)
- The living environment (other plants, people, animals, insects, fungi, etc.)
- Do landscapes change? How?



Plant communities change

- This is called plant succession
 - stable
 - unstable
 - in between
- Examples from native landscapes
- Examples from gardening





Stable unstable in between?



Stable unstable in between?



How do plants get through winter? (survival strategies)





Climate zones define the average low winter temperatures for large areas.

Your property may be in a microclimate that differs (either warmer or colder) from the general cold winter pattern for your region.

Do we care about climate zones for vegetables?

• Why or why not?



The importance of life cycles and winter survival strategies

- Annuals
 - winter
 - summer
- Biennials
- Perennials
 - Herbaceous
 - Woody
 - deciduous
 - evergreen



Winter annuals

- Spread exclusively by seeds that germinate in the fall/winter and go to seed in the spring to early summer and die.
- Some, in this climate, grow year round
- Examples: chickweed, groundsel, red dead nettle



Groundsel – Senecio vulgaris

Summer annuals

- Also spread by seed that germinate in the spring and summer
- Flower and seed by fall and die
- Compete with vegetable crops
- Examples: pigweed, lambsquarter, and...



Purslane

Biennials

- Spread by seed that germinate in spring-fall
- Overwinter as a "rosette"
- Flower and seed next year in the late spring-summer and die

Bull thistle – Cirsium vulgare



HERBACEOUS PERENNIALS

- TOPS DIE BACK
- NEW SHOOTS EACH SPRING FROM ROOTS/CROWN
- SPREAD BY SEED AND VEGETATIVE PIECES (DIVISIONS, CUTTINGS, ETC. IF WE LIKE THEM) AND DON'T DIE IN WINTER



HEDGE BINDWEED CALYSTEGIA SEPIUM AKA MORNING GLORY

WOODY PERENNIALS

- TEND TO SPREAD BY SEEDS.
- VEGETATIVE SPREAD WITH SOME SPECIES E.G. IVY, AND ROOT SUCKERS ON SOME TREES.
- PERENNIALS DON'T DIE WITHOUT CAUSE



VISITING A NURSERY – What might make a plant a good fit for a particular place in your garden or landscape?



RIGHT PLANT, RIGHT PLACE.

HORTICULTURAL PLANT CLASSIFICATIONS

- SUN OR SHADE
- ACID OR NEUTRAL OR ALKALINE SOILS
- DRAINAGE PREFERENCE
- GROWTH HABIT (WOODY VS. HERBACEOUS; TREE VS. SHRUB; EVERGREEN VS. DECIDUOUS; ETC.)
- COLD HARDINESS
- REPRODUCTIVE STRATEGY: ANNUAL, BIENNIAL, PERENNIAL.
- PLANT FAMILY

CLASSIFYING PLANTS INTO FAMILIES

- WHY DO WE CARE?
- WHAT ARE THE KEY MORPHOLOGICAL CHARACTERISTICS USED?
- WHICH ONE IS THE MOST IMPORTANT TO IDENTIFY ITS FAMILY? WHY?





WHY FLOWERS?

How do we know he was right in his plant family linages?

A QUICK TOUR OF THE PLANT KINGDOM...



SEPARATED INTO MONOCOTS AND DICOTS

Not Shown: Fungi, certain algae

LINNEAN CLASSIFICATION OF PLANTS

- LOWER VS. HIGHER PLANTS
- GYMNOSPERMS (CONIFERS AND OTHERS) AND ANGIOSPERMS
- MONOCOTS AND DICOTS
- FAMILY: ACERACEA
- GENUS: ACER
- SPECIES: RUBRUM HYBRID
- CULTIVAR: AUTUMN BLAZE



MONOCOTS VERSUS DICOTS



HOW PLANTS DIFFER FROM ANIMALS

- PLANTS CAN'T MOVE
- NO VITAL ORGANS
- WAYS TO RENEW PARTS THAT ARE DAMAGED
- DISTRIBUTED FUNCTIONS
- CAPTURE CARBON
- MANY CAPABLE OF CLONING
- LET'S SEE HOW PLANTS WORK!

WHAT ARE THE REQUIREMENTS FOR PLANT GROWTH?

LIGHT ENERGY

Heat (some)

STORED ENERGY

WATER

Carbon, hydrogen, oxygen Mineral elements



A FEW IMPORTANT CONCEPTS

• MERISTEMS

 PLANT HORMONES (AKA PLANT GROWTH REGULATORS) THAT INITIATE "DECISIONS" PLANTS MAKE.



MERISTEMS

AREAS OF ACTIVELY DIVIDING CELLS THAT DEVELOP INTO PLANT TISSUES AND ORGANS





PLANT HORMONES AKA PLANT GROWTH REGULATORS

CHEMICALS PRESENT IN TINY QUANTITIES THAT AFFECT PLANT RESPONSE TO THE ENVIRONMENT INCLUDING DORMANCY, STRUCTURAL GROWTH, FRUIT, FLOWERING, DISEASE, STRESS, ETC.



Plants have to start from something





Seed Anatomy

- EMBRYO MINIATURE PLANT IN AN ARRESTED STATE OF DEVELOPMENT
- ENDOSPERM FOOD SUPPLY (CAN BE COMPRISED OF PROTEINS, CARBOHYDRATES, FATS)
- SEED COAT HARD OUTER COVERING THAT PROTECTS FROM DISEASE AND INSECTS; ALSO REPELS WATER





Successful seed germination requirements

- WATER PENETRATES SEED COAT
- SEED EMBRYO ACTIVATED
- OXYGEN, FAVORABLE TEMPERATURE CYCLE, AND (IN SOME SPECIES) LIGHT REQUIRED, & OTHER CUES
- NO CRUST ON SOIL



Other germination factors





Seeds and Seedlings





The Three Big Plant Processes

- Photosynthesis captures sun's energy and transforms that energy and carbon into sugars
- Transpiration moves water through plant
- Respiration turn sugars into other useful compounds, materials, or biochemical energy within plants



Photosynthesis

- Key to web of life on earth!
- Plants make their own food
- ONLY PLANTS DO THIS!



PHOTOSYNTHESIS



CHLOROPLASTS EMBEDDED IN LEAVES CAPTURE LIGHT ENERGY IN THE PRESENCE OF WATER AND CO2 AND CONVERT IT TO SUGARS AND OXYGEN!

FACTORS THAT AFFECT PHOTOSYNTHETIC RATE

- CARBON DIOXIDE
 AVAILABILITY
- WATER
- LIGHT (QUALITY AND QUANTITY)
- TEMPERATURE



WHAT DO PLANTS MAKE OUT OF THE SUGARS?

- Physical parts i.e. leaves, roots, stems, etc.
- Biochemicals to store energy for later use, to deter being eaten, to encourage pollination, to guide new growth, and to do other "jobs" within plants



 $CO_2 + H_2O + LIGHT ENERGY = SUGARS + O_2$

WHERE THE MAGIC HAPPENS: LEAF CROSS-SECTION













WHY IS THIS ABILITY TO OPEN AND CLOSE IMPORTANT?

Epidermis

May have special adaptations like hairs or waxy layers that help with drought tolerance





stinging nettle

MANY ADAPTIONS ON THE LEAF EPIDERMIS



OTHER DEFENSIVE ADAPTIONS – CHEMICALS, ALERT COMPOUNDS, ETC.

WHAT IS RESPIRATION?

RESPIRATION IS THE **OPPOSITE** OF PHOTOSYNTHESIS

IN RESPIRATION, SUGAR IN THE PRESENCE OF OXYGEN IS BROKEN DOWN INTO ENERGY TO DRIVE BIOCHEMICAL REACTIONS WITH CARBON DIOXIDE AND WATER RELEASED.

FACTORS AFFECTING RESPIRATION RATE

Temperature Oxygen Soil condition



SUGARS + OXYGEN = CHEMICAL ENERGY + $CO_2 + H_2O$

A COMPARISON

PHOTOSYNTHESIS

- PRODUCES FOOD
- STORES ENERGY
- USES WATER
- USES CARBON
 DIOXIDE
- RELEASES OXYGEN
- OCCURS IN
 SUNLIGHT

RESPIRATION

- USES FOOD
- RELEASES ENERGY
- PRODUCES WATER
- RELEASES CARBON
 DIOXIDE
- USES OXYGEN
- OCCURS IN DARK & LIGHT

LET'S TALK ABOUT WATER

- Water is an amazing chemical. We can't imagine life without it.
- What does water do in plants and how does it move around within them?



WHAT IS TRANSPIRATION?

- TRANSPIRATION IS WATER LOSS (AS VAPOR) FROM A PLANT
- WATER IS TAKEN UP BY ROOTS, MOVED THROUGH THE PLANT AND THEN LOST AS VAPOR THROUGH STOMATA ON THE LEAVES



Transpiration Rate

- Transpiration rate is controlled by stomates opening and closing
- in response to...
 - -relative humidity
 - -temperature
 - -light & time of day
 - -wind
- under constraint of... – water availability
 - -plant nutrition



FUNCTIONS OF TRANSPIRATION

- COOL PLANTS
- MOVES MINERALS & SOME SUGARS
- MOVES PLANT HORMONES
- MAINTAINS LEAF TURGOR
- MATRIX FOR BIOCHEMICAL PROCESSES



What is turgor?





Transpiration requires...

- soil moisture
- functional root system
- functional stem & branch "plumbing"
- functional leaves



Vascular system ("plumbing")



Vascular Systems

- XYLEM WATER AND MINERAL CONDUCTING "PIPES" - ONE WAY FLOW UP
- Phloem sugars, Minerals, and other transport. Flow both UP and down



 CAMBIUM – A MERISTEM THAT DIVIDES TO PRODUCE XYLEM AND PHLOEM IN DICOTS



ROOT FUNCTIONS

- Absorbs water and minerals
- STORES FOOD
- REPRODUCTIVE ORGAN
- COMPETE WITH OTHER PLANTS FOR WATER AND MINERALS







MODIFIED ROOTS – HUMANS HAVE BEEN BUSY





TUBEROUS ROOT - SWEET POTATO







TUBEROUS ROOT, DAHLIA

What's inside a root?





Root hairs on a radish seedling

ROOT HAIRS ABSORB MOST OF THE WATER A PLANT GETS – VERY TINY

ROOT HAIR CROSS-SECTION



- DELICATE
- THIN-WALLED
- ROOM FOR LOTS OF
 WATER
- HAS LOWER WATER
 PRESSURE THAN THE
 OUTSIDE SOIL

Let's review



Mycorrhizae = fungal partners on/in higher plant roots





MYCORRHIZAL FUNGI



WHICH PARTNER GETS WHAT?



How much water do these plants move?





Corn

Big leaf maple



How does water get to the top of huge redwoods???

How does water get from the soil to the top of a tree?

ROOT HAIRS (OFTEN WITH THE HELP OF MYCORRHIZAE) ABSORB WATER FROM THE SOIL

XYLEM CELLS TRANSPORT WATER VIA CAPILLARY ACTION AND COHESIVE FORCE OF WATER





Factors influencing root growth

- Light captured
- Gravity
- Temperature
- Soil texture
- Oxygen
- Moisture
- Minerals
- Salt







WHAT DO THESE LAST TWO SLIDES SHOW?



WEED/CROP INTERACTION



IT'S ALL ABOUT LIGHT AND LEAF AREA!! Shaded or cut leaves gather less light. STORMS HAPPEN AND SO DO SHALLOW ROOT SYSTEMS FROM HIGH WINTER WATER TABLES





Root spread

Issues: construction, covering & stability certain herbicides problems yard invasion and suckering other problems



STEM CROSS-SECTIONS

Herbaceous monocot (corn) WOODY DICOT (MAPLE TREE)





XYLEM CELLS

- CARRY H₂O & DISSOLVED NUTRIENTS
- CELLS ARE:
 - LONG, OPEN-ENDED, CONNECTED END TO END
 - HAVE THICK CELL WALLS
 - RESEMBLE STRAWS



P. Dahiya: Nature Cell Biology

XYLEM CELLS ARE REALLY STRONG. WHY?

Phloem cells

- Active transport up & down of biochemicals, minerals, etc. from leaves to roots, stems, flowers & fruits. Cells are long and tube-like
- without extra cell wall thickening Not open but controlled



VASCULAR CAMBIUM

- CAMBIUM IS A MERISTEMATIC TISSUE, MEANING IT DIVIDES TO PRODUCE NEW TISSUES
- CAMBIUM DIVIDES TO PRODUCE
 - XYLEM: TO THE INSIDE (HEARTWOOD, PITH)
 - PHLOEM: TO THE OUTSIDE (PART OF BARK)
- RESPONSIBLE FOR "GIRTH GROWTH," OR INCREASED STEM DIAMETER IN WOODY PLANTS

Stems

ONLY DICOTS PRODUCE WOODY TISSUE.

How does grafting work?

WHAT HAPPENS WHEN A TREE STEM IS GIRDLED OR SUNBURNED.





Woody Stem Anatomy





?

What is bark?

Answer. Bark is the outer layer of cells on a tree containing cambium, compressed "dead" phloem, and sometimes, cork.

Stems evolve in response to selection pressure



Thorns for defense (rose)



Corky extensions (Euonymus alata)

Photosynthetic stems (Blueberry and Christmas cactus)

Stems selected by humans for storage



Stems evolved for vegetative propagation







WHAT DOES A STEM DO?



Physically support leaves, buds, flowers & fruits

TRANSPORT WATER, MINERALS & SUGARS AND OTHER COMPOUNDS

PROVIDES SUGAR STORAGE IN SOME PLANTS

EXTERNAL PARTS OF A WOODY STEM

NODE = PLACE WHERE LEAF IS (OR WAS) ATTACHED TO THE STEM



INTERNODE = DISTANCE BETWEEN NODES

LATERAL OR AXILLARY BUDS



LOCATED IN THE ANGLE WHERE THE LEAF ATTACHES TO THE STEM

Apical dominance



AXILLARY BUD

MAY PRODUCE LATERAL SHOOT OR BRANCH – LESS AUXIN EFFECT FURTHER FROM THE APEX DUE TO DILUTION



Auxin and fruit trees





Phototropism –





Buds and vegetative dormancy – what triggers the dormancy process and what brings them out of dormancy?









WINTER DORMANCY PROCESS SUMMARY

- Leaves measure decreasing daylength and at a certain time, start to get ready for winter by extracting nutrients from leaves, creating an abscission zone for leaves so they drop, and "hardening" buds.
- Measure the number of hours below 47 degrees F to satisfy chilling requirement
- Slowly, the buds can then emerge from deep dormancy, depending on weather.

LEAF FUNCTIONS

- USE SUNLIGHT TO MAKE SUGARS – PHOTOSYNTHESIS
- USE SUGARS TO MAKE ENERGY AND OTHER COMPOUNDS – RESPIRATION
- MOVE WATER FROM ROOTS THROUGHOUT THE PLANT – TRANSPIRATION
- SENSE DAYLENGTH



MAJOR LEAF PARTS



- LAMINA (LEAF BLADE) -HIGHLY VARIABLE IN SIZE AND SHAPE
- PETIOLE STALK AT BASE OF LEAF THAT ATTACHES LEAF BLADE TO STEM

MODIFIED LEAVES



CATCHING INSECTS

MORE MODIFIED LEAVES





scales



floating



tendrils



Succulence

LEAVES MODIFIED FOR STORAGE







Моносот OR DICOT?



LEAF ARRANGEMENT ON A **STEM**









These characteristics are important in identifying plants

What are the leaf arrangements of these plants?



bedstraw

snowberry

COMPOUND VS. SIMPLE LEAVES





COMPOUND LEAVES





PINNATELY COMPOUND

PALMATELY COMPOUND

What's going on inside the leaf and plant?

- Photosynthesis
- Respiration
- Transpiration

Balancing act



PLANT PROCESSES IN BALANCE

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- PHOTOSYNTHESIS VS TRANSPIRATION
- CARBOHYDRATE ALLOCATION WITHIN PLANT
- NUTRIENT ALLOCATION WITHIN PLANT
- GROWTH VS STORAGE VS REPRODUCTION VS DEFENSE...

2/18/2019



How plants reproduce (or are propagated by clever gardeners)

VEGETATIVE (ASEXUAL) PROPAGATION

Divisions Cuttings Layering Grafting/Budding Tissue culture



CUTTINGS

Formation of adventitious roots

Usually done with a rooting hormone powder

Timing important



2/18/2019



GRAFTING









FLOWERS & SEXUAL PROPAGATION

FLOWERS FACILITATE POLLINATION.

IF FERTILIZATION OCCURS, SEEDS ARE PRODUCED AND CARRIED IN CONES (CONIFERS) OR "FRUITS" (FLOWERING PLANTS)



FLOWERING RESPONSE TRIGGERS





JUVENILITY AND FLOWERING - APPLES











FLOWER TYPES

- COMPLETE HAS ALL FLORAL PARTS PRESENT (SEPALS, PETALS, STAMENS, PISTILS)
- Incomplete -flower lacks 1 or more of the 4 parts



Flower Types, Continued

- **Perfect** Has both stamens and pistils (male and female parts)
- IMPERFECT LACKS EITHER STAMENS OR PISTILS

COMPLETE OR INCOMPLETE? PERFECT OR IMPERFECT?



"male" flower (staminate) "female" flower (pistillate) Imperfect flowers can be either monoecious (on the same plant) or dioecious (on different plants)





HOLLY: DIOECIOUS

MALE AND FEMALE TREES. OTHERS INCLUDE SKIMMIA, MOST KIWIS, & CANADA THISTLE



Pollination

METHOD: WIND, INSECTS, BATS, LIZARDS, ETC.

Self-incompatibility: What is it and

WHY IT HAS EVOLUTIONARY VALUE?

Hybrids: Mostly man-made crosses between species but not always

POLLINATION VS. FERTILIZATION







BUMBLEBEES

BUTTERFLIES



big leaf maple BEETLES

willow

WIND



cape fuchsia HUMMINGBIRDS







skunk cabbage

BUTTERFLIES

FLIES

BEES





Dranuculus vulgaris



Carrion beetles

VEGETABLES THAT ARE MODIFIED, IMMATURE FLOWERS









SEEDS RELEASE HORMONES THAT CAUSE CELLS TO DIVIDE AND EXPAND. WHEN SEEDS ARE ONLY ON ONE SIDE LOPSIDED FRUIT RESULTS.

VERY INCOMPLETE POLLINATION = FRUIT DROP

Seed dispersal

- WIND
- WATER
- ANIMALS
- INSECTS
- OTHERS
- HOW FAR FROM SOURCE IS OPTIMAL? CAN VARY WITH PLANT TYPE, EG TREE, GRASS, ANNUAL BROADLEAF, ETC.



Fruit: Facilitates seed dispersal





Five plant growth regulators

Auxins Gibberellins Abscisic acid Cytokinins

Ethylene





Auxin

Apical dominance Phototropism



Gibberellic acid

Stimulate cell division and elongation Speeds seed germination Breaks seed dormancy





Abscisic acid

Induce and maintain dormancy Control stomatal closure Leaf abscision



Cytokinins

Stimulate cell division

Delay senescence

