A. Acidic Precipitation

1. Why "Clean Rain" is Acidic

- If instead of chasing Eve (or Adam) in the garden of Eden, you had decided to measure the pH of rain, it would still be acidic. That's because even without pollution, carbon dioxide dissolves in rainwater to produce the weak acid *carbonic acid* = H_2CO_3. This gives clean rain water a pH of 5.6.
- Another natural process that can add acids to the air is a volcanic eruption

2. So What is Acidic Precipitation?

Acidic precipitation is any form of precipitation (rain, snow, sleet, hail etc) with a pH less than 5.6. The main acids introduced by human activity are sulfuric (H_2SO_4) and nitric (HNO_3) acids.

3. What Causes Acid Rain?

About 60% is caused by the combustion of sulfur-containing fuels or by roasting sulfur-containing ores (Ores are impure metal compounds such as Cu_2S that can be purified to produce far more useful Cu). When this happens, sulfur reacts with oxygen to produce SO_2.
Then SO_2 reacts with an impurity in the atmosphere (the neutral but reactive hydroxyl radical = OH ; not hydroxide which is OH^{-1}) to produce acid

$SO_2 + 2\ OH \rightarrow H_2SO_4$

The rest results from the high temperature combustion of fuel within car and truck engines. Here the air itself reacts to produce NO_2 which goes on to react with the hydroxyl radical to produce another acid:

$NO_2 + OH \rightarrow HNO_3$

4. Acidic Precipitation's Impact on Health and the Environment

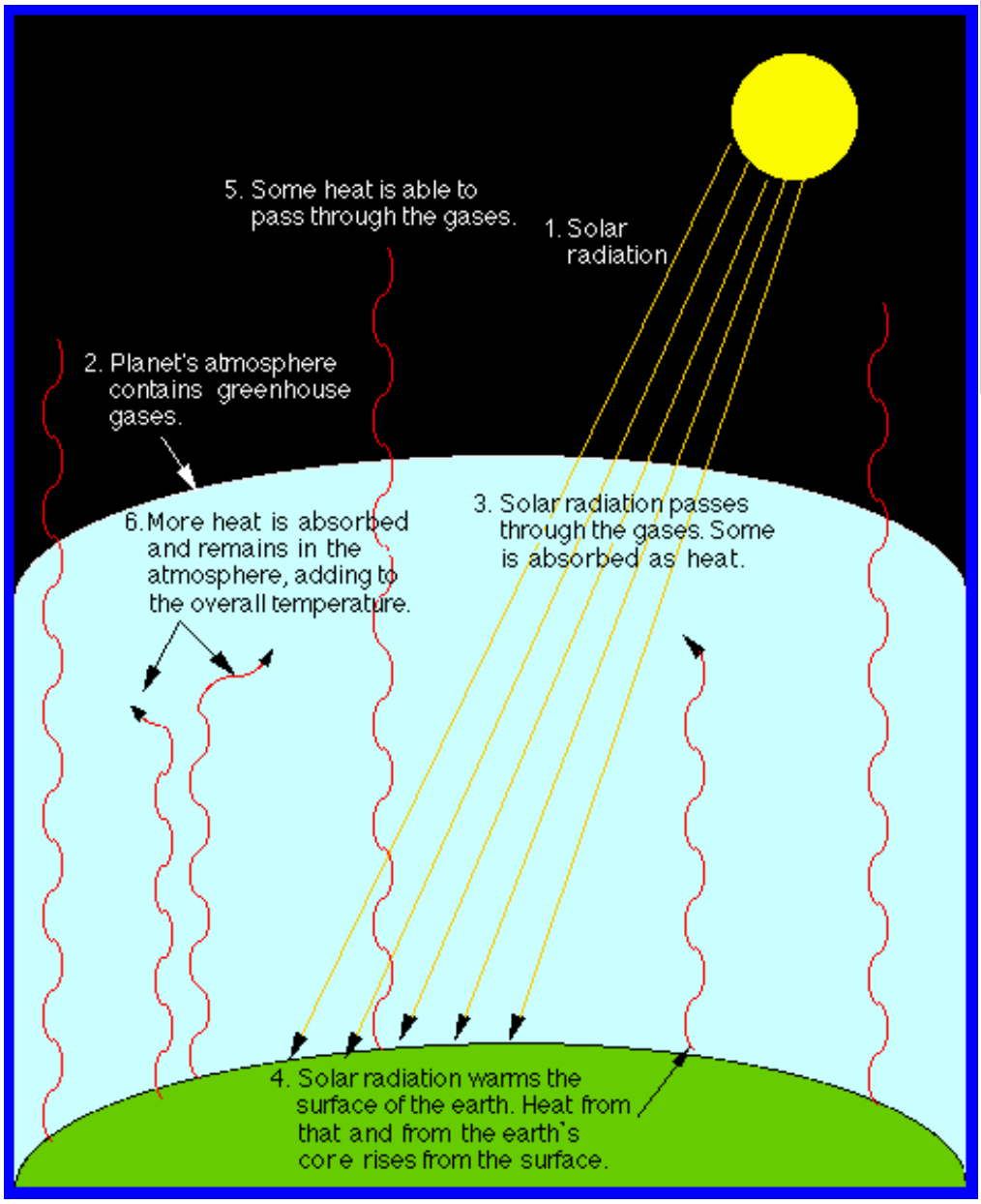
- Forests: These get damaged by acidic precipitation, especially if they are at higher altitudes.
- Where there is no carbonate in nearby soil to neutralize acid rain, acid kills sensitive fish species and changes the distribution of plankton(floating microscopic life forms)
- What man-made structures are destroyed by acid? Acid attacks marble, limestone, cement and metal.
- People with respiratory diseases (asthma, pneumonia, emphysema) are more likely to get serious attacks or die when there is a high level of acid in the air.

5. What Can Be Done to Solve the Problem

- Transportation: More people should rely on public transport and foot power. There should be more govt. encouragement of alternate fuel sources such as fuel cells.
- Filters(scrubbers): The latest available technology should filter sulfur from industrial sources.

B. Global Warming

1. What is the *greenhouse effect?*



The process,which is vital for life on earth (without it it would be too cold) is somewhat similar to what happens in a greenhouse. The glass in a greenhouse and the gases in the atmosphere both allow visible light to warm up the ground or earth, respectively, and they trap the heat that tries to escape.

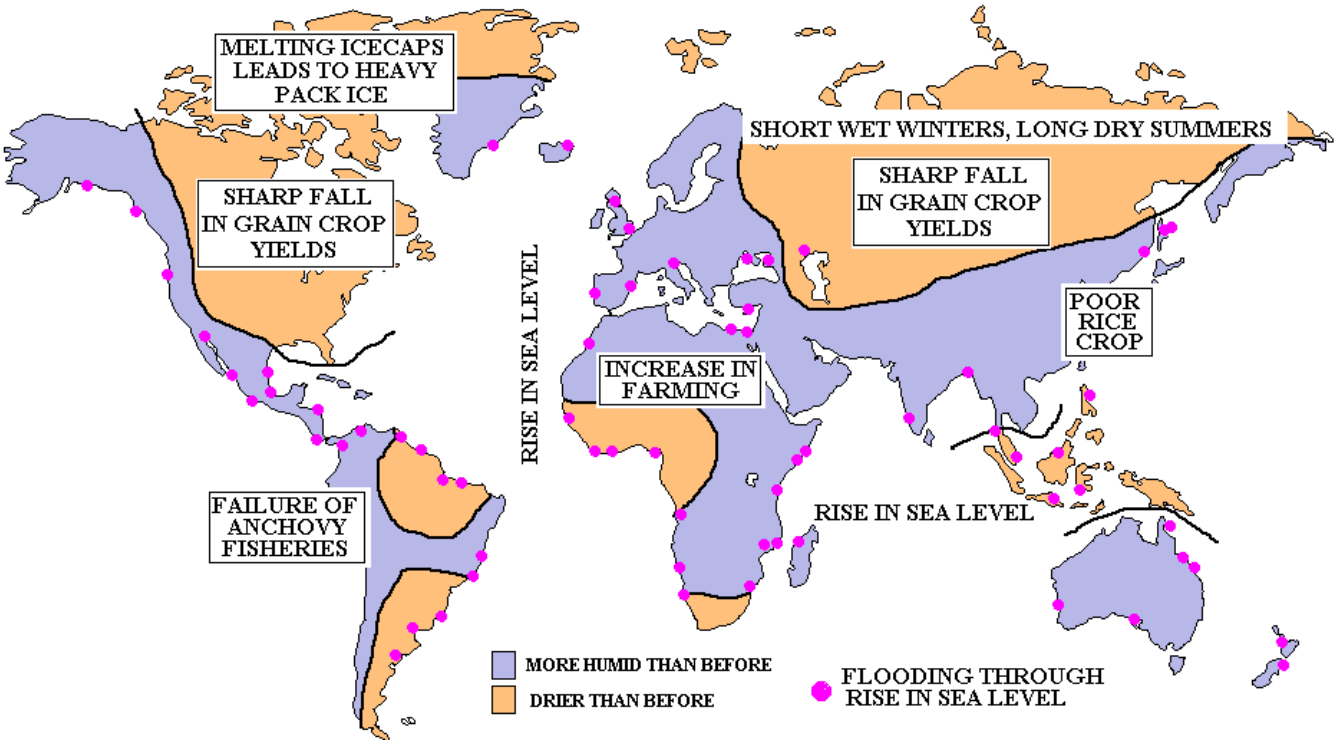
2. What gases cause the greenhouse effect or global warming?

1. CO_2
2. CH_4
3. CFC's
4. N_2O
5. H_2O* (although it is the most powerful greenhouse gas, human activities don't increase the already large amount in the atmosphere significantly)

3. Where do those gases come from?

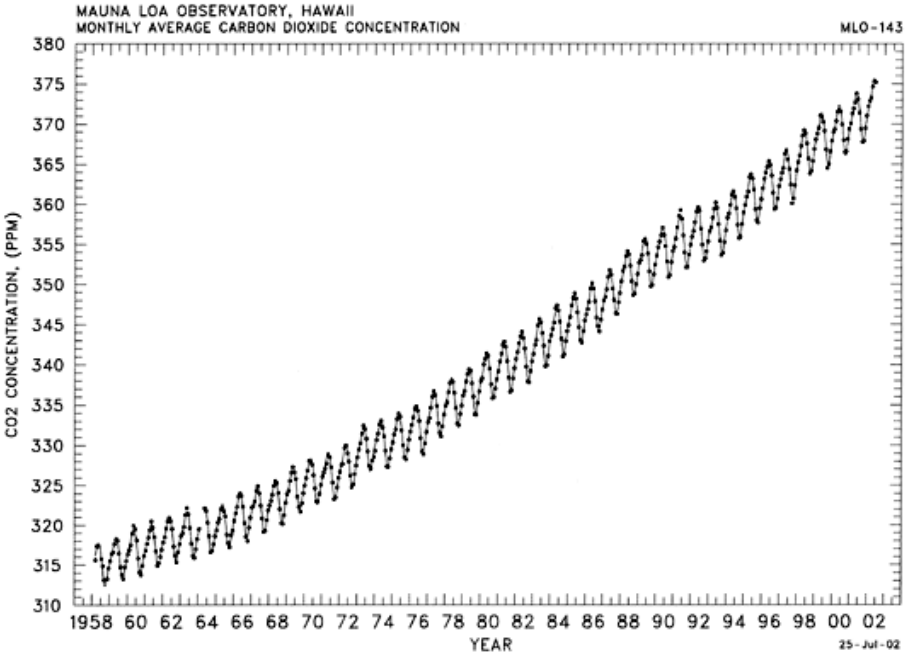
CO_2 is released mainly by combustion of fossil fuels. These make the most significant contribution to global warming. Methane comes from farming, landfills and mining coal.

4. What are the consequences of global warming? The actual effects of global warming are difficult to predict, but whatever the exact outcome is, the consensus is that it will have a serious impact on our lives and economies. See map

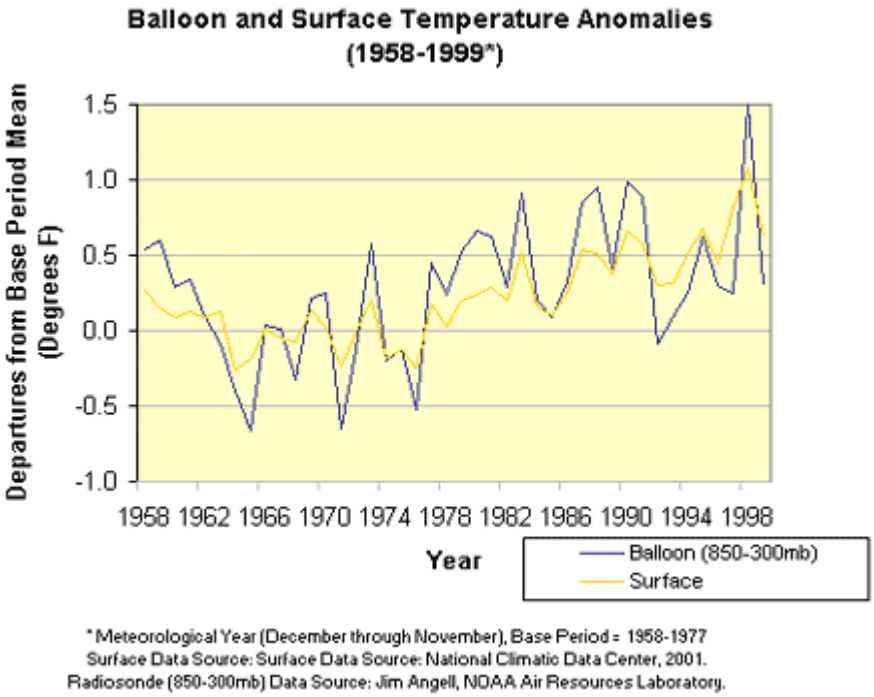


5. What evidence do we have for global warming?

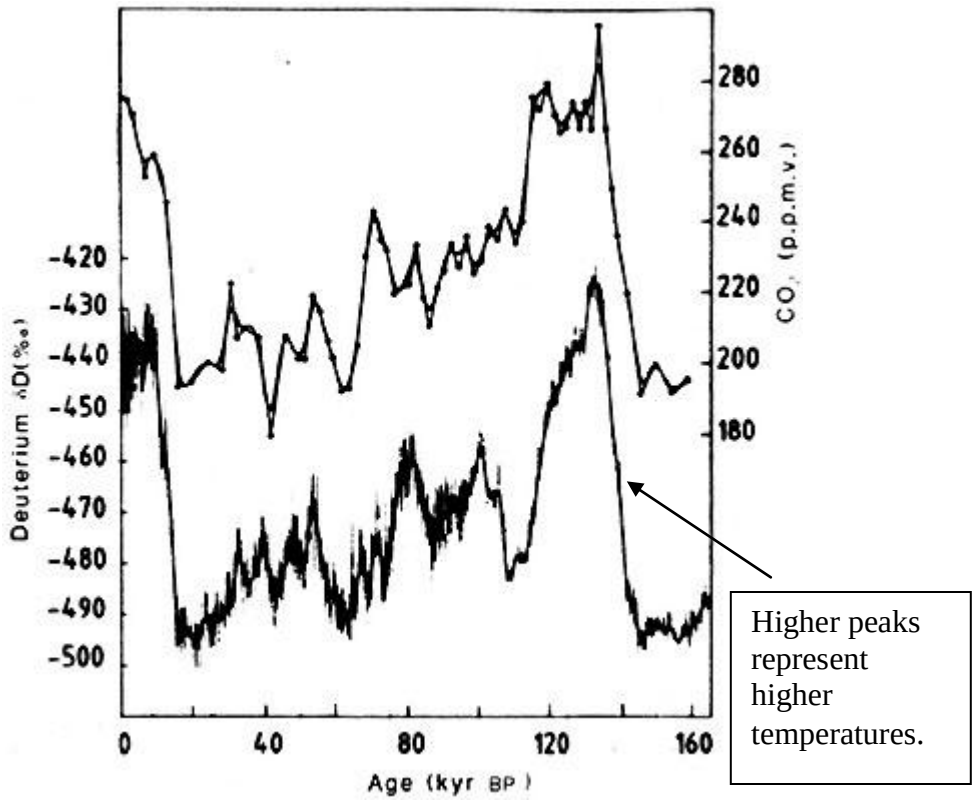
For this century and using isotopes for past centuries, we have been measuring both CO_2 levels and temperatures and both have been increasing in harmony, as shown by graphs 2 and 3.



See below for temperature graph.



But perhaps this is a coincidence. What makes a stronger connection between CO_2 levels and temperature is the historical record. By analyzing ice that has been around for a half million years we can measure CO_2 levels of the distant past. In addition O-18 to O-16 isotope ratios or H-2 to H-1 ratios give us an idea of temperature. The following data from Antarctica reveals that temperatures and CO_2 levels vary hand in hand.

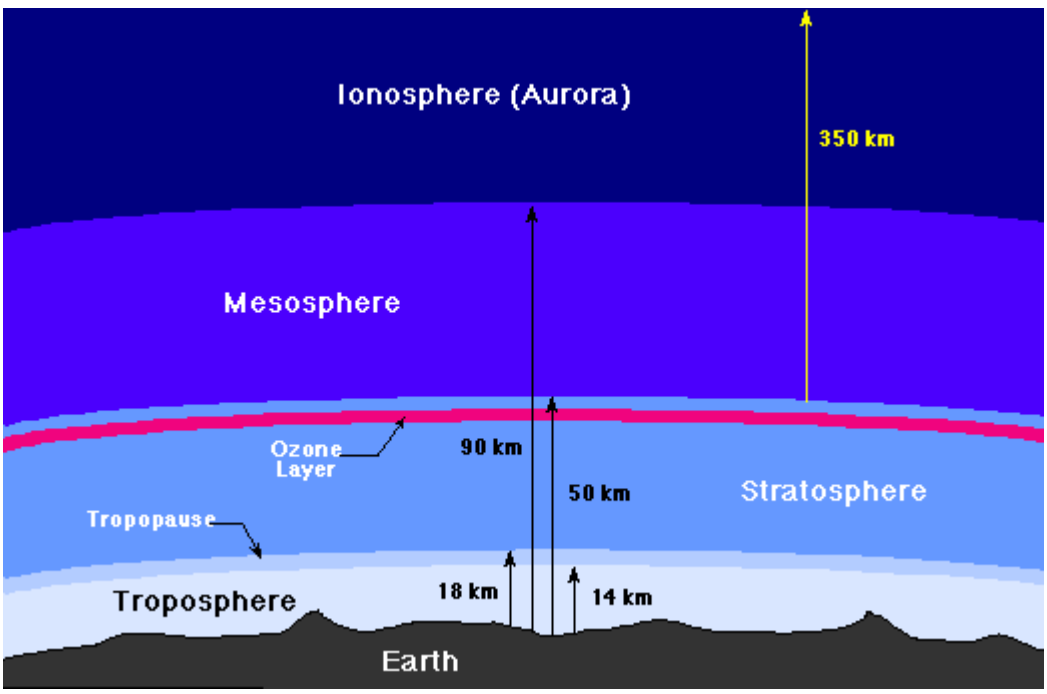


6. How do we fix the problem?

- We need filters for CO_2.
- Control population
- Conserve energy.

C. Ozone Depletion

1. What is ozone? Where is it found? Ozone is a form of oxygen, O_3. It can be found at ground level as a pollutant, but we want the ozone that is naturally produced high up in the stratosphere, about 50 km above the surface of the earth.



2. Why do we need an ozone layer?

Ozone absorbs harmful ultraviolet radiation from the sun and converts it into harmless heat:

O_3 + uv--> O_2 + O + heat

3. What man-made chemicals threaten the ozone layer? Why?

CFC's, which are found in older air conditioners and refrigerators, release Cl in the stratosphere. Then:

$Cl + O_3 \rightarrow ClO + O_2$
$ClO + O \rightarrow O_2 + Cl$

Notice how the Cl is recycled and free to attack more ozone.

4. What are the effects of a thinner ozone layer?

   This will result in more skin cancer cases, especially among fair-skinned people. It also has an impact on nature, as many plants and animals are also sensitive to UV.

5. How do we fix the problem?

   Maintain the ban of CFC's and avoid any illegally produced CFC.

D. Other Forms of Pollution

Pollution Source	**Ecosystem Affected**	**Specific Pollutant**	**Disease Caused**	**How?**
nuclear power plants	soil, water and air pollution	radioactive waste	cancer	radiation attacks DNA
industrial waste, batteries, treated wood	soil, water pollution	Pb(lead), Hg(mercury), As(arsenic), Cd(cadmium)	• Pb and Hg attack brain. • Arsenic is carcinogenic (cancer-causing) • Cadmium damages kidneys	unknown

Exercise

I *Acidic Precipitation*

1. Even clean rain is still a bit on the acidic side because of the presence of what gas in the atmosphere?

2. a. What pollutant causes HNO_3 to appear in rain?
   b. What pollutant causes H_2SO_4 to appear in rain?

3. a. How does burning coal and roasting metal ores lead to the formation of acidic precipitation?
b. How do cars, trucks and airplanes contribute to acidic precipitation?

4. How does acidic precipitation have an impact on…(don't be too brief!)

a. people's health?
b. our cities?
c. our lakes?
d. our forests?

II *Global Warming*

5. a. List the two main gases that cause global warming.
b. What human activities release these gases in large quantities?

6. Use 2 diagrams to explain what is meant by the greenhouse effect.

- The first diagram should include a sketch of the earth and the gases that cause global warming.
- The second diagram should include a diagram showing how an actual glass greenhouse traps heat.
- Then include a written explanation of what you've drawn.

7. What evidence do we have for global warming? Mention data from both the recent and distant past.

8. How is global warming a threat to society?

III The Ozone Problem

9. Fill in the blanks.

a. Ozone is actually formed from the common gas _____
b. The stratosphere is where harmful _____is/are converted into heat.
c. Older refrigerators, air conditioners, and freezers are a source of _____.
d. The atom from CFC's that actually destroys ozone is _____.
e. A disease that results from overexposure to UV is _____.

10. Why is there an ozone hole over Antarctica but much less thinning of the ozone over warmer areas?
What can be done to save the ozone?

IV *Miscellaneous Forms of Pollution(see chart on p118)*

11. What two metals can attack the brain and the nervous system?

12. What waste product from nuclear power plants is carcinogenic (cancer-causing)?

13. *From class notes*: What is the connection between acid rain and arsenic in treated wood?

V *Mixed Bag of Questions*

14. Match the chemical or technology with the associated environmental problem. For some letters, more than one number is necessary.

a. CO_2 _____
b. SO_2 _____
c. CFC's _____
d. CH_4 _____
e. NO_2 _____
f. Cl _____
g. Hg _____
h. deforestation_____
i.

_____
j. cattle ranches_____

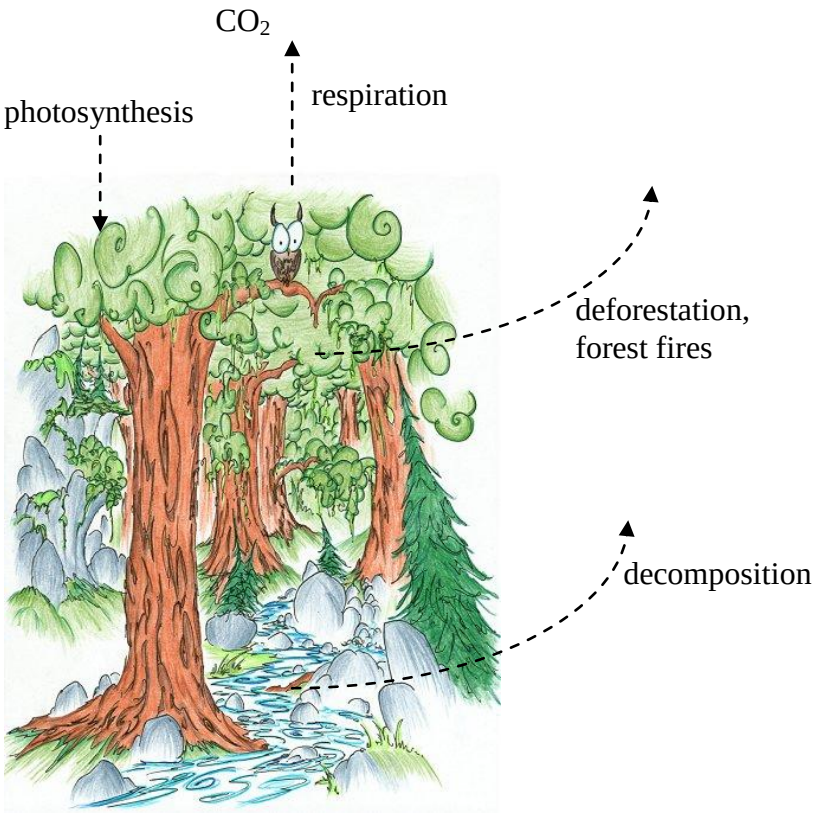
1. Acid rain
2. Global warming
3. Ozone depletion
4. Soil and water pollution

E. <u>The Carbon Cycle</u>

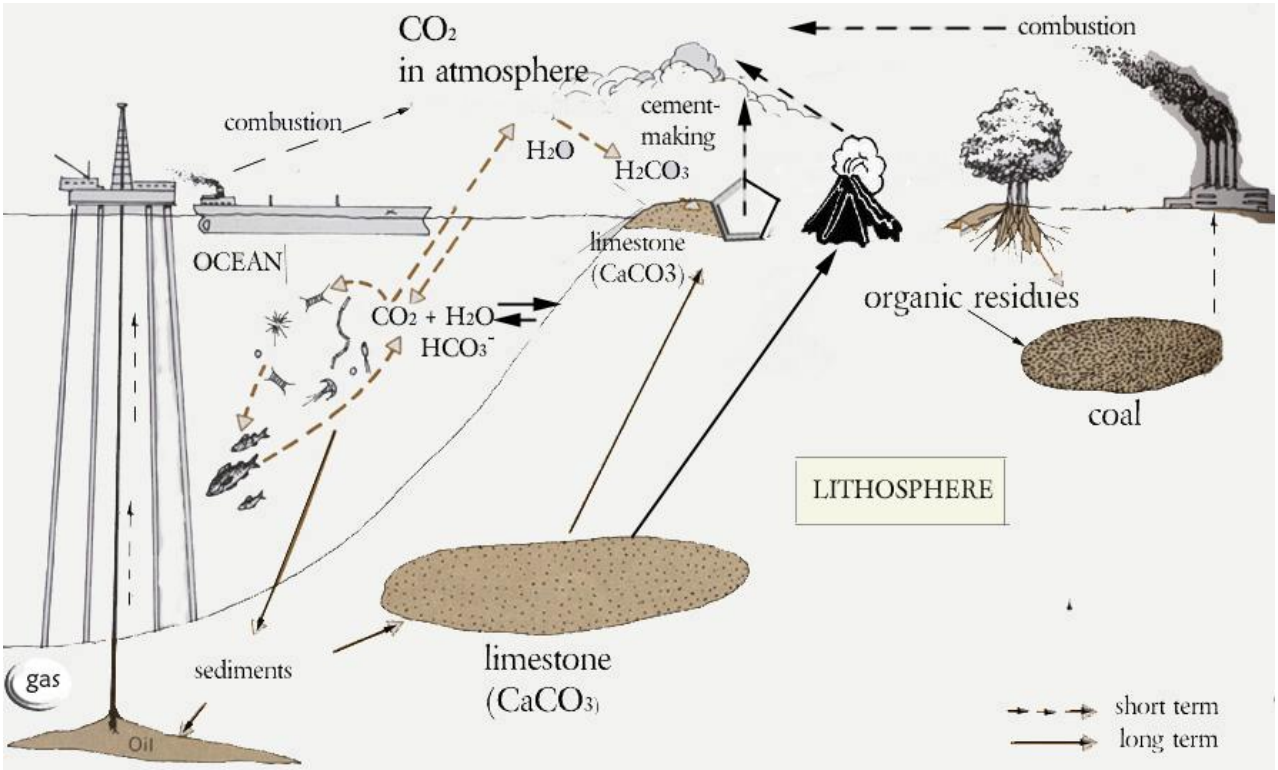
<u>The Carbon Cycle and the Biosphere</u>

Removal of CO_2 from atmosphere	Addition of CO_2 to atmosphere
• Photosynthesis begins the storage process by converting CO_2 into sugars. • reforestation	• Respiration and fermentation, processes that break down molecules to release useful energy return CO_2 to the atmosphere. • Decomposition of dead matter return CO_2 to the atmosphere • Deforestation and forest fires also pump CO_2 into the atmosphere.

All of the following exchanges occur on a short–term scale. (daily or seasonal)



(2) <u>The Carbon Cycle,the Lithosphere and the Ocean</u>



Example 1:

a) The diagram shows four processes that remove carbon from the lithosphere or ocean and add it to the atmosphere as carbon dioxide. List them. Then make the table complete by adding three more sources of CO_2 from the biosphere.

Process adding CO_2 to atmosphere
a)
b)From biosphere:

Example 2:

What two natural processes shown above remove CO_2 from the atmosphere? Then make the table complete by adding processes that remove CO_2 , one of which is shown in the biosphere-diagram.

Process removing CO_2 from the atmosphere
a)
b)From biosphere:

Exercises

1. a) List 3 ways by which humans add carbon dioxide to the atmosphere.

   b) In each case, list what can be done do reduce the amount of CO_2 emitted.

2. What processes added CO_2 to atmosphere, even when there were no human beings around?

3. Recall that the amount of carbon dioxide in the atmosphere has, for millions of years, been proportional to the average temperature on earth. How does life in general play a major role in acting like a thermostat, in that it regulates the temperature of the planet?

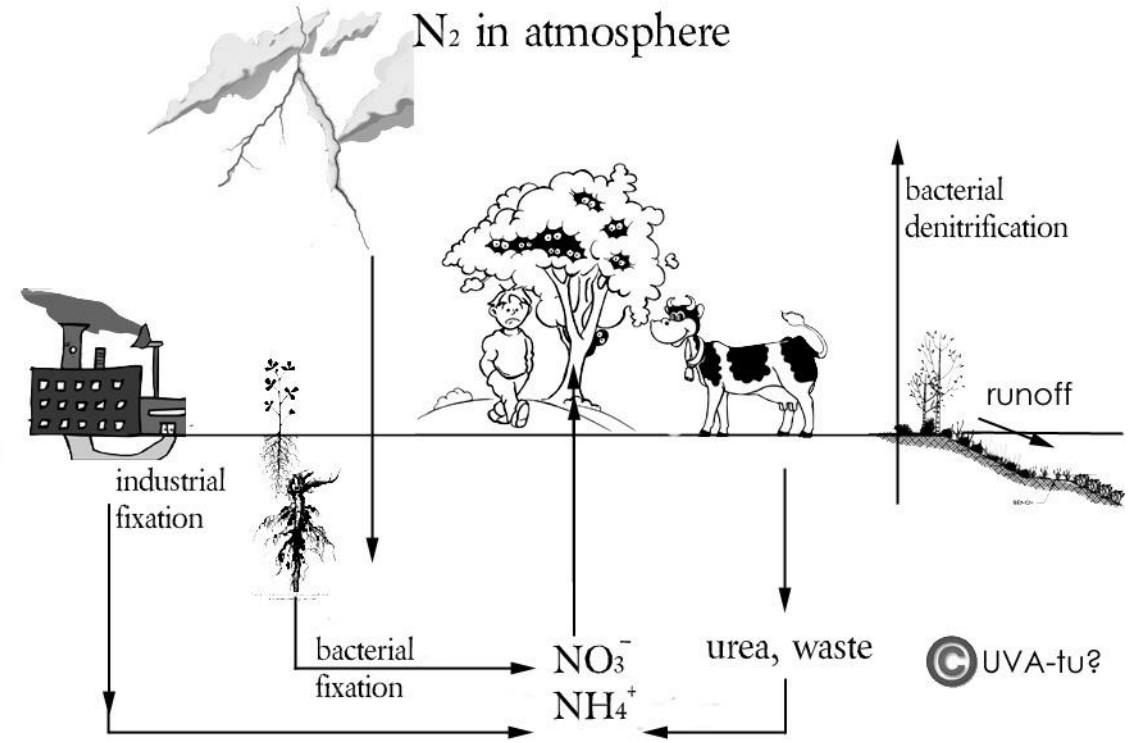
4. What forest industry activity helps ***remove*** carbon dioxide from the atmosphere?

5. Why does CO_2 accumulate in the atmosphere? Doesn't the excess amount get absorbed by the oceans and eventually get converted to limestone and petroleum?

6. Why does the combustion of fossil fuels release CO_2? (What do fossil fuels contain?)

7. Why does cement production release carbon dioxide? (Cement is made from $CaCO_3$)

E. **The Nitrogen Cycle**



Example 1: What three natural processes add nitrates to the soil either by oxidizing nitrogen from the atmosphere or by producing a compound which bacteria later convert into nitrates?	**Sources of Nitrates** 1. 2. 3.
Example 2: The diagram shows two natural chemical processes that remove nitrogen from the soil. (1) The first process relies on bacteria that first convert nitrates(NO_3^-) into atmospheric nitrogen(N_2). (2) Secondly, what organisms rely on ammonium(NH_4^+) and nitrates to produce amino acids and eventually proteins? (3) What *physical* process removes nitrates from the soil?	**How Nitrates are Removed from the Soil** 1. 2. 3.

Exercises

1. List two human activities that add nitrates or ammonium to the soil.

2. List two non-human activities that add nitrates or ammonium to the soil.

3. List three non-human activities that remove nitrates or ammonium from the soil.

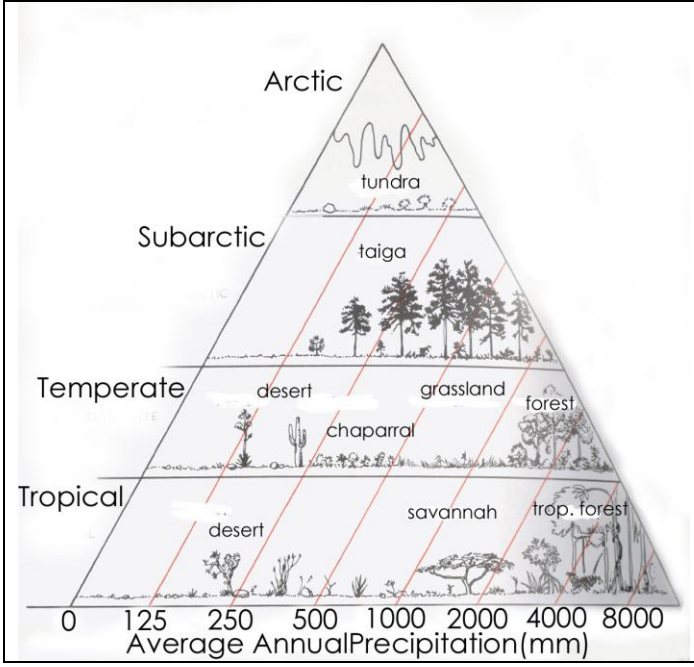
4. Why do plants need nitrates and ammonium?

5. Animals continuously excrete urea, which contains nitrogen. Animals do not eat fertilizer, so where do they get their nitrogen?

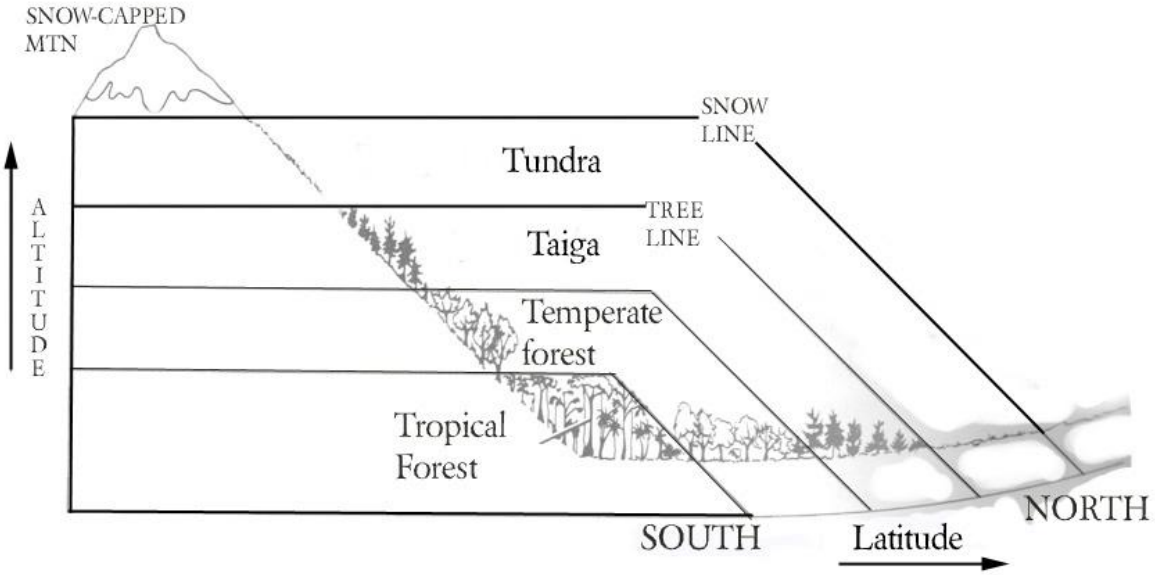
6. When industry creates fertilizer, they not only participate in the nitrogen cycle but also make an undesirable contribution to the carbon cycle. How?

F. Biomes

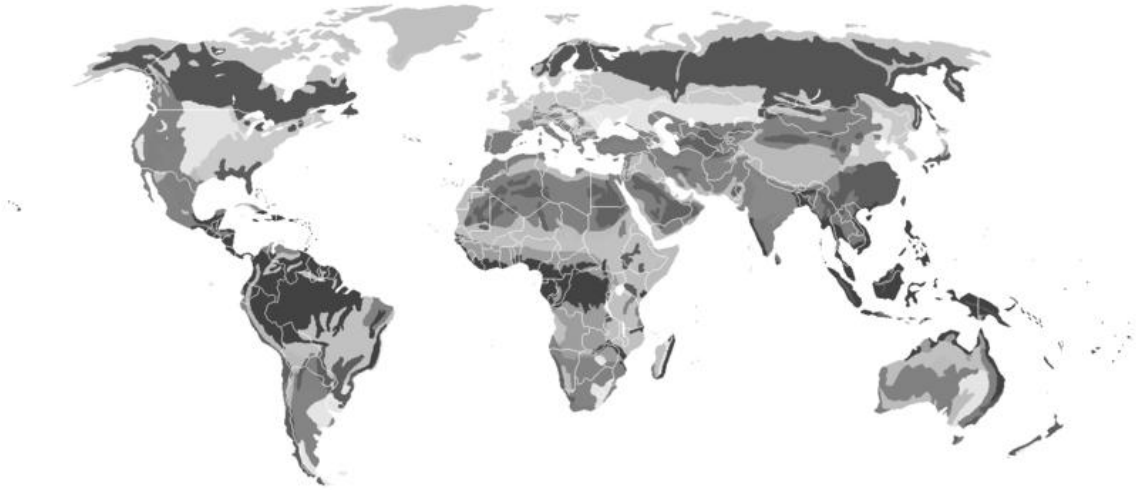
Definition: categories of characteristic plant life found in different regions on earth.



List Earth's 8 terrestrial biomes



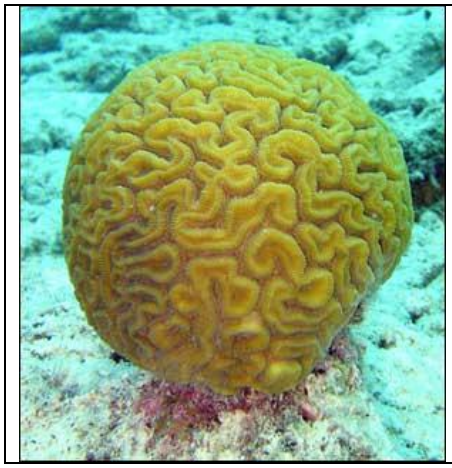
From examining the above 2 diagrams, what factors are responsible for creating biomes?



Marine Biomes

The marine regions are divided between **coral reefs**, **estuaries**, and **oceans**. Oceans represent the largest and most diverse of the ecosystems; salt water evaporates and turns to rain which falls on the land regions, while most of the oxygen in our atmosphere is generated by algae. Algae is also responsible for the absorption of large amounts of carbon dioxide from our atmosphere.

Coral reefs Coral reefs are found around the globe in warm waters. Corals cannot stand temperatures that drop much below an average temperature of 18°C. This limits their habitat to waters between 23°N and 23°S latitude. But, while latitude is important, so too is the current. The essence of what makes the coral reef work is the presence of of a unique symbiosis with unicellular algae called zooxanthellae. These zooxanthellae help the coral by giving the coral the by-products of their photosynthetic activity. Corals help the zooxanthellae by providing them with an environment to live.



Estuaries An estuary is a partially enclosed body of water formed where freshwater from rivers and streams flows into the ocean, mixing with the salty sea water. Estuaries and the lands surrounding them are places of transition from land to sea, and from fresh to salt water.

Oceans represent the largest and most diverse of the ecosystems; salt water evaporates and turns to rain which falls on the land regions, while most of the oxygen in our atmosphere is generated by algae. Algae is also responsible for the absorption of large amounts of carbon dioxide from our atmosphere.

Examples:

a) Why can't a coral grow in an estuary?

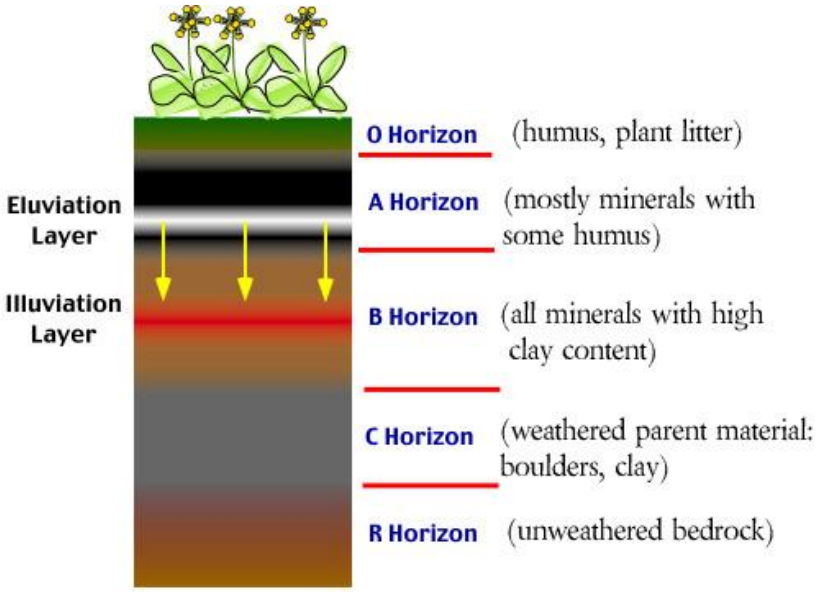
b) Can there be coral off the coast of Newfoundland?

c) Algae growing several miles from the coastline may not be able to survive in an estuary? Why not?

d) Coral reef bleaching, the whitening of corals, results from the loss of symbiotic zooxantheallae and/or a reduction in photosynthetic pigment concentrations in zooxanthellae. What human activites can possibly cause this?

Soil Profiles

Most **soils** have a distinct **profile** or sequence of horizontal layers. Generally, these horizons result from the processes of (1)chemical weathering, (2)**eluviation**(The lateral or downward movement of dissolved or suspended material within soil when rainfall exceeds evaporation.), (3)**illuviation**(The deposition of colloids, soluble salts, and suspended mineral particles in a lower soil horizon through the process of eluviation (downward movement) from an upper soil horizon.) and (4)**organic** decomposition.) Up to five layers can be present in a typical soil: **O**, **A**, **B**, **C**, and **R horizons**



The **O horizon** is the topmost layer of most soils. It is composed mainly of plant **litter** at various levels of decomposition and **humus**.

A horizon is found below the O layer. This layer is composed primarily of **mineral** particles. which has two characteristics: it is the layer in which humus and other organic materials are mixed with mineral particles, and it is a zone of translocation from which eluviation has removed finer particles and soluble substances, both of which may be deposited at a lower layer. Thus the A horizon is dark in color and usually light in texture and porous. The A horizon is commonly differentiated into a darker upper horizon or organic accumulation, and a lower horizon showing loss of material by eluviation.

The **B horizon** is a mineral soil layer which is strongly influenced by **illuviation**. Consequently, this layer receives material eluviated from the A horizon. The B horizon also has a higher bulk density than the A horizon due to its enrichment of clay particles. The B horizon may be colored by oxides of iron and aluminum or by calcium carbonate illuviated from the A horizon.

The **C horizon** is composed of **weathered** parent material. The texture of this material can be quite variable with particles ranging in size from clay to boulders. The C horizon has also not been significantly influenced by the **soil-forming** processes, translocation, and/or organic modification.

The final layer in a typical soil profile is called the **R horizon**. This soil layer simply consists of unweathered bedrock.

PERIODIC TABLE OF THE ELEMENTS

Key

Atomic number	Element Symbol	Atomic Mass
1	H	1.01

	IA 1	II A 2	III B 3	IV B 4	V B 5	VI B 6	VII B 7	VIII 8	VIII 9	VIII 10	I B 11	II B 12	III A 13	IV A 14	V A 15	VI A 16	VII A 17	VIII A 18
1	1 H 1.01																	2 He 4.00
2	3 Li 6.94	4 Be 9.01											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
3	11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
4	19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.90	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.71	29 Cu 63.55	30 Zn 65.39	31 Ga 69.72	32 Ge 72.59	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
5	37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc 98.91	44 Ru 101.07	45 Rh 102.91	46 Pd 106.40	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.75	52 Te 127.60	53 I 126.90	54 Xe 131.30
6	55 Cs 132.91	56 Ba 137.33	57-71 La-Lu	72 Hf 178.49	73 Ta 180.95	74 W 183.85	75 Re 186.21	76 Os 190.20	77 Ir 192.22	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
7	87 Fr (223)	88 Ra (226)	89-103 Ac-Lr	104 Rf (261)	105 Ha (262)													

6	57 La 138.91	58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm 145	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
7	89 Ac 227.03	90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np 237.05	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (254)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (260)