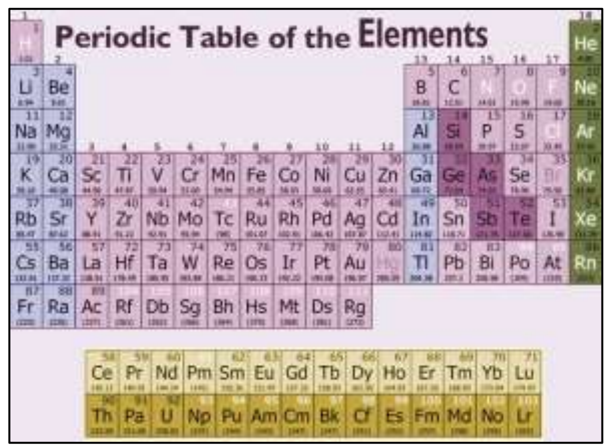
Aug 23 lecture notes
I. Atoms and molecules
II. Plant cells

PART I: ATOMS AND MOLECULES

This section (atoms and molecules) is largely presented as background material so that you can understand future lectures in which we refer to and explore various molecules. You do NOT need to re-master chemistry, but you should be comfortable with the following vocabulary and concepts:

- element
- atom
- proton
- electron
- molecule
- covalent bond (recognize a single vs. double covalent bond in a structural formula)
- molecular formula
- structural formula
- chemical reaction
- reactants
- products

Living organisms - and <u>all</u> solids, liquids, and gasses on Earth - are comprised of **matter**



Matter: anything that occupies space and has mass.
All matter is made of 1 or more of the **elements** (see periodic table).
Element: components of matter that cannot be broken down (turned into a new or different element) by ordinary chemical means (but can combine to make new substances). The elements on Earth are arranged into the Periodic Table of the Elements. The letter(s) in each cell on the periodic table is the atomic symbol for each element.

The smallest tiny bit of matter that an element can be reduced to is an **atom**. Alternatively;
Atom: The smallest unit of matter that retains the properties of an element.

Atoms – word origin "a" (not/non) + "tom" divide = non dividable.
Indicates cannot be divided (few noteworthy exceptions…).

Atoms are built from three different **subatomic particles**:

1) **Protons**: positive charge (in atomic nucleus). The element to which an atom belongs (i.e., the type of element an atom "is") is dictated by the number of protons.
2) **Neutrons**: no charge (in atomic nucleus)
3) **Electrons** (notation: **e^-**) : negative charge. Orbit around the nucleus in **valence shells**.

…BTW, nearly all individual atoms contain equal #'s of protons, neutrons, and electrons…
(exceptions are neutrons…which we will not cover…)

Some elements exist in nature single atoms or clusters of one type of atom in their elemental form. EX: gold (Au), silver (Ag), oxygen (O)
Atoms can combine and form “new” types of matter (i.e., matter that does not exist on the periodic table in a pure elemental form) by forming molecules:

Molecule: a group of atoms held together by two or more chemical bonds

Chemical bond: An attraction between two atoms, resulting from the transfer of electrons (ionic bond) or sharing of electrons (covalent bond).

We WILL NOT study molecules formed by ionic bonds (but an important example is salt, NaCl).
We WILL (!) study lots of molecules formed by covalent bonds. You do not need to understand the chemistry of covalent bonds, but you will need to recognize some common molecules in two common ways in which molecules are written (a few examples follow):

Example molecule	**Molecular formula**	**Structural formula**
Molecular hydrogen (typically a gas)	H_2	H-H (the line between H atoms represents a single covalent bond)*
Molecular oxygen (typically a gas)	O_2	O=O (the line between O atoms represents a double covalent bond)*
Water	H_2O	H-O-H (but bent, and polar – see your notes from lecture!)

* Don’t worry about the technical difference between a single vs. double covalent bond, just recognize the symbols reported here. They will be important in an upcoming lab. If you are curious about the difference – come see me in office hours.

Molecules are formed and broken apart through chemical reactions:
Chemical reactions: The making and breaking of chemical bonds

Reactants: the starting atoms/molecules that are “used up” in a chemical reaction
Products: the atoms/molecules that are produced in a chemical reaction

Balancing reactions – matter (atoms) is neither created nor destroyed during reactions, so make sure all atoms are accounted for on both sides of equation!!

We discussed the shape and charge around water molecules, and established that this is important because water molecules in contact with each other can form hydrogen bonds. These were drawn and explained in lecture.

Hydrogen bonds: weak bond within or among molecules containing a charged hydrogen atom – THE key example in biology is water. See your lecture notes!!

Essential element: An element required for normal growth and reproduction.
The essential elements that comprise the tissue of plants are often divided into two categories:

M**acronutrients** (aka; macro essential elements): essential elements required in large quantities by plants.

M**icronutrients** (a.k.a. micro essential elements, or trace elements): essential elements required in very low quantities.
(We will not explore how/why these elements are needed and used in plant tissues)

The useful mnemonic device for remembering the **macronutrients** is as follows:
C H O P K N S Ca Fe Mg (pronounced as: "C Hopkins Café, Mmmm Good"), in which each letter (or two letters in the case of Ca, Fe, and Mg) represents atomic symbols on the periodic table.

Macronutrients and where they are found in plants cells – you do NOT need to know this list, I provide here for reference and in the interest of being complete!!

Macronutrient	(importance/role in plants)	(Approximate % of dry weight in non-woody plant tissue)
C – Carbon	(abundant in biomolecules)	(45%)
H – Hydrogen	(abundant in biomolecules, water)	(6%)
O – Oxygen	(abundant in biomolecules, water)	(45%)
P – Phosphorous	(in ATP, DNA, phospholipids; basic cell function)	(0.2%)
K – Potassium	(stomata guard cell opening/closing; basic cell function)	(1.0%)
N – Nitrogen	(in amino acids [thus proteins], DNA, many other molecules)	(1.5%)
S – Sulfur	(in some amino acids – *you will not be asked about* S *on exams*)	(0.1%)
Ca – Calcium	(in cell wall – *you will not be asked about* Ca *on exams*)	(0.5%)
Fe – Iron	(needed for synthesis of chlorophyll)	(0.01%)
Mg – Magnesium	(in chlorophyll molecule)	(0.2%)

As we progress through the semester, we might touch upon the importance or role of each macronutrient – but a summary is provided next to each element above.

Important facts about some macronutrients, you should know this for exams!
C, O, H – plants obtain these from air and/or water, not necessary to have in fertilizer.
N, P, K – plants obtain these from soil and they are heavily utilized (they are therefore referred to as the "primary macronutrients"). In agriculture/horticulture, these elements are the main ingredients of fertilizer. Be able to identify/explain an **N-P-K fertilizer formula** on exams. We discussed that N, P, and K have many fundamental roles in cell function and are essential to plant function throughout life – BUT - high N is most important during vegetative growth, while P and K support/enhance flowering & fruiting. Thus, you need to have a general sense of how an ideal **N-P-K fertilizer ratio** might change during the course of your gardening season!

PART II. CELLS

Cell: A basic unit of living matter separated from its environment by a plasma membrane; the fundamental structural unit of life

1665: The term 'cell' was first coined by Robert Hooke in 1665 as he peered through his microscope at a sample of cork (bark material from the cork oak *Quercus suber* – a specimen of this species is on SBCC campus near the barrel cacti we might have examined during lab in week 1). The individual spaces, or "cells", reminded Hooke of monastic cells (the small cells in which monks dwell and ponder), hence the name.

1674: Antonie van Leeuwenhoek is first human to record observations of live single celled organisms (the alga *Spirogyra* sp.) under a microscope.

Mid 1800's – cell theory developed and formalized (a joint effort building upon the observations of Hooke, van Leeuwenhoek and many others)

Cell Theory (three important premises – I will NOT ask you this on exams!!):

1) Cells are the fundamental unit of structure and function in all organisms
2) All living things are composed of cells
3) All cells are derived from other living cells

Cell sizes: generally 1-10µm (bacteria/archaea); 10-100 µm (plant and animal cells)
(1meter = 1000mm; 1mm = 1000 µm [micrometer or 'micron'])
(by the way, 1 meter = 1 ten millionth of the distance from the equator to the north pole – you don't need to know this….!!!)

(FYI: notably large (and common) single cells are <u>unfertilized</u> eggs of birds such as chickens and ostriches (the latter is one of the largest single cells in known to biology).

PLANT CELL STRUCTURE

Plant cells have the following structures (that you need to know for this class, LOTS of other cell structures exist but are not included here. You're welcome…).

- **Cell wall –** Rigid structure surrounding the entire cell and cell membrane. In plants, the cell wall constructed primarily from cellulose (which we will discuss in depth) and other molecules (that we will touch upon more briefly). We will explore the structure of cell walls after Midterm #1.
- **Plasma membrane (cell membrane)** - lipid bilayer that separates the inside of the cell from the outside environment, thereby allowing the cell to maintain conditions (e.g., solute concentrations) that differ from the environment.
- **Cytoplasm/cytosol (…and protoplasm)**

  Cytoplasm – everything inside the plasma membrane, minus the nucleus (if you're dealing with a eukaryote!) and vacuole(s).

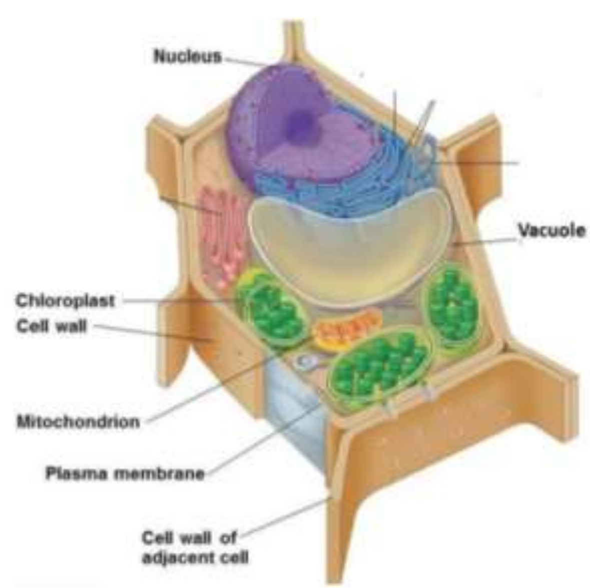
  Cytosol - The liquid portion of the cytoplasm

  Protoplasm – all the contents of a plant cell inside the cell wall (i.e., not including the cell wall). (When referring to a single cell, we often call the protoplasm the "protoplast.") I will NOT ask you the terms "protoplasm/protoplast" on exams…but you might encounter them elsewhere…
- **Nucleus** – membrane-bound structure that contains the cell's DNA
- **Mitochondria** – powerhouse of the cell - produce ATP which provides energy for all cell functions.

- **Plastids** – Sites of manufacture and storage of chemical compounds.
    - **Chloroplasts** – organelles where photosynthesis occurs (also present in some Protista)
    - **Amyloplasts** – storage of sugars (starch). Especially abundant in seeds and storage organs such as tubers. (Light levels can cause conversion from amyloplasts <-> chloroplasts)
    - **Chromoplasts*** – contain fat-soluble pigments called carotenoids (yellow and orange hues).
- **Vacuoles**: Very important! Several roles (FYI – prominent in plants; present in few other cells):
    1) Turgor pressure: the pressure exerted by water on the inside of a cell or vacuole. (Think water balloon…). This maintains the shape of plants cells (the cell wall helps too – a big reason it's there!) and soft tissues such as leaves, stems, flower petals.
    2) Rapid growth of plant cells b/c they (vacuoles) swell with water (think of a flower opening, or a fern fiddlehead unfurling – this is all driven by cell division or cell expansion (which can be accelerated by swelling of vacuoles). Young cells can have many vacuoles, and they typically coalesce into a large central vacuole in mature cells.
    3) Water storage. This is important b/c plants must endure dry/drought periods {VIDEO – Planet Earth, "Deserts" 18:00-19:50}
    4) Waste storage. Plants do not have an excretory system – weird eh? So, many wastes get stored in the vacuole. Many plants have evolved to benefit from this arrangement by making nasty wastes/toxins that serve as chemical defenses.
    5) Pigment storage*. Anthocyanins are water soluble pigments stored in vacuoles.
    6) General storage and recycling location. The vacuole is a logical location to store materials and to chemically break apart and recycle cellular materials, because the vacuole is isolated from the cytoplasm by the single membrane that surrounds it (the tonoplast)
- **Plasmodesmata:** tiny strands of cytoplasm (not protoplasm! Why not? – see the distinction and need for this vocabulary?!!) that extend through small holes in cell walls and connect plant cells.

*Note the difference in pigments found in vacuoles vs. chromoplasts.
Vacuoles contain anthocyanins (red/purple/blue colors), which are water soluble (dissolve in water).
Chromoplasts contain carotenoids (yellow/orange/red colors), which aren't water soluble.
In structures like flowers, there is a wide diversity of colors because plants can have variable concentrations and combinations of different pigments, and in some cases "overlap" anthocyanins and carotenoids to yield 'new' colors (colors not attainable with a single pigment type (anthocyanin or carotenoid). Patterns are formed by allocating pigments in chromoplasts/vacuoles in cells that from the distinct patterns. We discussed this in lecture and in lab – I think it is interesting…which means it will probably be on an exam! We will discuss many, many (!) other features of plant cells throughout the semester – but let's wait until we encounter the appropriate context. For now, the list above provides us with a solid foundation.

At right is a generalized plant cell. On future exams and quizzes you will be responsible for identifying the structures indicated here and for knowing their general function in the cell (1 sentence descriptions will be adequate…assuming they are accurate!!). We'll discuss the function of most organelles in future lectures. Not labeled here are the plasmodesmata (the little holes that connect the cytoplasm of adjacent cells). Not pictured here are other plastids.



Binomial nomenclature. covered in lab, but you need to know the basics

Binomial nomenclature: a formal system of naming individual species with names comprised of two Latin words (sometimes borrowing roots from other languages such as Greek). (These names are often referred to as *Latin names* or *scientific names*.) Developed by Carl Linneus (1707-1778).

In a scientific name, the first Latin word is the genus name, and the second is the species epithet:
Example (from lab):
Foeniculum *vulgare*
(genus name) (species epithet)

(BTW: recall that the common name for this plant was fennel, and it is in the APIACEAE (carrot family))

Proper reporting of scientific names:

- First letter of the genus name is capitalized
- Species epithet is not capitalized
- Both are italicized (or, underlined if written by hand)

Correct:

- *Nicotiana glauca*
- Nicotiana glauca (if handwritten)

Incorrect (can you see why?):

- nicotiana glauca
- *nicotiana glauca*
- NICOTIANA GLAUCA
- *NICOTIANA GLAUCA*
- Nicotiana Glauca