

# Global Climate Change: What is science is telling us?

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13 Aug. 1941

31 Aug. 2004

**Muir Glacier, Alaska**

Nat. Snow and Ice Data Center, Boulder Colorado;  
[http://www.nsidc.org/data/glacier\\_photo/index.html](http://www.nsidc.org/data/glacier_photo/index.html)

# Mt. Kilimanjaro, Africa

Feb. 17, 1993

80% decrease

Feb. 21, 2000

February 17, 1993

February 21, 2000



# Reduction in North Pole ice:



1979



1979



2003



2003

# Coral die offs





**TOP 5 WARMEST YEARS  
WORLDWIDE  
SINCE THE 1890s**

- 1) 2005**
- 2) 1998**
- 3) 2002**
- 4) 2003**
- 5) 2004**

# How are the behaviors and habitats of plants & animals changing?



- Many plants now leaf-out and flower sooner than they used to, many birds arrive and nest sooner, and many insects emerge sooner in the spring.
- Habitats which some plants and animals depend on will move; some species can follow, others cannot.



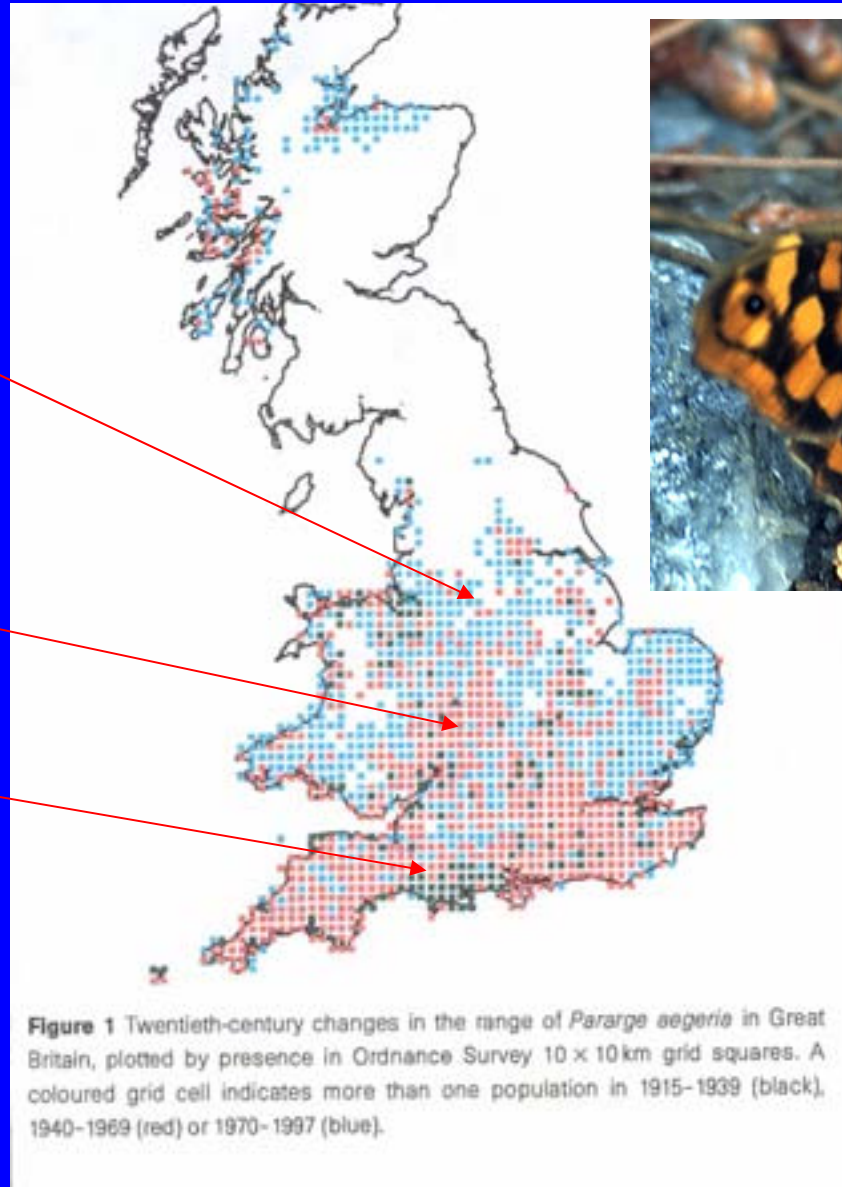
**Kirtland's Warbler**

# 20<sup>th</sup> century changes in the range of butterfly *Pararge aegeria* in Great Britain (Nature, June 1999)

1970-1997

1940-1969

1950-1939

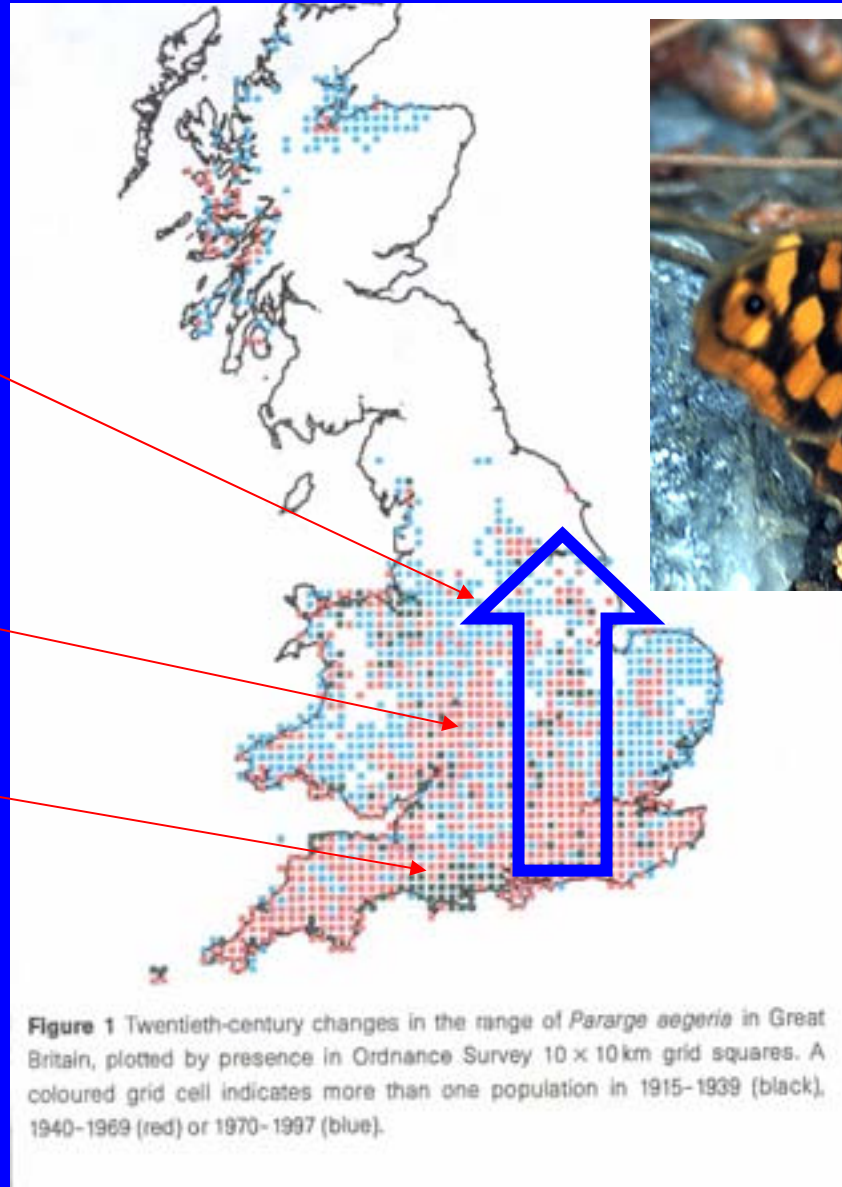


# 20<sup>th</sup> century changes in the range of butterfly *Pararge aegeria* in Great Britain (Nature, June 1999)

1970-1997

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**This species of butterfly extended its range to the north.**

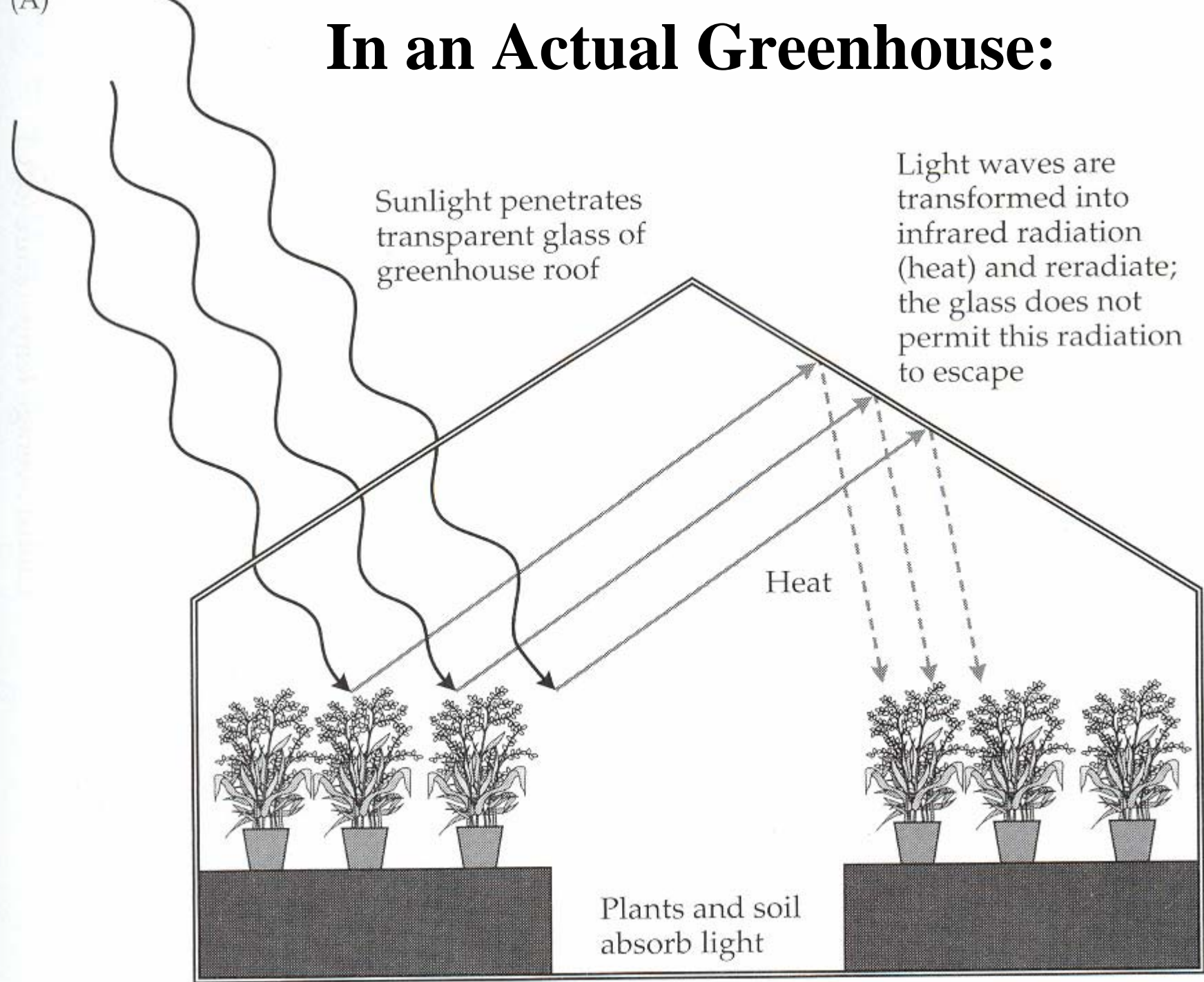


# How is Global Warming different from Global Climate Change?

- **Global warming** – increased temperature resulting from greenhouse effect.
- **Global Climate Change** – the broad set of changing climate characteristics changing now and into the future including temperature, precipitation and wind patterns.

**How does the Greenhouse Effect work?**

# In an Actual Greenhouse:



(B)

# In the Earth's Atmosphere:

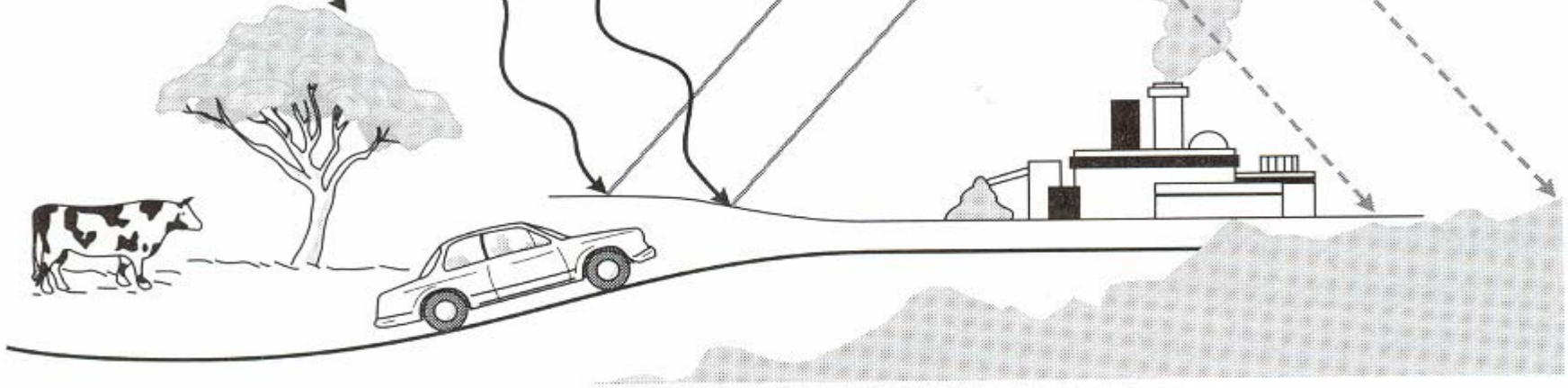
Greenhouse gases in the atmosphere (CO<sub>2</sub>, methane nitrous oxide, etc.) trap the reradiated heat near the Earth's surface

**More CO<sub>2</sub> = more heat trapped**

Solar radiation

Clouds

Heat

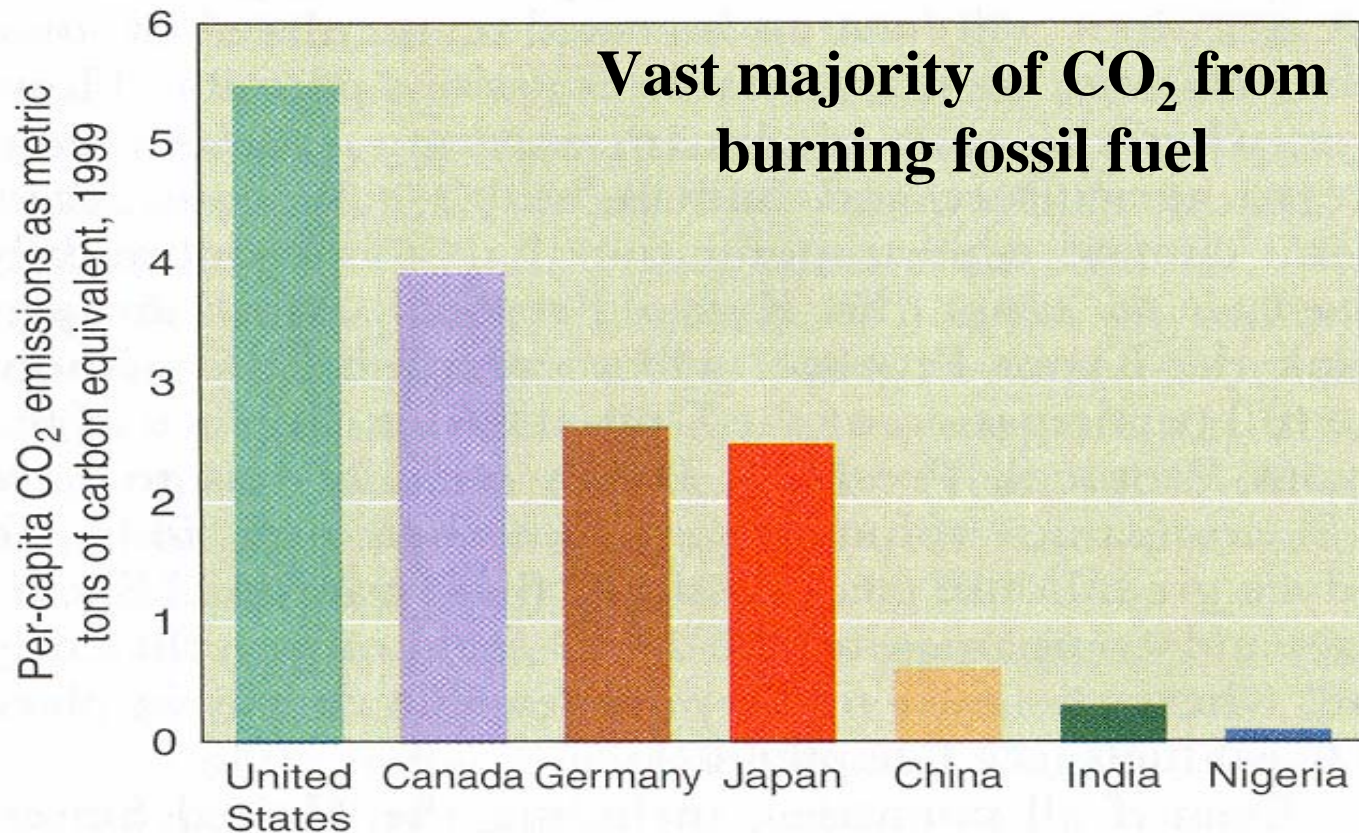


Light waves are transformed into infrared radiation (heat) and reradiated

# What are Greenhouse Gasses?

- **Greenhouse Gasses** - gasses that trap heat in atmosphere (like glass in a greenhouse)
- **What causes greenhouse gas?**
  - Burning fossil fuels including gasoline, coal, and natural gas
- **Where in the world do these gasses come from?**





**Figure 20.10** Per-capita carbon dioxide (CO<sub>2</sub>) emission estimates for selected countries, 1999. Note that industrialized nations currently produce a disproportionate share of CO<sub>2</sub> emissions. As developing nations such as China, India, and Nigeria industrialize, however, their per-capita CO<sub>2</sub> emissions increase. (In conformance with scientific practice, CO<sub>2</sub> emissions are quantified by their weight in carbon. One metric ton of carbon equivalent equals 3.67 metric tons of CO<sub>2</sub>.)

# Historically, how have changes in CO<sub>2</sub> concentrations been correlated with global temperature?

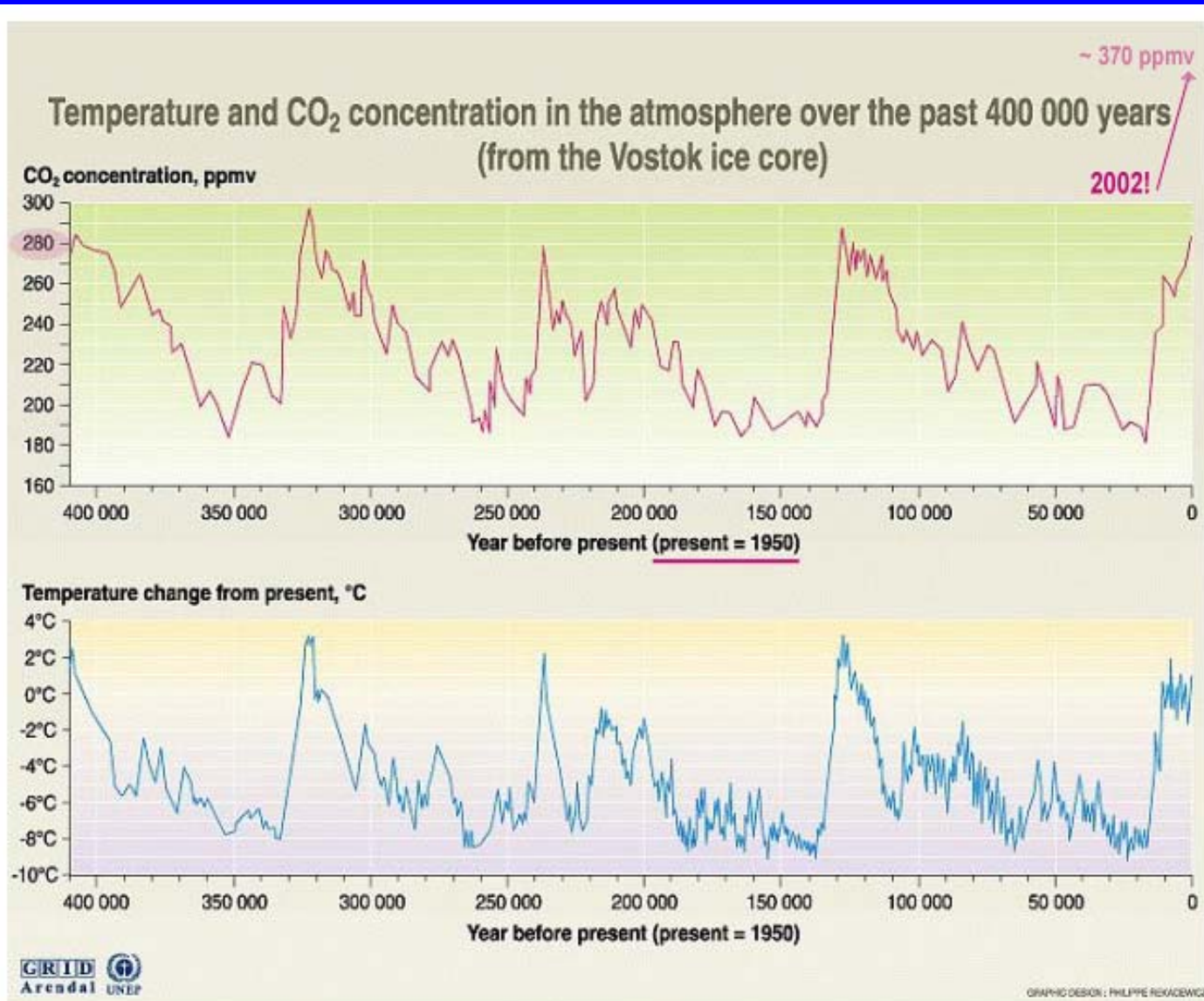
In the last 400 years) we can directly measure temperature.

To go back further, we use proxy measures of past climate conditions, such as: ice cores, tree rings, lake sediment samples.

**These can be used by scientists to reconstruct past temperature and CO<sub>2</sub> concentrations..**



# How have changes in CO<sub>2</sub> concentrations been correlated with global temperature?



400,000  
years of  
change in:

CO<sub>2</sub>

Temperature

Source: J.R. Petit, J. Jouzel, et al. Climate and atmospheric history of the past 420 000 years from the Vostok ice core in Antarctica, Nature 399 (3/June), pp 429-436, 1998.

(Note: 2002 information added to diagram)

# How does one decide whether global climate change is happening?

- You can ask your parents,
- You can ask your teachers,
- You can read articles and books,
- You can ask an expert, or lots of experts



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**What would qualify someone as an expert on global climate change?**

# How do we decide whether global climate change is happening?

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## **What would qualify someone as an expert on global climate change?**

- You could look at someone's credentials, what they studied in college, their research history, etc.

# Science

Science is designed to help us answer  
complex questions

What we know about global climate change comes from science and scientists.

Science is a way of knowing.



# Modern scientific method

- A way of answering questions based on testing and looking critically at the results.



# Modern Scientific Method: 3 key steps

Ask a question .....

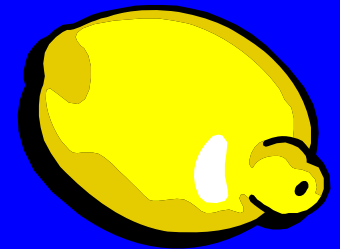
1. **Gather facts or observations**, or perform an experiment to answer the question.
2. **Analyze data**. What do the facts tell you?  
Ask other scientists.
3. **Draw conclusions**....until we learn more.

**EXAMPLE:** you are interested in lemons...

## 1. Gather observations



*So...you lick a lemon and conclude that it is sour - a particular detail. Lick 10 more and you conclude that lemons in general are sour – **here's a pattern!**...you have derived a general principle – no details contradict the evidence.*





EXAMPLE continued:

- You are becoming more convinced that: **Lemons are sour** based on your past experience or what someone told you.
- Now you want to find out if others agree with your assessment of lemons.



## 2. Analyze data

Suppose you then want to test this hypothesis by having thousands of 6<sup>th</sup>, 7<sup>th</sup>, and 8<sup>th</sup> graders lick thousands of lemons from throughout the world.

*Volunteers?*



**Results:** you find that one variety of lemon is actually sweet (Meyer lemon) and that some people have no sense of taste.

Based on these data/observations, you modify your conclusion to say that:

“If *most* people lick any lemon *except* the Meyer lemon, they will get a sour taste in their mouth”



“If *most* people lick any lemon *except* the Meyer lemon, they will get a sour taste in their mouth.”

You have increased the accuracy of  
how you understand lemons and  
human taste, **but:**

You can never be absolutely sure that your hypothesis is always correct, but you can say that it has a high probability of not being wrong, based on the evidence and your previous tests.

# What we know about global climate change comes from scientific observations.

**That means our growing understanding of global climate change is based on information gathered using the scientific method:**

**Not just opinions**

**Not gut feelings**

**Scientists must test and retest their conclusions, expose them to the critical eye of others, and modify their views based on the strength of the evidence.**

**Some issues that science deals with may seem trivial, such as whether lemons are sour...**

**Other issues that science deals with are very important:**

- How to treat human illness
- How to develop new technologies
- How to understand the physical and biological world and our dependence on it
- How the Earth's atmosphere can change and how that might influence conditions on the planet

### 3. Draw conclusions

- The U.S. National Academy of Science (who are experts in atmospheric science, climate change, etc.) states:
  - “The conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue”

# Do scientists disagree on the causes of climate change?

- This can be tested:

# Do scientists disagree on the causes of climate change?

- Of the 928 papers in scientific journals between 1993-2003 that listed “climate change” in key words\* ...**not one disagreed** or took the position that current climate change is entirely natural (not caused by human activities).

\* From: N. Oreskes. 2004. The scientific consensus on climate change. Science 306:1686.



# Conclusions

- Scientists publishing in respected scientific journals agree that climate change is happening and that humans are largely responsible.
- The impression that there is scientific confusion over *whether climate change is happening* is incorrect.
- The impression that there is scientific confusion over *the forces contributing to climate change* is also incorrect

So if nearly all scientists agree that climate change is happening, and that humans are causing most of it, *why do some people continue to say that it is highly uncertain?*

So if nearly all scientists agree that climate change is happening, and that humans are causing most of it, *why do some people continue to say that it is highly uncertain?*

## 2 reasons:

1. It is hard to predict what the exact future will be like...it's scary.
2. Some people feel that accepting the science threatens them.
  - oil industry
  - electric utilities that burn coal might have to change
  - cars that use gasoline might have to change in order to stop putting carbon into the air.



So if nearly all scientists agree that climate change is happening, and that humans are causing most of it, why do some people have the impression that it is highly uncertain?

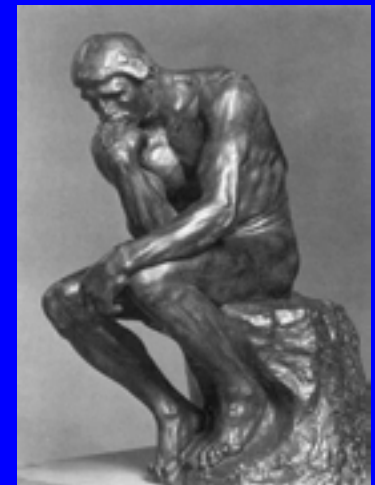
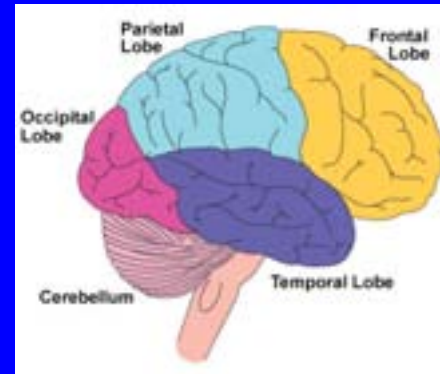
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**How did the tobacco industry respond to scientific evidence that cigarettes cause cancer?**



# Here's where YOUR brain comes in.....



**When deciding what to believe, ask yourself:**

- Is this person an expert in this field?

- What are his or her credentials?

(You would not expect your dentist to know much about how to fix your car)

- Who is paying this person or organization to distribute this opinion?



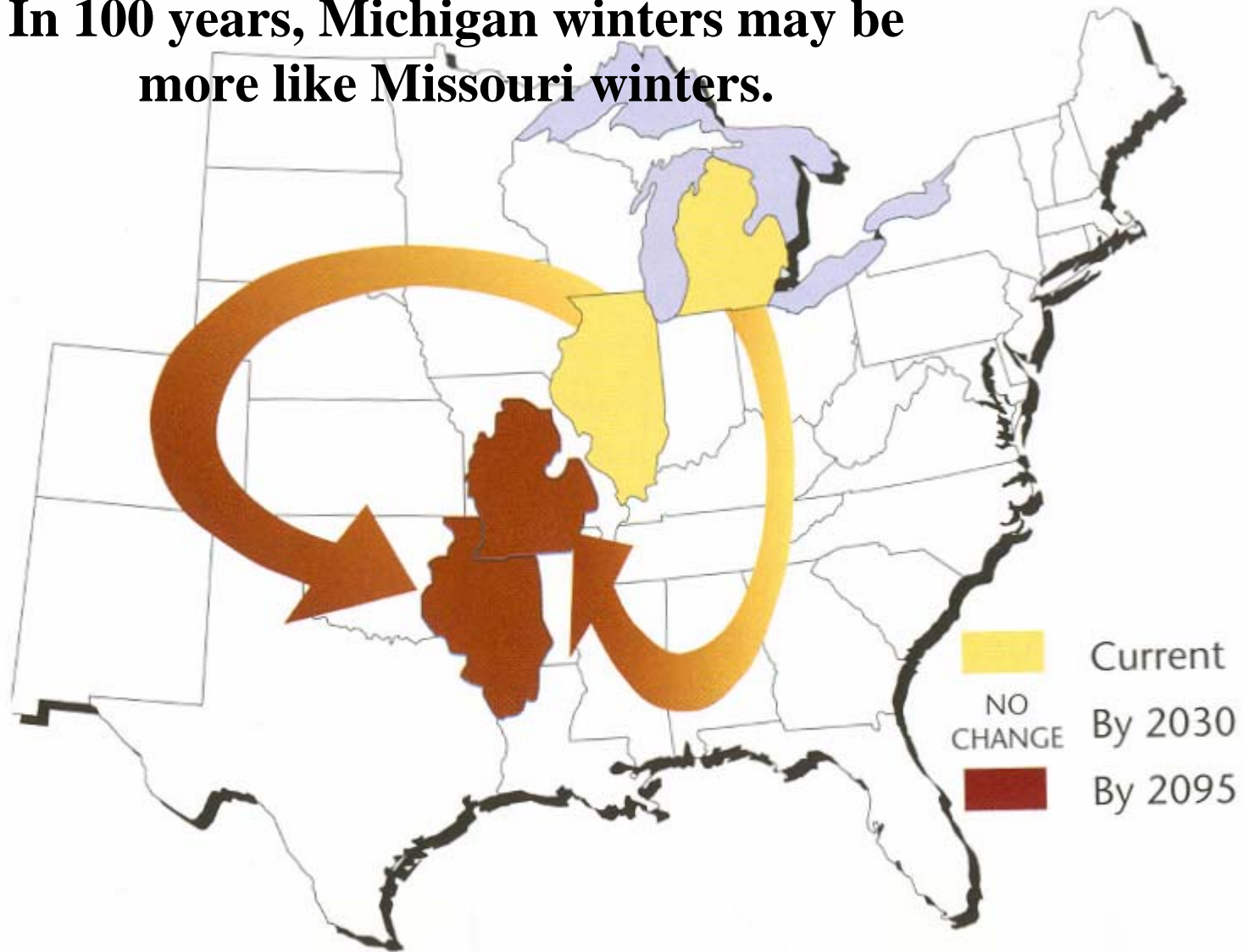
## Arnold Schwarzenegger, Republican Governor of California

**In reference to the high level of agreement  
among scientists that humans are causing  
climate change:**

**“If 98 doctors say my son is ill and  
needs medication and two say ‘No,  
he doesn’t, he is fine’, I will go with  
the 98. It’s common sense...”**

**How might climate  
change affect our climate  
here in Michigan?**

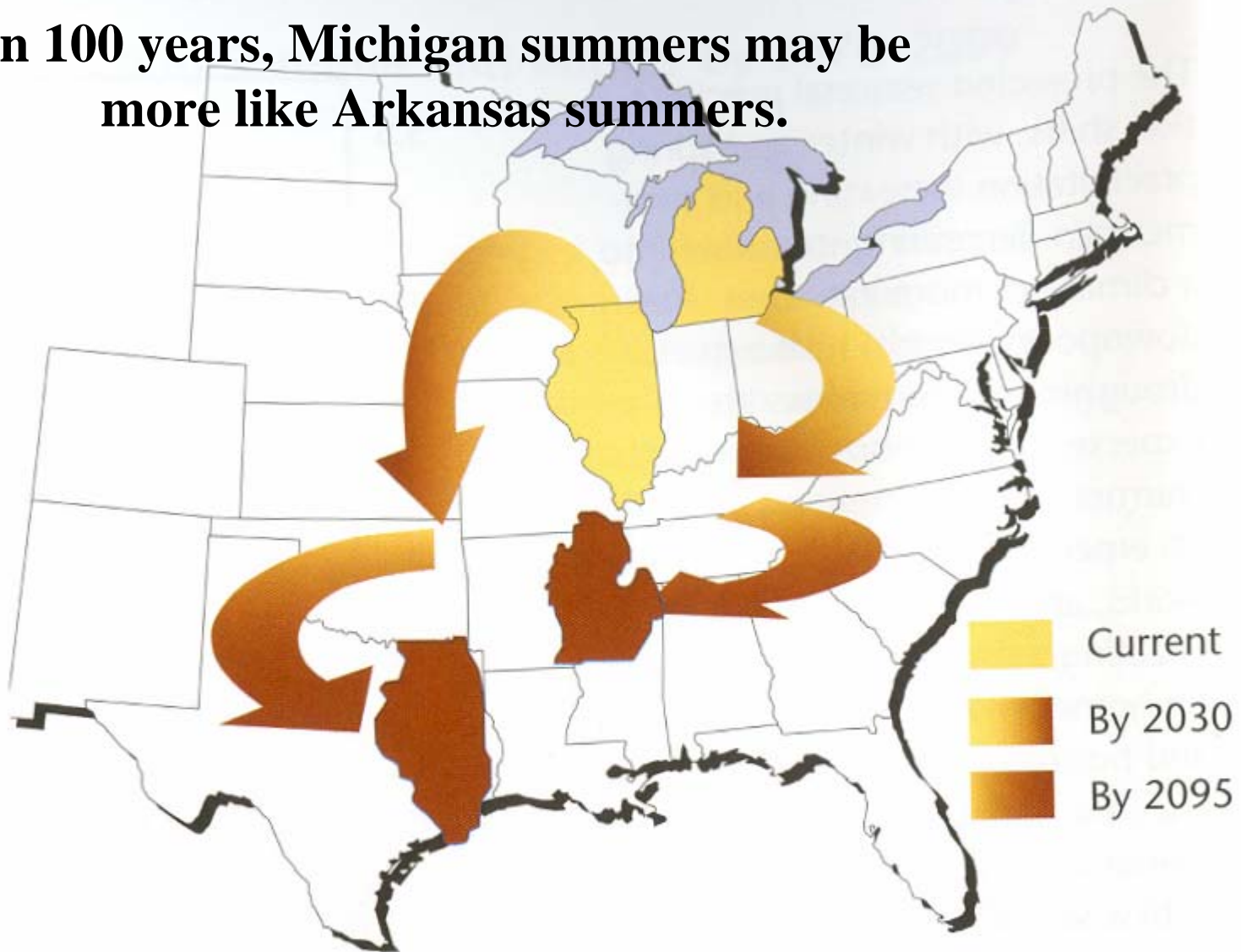
**In 100 years, Michigan winters may be more like Missouri winters.**



Changing Winters (DJF average)  
in Illinois and Michigan



**In 100 years, Michigan summers may be more like Arkansas summers.**



Changing Summers (JJA average)  
in Illinois and Michigan

If climate change is happening,  
what can be done?

# Solutions need to:

- Reduce greenhouse gas emissions
  - Use less fossil fuel (gasoline, coal, natural gas)
- Provide alternatives to burning fossil fuels:
  - Offers many other benefits including national security, keeping ahead on technological advances



# What can each of us do?



- 1. Support energy conservation and efficiency.**
  - Ride a bike, use less electricity, use mass-transit, etc.
- 2. Support transition to other energy sources that emit less carbon** such as solar, hydroelectric, wind power.
- 3. Be informed, and act** for your sake and for the long-term good of the U.S. and the world.

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BECAUSE.....

**Everyone Makes a Difference.**

**It is up to you to decide what that  
difference will be.**

# Good Planets are Hard to Find

This is about the world that you and your children will inherit



**Questions?**