Big Idea 2: Biological systems utilize free energy and molecular building blocks to grow, to reproduce and to maintain dynamic homeostasis.

Enduring understanding 2.D: Growth and dynamic homeostasis of a biological system are influenced by changes in the system's environment.

Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

a. Disruptions at the molecular and cellular levels affect the health of the organism.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

Immunological responses to pathogens, toxins and allergens

Physiological responses to toxic substances

Dehydration

A little background first...

Animal Defenses against Pathogens

Now we will explore the fight against the smallest invaders whose threat can be just as great as larger predator.

- The animal strategy against bacteria, viruses and parasites has two goals.
- First goal: Do not let the pathogen in the body or cell(s).
- Second goal: Should the pathogen "get in" then the animal must find, recognize and destroy it before it inflicts it damage.

Animal Defenses against Pathogens

Note: Vertebrate defense mechanisms are so similar to invertebrates that we study the human model and apply the concepts and mechanisms to all other animals.

- First goal: Do not let the pathogen in the body or cell(s).
  - *This is accomplished through the Integumentary, Lymphatic & Immune Systems*
  - *This immunity is called innate immunity or non-specific defenses.*
- Second goal: Should the pathogen "get in" then the animal must find, recognize and destroy it before it inflicts it damage.
  - *This is accomplished through the Immune System.*
  - *This immunity is called acquired immunity or specific defenses.*

Animal Defenses against Pathogens

Why do you suppose pathogens "want in"?
Why do they infect multicellular organisms?

Animal Defenses against Pathogens

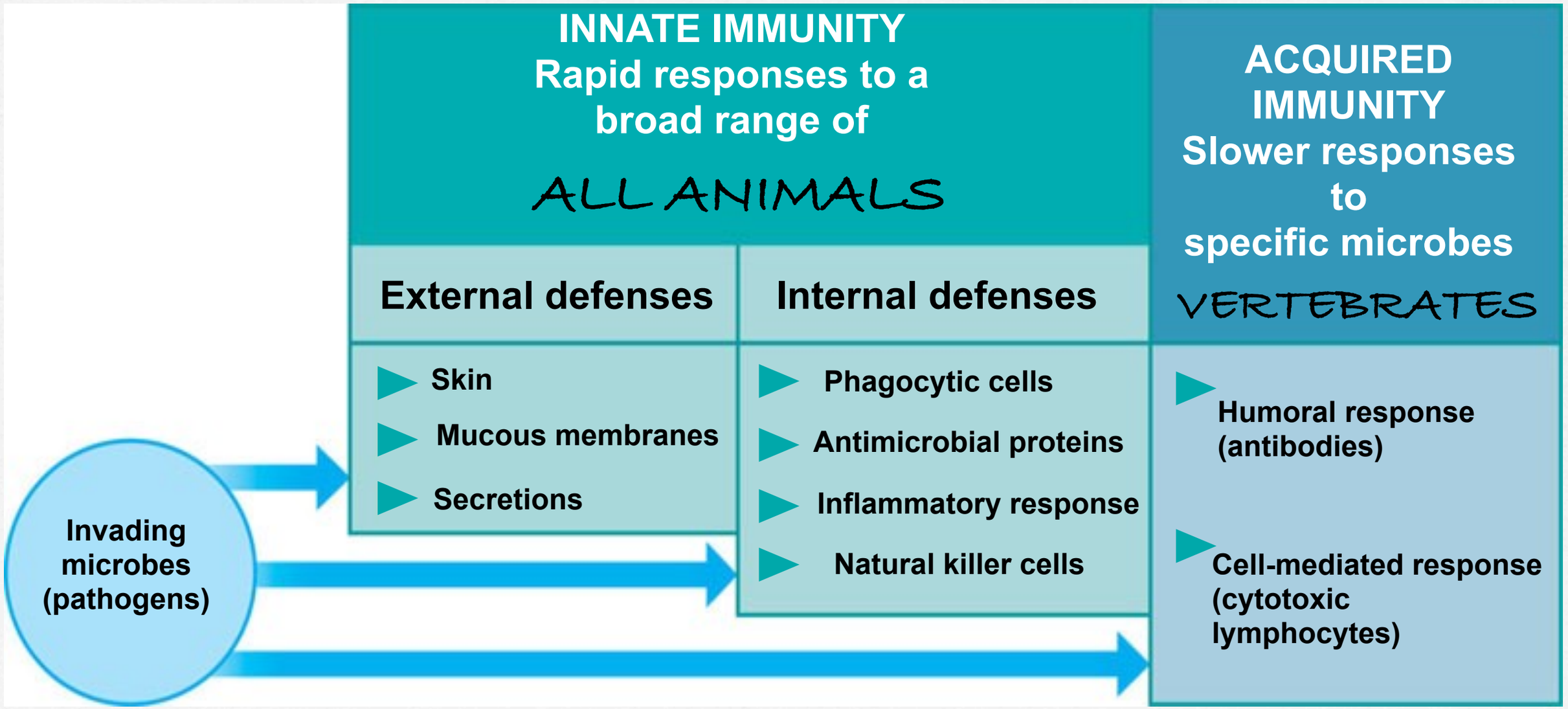
Why do you suppose pathogens "want in"?
Why do they infect multicellular organisms?

Multicellular organisms have worked hard to provide an ideal environment for the cells that make up the organism; they are protected, they are fed, they wastes are eliminated etc and the pathogens are looking for a free ride!

Animal Defenses against Pathogens

Always present even before exposure to pathogen etc.

Develops after exposure to pathogen etc.



Animal Defenses against Pathogens

Non-Specific External Defenses. (PHYSICAL BARRIERS)

- SKIN: physical barrier against microbes etc.
    - *multiple layers of flat skin cells provide increased protection*
- MUCOUS MEMBRANES: produce a viscous fluid that traps microbes
    - *much of this mucous ends up in the stomach a very inhospitable place*
- RESIDENT BACTERIA: prevents the attachment of foreign microbes

Animal Defenses against Pathogens

Non-Specific External Defenses. (CHEMICAL BARRIERS)

- SECRETIONS: create a hostile environment against microbes
  - *create a skin pH of 3-5 and it also contains lysozyme an enzyme that digests the cell wall of many bacteria*
  - *salts, fatty acids of skin inhibit microbial growth,*
  - *ANTIMICROBIAL AGENTS: generate lysozymes that punch holes into the bacteria thus killing them*

Can vomiting and diarrhea be considered innate immunity? Why? or Why Not?

Animal Defenses against Pathogens

Non-Specific External Defenses. (CHEMICAL BARRIERS)

- SECRETIONS: create a hostile environment against microbes
  - *create a skin pH of 3-5 and it also contains lysozyme an enzyme that digests the cell wall of many bacteria*
  - *salts, fatty acids of skin inhibit microbial growth,*
  - *ANTIMICROBIAL AGENTS: generate lysozymes that punch holes into the bacteria thus killing them*

Can vomiting and diarrhea be considered innate immunity? Why? or Why Not?

Yes...Both indiscriminately purge harmful agents

Animal Defenses against Pathogens

Non-Specific <u>Internal</u> Defenses.

- All internal defenses requires the identification of "self" and "non-self"
- This "self" and "non-self" identification requires *molecular recognition.*
    - *where receptor molecules bind to specific molecules that are foreign or molecules that are part of foreign cells*

Animal Defenses against Pathogens

Non-Specific Internal Defenses. (CHEMICAL AGENTS)

- INTERFERONS: *provide innate protection against viruses and activate macrophages*
- HISTAMINES: increased capillary permeability with *increased blood flow brings more white blood cells to area of infection.*
- *PYROGENS: induce fever that inhibits pathogen reproduction*

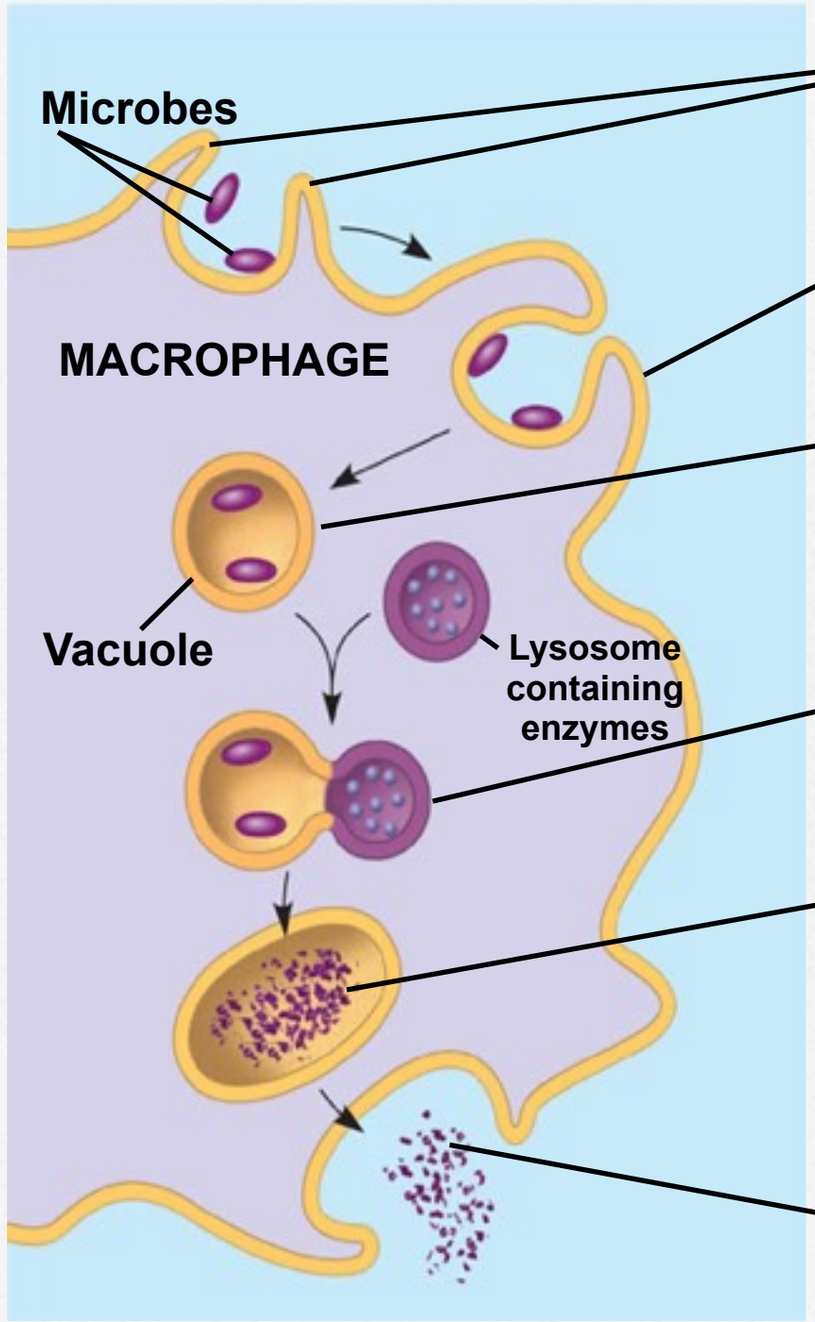
OK, Back to the

Immunological responses to pathogens, toxins and allergens

Animal Defenses against Pathogens

Non-Specific External Defenses. (PHAGOCYTOSIS)

- PHAGOCYTES: white blood cells
  - *ingest invading microbes & initiate the inflammatory response*
- MACROPHAGES: a specific type of phagocyte can be found migrating through the body



Animal Defenses against Pathogens

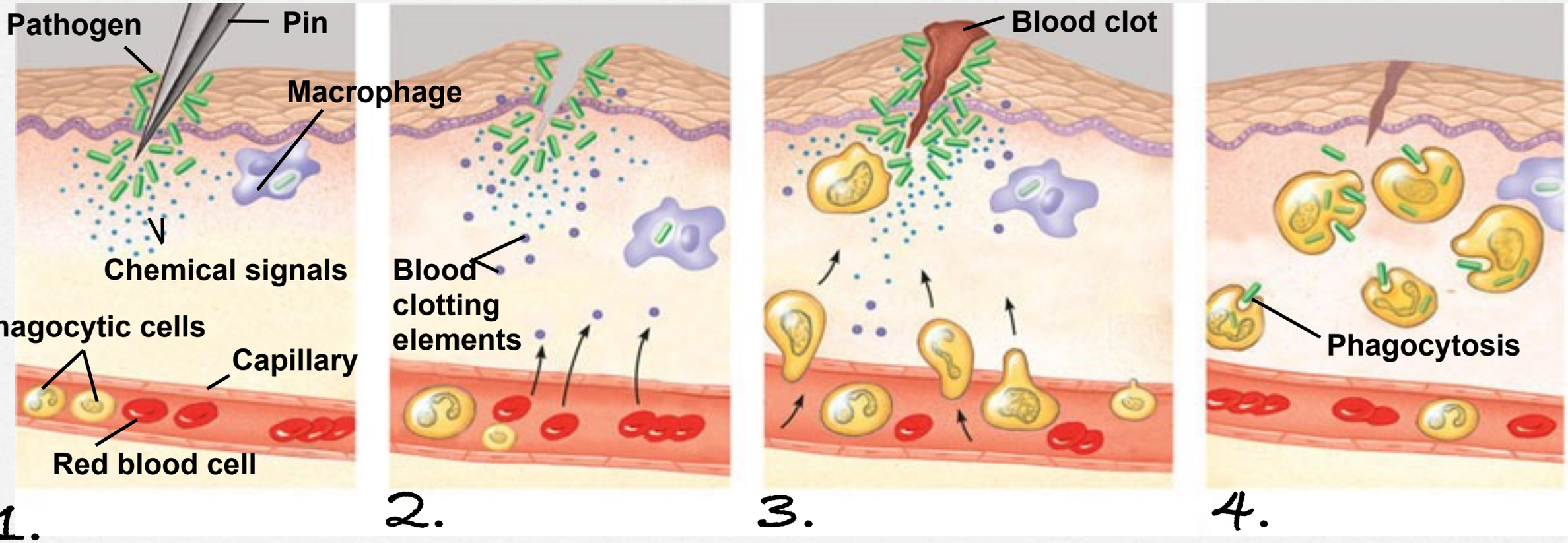
Non-Specific Internal Defenses. (INFLAMMATION)

- INFLAMMATORY RESPONSE: *dilates blood vessels that allow more fluid, phagocytes and antimicrobial proteins to enter the tissues at the site of infection.*

- *the response is trigger by the release of histamines and other chemicals from the injured cells*

Animal Defenses against Pathogens

Inflammation



1. Chemical signals released by activated macrophages and mast cells at the injury site cause nearby capillaries to widen and become more permeable.

2. Fluid, antimicrobial proteins, and clotting elements move from the blood to the site. Clotting begins.

3. Chemokines released by various kinds of cells attract more phagocytic cells from the blood to the injury site.

4. Neutrophils and macrophages phagocytose pathogens and cell debris at the site, and the tissue heals.

Animal Defenses against Pathogens

<u>Specific</u> Internal Defenses.

- SEE 2.D.4 powerpoint

Essential knowledge 2.D.3: Biological systems are affected by disruptions to their dynamic homeostasis.

b. Disruptions to ecosystems impact the dynamic homeostasis or balance of the ecosystem.

To foster student understanding of this concept, instructors can choose an illustrative example such as:

Hurricanes, floods, earthquakes, volcanoes, fires

Invasive and/or eruptive species

Water limitation

Human impact

Salination

✘ No specific system is required for teaching the above concepts. Teachers are free to choose the system that best fosters student understanding.

Conservation Ecology

Main Idea: The earth's habitats and climate are changing.

Main Idea: The rate of change is greater than changes of the past.

Main Idea: Human actions are responsible for some of these changes and the rate at which they are occurring.

EARTH IS CHANGING RAPIDLY AS A RESULT OF HUMAN ACTIONS

Nutrient Enrichment

- Human activity removes nutrients from one part of the biosphere and adds them to another! Consider the following..
  - Small scale: Floridian consumes corn grown in Iowa.
  - Large scale: Fertilizer runs off from that same farm in Iowa into the Mississippi River.
  - Additionally humans are adding synthetic, novel and some toxic nutrients to ecosystems as well

Lets take a closer look at “farming”...

- **Farming** removes nutrients from the soil.
  - Grasslands have a "free period" that lasts decades.
  - Tropical Rain Forests' "free period" is only a couple of years.
  - Despite variations nutrients will eventually be depleted and *nitrogen* is often the first to go.

- Recent studies indicate that 3 human activities have more than doubled the amount of fixed nitrogen available to producers.

1. industrial fertilizers, 2. fossil fuel consumption and 3. increased cultivation of legumes.

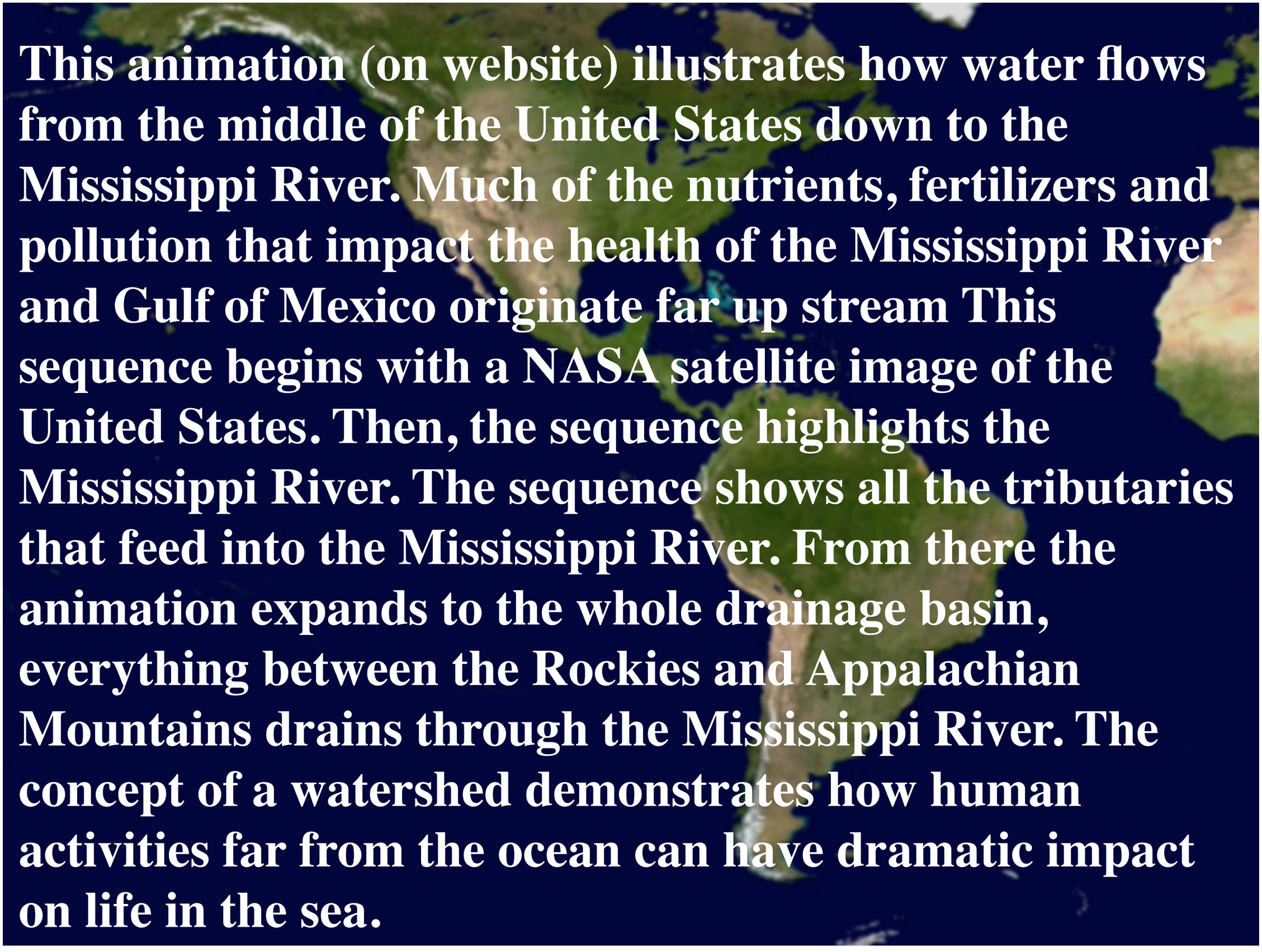
- Unfortunately problems arise when nutrient load exceeds, the critical load, the amount of nutrients that plants can absorb without damaging the ecosystems.

  - Excess nutrients run-off into bodies of water and groundwater leading to...

1. contamination, 2. eutrophication 3. dead zones

*Lake Erie was nearly wiped out in the 1960's due to eutrophication and over-fishing. Since then *REGULATIONS have helped the recovery efforts but some organisms have yet to recover.*

Mississippi Water Shed



Dead zones are areas of water so devoid of oxygen that sea life cannot live there.

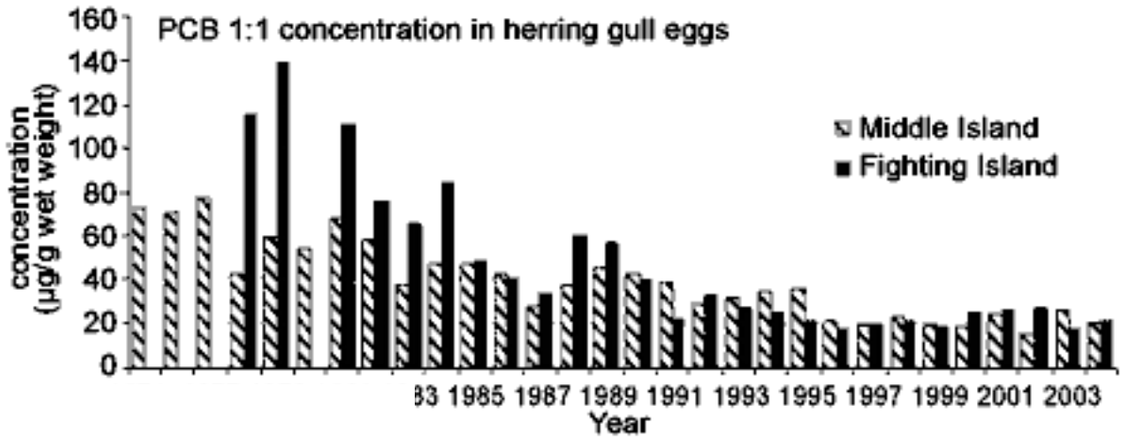
If phytoplankton productivity is enhanced by fertilizers or other nutrients, more organic matter is produced at the surface of the ocean. The organic matter sinks to the bottom, where bacteria break it down and release carbon dioxide. Bacteria thrives off excessive organic matter and absorb oxygen, the same oxygen that fish, crabs and other sea creatures rely on for life.

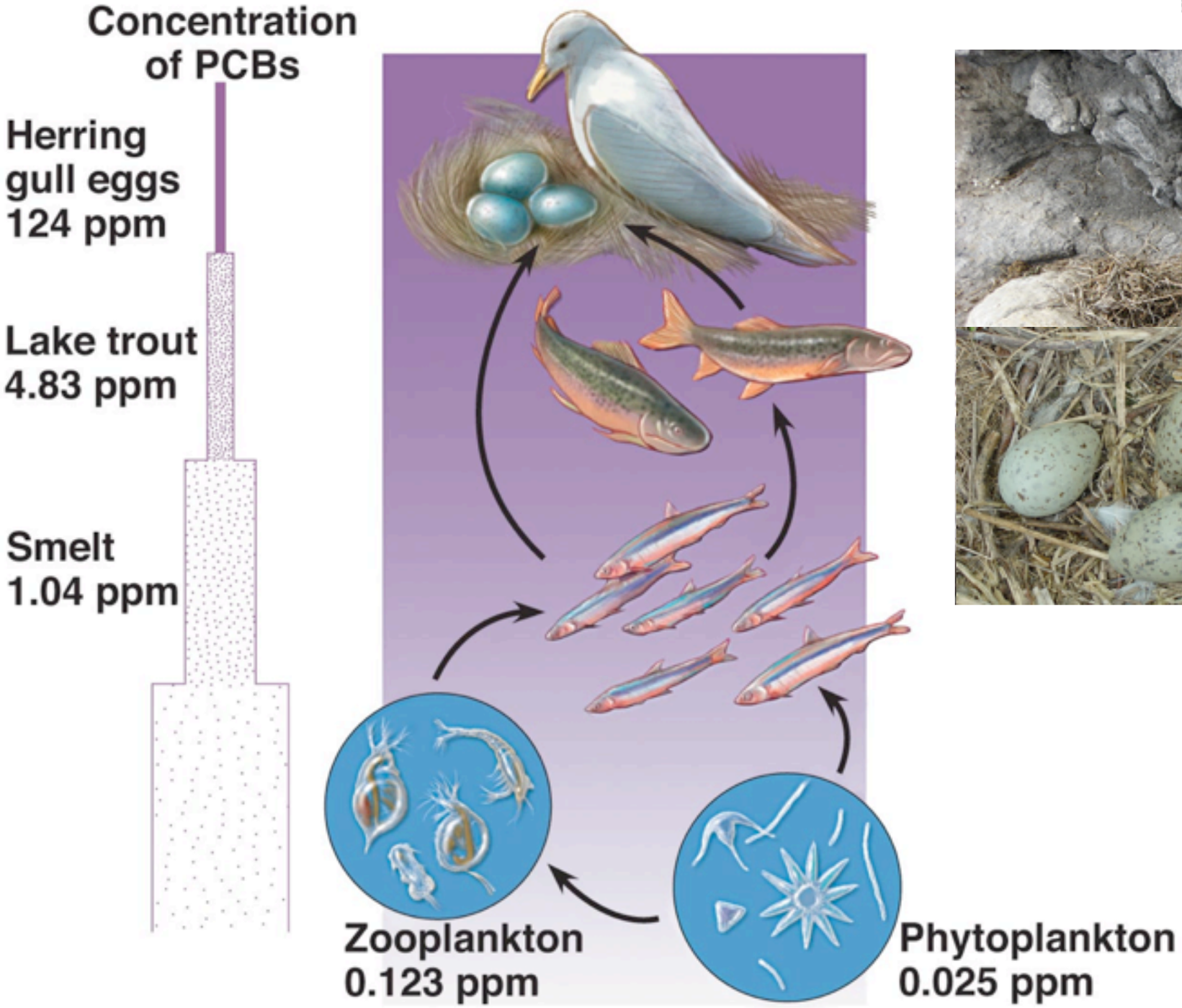
Recent reports indicate that the large region of low oxygen water often referred to as the 'Dead Zone' has spread across nearly 5,800 square miles of the Gulf of Mexico again in what appears to be an annual event. NASA satellites monitor the health of the oceans and spots the conditions that lead to a dead zone. These images show how ocean color changes from winter to summer in the Gulf of Mexico. Summertime satellite observations of ocean color from MODIS Aqua show highly turbid waters which may include large blooms of phytoplankton extending from the mouth of the Mississippi River all the way to the Texas coast. When these blooms die and sink to the bottom, bacterial decomposition strips oxygen from the surrounding water, creating an environment very difficult for marine life to survive in. Reds and oranges represent high concentrations of phytoplankton and river sediment. The National Oceanic and Atmospheric Administration (NOAA) ships measured low oxygen water in the same location as the highly turbid water in the satellite images. Most studies indicate that fertilizers and runoff from human sources is one of the major stresses impacting coastal ecosystems. In the third image using NOAA data, reds and oranges represent low oxygen concentrations. For additional information, see: http://www.gsfc.nasa.gov/topstory/2004/0810deadzone.html

Toxins in the Environment

- Humans release a variety of toxins, often times synthetic (novel to organisms) into the environment.
- Many toxins can't be degraded by microorganisms and persist in the environment for years.
  - In fact some chemicals released are benign only to be later converted into toxic forms
    - Ex. Insoluble mercury dumped in waterways is converted by bacteria on the bottom into methyl mercury; water soluble and highly toxic compound.
- Some toxins are excreted by organisms but many accumulate in the fatty tissue.
  - These toxins become more concentrated with each successive trophic level. ***(biological magnification)***
  - Two well documented examples illustrate this process.
    - The industrial compound PCB's & the pesticide DDT

Bioaccumulation: PCB's





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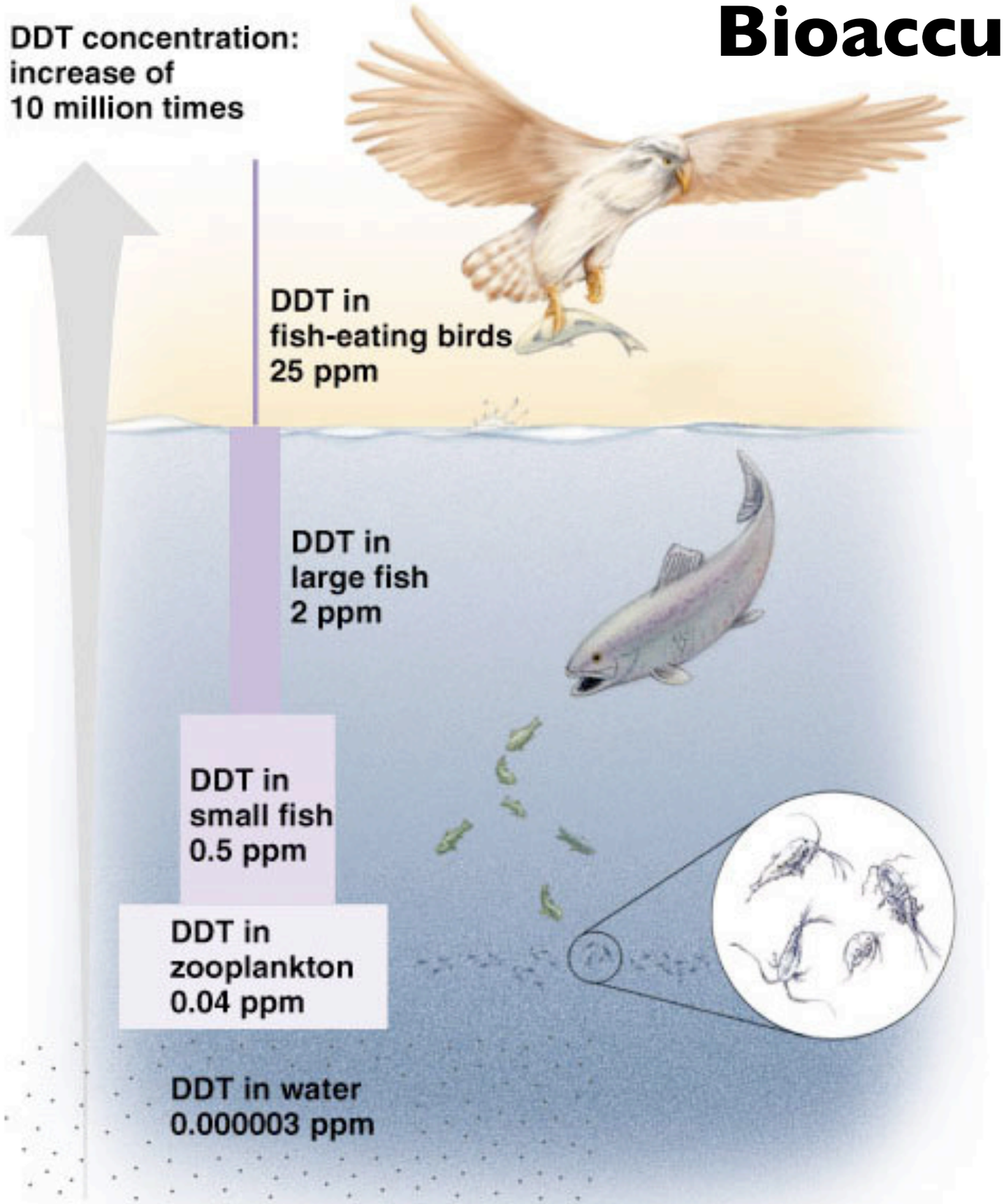
PCB's prevented calcium deposition in egg shells

Bioaccumulation: DDT



Then, in 1939, Swiss chemist Paul Hermann Müller (1899–1965) discovered that DDT was highly poisonous to insects. The discovery was very important because of its potential for use in killing insects that cause disease and eat agricultural crops. For his work, Müller was awarded the Nobel Prize in medicine in 1948.

During and after World War II (1939–45), DDT became extremely popular among public health workers, farmers, and foresters. Peak production of the compound reached 386 million pounds (175 million kilograms) globally in 1970. Between 1950 and 1970, 22,204 tons (20,000 metric tons) of DDT was used annually in the former Soviet Union. The greatest use of DDT in the United States occurred in 1959, when 79 million pounds (36 million kilograms) of the chemical were sprayed.

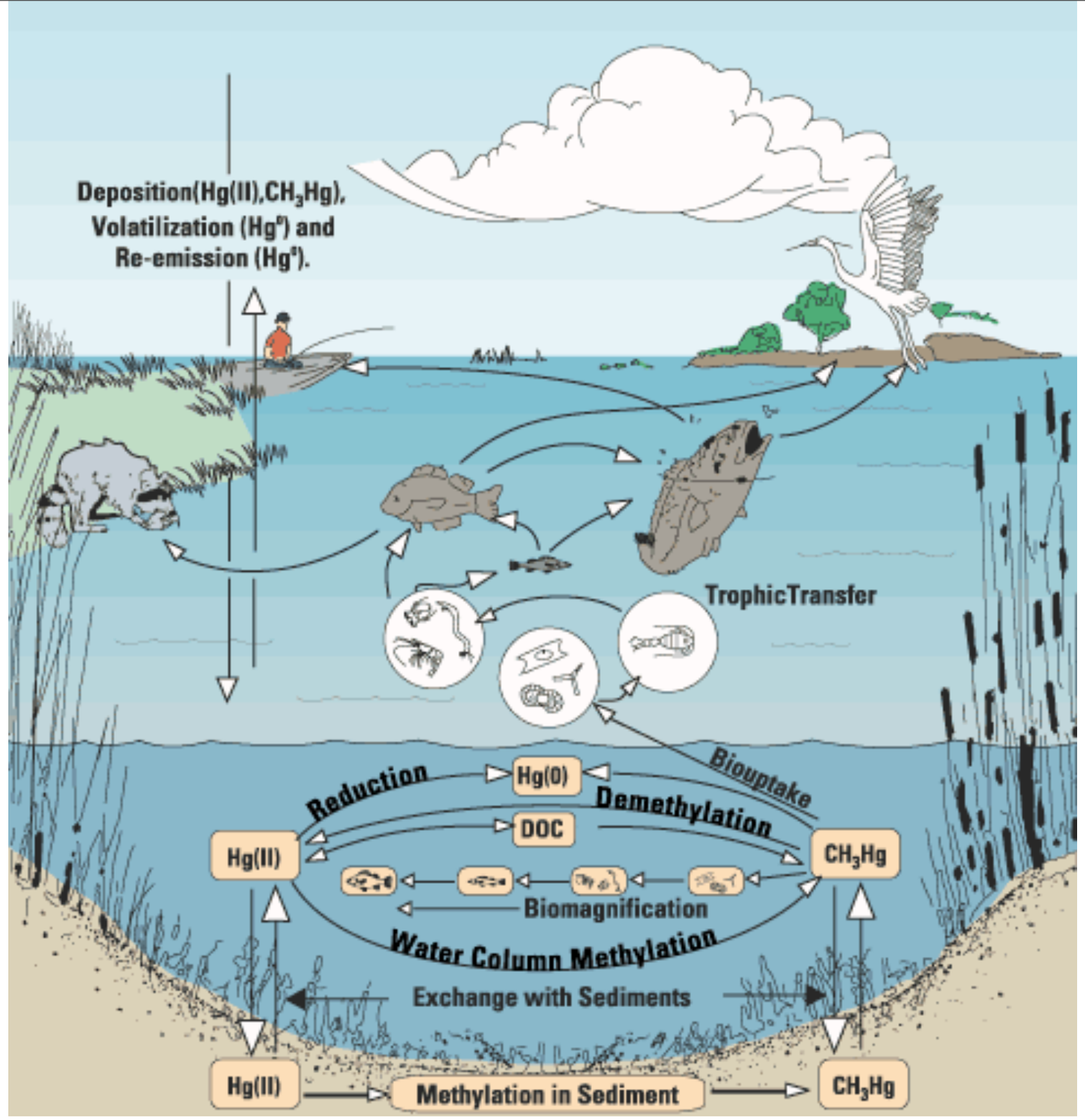
By the early 1970s, however, serious questions were being raised about the environmental effects of DDT. Reports indicated that harmless insects (such as bees), fish, birds, and other animals were being killed or harmed as a result of exposure to DDT. The pesticide was even blamed for the near-extinction of at least one bird, the peregrine falcon. Convinced that the environmental damage from DDT was greater than the compound's possible benefits, the U.S. Environmental Protection Agency banned the use of DDT in the United States in 1973. Its use in certain other countries has continued, however, since some nations face health and environmental problems quite different from those of the United States.

In December 2000, in a convention organized by the United Nations Environment Program, 122 nations agreed to a treaty banning twelve very toxic chemicals. Included among the twelve was DDT. However, the treaty allowed the use of DDT to combat malaria until other alternatives become available. Before it can take effect, the treaty must be ratified by 50 of the nations that agreed to it in principle.

What is an endocrine disrupter?


"DDT is good for me-e-e!"
The great expectations held for DDT have been realized. During 1946, exhaustive scientific tests have shown that, when properly used, DDT kills a host of destructive insect pests, and is a benefactor of all humanity.
Pennsalt produces DDT and its products in all standard forms and is now one of the country's largest producers of this amazing insecticide. Today, everyone can enjoy added comfort, health and safety through the insect-killing powers of Pennsalt DDT products . . . and DDT is only one of Pennsalt's many chemical products which benefit industry, farm and home.
KILLING SALT
CHEMICALS


DDT



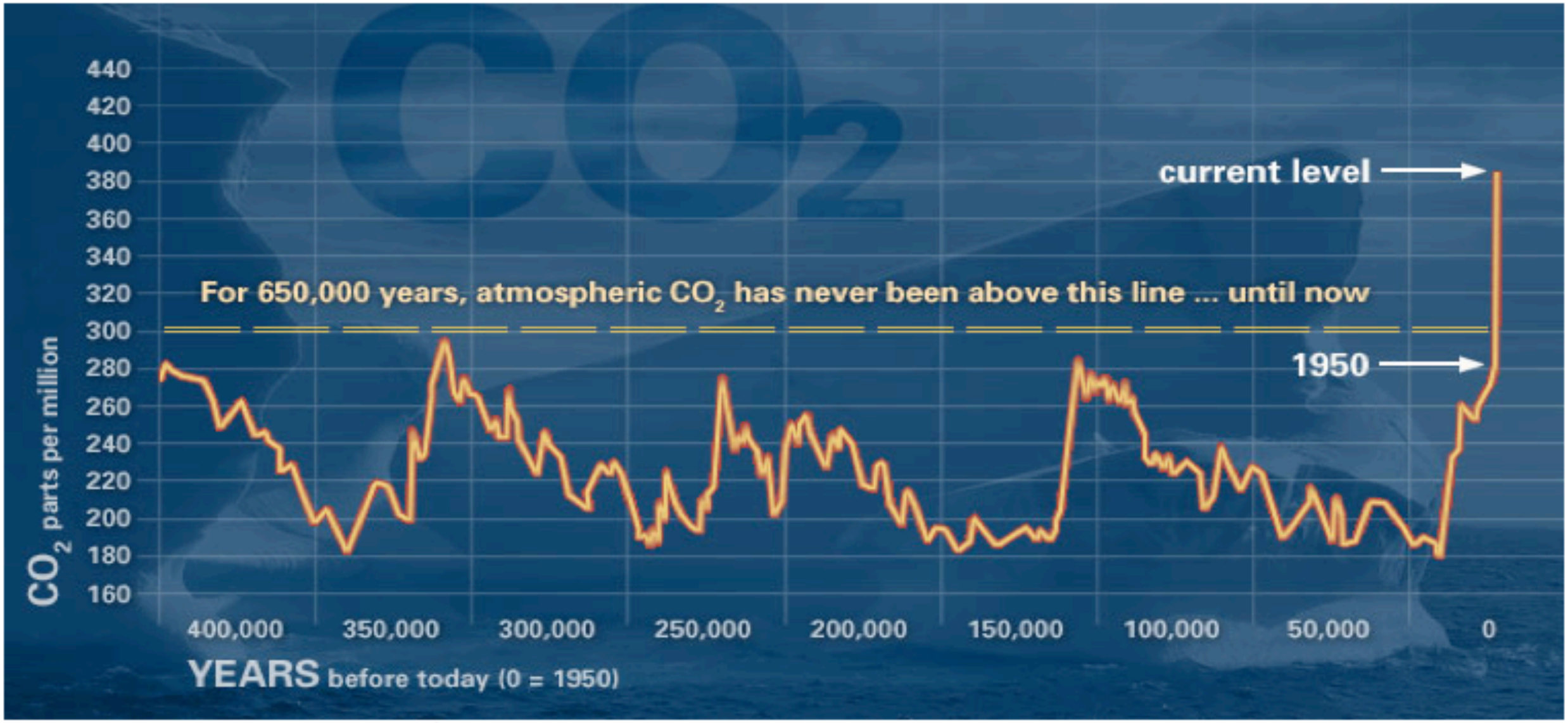
In the environment, sulfate-reducing bacteria take up mercury in its inorganic form and through metabolic processes convert it to methylmercury. Sulfate-reducing bacteria are found in anaerobic conditions, typical of the well-buried muddy sediments of rivers, lakes, and oceans where methylmercury concentrations tend to be highest. Sulfate-reducing bacteria use sulfur rather than oxygen as their cellular energy-driving system. One hypothesis is that the uptake of inorganic mercury by sulfate-reducing bacteria occurs via passive diffusion of the dissolved complex HgS. Once the bacterium has taken up this complex, it utilizes detoxification enzymes to strip the sulfur group from the complex and replaces it with a methyl group:

Greenhouse Gases & Global Warming

Rising atmospheric CO_2 levels

- Since the industrial revolution the levels of CO_2 in atmosphere have been increasing. (estimates of 274 ppm in 1850)
- Since 1958 we have been able to accurately measure CO_2 levels in the atmosphere. (1958 = 316ppm), (today it exceeds 385 ppm)
- Computer models estimate that in 60 years the amount of CO_2 in the atmosphere will be double what it was in the 19th century.
  - These rising levels are not questioned by even the skeptics.

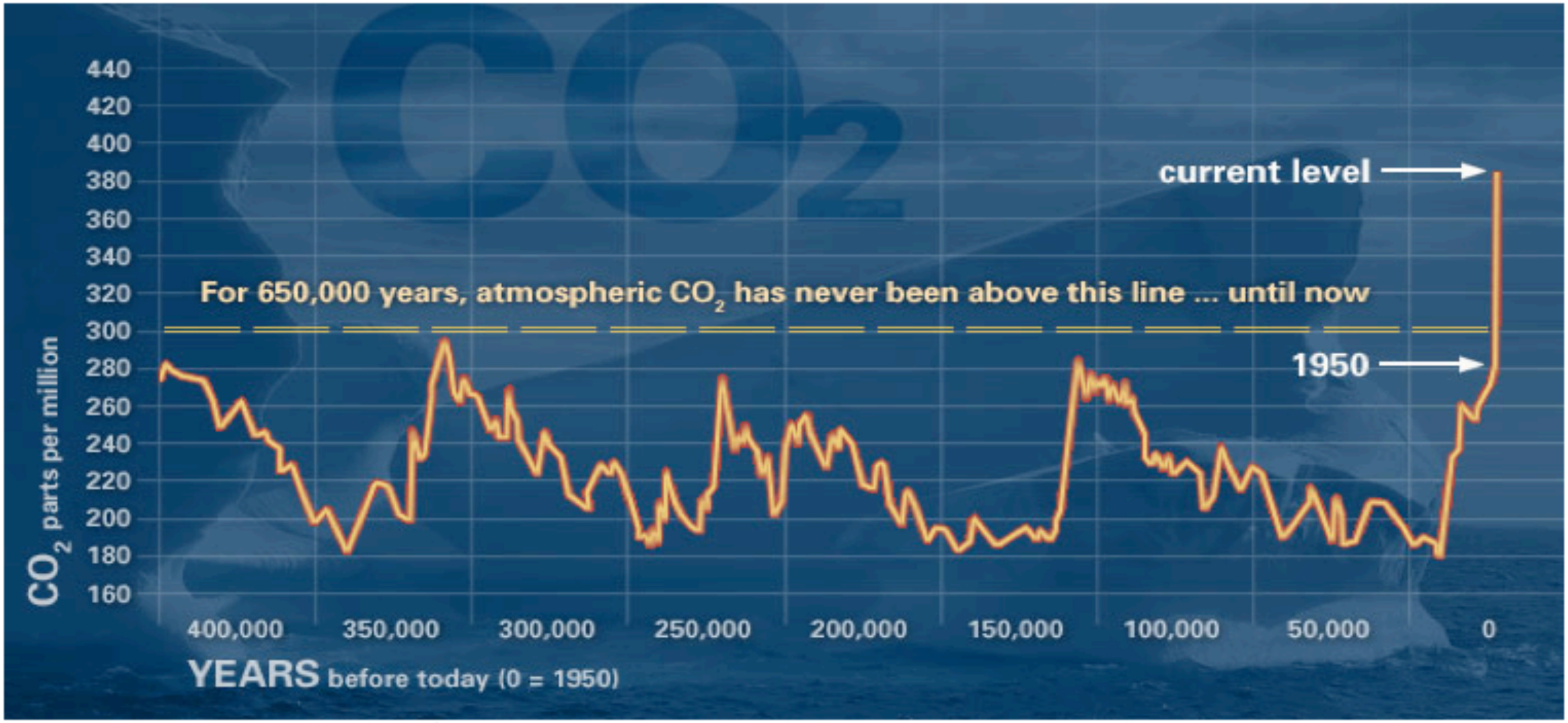
Climate change: How do we know?



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. (Source: NOAA)

What do the skeptics say about the rising CO_2 levels in the atmosphere?

Climate change: How do we know?



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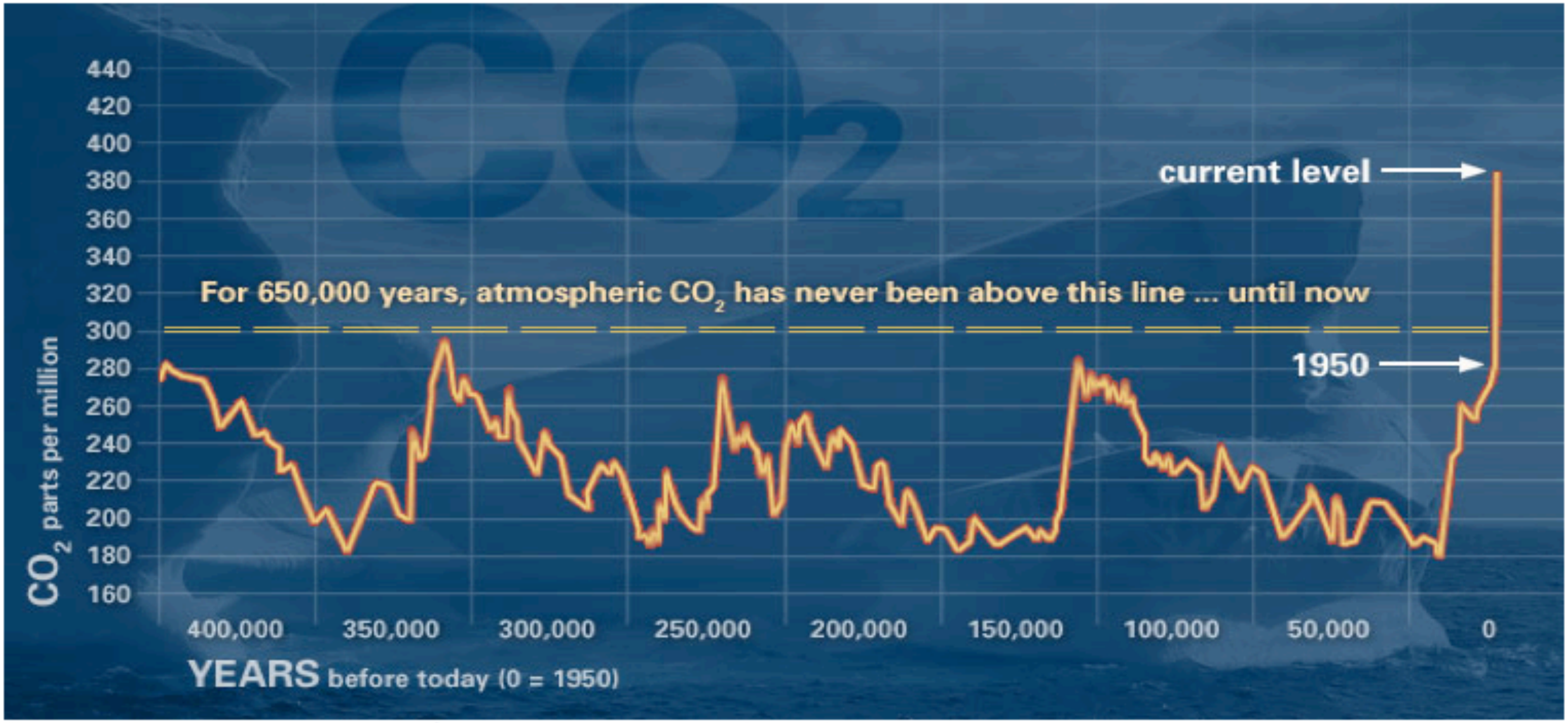
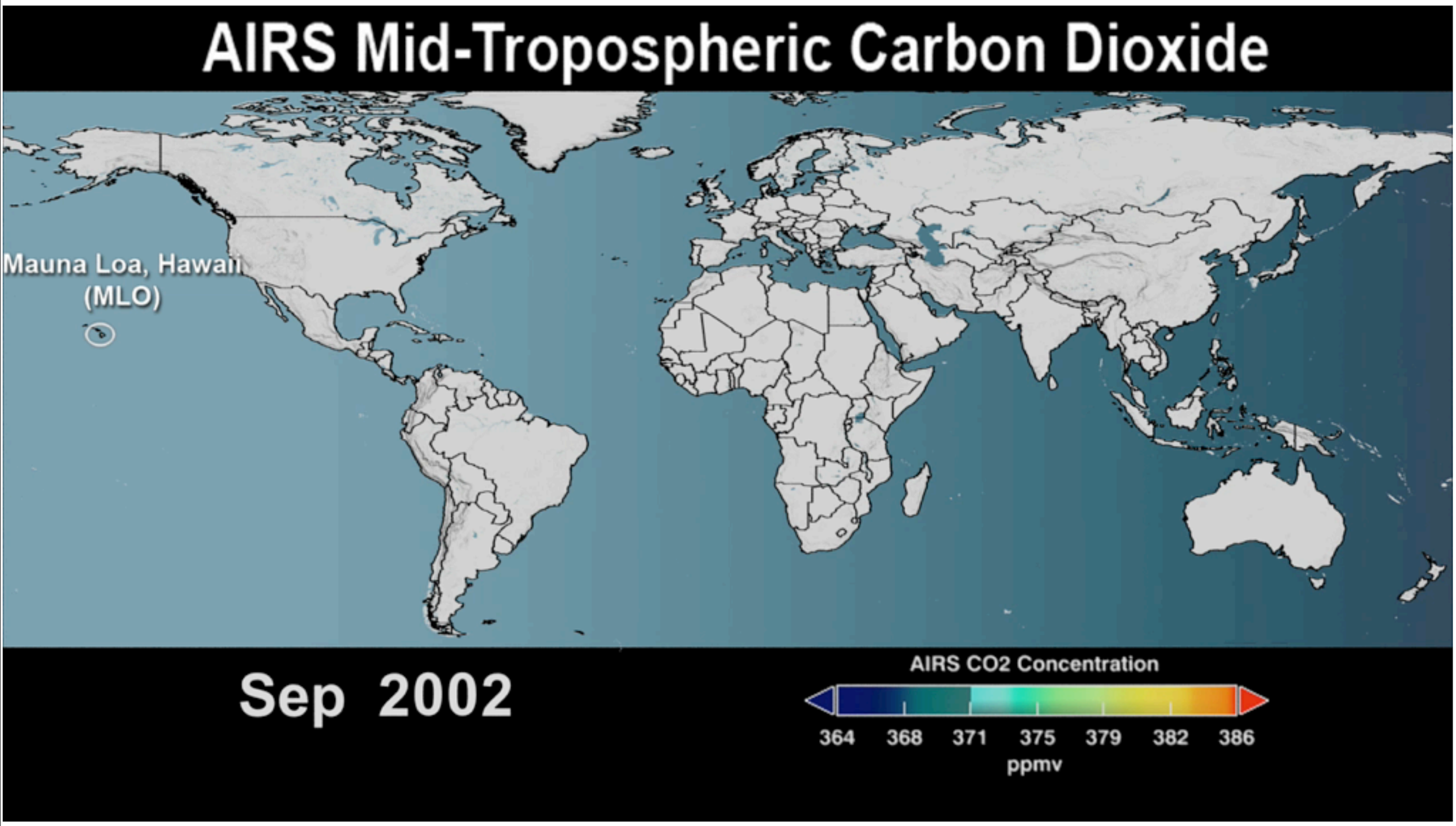


This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution. (Source: NOAA)

What do the skeptics say about the rising CO_2 levels in the atmosphere?

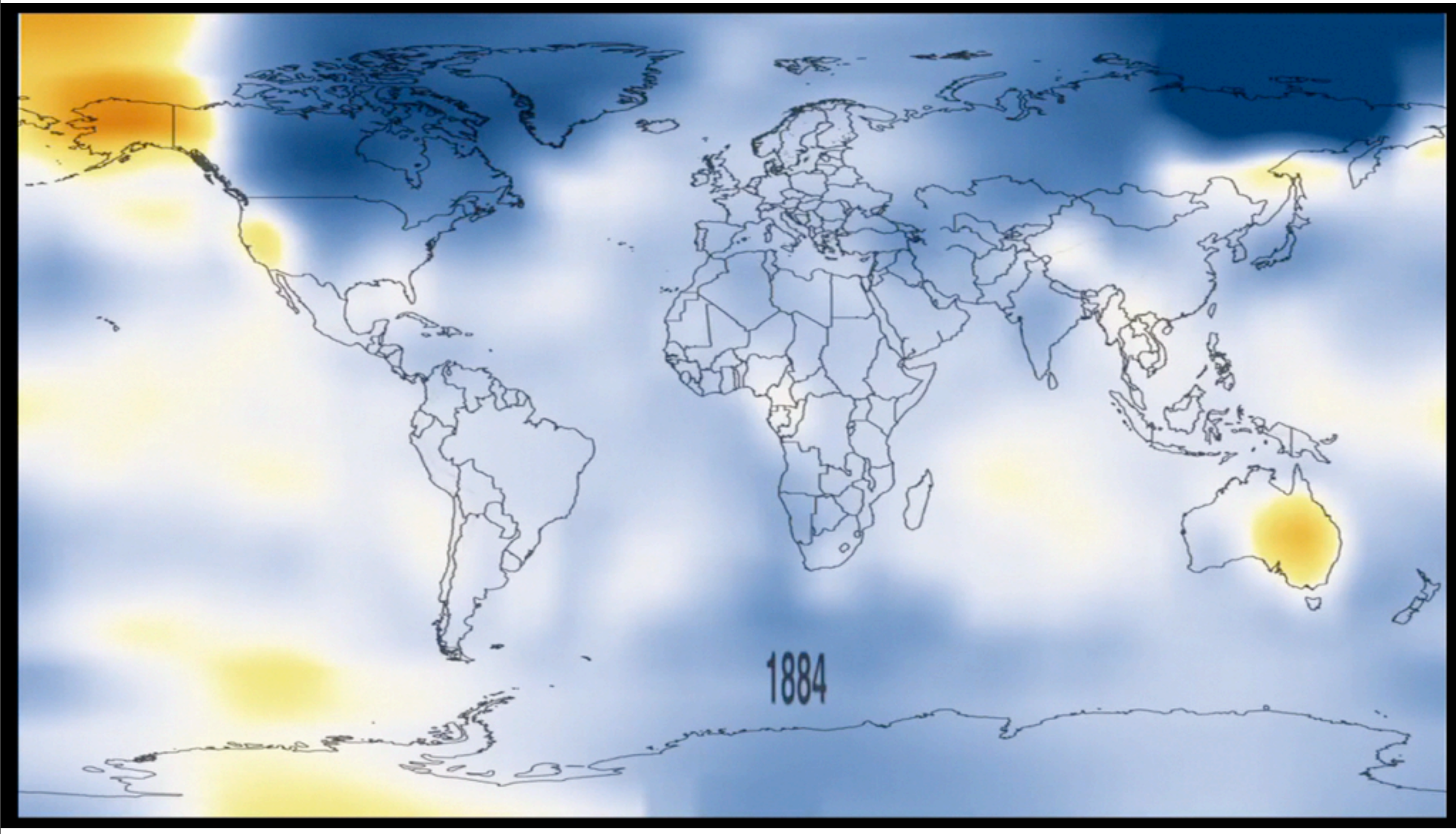
"Yes, our climates change. They've been changing ever since the earth was formed."

17 August 2011 (Source)



Why do the carbon dioxide levels rise and fall?

Temperature Differences Over Time



A warming earth has many real and potential consequences...

Indicators of a Warming World

Humidity

Glaciers

Temperature Over Land

Temperature Over Oceans

Snow Cover

Air Temperature Near Surface (troposphere)

Tree-lines shifting poleward and upward

Sea Surface Temperature

Sea Level

Spring coming earlier

Sea Ice

Ice Sheets

Species migrating poleward and upward

Ocean Heat Content

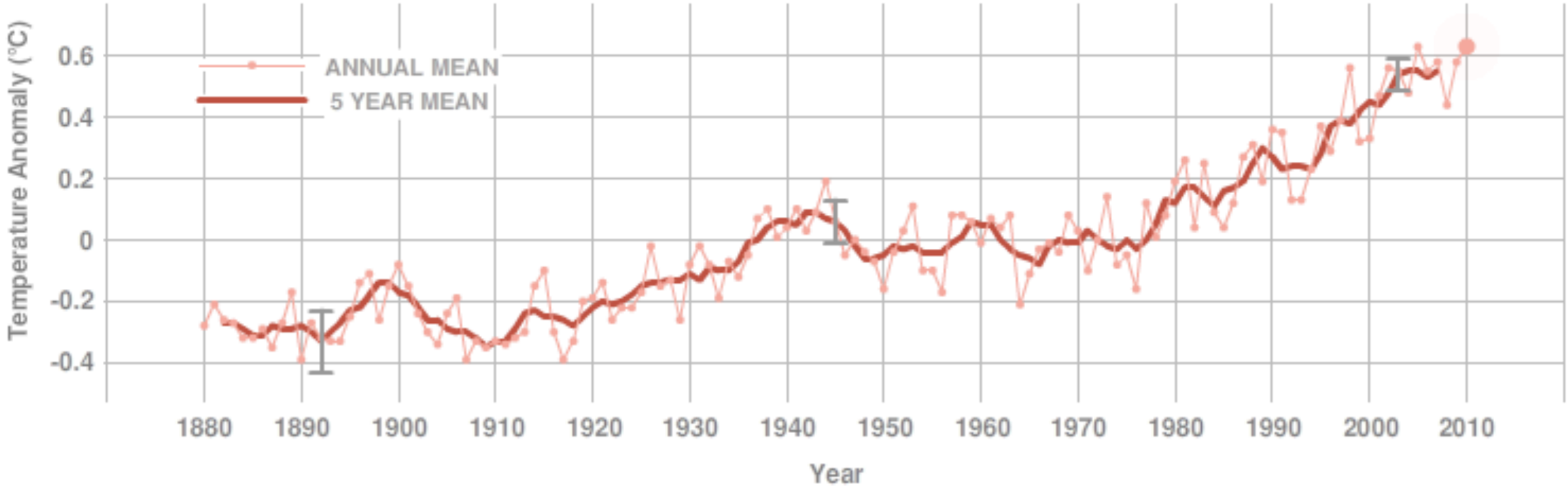
Global Surface Temperature

download data

Data updated 4.18.11

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Source: NASA/GISS. This research is broadly consistent with similar constructions prepared by the Climatic Research Unit and the National Atmospheric and Oceanic Administration. Credit: NASA/GISS



Politician	Objective Data	Politician
"the last 4 or 5 years, have they been cooler or warmer?" 31 March 2011 (Source)	Global temperature is still rising and 2010 was the hottest recorded.	"we've actually had global cooling in the last ten years" 7 December 2009 (Source)
"would it be fair to say then that there has been a cooling of global temperatures at least over the last 13 years compared to 1998?" 31 March 2011 (Source)	The last decade 2000-2009 was the hottest on record.	"What the science says is that temperatures peaked out globally in 1998. So we've gone for 10 plus years where the temperatures have gone down." 14 April 2009 (Source)

Sea Level

download data

Data updated 8.5.11

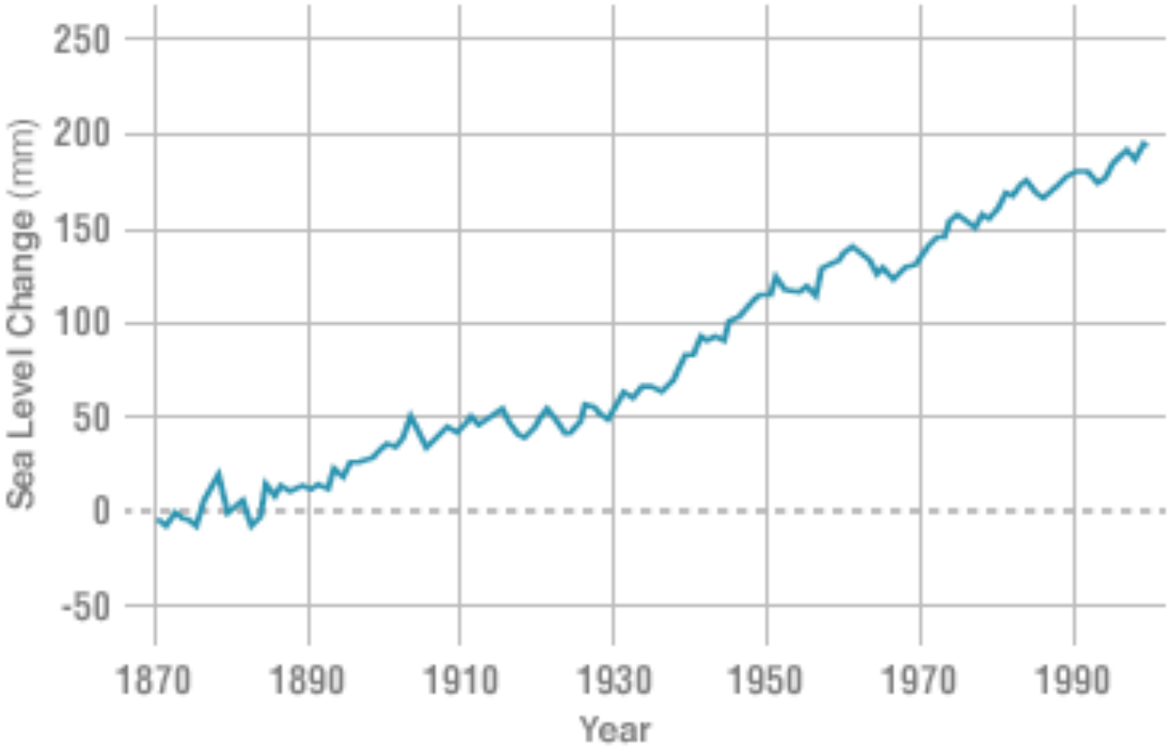
GROUND DATA: 1870-2000

Data source: Coastal tide gauge records.

Credit: CSIRO

RATE OF CHANGE

↑1.70 mm per yr*



*estimate for 20th century

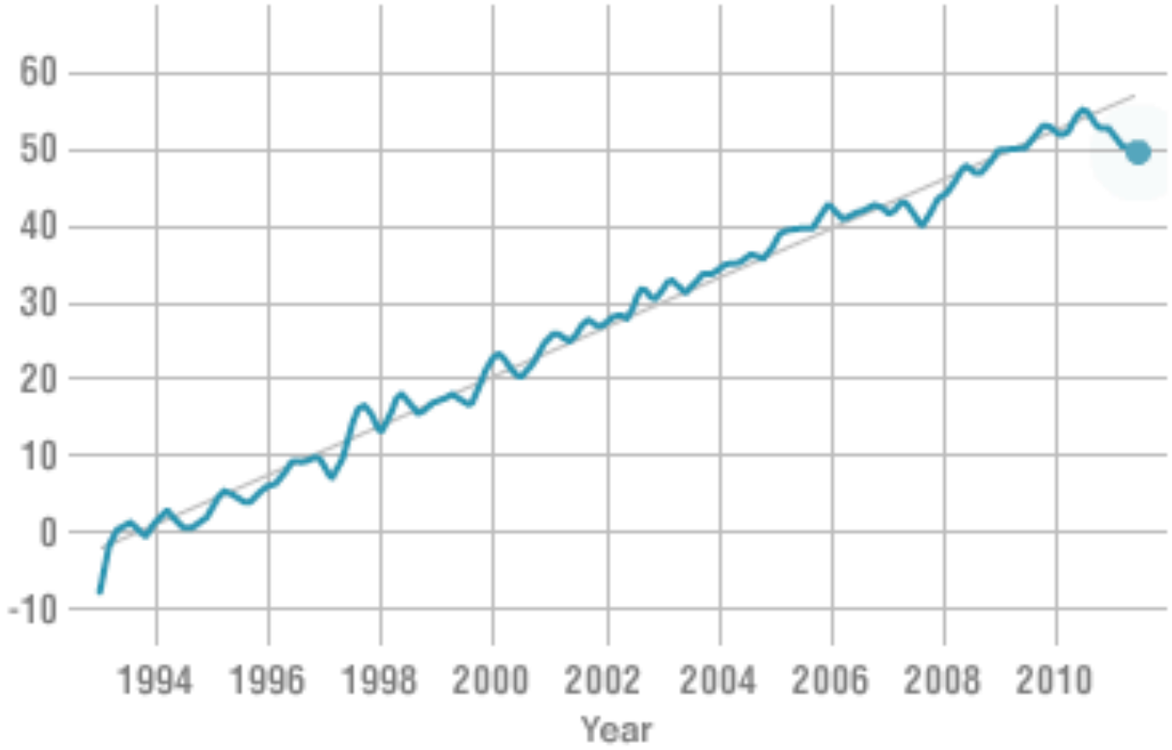
SATELLITE DATA: 1993-PRESENT

Data source: Satellite sea level observations.

Credit: CLS/Cnes/Legos

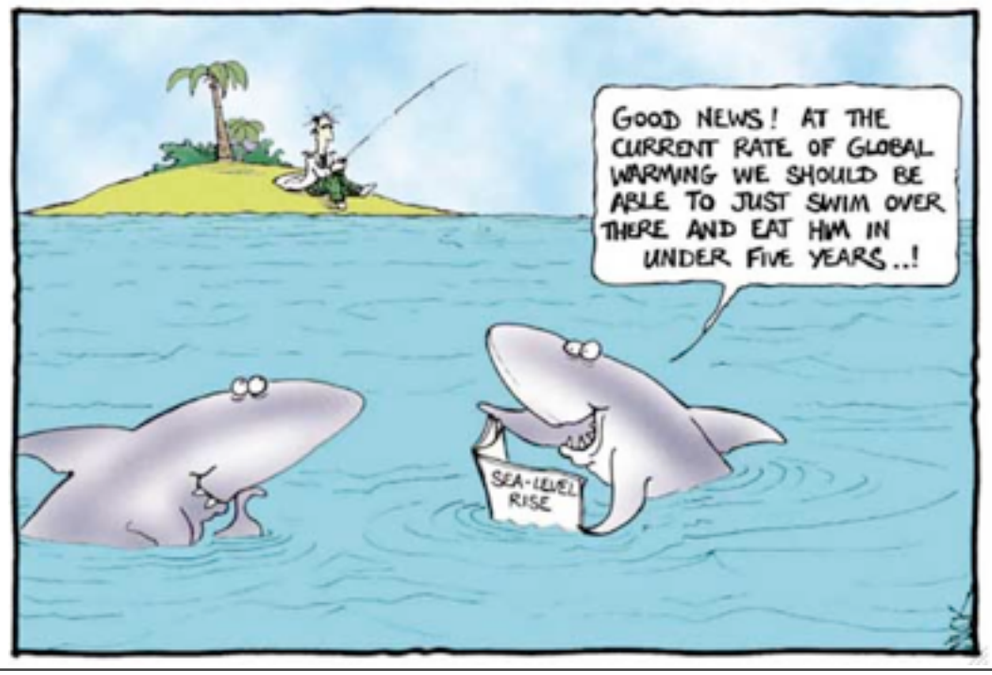
RATE OF CHANGE

↑3.27 mm per yr*



Inverse barometer applied and seasonal signals removed.

*estimate for 1993-2010



Arctic Sea Ice

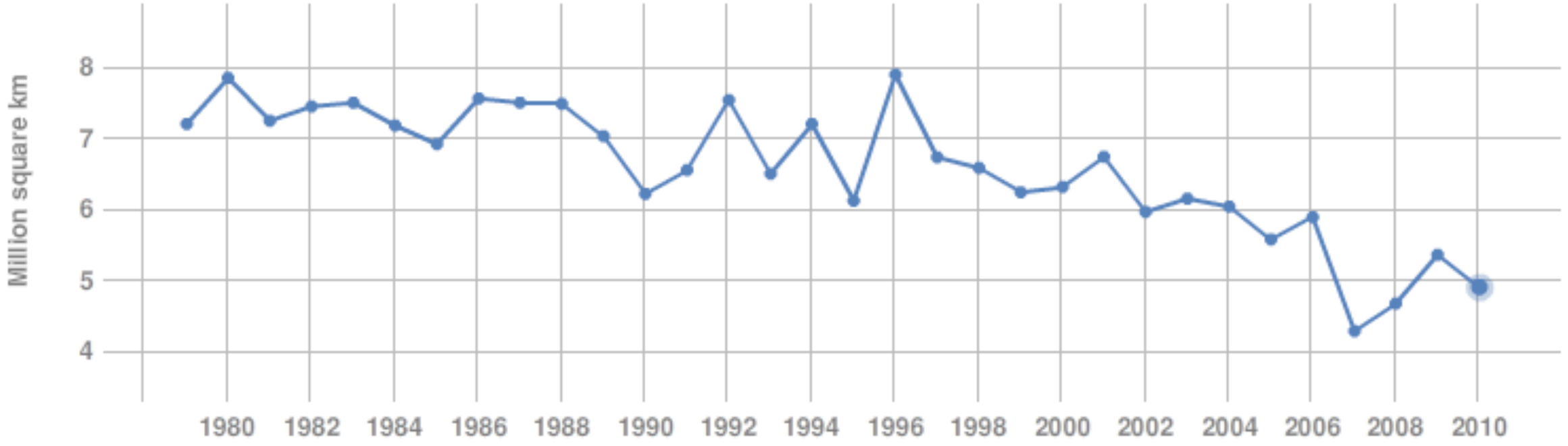
download data

Data updated 2.23.11

AVERAGE SEPTEMBER EXTENT

Data source: Satellite observations

Credit: NSIDC



Land Ice

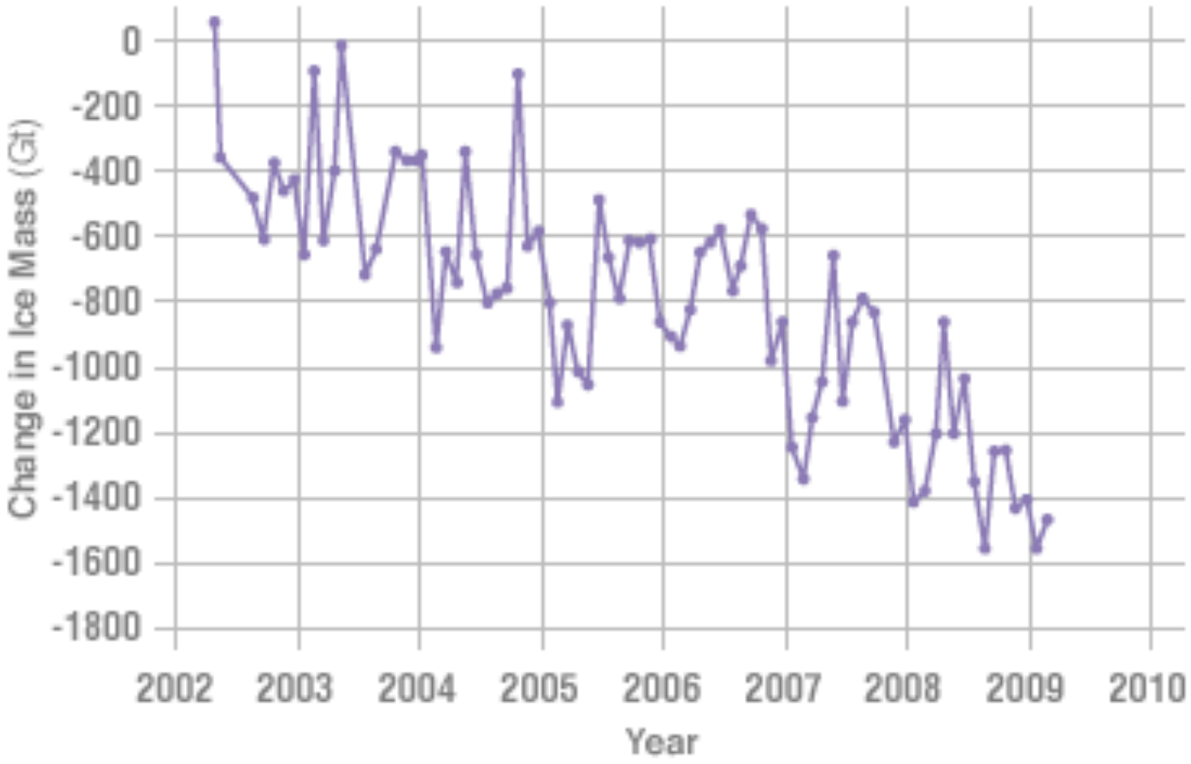
download data

Data updated 2.23.11

ANTARCTICA MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.

Credit: NASA/University of California, Irvine



GREENLAND MASS VARIATION SINCE 2002

Data source: Ice mass measurement by NASA's Grace satellites.

Credit: NASA/University of California, Irvine

Note: In the above charts, negative numbers indicate mass loss; positive numbers indicate mass gain. (Reference)

"in the Antarctic, where the penguins are, there is a buildup of ice."

18 March 2009 (Source)

Really?

"the ice in the Antarctic is growing"

8 March 2011 (Source)

Further Evidence of Climate Change

Ocean acidification

Since the beginning of the Industrial Revolution, the acidity of surface ocean waters has increased by about 30 percent.[12,13] This increase is the result of humans emitting more carbon dioxide into the atmosphere and hence more being absorbed into the oceans. The amount of carbon dioxide absorbed by the upper layer of the oceans is increasing by about 2 billion tons per year.[14,15]

Warming oceans

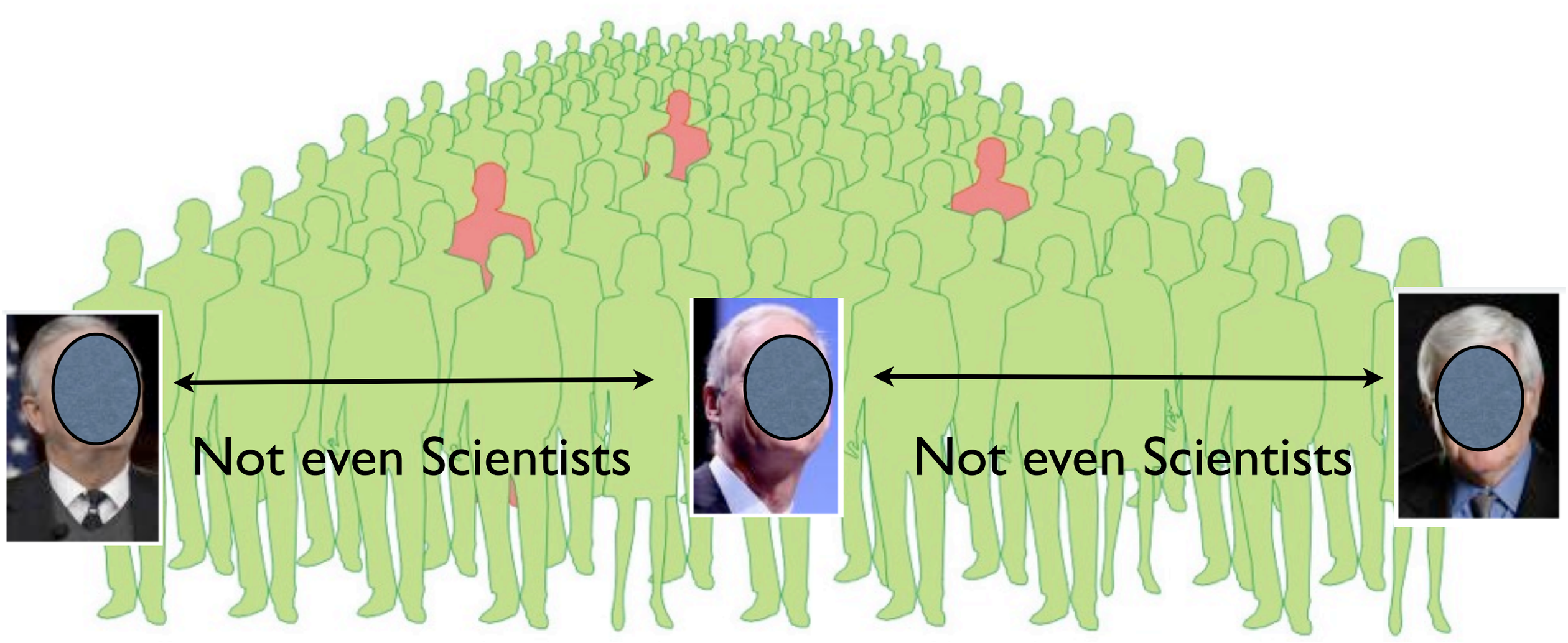
The oceans have absorbed much of this increased heat, with the top 700 meters (about 2,300 feet) of ocean showing warming of 0.302 degrees Fahrenheit since 1969.[8]

Extreme events

The number of record high temperature events in the United States has been increasing, while the number of record low temperature events has been decreasing, since 1950. The U.S. has also witnessed increasing numbers of intense rainfall events.[11]

Despite Evidence of Climate Change Some Want Us to Believe that there is Debate Among Scientists...NO

97 out of 100 climate experts think humans are changing global temperature



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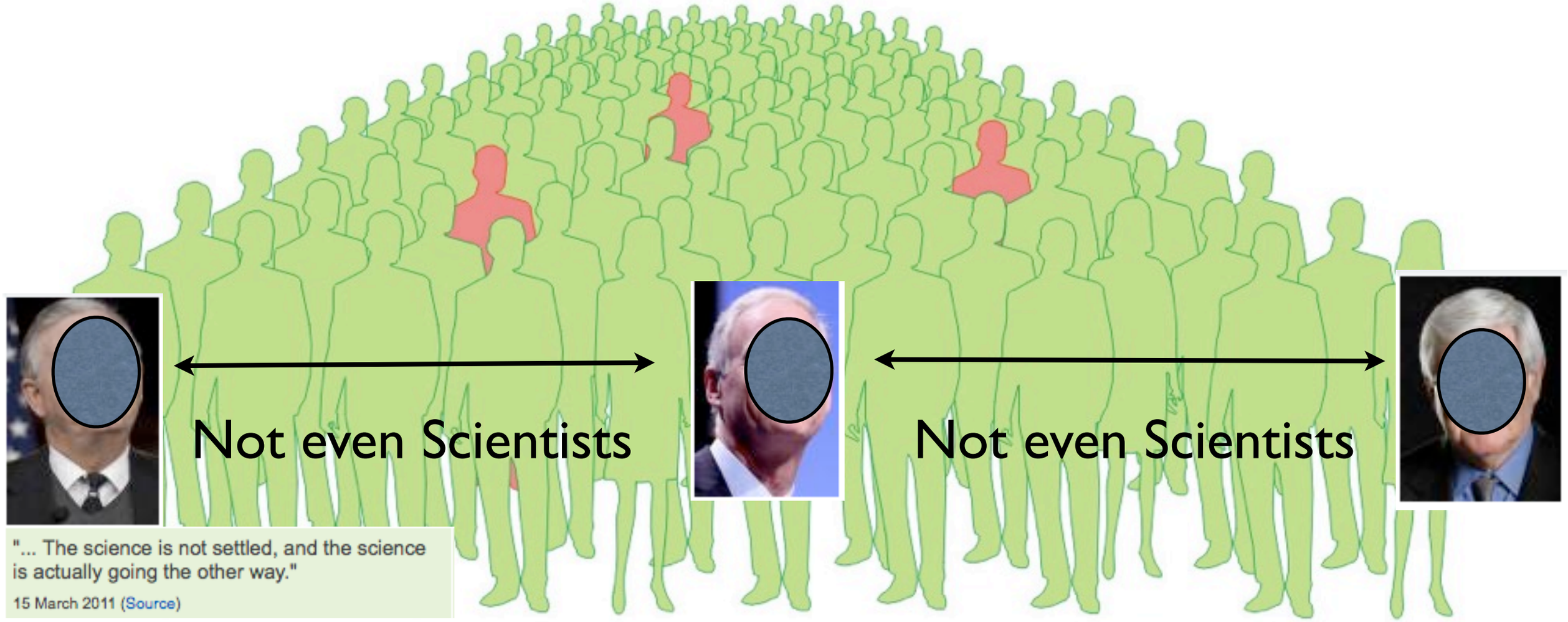

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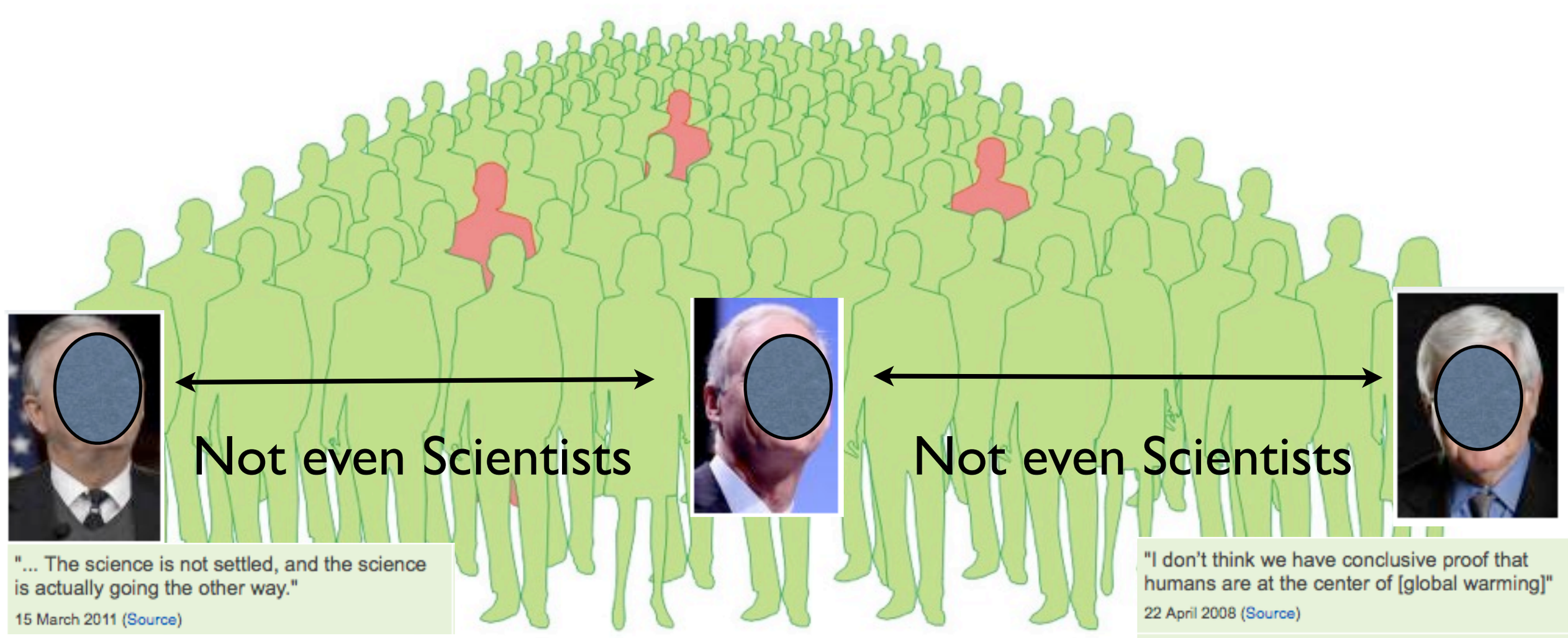

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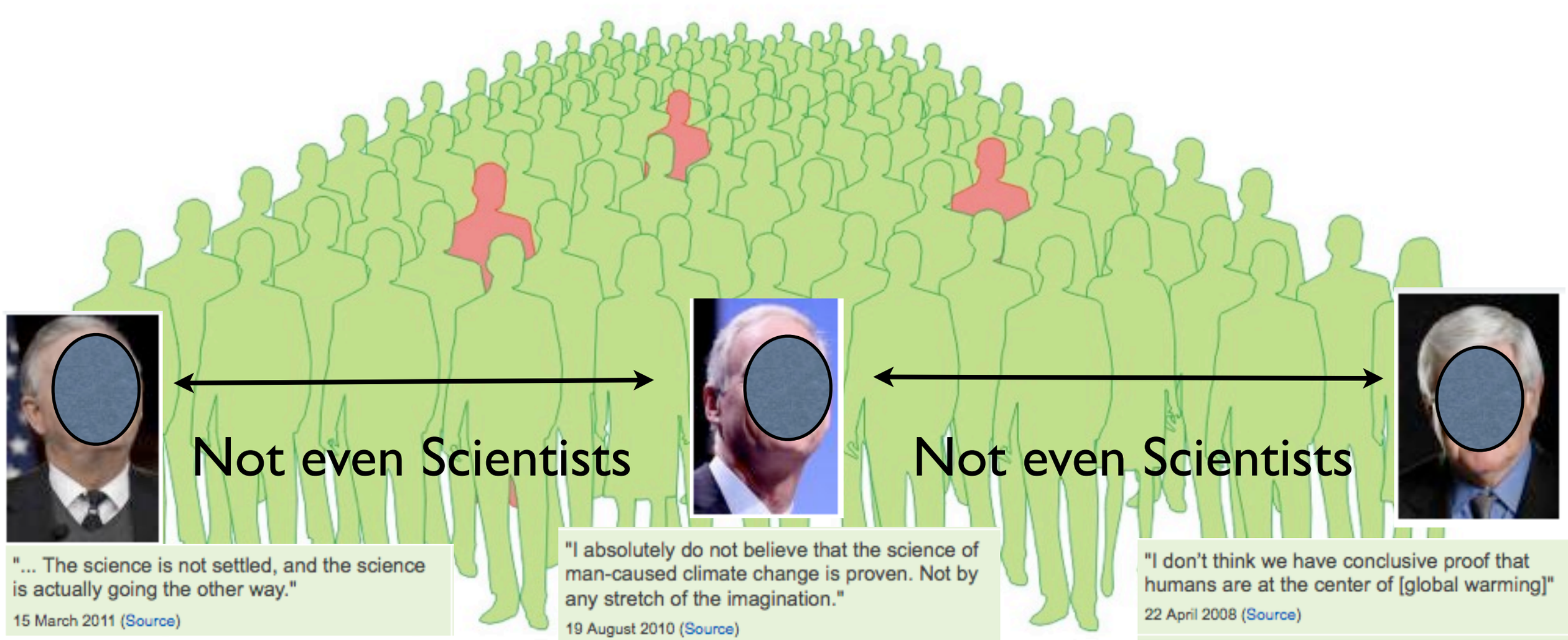


Despite Evidence of Climate Change Skeptics continue to make statements that illustrate their ignorance of science

"The idea that carbon dioxide is a carcinogen that is harmful to our environment is almost comical. Every time we exhale, we exhale carbon dioxide. Every cow in the world—you know when they do what they do—you've got more carbon dioxide."

[redacted] / ABC's *This Week* / April 2010

Despite Evidence of Climate Change Skeptics continue to make statements that fly in the face of data

"There are just as many glaciers that are growing that are shrinking."

THE SHRINKING PUNCAK JAYA

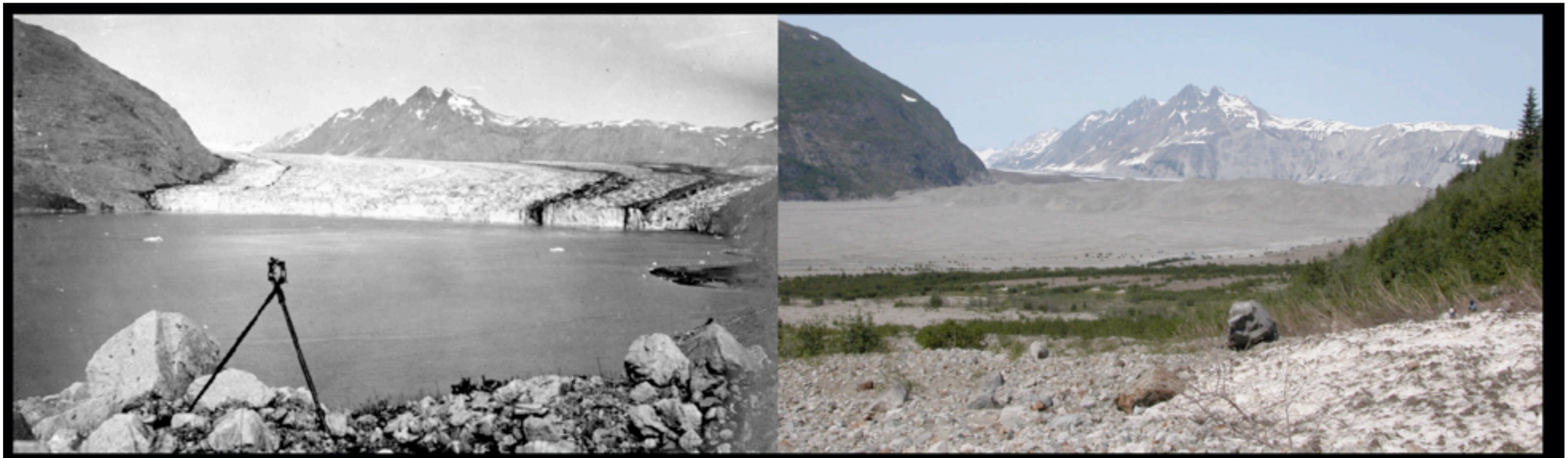
Puncak Jaya Glacier in the Irian Jaya province of Indonesia. Left: 1936. Middle: 1972. Right: 2005. Click here to download image.

BAKED ALASKA

McCarty Glacier, Alaska. Left: July 30, 1909. Right: August 11, 2004. Click here to download image.

PERU VIEW

Qori Kalis Glacier in Peru. Left: July 1978. Right: July 2004. Click here to download image.



RETREAT OF CARROLL GLACIER, ALASKA

Left: August 1906. Right: June 21, 2004. Click here to download image.

BEAR GLACIER, ALASKA, THEN AND NOW

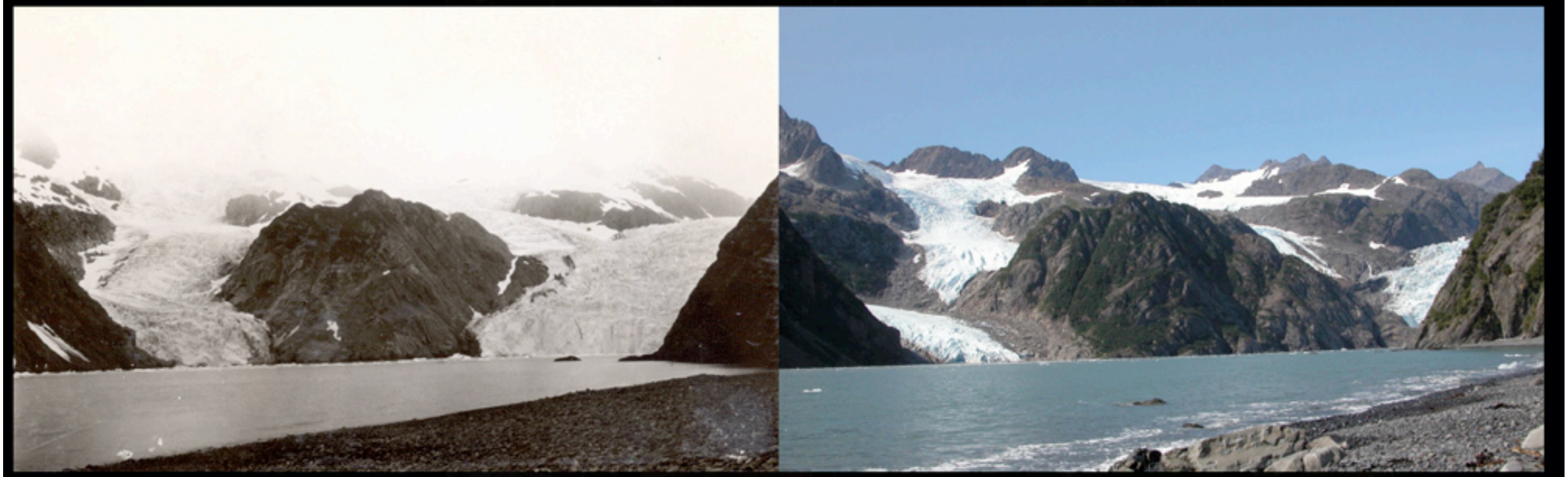
Bear Glacier in Alaska, photographed by Ulysses Sherman Grant on July 20, 1909 (left) and by Bruce F. Molnia on August 5, 2005 (right). Click here to download image.

IMJA GLACIER, HIMALAYAS

Imja Glacier in the Himalayas, as seen from a point above Amphu Lake and from the upper slopes of Island Peak. Left: Autumn, circa 1956. Right: October 18, 2007. The latter image shows pronounced retreat and collapse of the lower tongue of the glacier and the formation of new melt ponds. Click here to download image.

LESS IS MUIR

Muir Glacier, Alaska. Left: September 2, 1892. Right: August 8, 2005. Click here to download image.



THE MELTING OF HOLGATE GLACIER

Holgate Glacier, Alaska. Left: July 24, 1909. Right: August 13, 2004. Click here to download image.

PEDERSEN PAST AND PRESENT

The retreat of Pedersen Glacier, Alaska. Left: summer 1917. Right: summer 2005. Click here to download image.

OKPILAK GLACIER, ALASKA

Left: June 1907. Right: August 5, 2004. Click here to download image.

SLIPPERY SLOPE, COLORADO

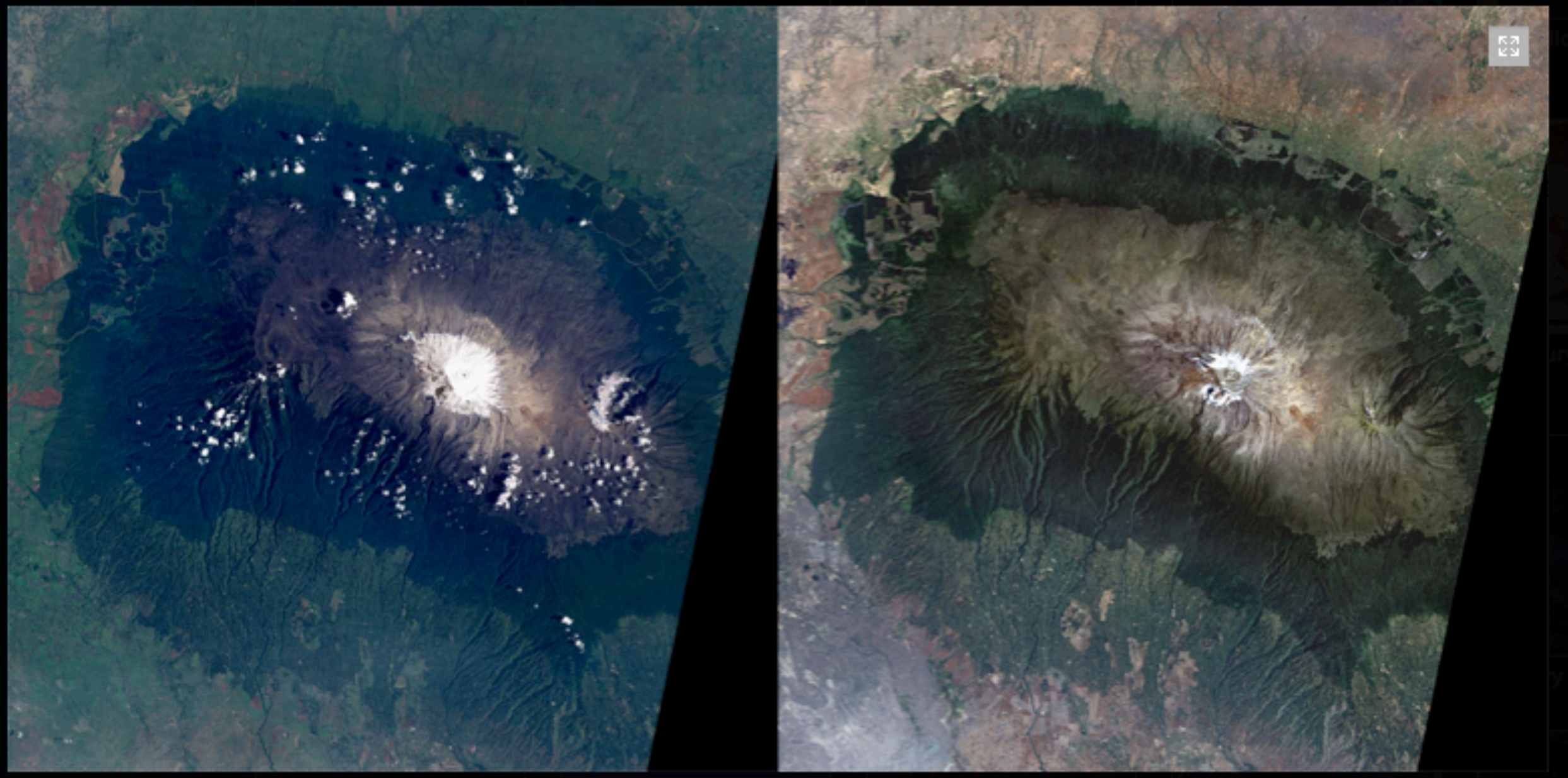
Arapaho Glacier, Colorado. Left: 1898. Right: 2003. Click here to download image.

MELTING MCCALL

McCall Glacier, Alaska. Left: July 1958. Right: August 14, 2003. Click here to download image.

MIGHTY MATTERHORN

The nearly 15,000-ft-high Matterhorn mountain, located in the Alps on the border between Italy and Switzerland. Left: August 16, 1960 at 9.00 am. Right: August 18, 2005 at 9.10 am. Click here to download image.

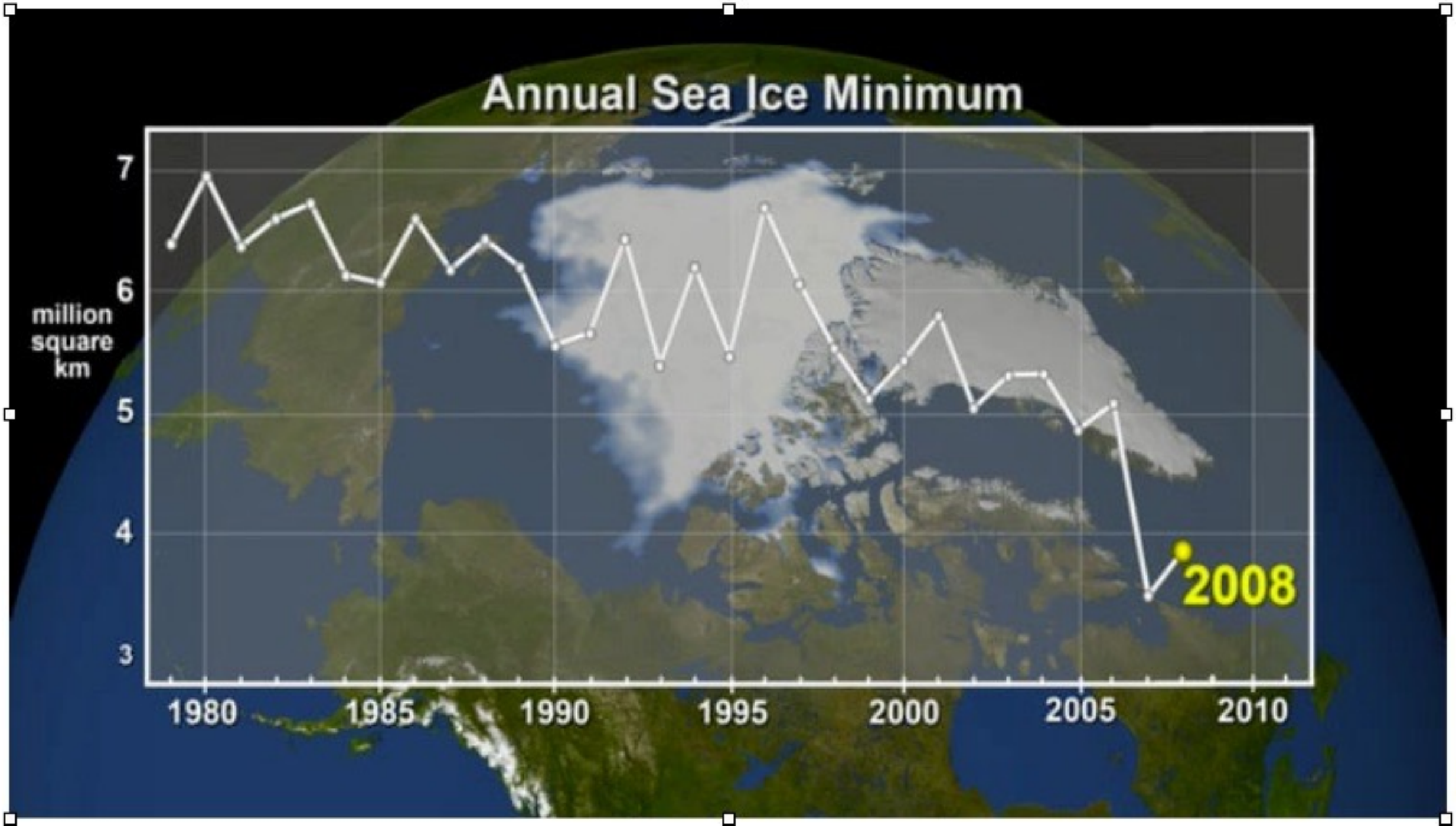


MOUNT KILIMANJARO, AFRICA

Kilimanjaro Glacier top view and side view, photographed by NASA's Landsat satellite on 17 February, 1993 (left) and again on 21 February, 2000 (right). Click here to download image.

That makes 14 examples of shrinking ones (there are more) do you think he can find that many that are growing?

That politician must have talking about sea ice?!@#?



NO?!@#?
How about the ice covering Greenland?

NO! Again ?!@#?, What about icebergs?

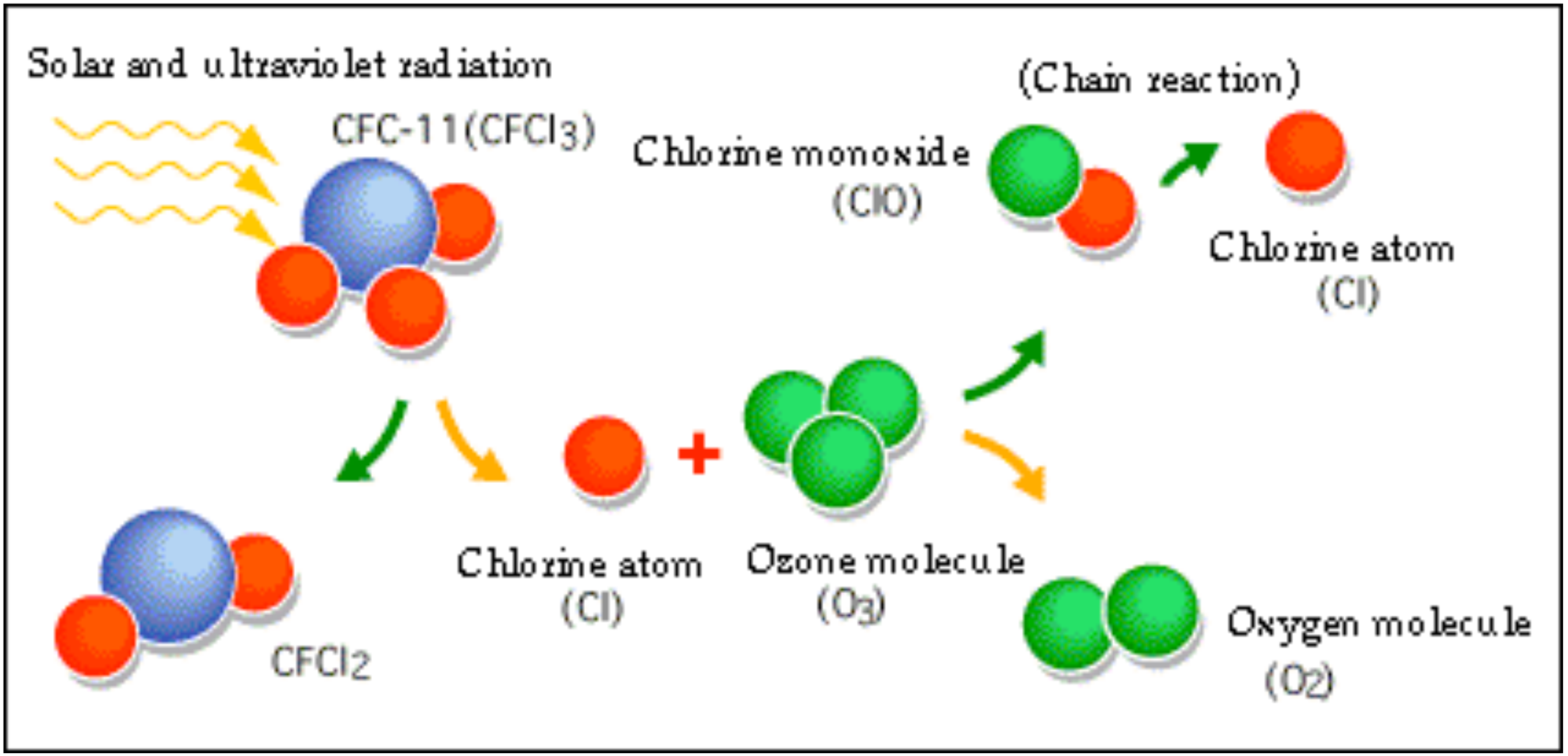
OK I Give Up! What hypothesis would draw from these observations?

As a footnote consider this...

Depletion of Atmospheric Ozone

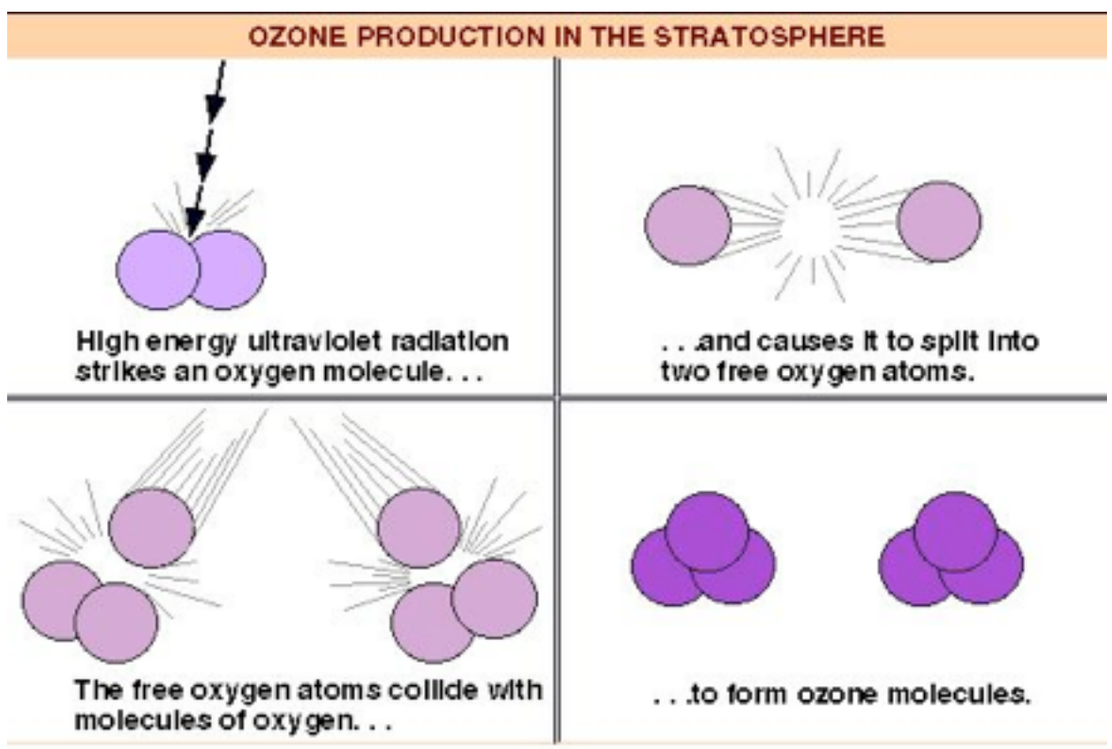
- Like atmospheric levels of CO_2 the levels atmospheric ozone (O_3) have been changing as well
  - Life on earth is protected from the damaging effects of UV radiation by layer of ozone located in the stratosphere.
- Ozone has changed as a result of human activities.
  - The destruction of ozone results primarily from the accumulation of chloroflourocarbons (CFC's), chemicals used in refrigeration and manufacturing.

- UV radiation damages DNA, experts expect to see a rise in mutation rates and cancer.
    - The effect is unpredictable for crop plants and phytoplankton.
- Bad News: ozone levels have decreased 2-10% in the last 2 decades.
- Good News: Since 1987, 190 countries have signed the Montreal Protocol (a treaty that regulates ozone depleting chemicals)
- Good News: Most nations have ended the production of CFC's and the ozone depletion is slowing.
- Bad News: The chlorine molecules already in the atmosphere will remain there for at least 50 more years



CFC Destruction of Ozone

Natural Production of Ozone



Learning Objectives:

LO 2.28 The student is able to use representations or models to analyze quantitatively and qualitatively the effects of disruptions to dynamic homeostasis in biological systems. [See SP 1.4]