Wind Crest Learners

Lecture 5: Population and affluence

Climate Redux:

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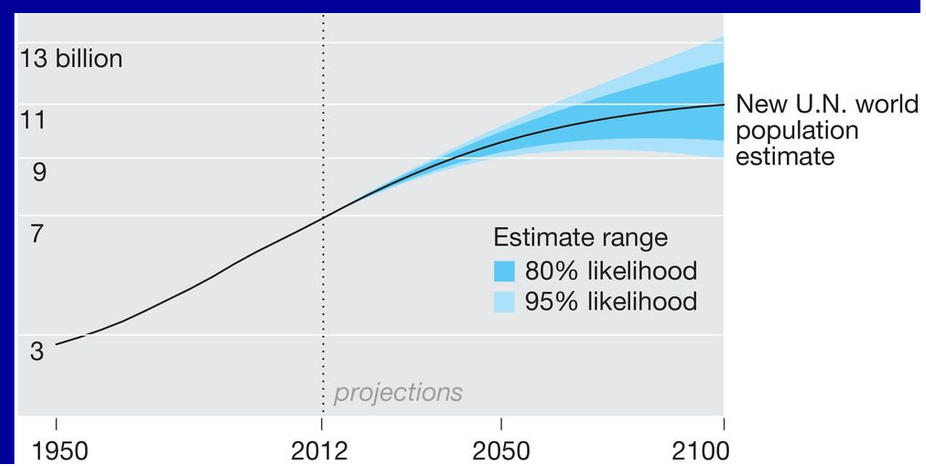
What I’m going to discuss today

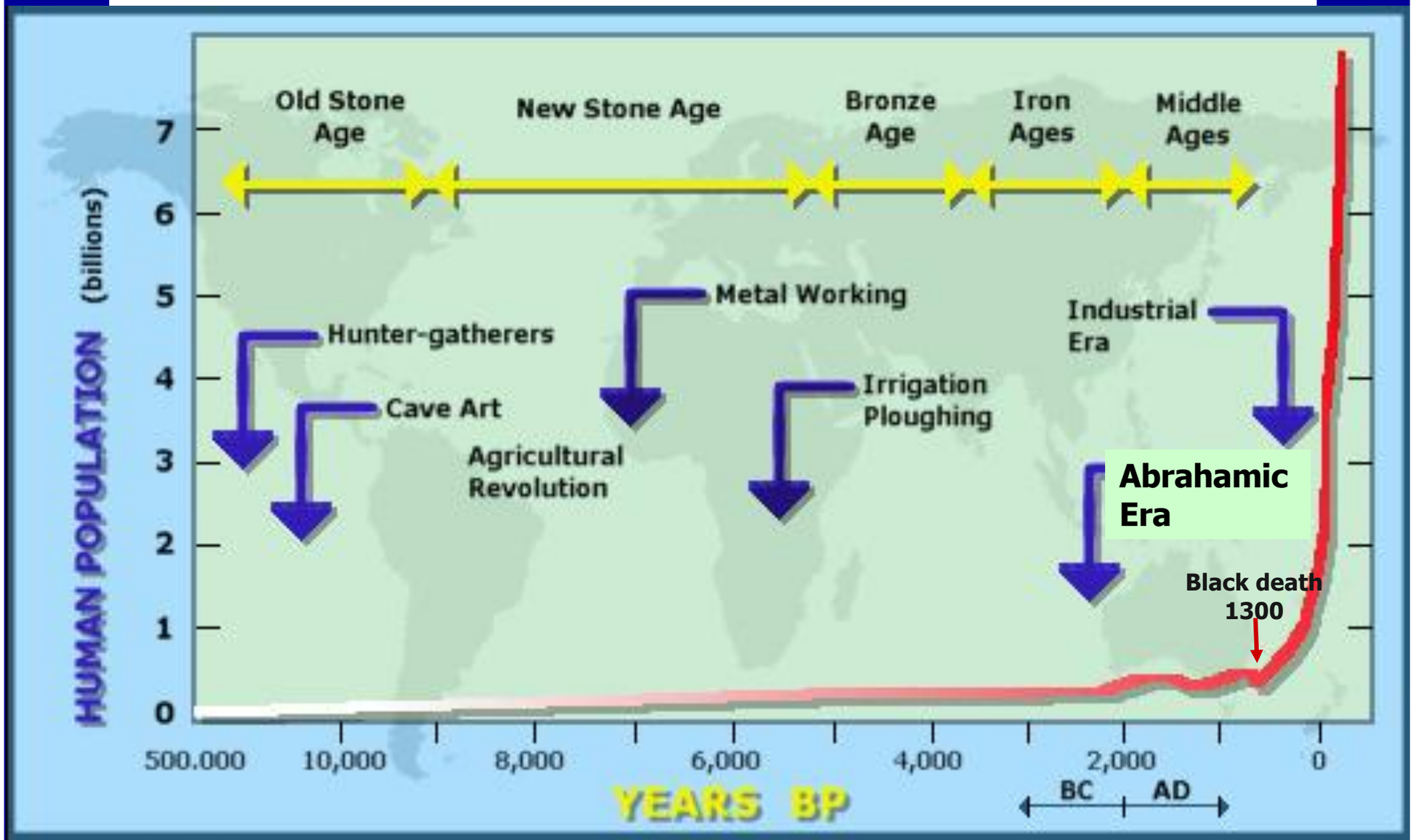
- Population history and projections
  - Why 11 billion is baked in
- Arable land
  - Vertical farming
- Affluence

Background

- Population and affluence are drivers on energy use
  - Population growth rate is declining (ZPG by 2100??)
  - Per capita energy use is growing (developing countries)
  - Energy use => fossil fuels => global warming
- Carrying capacity of Earth
  - How many people can we feed
  - Land and water as resources
- Human impact on biosphere



World Population Growth Through History

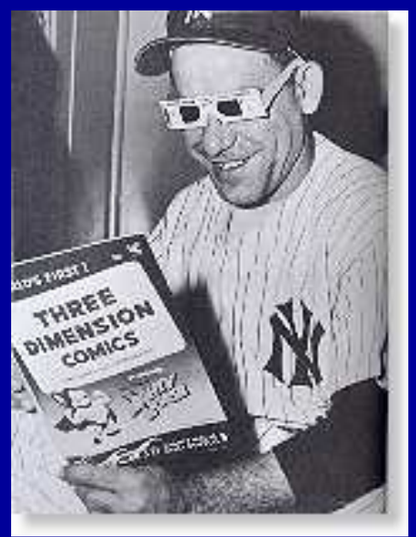


- "It's hard to make predictions, especially about the future."

Lawrence Peter "Yogi" Berra

How long will it take for my investment to double?
Use Rule of 70

$$\frac{70}{\text{Annual interest rate}} = \text{\# years for investment to double}$$



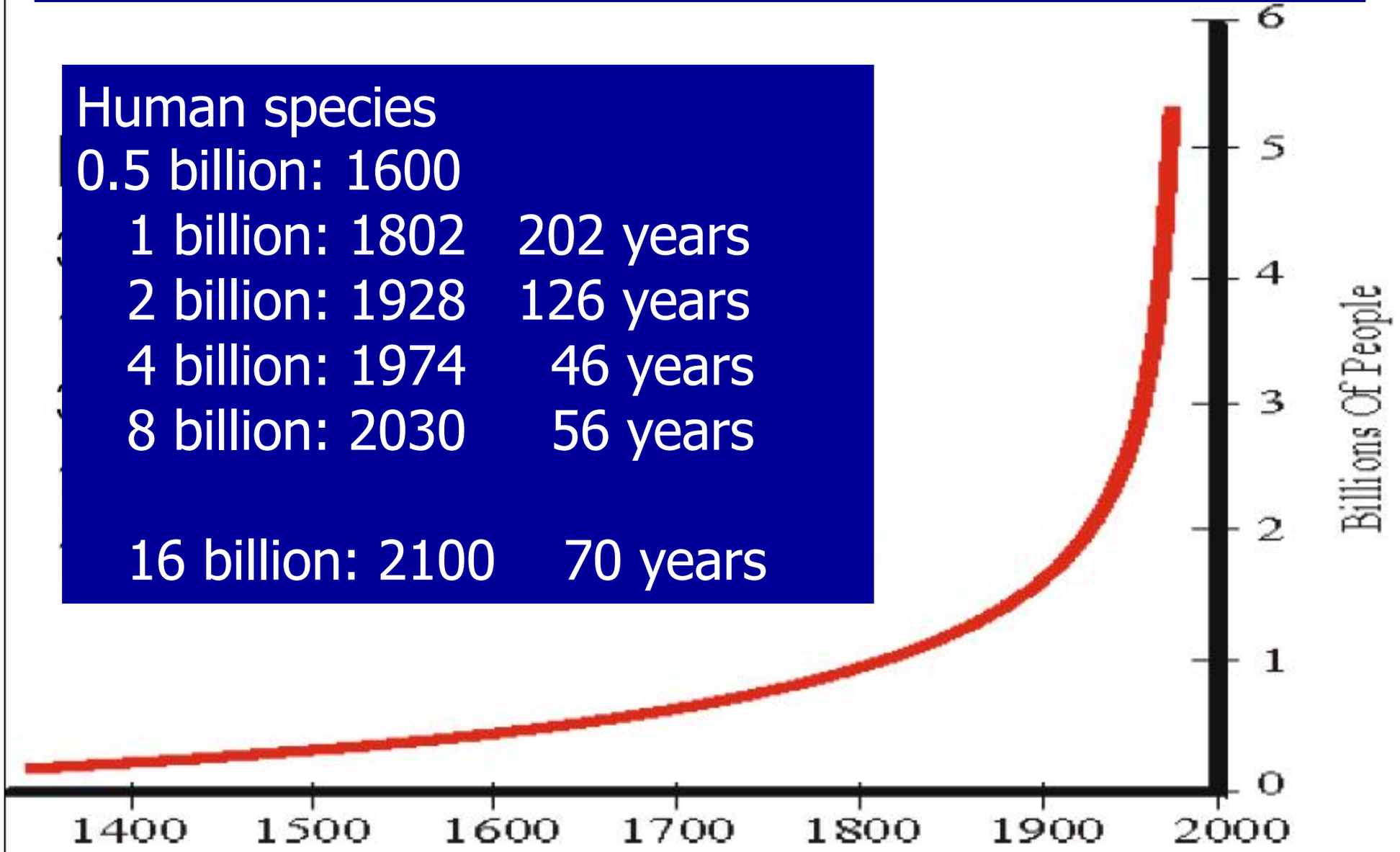
Works for population growth, too.

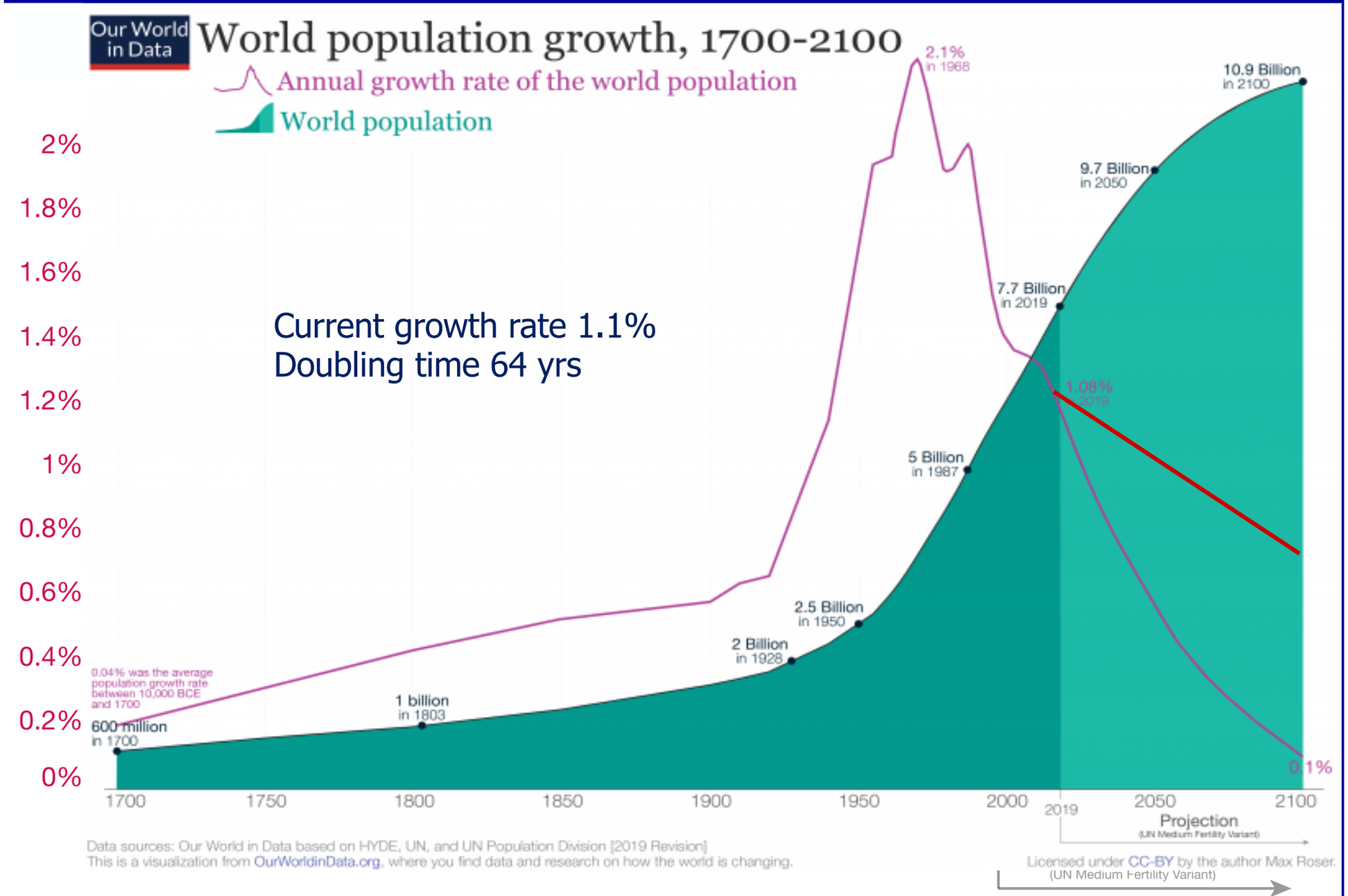
$$\frac{70}{\text{1\% Annual growth rate}} = \text{70 years for population to double}$$

20th Century growth rate was "super exponential" until inflection point circa 1980

Human species

0.5 billion:	1600	
1 billion:	1802	202 years
2 billion:	1928	126 years
4 billion:	1974	46 years
8 billion:	2030	56 years
16 billion:	2100	70 years



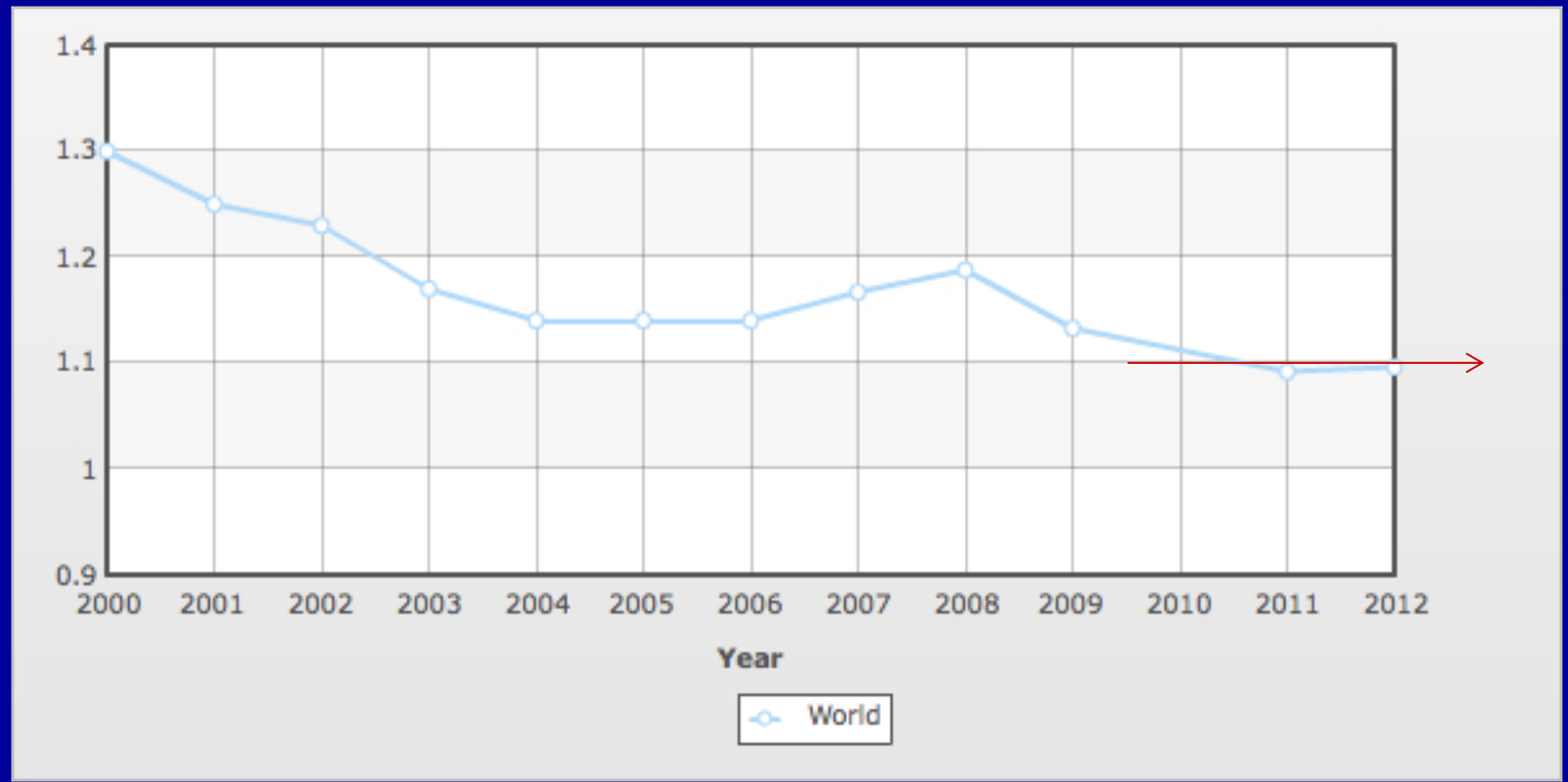


(UN Medium Fertility Variant)

Data sources: Up to 2015 OurWorldInData series based on UN and HYDE. Projections for 2015 to 2100: UN Population Division (2015) – Medium Variant.
The data visualization is taken from OurWorldinData.org. There you find the raw data and more visualizations on this topic.

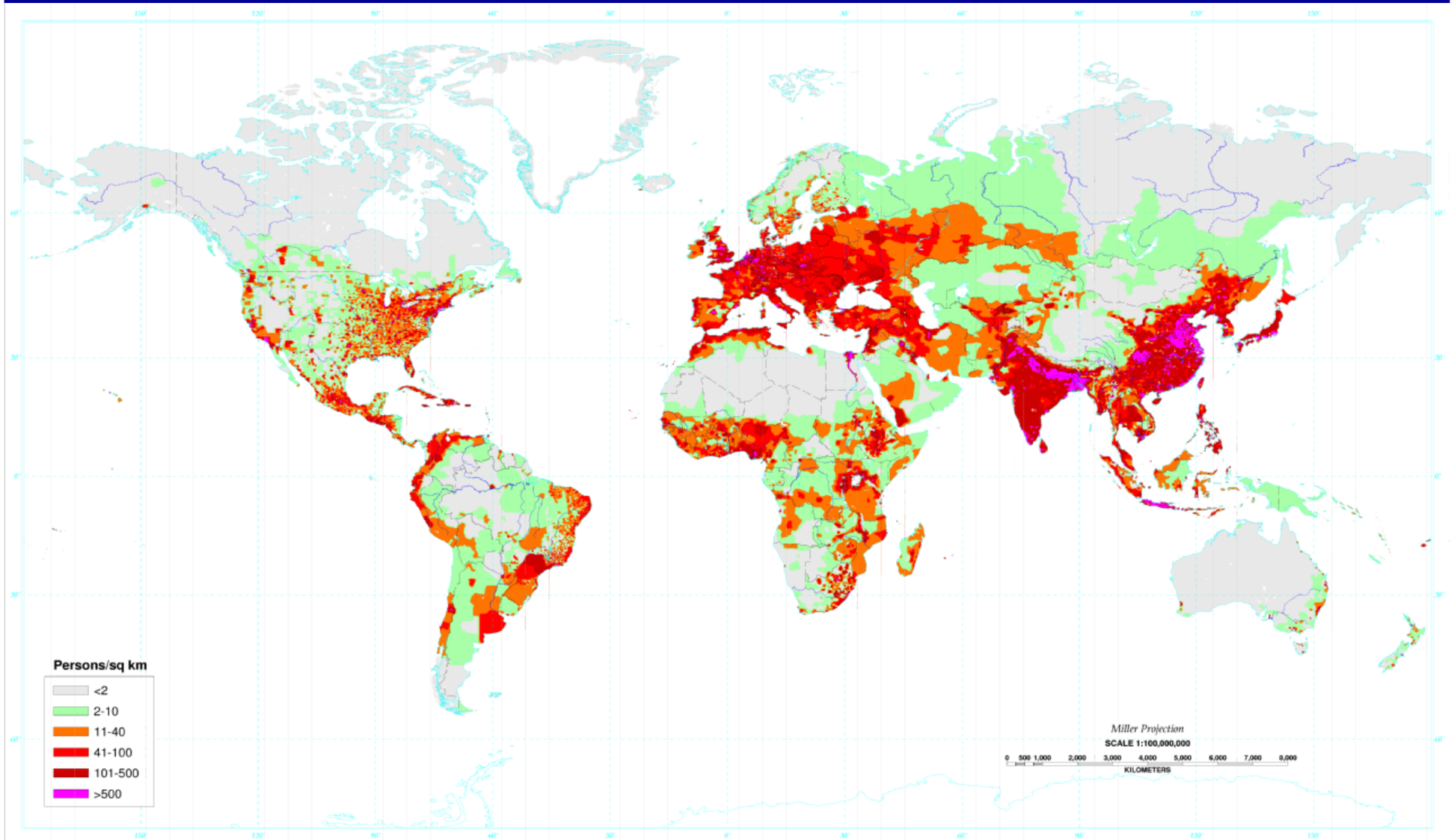
A different data set

http://www.indexmundi.com/g/g.aspx?c=xx&v=24

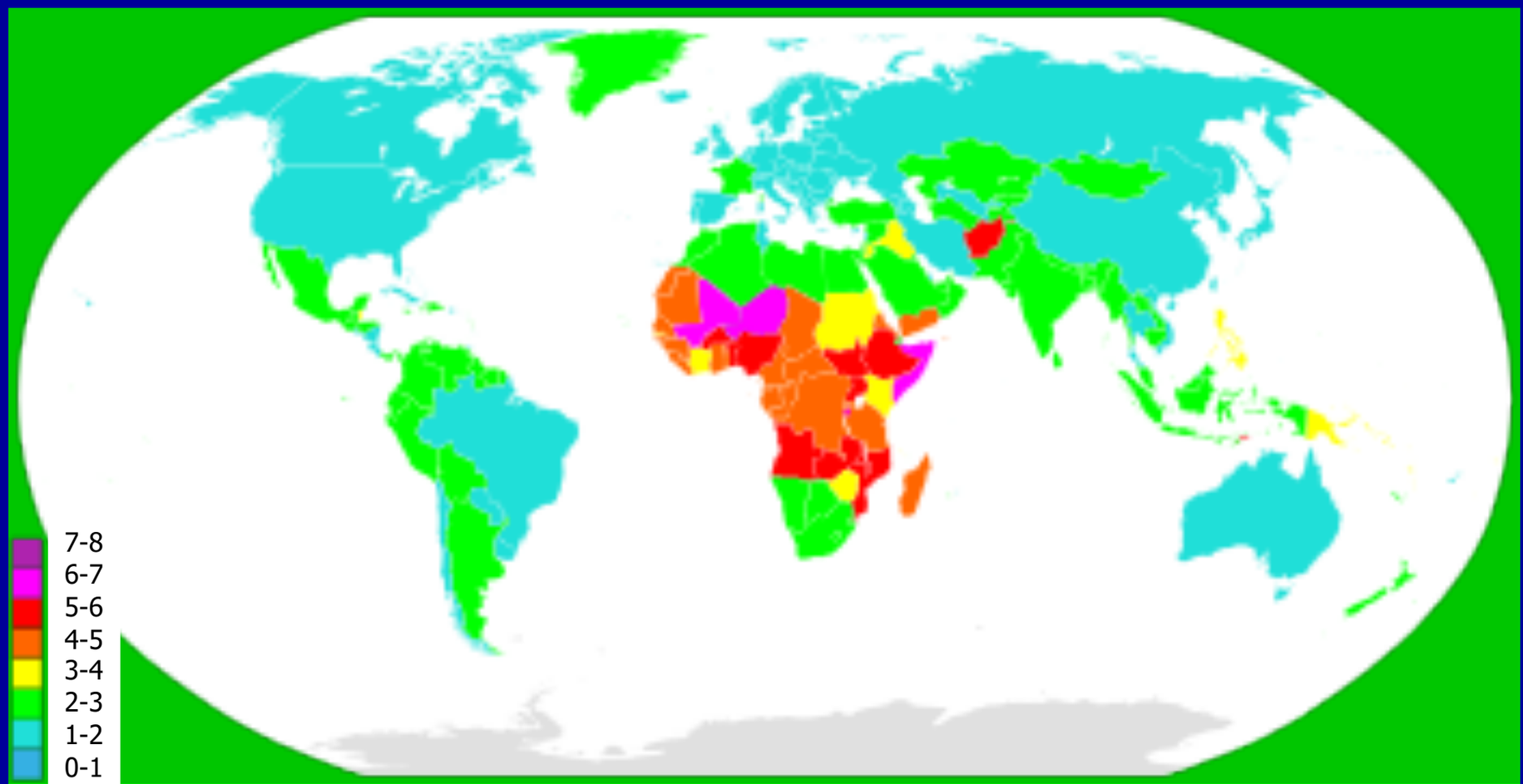


This plot doesn't even have ZPG on it.
If we keep going at 1.1%/year, by 2100 there will be > 25B souls on the planet!

Population density



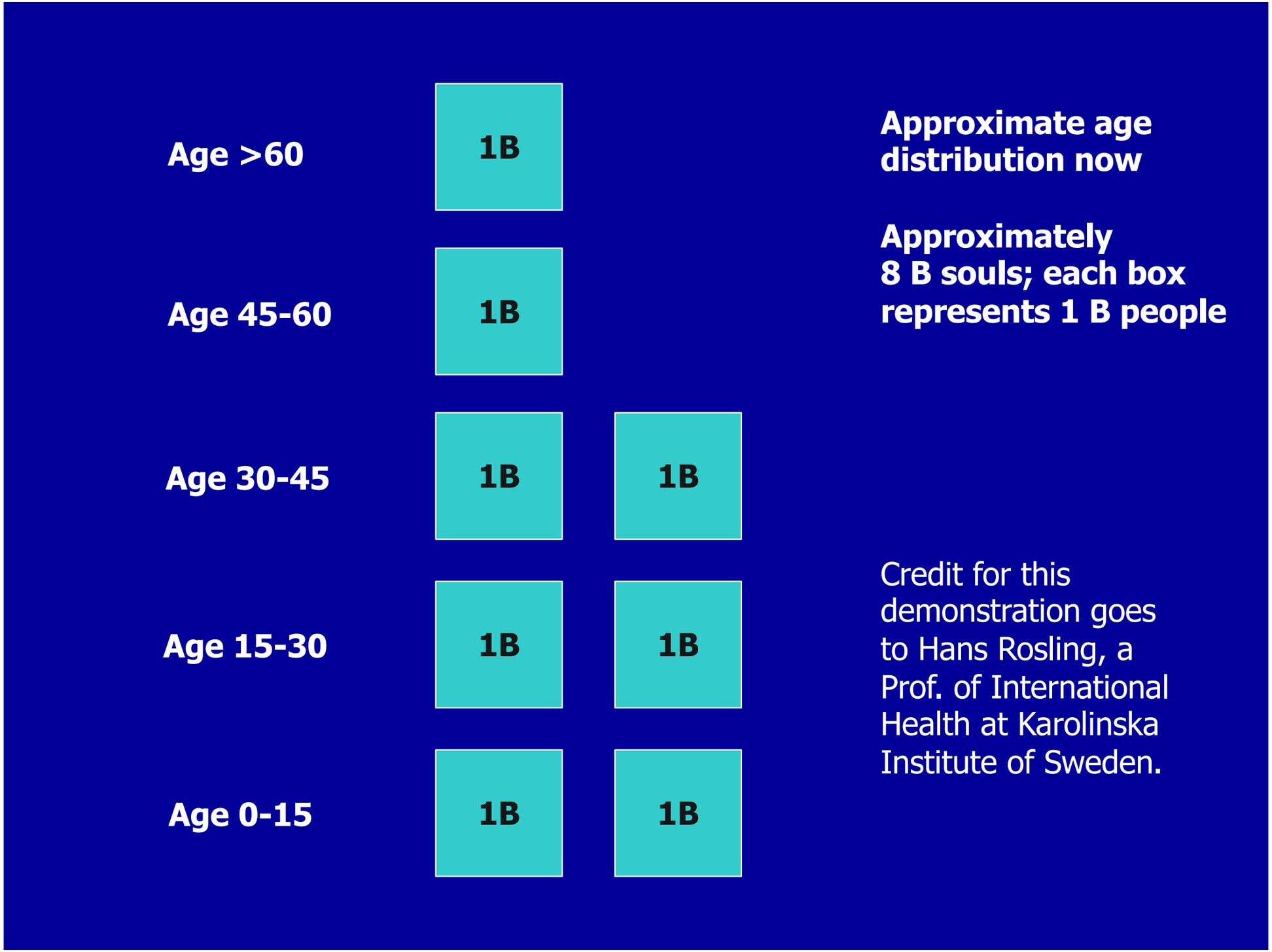
Population growth rate

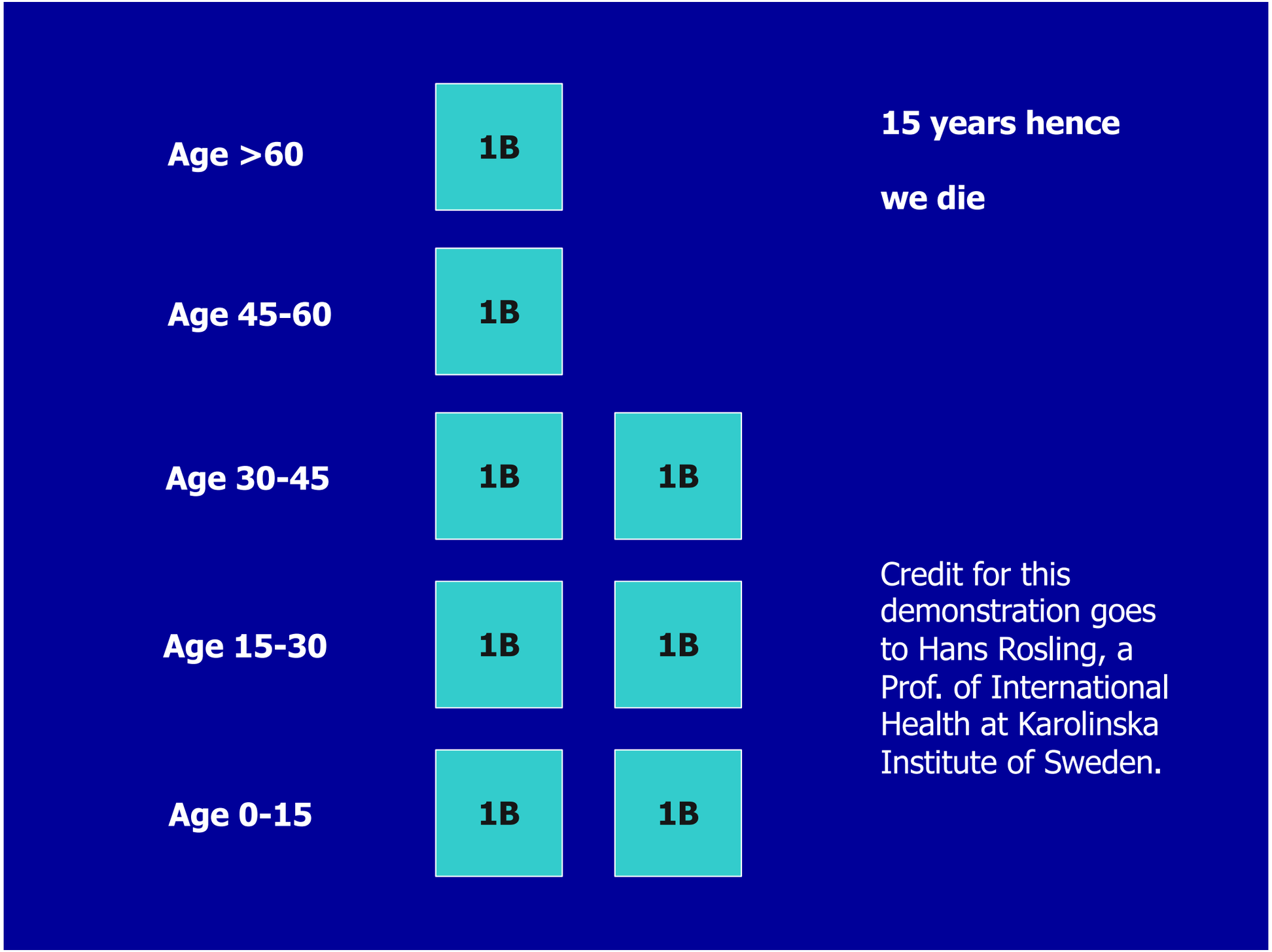


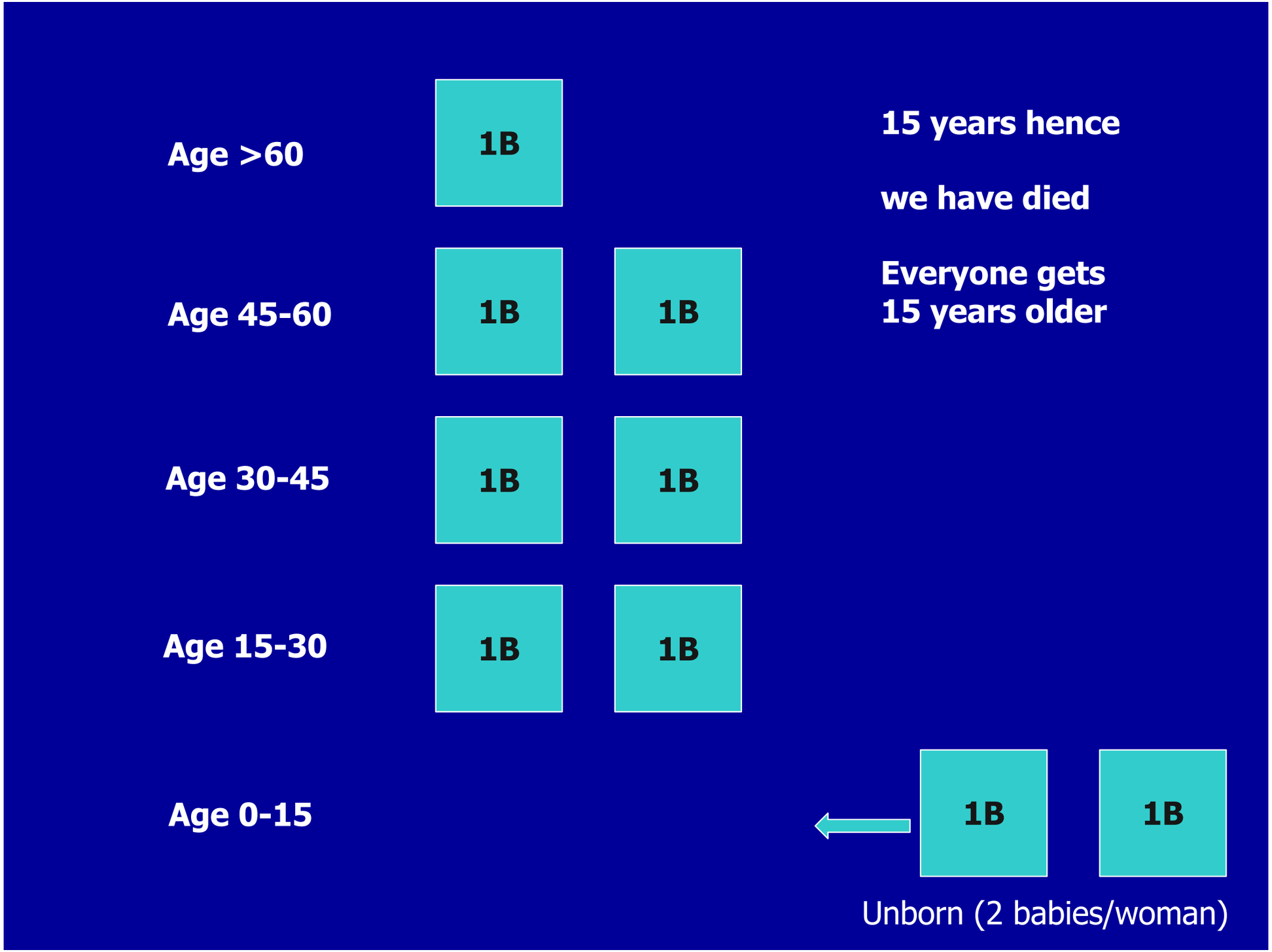
Scale: children per mother

20th century growth was superexponential

Consequences:
There were lots of young people and fewer old people.
And it will take a generation to stabilize even at no increase in growth rate.


Age >60
1B
Age 45-60
1B
Age 30-45
1B
1B
Age 15-30
1B
1B
Age 0-15
1B
1B
Approximate age distribution now
Approximately 8 B souls; each box represents 1 B people
Credit for this demonstration goes to Hans Rosling, a Prof. of International Health at Karolinska Institute of Sweden.


Age >60
1B
Age 45-60
1B
Age 30-45
1B
1B
Age 15-30
1B
1B
Age 0-15
1B
1B
15 years hence
we die
Credit for this demonstration goes to Hans Rosling, a Prof. of International Health at Karolinska Institute of Sweden.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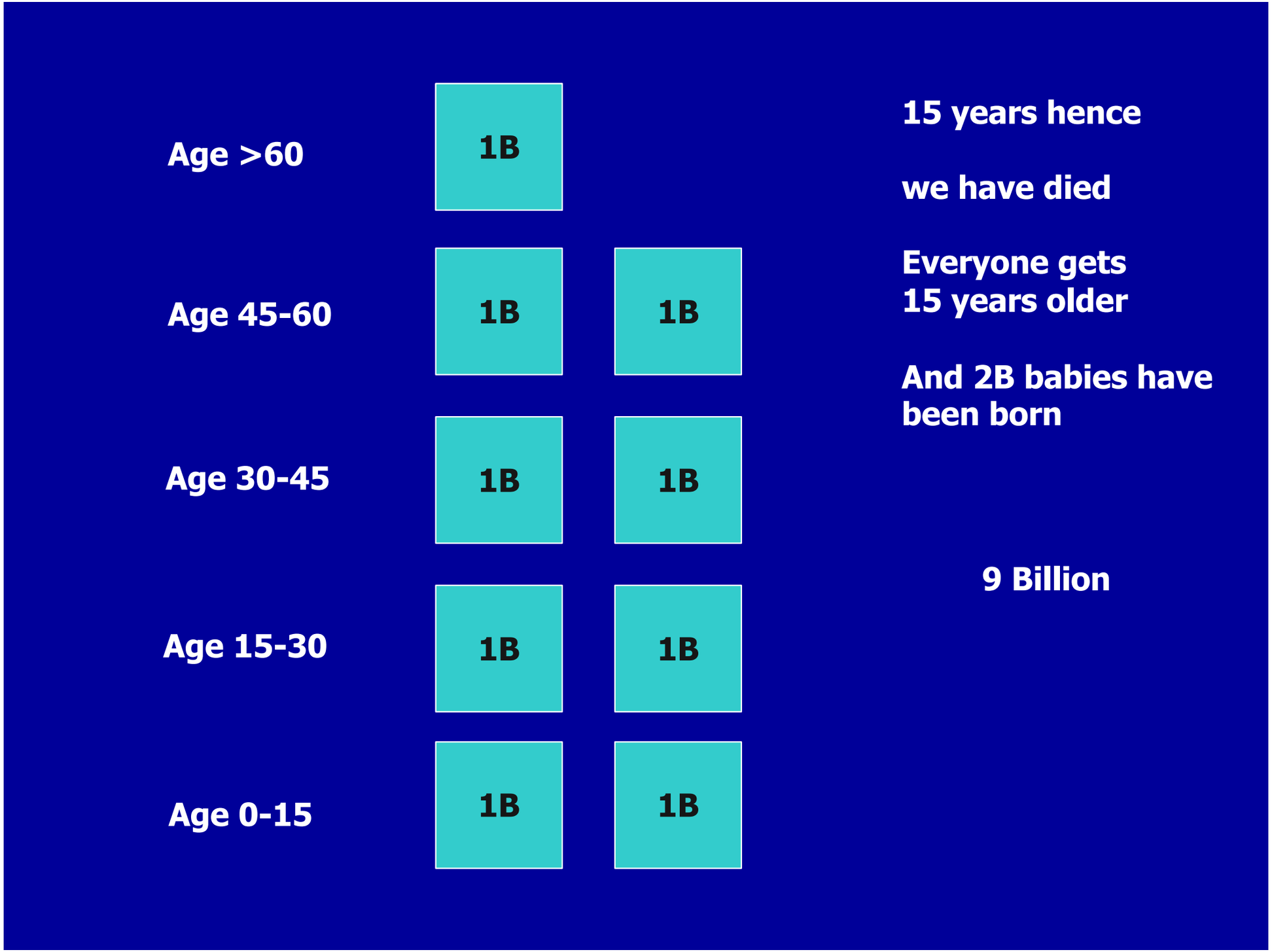
1B
Age 45-60
1B
1B
Age 30-45
1B
1B
Age 15-30
1B
1B
Age 0-15
1B
1B
Unborn (2 babies/woman)
15 years hence
we have died
Everyone gets
15 years older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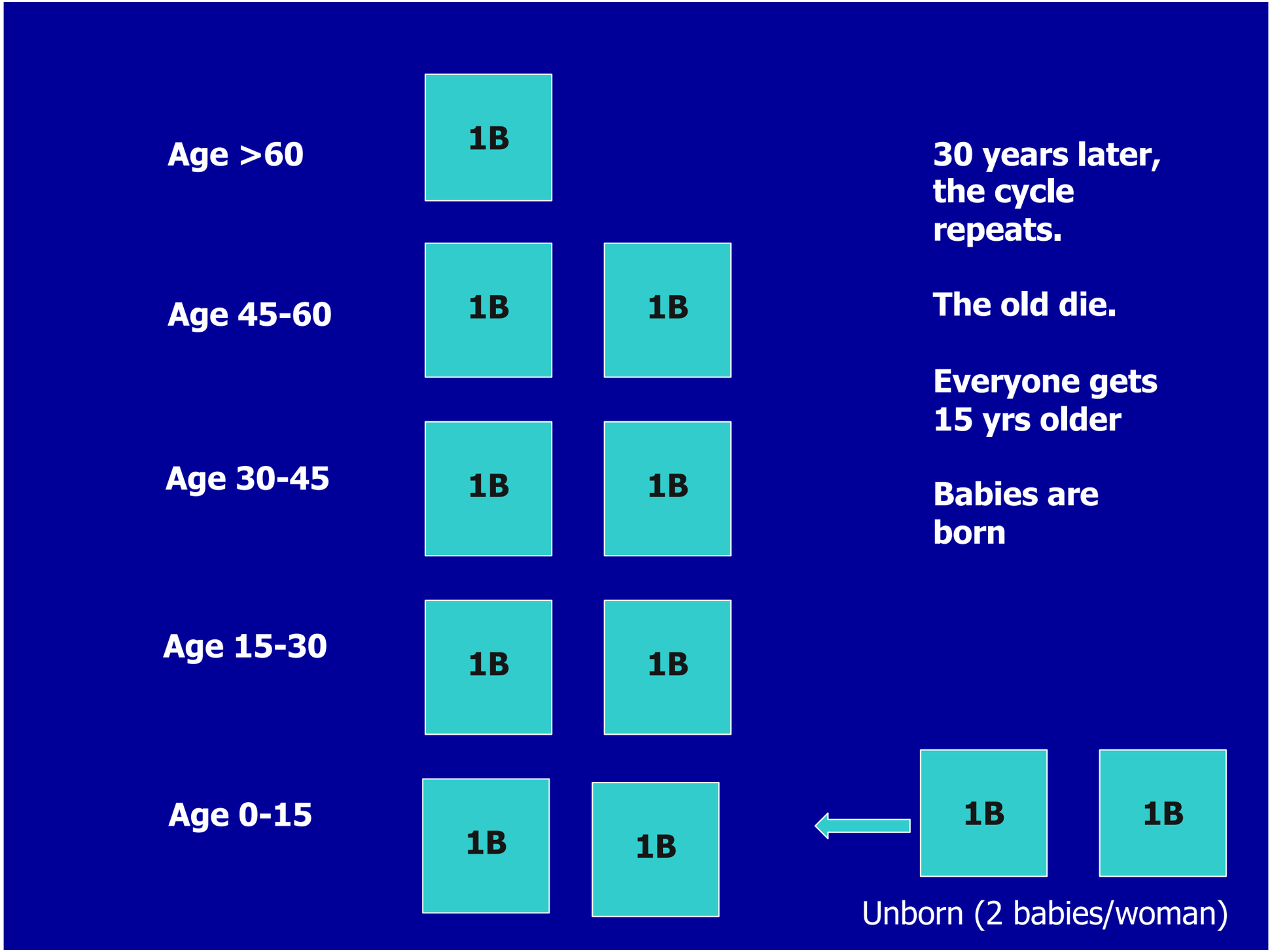
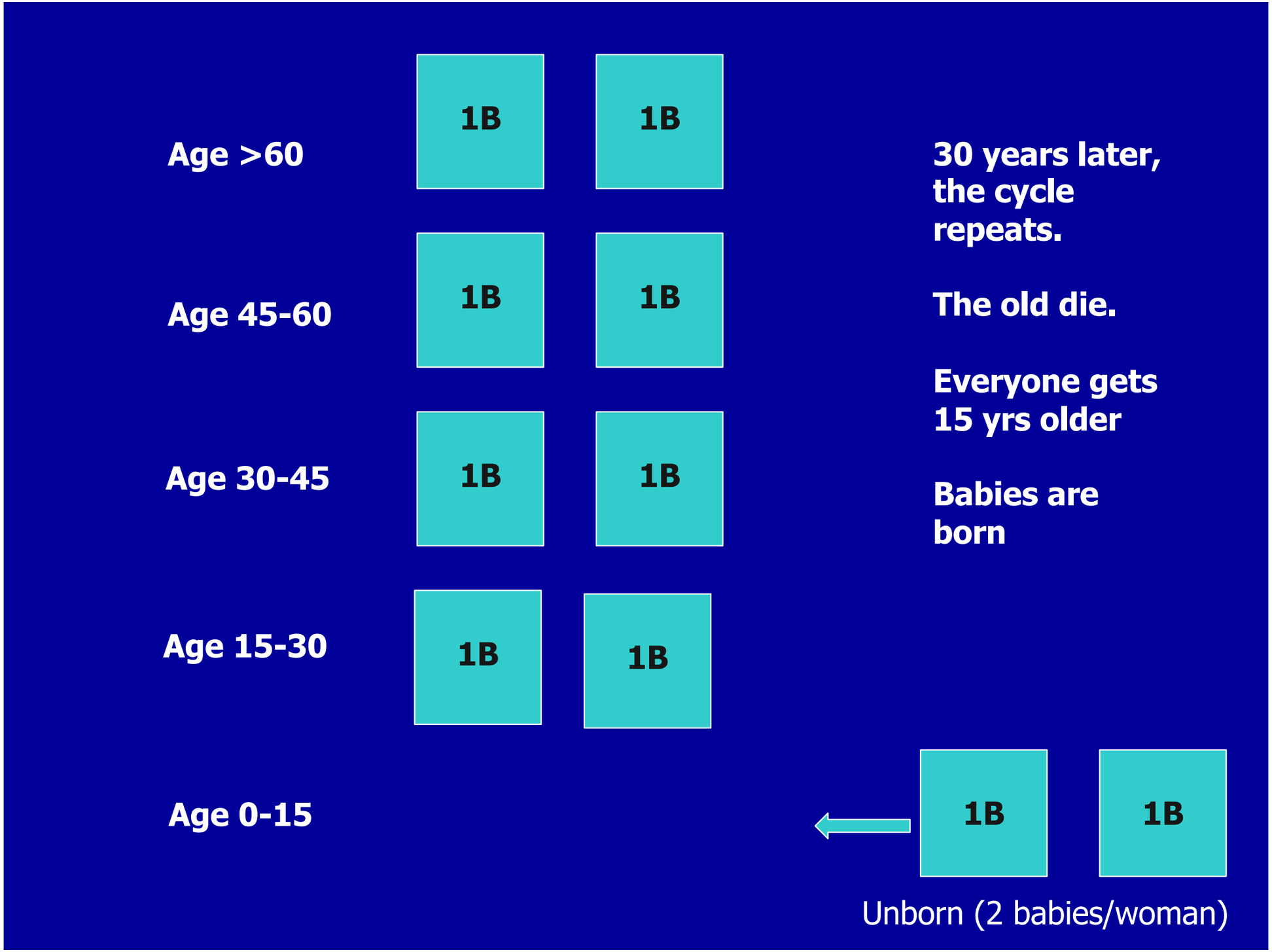
Age 45-60
1B
1B
Age 30-45
1B
1B
Age 15-30
1B
1B
Age 0-15
1B
1B
15 years hence
we have died
Everyone gets
15 years older
And 2B babies have
been born
9 Billion


Age >60
1B
Age 45-60
1B
1B
Age 30-45
1B
1B
Age 15-30
1B
1B
Age 0-15
1B
1B
30 years later, the cycle repeats.
The old die.
Everyone gets 15 yrs older
Babies are born
1B
1B
Unborn (2 babies/woman)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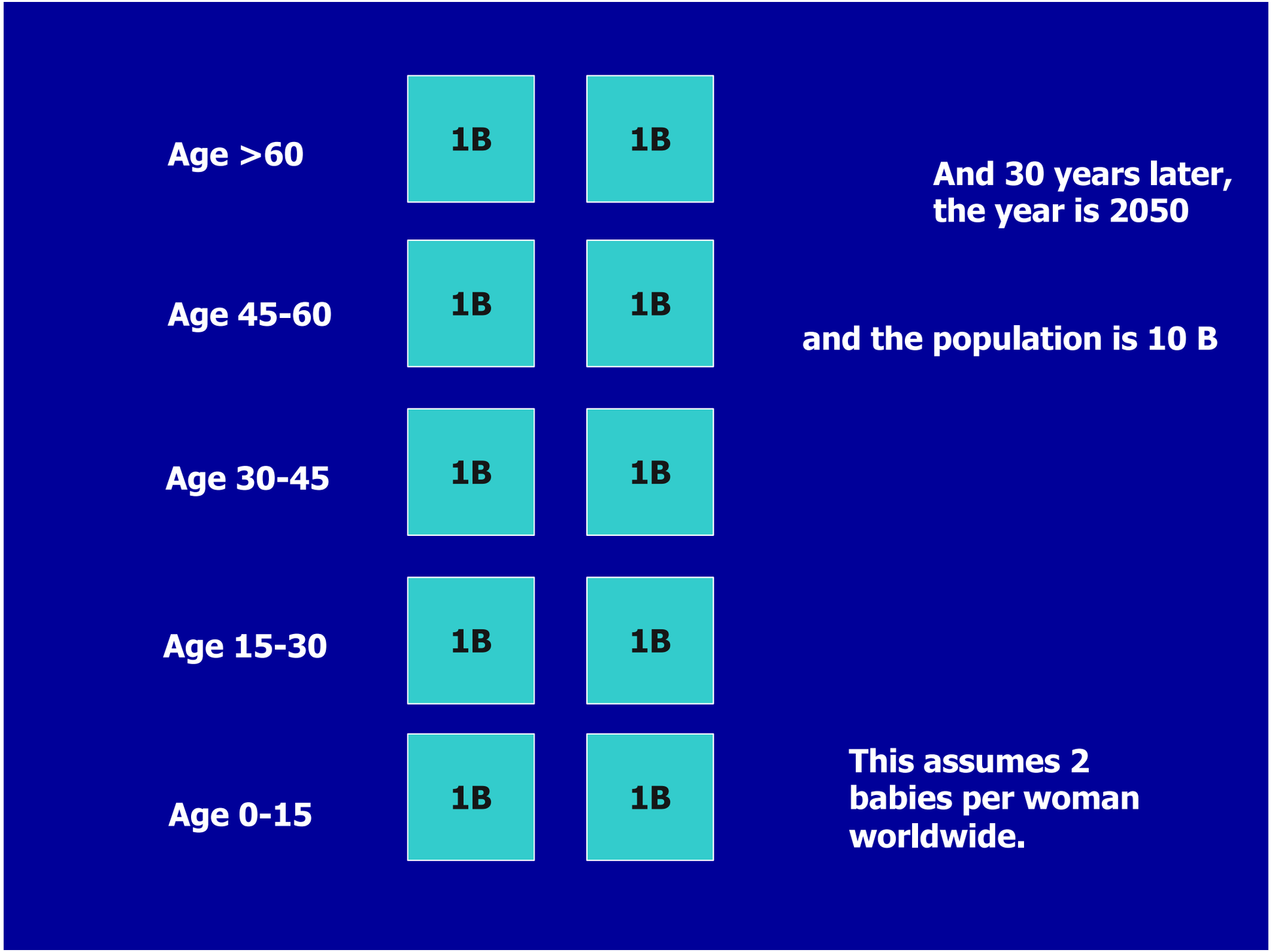
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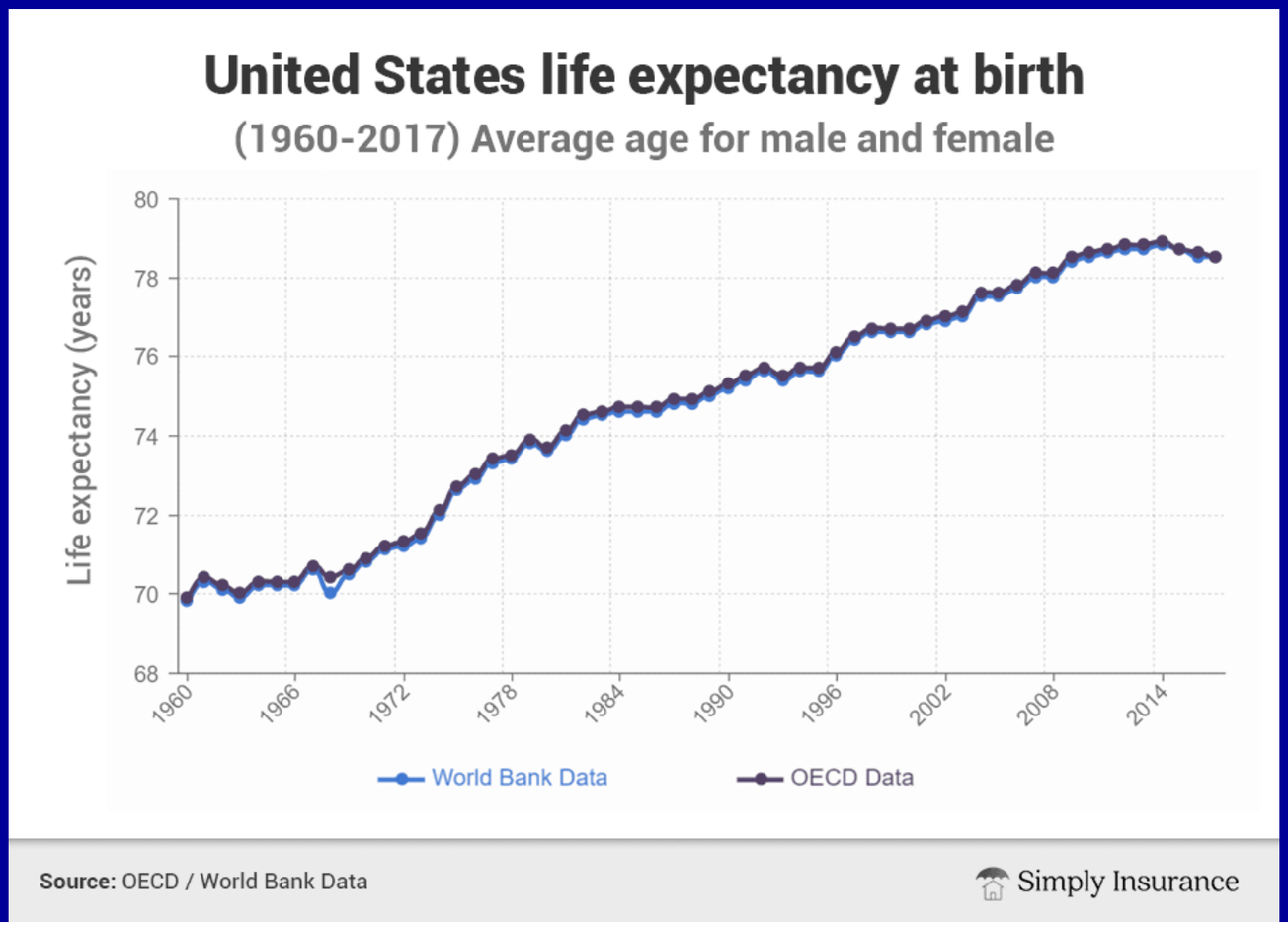
1B
1B
Age 45-60
1B
1B
Age 30-45
1B
1B
Age 15-30
1B
1B
Age 0-15
1B
1B
And 30 years later, the year is 2050
and the population is 10 B
This assumes 2 babies per woman worldwide.

1B

11 B by 2100

One more box is added because life expectancy is slowly increasing.



Population's future

- We will reach ~11 billion unless some catastrophe occurs
- Empower women to bring the poorest 2 B out of poverty, else growth will continue
- Assuming this happens, the age distribution will become more uniform and potentially stable
- Main issue is the carrying capacity of the Earth: How many can we water and feed?

Babies per woman decrease when

- Children survive
- Children not needed for work
- Women get education and join the workforce
- Family planning is accessible

Empower women

Credit Hans Rosling, TED talk 2012

Summary

The **high fertility curve** won't happen because the planet cannot support that many people.

Mother Nature will limit population

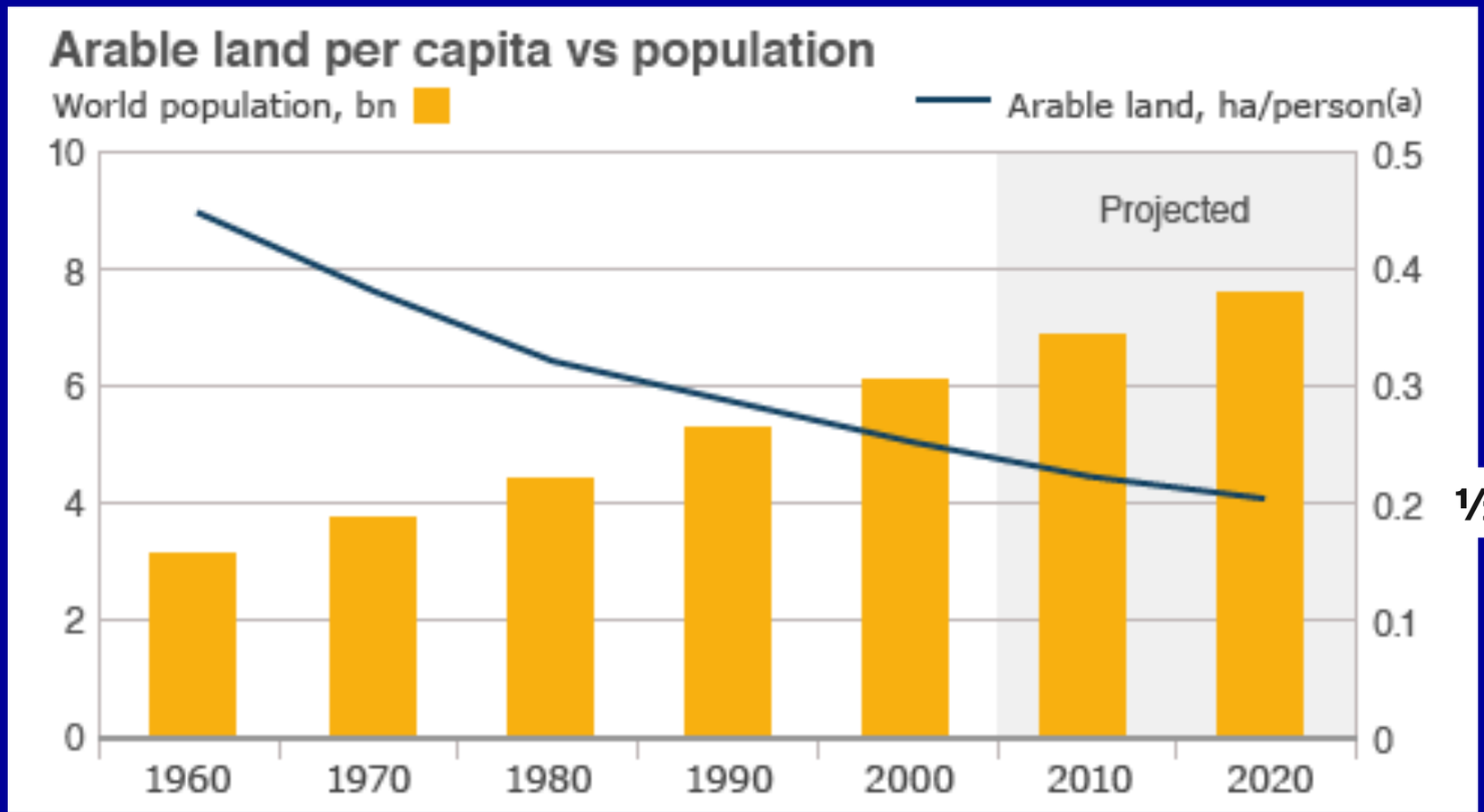
- How she does it might not be pretty

People require food:
requires water and arable land

How many people can the planet support: aka "carrying capacity"

- Depends on lifestyle
  - Estimates vary from 2 to 40 billion
  - 2B if everyone on Earth lived like a middle-class American, consuming roughly 3.3 times the subsistence level of food and about 250 times the subsistence level of clean water
  - 40 B if everyone on the planet consumed only what he or she needed
- Can technology save us from Malthus?

Per capita arable land



½ an acr

Arable land is a finite resource

Global scale problem predicted within 70 years

UN Intergovernmental Technical Panel on Soils (ITPS like IPCC)

Threats

- Nutrient depletion
- Salinization
- Erosion
- Urbanization
- Chemical pollution

In hectares
1 hectare
= 2.47 acres

Bruce Sundquist, Carrying Capacity Committee, Allegheny Group, Sierra Club
Maximum Population, Aug. 23, 1999.

http://home.windstream.net/bsundquist1/

Vertical farming

Hydroponics: nutrients in water, no soil
Aquaponics: fish and plants in a closed system
Aeroponics: NASA inspired; grow in special nutrients

Need light, water and nutrients
Energy intensive (nuclear??)
Need water and maybe a CO_2 source

Daily per capita consumption of energy (footprint)

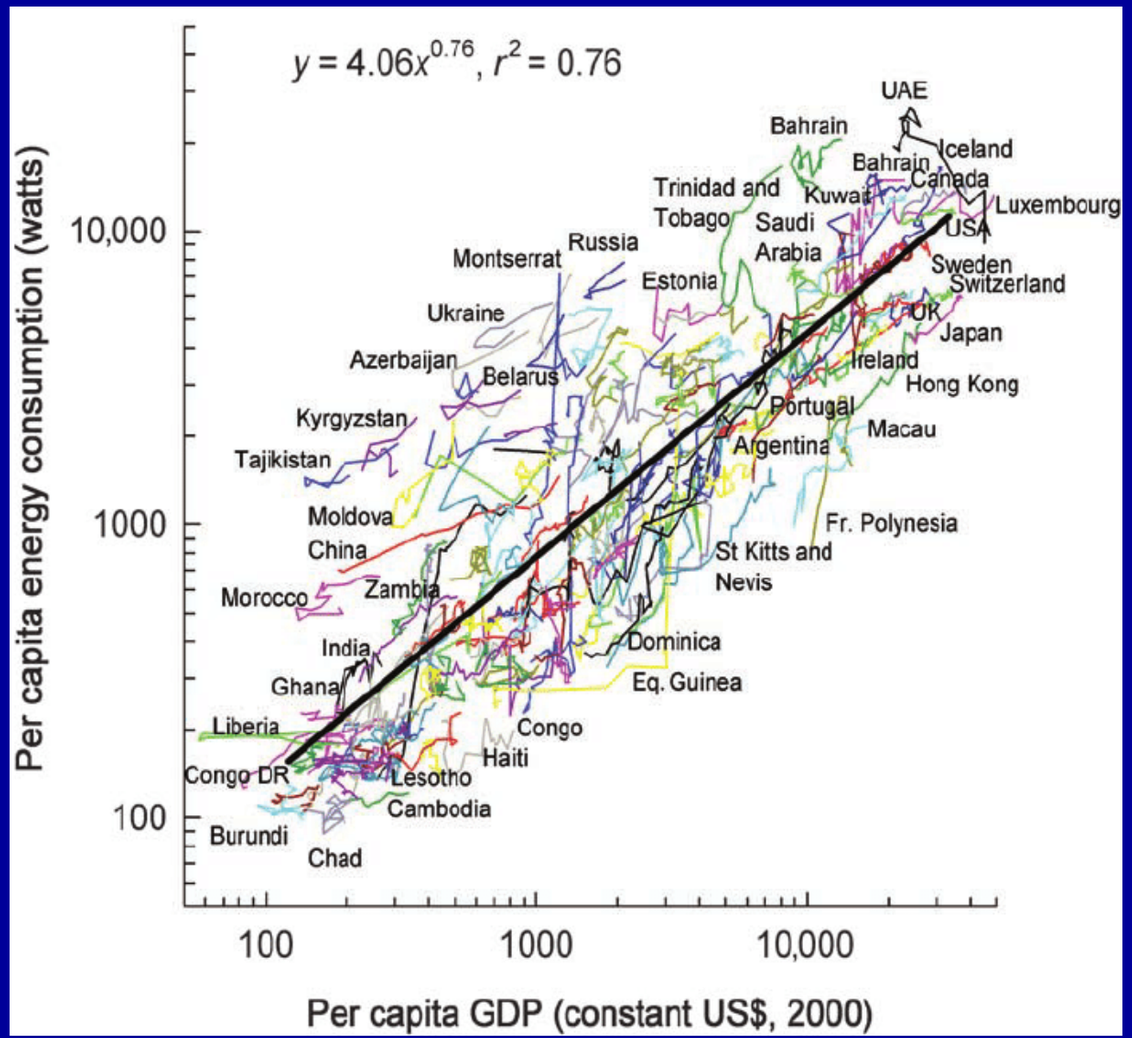
	Primitive society	Hunting society	Primitive agriculture	Advanced agriculture	Industrial society	Technological society
Food	2	2	4	6	7	10
Home and commerce		3	4	12	32	66
Agriculture and industry			4	7	24	91
Transportation				1	14	63
Total	**2**	**5**	**12**	**26**	**77**	**230**

Units: kWhr per person per day = 3.6 M-Joules/person/day

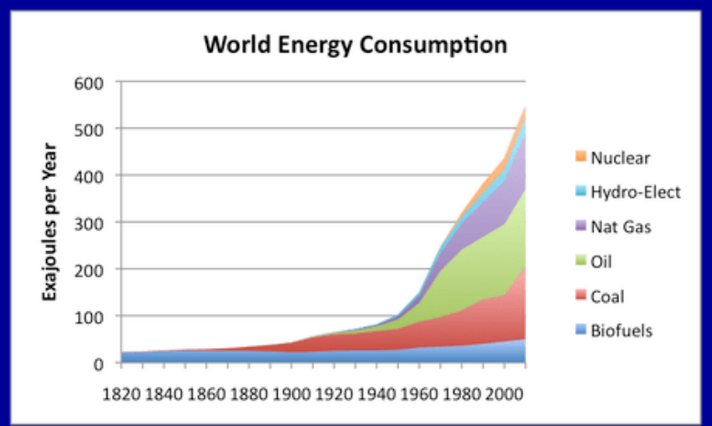
230 kWhr/person/day was in 2005; now about 270 kWhr/person/day

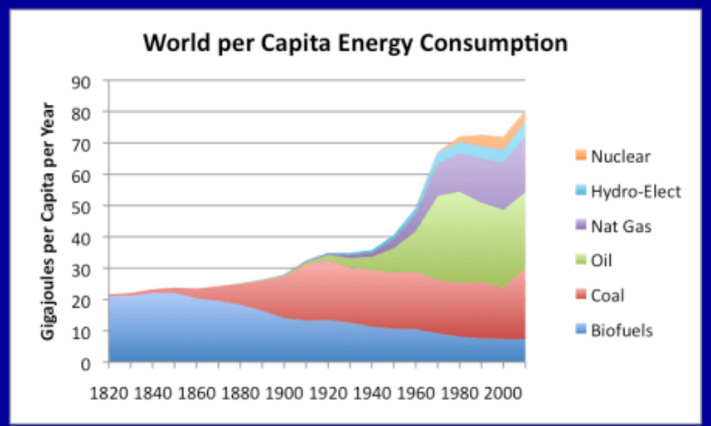
Adapted from: E. Cook, "The Flow of Energy in an Industrial Society" Scientific American, 1971 p. 135.

Energy consumption vs. GDP



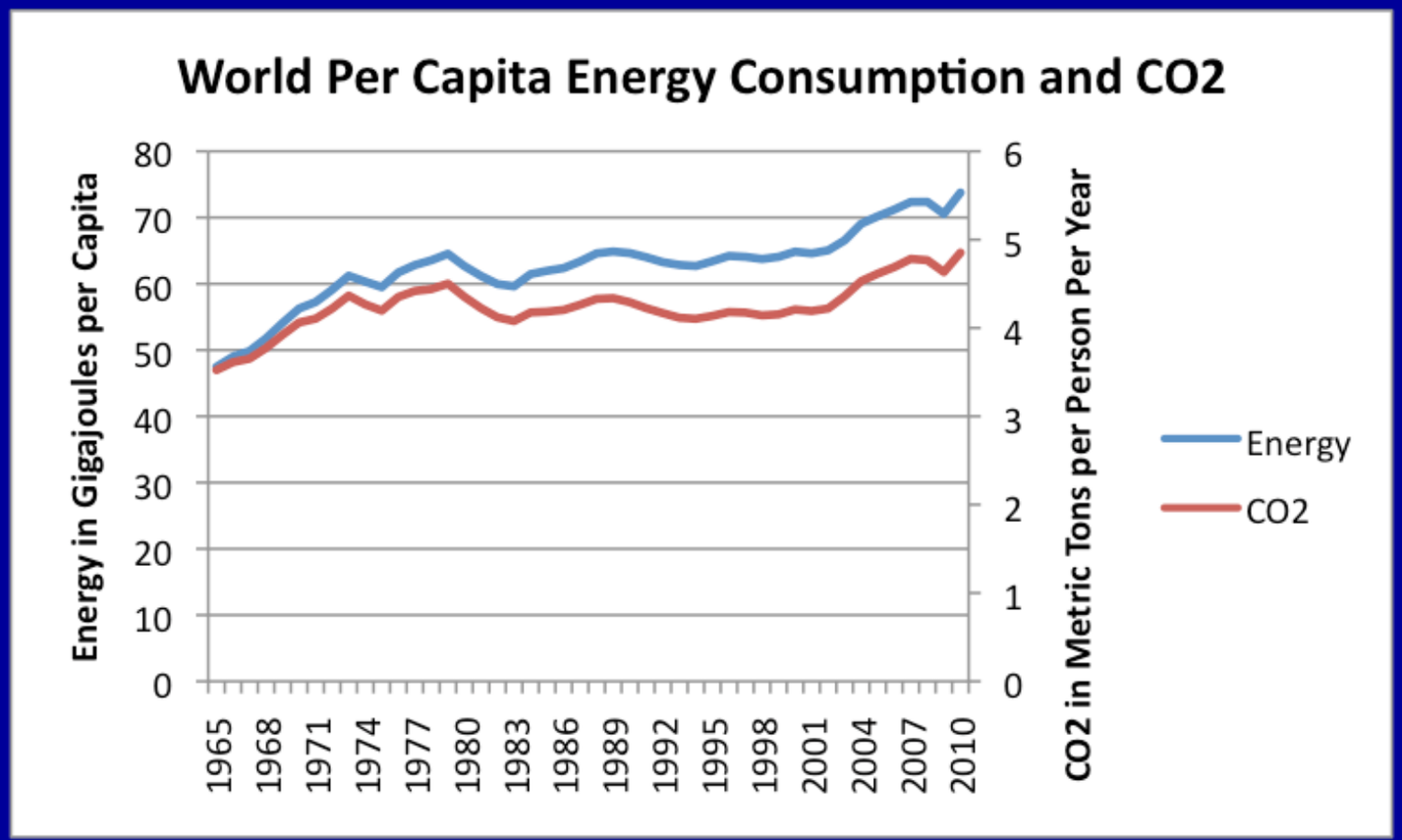
Energy consumption





Recent bump due to lifestyle changes in Asia.

Efficiency has helped somewhat



Affluence

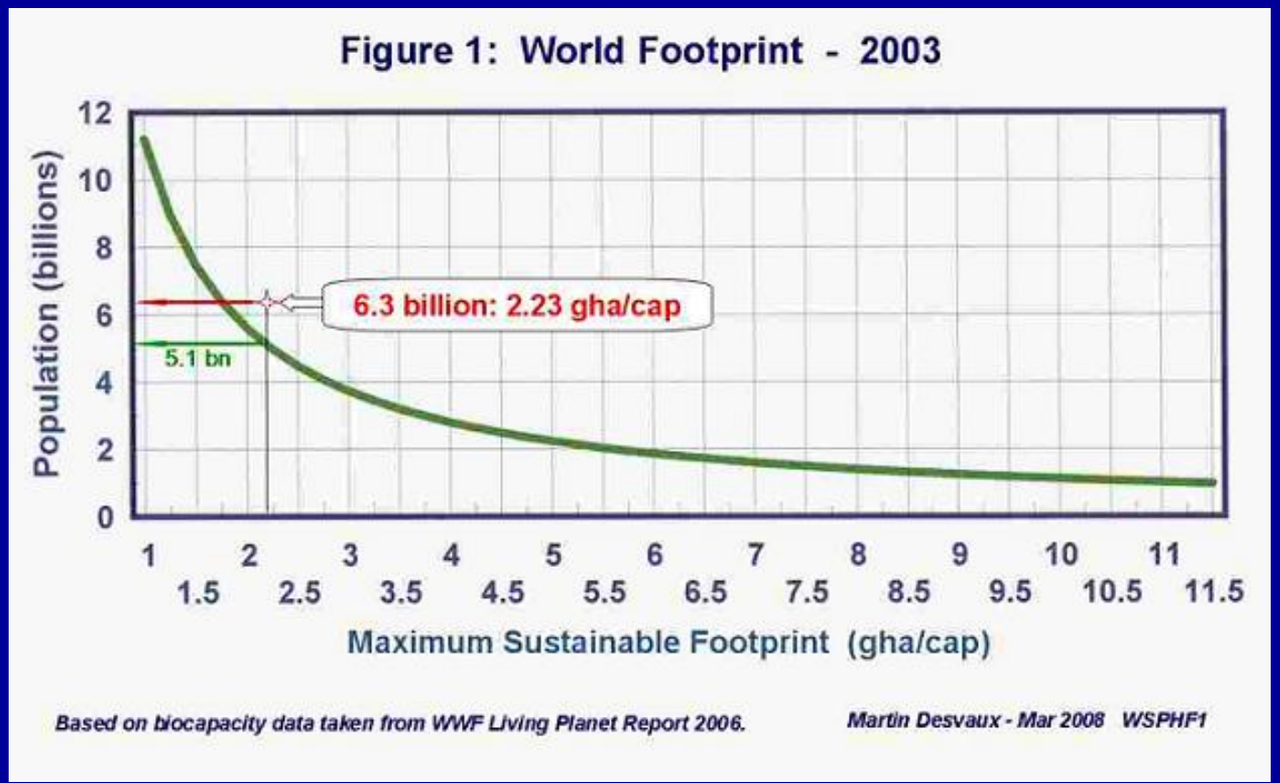
- Per capita consumption of goods and services

- Represented by GDP per capita
- Equivalently energy consumption per capita

The good life! Cars, travel, restaurant food, fresh fruit from far, far away, ….

Biocapacity of the earth = 11.2 gha

= Maximum per capita footprint ×
size of sustainable population



Available:
1.64 gha/cap

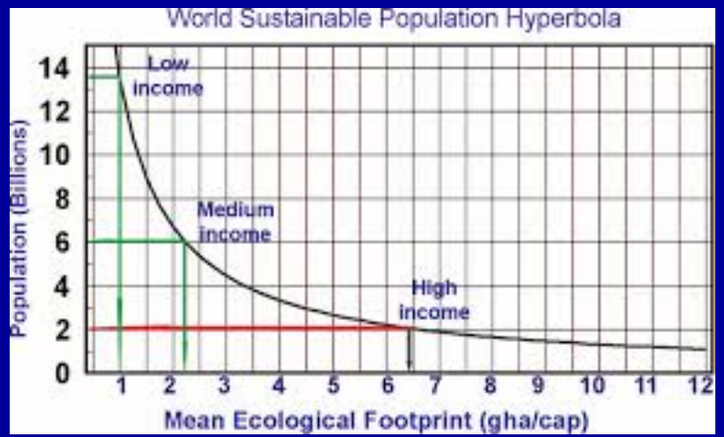
Use
Ave: 2.23 gha/cap
USA: 9.4 gha/cap
EU: 4.8 gha/cap
China: 1.6 gha/cap

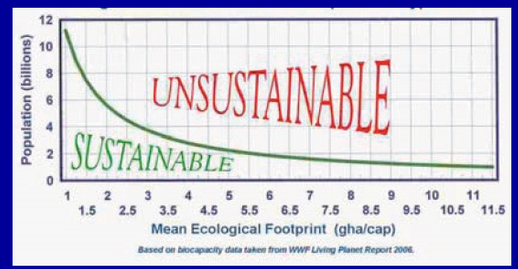
gha/cap = global hectares per capita: Global total 11.2 gha

http://www.optimumpopulation.org/opt.optimum.html

(1 hectare = 0.405 acres)

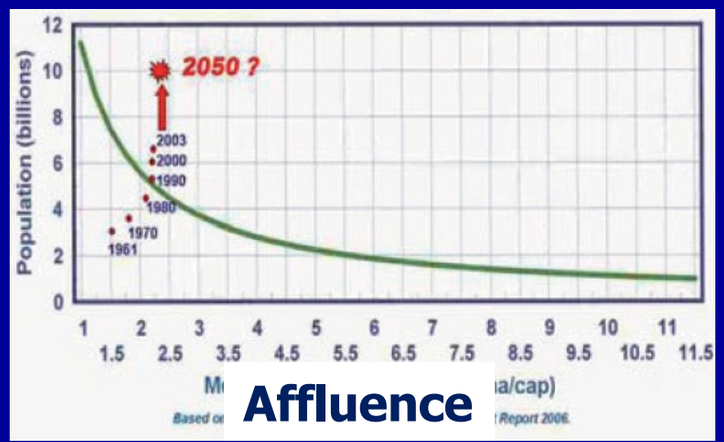
Sustainable Population Hyperbola

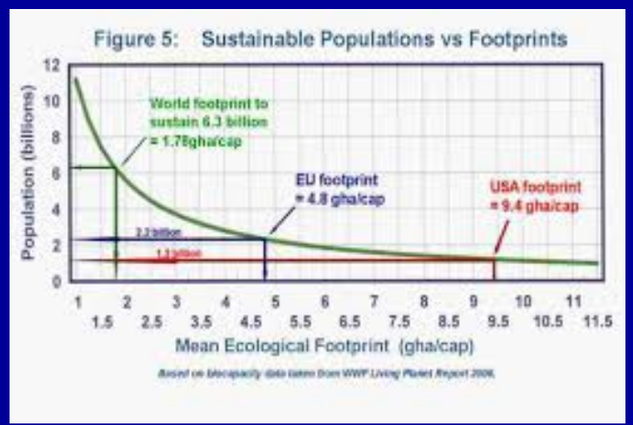




Biocapacity of the planet
gha/cap: Global hectares per capita.

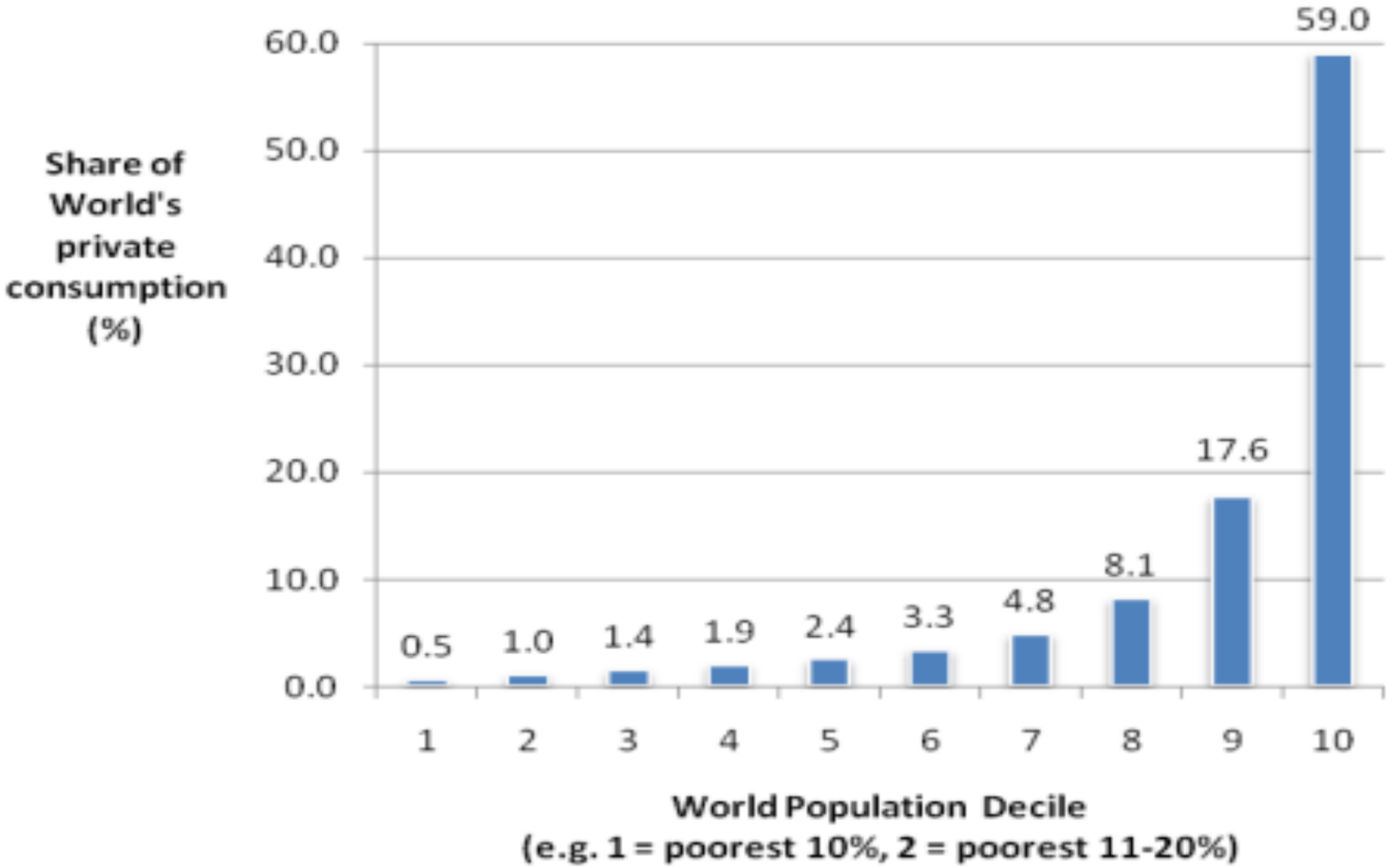
For acres/person, multiply by 2.47





The location of the hyperbola is debated.

Inequality of Consumption, 2005



Source: World Bank Development Indicators 2008

Summary

- Water and land determine the carrying capacity
- We are arguably using more resources than the planet can provide
- Must "borrow" from the Earth to support additional people temporarily (how long??)
  - finite resources provide limit
- More for us, less for other species

What I discussed today

- Population history and projections
  - Why 11 billion is "baked in"
- Arable land
  - Vertical farming
- Affluence
  - Whose problem is this?

The existential question: can all of humanity afford to live the lifestyle of a technological society and is it morally right to ask that they don't.

What can an individual do?

- Vote climate
- Reduce your own carbon footprint
  - Drive and fly less
  - Eat low on the food chain (e.g. minimize cattle and hogs)
  - Buy local
  - Solar energy and home insulation
- Help plant trees (A billion needed globally)
- Support environmental organizations
  - Nature Conservancy
  - Sierra Club
  - Environmental Defense Fund
- Citizen's Climate Lobby
  - Bi-partisan for Carbon "Fee and Dividend"

The end