ES 10: Environmental Science
Lecture key points – my somewhat random notes really

MATTER and ENERGY and some CHEMISTRY

Major source of energy to the planet is sunlight
Matter takes up space and mass
Energy is the ability to do work

Matter has 3 phases:
Gas – disorganized (atoms hit occasionally)
Liquid - more organized (atoms hit more regularly)
Solid – highly 'organized', atoms vibrate in their own space

Takes energy to change these phases

Matter comes in high quality (organized) and low quality (less organized, more diffuse). I used manganese nodules as an example

Energy: kinetic (motion) and potential (stored).

Energy Types:
General:
Ionizing: high energy–X-ray, UV (sun), gamma, cosmic. Can cause real health risks due to the high level of energy which can also affect us (eg cancer and UV radiation)

Non-ionizing: Lower energy–Visible light, microwaves, TV, radio

Specific types:

Solar Energy: 99% of the earth's heat/energy. Drives life on earth (through plants which can harness the sun's energy directly). Two types
1) Direct (eg. Heat and light
2) Indirect (wind, flowing water, biomass)

Harnessing the sun's energy can be done in two main ways:
- Passive solar energy (eg through a window, or using a black surface to warm something up)
- Active: by using solar panels and photovoltaic cells (like a battery used to harness and store solar energy). A windmill is also an example – harnesses the wind energy (an indirect source of solar energy)

Non commercial energy is generally from solar sources (direct or indirect) and include things like fuel wood, crop waste (biomass), and dung (animal waste).

Commercial energy (remaining 1%): minerals and fossil fuels (oil, gas, coal).

Nuclear Energy: Very high energy, problems with human health. Also problems with storing the waste which is still radioactive and dangerous, often for a LONG time due to the long *half life* (time it takes for half of the radio-isotope to emit its radiation).
Fission – breaking apart. This is what nuclear power-plants do.
Fusion – this is what happens on the sun, and how we made the H-bomb. Takes more energy than fission to make it happen, but the end result is that it produces much more energy.

Energy Quality:

Know this concept. Incandescent bulbs are very inefficient (95% of the energy produced is wasted, eg. In the form of heat). Internal combustion engines (cars) are 90% inefficient. Fuel cell technology is much more efficient, and is just starting to be more used.

Thermodynamics and energy transfer:

1st Law of Thermodynamics:

Energy can not be created or destroyed but can change from one form to another.

(Except nuclear changes)

Energy In = Energy Out

2nd Law of Thermodynamics:

As energy changes from one form to another some of the energy degrades. (Entropy increases in spontaneous reactions)

Higher energy Form Lower Energy Form + Heat

Law of Conservation of Matter

Matter is not created or destroyed it just changes physical form or chemically

*"Nothing gets thrown away"

* The earth is a closed system

Elements, molecules , compounds (mixtures)

Element: pure form of something – the 'periodic table of the elements' organizes these. Examples are gold, copper, hydrogen, carbon (pure form of which is diamond!). Elements important to living systems the 'big 4' = CHON (Carbon, Hydrogen Oxygen, Nitrogen,)

Molecules: are combinations of elements to form compounds

Compounds: combinations of elements and molecules, eg water (H_2O)

Mixtures: combinations of all of the above (more complex). Air is an example of this (air consists of Nitrogen (N_2), oxygen O_2, carbon dioxide (CO_2) and others.

Electrons and stability:
Down to basics: Elements are composed of atoms which have a nucleus and subatomic particles

Electrons have a negative charge (-)
Protons have a positive charge (+)
Neutrons are neutral (no charge)

Atoms seek stability. This is what drives chemical reactions to happen. The arrangement of electrons will always want to be stable. So…two is better than one. A Hydrogen atom has one electron, so it will want to pair with another hydrogen to have two. They will attach via a bond.

After they have attached they are in a combination which we define using a molecular formula. NaCl is the molecular for sodium chloride (salt). Sodium = Na, Chloride = Cl

H_2O is the molecular formula for water. NaCl and H_2O are examples of compounds.

Back to bonds:
1) A covalent bond is one where atoms share electrons (as in the hydrogen example),
2) A hydrogen or Polar bond is one where a molecule is attracted to another because of negative or positively charged *regions* on the molecule. For example in the water molecule, the negatively charge region near the oxygen will attract the positively charged region near the hydrogen. Although this is a weak bond, it has strength in numbers.
3) Ionic bonds: bonding as a result of positive and negative charges (as opposed to regions such as in polar/hydrogen bonds). An example here is sodium (Na^+) which has a net positive charge (eg an extra *proton*) and chloride (Cl^-) which has a net negative charge (eg. An extra *electron*), they come together with a strong bond.

Order of bond strength:
Strongest: Ionic (though covalent can be argued to be equally as strong or stronger in some cases)
Strong: covalent
Least strong: hydrogen/polar (though can be strong if there are lots of them…)

Definition of Organic: anything carbon based. All life is carbon based. Most organic molecules can be characterized as having Carbon-Hydrogen bonds, such as the large biological macromolecules: Lipids, Carbohydrates, Nucleic acids and Proteins.

Chemical reactions:
These result in a change in the chemical composition of elements, compounds or mixtures. A chemical reaction requires *activation energy*.
Activation energy is the energy required to move the reaction forward. This energy 'excites' or bumps electrons around to make them less stable and more reactive. If the energy is not sufficient to cause a reaction, the electrons will *settle back down.* If the energy is sufficient, the electrons *will rearrange, and new bonds will be formed* (with old ones broken). This is a *chemical reaction.*

Two examples of very important reactions:

Photosynthesis: sunlight is the energy. Plants do this
Energy =
CO_2 (Carbon Dioxide) + H_2O (water)----- Sugars/carbohydrates + O_2 (oxygen) + heat

Plants provide us with oxygen this way! (as well as energy in the form of starch and carbos)

Respiration: Plants and animals do this. It's the opposite of photosynthesis
Animals and plants have to 'make' energy to fuel this (eg. For you biologists, ATP)

Sugars/carbohydrates + O_2 (oxygen) ------ CO_2 (Carbon Dioxide) + H_2O (water) + heat

Some organisms (such as some bacteria) use *chemosynthesis*, which is instead of sunlight, they use chemicals such as sulfer to fuel chemical reactions. An example is some organisms in the deep sea.

WATER Solid state is less dense than liquid! (structure of ice)

- excellent solvent
- high freezing pt and less dense solid (ice)
- high specific heat capacity – doesn't change temperature quickly
- high thermal conductivity (conducts heat well)
- high boiling point
- good evaporative coolant

As water cools (like anything else) it becomes more dense. Unlike most other substances, when it cools enough to reach its solid state, it becomes less dense, and thus floats.

Cooling water on the surface of the ocean sinks as it becomes more dense. This drives deep ocean circulation-an important process.