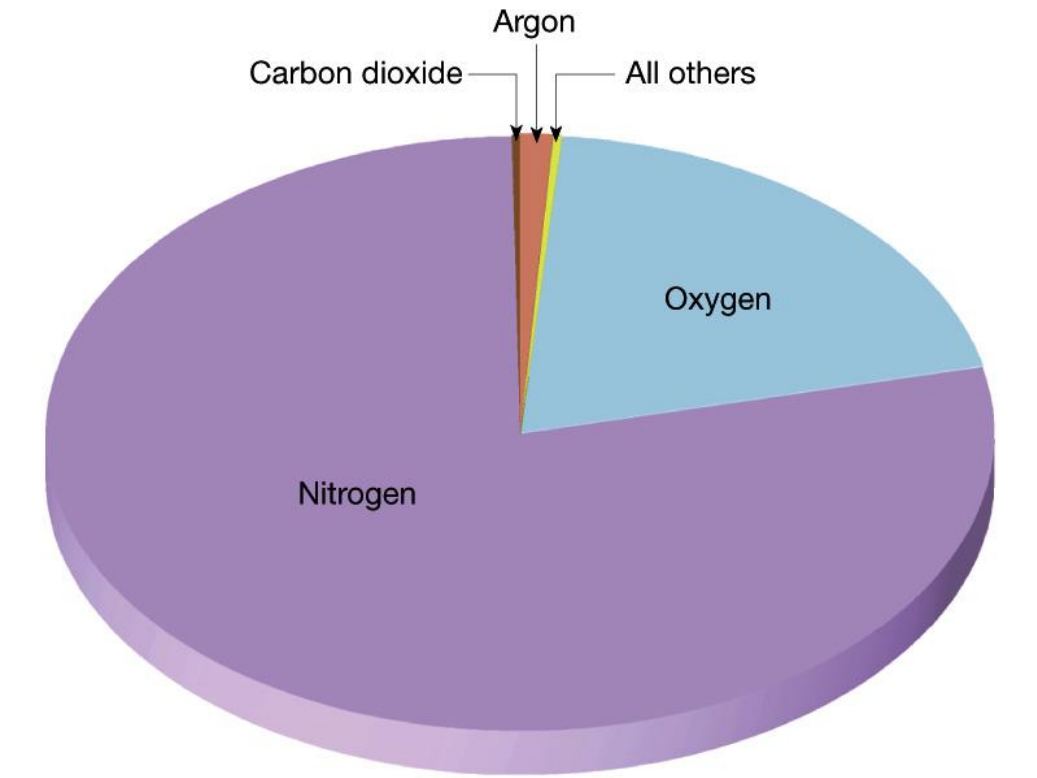
Earth's Atmosphere

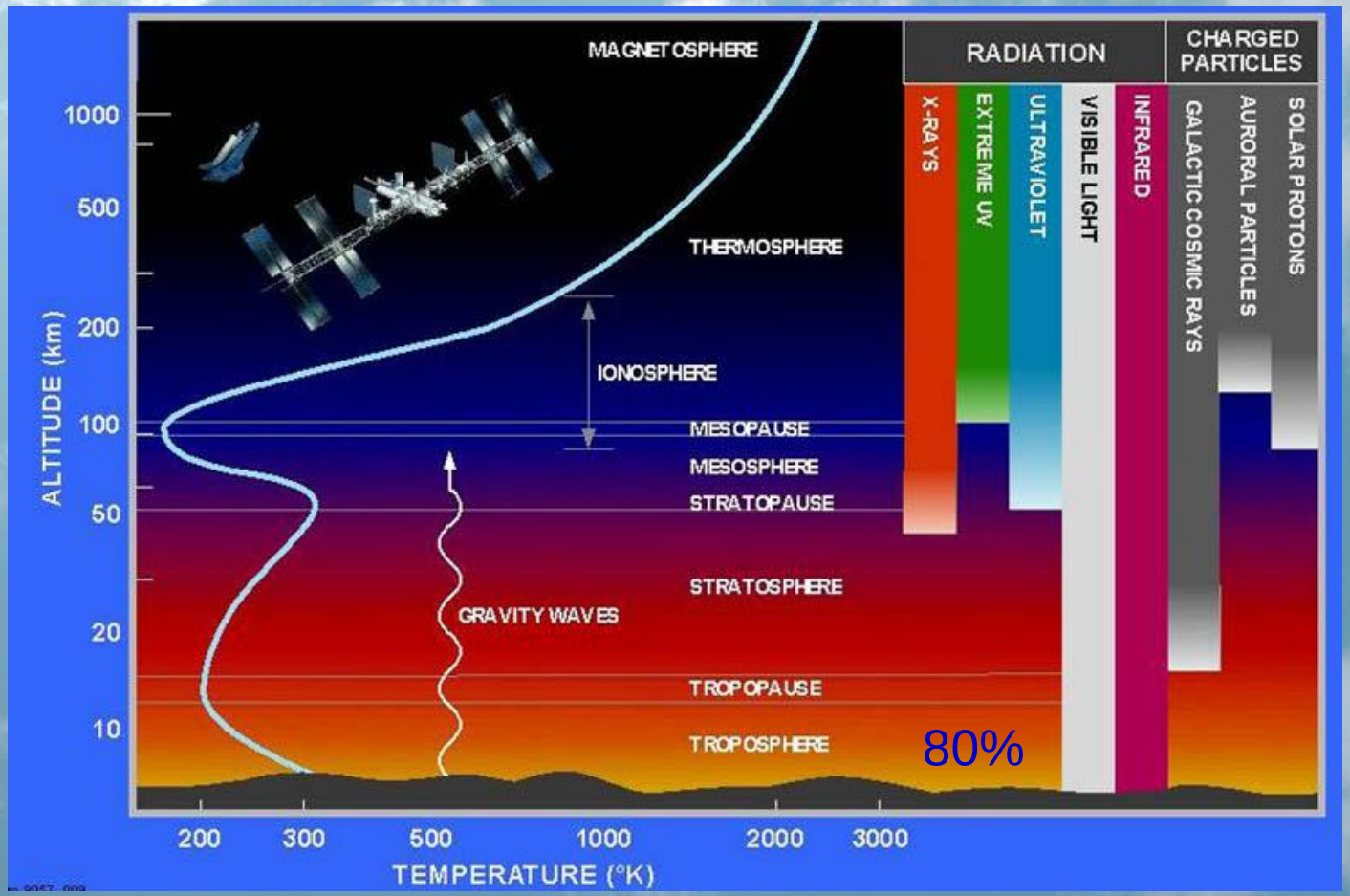
Earth's Present Atmosphere



http://www.ux1.eiu.edu/~cfjps/1400/FIG01_010.JPG

- Nitrogen 78.1%
- Oxygen 20.9%
- Argon 0.9%
- Carbon Dioxide 0.035%
- Water 0 - 4%

Layers of the Atmosphere



Comparison of Terrestrial Planet Atmospheres

Atmospheric Gases

Earth		Venus		Mars		Jupiter	Saturn	Uranus	Neptune
N_2	78%	CO_2	96%	CO_2	95%	H_2	H_2	H_2	H_2
O_2	21%	N_2	3%	N_2	3%	He	He	CH_4	He
Ar	0.9%	H_2O	0.1%	Ar	1.6%	CH_4	etc.	He?	CH_4?
CO_2	0.03%	Ar	0.01%	O_2	0.1%	NH_3			
H_2O	0-3%	O_2	0.01%	H_2O	0.03%	Ne			

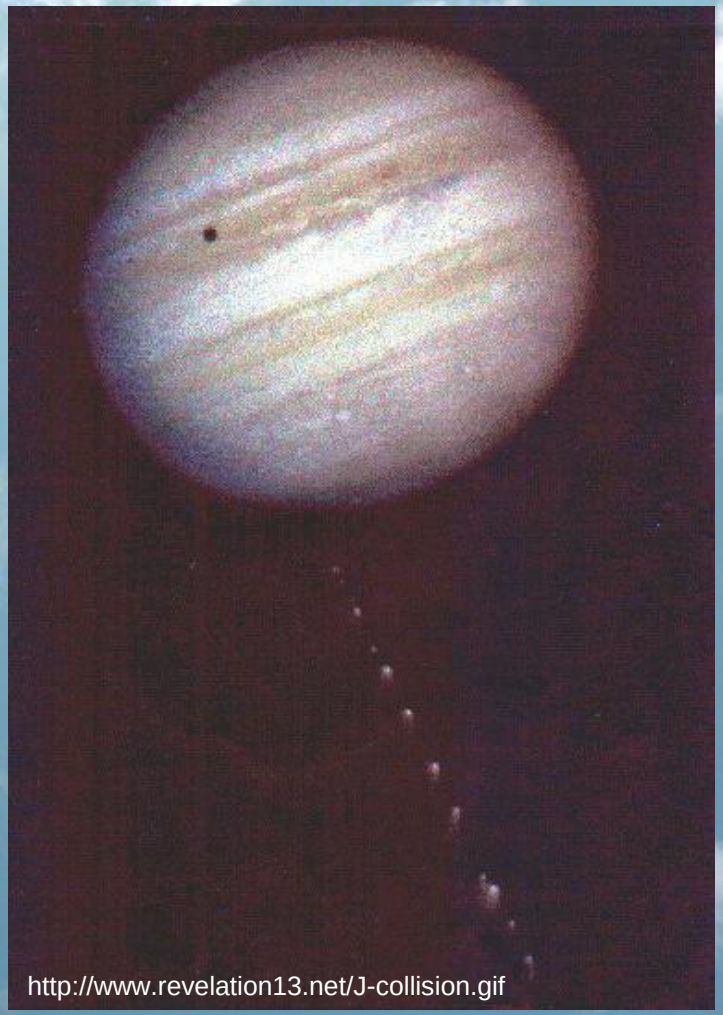
traces	volcanoes	meteorites
O_3	H_2O	CO_2
Ne	CO_2	CO
He	SO_2	H_2
Kr	N_2	N_2
Xe	SO_3	SO_2
H_2	CO	CH_4
CH_4	H_2	N_2O
	Ar	CS_2
	Cl_2	*organic compounds*

Sources:

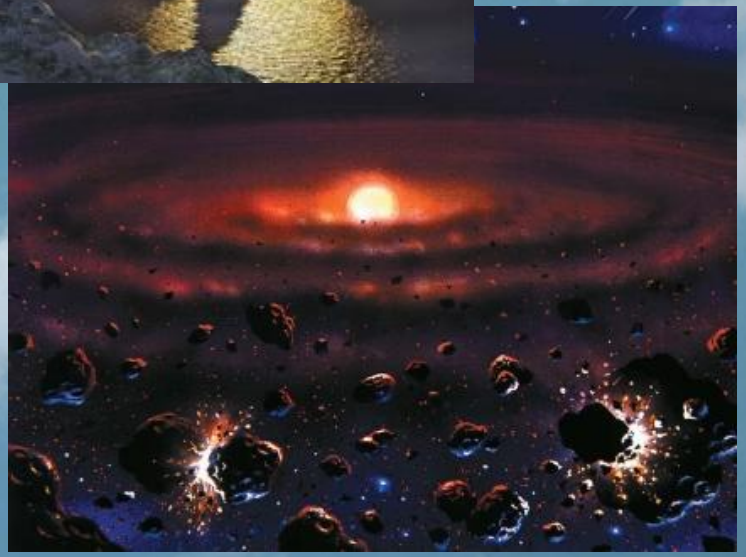
Dott and Prothero, 2004 (Earth, meteorites, volcanoes)
Danielson, Levin, Abrams (1998 (Earth, Venus, Mars)
Levin, 1996 (Jupiter, Saturn, Uranus, Neptune)

Cometary Collisions

www.msnbc.msn.com/id/29656682/

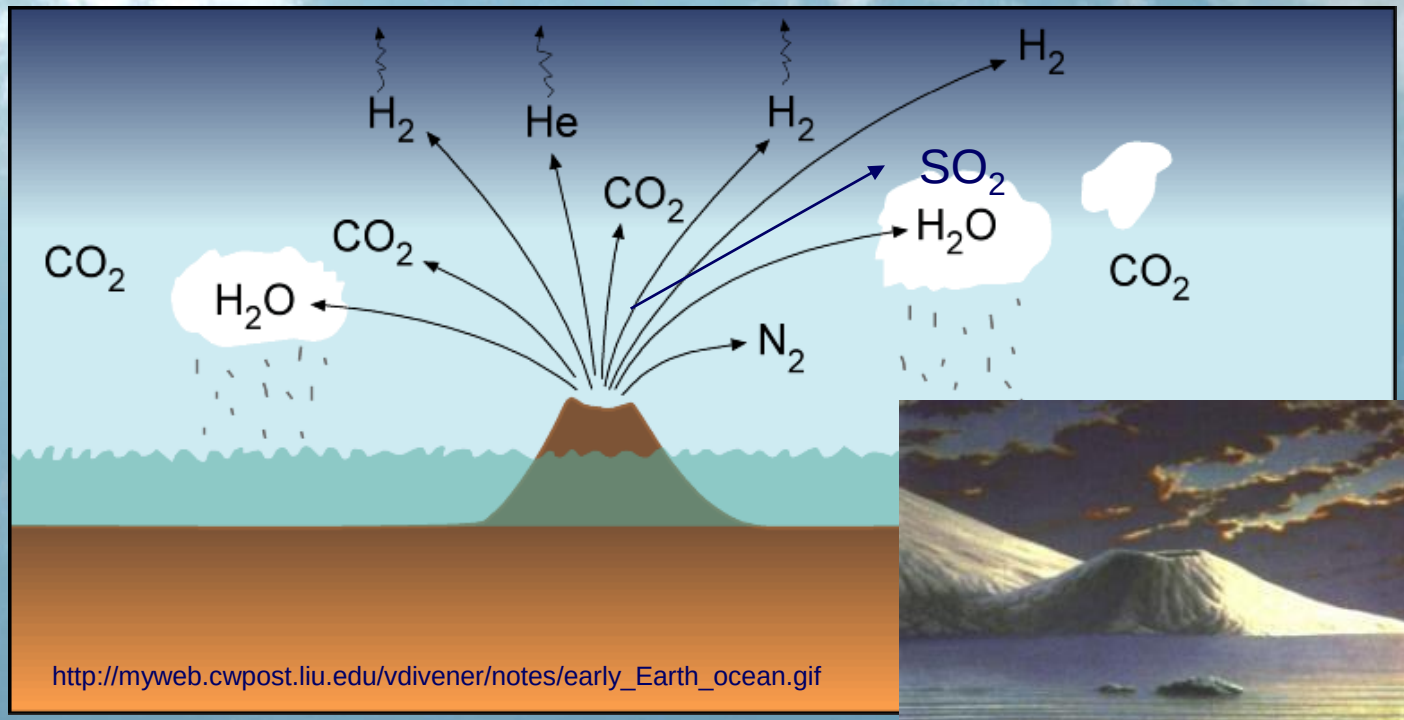


http://www.revelation13.net/J-collision.gif



http://www.scienceclarified.com/images/uesc_09_img0528.jpg

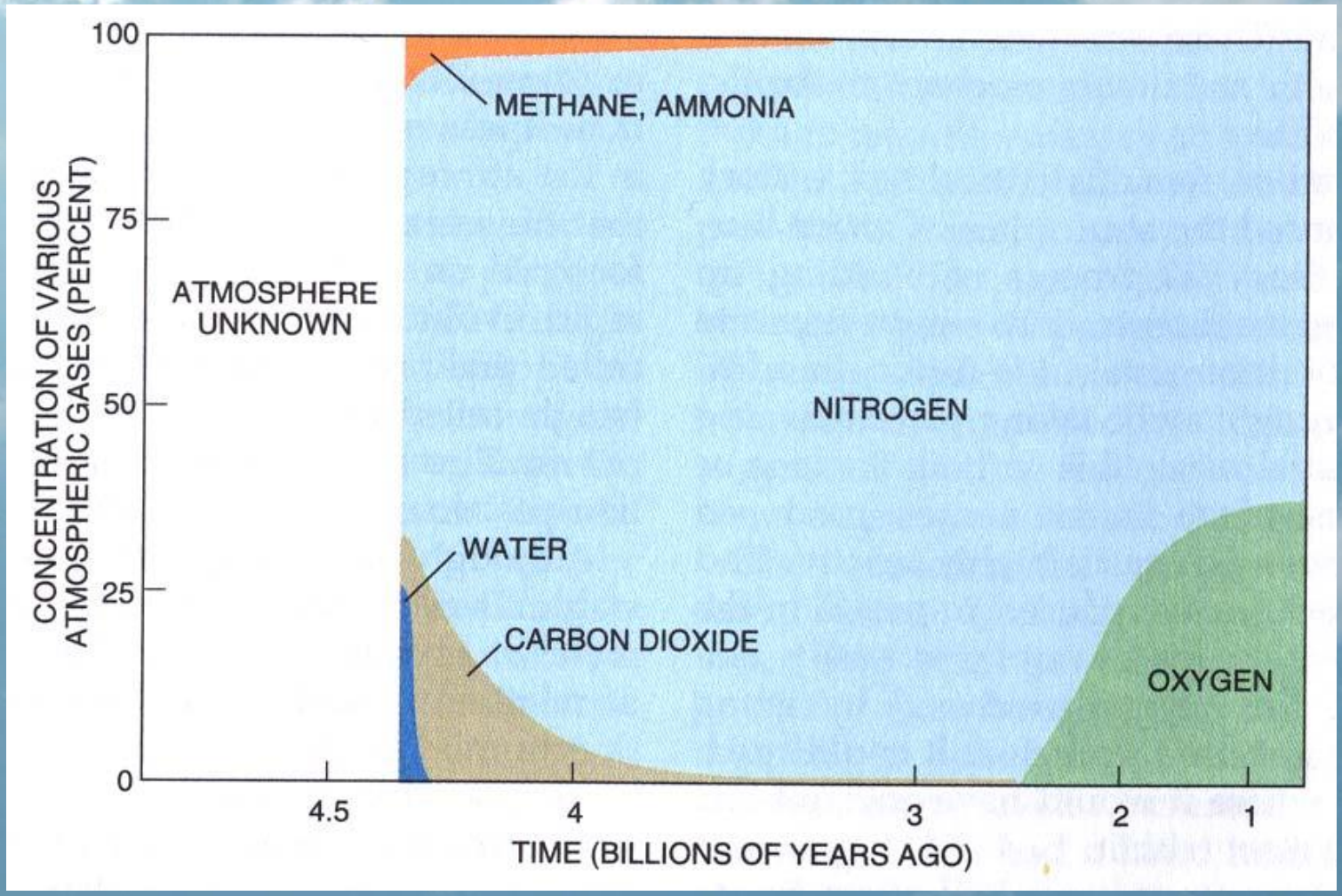
Volcanic Gas Emissions



http://myweb.cwpost.liu.edu/vdivener/notes/early_Earth_ocean.gif

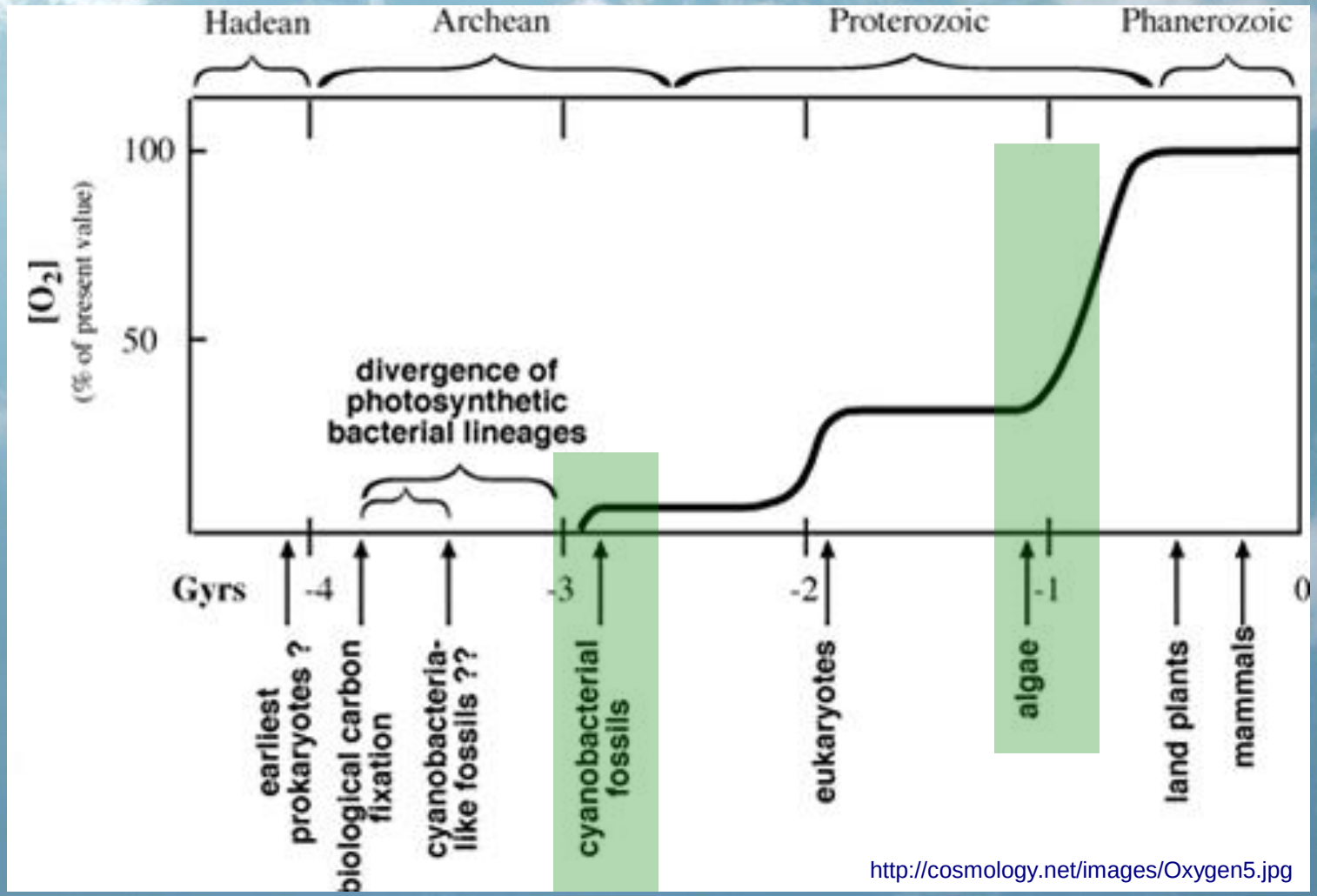
http://temp.geobio.uib.no/uploads/images/research-groups/archean_earth.jpg

Composition of Earth's Atmosphere Over Time

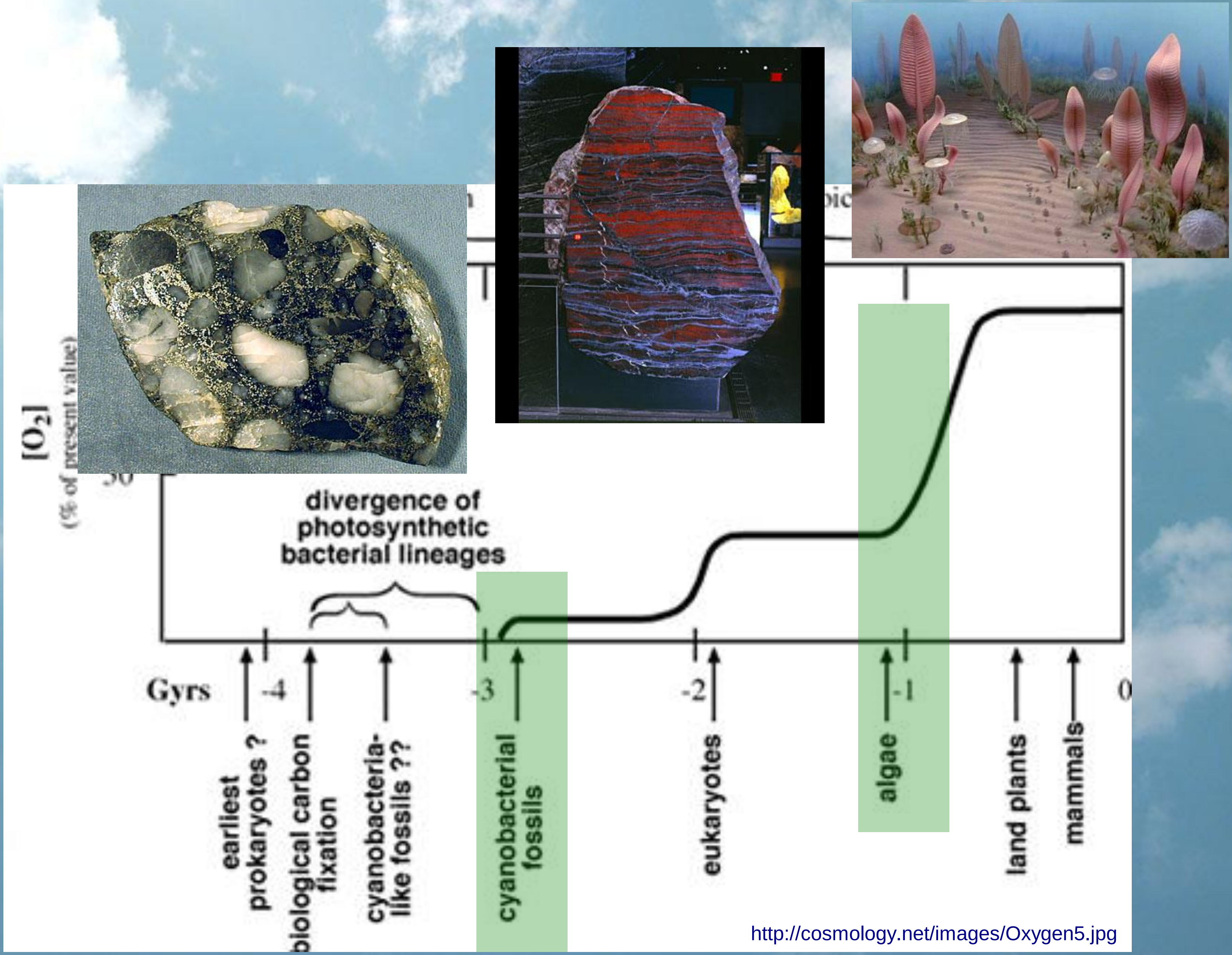


http://ircamera.as.arizona.edu/NatSci102/NatSci102/images/atmosgases.jpg

O_2 Levels through Earth History



http://cosmology.net/images/Oxygen5.jpg

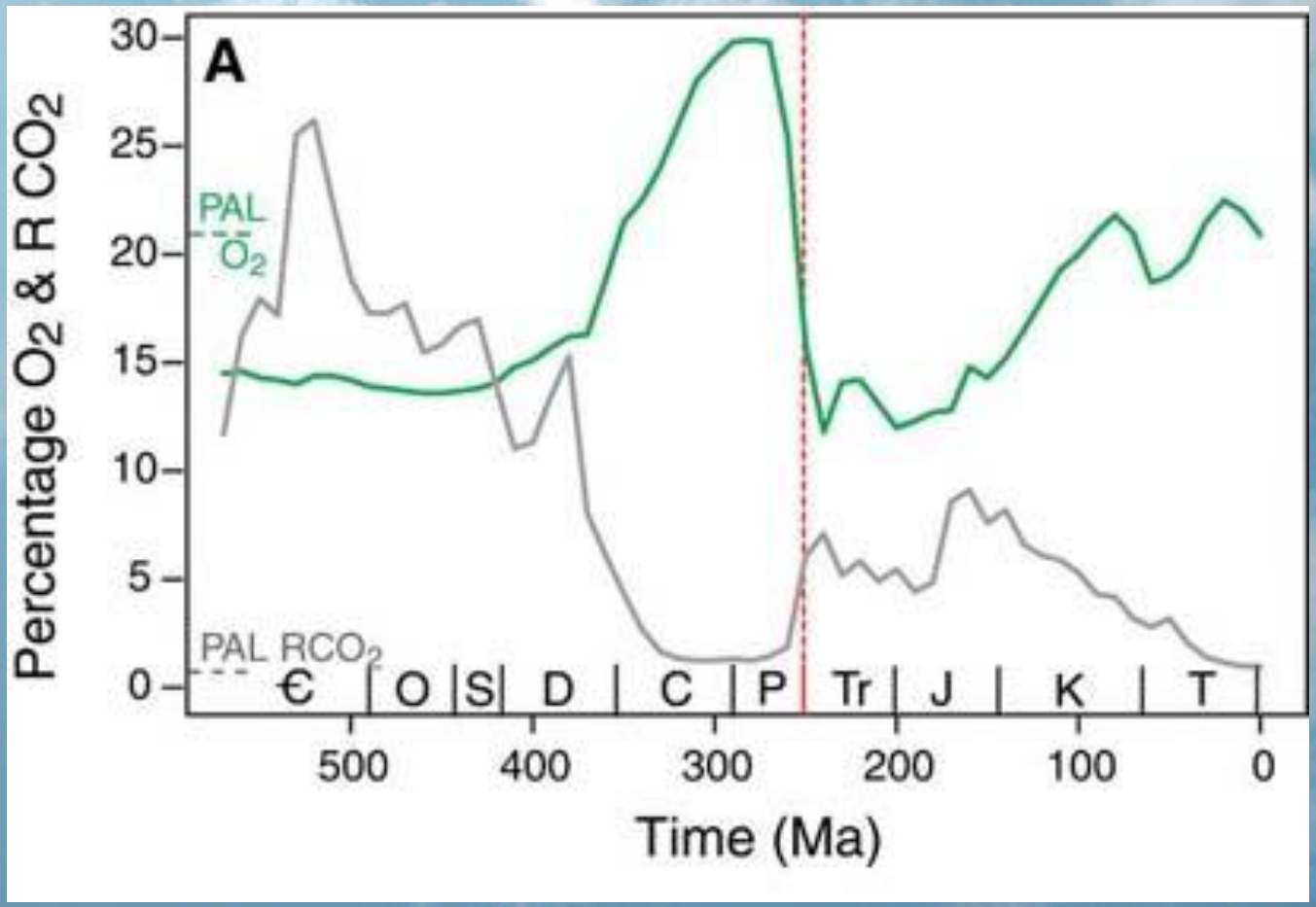


http://cosmology.net/images/Oxygen5.jpg

Limestone and CO_2

http://cosmology.net/images/Oxygen5.jpg

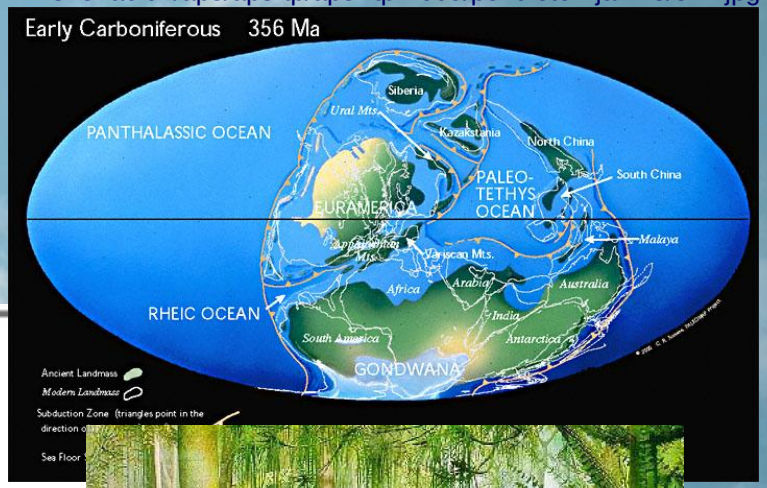
O_2 and CO_2: 544Ma to Present



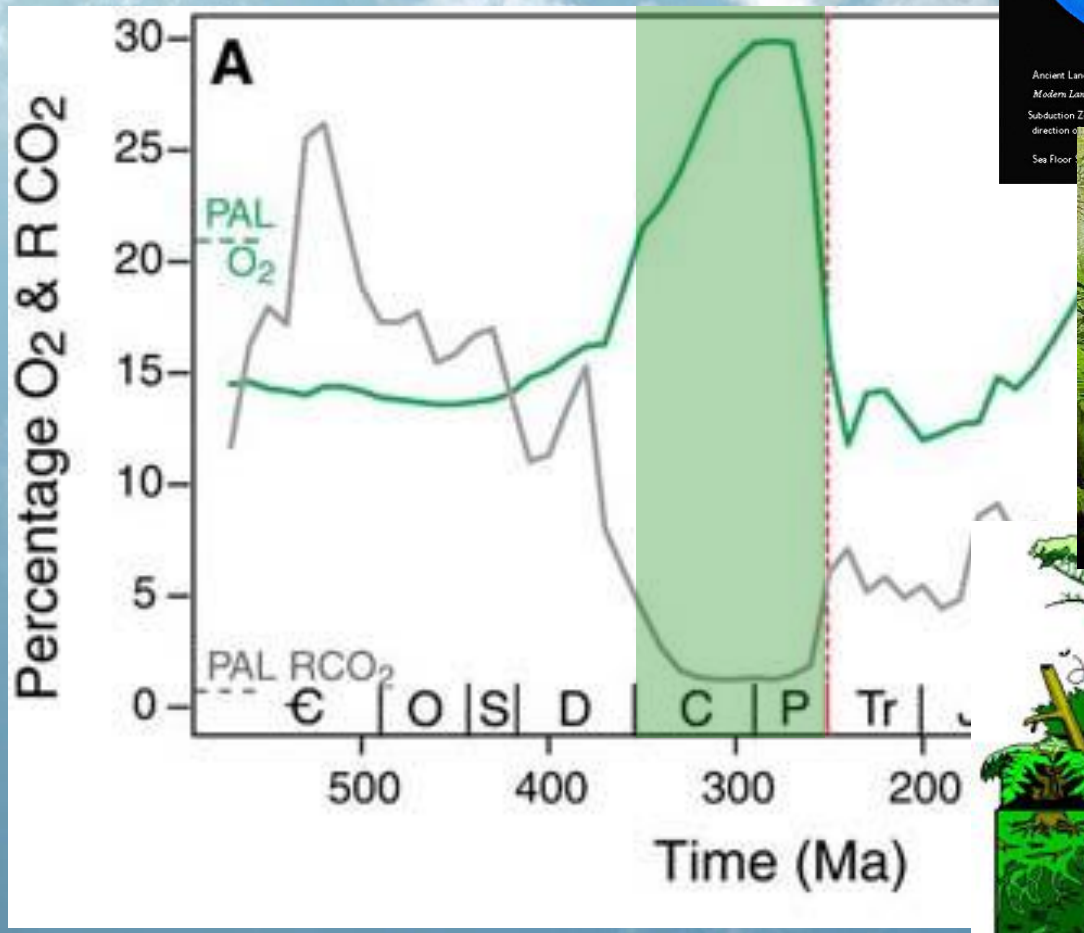
http://www.killerinourmidst.com/grafix/PhanerozoicOxygen.jpg

The Carboniferous, Coal, and CO_2

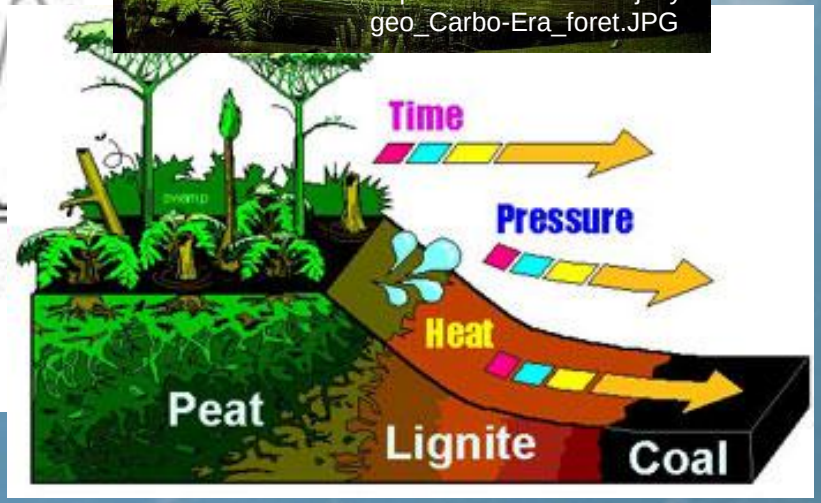
http://www.shef.ac.uk/aps/apsrtp/aps-rtp-2009/pendleton-janine/342.jpg



http://web.rollins.edu/~jsiry/geo_Carbo-Era_foret.JPG



http://www.killerinourmidst.com/grafix/PhanerozoicOxygen.jpg



http://www.learner.org/courses/envsci/visual/img_med/coal_formation.jpg

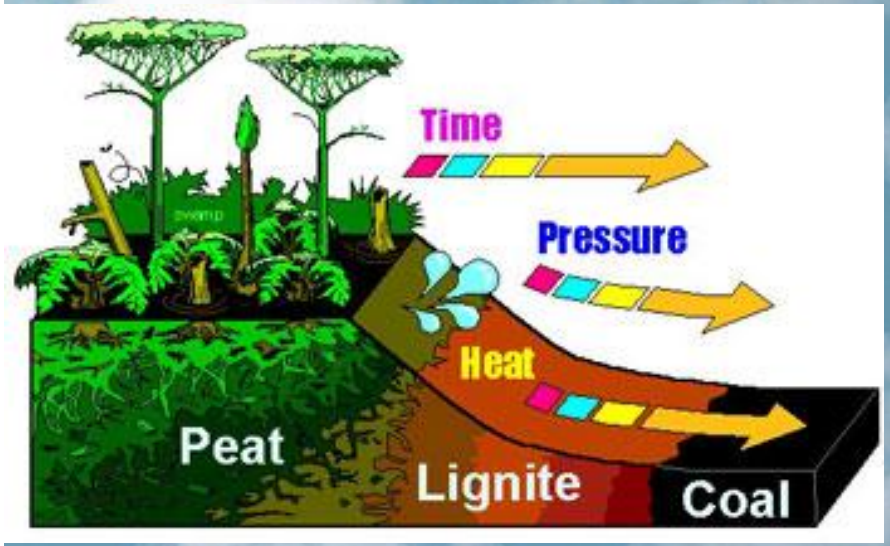
Fossil Fuel Formation and CO_2

Photosynthesis

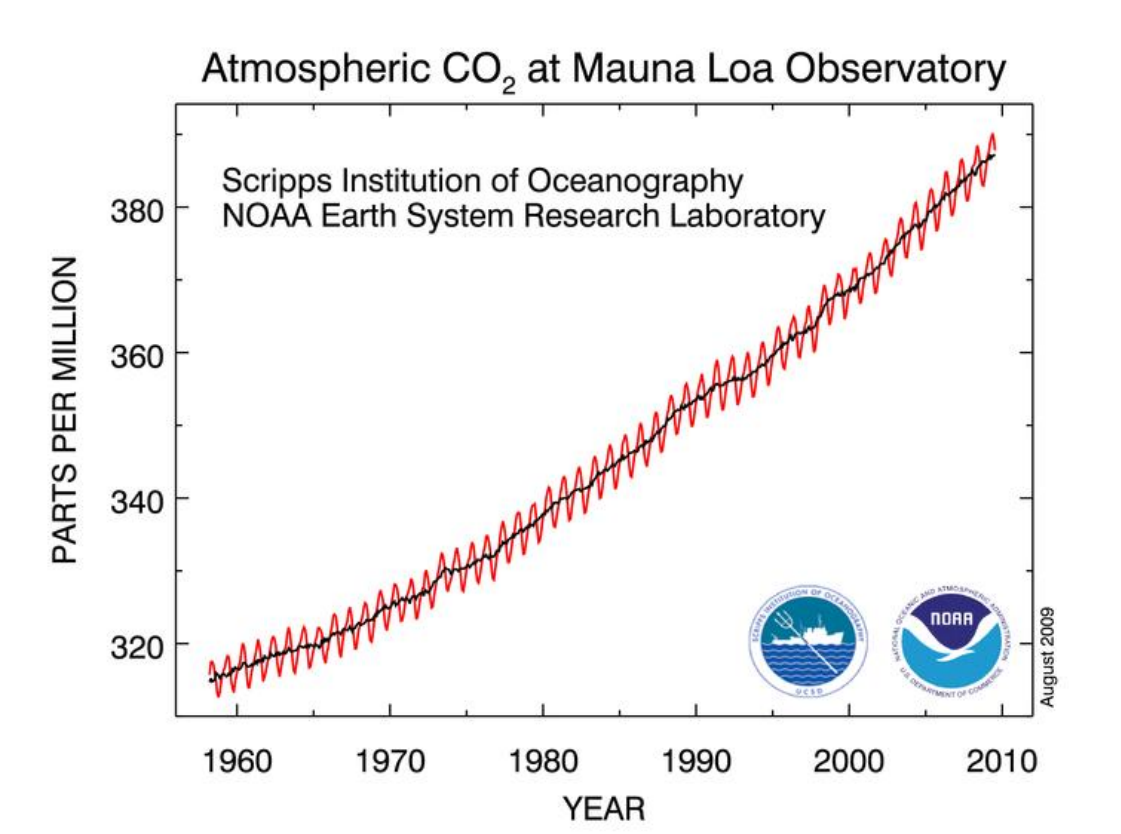
Ingredients	*Product*
Sunlight +	
$H_2O + CO_2 +$ Nutrients →	"CH_2O" + O_2
Water	"Organic matter"
Carbon dioxide	Oxygen
Nitrate NO_3	
Phosphate PO_4	
Iron	
Silica	
...	

Earthguide http://earthguide.ucsd.edu
Memorie Yasuda

Same rule applies to marine life that applies to terrestrial life.



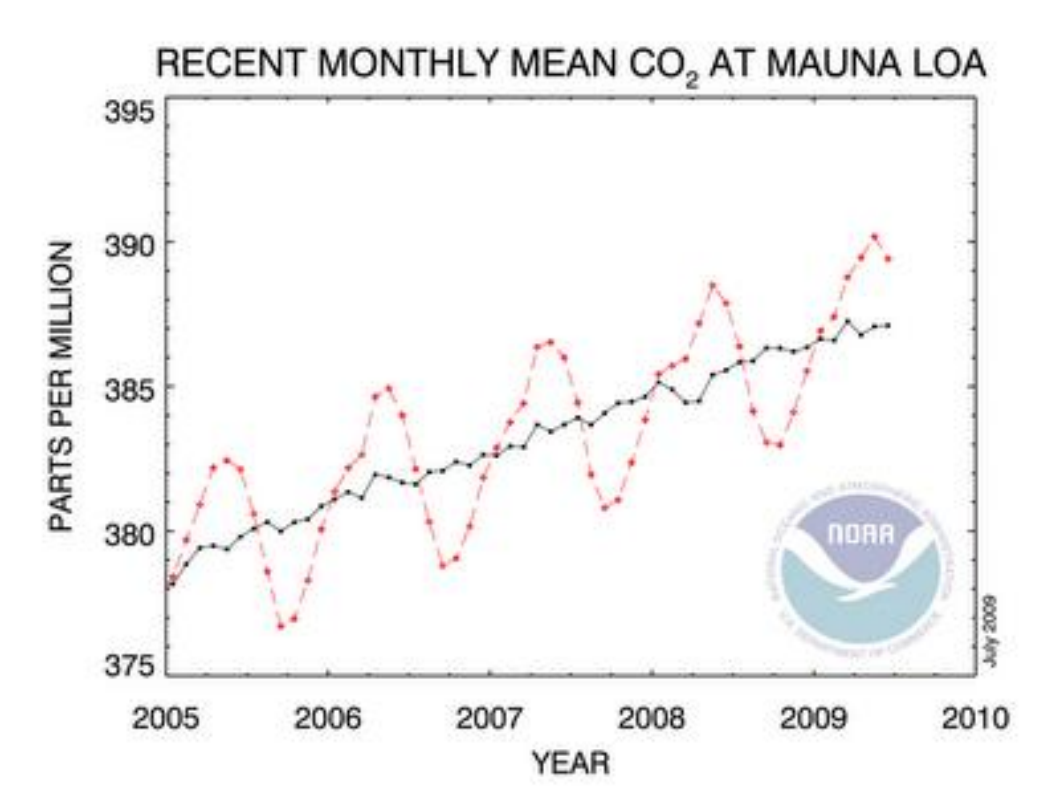
Earth's Recent Atmosphere Changes



http://www.esrl.noaa.gov/gmd/webdata/ccgg/trends/co2_data_mlo.png

Nitrogen	78.1%
Oxygen	20.9%
Argon	0.9%
Carbon Dioxide	0.035%
Water	0 - 4%

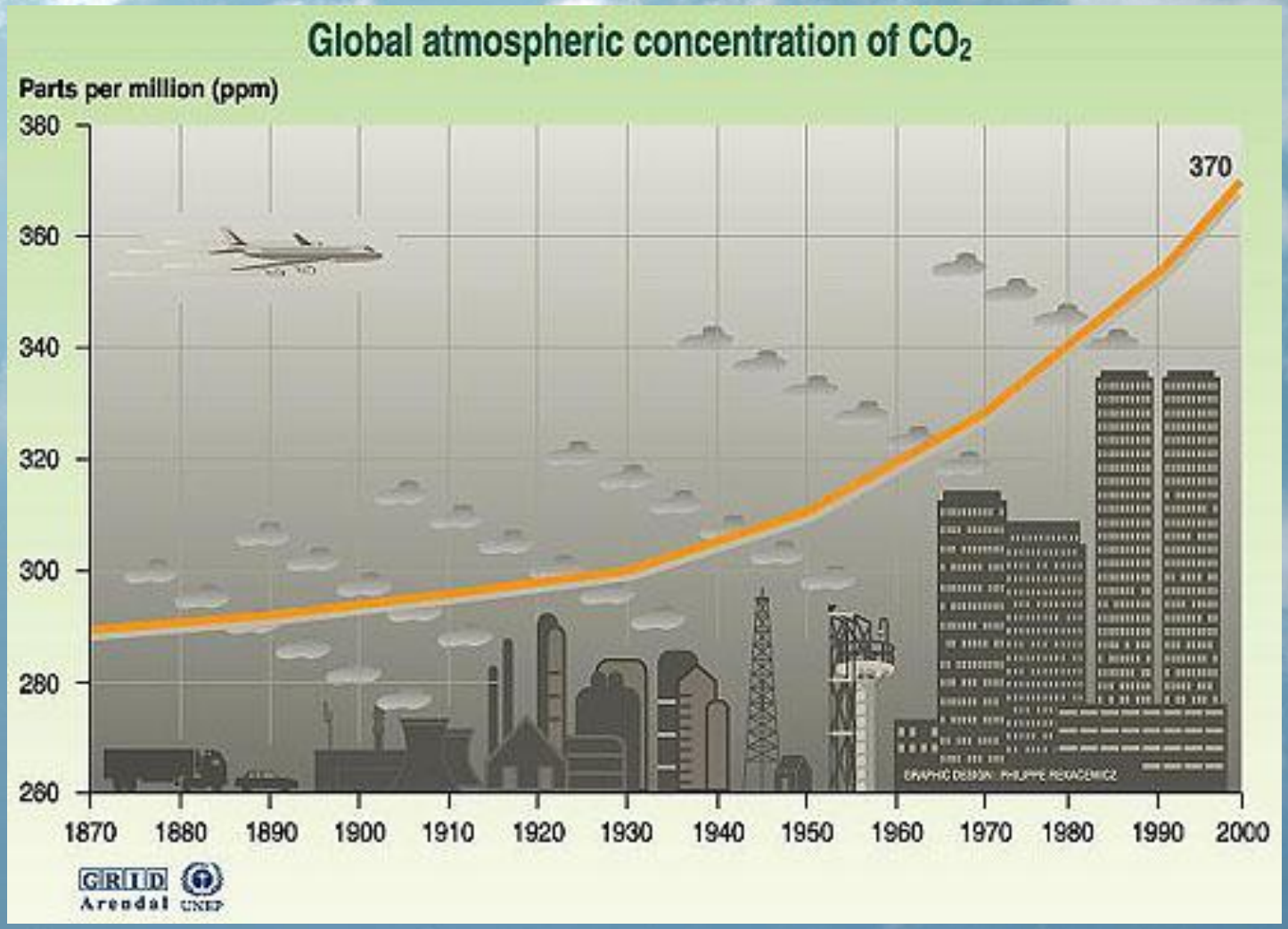
Earth's Recent Atmosphere Changes



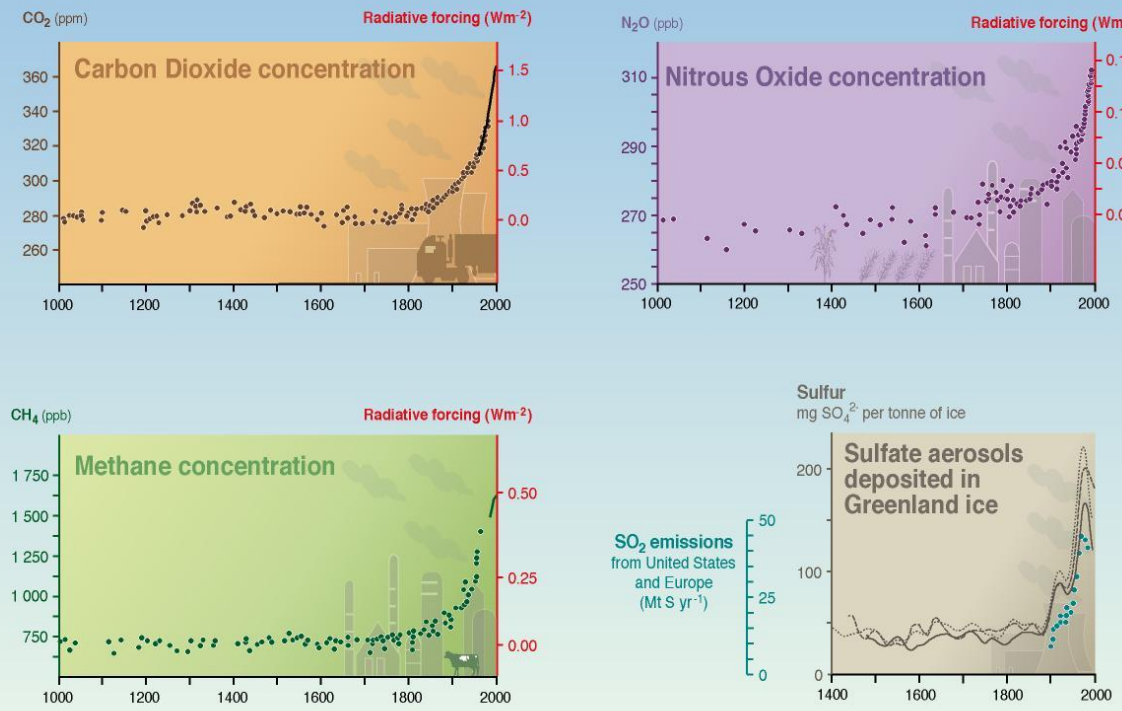
- Atmospheric CO_2 concentrations vary with the seasons
  - Lower CO_2 in the summer
  - Higher CO_2 in the winter
  - Due to plant productivity

http://lh6.ggpht.com/_WtnYwFZtgHI/SmKOQ7kkYiI/AAAAAAAAAa4/THWQ7OYkGzE/s400/co2_trend_mlo.png

CO_2 and the Industrial Revolution

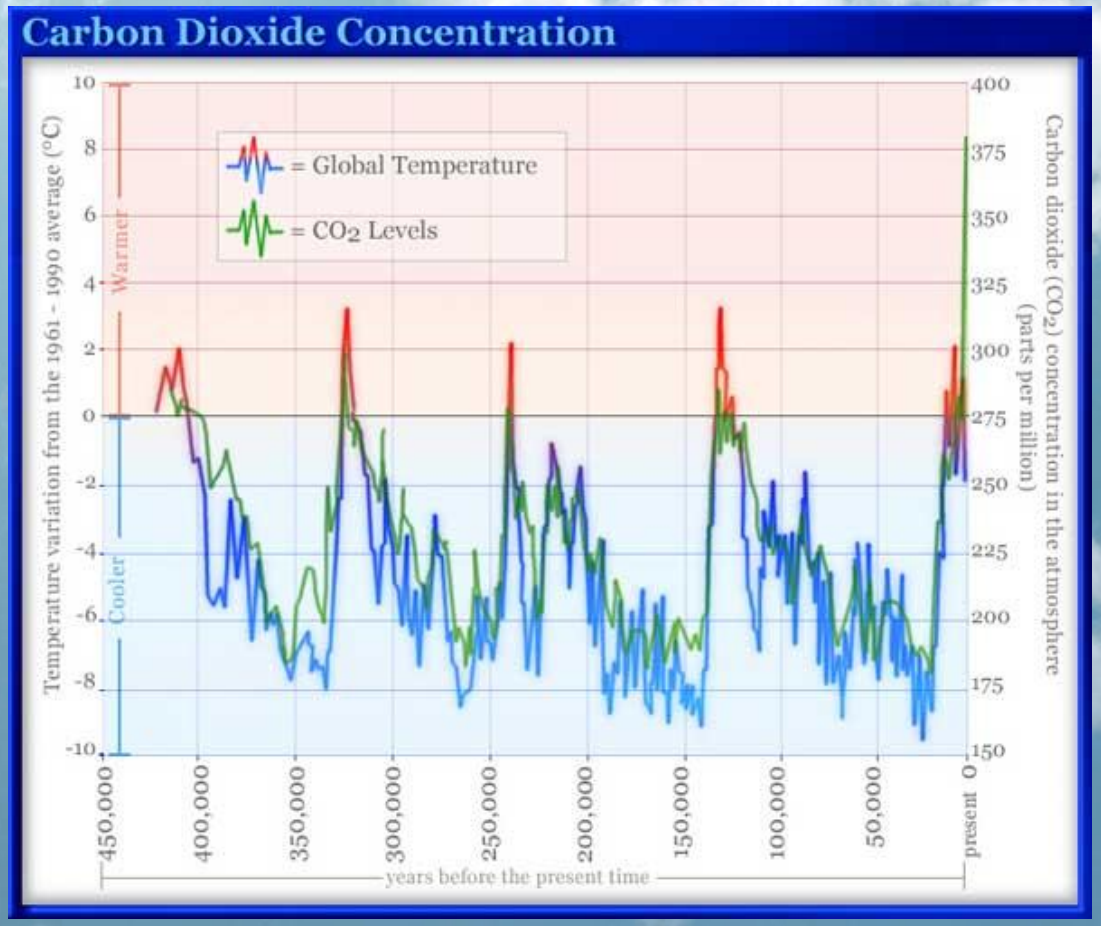


Indicators of the human influence on the atmosphere during the Industrial era



SYR - FIGURE 2-1
WG1 FIGURE SPM-2

Earth's Less Recent Atmosphere Changes

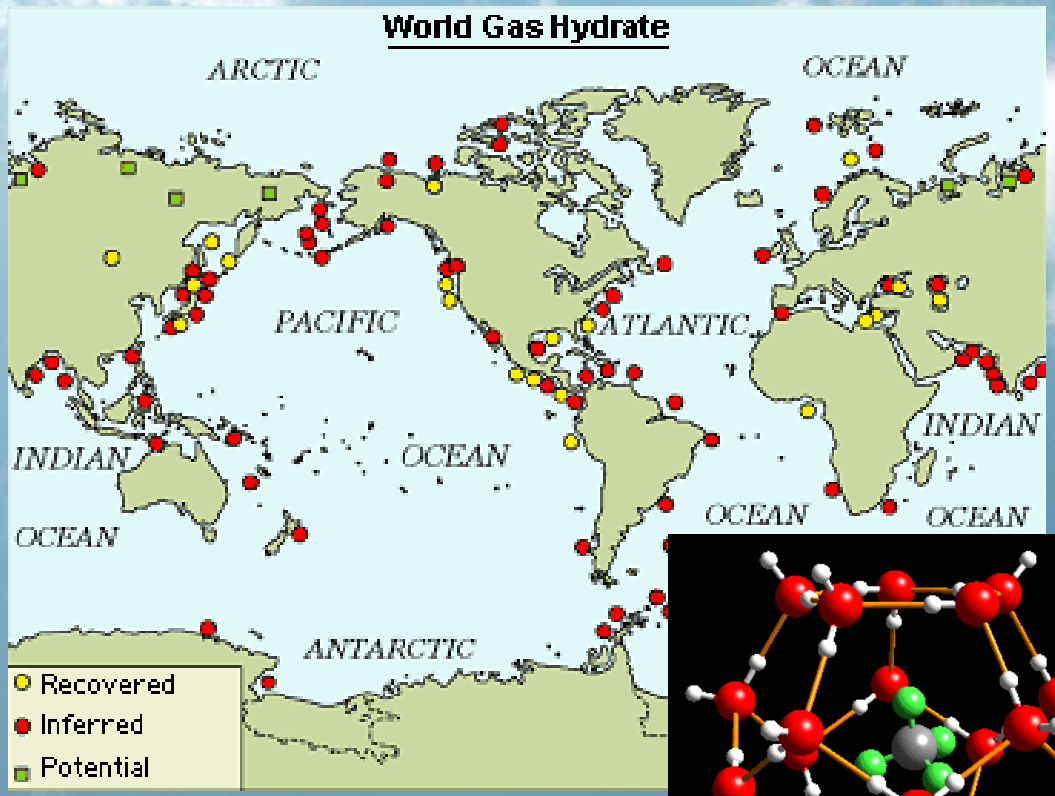


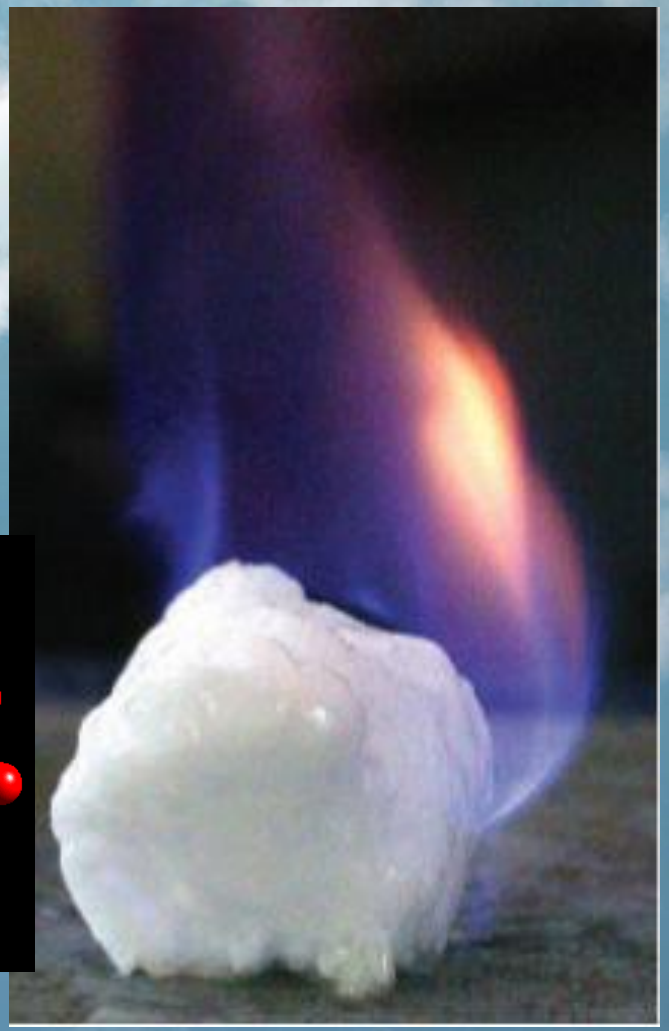
http://www.tallbergforum.org/Portals/0/Images/carbon_dioxide.jpg

- Cyclicity of atmospheric CO_2 concentrations over past half million years
- Current CO_2 levels higher than at any other time during that interval

Methane Clathrates

http://upload.wikimedia.org/wikipedia/commons/f/f8/Methane_Clathrate_Location_Map_USGS.gif





http://www.blog.speculist.com/archives/methanehydrate.jpg

Carbon Dioxide Monitor

- Range: 0-3000 ppm
- Accuracy: ± 50 ppm
- Repeatability (Precision): ± 50 ppm
- Logs data every 30 minutes over a 24-hour period

Determining Atmospheric Quality

AQI Values	Levels of Health Concern	Cautionary Statements
0 to 50	Good	None.
51 to 100	Moderate	Unusually sensitive people should consider reducing prolonged or heavy exertion.
101 to 150	Unhealthy for Sensitive Groups	People with heart or lung disease, older adults, and children should reduce prolonged or heavy exertion.
151 to 200	Unhealthy	People with heart or lung disease, older adults, and children should avoid prolonged or heavy exertion. Everyone else should reduce prolonged or heavy exertion.
201 to 300	Very Unhealthy	People with heart or lung disease, older adults, and children should avoid all physical activity outdoors. Everyone else should avoid prolonged or heavy exertion.
301 to 500	Hazardous	People with heart or lung disease, older adults, and children should remain indoors and keep activity levels low. Everyone else should avoid all physical activity outdoors.

AQI:
Air Quality Index

- The Air Quality Index is a color-coded indicator of air quality, that is based upon air pollutants that adversely affect human health.

- EPA calculates the AQI for five major regulated air pollutants:
  - ground-level ozone
  - particulate matter
  - carbon monoxide
  - sulfur dioxide
  - nitrogen dioxide.

Critical Values for AQI

Breakpoints for the AQI

These Breakpoints						equal these AQIs…		Category
O_3 (ppm) 8-hour	O_3 (ppm) 1-hour[1]	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	CO (ppm)	SO_2 (ppm)	NO_2 (ppm)	AQI	
0.000-0.064	-	0.0 – 15.4	0 – 54	0.0-4.4	0.000-0.034	([2])	0 – 50	Good
0.065-0.084	-	15.5 – 40.4	55 – 154	4.5-9.4	0.035-0.144	([2])	51 – 100	Moderate
0.085-0.104	0.125-0.164	40.5 – 65.4	155 – 254	9.5-12.4	0.145-0.224	([2])	101 – 150	Unhealthy for sensitive groups
0.105-0.124	0.165-0.204	65.5 – 150.4	255 – 354	12.5-15.4	0.225-0.304	([2])	151 – 200	Unhealthy
0.125-0.374	0.205-0.404	150.5–250.4	355 – 424	15.5-30.4	0.305-0.604	0.65-1.24	201 – 300	Very Unhealthy
([3])	0.405-0.504	250.5-350.4	425 – 504	30.5-40.4	0.605-0.804	1.25-1.64	301 – 400	Hazardous
([3])	0.505-0.604	350.5-500.4	505 – 604	40.5-50.4	0.805-1.004	1.65-2.04	401 – 500	Hazardous

[1] Areas are generally required to report the AQI based on 8-hour ozone values. However, there are a small number of areas where an AQI based on 1-hour ozone values would be more precautionary. In these cases, in addition to calculating the 8-hour ozone index value, the 1-hour ozone index value may be calculated and the maximum of the two values is reported.

[2] NO_2 has no short-term NAAQS and can generate a AQI only above a AQI value of 200.

[3] When 8-hour O_3 concentrations exceed 0.374ppm, AQI values of 301 or higher must be calculated with 1-hour O_3 concentrations.

NYS Air Quality Index Forecasts

http://www.dec.ny.gov/chemical/34985.html

National Air Quality Index Forecasts

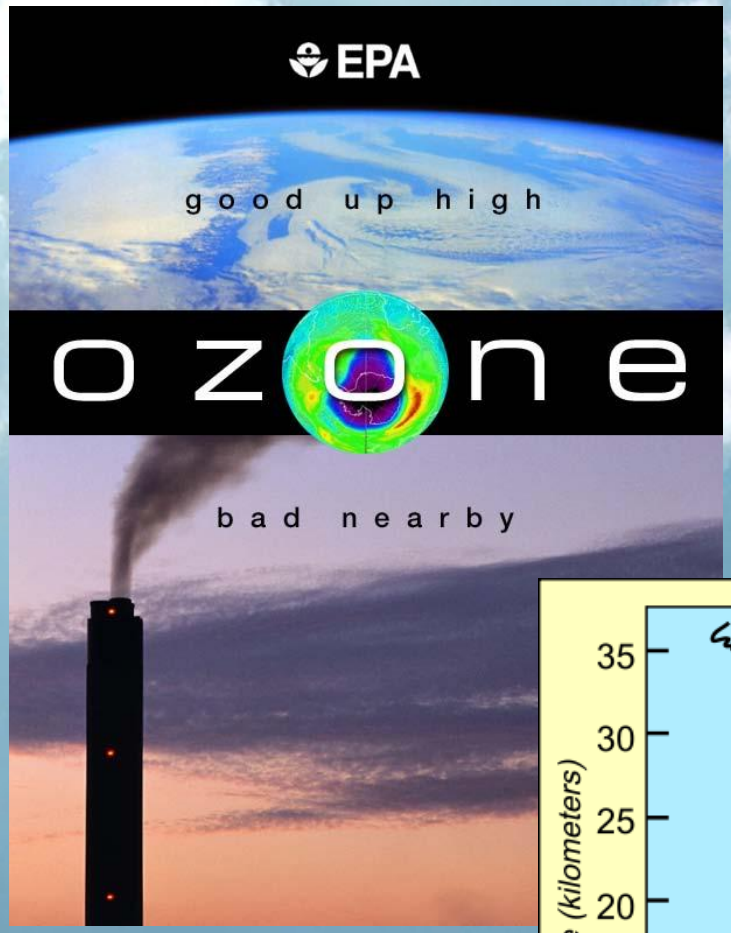
http://www.airnow.gov/index.cfm?action=airnow.national

Particulate Matter

- Tiny solid particles suspended in the air

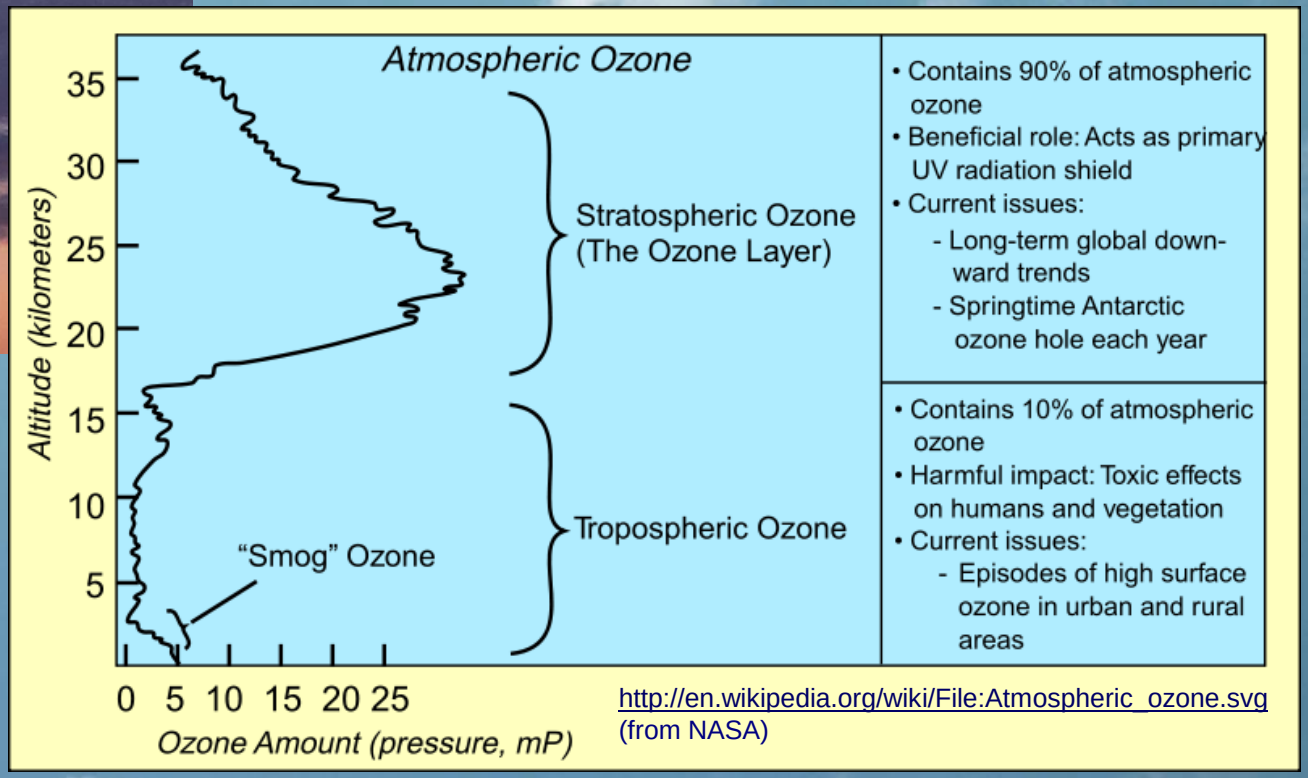
- The focus of an upcoming class

Occurence of Ozone



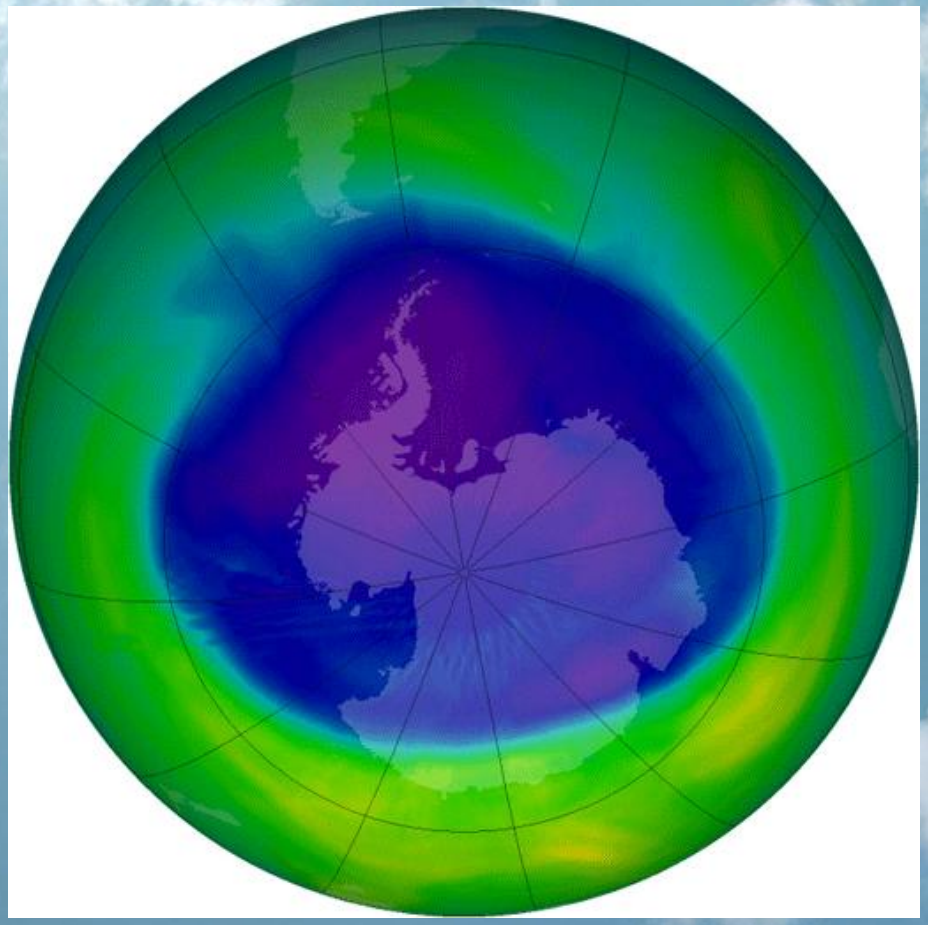
EPA Ozone Brochure

- Ozone is concentrated at two horizons in the atmosphere



http://en.wikipedia.org/wiki/File:Atmospheric_ozone.svg
(from NASA)

Stratospheric Ozone

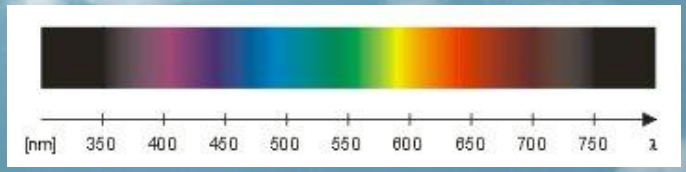


http://www.nasa.gov/images/content/139207main_ozone_hole_img.gif

$$O_2 + hv = O + O$$

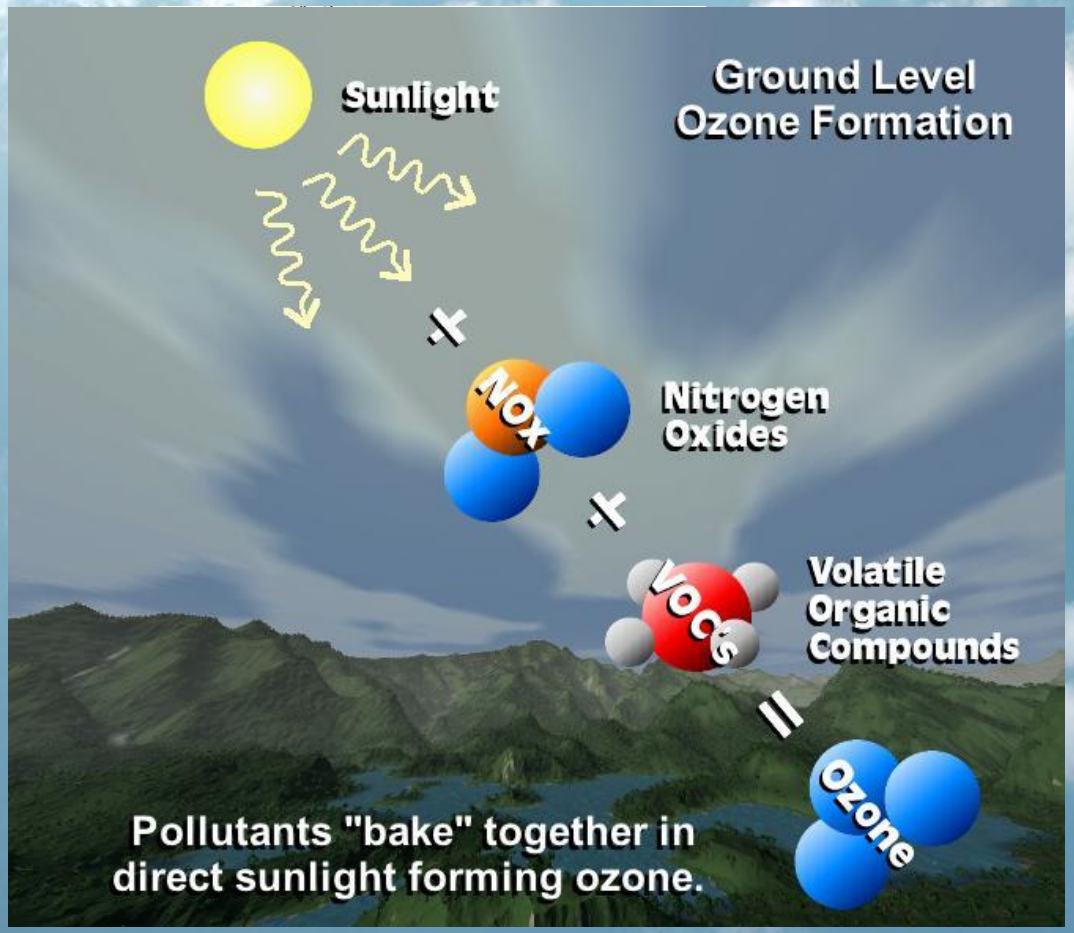
$$O + O_2 = O_3$$

hv = wavelength < 240 nm (ultraviolet)

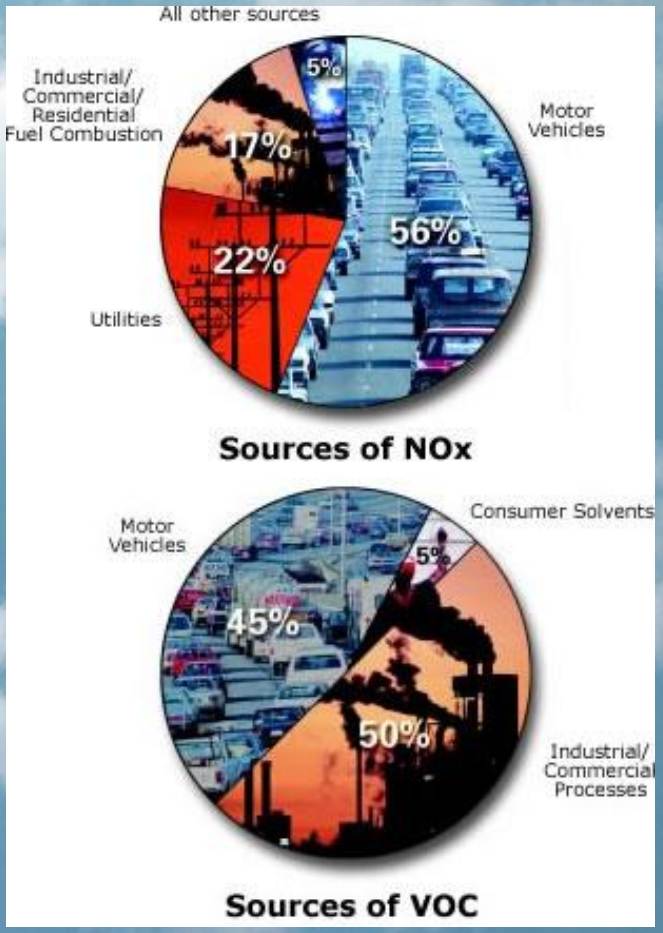


- Antarctic ozone hole formed by destruction of ozone by Cl and Br
- In upper atmosphere, UV breaks Cl and Br off of long-lived pollutants (CFCs, HCFCs, carbon tetrachloride, methyl chloroform, halons and methyl bromide)

Formation of Ground Level Ozone



www.geo.sunysb.edu/bad-ozone/Resources.html



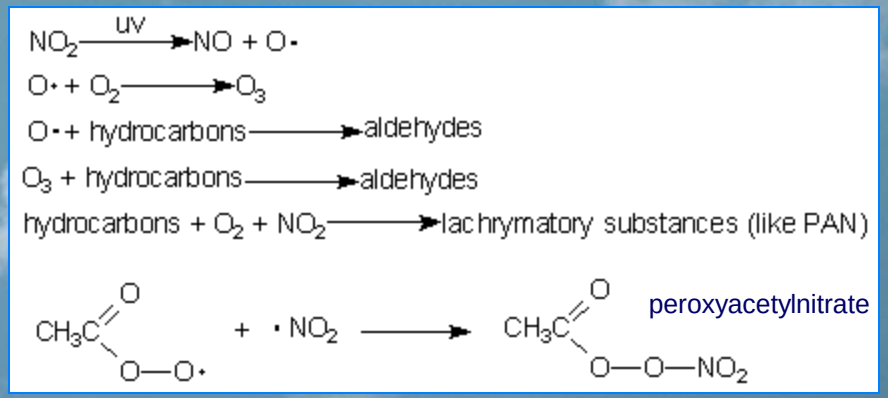
epa.gov/air/oaqps/gooduphigh/bad.html

Ozone And Photochemical Smog

http://gothamist.com/attachments/Joe%20Schumacher/tankengine_smog_0627.jpg

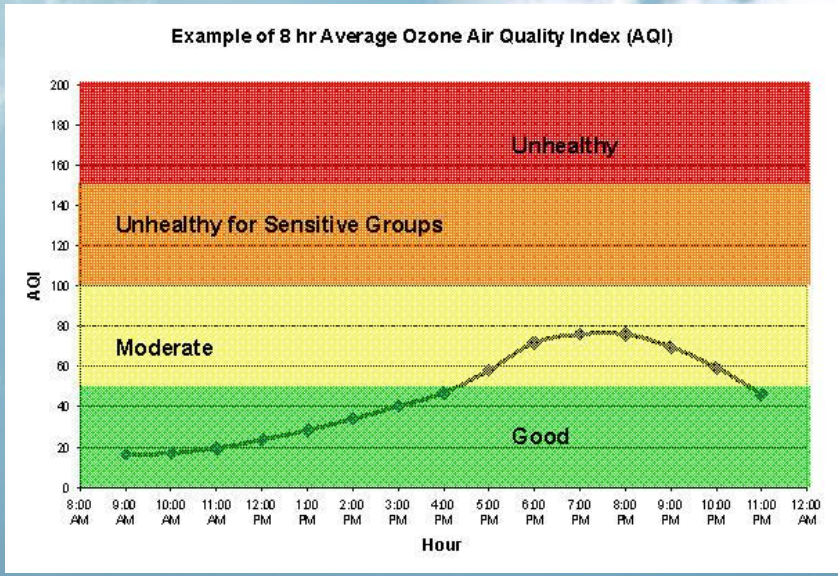
http://wildgreenyonder.files.wordpress.com/2007/05/la_smog.jpg

- Ground-level ozone is a major constituent of photochemical smog
- Smog = “Smoke + Fog”

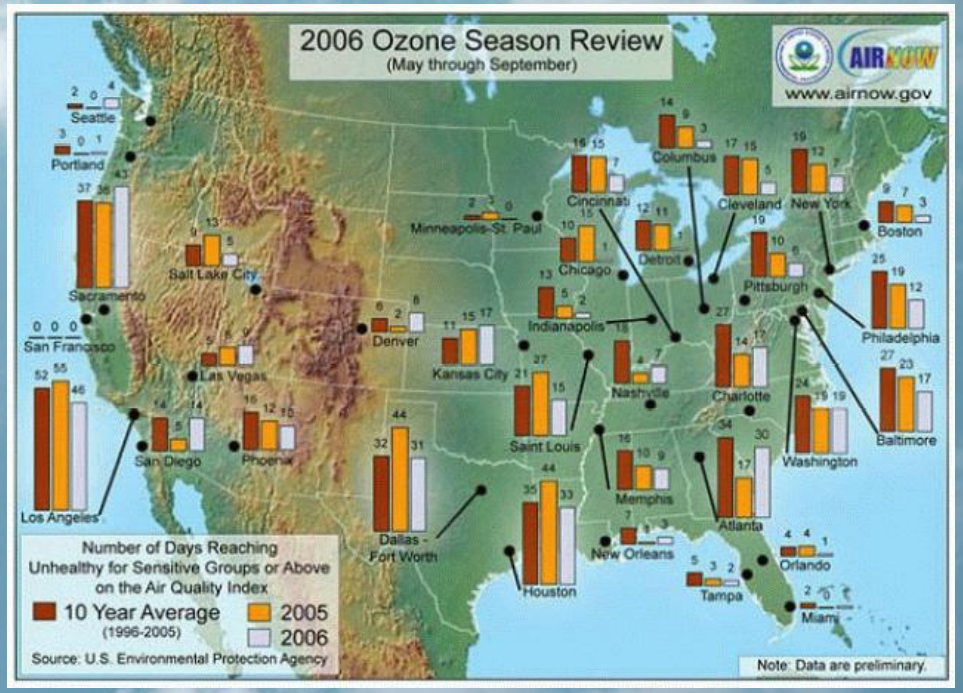


http://hk.geocities.com/xavier114fch/03/03b.htm

Ground-Level Ozone Controls



http://www.deq.state.or.us/aq/images/ozone.jpg



http://www.wunderground.com/hurricane/2007/ozone_recap.jpg

- Ground-level ozone requires heat and sunlight
  - Varies by time, season, and location

Catalytic Converters

- Catalytic Converters use platinum group elements to help complete the combustion process in cars:

Reduction of nitrogen oxides:

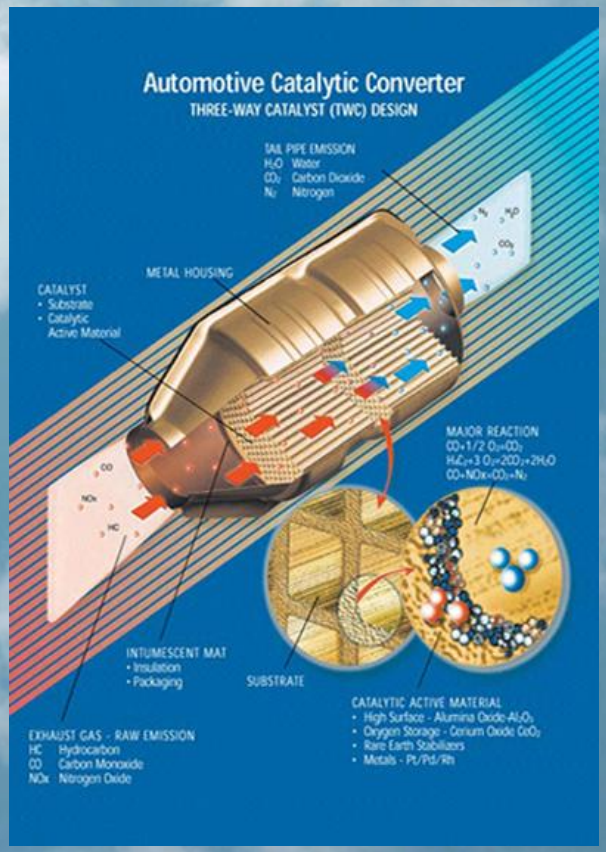
$$2NOx \rightarrow xO_2 + N_2$$

Oxidation of carbon monoxide:

$$2CO + O_2 \rightarrow 2CO_2$$

Oxidation of unburnt hydrocarbons:

$$C_xH_{2x+2} + 2xO_2 \rightarrow xCO_2 + 2xH_2O$$

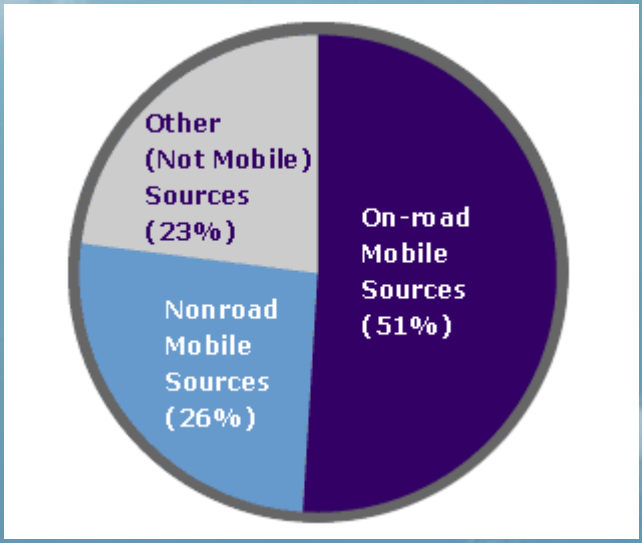


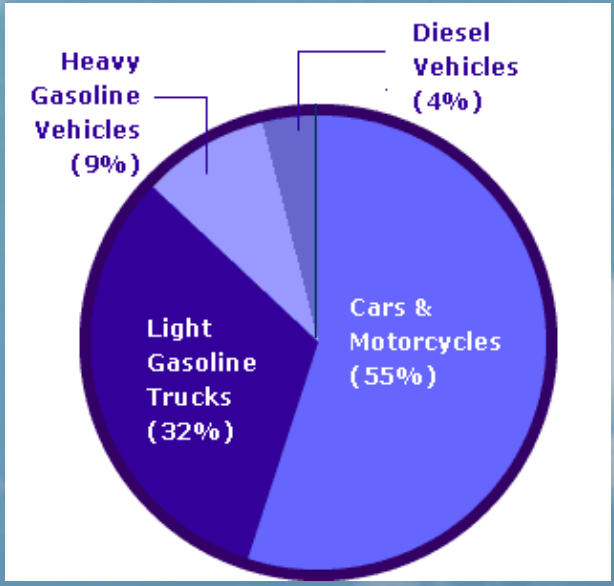
http://www.autocatalyst-recycling.umicore.com/catalyticConverter/catalyticConvertorEng.jpg

Carbon Monoxide (CO)

- Carbon monoxide (CO) is a deadly, colorless, odorless, poisonous gas that is produced by the incomplete combustion of fuels

- Urban sources include cars, furnaces, and stoves

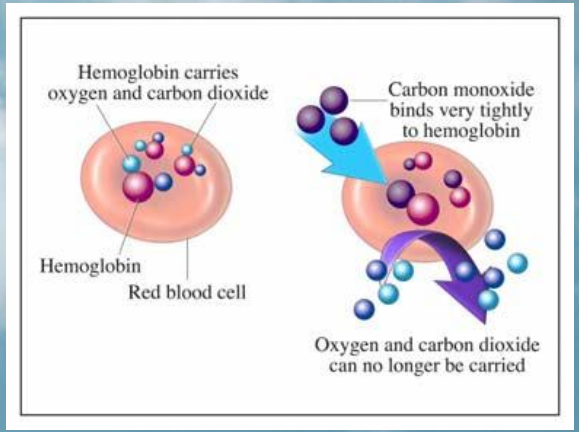




http://www.epa.gov/OMS/invntory/overview/pollutants/carbonmon.htm

Carbon Monoxide Effects

- 1 to 70 ppm: No symptoms for most people
- 70 to 150 ppm: Symptoms (headache, fatigue and nausea) become more noticeable.
- 150 to 200 ppm (sustained): Disorientation, unconsciousness, and death are possible.



http://www.kenthospital.org/healthGate/images/si55551241.jpg

- From 2000-2005, >400 New Yorkers were hospitalized and 30 died from CO poisoning.
- NYC buildings require CO sensors that can shut down furnaces. Building owners in NYC must install CO detectors in every dwelling unit

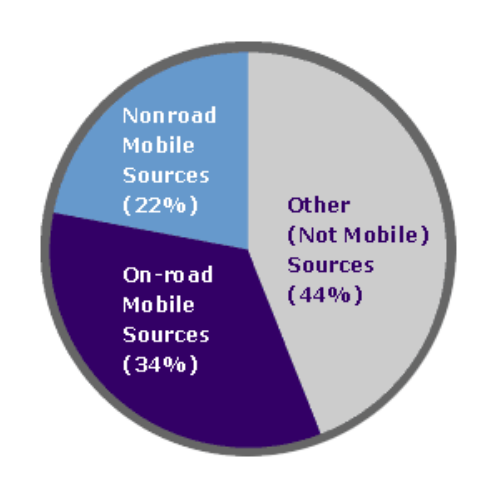
Portable CO Meter

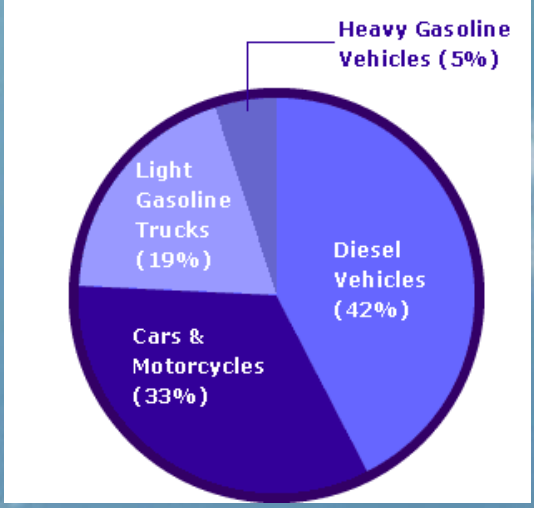
- Range: 0-500 ppm
- Accuracy: ±3%
- Repeatability (Precision): 20%
- 12 hour or “Always On”
- Max/Min, Total, Average
- Used by Inspectors from the NYC Department of Buildings

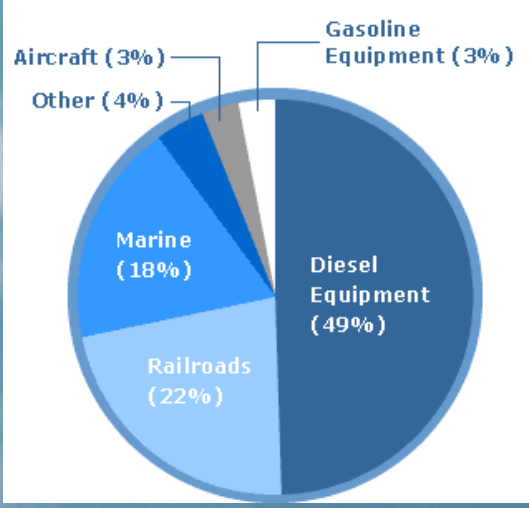
Office: 0 ppm
Living Room: 0 ppm
Kitchen (Dinner): 7 ppm
Downwind of charcoal grill: 84 ppm

Nitrogen Oxides (NO_x)

- Formed from high-temperature burning of fuels
- Contributes to ground-level ozone and fine particulate matter
- Dissolves in water to form nitric acid

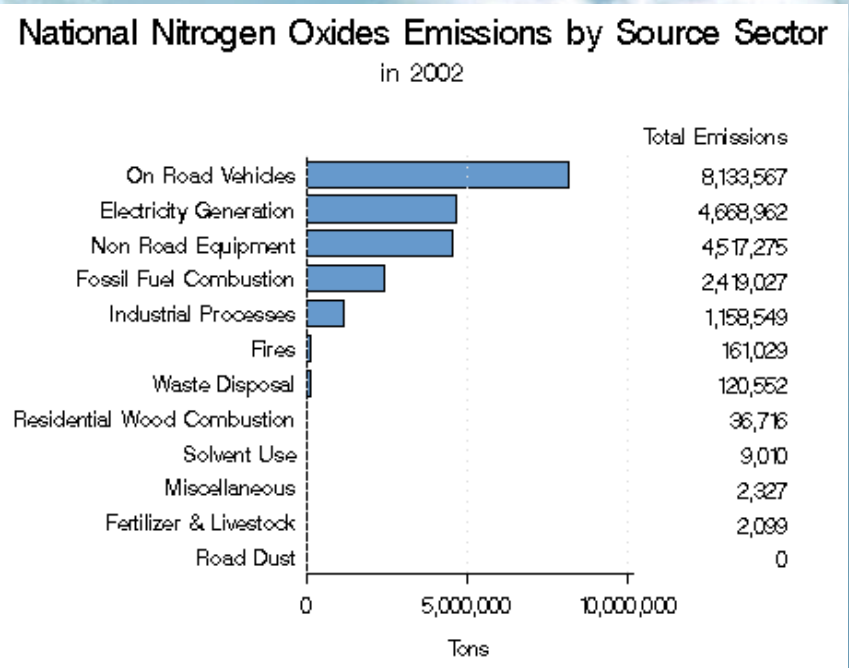


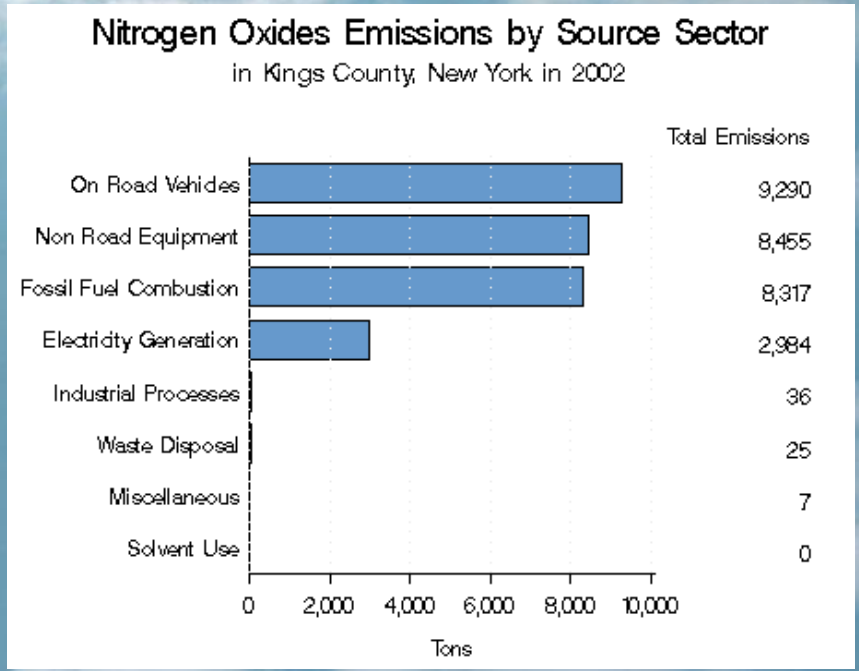




http://www.epa.gov/oms/invntory/overview/pollutants/nox.htm

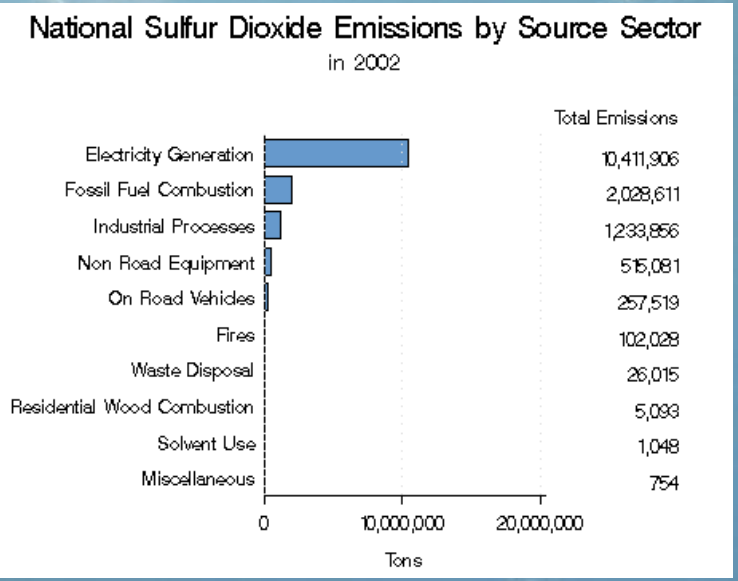
National and Local NOx Sources

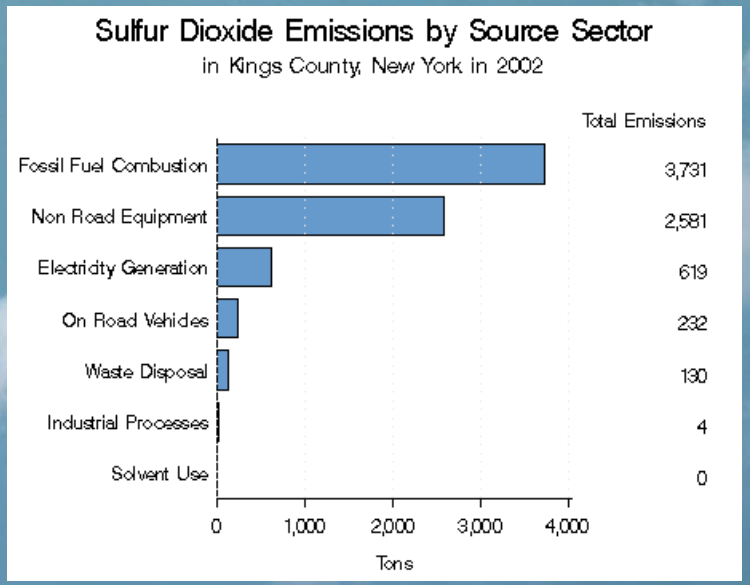




Sulfur Dioxide (SO_2)

- Produced from the burning of fossil fuels
- Dissolves in water and contributes to formation of acid rain
- Emissions can travel far from their source





http://www.epa.gov/oar/urbanair/so2/

Group Assignment

- Form six groups
- Assignment of either a CO or CO_2 monitor
- Discuss possible hypotheses that you could investigate within a day with your assigned monitor
- Select one hypothesis to test by next Tuesday's class. Be sure that your investigation is: safe, logistically possible, testable, brief.
- Report your proposed research investigation to the class

30 Minutes