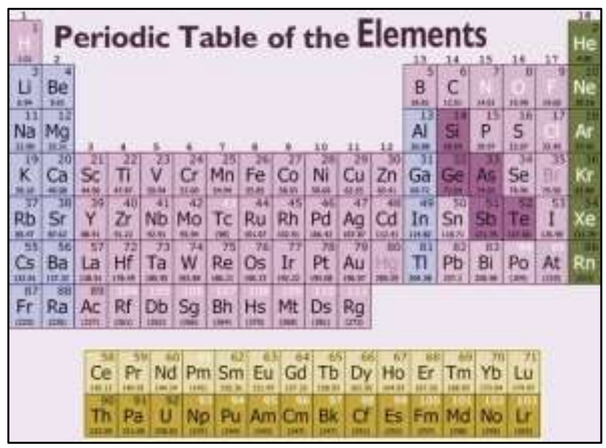
Jan 24 lecture notes
I. Atoms and molecules
II. Chaparral and wildfire, a very brief introduction (more later this semester)

<u>PART I: ATOMS AND MOLECULES</u>

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!

II. CA wildfire and botany, a very brief introduction (we will investigate this more later in the semester)

In plant communities where fire is common (almost ALL of California), fire is often a selective pressure that can kill or stunt plants. Not surprisingly, many plants have adaptations to survive and/or reproduce in the presence of fire. In some ecosystems, especially coniferous forests, frequent fire is required to maintain ecosystem health. We will discuss many of these concepts at a later date. Given the extent and proximity of the recent Thomas Fire, however, we "peek ahead" today and briefly explore how plants recover form fire in THE dominant plant community in our own backyard: chaparral.

Plant community: an assemblage of plant species growing together in a particular area.

Chaparral: A plant community with dense thickets of short woody plants that are:

- 4-12' (or more) in height,
- fire resilient,
- drought tolerant,
- have small sclerophyllous leaves (sclerophylls)

Chaparral factoids:

- Most widespread plant community in CA
- Covers ~5-9% of the total area of the state (estimates vary by source)

Examine the definition and description of chaparral above, and think about the plants you encounter on a typical trail above Santa Barbara in the Santa Ynez Mountains. Sound familiar? It should, it is virtually impossible to hike in Santa Barbara and not encounter chaparral. In fact, if one looks up "chaparral" on Wikipedia (the ultimate source on everything, right…?) the image at right is displayed…it is the Santa Ynez Mountains behind Santa Barbara.

OK, this is a sinfully brief and superficial introduction to the chaparral, but we will return to it later in the semester as we discuss plant communities. That being said, in the short time that we have spent together this semester, you have "met", sketched, and pressed two common chaparral plants: *Ceanothus megacarpus* (big pod ceanothus), and *Ceanothus spinosus* (greenbark ceanothus). The interesting (and not coincidental) biology of these two plants is that exhibit the two most common but fundamentally different adaptations for recovering from catastrophic fire (by "catastrophic fire", I mean that all aboveground tissue of a plant is killed/destroyed by the fire). These two adaptations are: 1) resprouting, and 2) reseeding. We discussed these in lecture

1) Resprouting from below-ground tissues called lignotubers (*Ceanothus spinosus* is a species that does this, remember the image from lecture because we'll visit that very plant later in the semester):

Lignotuber: A woody swelling of the root crown, which contains buds, and from which new shoots can grow (often referred to as a basal burl).

2) Germination of seeds that are buried in the soil, they accumulate there in the soil seed bank. Chaparral plants produce large numbers of seeds that can remain dormant over long periods of time. In order to germinate, their seed coat must be compromised or scarified:

Scarification: cutting, weakening, or softening of the seed coat to hasten germination. Typically via heat, physical abrasion, or chemicals.

Wildfires can burn through chaparral communities at extremely high temps: often 800-1200 F. Seeds exposed to these temperatures are destroyed, but seeds buried beneath the surface are exposed to much lower temps of ~200-400 F. (Wildfires move very fast and seeds need not be buried too deeply to be insulated from lethal temps – a few inches is adequate). Such temps are in the range that scarifies *Ceanothus megacarpus* (and other species) seeds and breaks their dormancy – and they sprout at an opportune time when competition is eliminated.

That's enough material for now. Again, we will return to the chaparral and fire later in the semester. However, I wanted to make you aware of these adaptations now, so that as you hike our local trails this winter and spring you can witness and recognize these adaptations in action as chaparral recovers from the Thomas fire.

For many of victims of the Thomas Fire and subsequent mudslides, recovery will not be so simple. As a community we send our thoughts and support to the victims of the Thomas fire and mudslides.

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