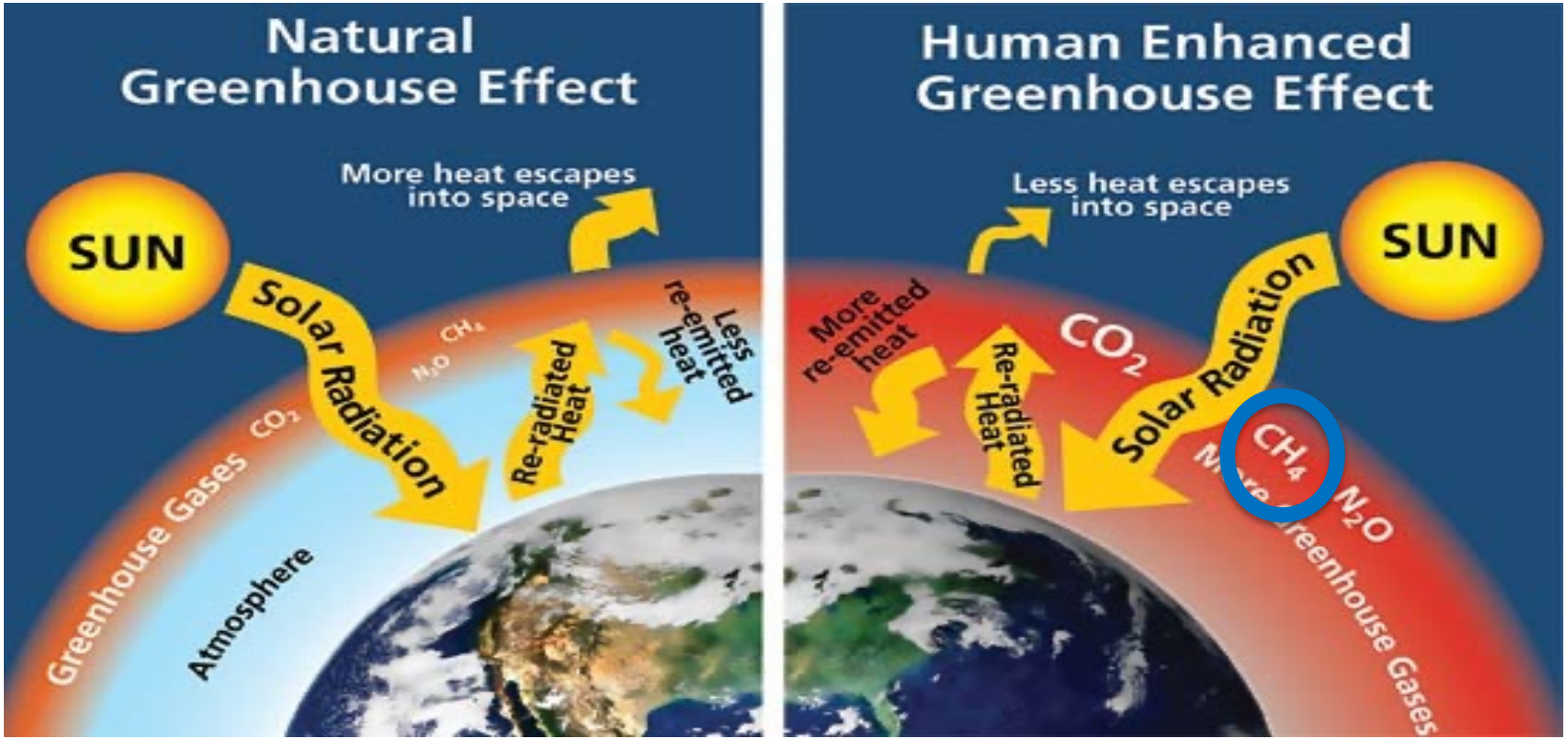
Lifetime Learning Institute, January 13, 2022



22SPO6 – METHANE'S ROLE IN CLIMATE CHANGE

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WHAT WE WILL TALK ABOUT

- ❑ WHY I CHOSE METHANE
- ❑ CHEMISTRY OF HYDROCARBONS
- ❑ METHANE 101
- ❑ METHANE'S NONCONTAINMENT
- ❑ METHANE'S EFFECT
- ❑ CLIMATE MITIGATION
- ❑ CLIMATE CHANGE ONE LAST TIME

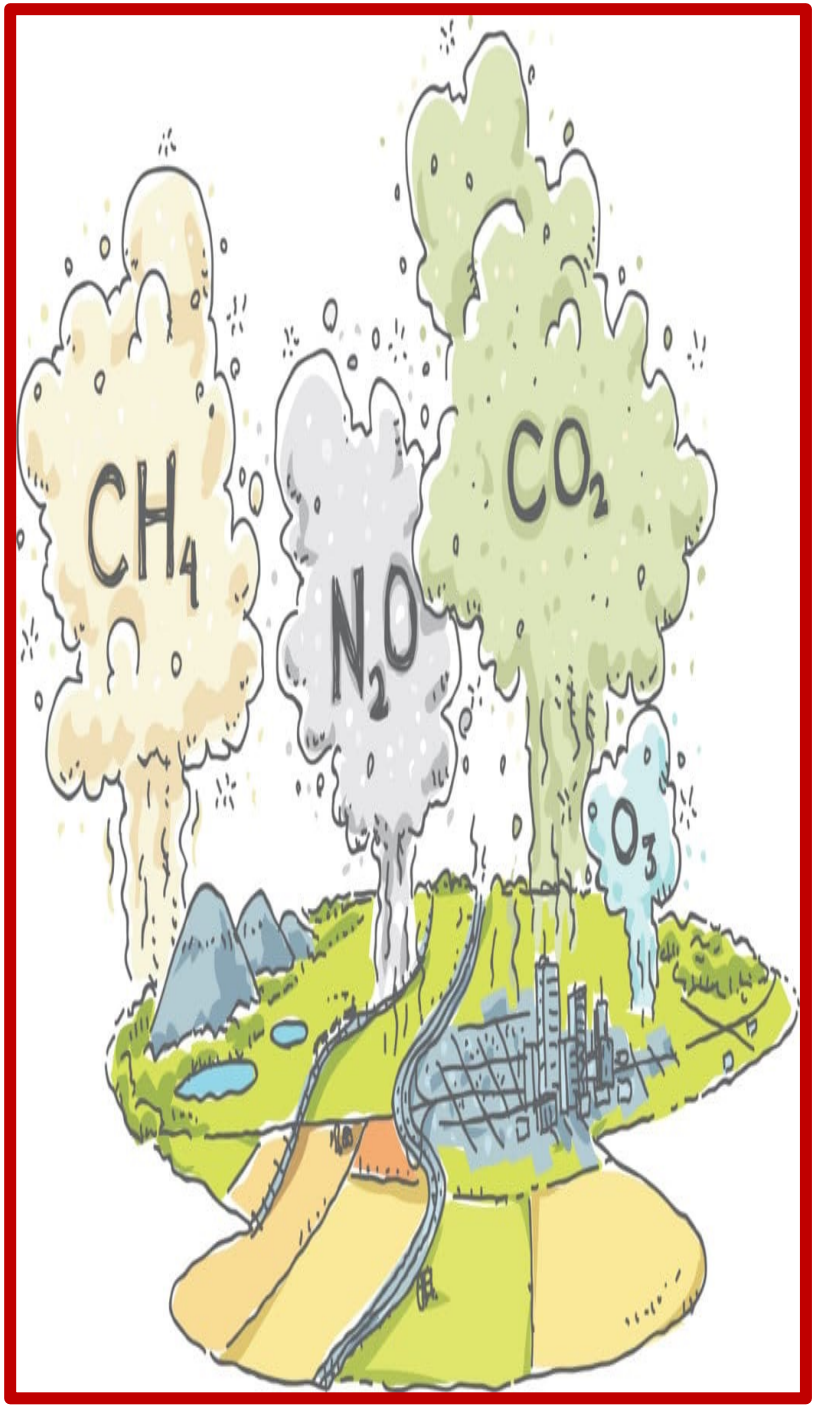
WHY I CHOSE METHANE?

Types of Greenhouse Gases

GHG Categories	GWP Value*	Major Sources
Carbon dioxide (CO_2)	1	Fossil fuel combustion, deforestation
Methane (CH_4)	25	Landfills, rice paddies, digestive tracts of cattle and sheep
Nitrous oxide (N_2O)	298	Fertilizer, animal waste
Hydrofluorocarbons (HFCs)	Varies (up to 14,800)	Semiconductor manufacturing and other industrial processes
Perfluorocarbons (PFCs)	Varies (up to 12,200)	Same as HFCs, plus aluminum smelting
Sulfur hexafluoride (SF_6)	22,800	Electrical transmission systems, magnesium and aluminum production

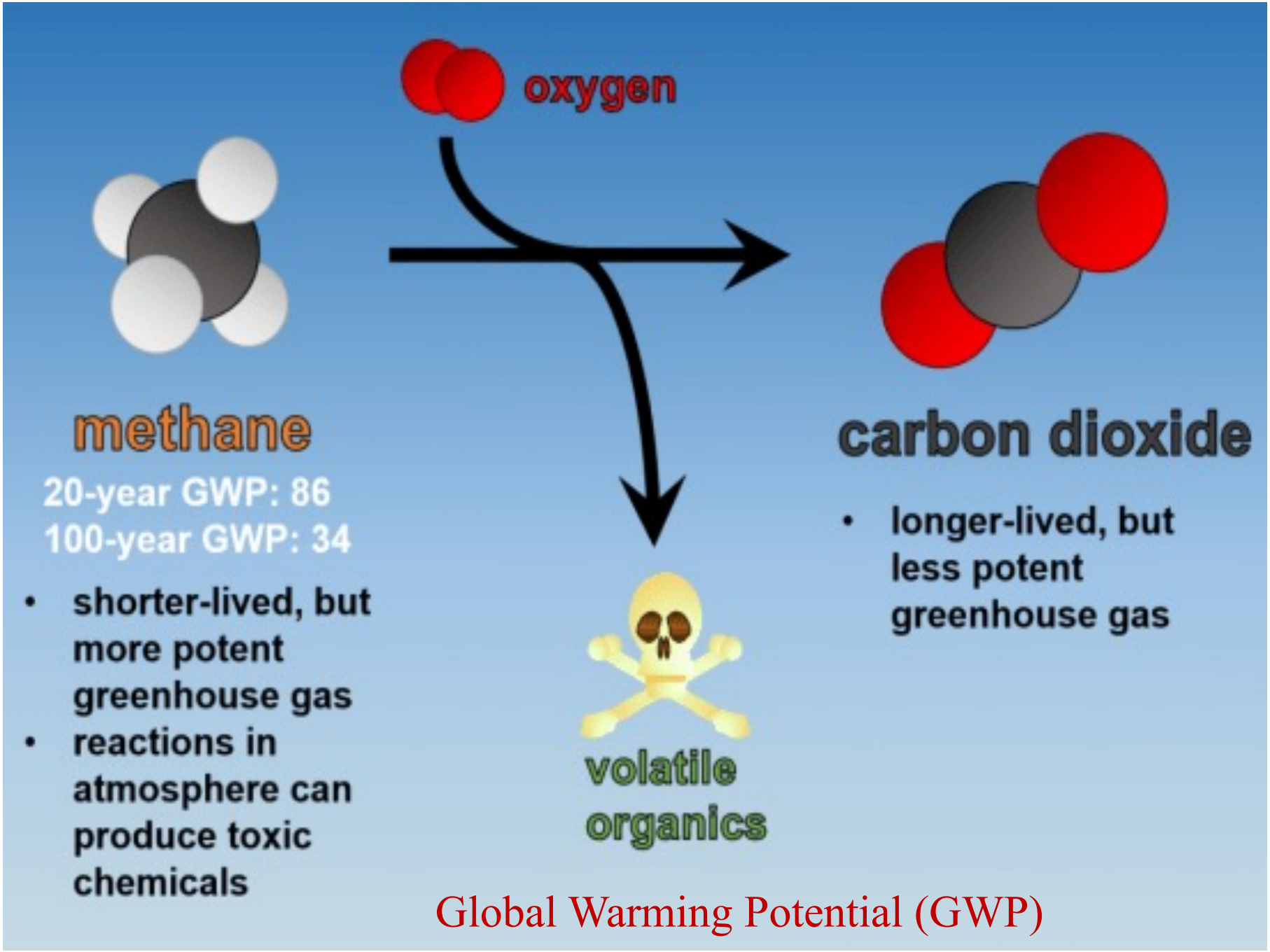
* Global warming potential

Source: U.S. Environmental Protection Agency



Why Methane Matters

- Methane currently accounts for around 20% of man-made global greenhouse gas emissions on a like-for-like basis.
  - ✓ It has a shorter lifetime in the atmosphere than carbon dioxide (**CO_2**), but a greater near-term warming potential. (GWP)
  - ✓ Methane has more than 86 times the warming power of CO_2 over the first 20 years after it reaches the atmosphere.
- As methane is emitted into the air, it reacts in several hazardous ways:
  - ✓ For one, methane primarily leaves the atmosphere through oxidization, forming ***water vapor*** and ***carbon dioxide***.
  - ✓ So, not only does methane contribute to global warming directly but also, indirectly through the release of *carbon dioxide.*
  - ✓ It is a major source of ground-level ozone pollution, which damages human health and plants.
  - ✓ Ozone is itself a short-lived greenhouse gas.



Global Warming Potential (GWP)

CARBON FOOTPRINT?

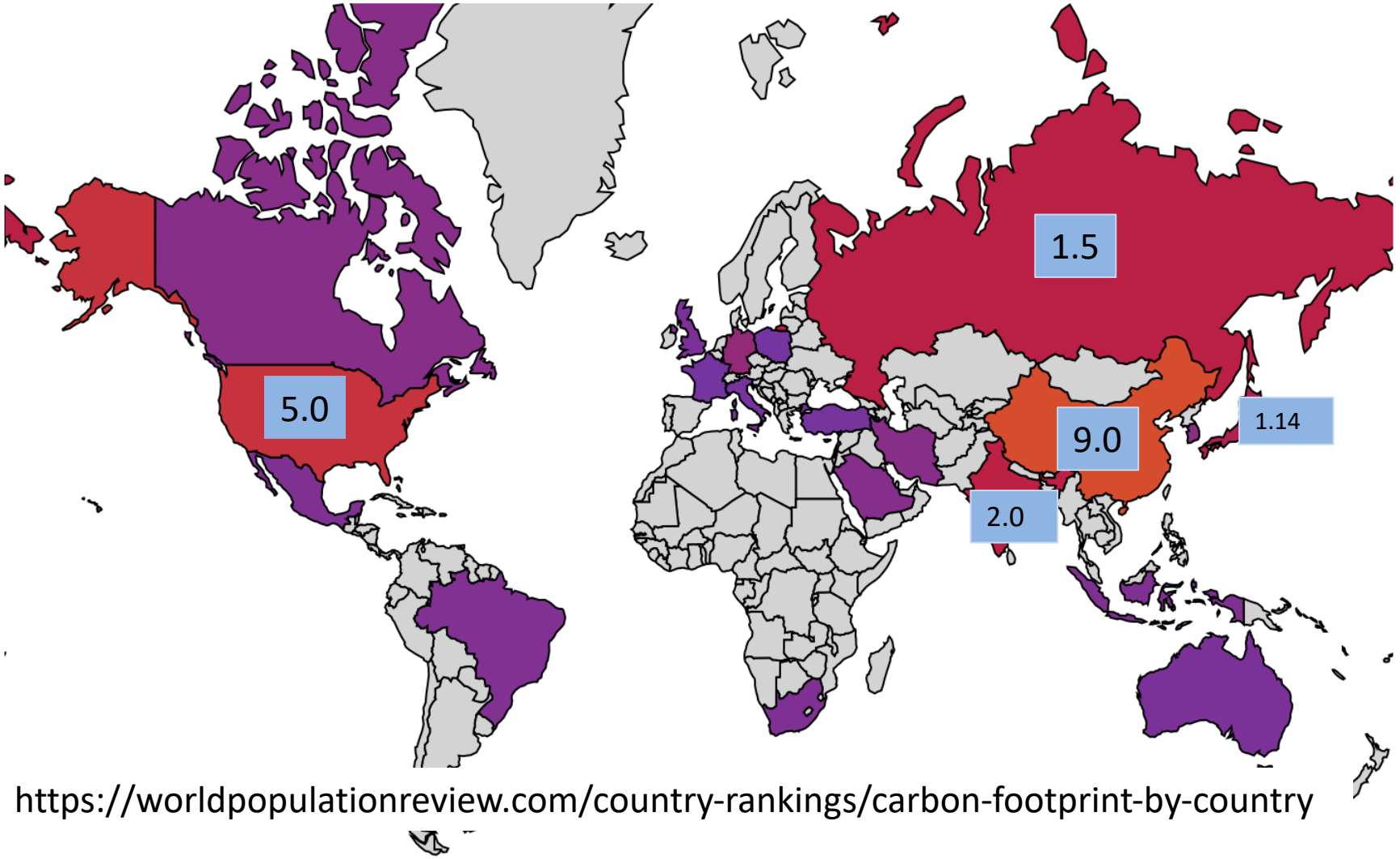
A carbon footprint is the total amount of greenhouse gases (including carbon dioxide and methane) that are generated by our actions.

The average carbon footprint for a person in the United States is 16 tons, one of the highest rates in the world.

Globally, the average carbon footprint is closer to 4 tons.

To have the best chance of avoiding a 2°C (3.6 F) rise in global temperatures, the average global carbon footprint per year needs to drop to under 2 tons by 2050

Carbon Footprint by Country 2021



https://worldpopulationreview.com/country-rankings/carbon-footprint-by-country

Total Emissions

0 | 1.00 Bn | 2.00 Bn | 3.00 Bn | 4.00 Bn | 5.00 Bn | 6.00 Bn | 7.00 Bn | 8.00 Bn | 9.00 Bn | 10.00 Bn

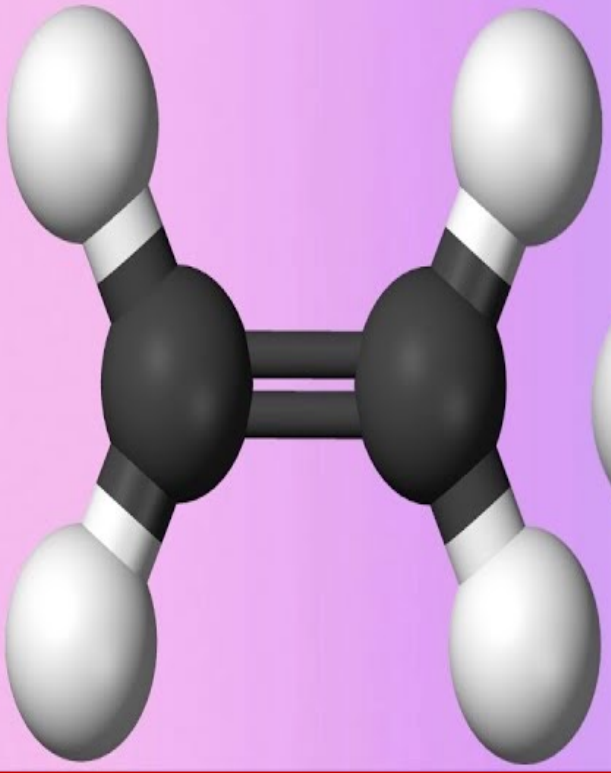
United States **Total Emissions:** 5.00 Bn **Per Capita Emissions:** 15.53 **2021 Population:** 332,915,073

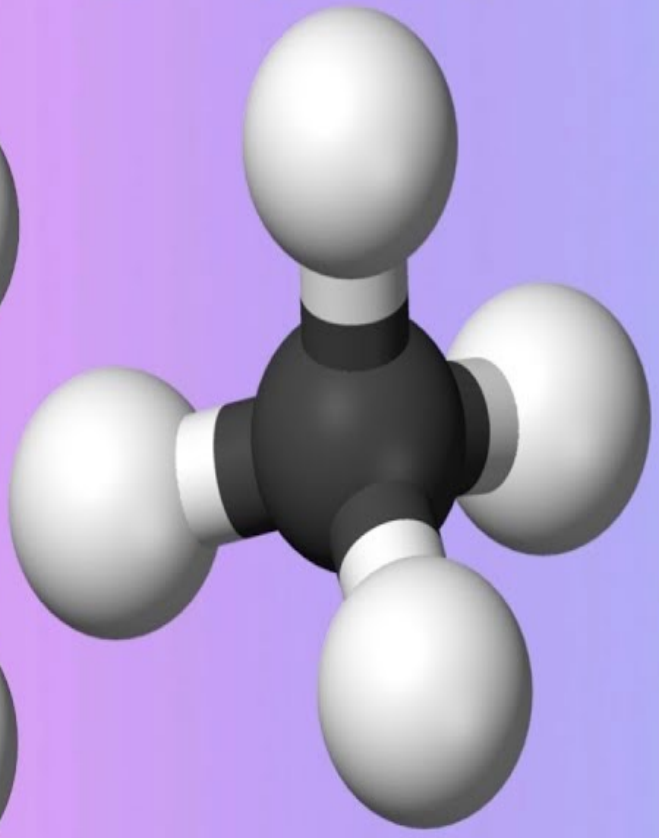
CHEMISTRY OF HYDROCARBONS

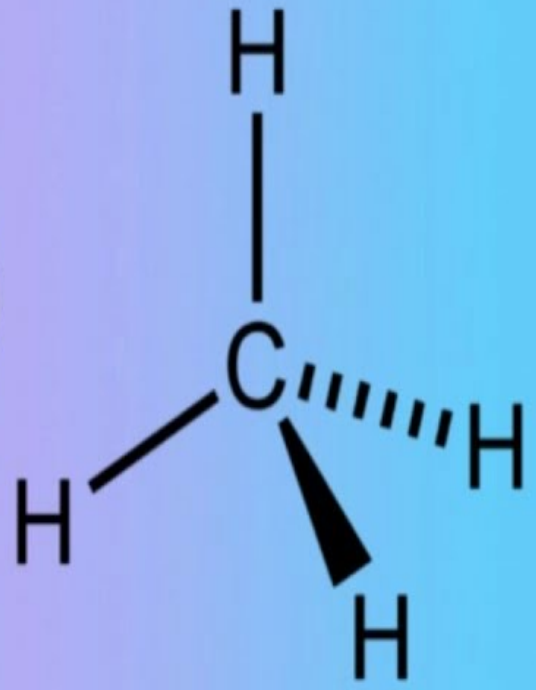
WHY CARBON?

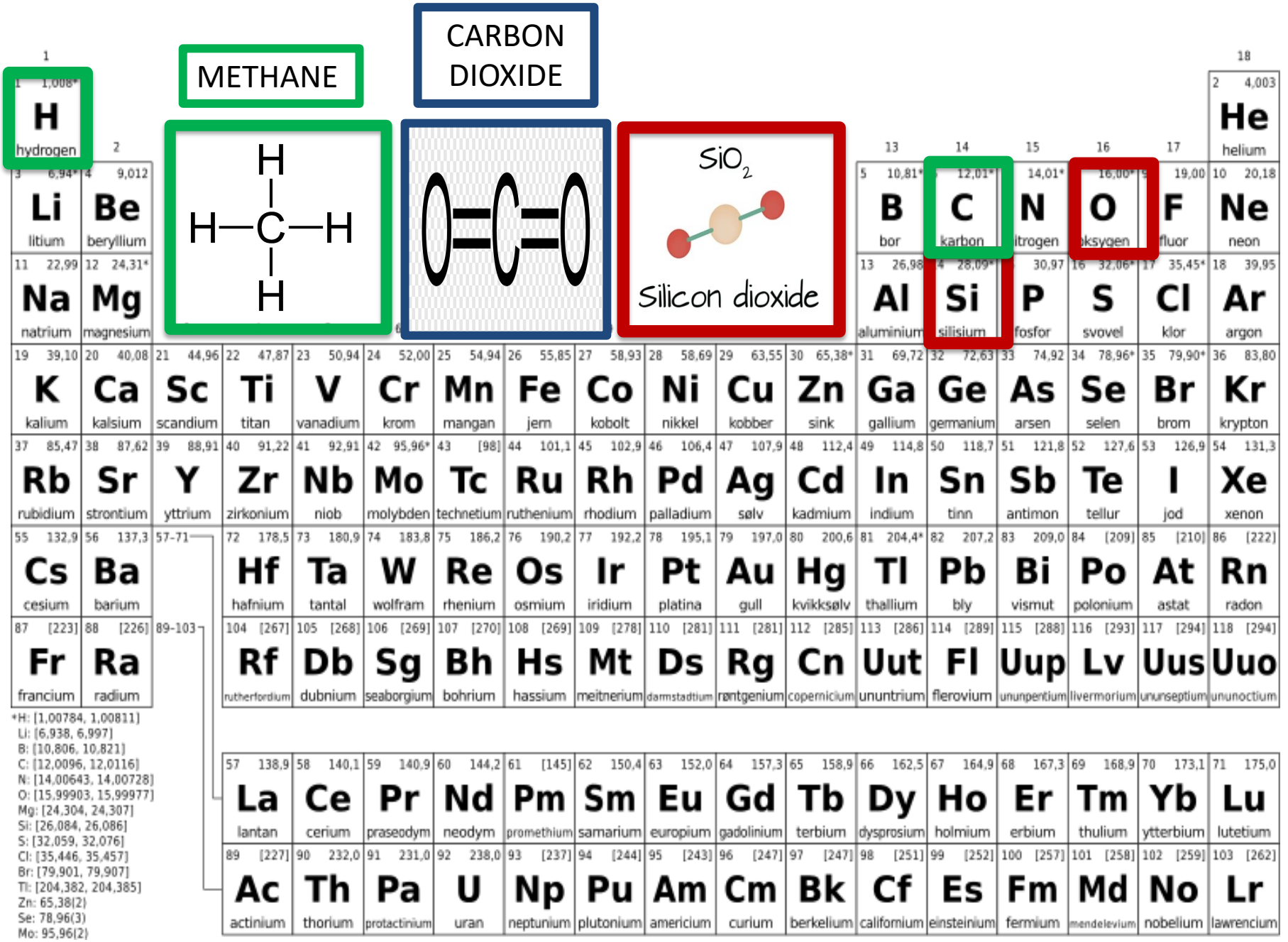
- **Carbon is the only element that can form so many different compounds.**
- **Each carbon atom can form four chemical bonds to other atoms.**
- **The carbon atom is just the right, small size to fit in comfortably as parts of very large molecules.**
- **We, as humans, are a collection of very large carbon molecules!**

Hydrocarbons








METHANE
CARBON DIOXIDE
SiO2
Silicon dioxide
1
18
1 1,008* H hydrogen
2 4,003 He helium
3 6,94* Li litium
4 9,012 Be beryllium
5 10,81* B bor
6 12,01* C karbon
7 14,01* N itrogen
8 16,00* O ksygen
9 19,00 F fluor
10 20,18 Ne neon
11 22,99 Na natrium
12 24,31* Mg magnesium
13 26,98 Al aluminium
14 28,09* Si silisium
15 30,97 P fosfor
16 32,06* S svovel
17 35,45* Cl klor
18 39,95 Ar argon
19 39,10 K kalium
20 40,08 Ca kalsium
21 44,96 Sc scandium
22 47,87 Ti titan
23 50,94 V vanadium
24 52,00 Cr krom
25 54,94 Mn mangan
26 55,85 Fe jern
27 58,93 Co kobolt
28 58,69 Ni nikkel
29 63,55 Cu kobber
30 65,38* Zn sink
31 69,72 Ga gallium
32 72,63 Ge germanium
33 74,92 As arsen
34 78,96* Se selen
35 79,90* Br brom
36 83,80 Kr krypton
37 85,47 Rb rubidium
38 87,62 Sr strontium
39 88,91 Y yttrium
40 91,22 Zr zirkonium
41 92,91 Nb niob
42 95,96* Mo molybden
43 [98] Tc technetium
44 101,1 Ru ruthenium
45 102,9 Rh rhodium
46 106,4 Pd palladium
47 107,9 Sølv
48 112,4 Cd kadmium
49 114,8 In indium
50 118,7 Sn tinn
51 121,8 Sb antimon
52 127,6 Te tellur
53 126,9 I jod
54 131,3 Xe xenon
55 132,9 Cs cesium
56 137,3 Ba barium
57-71
72 178,5 Hf hafnium
73 180,9 Ta tantal
74 183,8 W wolfram
75 186,2 Re rhenium
76 190,2 Os osmium
77 192,2 Ir iridium
78 195,1 Pt platina
79 197,0 Au gull
80 200,6 Hg kvikksølv
81 204,4* Tl thallium
82 207,2 Pb bly
83 209,0 Bi vismut
84 [209] Po polonium
85 [210] At astat
86 [222] Rn radon
87 [223] Fr francium
88 [226] Ra radium
89-103
104 [267] Rf rutherfordium
105 [268] Db dubnium
106 [269] Sg seaborgium
107 [270] Bh bohrium
108 [269] Hs hassium
109 [278] Mt meitnerium
110 [281] Ds darmstadtium
111 [281] Rg røntgenium
112 [285] Cn copernicium
113 [286] Uut ununtrium
114 [289] Fl flerovium
115 [288] Uup ununpentium
116 [293] Lv livermorium
117 [294] Uus ununseptium
118 [294] Uuo ununoctium
57 138,9 La lantan
58 140,1 Ce cerium
59 140,9 Pr praseodym
60 144,2 Nd neodym
61 [145] Pm promethium
62 150,4 Sm samarium
63 152,0 Eu europium
64 157,3 Gd gadolinium
65 158,9 Tb terbium
66 162,5 Dy dysprosium
67 164,9 Ho holmium
68 167,3 Er erbium
69 168,9 Tm thulium
70 173,1 Yb ytterbium
71 175,0 Lu lutetium
89 [227] Ac actinium
90 232,0 Th thorium
91 231,0 Pa protactinium
92 238,0 U uran
93 [237] Np neptunium
94 [244] Pu plutonium
95 [243] Am americium
96 [247] Cm curium
97 [247] Bk berkelium
98 [251] Cf californium
99 [252] Es einsteinium
100 [257] Fm fermium
101 [258] Md mendelevium
102 [259] No nobelium
103 [262] Lr lawrencium
*H: [1,00784, 1,00811]
Li: [6,938, 6,997]
B: [10,806, 10,821]
C: [12,0096, 12,0116]
N: [14,00643, 14,00728]
O: [15,99903, 15,99977]
Mg: [24,304, 24,307]
Si: [26,084, 26,086]
S: [32,059, 32,076]
Cl: [35,446, 35,457]
Br: [79,901, 79,907]
Tl: [204,382, 204,385]
Zn: 65,38(2)
Se: 78,96(3)
Mo: 95,96(2)

Alkanes are compounds that consist entirely of **atoms of carbon and hydrogen bonded to one another** by carbon-carbon and carbon-hydrogen single bonds.

General formula

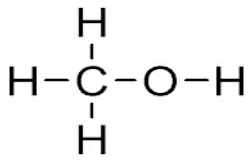
The alkanes C_nH_{2n+2}

- Methane CH_4
- Ethane C_2H_6
- Propane C_3H_8
- Butane C_4H_{10}
- Pentane C_5H_{12}
- Hexane C_6H_{14}
- Octane C_8H_{18}

Homologous group – similar chemical properties, structures and functional groups

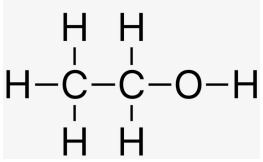
CH_4 is also Carbon tetrahydride

Alcohol is any chemical having an OH functional group.



Methanol

- When ingested, the body metabolizes methanol into formaldehyde and formic acid,which in large amounts are **toxic/fatal**.



Ethanol

- Ethanol (or ethyl alcohol) is the type of alcohol that over two billion people drink every day.
- ✓ This type of alcohol is produced by the fermentation of yeast, sugars, and starches.

- **Ethanol** is a renewable fuel made from various plant materials collectively known as "biomass."
- More than 98% of U.S. gasoline contains ethanol, typically E10 (10% ethanol, 90% gasoline), to oxygenate the fuel, which reduces air pollution.

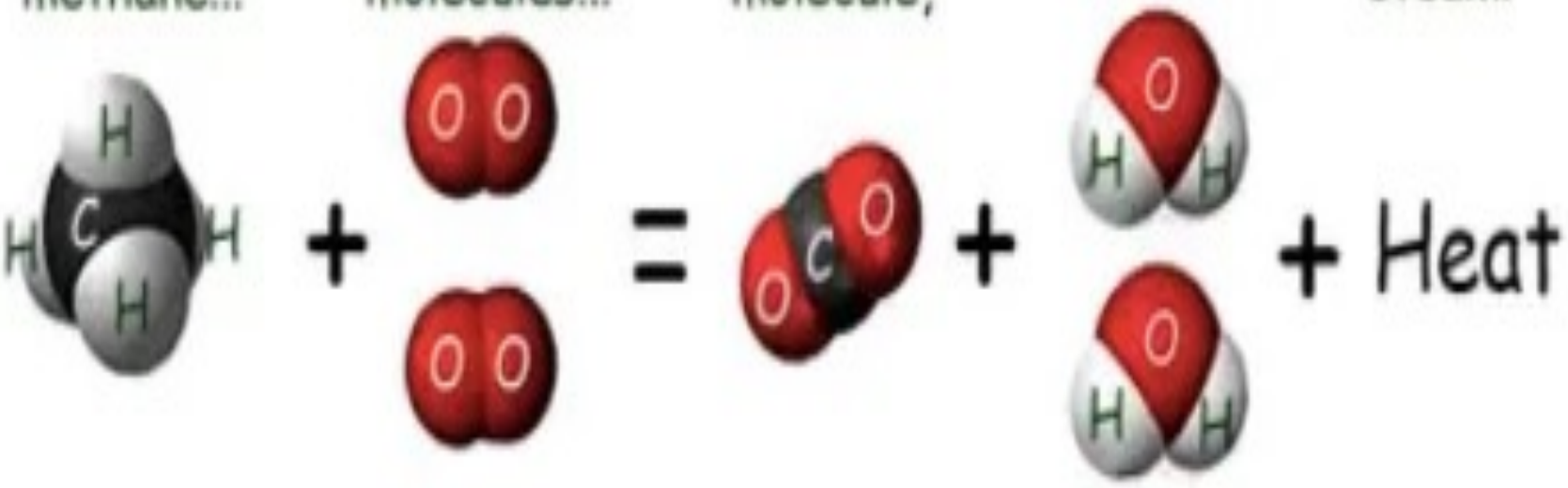
Burning one molecule of methane...

...with two oxygen molecules...

makes one carbon dioxide molecule,

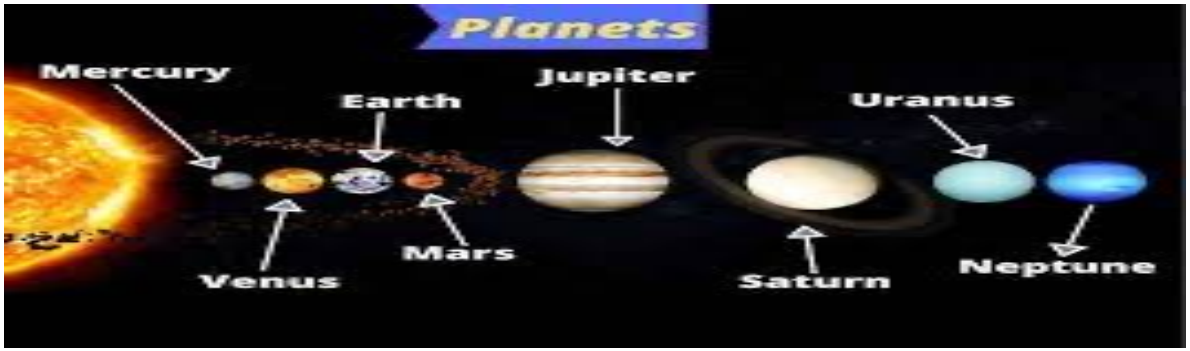
two water molecules...

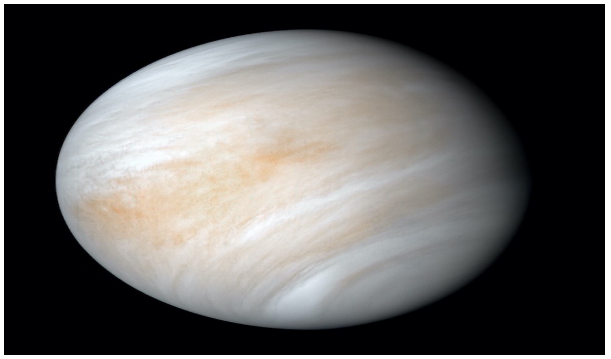
...and heat to make steam.



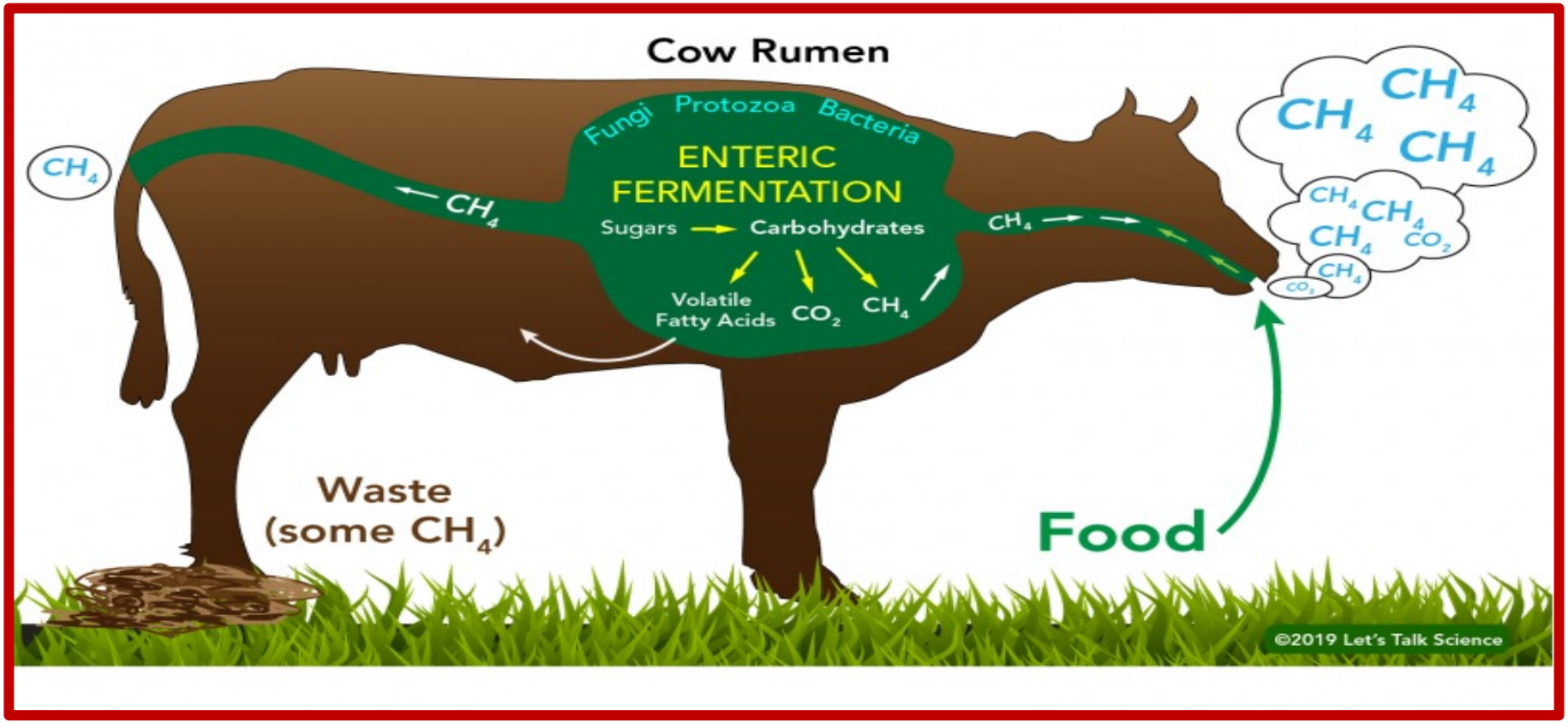
$$CH_4 + 2O_2 = CO_2 + 2H_2O + \text{Heat}$$

METHANE 101





- Methane (CH_4) is abundant on the giant planets—**Jupiter, Saturn, Uranus and Neptune**.
- **Jupiter** is the largest planet in the Solar System.
  - ✓ ***Methane*** is the most abundant gas after hydrogen and helium.
- On **Mars**, a background level of methane at **about 0.41 parts per billion** has been constant. .
  - ✓ Methane in the atmosphere of Mars is of interest to geologists and astrobiologists, as methane **may** **indicate the presence of microbial life on Mars**.
  - ✓ NASA has noted six separate occasions where the amount of methane in the vicinity of *Curiosity* has increased significantly.

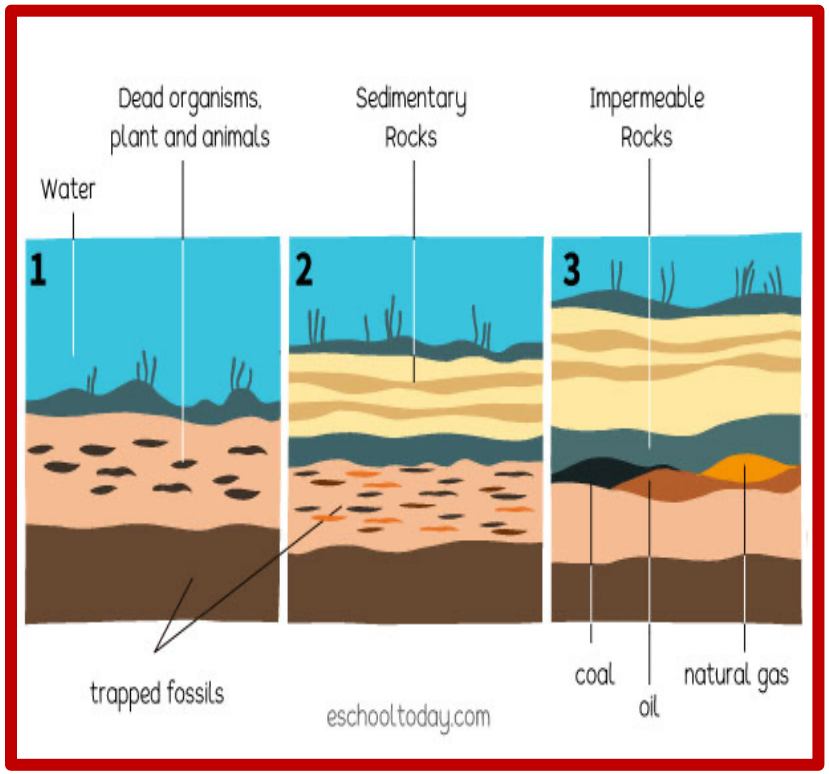


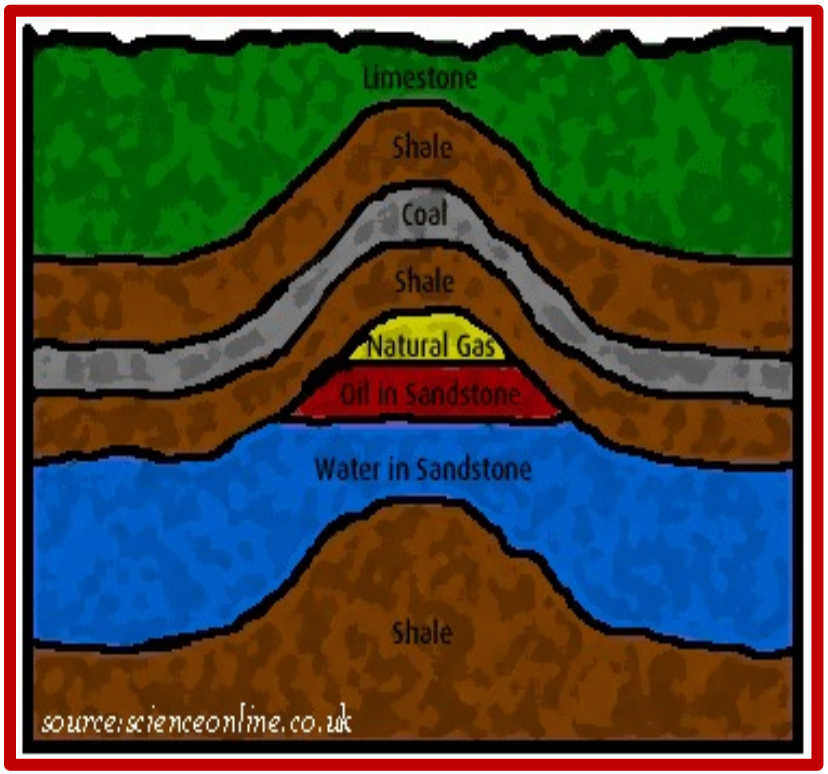
- An important process called **enteric fermentation** takes place in the rumen.
- Bacteria break down complex carbohydrates into simple sugars.
- The end products of enteric fermentation by bacteria include **volatile fatty acids (VFAs)** as well as gases, such as: carbon dioxide & methane.


THE GOOD NEWS IS, WE'RE NOT SO BAD FOR THE ENVIRONMENT...
AND THE BAD NEWS?
WE'RE BACK ON THE MENU
BEEF OFF WORST OFFENDERS LIST


Cow Methane Emissions
(Burp - 95% Fart - 5%)
95%
5%
shutterstock.com · 1483662548

- Natural gas is formed **when layers of decomposing plant and animal matter are exposed to intense heat and pressure under the surface of the Earth over millions of years**.
- The energy that the plants originally obtained from the sun is stored in the form of chemical bonds in the gas.
- Natural gas is a fossil fuel.

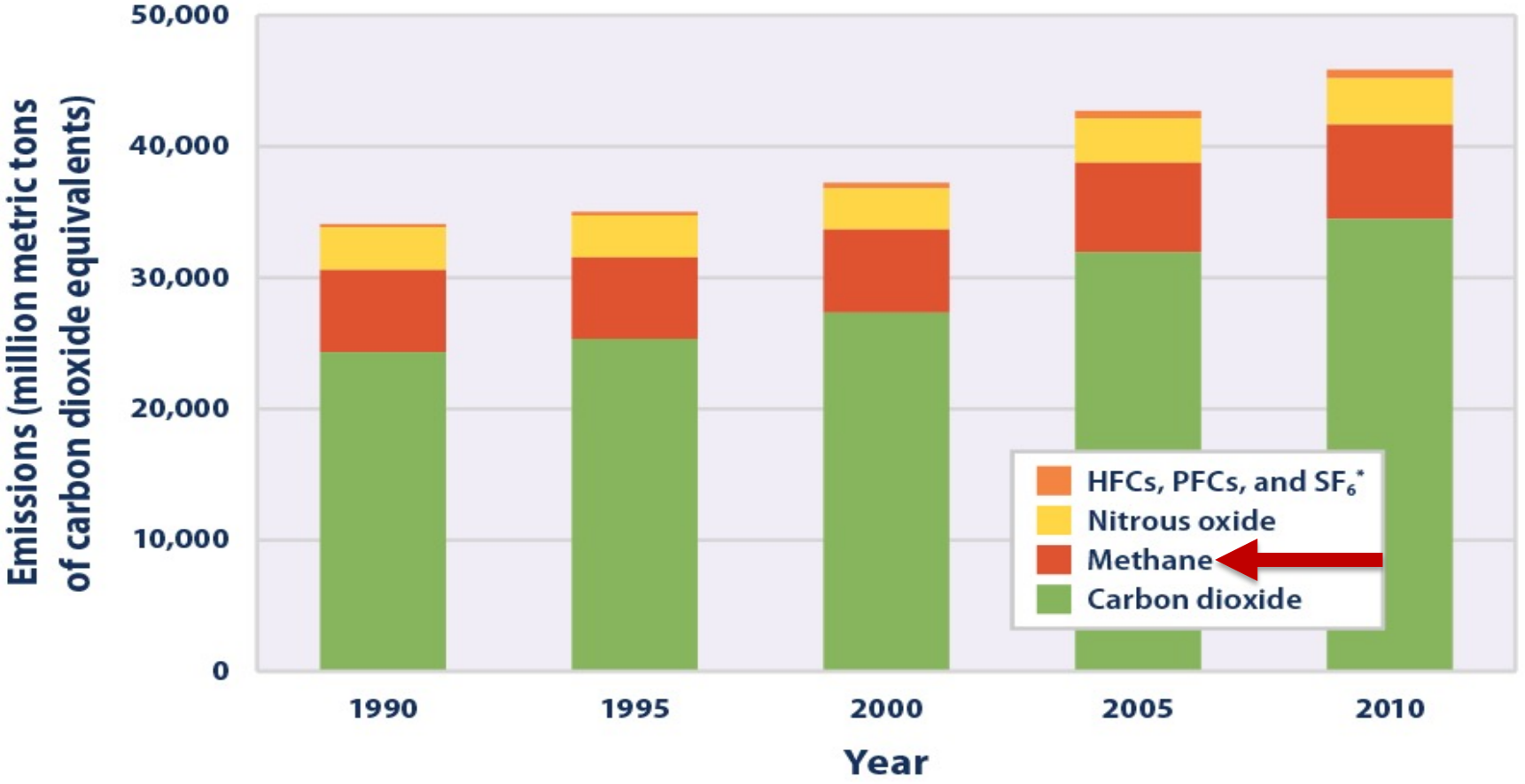




Crude oil and natural gas have different uses:

- After refinement Crude Oil is generally used for:
  - ✓ *Gasoline*
  - ✓ *Heating Oil & Diesel Fuels*
  - ✓ *Other Products (such as plastics)*
  - ✓ *Jet Fuel*
  - ✓ *Propane*
  - ✓ *Residential Fuel Oil*
  - ✓ *Asphalt*
- Whereas Natural Gas is used for:
  - ✓ *Electrical Power Generation*
  - ✓ *Residential Heating*
  - ✓ *Commercial Heating*
  - ✓ *Industrial Production*

Global Greenhouse Gas Emissions by Gas, 1990–2010



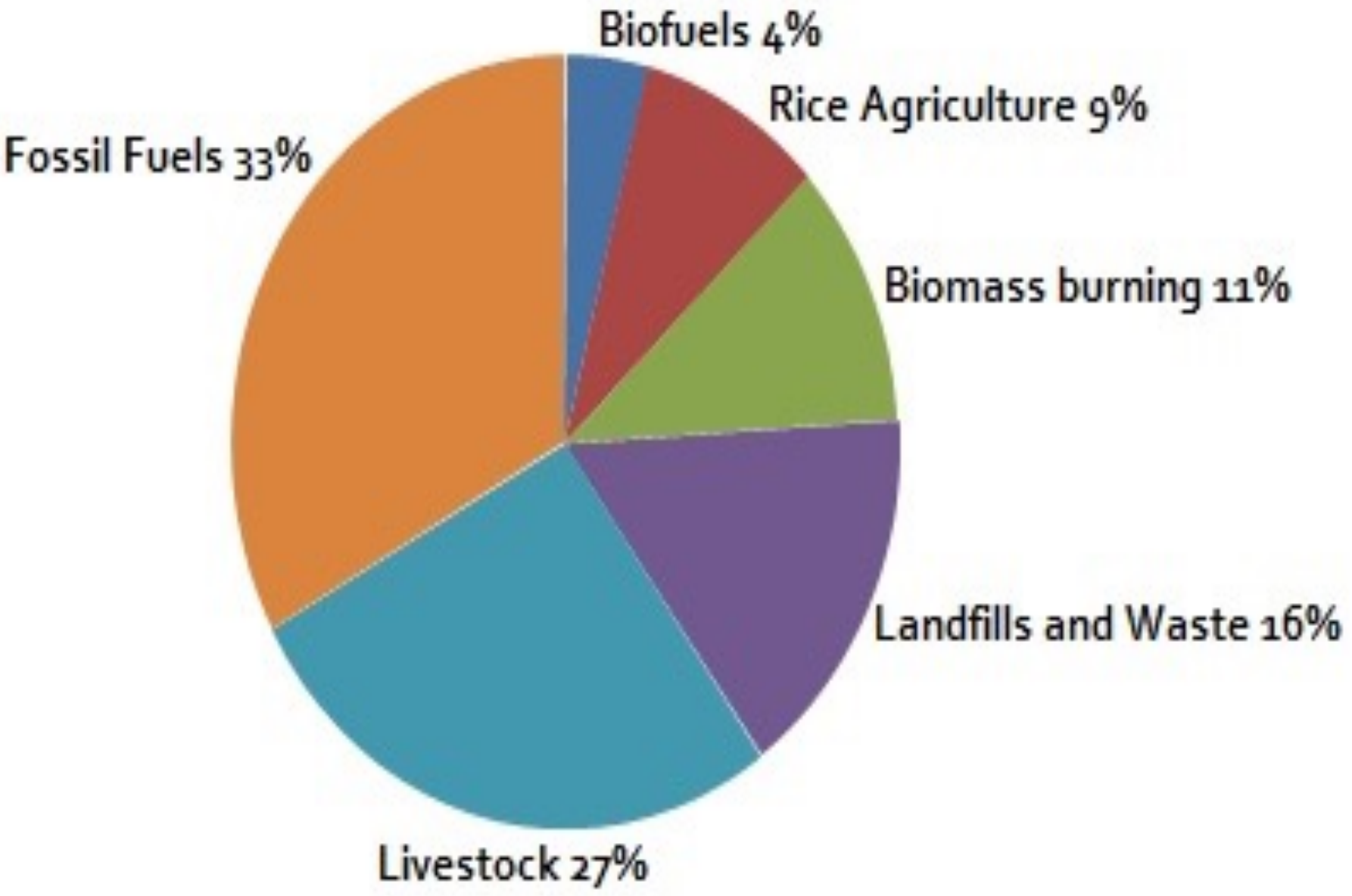
* HFCs are hydrofluorocarbons, PFCs are perfluorocarbons, and SF_6 is sulfur hexafluoride.

Data sources:

- WRI (World Resources Institute). 2014. Climate Analysis Indicators Tool (CAIT) 2.0: WRI's climate data explorer. Accessed May 2014. http://cait.wri.org.
- FAO (Food and Agriculture Organization). 2014. FAOSTAT: Emissions—land use. Accessed May 2014. http://faostat3.fao.org/faostat-gateway/go/to/download/G2/*/E./bird/bacc/techreport.html.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climate-indicators.

METHANE SOURCES



METHANE NONCONTAINMENT

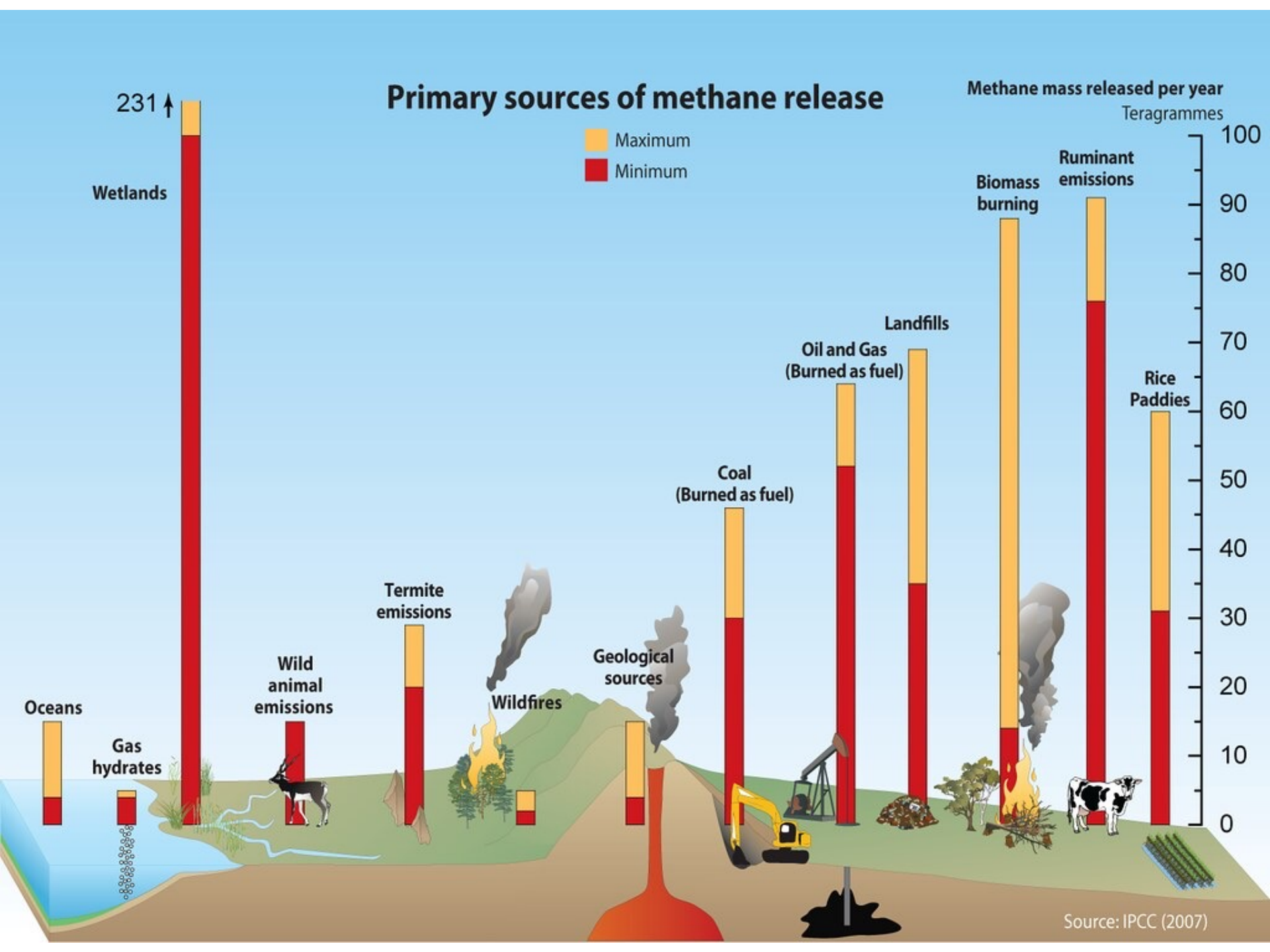
- Natural gas is an odorless, gaseous mixture of hydrocarbons—predominantly made up of methane (**CH4**).
- For easy detection, **a harmless chemical called *mercaptan* is added** to give gas a distinctive odor.
- It accounts for about 30% of the energy used in the United States.
  - ✓ About 40% of the fuel goes to electric power production and the remaining is split between residential and commercial uses.
  - ✓ Although natural gas has long been used to power natural gas vehicles, only about two-tenths of 1% is used for transportation fuel.
- Renewable natural gas (RNG), (*biomethane)*, is a vehicle fuel produced from organic materials through anaerobic digestion.
- RNG qualifies as an advanced biofuel under the Renewable Fuel Standard.

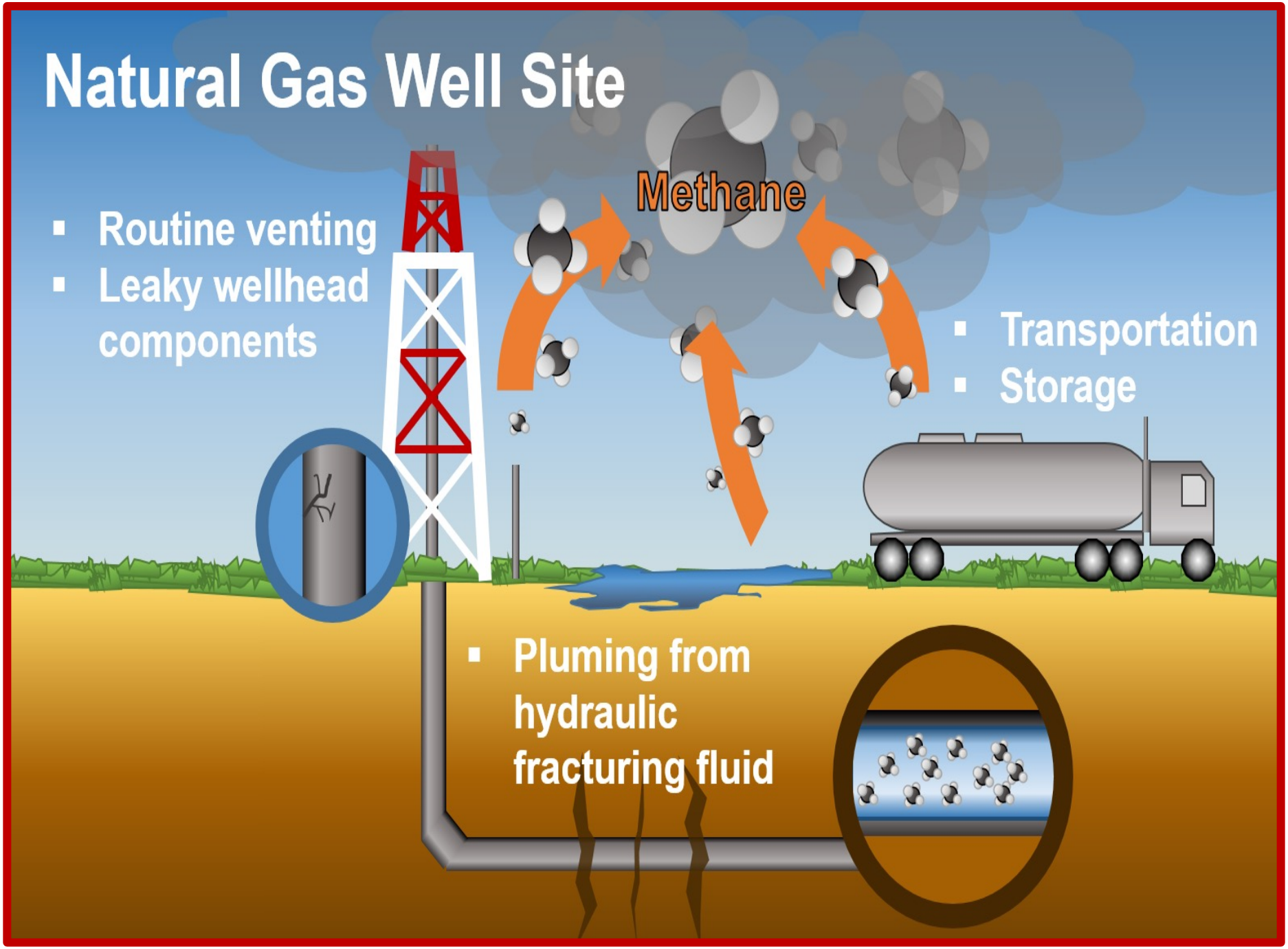
Risks of Methane Gas Poisoning Exposure

- **While low concentrations are generally not harmful, higher concentrations lead to less oxygen availability and a range of symptoms may be experienced, including:**

Rapid breathing	**Weakness**
Increased heart rate	**Fatigue**
Clumsiness and dizziness	**Fainting and collapse**
Decreased vision	**Euphoria**
Decreased alertness	**Loss of memory**
Emotional responses	**Convulsions**
Coma	**Death**

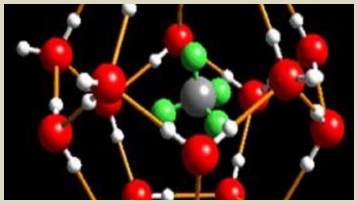
- **Long-term effects can include lasting cardiovascular, respiratory, and neurological problems.**
- **Those who have been exposed are also at an increased risk of:**
  - ✓ **developing memory loss**
  - ✓ **depression**
  - ✓ **epilepsy**
  - ✓ **claustrophobia**
  - ✓ **heart problems**


Primary sources of methane release
Maximum
Minimum
231
Wetlands
Oceans
Gas hydrates
Wild animal emissions
Termite emissions
Wildfires
Geological sources
Coal (Burned as fuel)
Oil and Gas (Burned as fuel)
Landfills
Biomass burning
Ruminant emissions
Rice Paddies
Methane mass released per year
Teragrammes
100
90
80
70
60
50
40
30
20
10
0
Source: IPCC (2007)


Natural Gas Well Site
Methane
Routine venting
Leaky wellhead components
Transportation
Storage
Pluming from hydraulic fracturing fluid

What are gas hydrates?

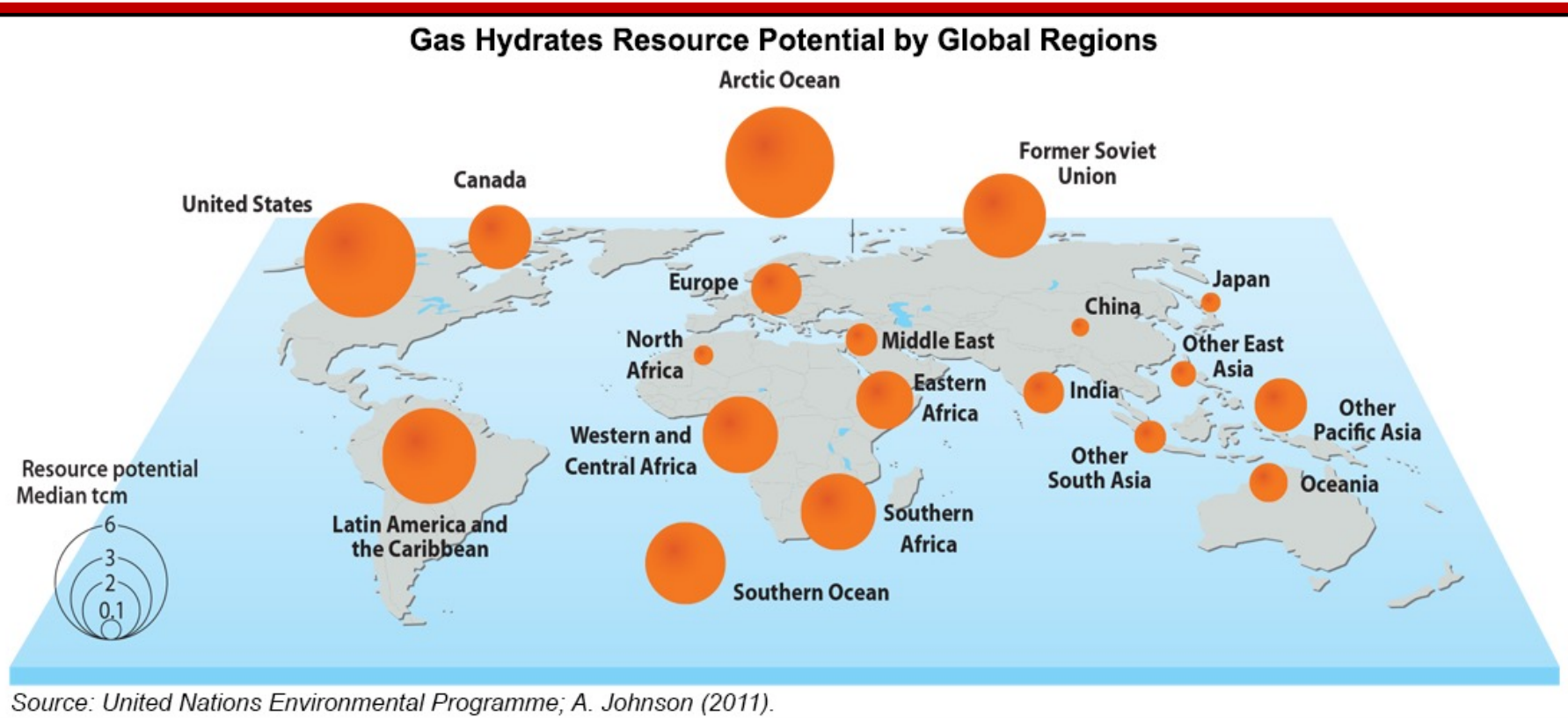
- Gas hydrates are a crystalline solid formed of water and gas. It looks and acts much like ice, but it contains huge amounts of methane;

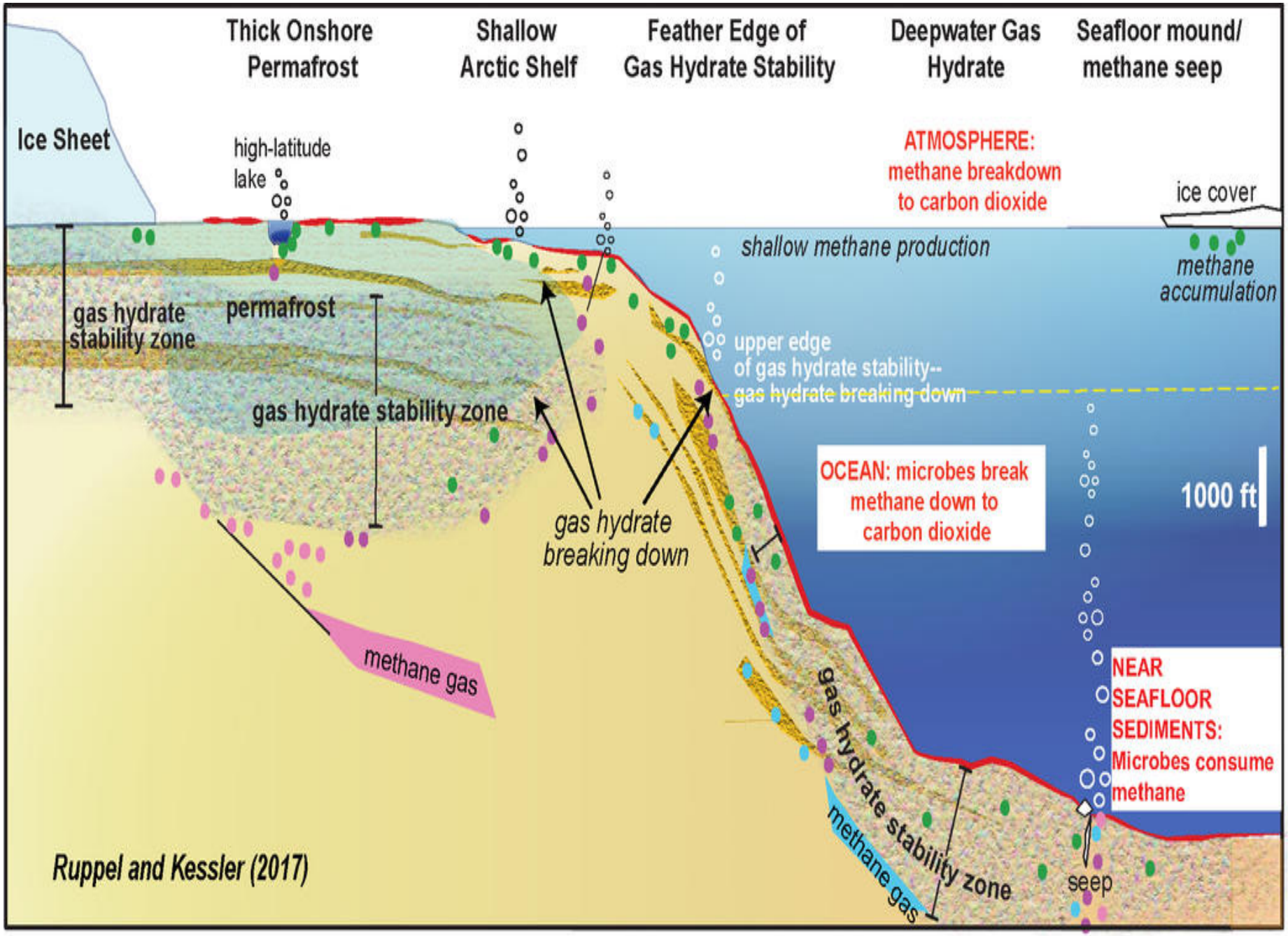


  - ✓ It is known to occur on every continent.
  - ✓ It exists in huge quantities in marine sediments in a layer. several hundred meters thick directly below the sea floor
  - ✓ It is associated with permafrost in the Arctic.
- It is not stable at normal sea-level pressures and temperatures, which is the primary reason that it is a challenge to study.
- Gas hydrates are important for three reasons:
  - ✓ As a major energy resource
  - ✓ It alters sea floor sediment stability, influencing landsliding
  - ✓ It has strong influence on the environment and climate.

Where Does Methane Hydrate Occur?

- Gas hydrate has been recovered or inferred in
  - ✓ many continental margin settings
  - ✓ onshore permafrost
  - ✓ offshore relic permafrost flooded by sea level rise
  - ✓ sediments beneath Lake Baikal, Earth's largest freshwater lake.



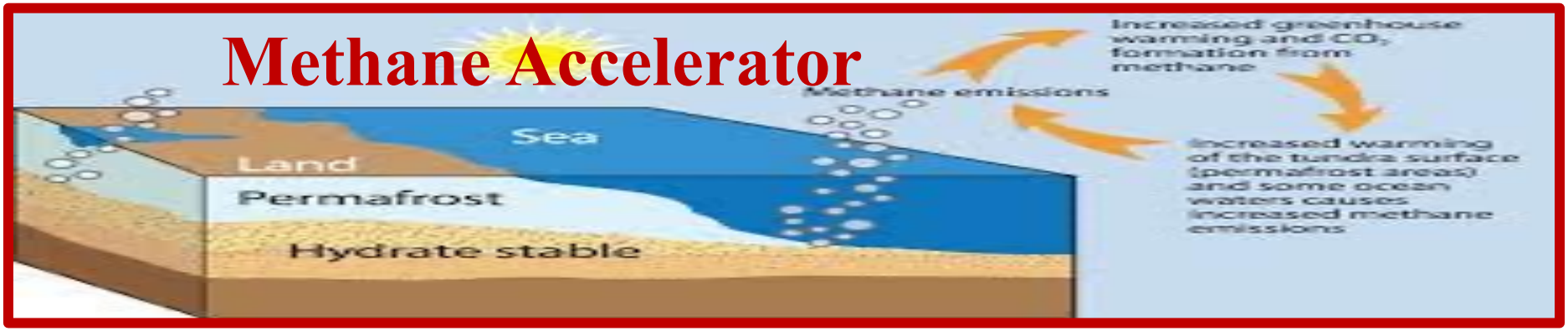

Thick Onshore Permafrost
Shallow Arctic Shelf
Feather Edge of Gas Hydrate Stability
Deepwater Gas Hydrate
Seafloor mound/ methane seep
Ice Sheet
high-latitude lake
ATMOSPHERE: methane breakdown to carbon dioxide
ice cover
shallow methane production
methane accumulation
gas hydrate stability zone
permafrost
upper edge of gas hydrate stability-- gas hydrate breaking down
gas hydrate stability zone
OCEAN: microbes break methane down to carbon dioxide
1000 ft
gas hydrate breaking down
methane gas
NEAR SEAFLOOR SEDIMENTS: Microbes consume methane
gas hydrate stability zone
methane gas
seep
Ruppel and Kessler (2017)

SO WHAT?

- New attention to methane means the public will be hearing that climate change is:
  - ✓ Much more severe than previously thought.
  - ✓ Accelerating at a geometric (as opposed to an arithmetic) rate.
- The released methane is the "X Factor" in climate change, independently functioning as:
  - ✓ a powerful accelerant of greater atmospheric heating,
  - ✓ faster ice melt
  - ✓ more severe weather disturbances
  - ✓ ocean acidification
  - ✓ rising seas.
- This Vicious Feedback Loop is known as the:

Methane Accelerator

Methane Accelerator



- When the cumulative effects from the Methane Accelerator are fully considered:
  - ✓ Mankind is likely to have already passed the "tipping point!"
  - ✓ Reducing CO2 emissions, ***even to zero***, can not curtail the catastrophic effects of climate change.
- Geologic records from two prior extinction events showed:
  - ✓ A mass extinction of deep-sea organisms.
  - ✓ A killing of over **93%** of all life forms on Earth.
- Compelling evidence ***these events***:

were linked to a rapid escape of methane from marine hydrate reservoirs on continental slopes!!

Darvaza gas crater

Darvaza gas crater, 2011

Location of Darvaza gas crater

Country Turkmenistan

- The **Darvaza gas crater** also known as the **Door to Hell** or **Gates of Hell**, is a natural gas field collapsed into a cavern near Darvaza, Turkmenistan.
- Accurate records of how the crater ignited have not been discovered, and some facts are disputed.
  - ✓ One theory is that Soviet geologists intentionally set it on fire in 1971 to prevent the spread of methane gas.
  - ✓ It is thought to have been burning continuously ever since.
- The gas crater has an area of 1⅓ acres with a diameter is 226 ft and a depth is 98 ft.
- The crater has become a popular tourist attraction

NEXT

Back

METHANE'S EFFECTS

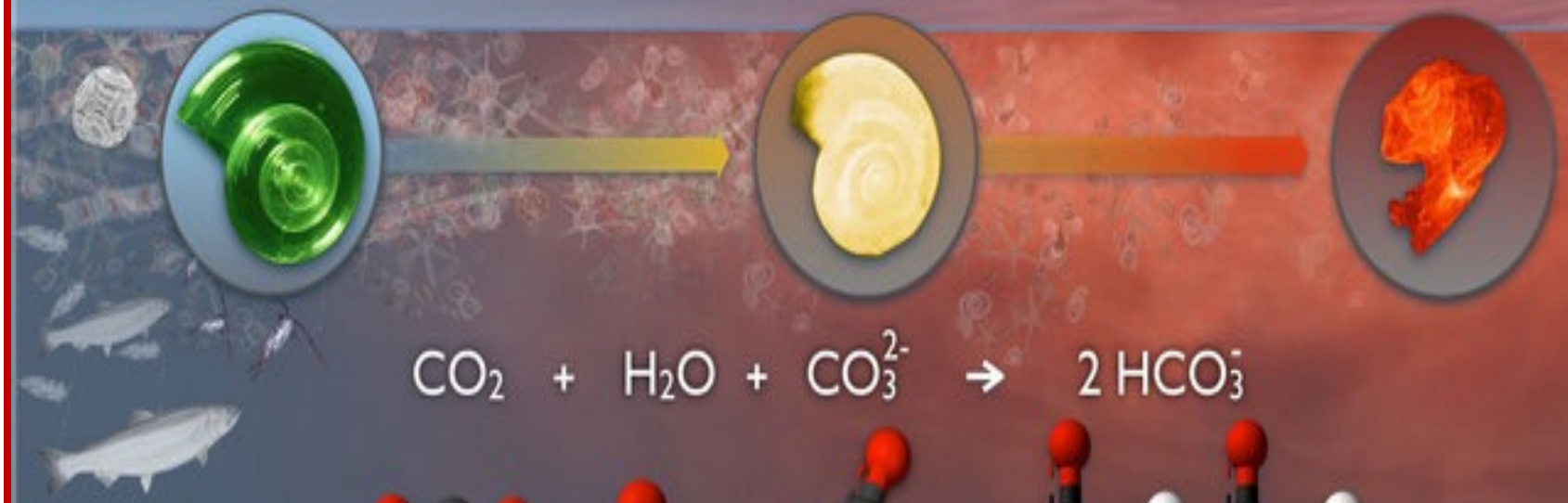
How Does Methane Contribute to Global Warming?

- ***Methane***, a primary component of natural gas, accounts for ¼ of all the heat trapped in the atmosphere since the pre-industrial era.
- Methane is the second biggest contributor to greenhouse gases after carbon dioxide, and 28 to 34 times as warming as CO2 over a century.
- While methane can trap heat at higher rates than CO2, it degrades quickly and breaks down in the atmosphere faster.
- Atmospheric levels of methane have climbed 150% over the past 200 years while global CO2 levels have risen about 50%.

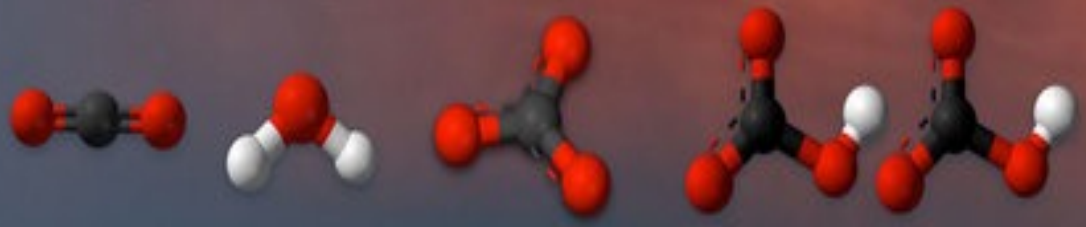
OCEAN ACIDIFICATION

HOW WILL CHANGES IN OCEAN CHEMISTRY AFFECT MARINE LIFE?

CO_2 absorbed from the atmosphere

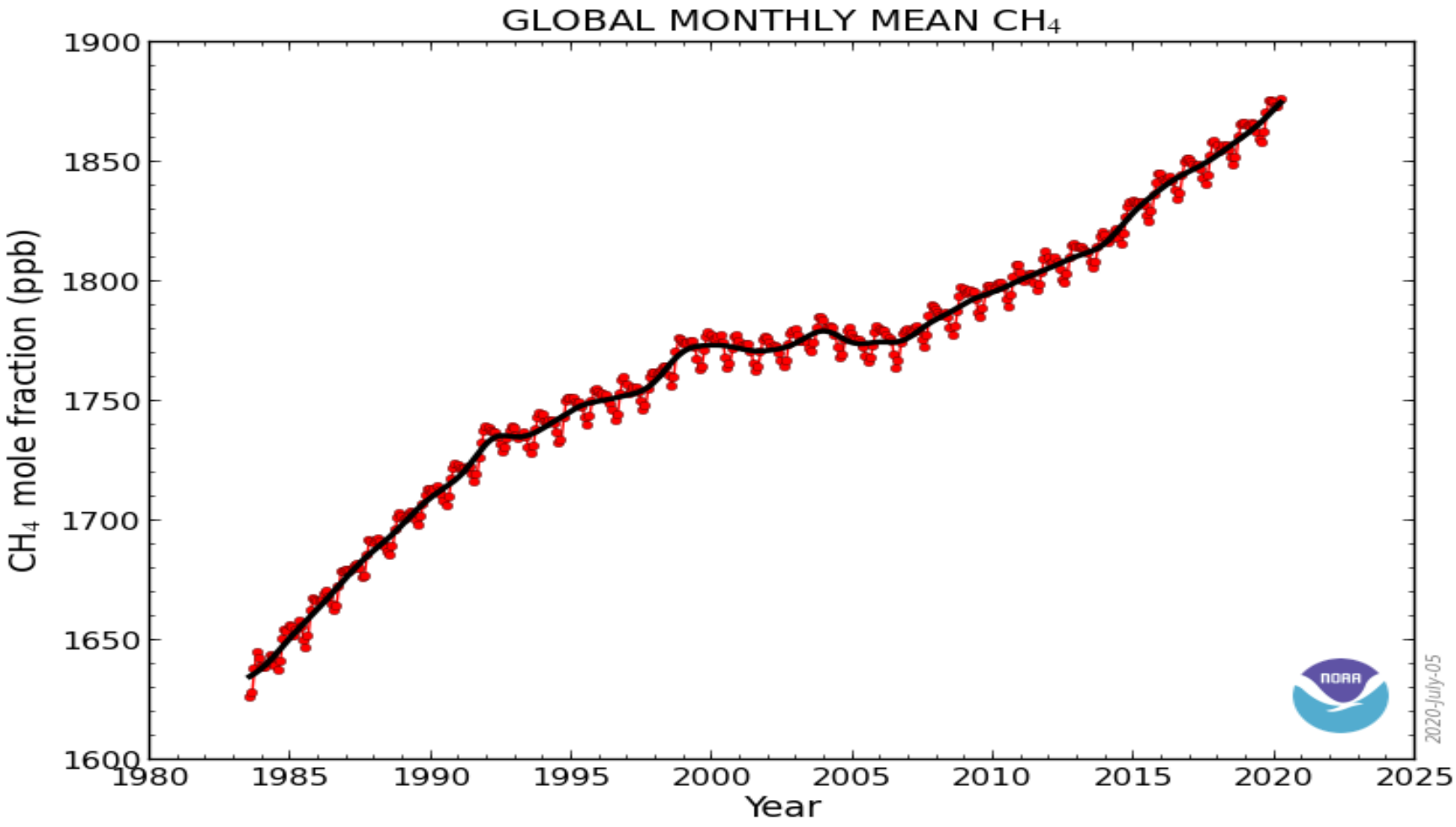


$$CO_2 + H_2O + CO_3^{2-} \rightarrow 2\,HCO_3^-$$



carbon dioxide | water | carbonate ion | 2 bicarbonate ions

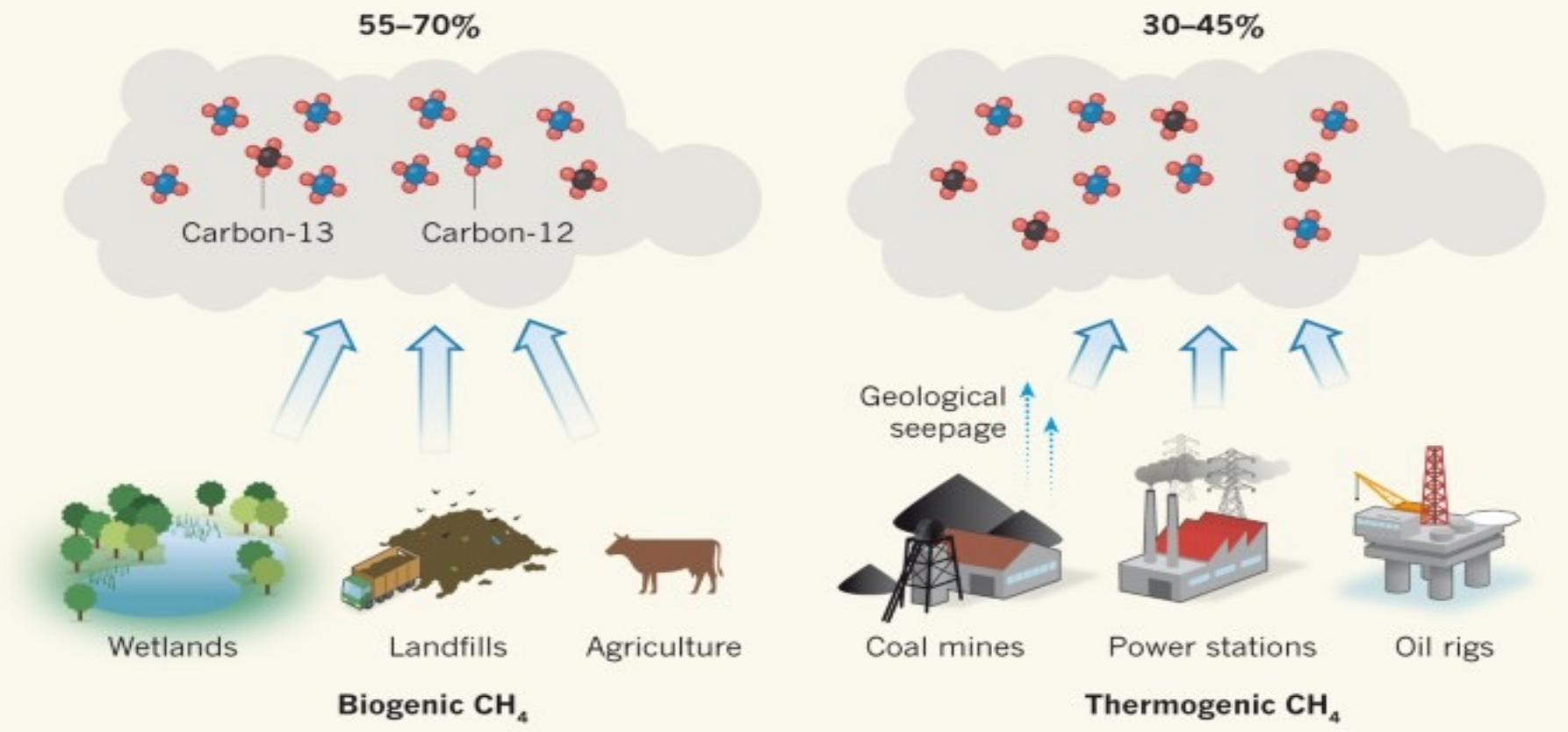
consumption of carbonate ions impedes calcification



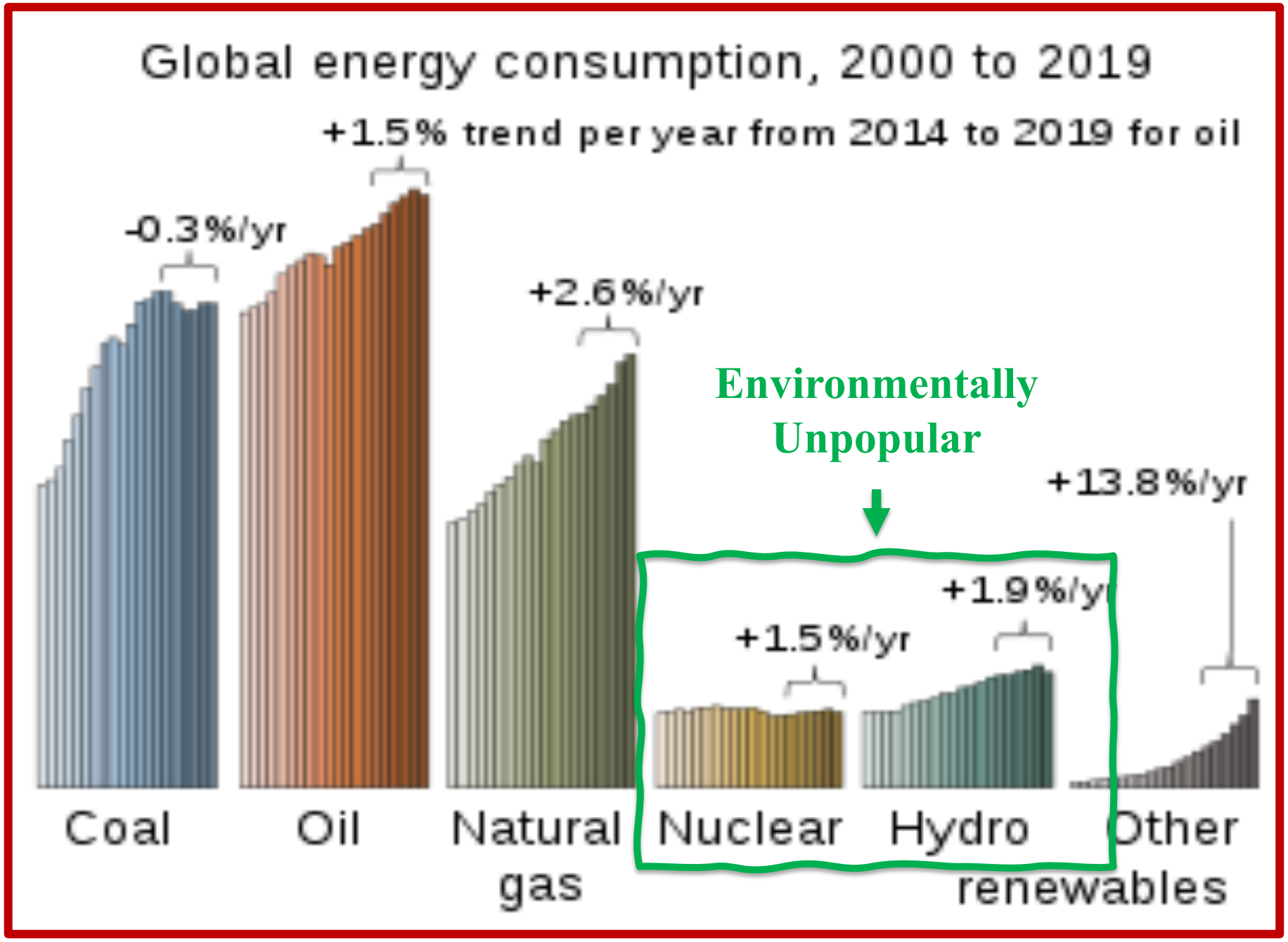
- The increase in methane emissions is mainly attributed to anthropogenic emissions: 60% from agriculture and waste, and 40% from fossil fuel sources.

CLIMATE MITIGATION

Upward revision of global fossil fuel methane emissions



- A database of the carbon-isotope 'fingerprints' of methane has been used to constrain the contributions of different sources to the global methane budget.


Global energy consumption, 2000 to 2019
+1.5% trend per year from 2014 to 2019 for oil
-0.3%/yr
+2.6%/yr
Environmentally Unpopular
+13.8%/yr
+1.9%/yr
+1.5%/yr
Coal
Oil
Natural gas
Nuclear
Hydro
Other renewables

UN CLIMATE CHANGE CONFERENCE UK 2021

IN PARTNERSHIP WITH ITALY

UN

- After over two weeks of conferencing, (COP26) finalized the **Glasgow Climate Pact** listing the accomplishments of the summit:
  - ✓ The Glasgow Pact reaffirms the long-term global goals to:
    - ➢ hold the increase in the global average temperature to "***well below 2°C***" ***above pre-industrial levels***
    - ➢ to pursue efforts to limit temperature increase ***to 1.5°C above pre-industrial levels.***
  - ✓ It also states that limiting global warming to 1.5°C requires "rapid, deep, and sustained reductions in global greenhouse gas emissions, including:
    - ➢ reducing global carbon dioxide emissions by ***45 per cent by 2030 relative to the 2010 level***
    - ➢ Reducing CO_2 emissions ***to net zero around mid-century***, as well as deep reductions in other greenhouse gases."

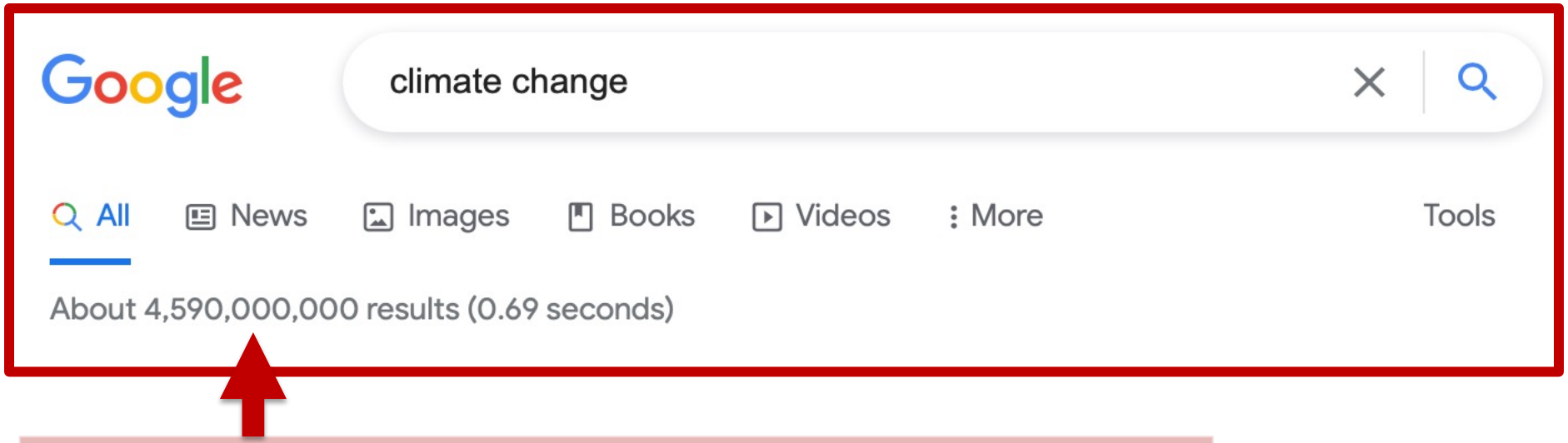
5 key takeaways from COP26

1. For the first time, country commitments bring us closer to the goal of limiting global warming to well below 2ºC.
2. Methane took center stage, with more than 100 countries signing on to the Global Methane Pledge.
3. A broader-than-expected coalition signed on to a commitment to halt global deforestation.
4. References to coal and fossil fuel subsidies made their way into a new Glasgow Climate Pact.
5. The rulebook for voluntary carbon markets was finally established.

Methane Mitigation

- Mitigation strategies include:
  - ✓ reducing waste that ends up in landfills, by recycling and composting
  - ✓ **capturing methane gas**
  - ✓ burning methane gas, which is known as flaring
- In this case, every molecule of methane that goes into the atmosphere remains there for 8 years until it is removed by oxidization into **carbon dioxide (CO2) and water (H2O)**.
- Here are several ways you can help reduce the level of methane in our atmosphere**:**
  - ✓ Support Organic Farming Practices.
    - ➢ Organic farmers keep livestock longer instead of replacing old cows with younger calves. ...
  - ✓ Eat Less Red Meat. ...
  - ✓ Support Farms who use "digesters" ...
  - ✓ Become Active in Your Community…..

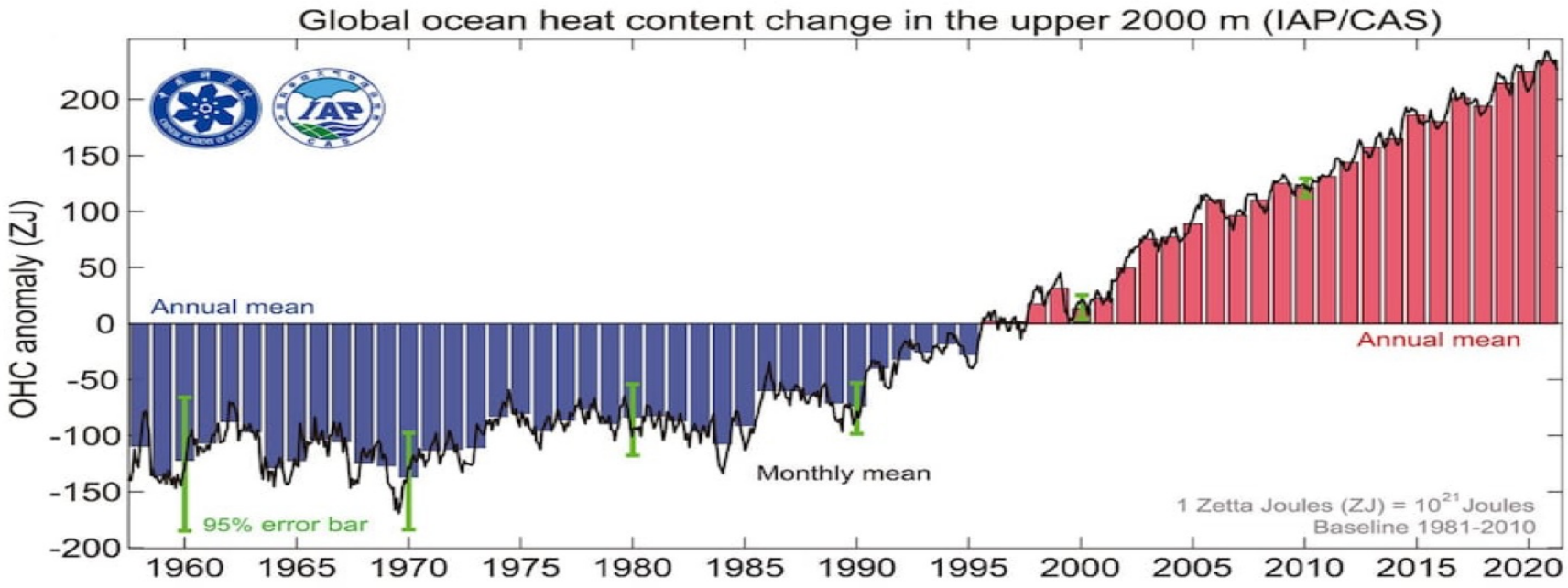
CLIMATE CHANGE ONE MORE TIME



That's 4,590,000,000 hits, as in ~4.6 BILLION

Capital Weather Gang **January 12, 2022**

Ocean warmth sets record high in 2021 as a result of greenhouse gas emissions



- A new analysis, published Tuesday showed that oceans contained the most heat energy in 2021 since measurements began six decades ago — accelerating at a rate only possible because of human-emitted greenhouse gases.
- Since the late 1980s, Earth's oceans warmed at a rate eight times faster than in the preceding decades.

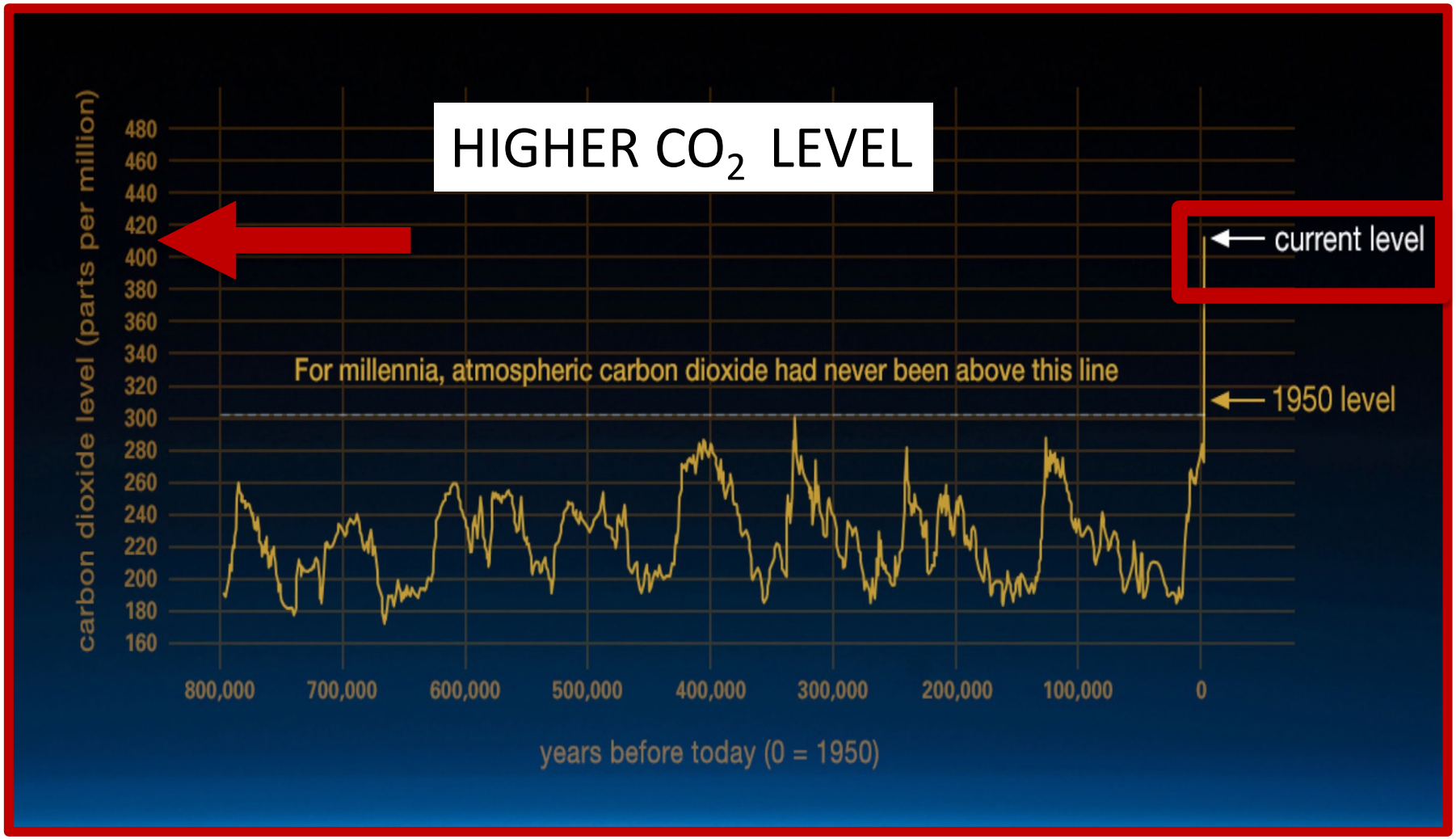
United Nations | UN News
Global perspective Human stories

Home | Topics | In depth

Climate change: For 25th year in a row, Greenland ice sheet shrinks

7 January 2022

- 2021 marked the 25th year in a row in which the key Greenland ice sheet lost more mass during the melting season, than it gained during the winter, according to a new UN-endorsed report issued on Friday.



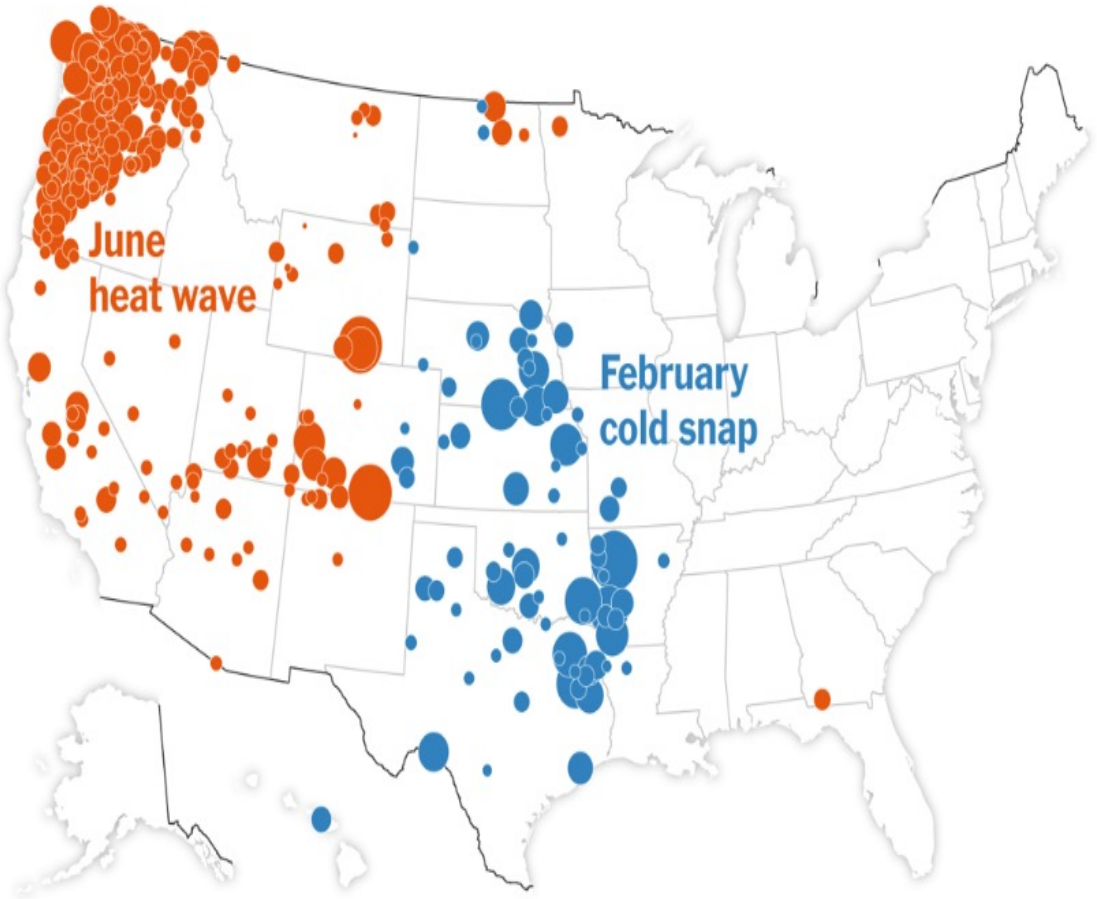
- **This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution.**

The New York Times

Tuesday, January 11, 2022

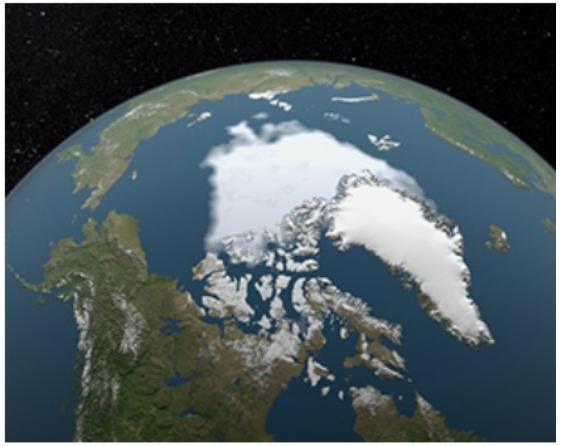
A Vivid View of Extreme Weather: Temperature Records in the U.S. in 2021

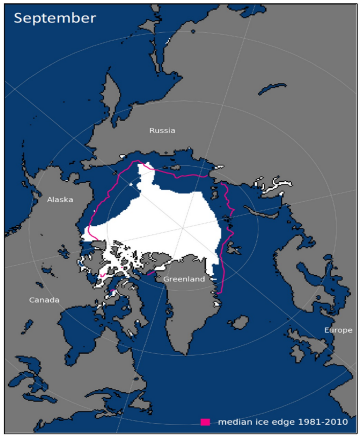
Last year, the U.S. saw some of the hottest and coldest temperatures ever recorded, with numerous records broken by double digits, a Times analysis found.

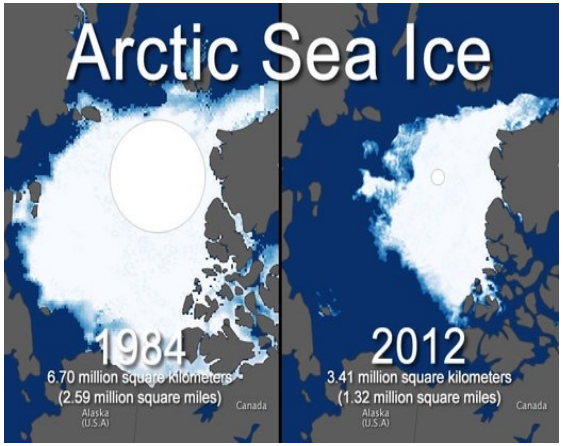


Sea Level Rise

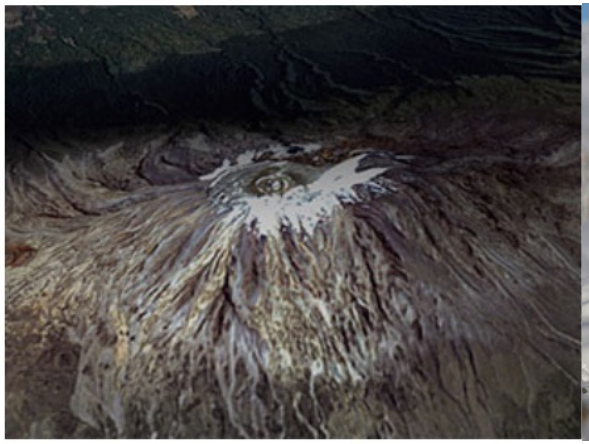
Declining Arctic Sea Ice

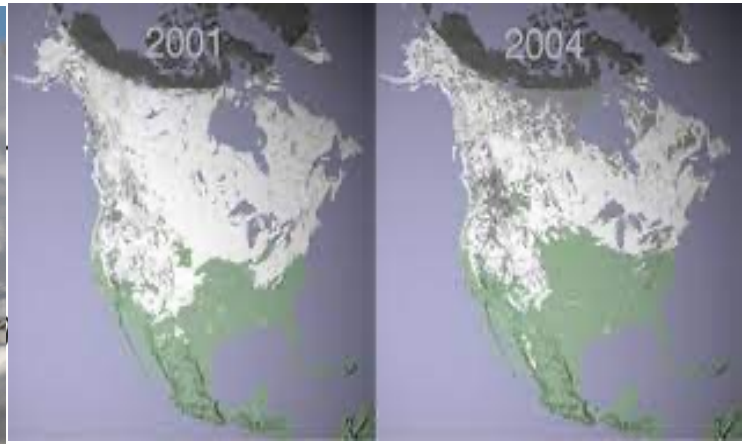






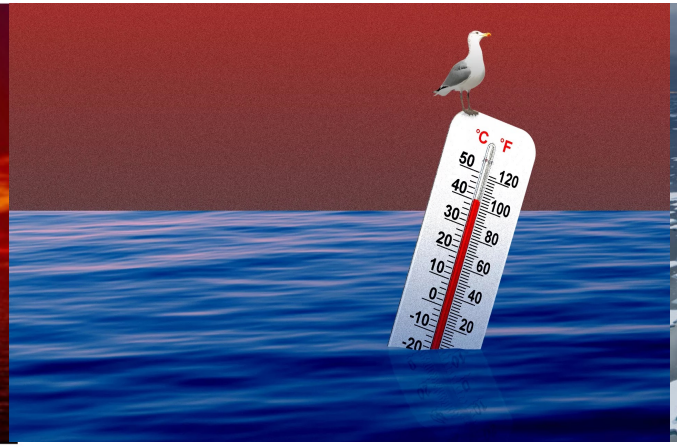
Glacial Retreat





Decreased Snow Cover

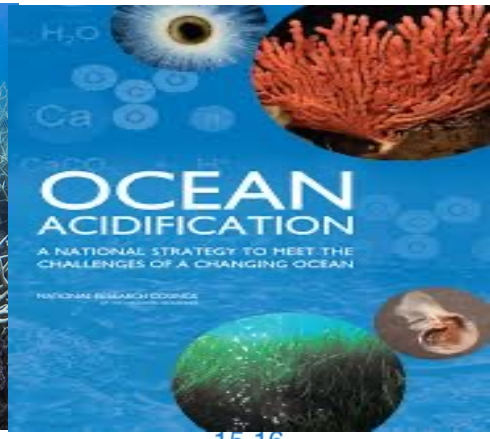
Warming Ocean



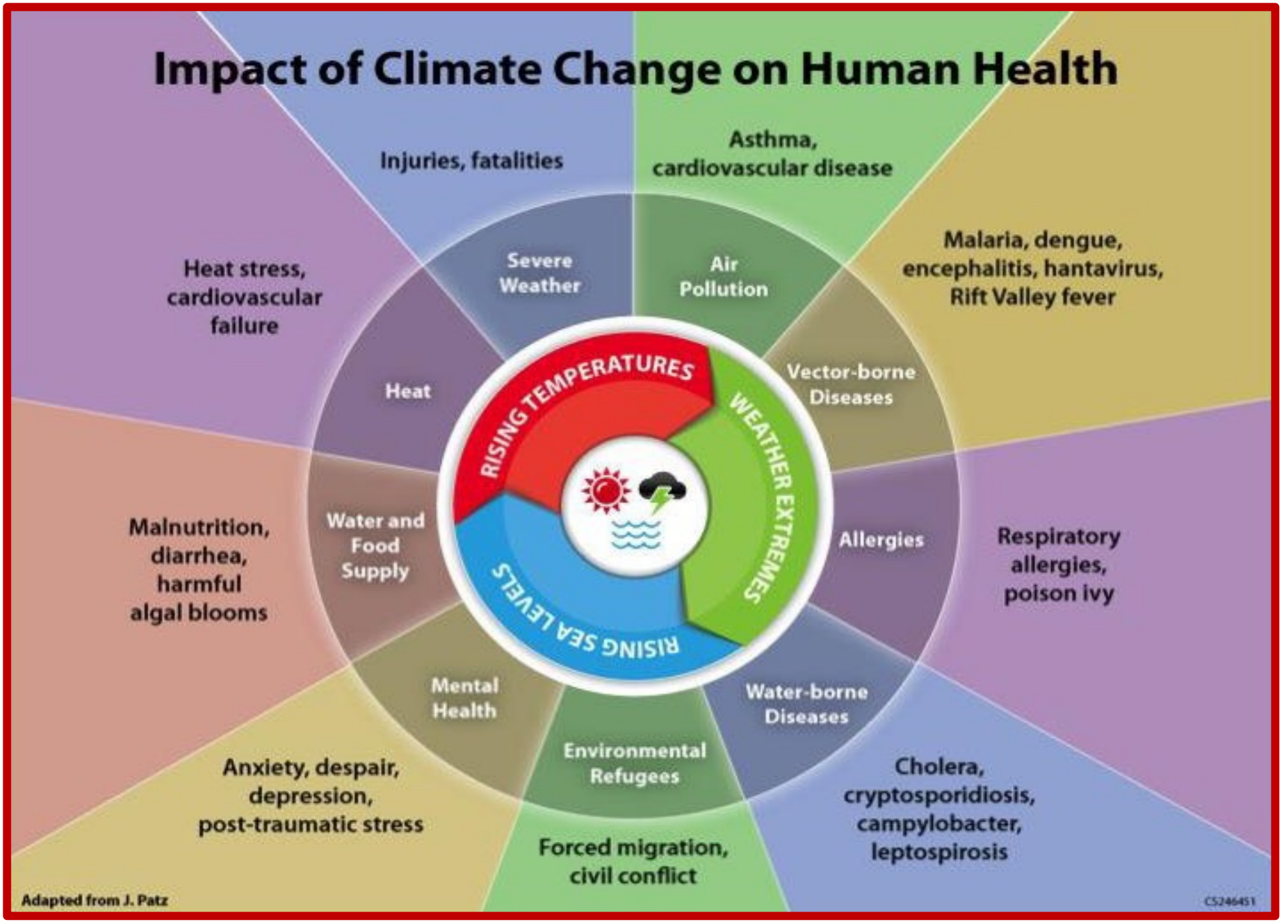
Shrinking Ice Sheets

Extreme Events

Ocean Acidification



15,16


Impact of Climate Change on Human Health
Injuries, fatalities
Asthma, cardiovascular disease
Heat stress, cardiovascular failure
Severe Weather
Air Pollution
Malaria, dengue, encephalitis, hantavirus, Rift Valley fever
Heat
Vector-borne Diseases
RISING TEMPERATURES
WEATHER EXTREMES
RISING SEA LEVELS
Malnutrition, diarrhea, harmful algal blooms
Water and Food Supply
Allergies
Respiratory allergies, poison ivy
Mental Health
Water-borne Diseases
Anxiety, despair, depression, post-traumatic stress
Environmental Refugees
Cholera, cryptosporidiosis, campylobacter, leptospirosis
Forced migration, civil conflict
Adapted from J. Patz
CS246451

- ✓ **The entire Atlantic seaboard would vanish, along with Florida and the Gulf Coast.**
- ✓ **In California, San Francisco's hills would become a cluster of islands and the Central Valley a giant bay.**
- ✓ **The Gulf of California would stretch north past the latitude of San Diego—not that there'd be a San Diego.**

GIVE NOW

CLIMATE CENTRAL

Researching and reporting the science and impacts of climate change

WHO WE ARE

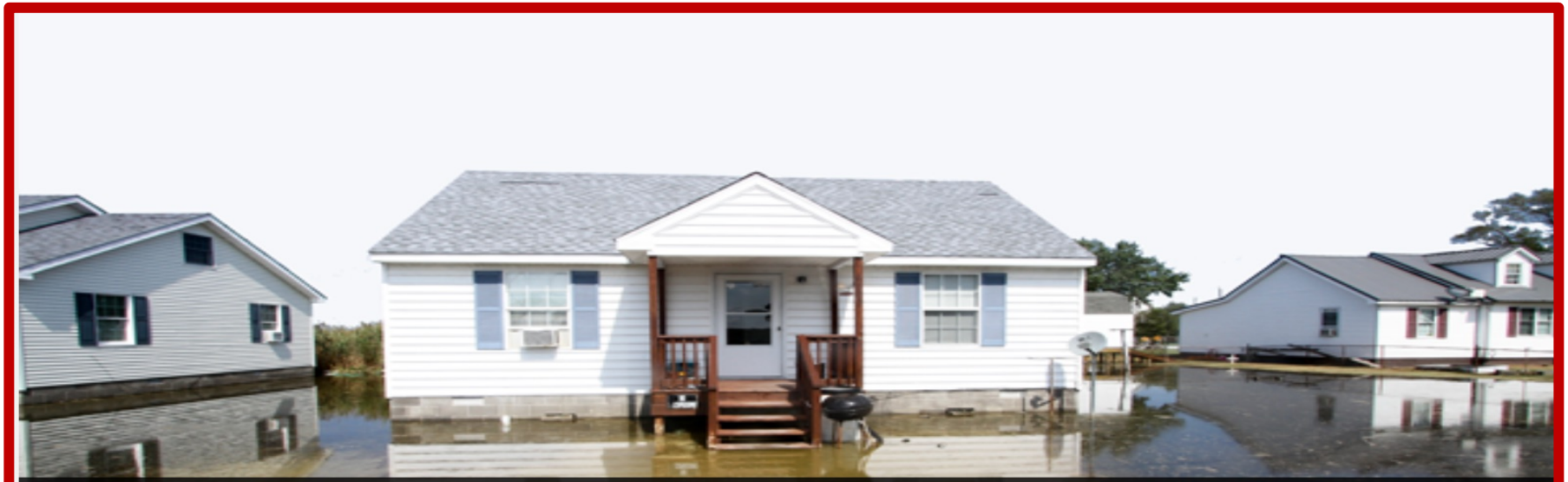
An independent organization of leading scientists and journalists researching and reporting the facts about our changing climate and its impact on the public.

WHAT WE DO

Climate Central surveys and conducts scientific research on climate change and informs the public of key findings. Our scientists publish and our journalists report on climate science, energy, sea level rise. Read More

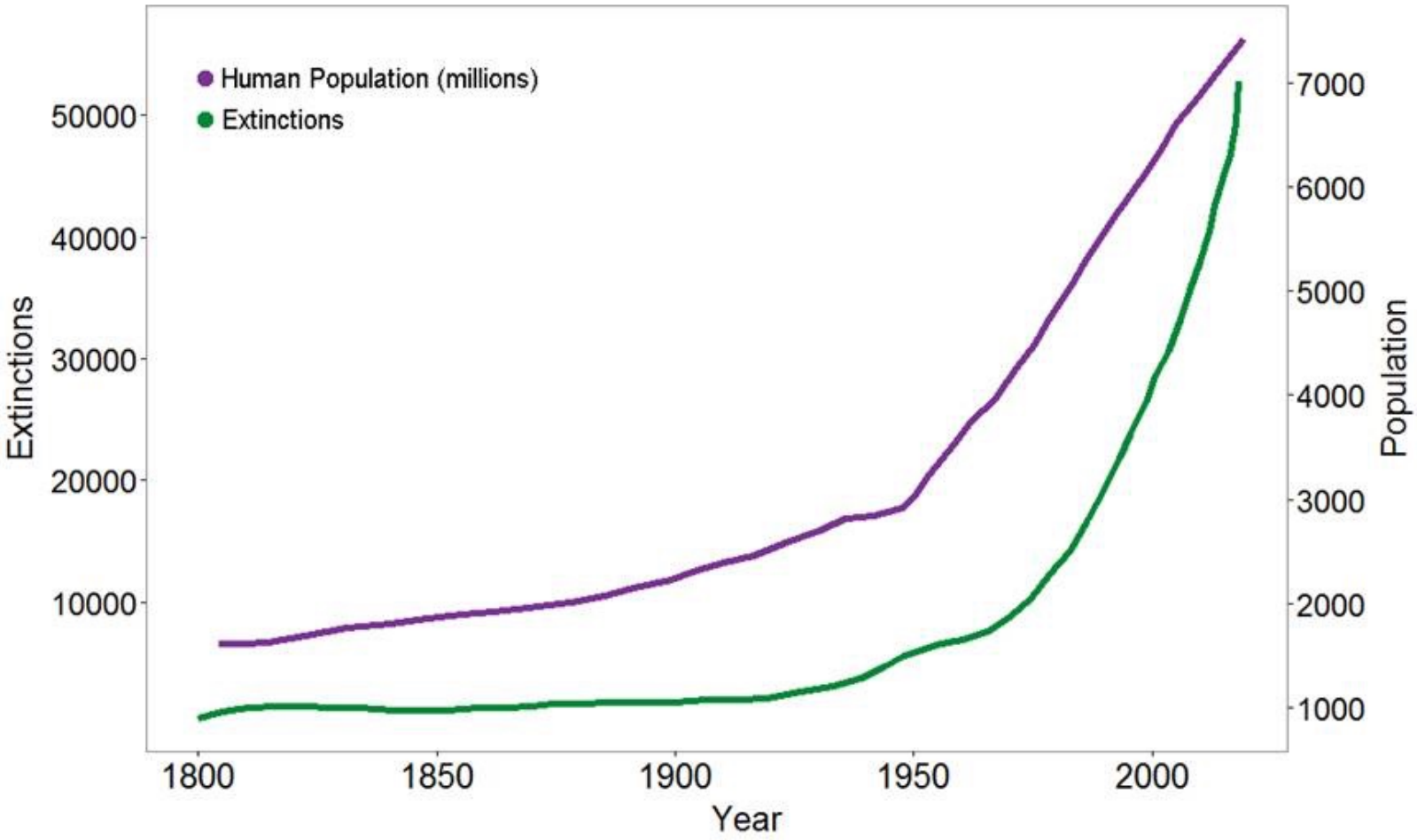
ABOUT OUR EXPERTISE

Members of the Climate Central staff and board are among the most respected leaders in climate science. Staff members are authorities in communicating climate and weather links, sea level rise, climate. Read More

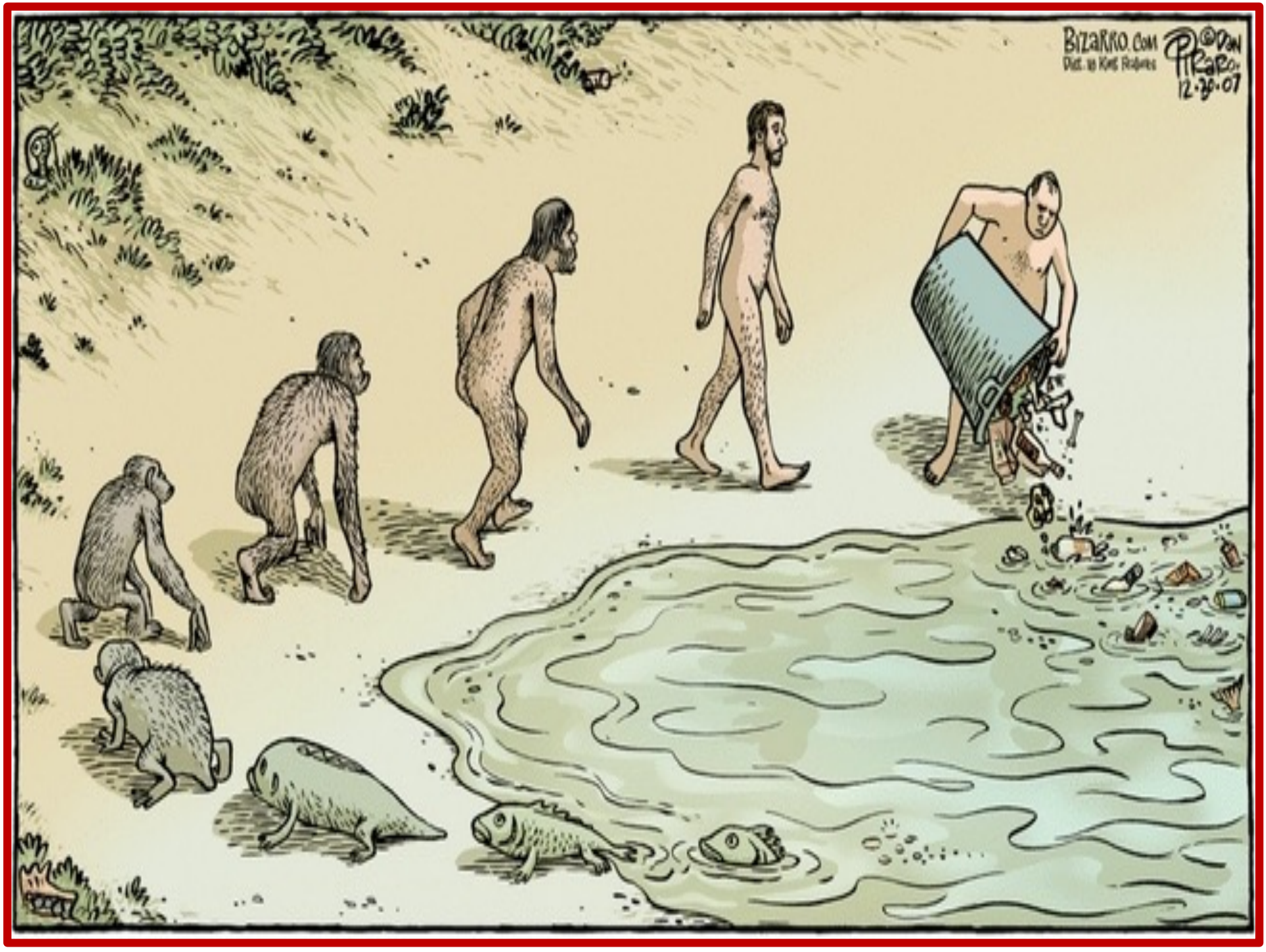


[2 Degree Temperature Rise and Sea Level`]

Humans & The Extinction Crisis



Data source: Scott, J.M. 2008. *Threats to Biological Diversity: Global, Continental, Local*. U.S. Geological Survey, Idaho Cooperative Fish and Wildlife, Research Unit, University Of Idaho.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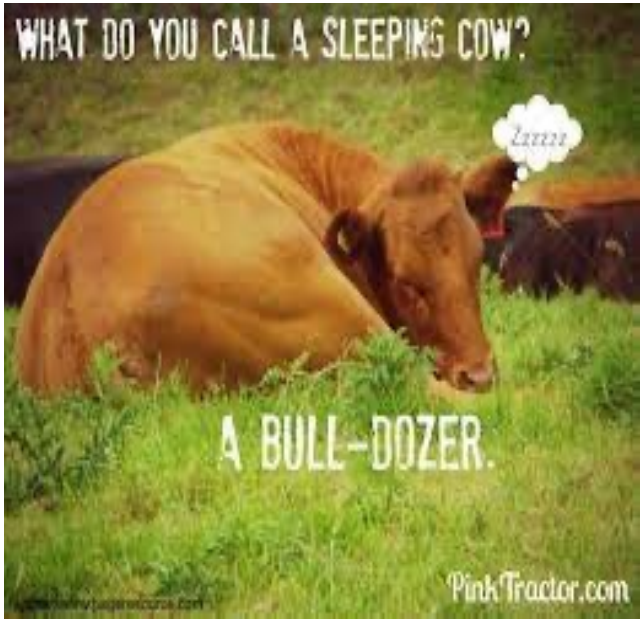
12-30-07

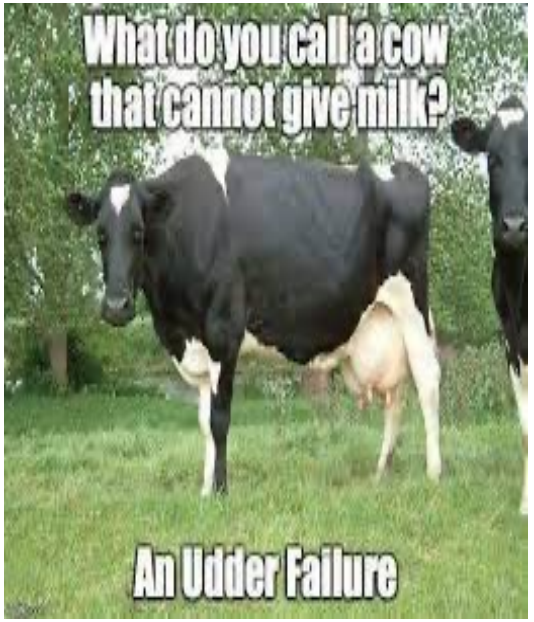

WE DO NOT INHERIT THE EARTH FROM OUR ANCESTORS, WE BORROW IT FROM OUR CHILDREN.
NATIVE AMERICAN PROVERB

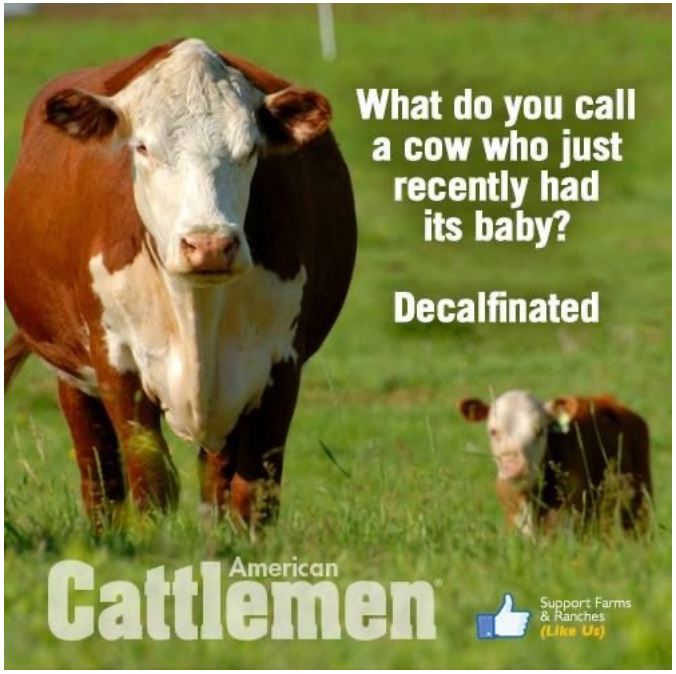
WHAT WE TALKED ABOUT

- ❑ WHY I CHOSE METHANE
- ❑ CHEMISTRY OF HYDROCARBONS
- ❑ METHANE 101
- ❑ METHANE'S NONCONTAINMENT
- ❑ METHANE'S EFFECTS
- ❑ CLIMATE MITIGATION
- ❑ CLIMATE CHANGE ONE LAST TIME


Why can't cows wear shoes?
Because they lactose.
COW JOKES - WWW.PUN.ME


WHAT DO YOU CALL A SLEEPING COW?
A BULL-DOZER.
PinkTractor.com


What do you call a cow that cannot give milk?
An Udder Failure


What do you call a cow who just recently had its baby?
Decalfinated
American Cattlemen
Support Farms & Ranches (Like Us)


What did the mama cow say to the baby cow?
"It's pasture bedtime."
American Cattlemen


Where do cows usually go on a Saturday night?
To the moovies!
Parade