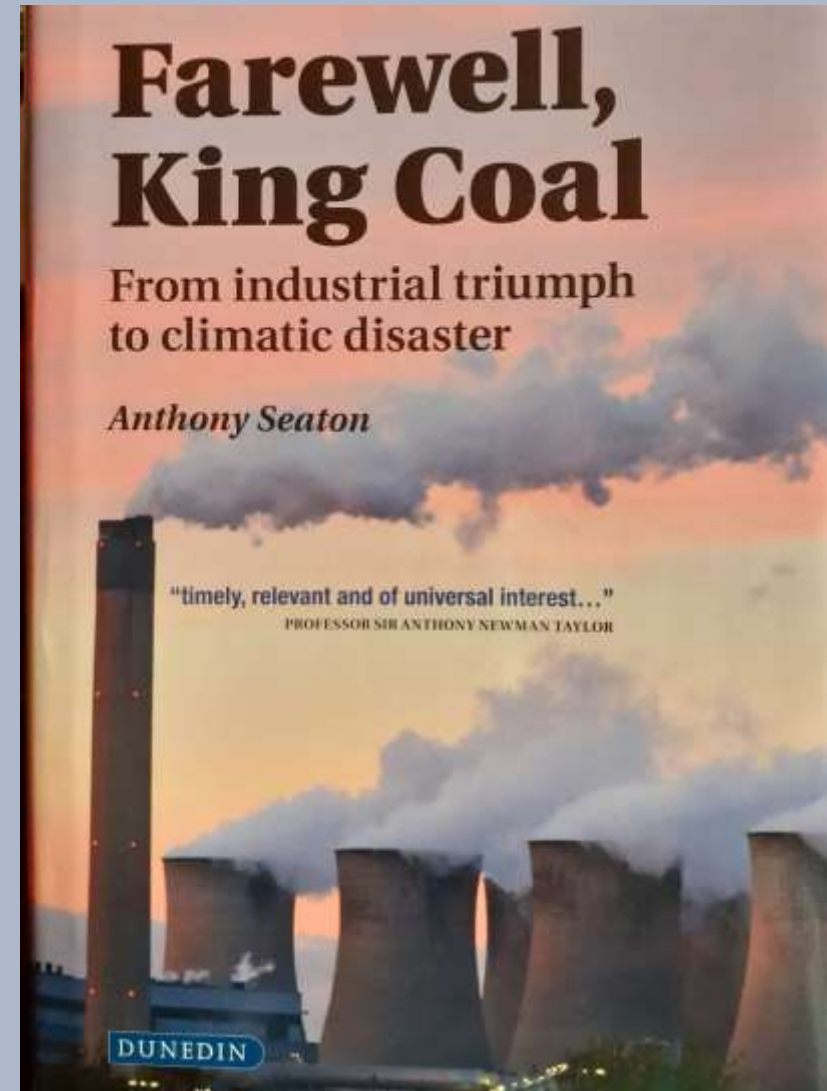


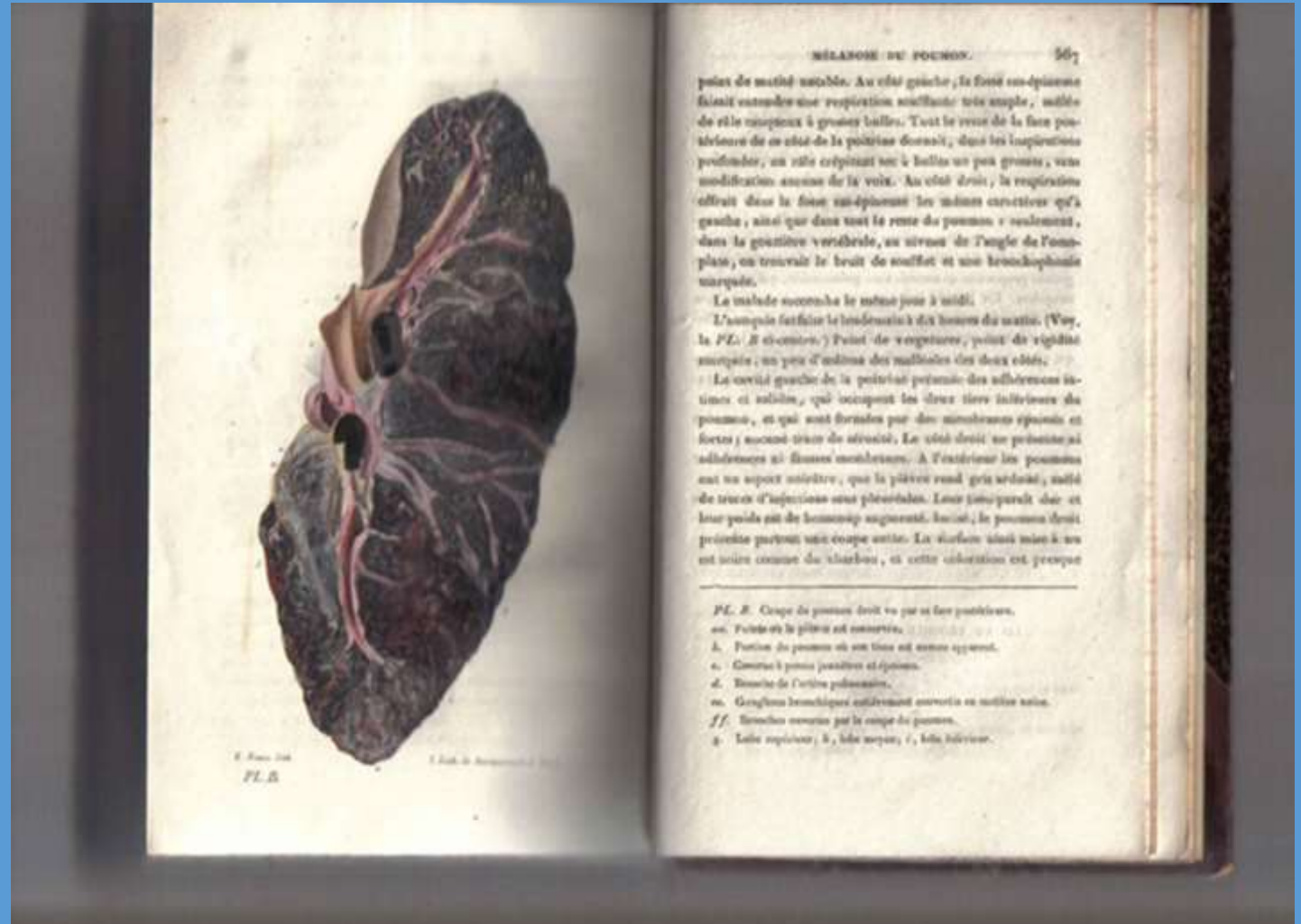


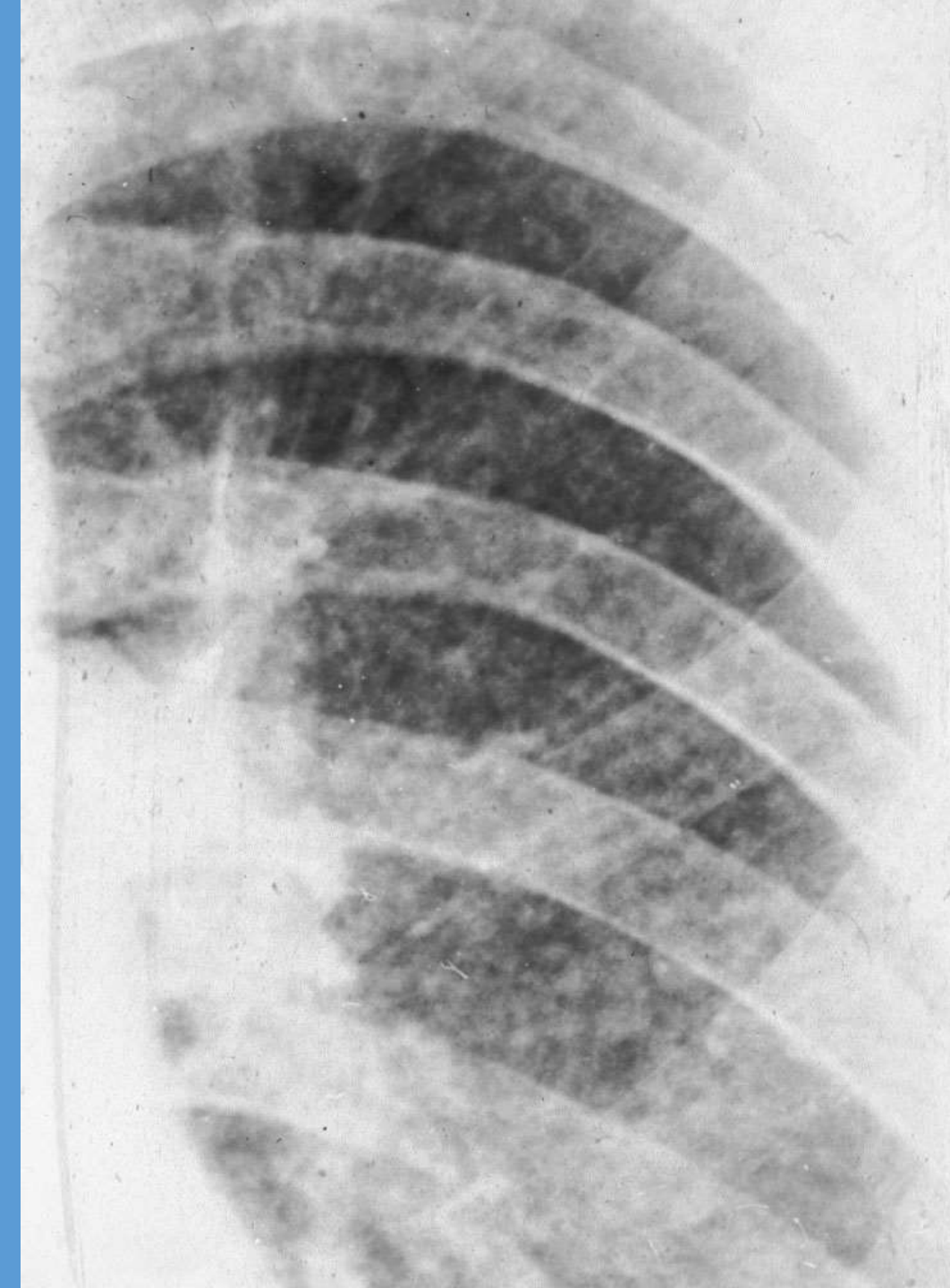
# Coal, Quartz, and Climate Change

**Anthony Seaton**

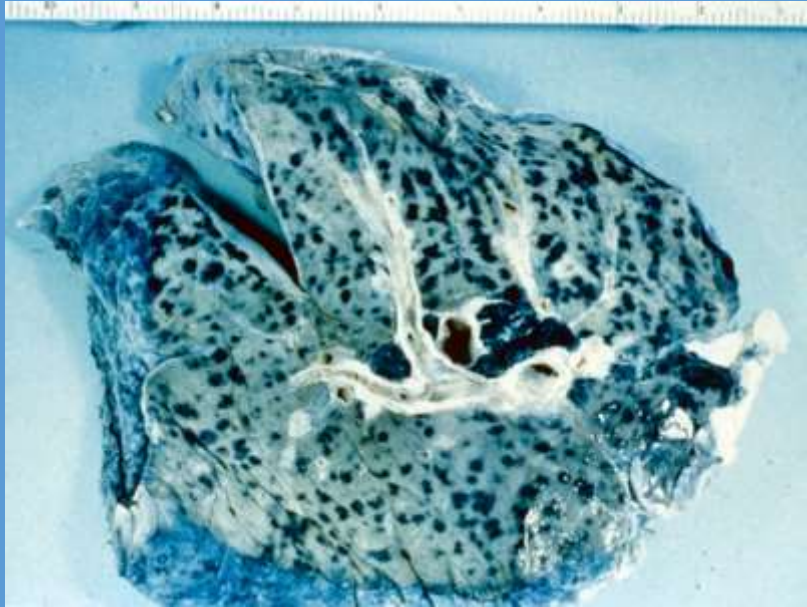


# The discovery of coalworkers' pneumoconiosis by Gregory (1831) and its recognition by Laënnec (1837).





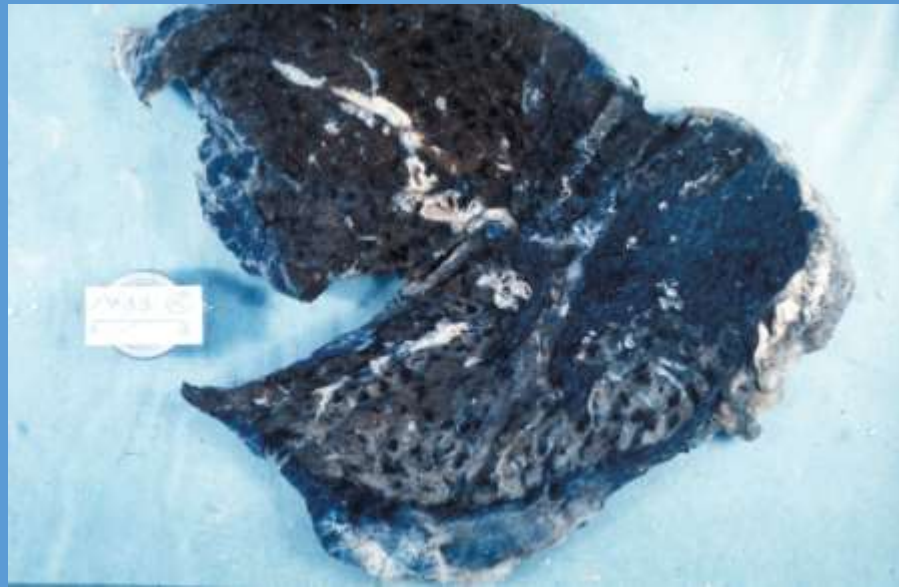
Simple pneumoconiosis



Emphysema



Massive fibrosis



# Nationalisation of UK coal industry 1946

- 55 coke works, 850 mines, 30 smokeless fuel plants
- 800,000 workers
- Set up a medical service (pre-NHS) and regular health checks
- How much and what sort of dust was causing pneumoconiosis?
- What dust levels would ensure workers would not become disabled by lung disease?



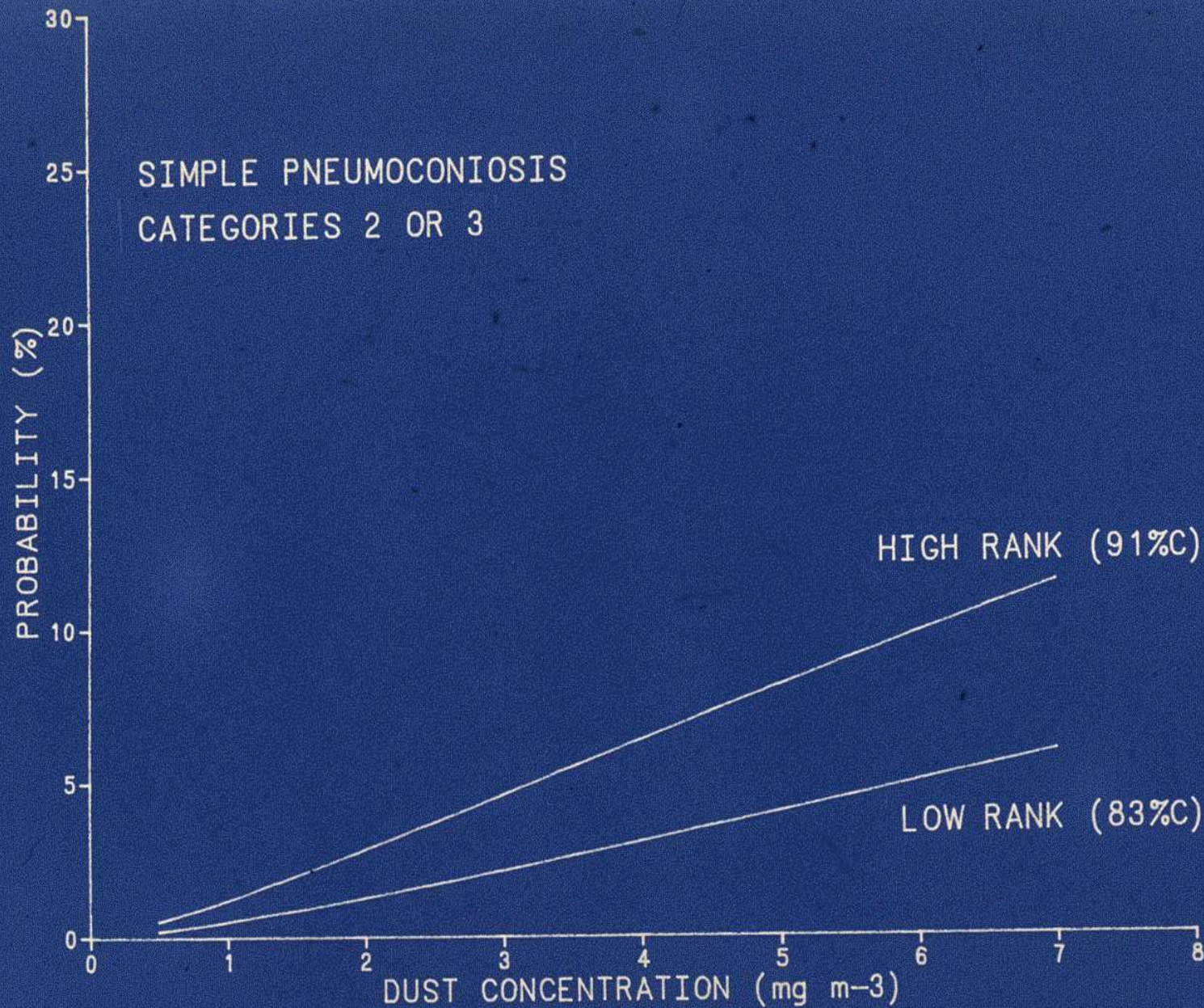
# Coal, pneumoconiosis and emphysema

## The pneumoconiosis field research 1953-89

- Sample of c50,000 miners from 25 pits studied over 30 years
- symptoms, smoking, spirometry, chest x-ray every 5 years
- detailed estimates of lifetime dust exposure
- collection of lungs *post mortem*

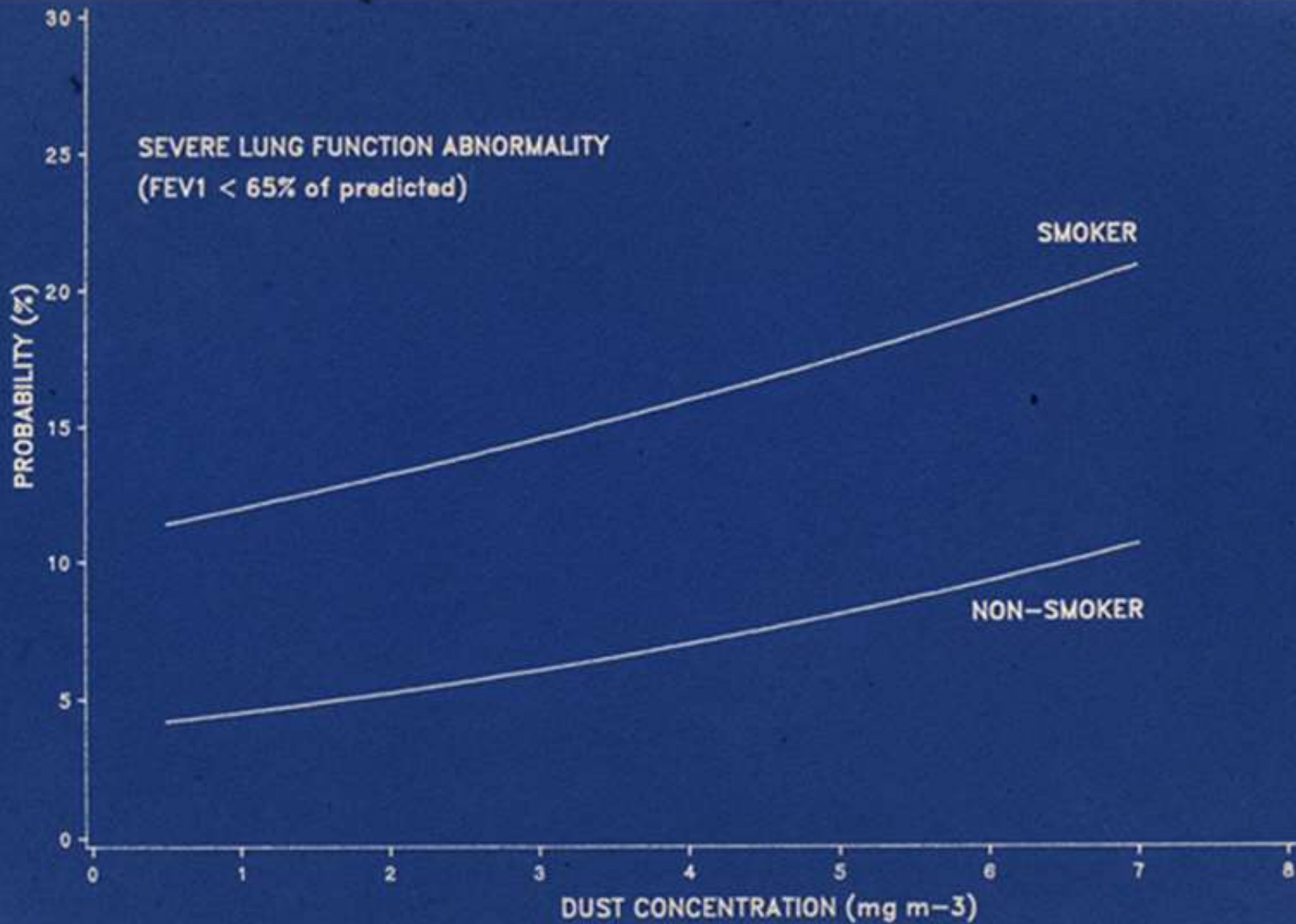
# The key to measuring risks of lung disease – the MRE 113a dust sampler, 1967



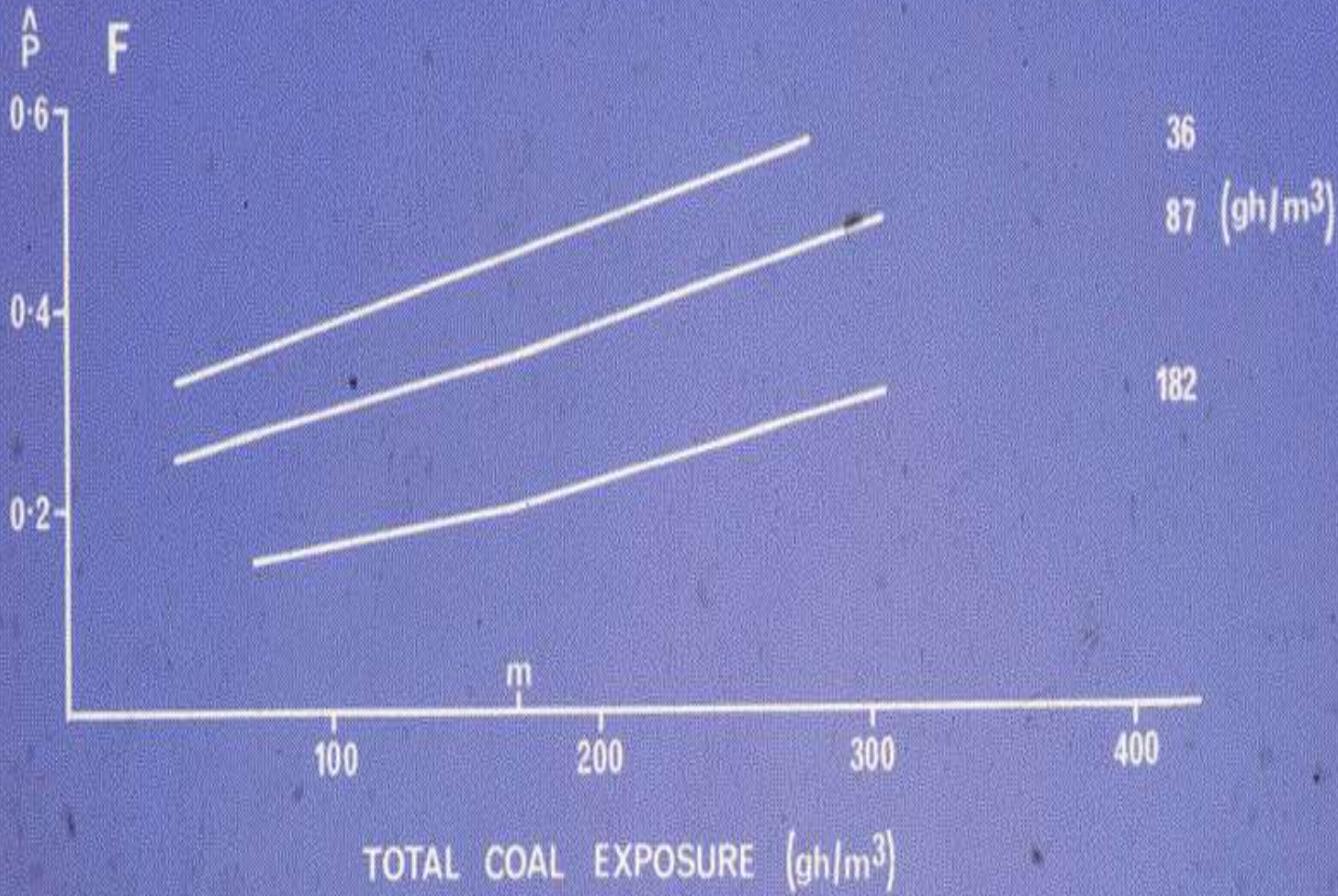


Risks of simple pneumoconiosis in relation to mean coal dust exposure over a working lifetime, in mg/m<sup>3</sup>





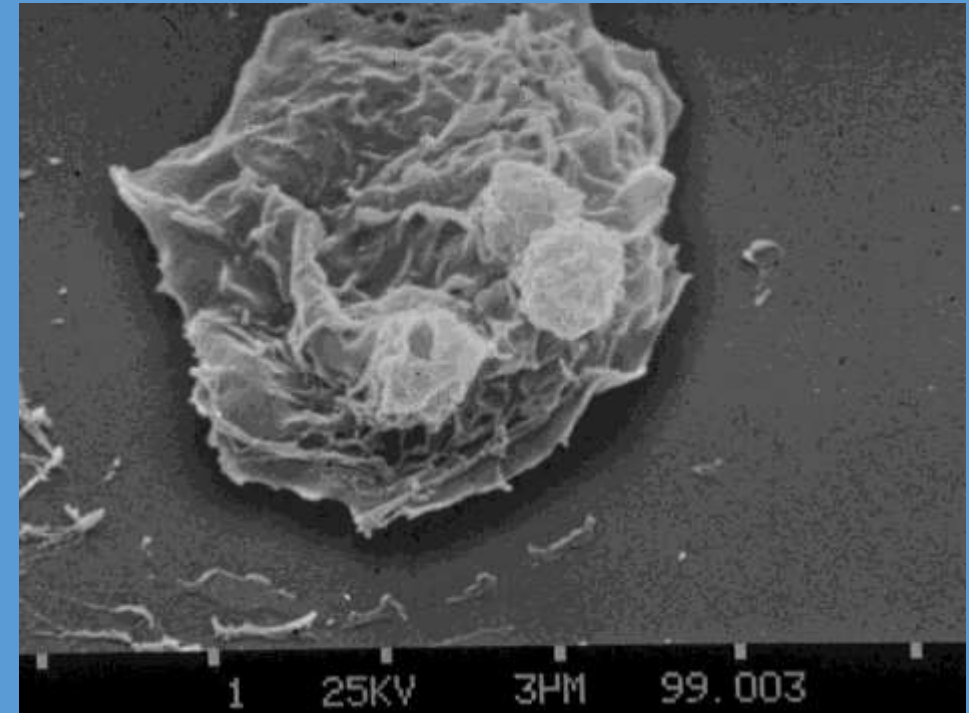
Risks of COPD  
(FEV1 < 65%  
predicted) in  
relation to  
mean dust  
exposure  
mg/m<sup>3</sup>



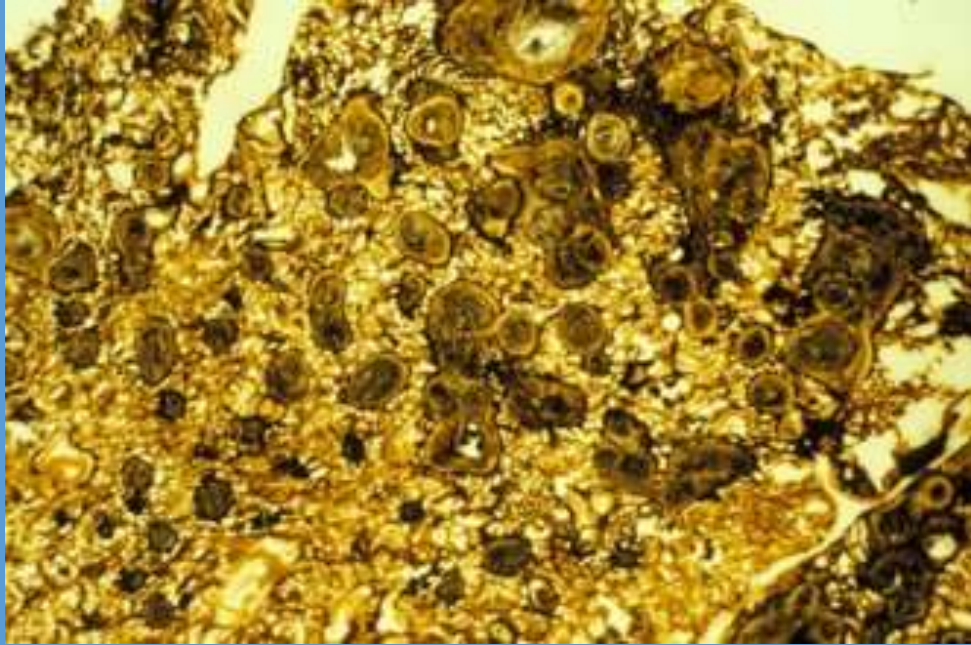
Relationship between risk of >30% centriacinar emphysema and cumulative exposure to coal dust and its silica content  
 ghrs/m<sup>3</sup>

Macrophage is the key, the first line of alveolar defence

- Inflammation
- Release of cytokines - fibrosis
- Recruitment of leukocytes – elastolysis
- Sometimes carcinogenesis



# Silicosis



Nodular lung fibrosis  
caused by inhalation  
of crystalline silicon  
dioxide (quartz)



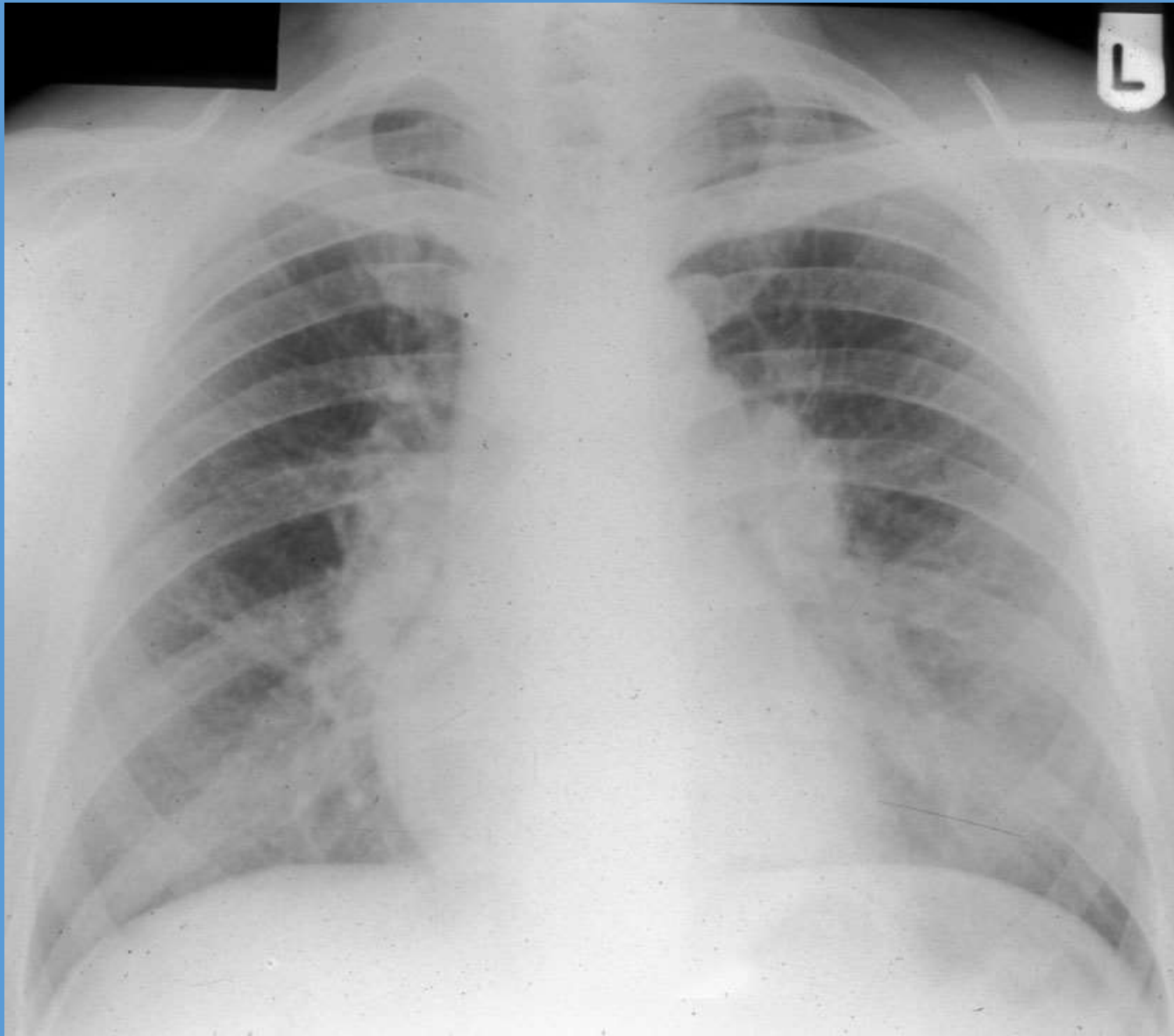
Coal miner with silicosis

Two stone masons *with chronic low level, then acute high level, exposures* – died from respiratory failure



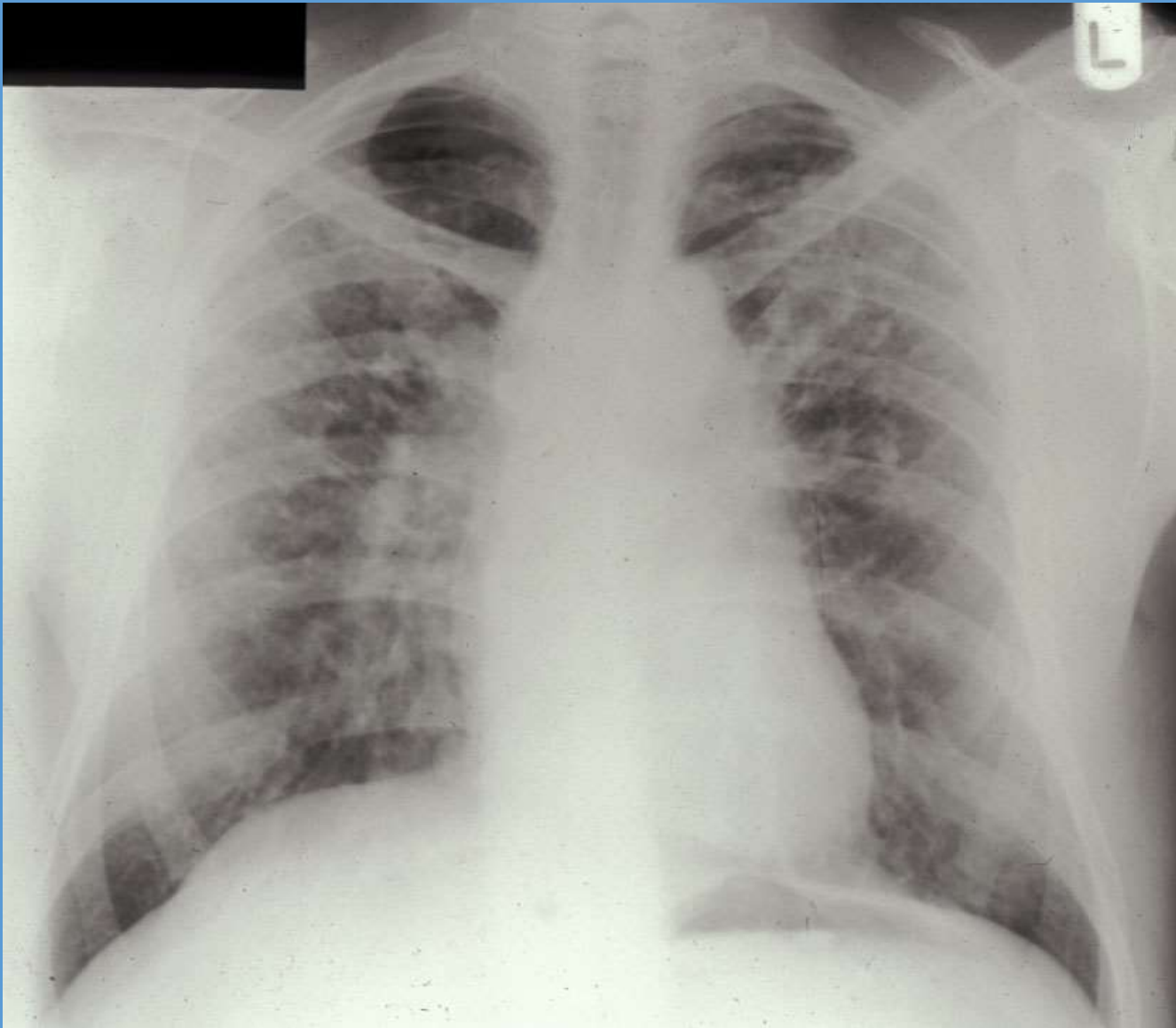
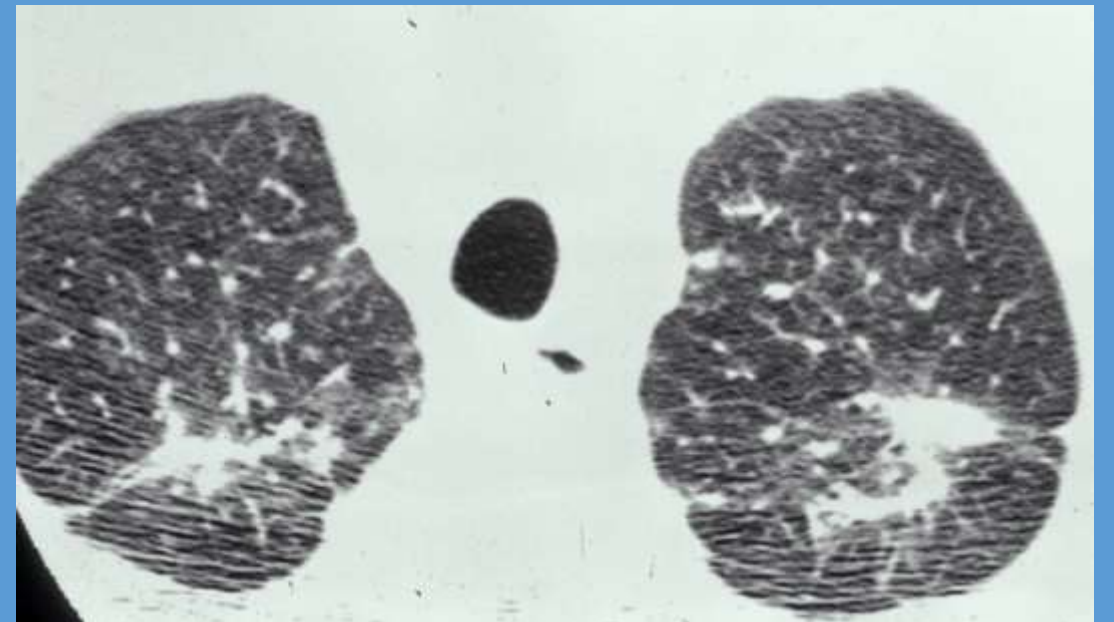
# Elgin Cathedral 1991





Apprentice stone mason *with same acute exposure* – large hilar nodes ?sarcoidosis.

Three years later with  
no further exposure...  
silicotic massive  
fibrosis.





# Indirect consequences of quartz exposure

- Tuberculosis – macrophage impairment
- Renal tubular disease – ?direct quartz toxicity
- Scleroderma and other collagen diseases –  
?release of nuclear material and autoimmunity
- Increased risk of lung cancer - ?inflammation

# The nail in the coffin of King Coal: climate change



# Main greenhouse gases

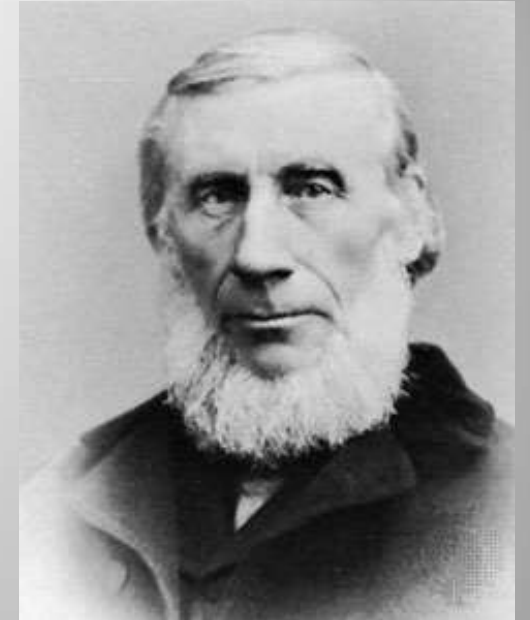
- Carbon dioxide

- Combustion of fossil fuel
- Animal respiration
- Microbial respiration in soil



- Methane

- Agriculture, including rice, from soil and livestock
- Fossil fuel production
- Landfill, biomass burning
- Melting permafrost



John Tyndall 1860

# The changing atmosphere

## Where is carbon dioxide distributed?

- 750 billion tonnes (Gt) in atmosphere
- Uptake by the oceans
  - Lots of water – contains 39,000 Gt carbon
- Uptake by vegetation
  - Lots of plants – contain 2,500 Gt carbon

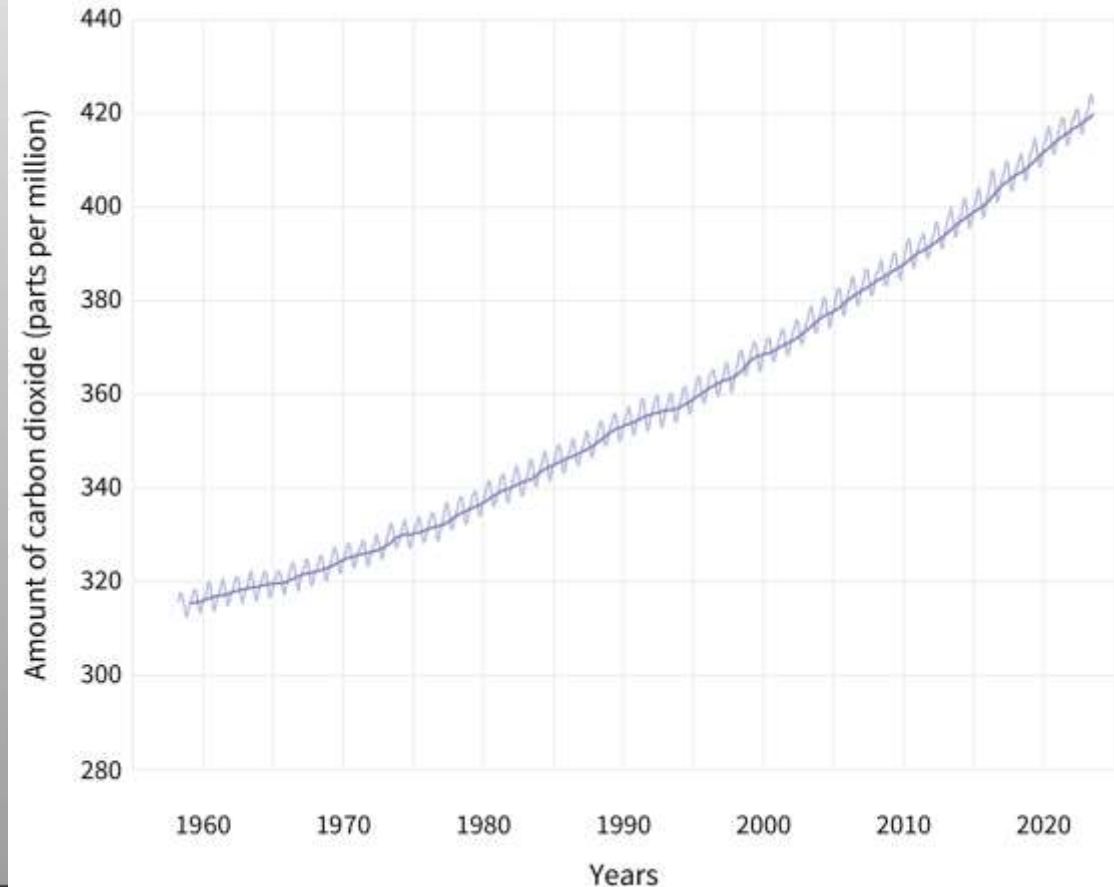
CO<sub>2</sub> - Mauna Loa  
(Jan 2024 420ppm)



Charles David Keeling  
(1928-2005)

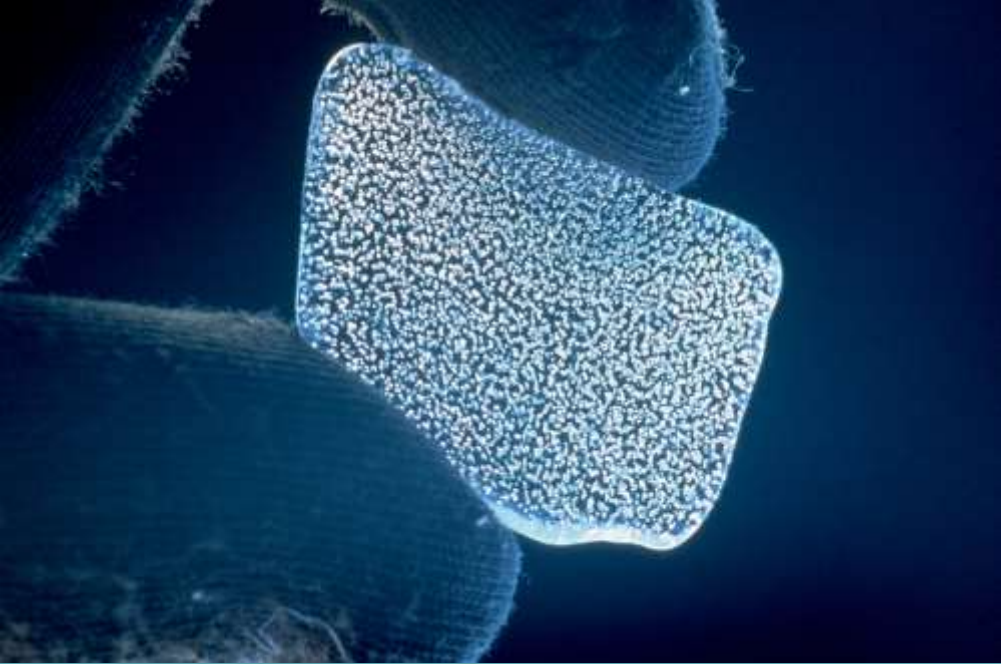


### ATMOSPHERIC CARBON DIOXIDE

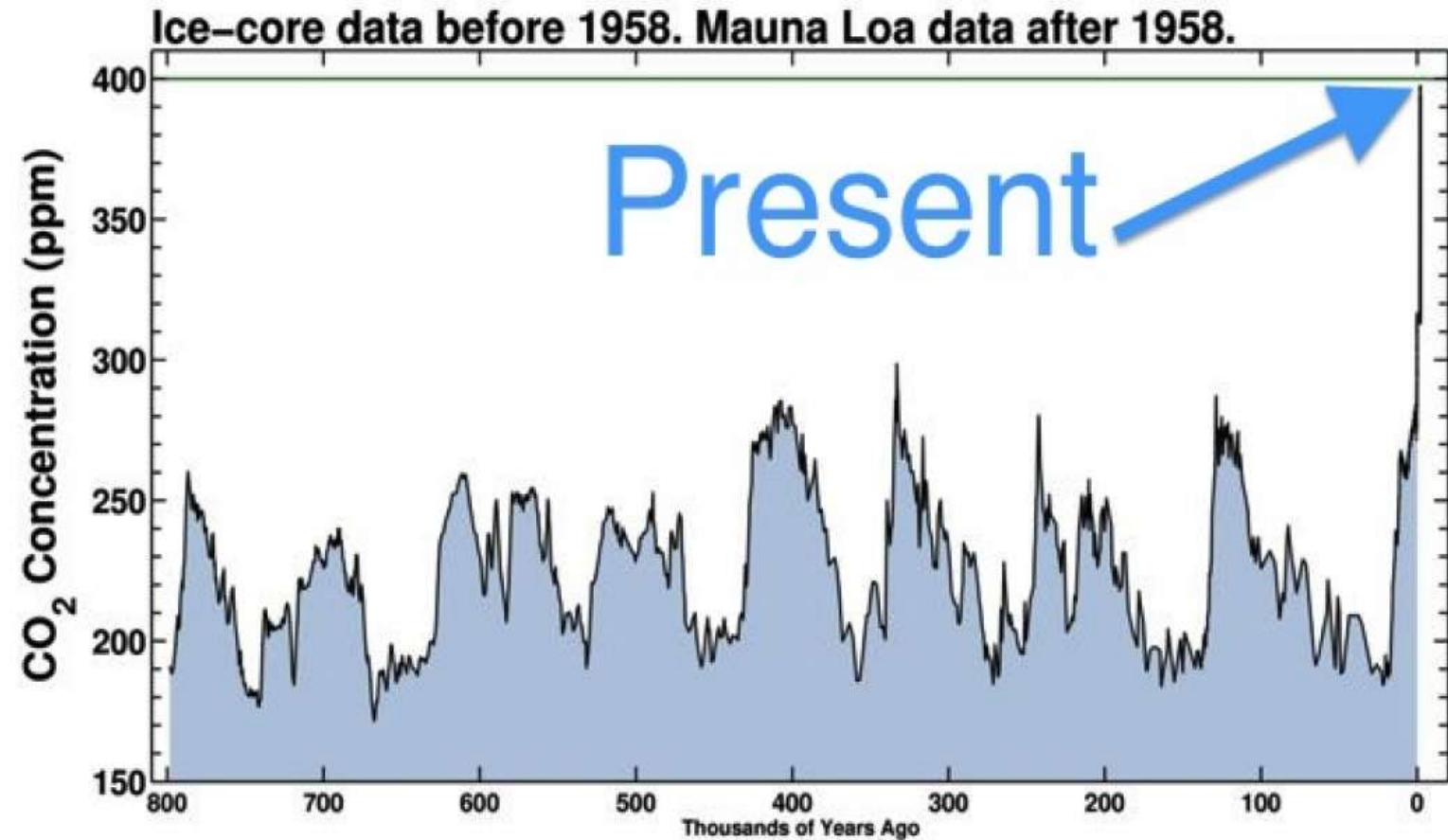


# An ice core from the Greenland glacier





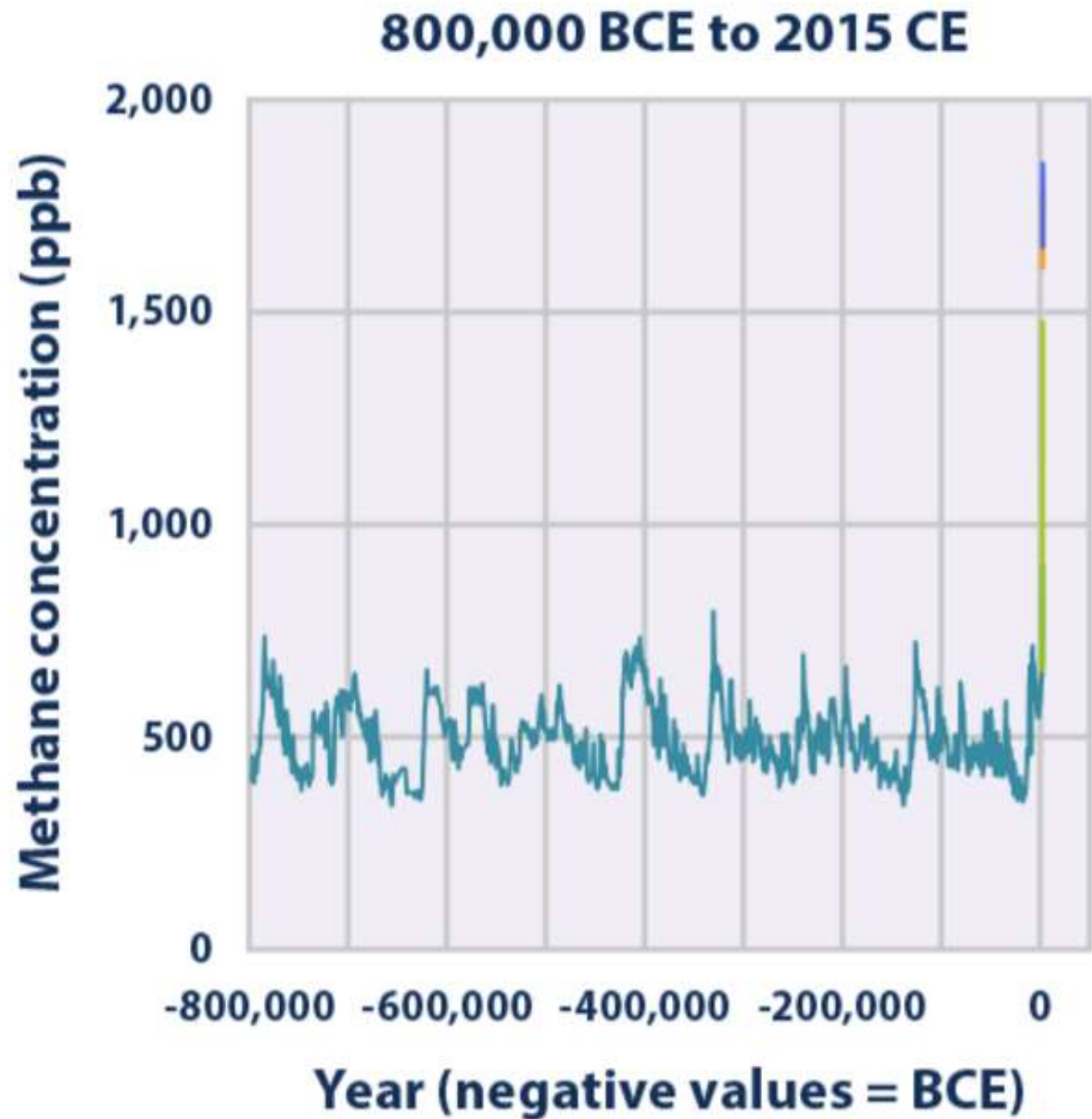
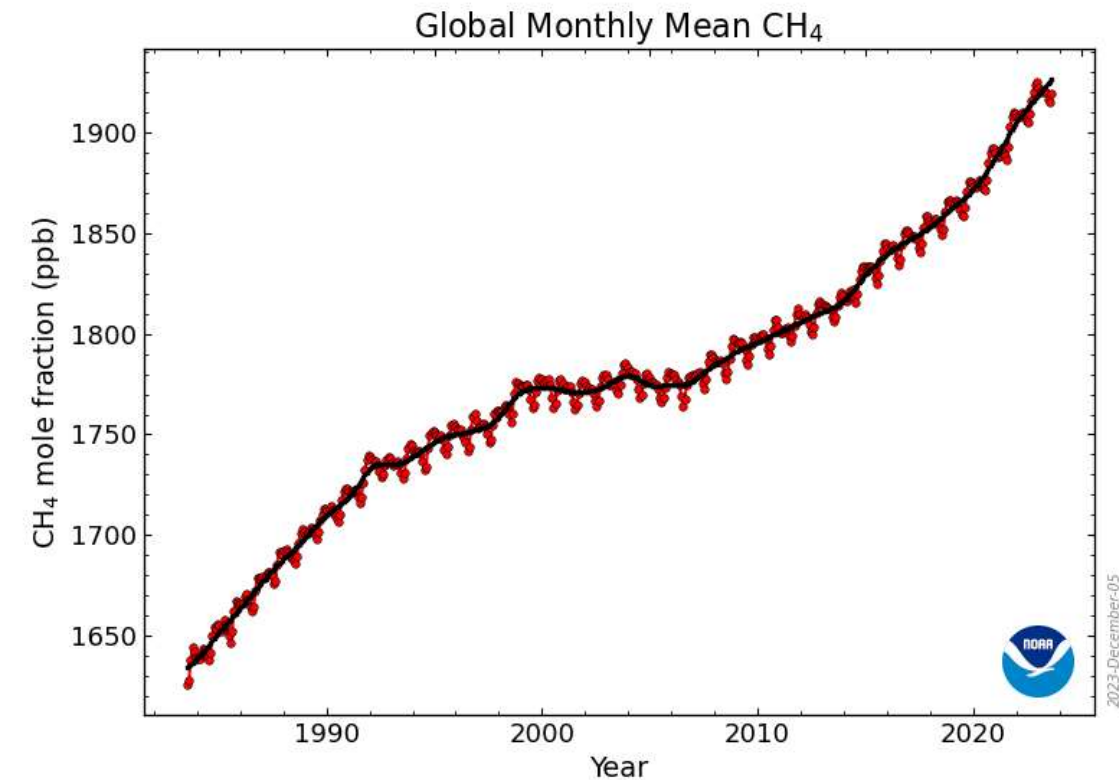
The atmosphere is hidden in the ice



# Atmospheric methane

2023: 1920 ppb

1960: 1211 ppb





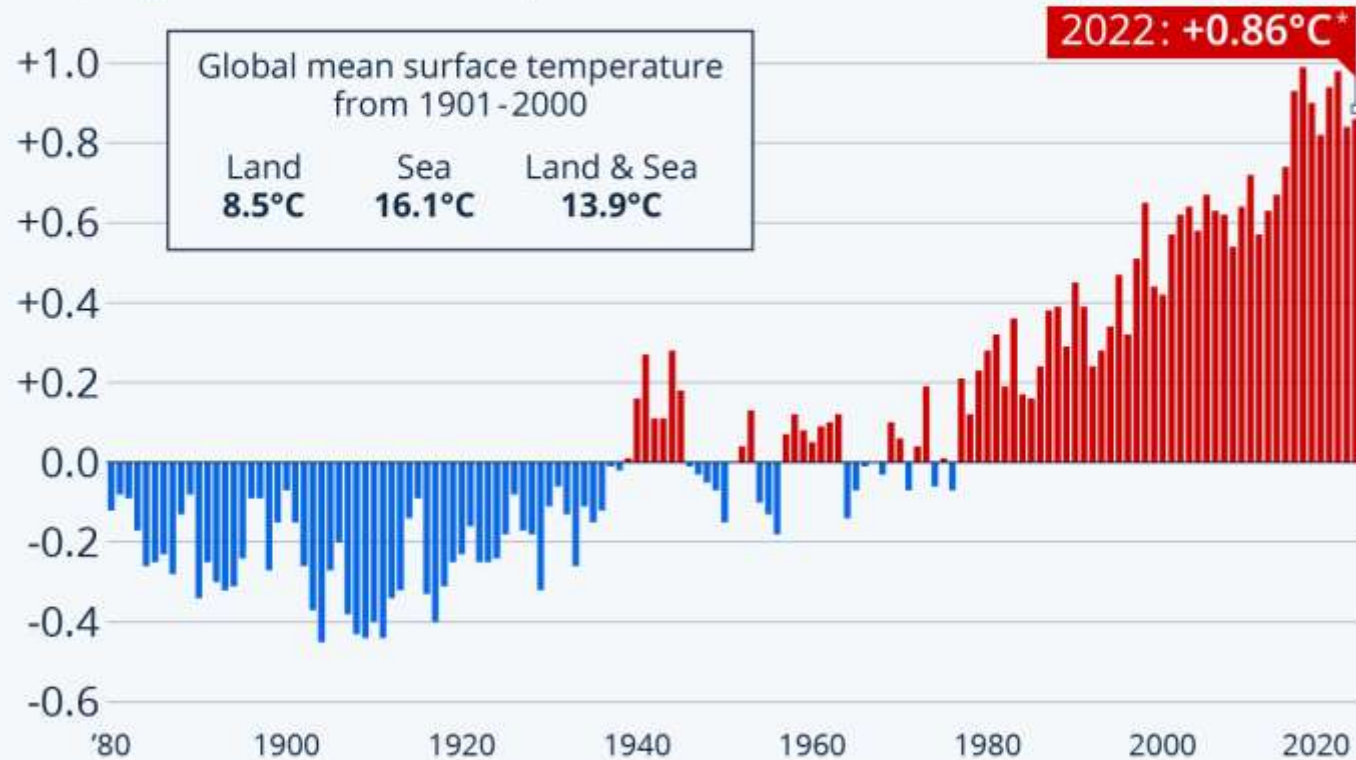
# What are the consequences?

- Rising temperatures
  - heatwaves
- Flooding
  - Increased rainfall and raised sea level
- Drought
  - Decreased rainfall and increased evaporation
- Increasingly violent storms
- Migration



# The Last 8 Years Have Been the Warmest on Record

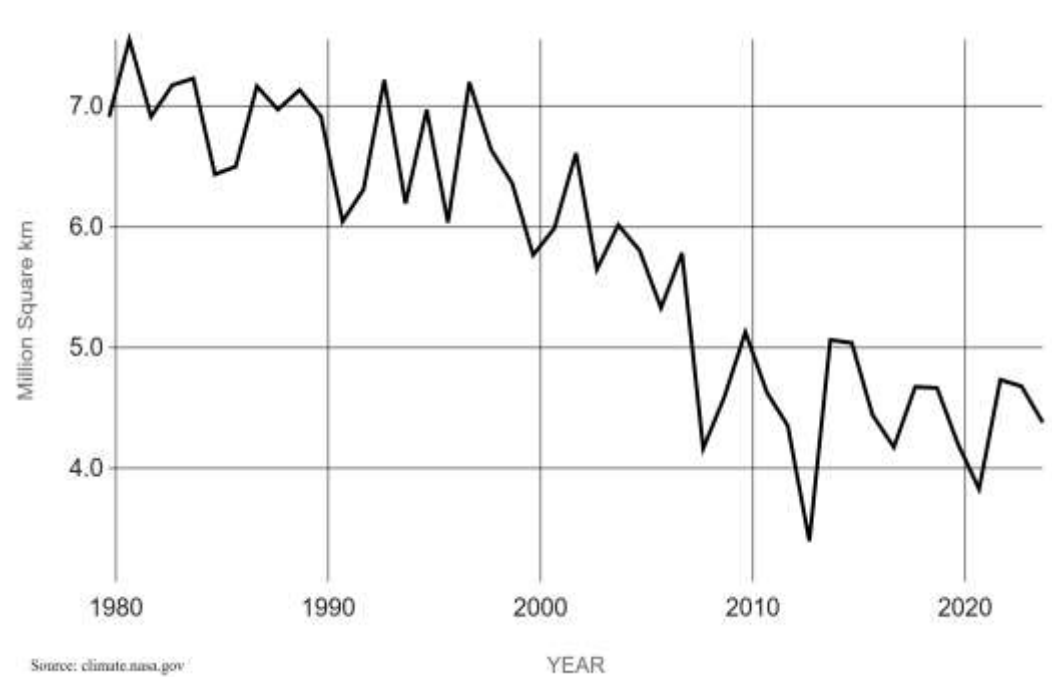
Global land and ocean surface temperature anomalies (degrees Celsius compared to the 20th century average)



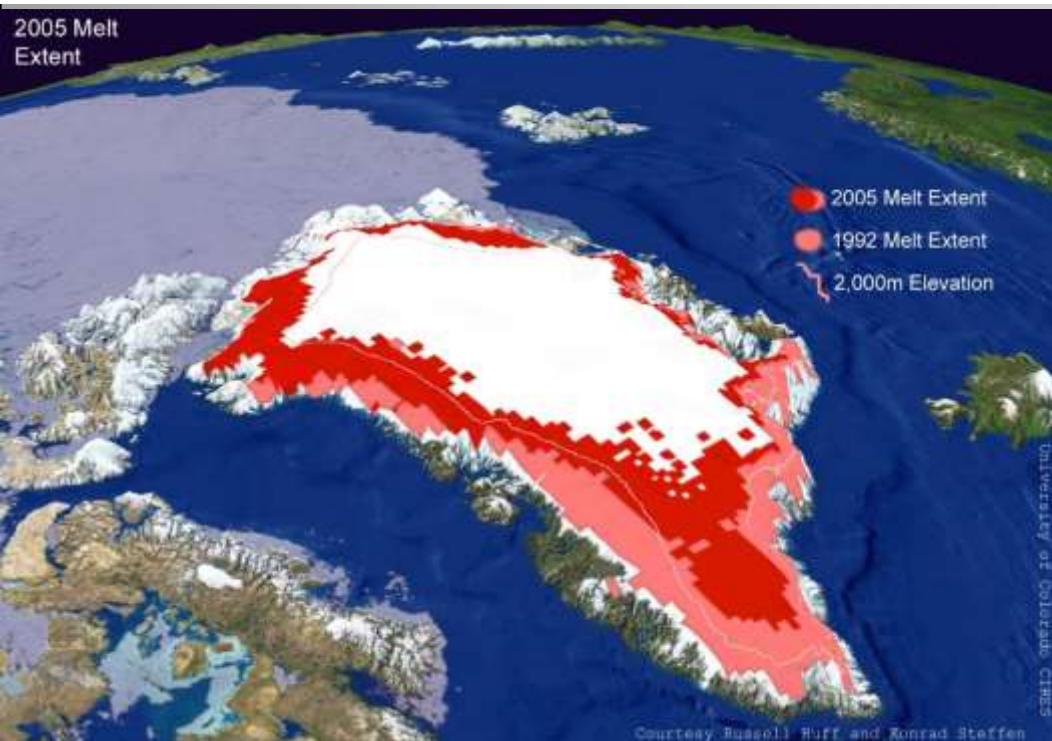
\* 2022 figure refers to the temperature anomaly for January through September

Source: NOAA





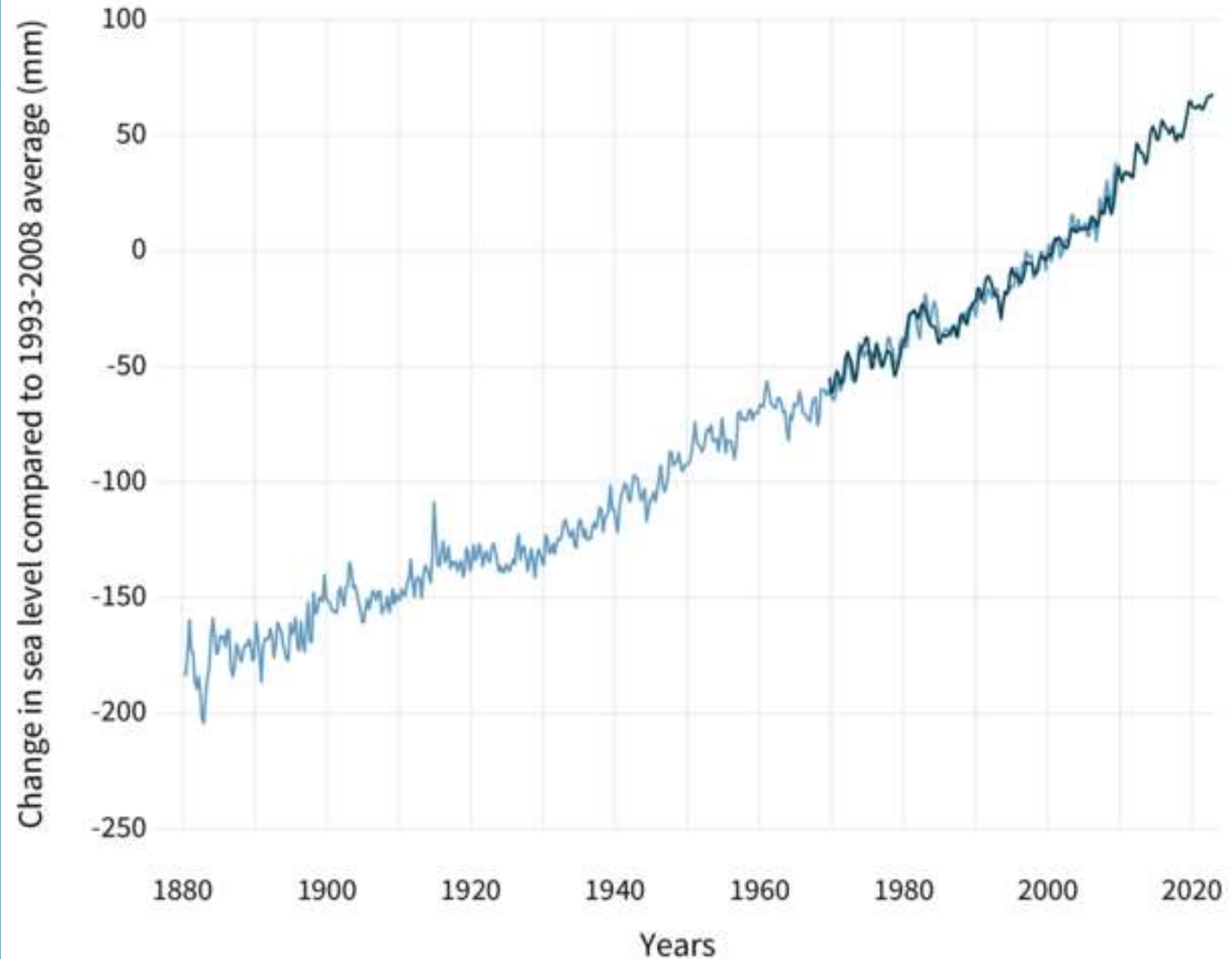
Melting of polar ice:  
reduced albedo increases  
temperature rise.



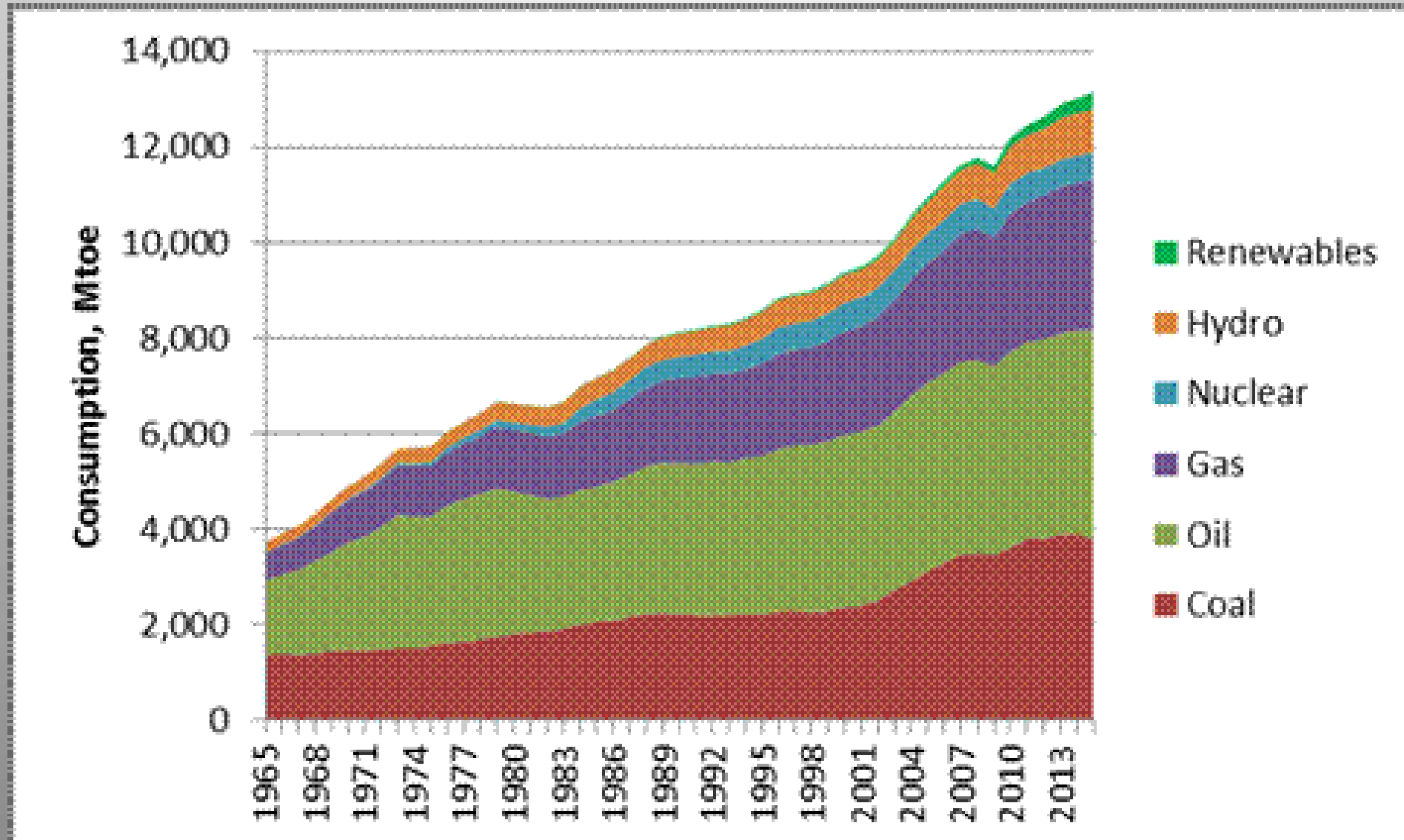
Melting of the Greenland  
glacier:  
1 metre sea rise by 2100,  
potential 7 metre rise when  
it all melts.

Acceleration in  
sea level change  
since Industrial  
Revolution.  
(NOAA data)

## GLOBAL SEA LEVEL



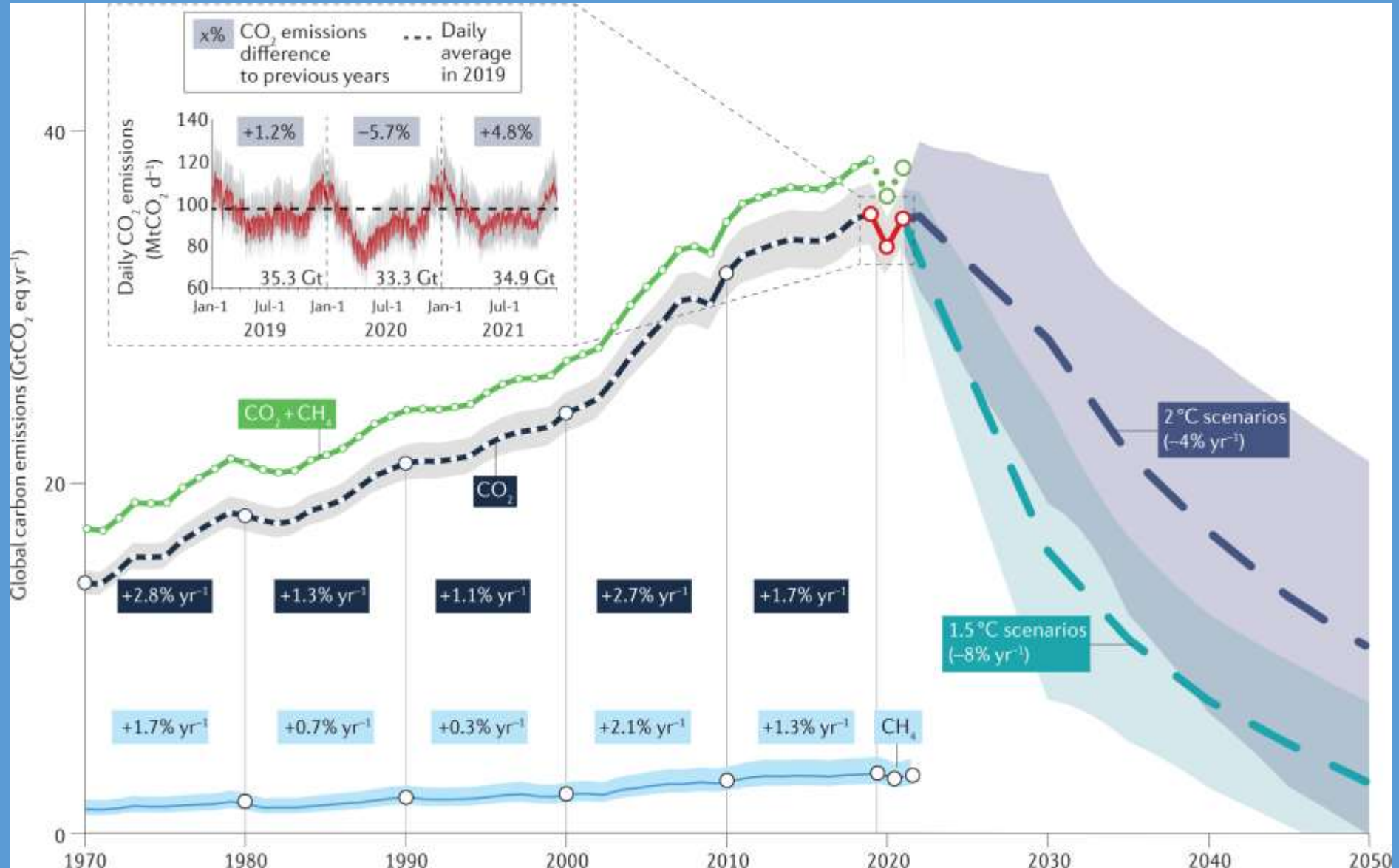
# Global energy consumption 1965-2015



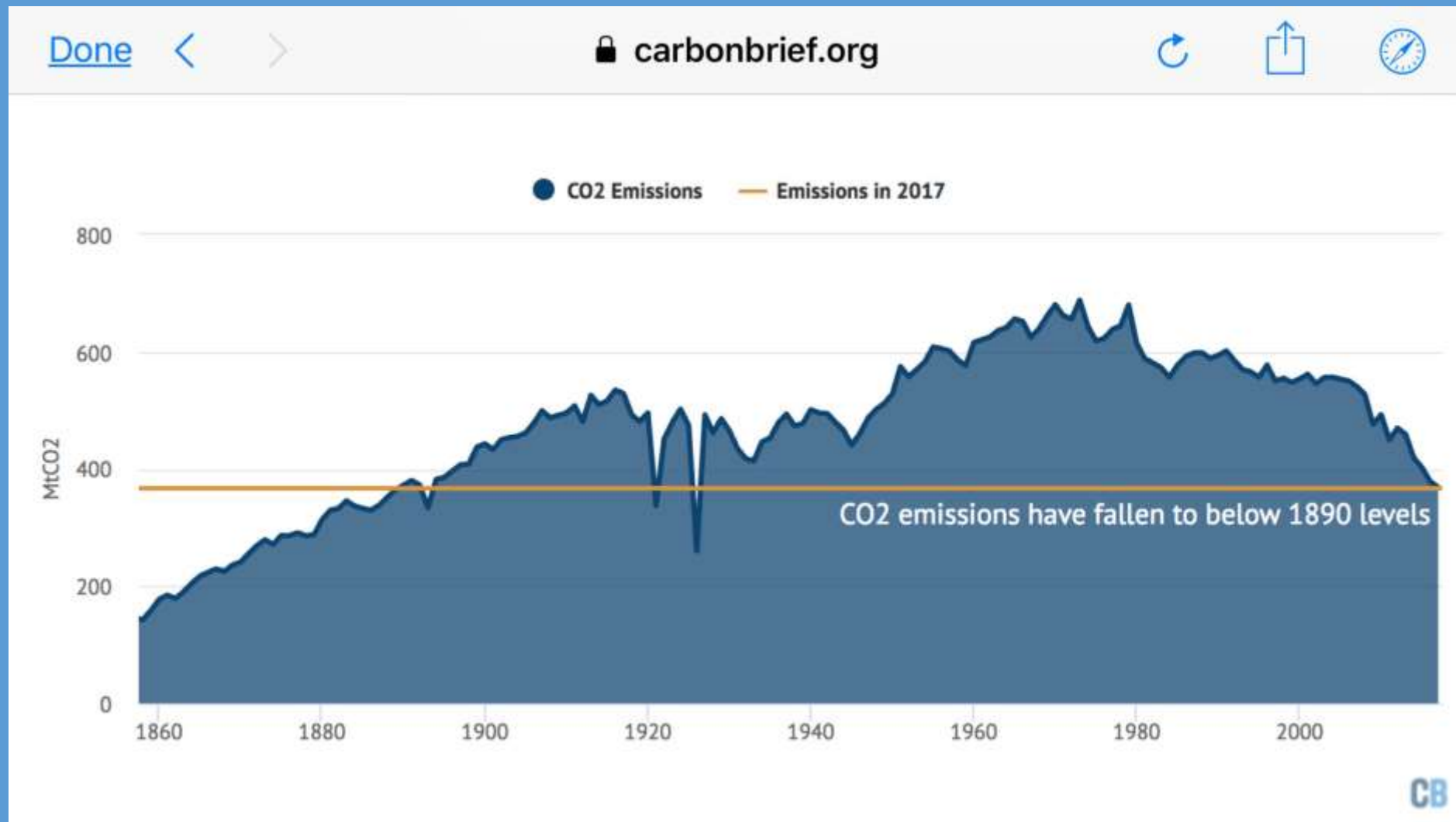
# Are there any solutions?

- International agreement is essential (28 CoPs so far).
- Divest from all fossil fuels.
- Reconsider the role of economic growth and free trade.
- Massive investment in renewables, with nuclear as a backup.
- Change farming and food distribution practices.
- Improve energy distribution and storage.

# Global greenhouse gas emissions 1970-2022

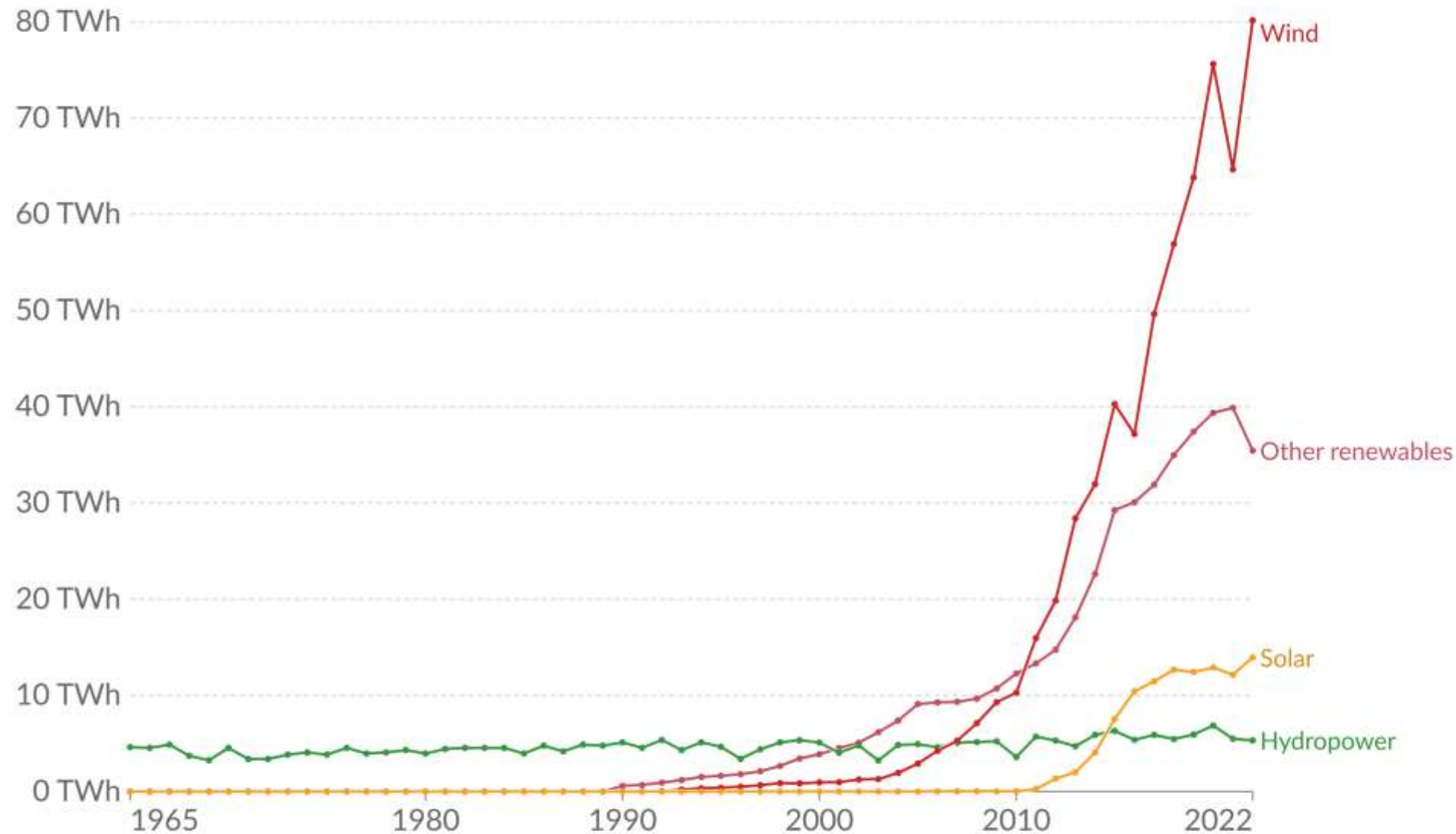


# UK CO<sub>2</sub> emissions 1860-2022





# Renewable energy generation, United Kingdom



Data source: Energy Institute - Statistical Review of World Energy (2023)

[OurWorldInData.org/renewable-energy/](https://OurWorldInData.org/renewable-energy/) | CC BY

Note: 'Other renewables' refers to renewable sources including geothermal, biomass, waste, wave and tidal. Traditional biomass is not included.

# How to make matters worse: the world's wealthiest 1% (income >£80k pa) produce 50% of the greenhouse gases

- Drive on fossil fuel – average car produces 1.5 kg CO<sub>2</sub> per 100 miles
- Have large (or more than one) cars
- Fly – London to Rome = 240 kg CO<sub>2</sub>  
London to New York = 1000 kg CO<sub>2</sub>
- Travel to multiple conferences
- Overheat the house and consume more than needed

# UK total and individual annual energy consumption and renewable production 2022

Total UK consumption: 1.512 million MWatt hours

Total UK renewable production: 224 million MWh

Total UK nuclear production: 44 million MWh

Mean individual consumption: 22.5 MWh

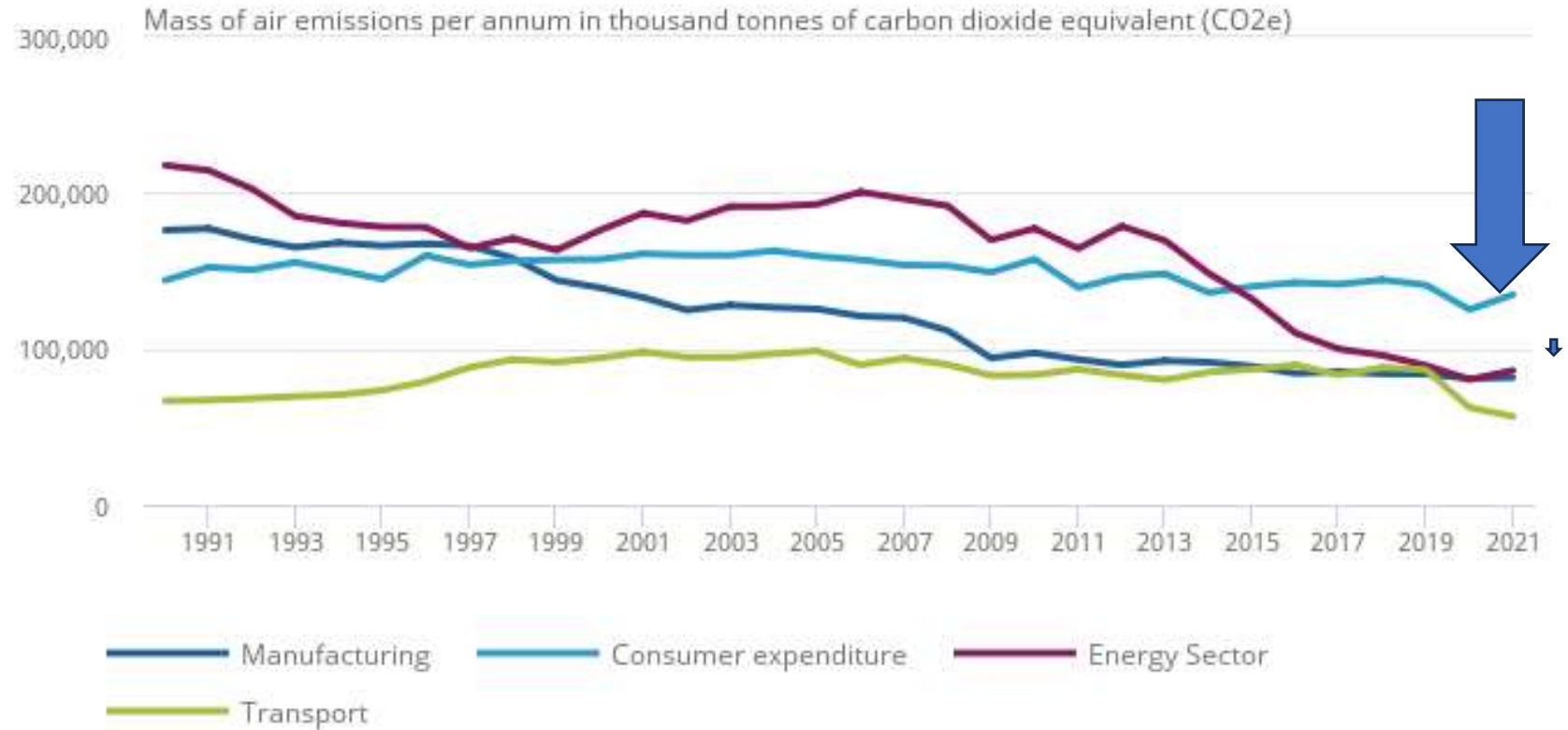
My personal consumption: 9 MWh

My solar generation: 3 MWh (average over 11 years)

In the UK, households are now the main contributors to fossil fuel emissions

Figure 1: Households remain the highest contributors to overall UK greenhouse gas emissions in 2021

Trend for greenhouse gas emissions for the three highest-emitting industries and households in 1990 to 2021 (residence basis)



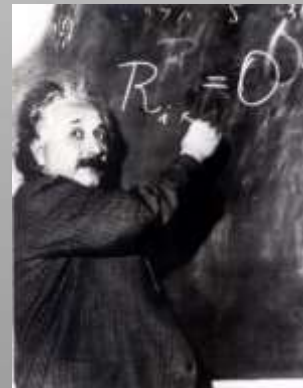
Source: UK Environmental Accounts from Ricardo Energy and Environment, and the Office for National Statistics

Civilisations fall; the writing on the wall?



# The human species

- *Homo erectus*
  - 1.9 million – 50,000 ybp
- *Homo neanderthalensis*
  - 250,000 - 40,000 ybp
- *Homo sapiens*
  - 200,000 ybp - present



Or will our grandchildren think of us  
as  
*Homo stupidus?*





It's up to us – you and me.

Thank you.



# What we should do locally and as individuals.

1. Insulate houses and turn down heating
2. Reduce gas and electricity use. Get heat pump.
3. Use renewable energy where possible. Local networks.
4. Walk, cycle, bus, drive economically. Go electric.
5. Train rather than aeroplane.
6. Cut foreign holidays and conferences.
7. Reduce meat intake and source food locally.
8. Think what we buy – where from? Recycle and avoid plastic.
9. Invest in renewables and divest from fossil fuel.
10. Spread the word

# Svante Arrhenius (1859-1927)

“On the influence of carbonic acid in the air upon the temperature on the ground” (1896)

Predicted 50% increase in CO<sub>2</sub> would raise temperature c3.5°C, that is from c225 to c336ppb.

Should Increase agricultural productivity, allow population growth and prevent another ice age.





## John Tyndall (1820-93)

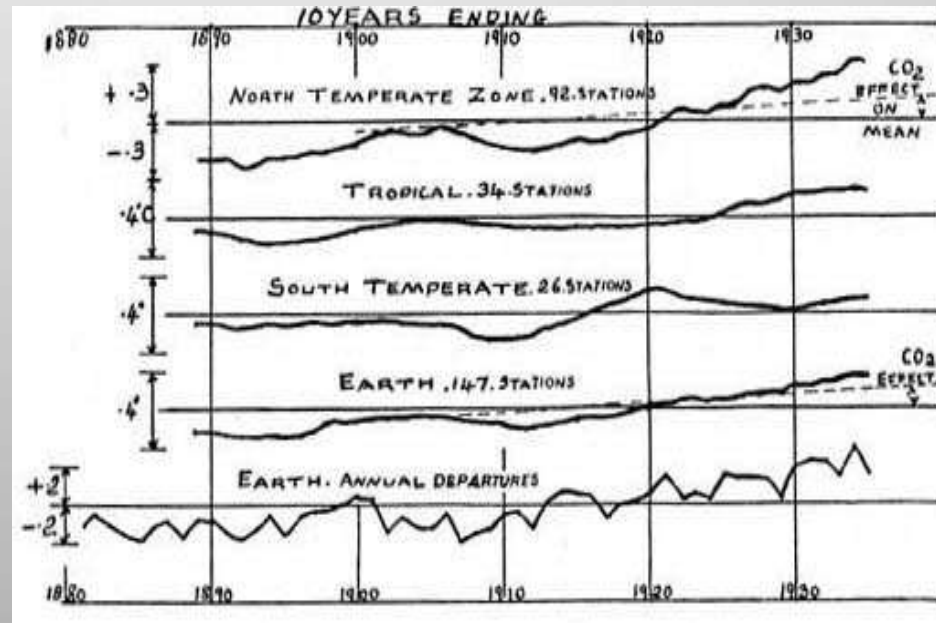
His experiments showed that compound gases absorbed emitted (infra red) radiation, notably CO<sub>2</sub>, water vapour, and hydrocarbons, thus reducing heat loss into space.

In 1860, when he showed this, atmospheric CO<sub>2</sub> was about 225ppb.



# The oceans

Guy Callender (1898-1954)



In 1938 noted the rise in air temperature and CO<sub>2</sub>, and suggested the ocean's capacity to absorb it was limited.



## Roger Revelle (1909-91)

Showed in 1957 that the oceans had not been absorbing the CO<sub>2</sub> at a sufficient rate over a few decades; recruited Keeling who had invented apparatus to measure it in the atmosphere

Taught Al Gore at university.

# Understanding of climate change

- 1754 Joseph Black discovered CO<sub>2</sub>
- 1776 Alessandro Volta discovered methane
- 1827 J-B Fourier described the greenhouse effect
- 1859 John Tyndall showed compound gases to be responsible
- 1896 Svente Arrhenius showed the relation between rise in CO<sub>2</sub> and the Earth's temperature.
- 1938 Guy Callender showed that the oceans were not absorbing CO<sub>2</sub> at a fast enough rate
- 1957 Roger Revelle started his research on ocean acidification

# Solar energy

- Current solar panel arrays will produce on average 3-4MWh per annum.
- 250,000 new houses were built in UK in 2022
- This represents an annual opportunity to produce up to a million MWh (1 terawatt hour) of power from new builds alone.
- Why is this not in building regulations?
- One Edinburgh Co-op has put panels on all primary Schools.