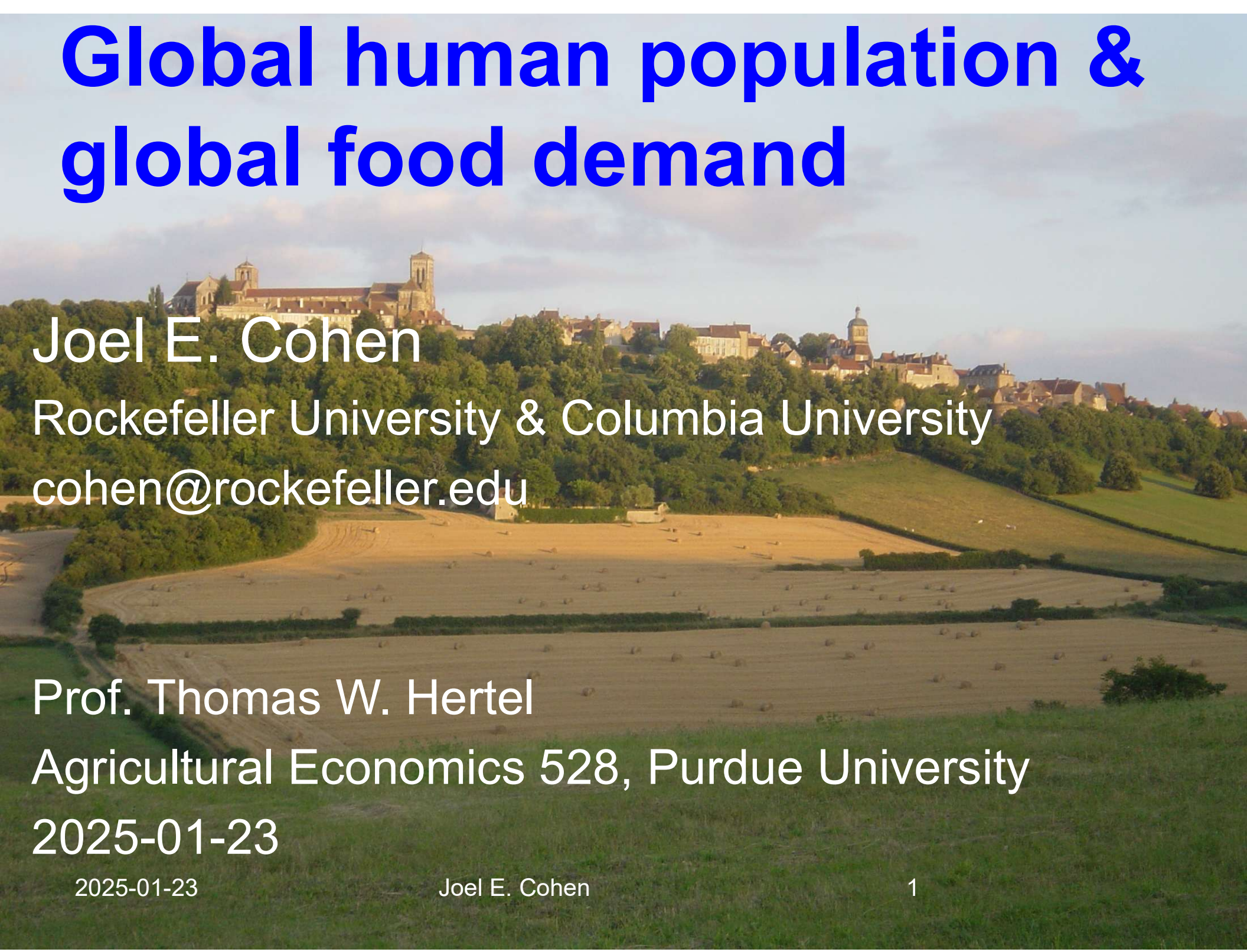
Global human population & global food demand



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Prof. Thomas W. Hertel
Agricultural Economics 528, Purdue University
2025-01-23

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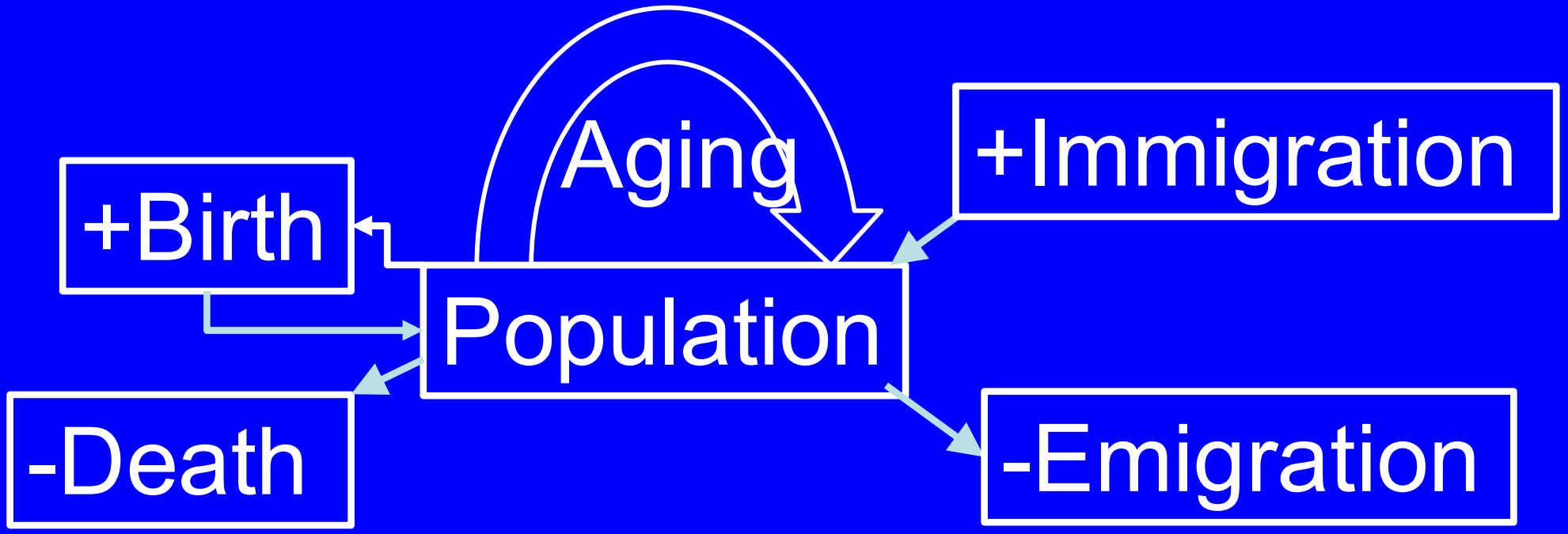
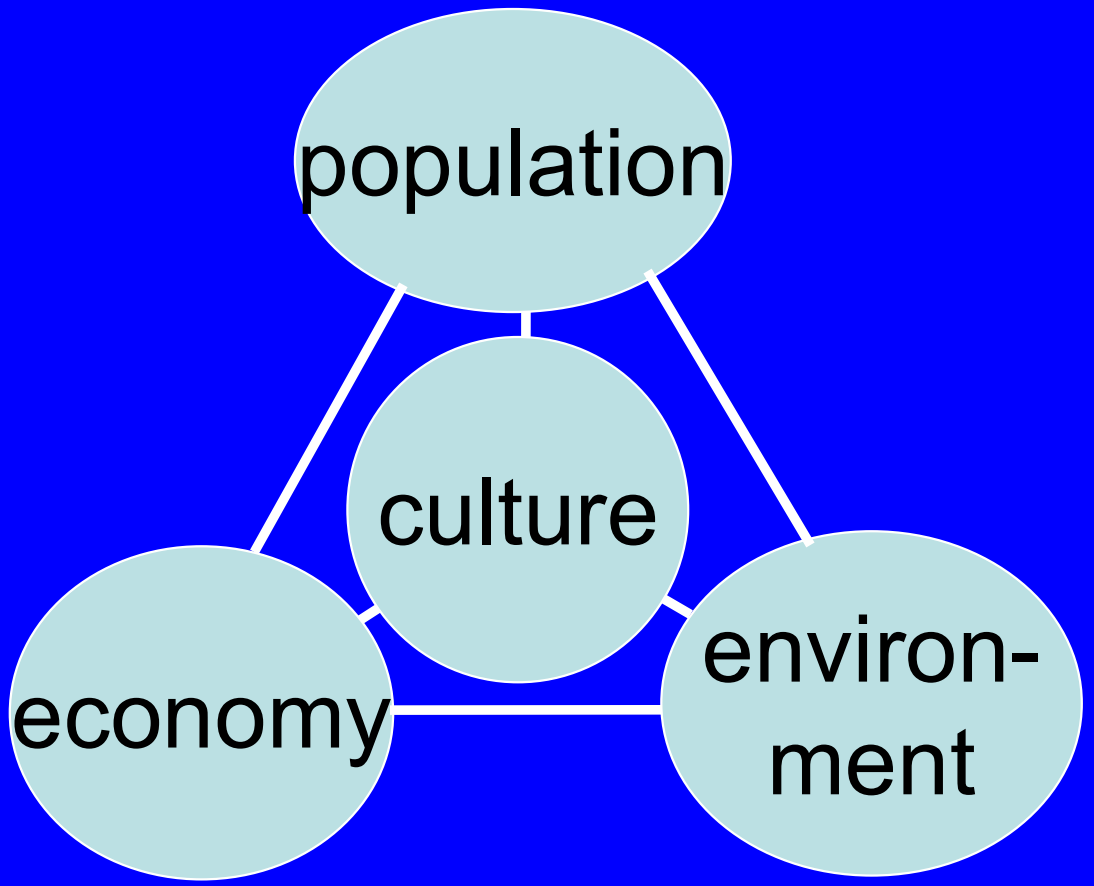
Overview

Population size, age structure, & composition change by birth, death, & migration.



Population, economy, environment, culture interact.



Global human population: summary

Past: ~1 billion → ~8 billion in ~200 years.
Growth was **not** exponential.

Present: Increasing ~70 million/year (another USA population in <5 years).
Nearly 1 bln people (~1 in 10) are chronically hungry. >1 child in 5 under age 5 is stunted from chronic hunger.

Future: If no nuclear war, plague, climate catastrophe, comets, 9 billion people by ~2035, 10 bln by ~2057, peak 2084? & growing older, more urban, more slowly, more Asian, more African, more migratory.

Demographic numbers are estimates or projections, not exact.

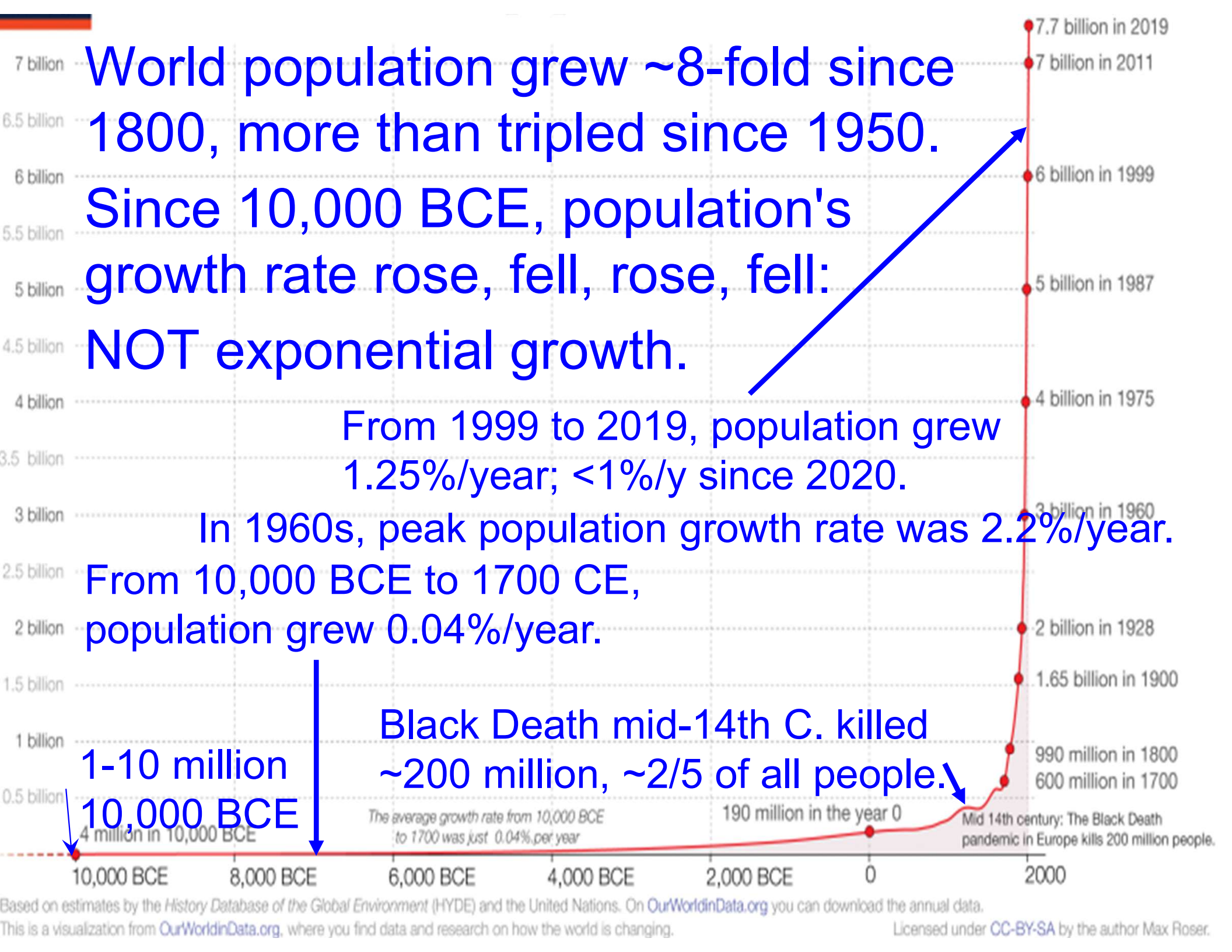
UN *World Population Prospects 2024*, p. 51:

"Population data from censuses or registers referring to 2019 or later were available for 114 countries and areas, representing 48 per cent of the 237 countries and areas included in this analysis (and 54 per cent of the global population). For 100 countries and areas, the most recent available population count was from the period 2009–2018. For the remaining 23 countries and areas, the most recent available census data were from before 2009, that is, more than 15 years ago."

Past

2025-01-23

2019-09-06
Cevennes, France


World population grew ~8-fold since 1800, more than tripled since 1950.
Since 10,000 BCE, population's growth rate rose, fell, rose, fell:
NOT exponential growth.
From 1999 to 2019, population grew 1.25%/year; <1%/y since 2020.
In 1960s, peak population growth rate was 2.2%/year.
From 10,000 BCE to 1700 CE, population grew 0.04%/year.
1-10 million 10,000 BCE
Black Death mid-14th C. killed ~200 million, ~2/5 of all people.
7.7 billion in 2019
7 billion in 2011
6 billion in 1999
5 billion in 1987
4 billion in 1975
3 billion in 1960
2 billion in 1928
1.65 billion in 1900
990 million in 1800
600 million in 1700
190 million in the year 0
4 million in 10,000 BCE
The average growth rate from 10,000 BCE to 1700 was just 0.04% per year
Mid 14th century: The Black Death pandemic in Europe kills 200 million people.
7 billion
6.5 billion
6 billion
5.5 billion
5 billion
4.5 billion
4 billion
3.5 billion
3 billion
2.5 billion
2 billion
1.5 billion
1 billion
0.5 billion
10,000 BCE
8,000 BCE
6,000 BCE
4,000 BCE
2,000 BCE
0
2000
Based on estimates by the History Database of the Global Environment (HYDE) and the United Nations. On OurWorldinData.org you can download the annual data.
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.
Licensed under CC-BY-SA by the author Max Roser.

4 changes in population growth

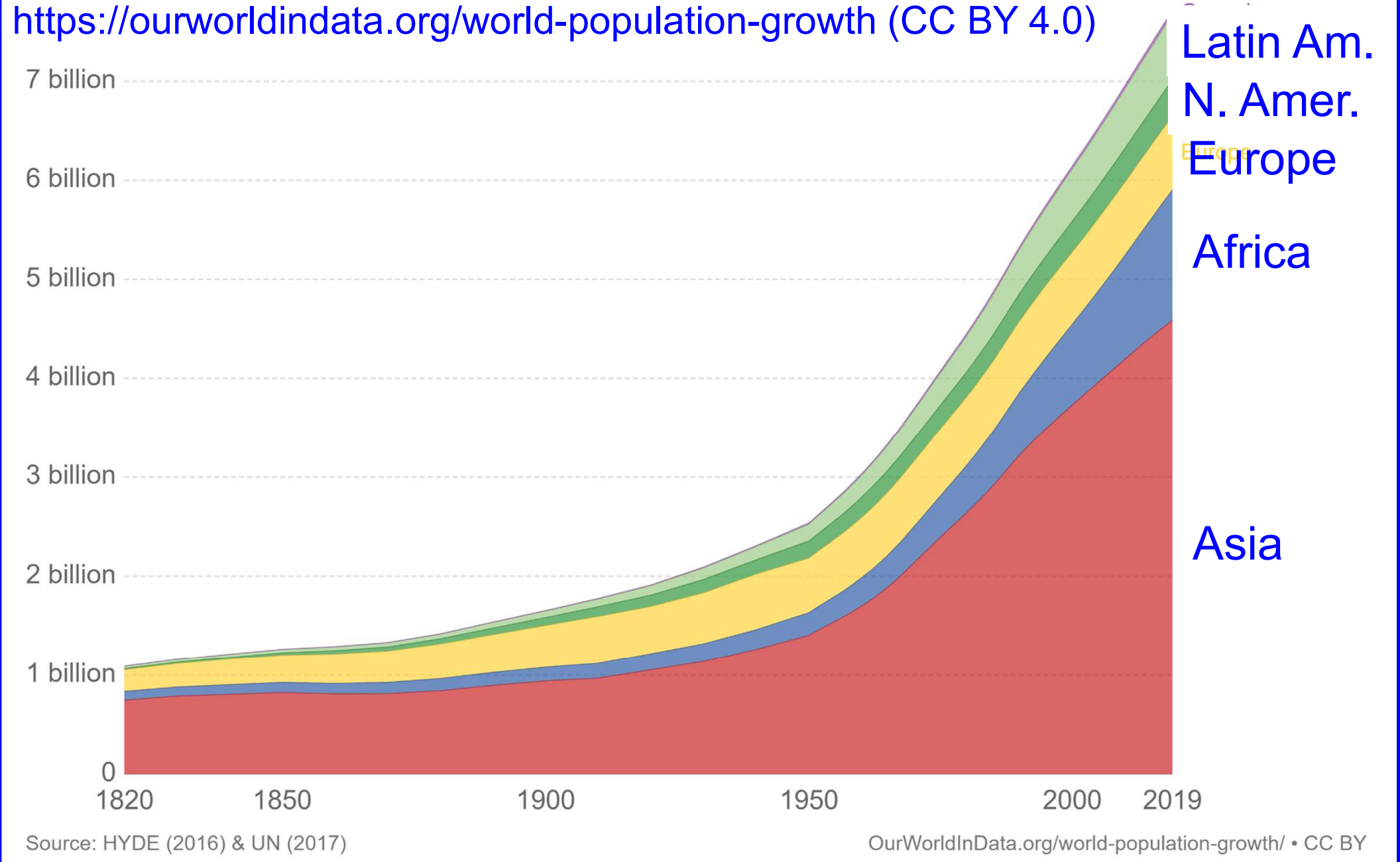
			doubling time (years)	
invention	dates	people	before	after
1 local agriculture	10,000-6,000 BCE	1-10 million	35,000-350,000	1,400-3,000
independent inventions of agriculture in Middle East, Asia, Africa, Americas				
2 global agriculture	1750	750 million	750-1,800	100-130
exchanges of plants, animals, & people between Old World & New World				
3 public health	1950	2.5 billion	87	36
massive reductions in death rates of children in poor countries				
4 fertility control	1970	3.7 billion	34	50
decline in fertility rates & Green Revolution				

20th century was unique demographically.

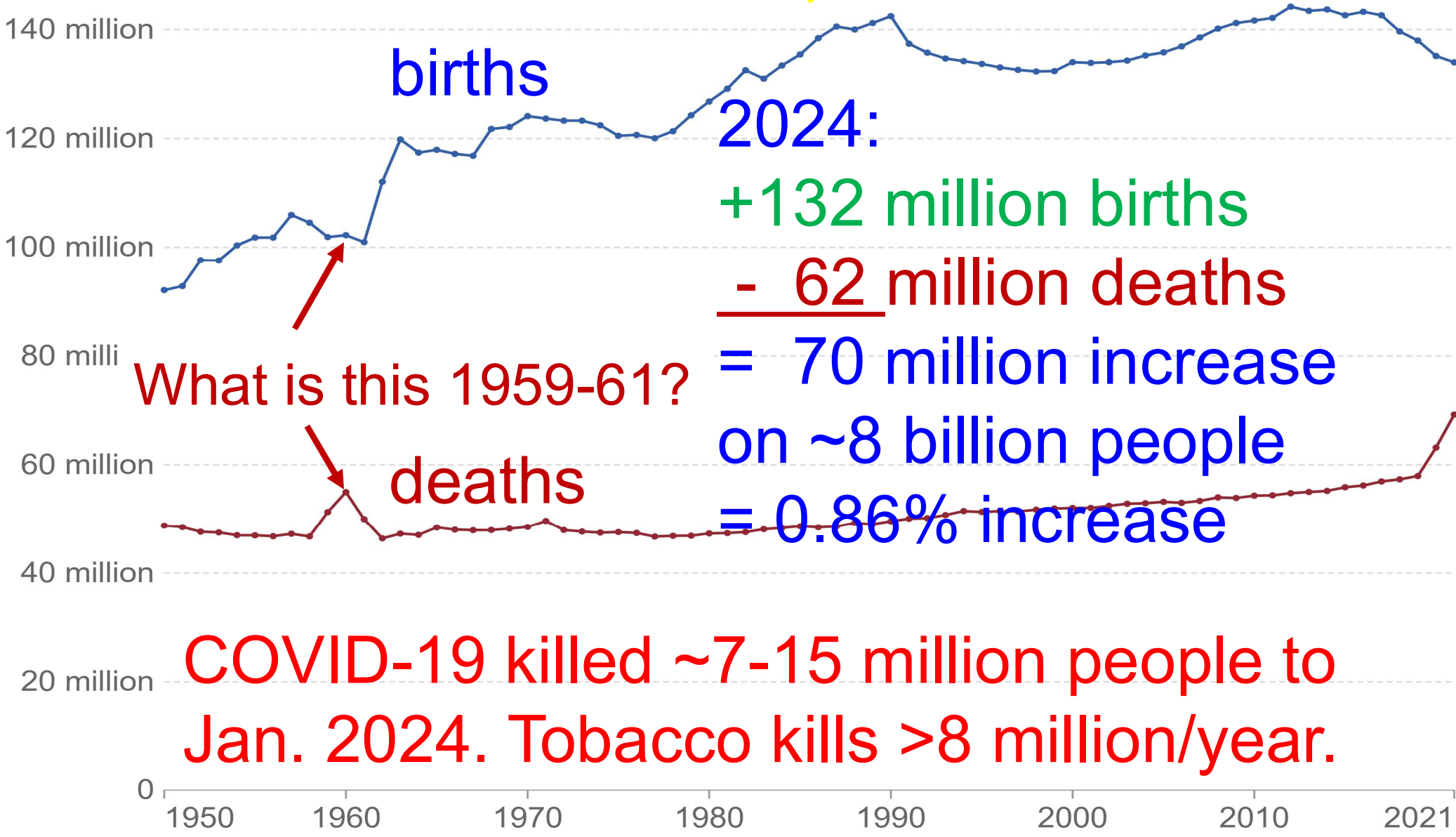
1. Highest global population growth rate in history: only century in which global population doubled (grew 3.8 x)
2. Largest voluntary decline in fertility
3. Last century with more young people than old people
4. Last century with more rural people than urban people

World population by region 1820-2019

https://ourworldindata.org/world-population-growth (CC BY 4.0)



Population grew ~80 million/year before COVID-19; now slower.



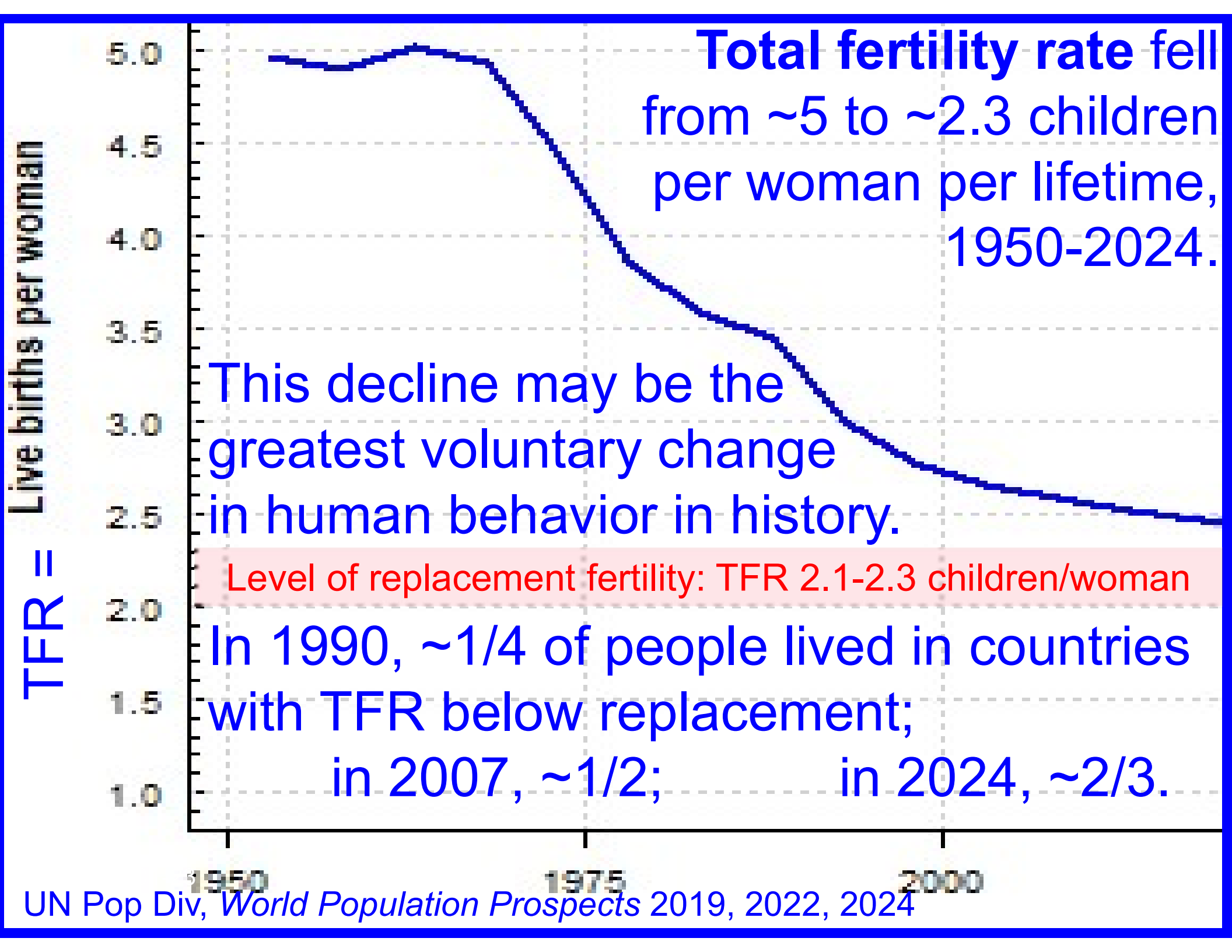
Source: United Nations - Population Division (2022)

OurWorldInData.org/future-population-gro

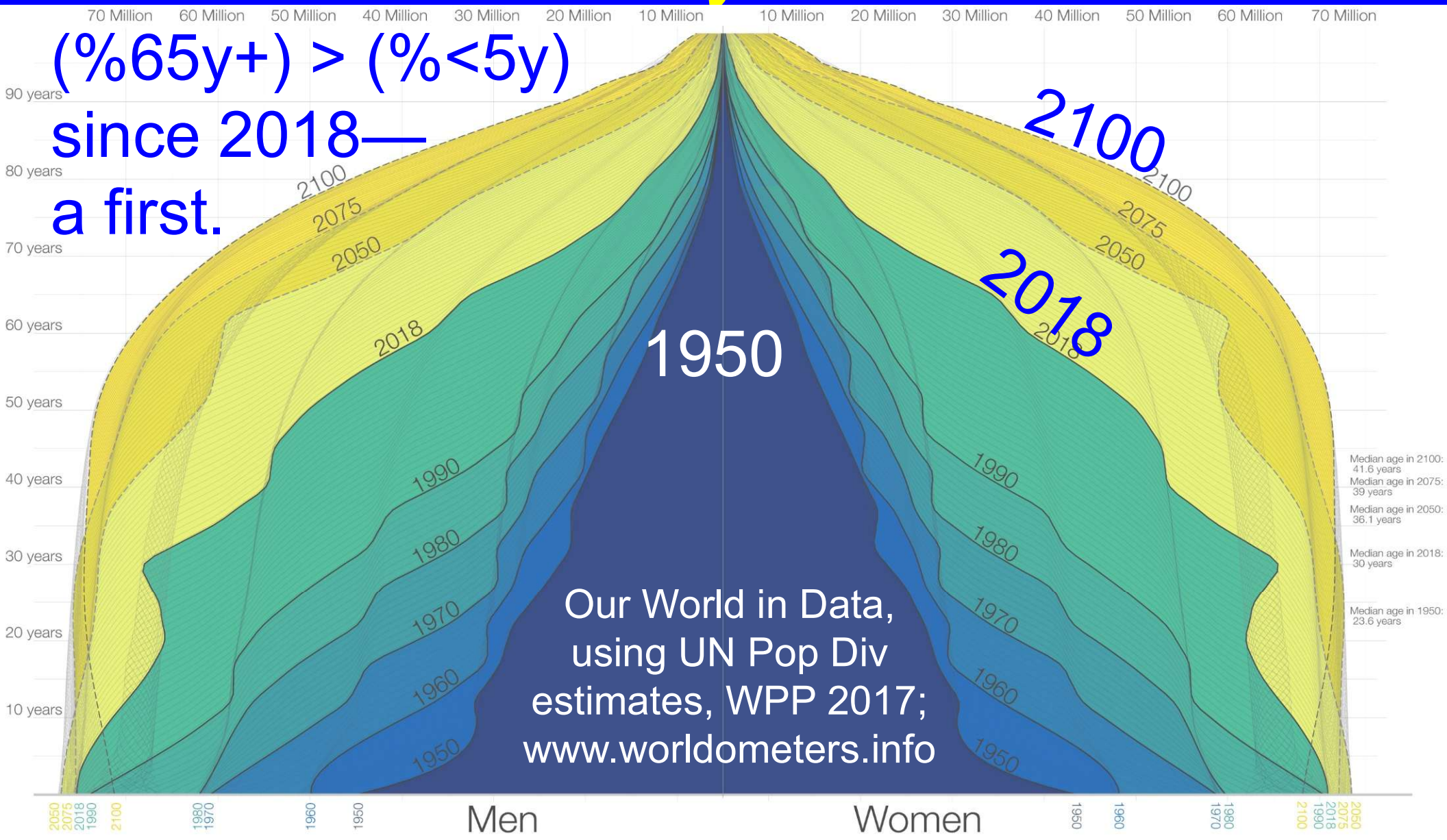
Total fertility rate (TFR)

For a given year, TFR is average number of children born to a hypothetical woman who lives through childbearing years and experiences the same age-specific fertility rates (of live births) throughout her whole reproductive life as the age-specific fertility rates seen in that particular year.

TFR, a period measure, differs from cohort fertility rate and from fecundity or biological fertility (the ability of a person to conceive).

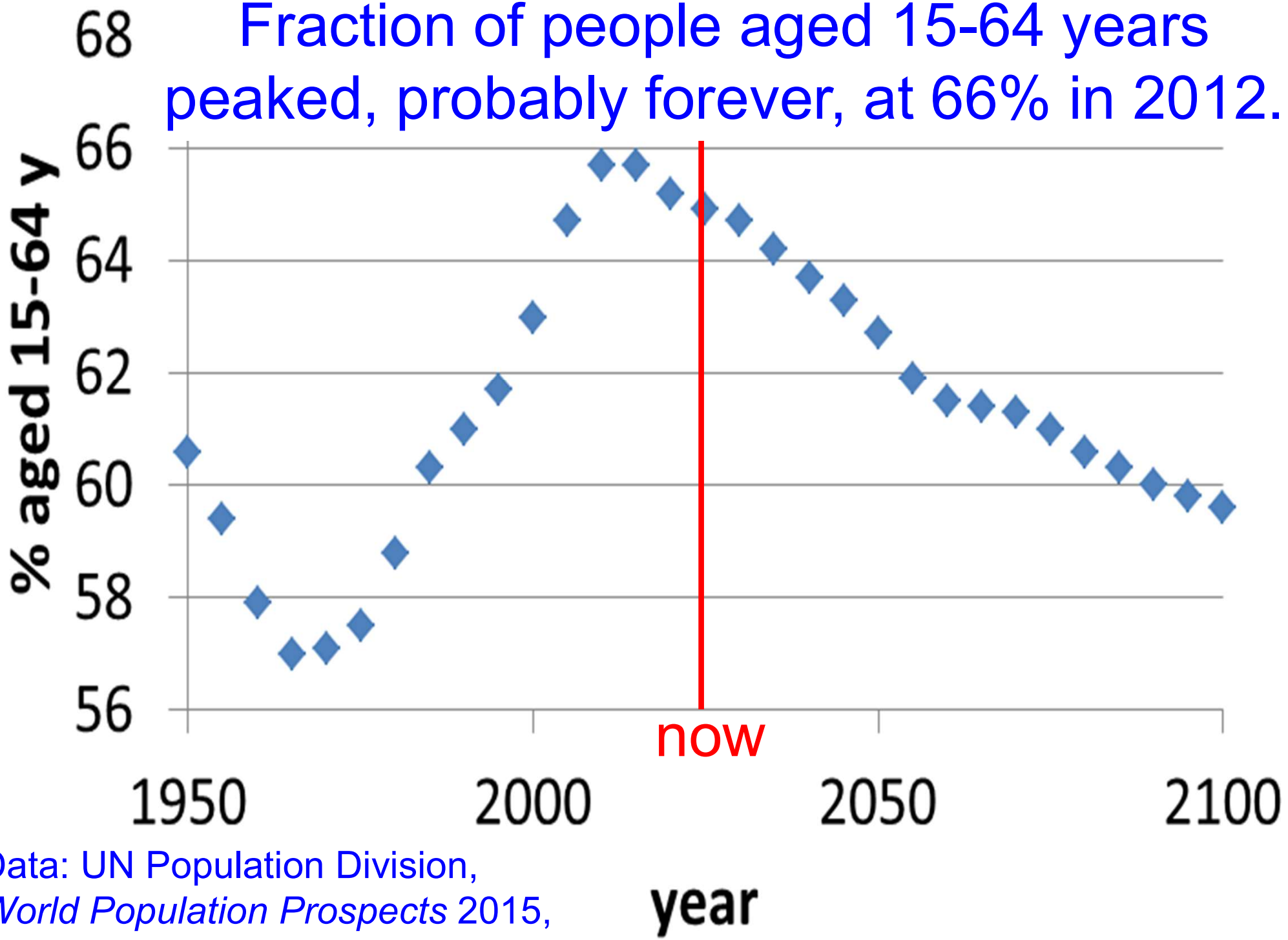

Total fertility rate fell
from ~5 to ~2.3 children
per woman per lifetime,
1950-2024.
This decline may be the
greatest voluntary change
in human behavior in history.
Level of replacement fertility: TFR 2.1-2.3 children/woman
In 1990, ~1/4 of people lived in countries
with TFR below replacement;
in 2007, ~1/2; in 2024, ~2/3.
TFR = Live births per woman
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
1950
1975
2000
UN Pop Div, World Population Prospects 2019, 2022, 2024

Median age rose from 21.5 years in 1970 to 30.7 years in 2024.



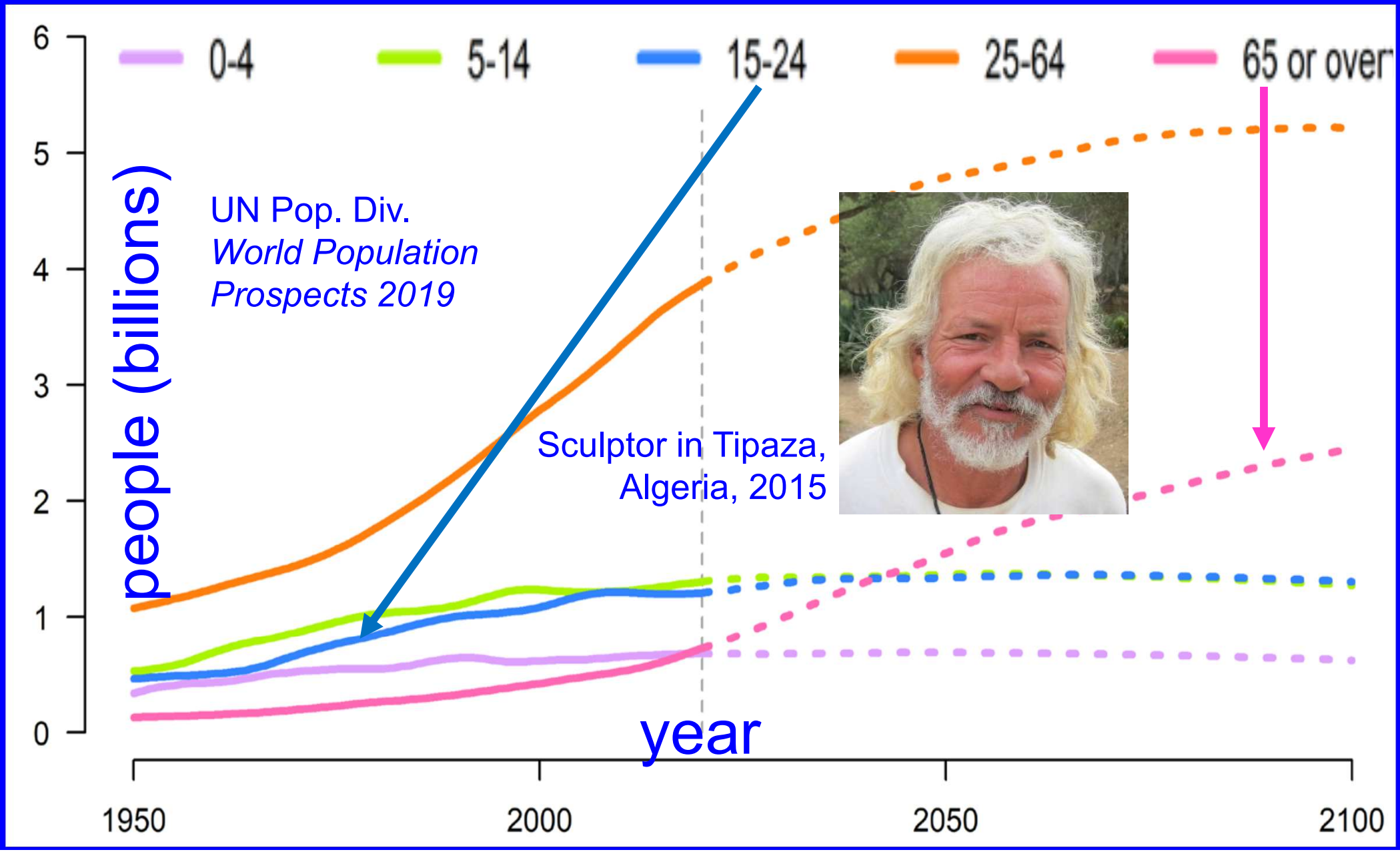
Data source: United Nations Population Division – World Population Prospects 2017; Medium Variant.
The data visualization is available at OurWorldinData.org, where you find more research on how the world is changing and why.

Fraction of people aged 15-64 years peaked, probably forever, at 66% in 2012.



Data: UN Population Division,
World Population Prospects 2015,
Medium variant; updated data.worldbank.org/indicator/SP.POP.1564.TO.ZS

People 65+ are fastest growing age group.



70 is the new 60.

In USA, people (of both sexes) aged 70-74 in 2005-2009 had remaining life expectancy of people aged 60-64 years in 1935-39.

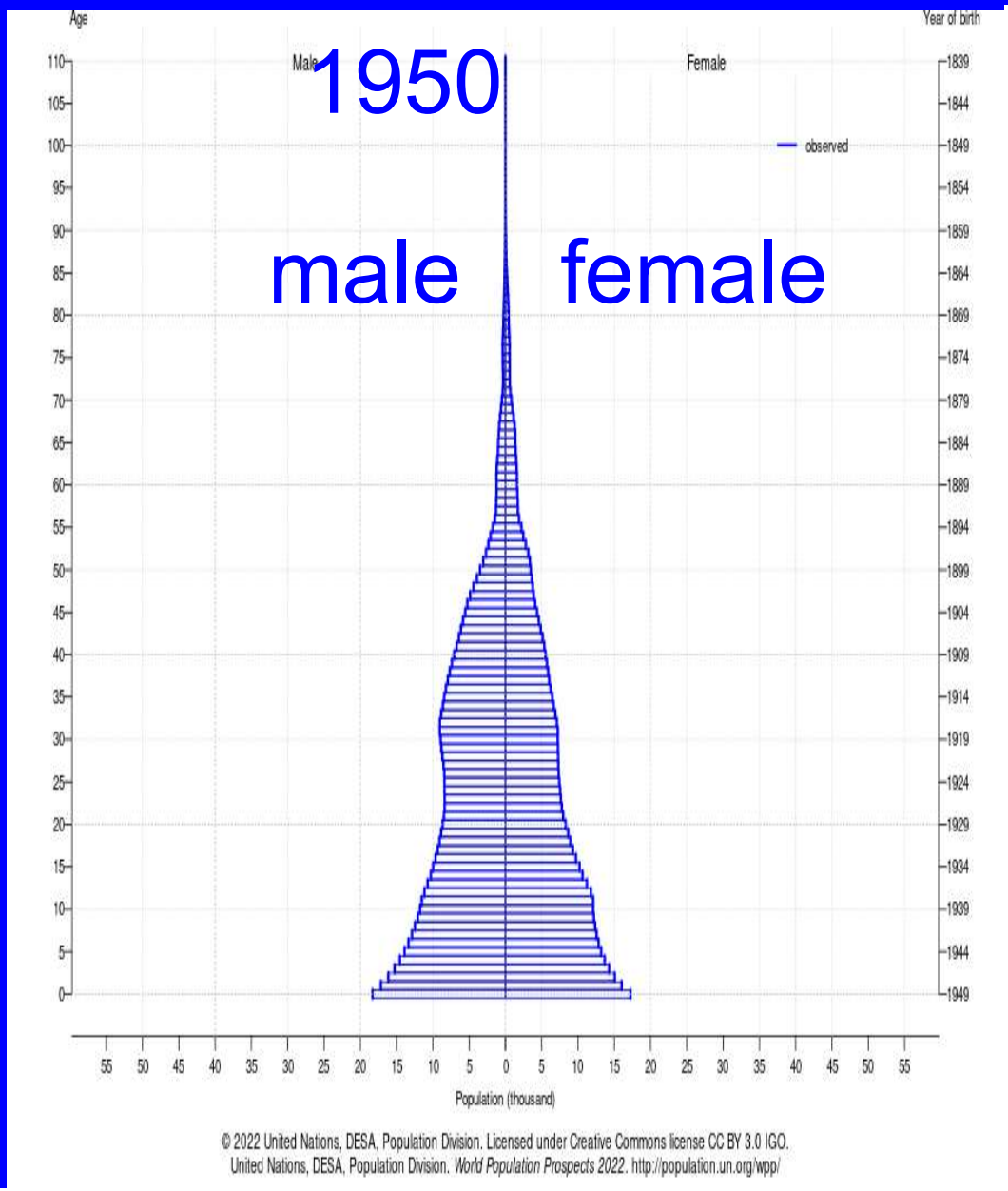
Year	Age	Remaining life expectancy
1935-1939	70-74	9.95
1935-1939	60-64	15.72
2005-2009	70-74	15.24

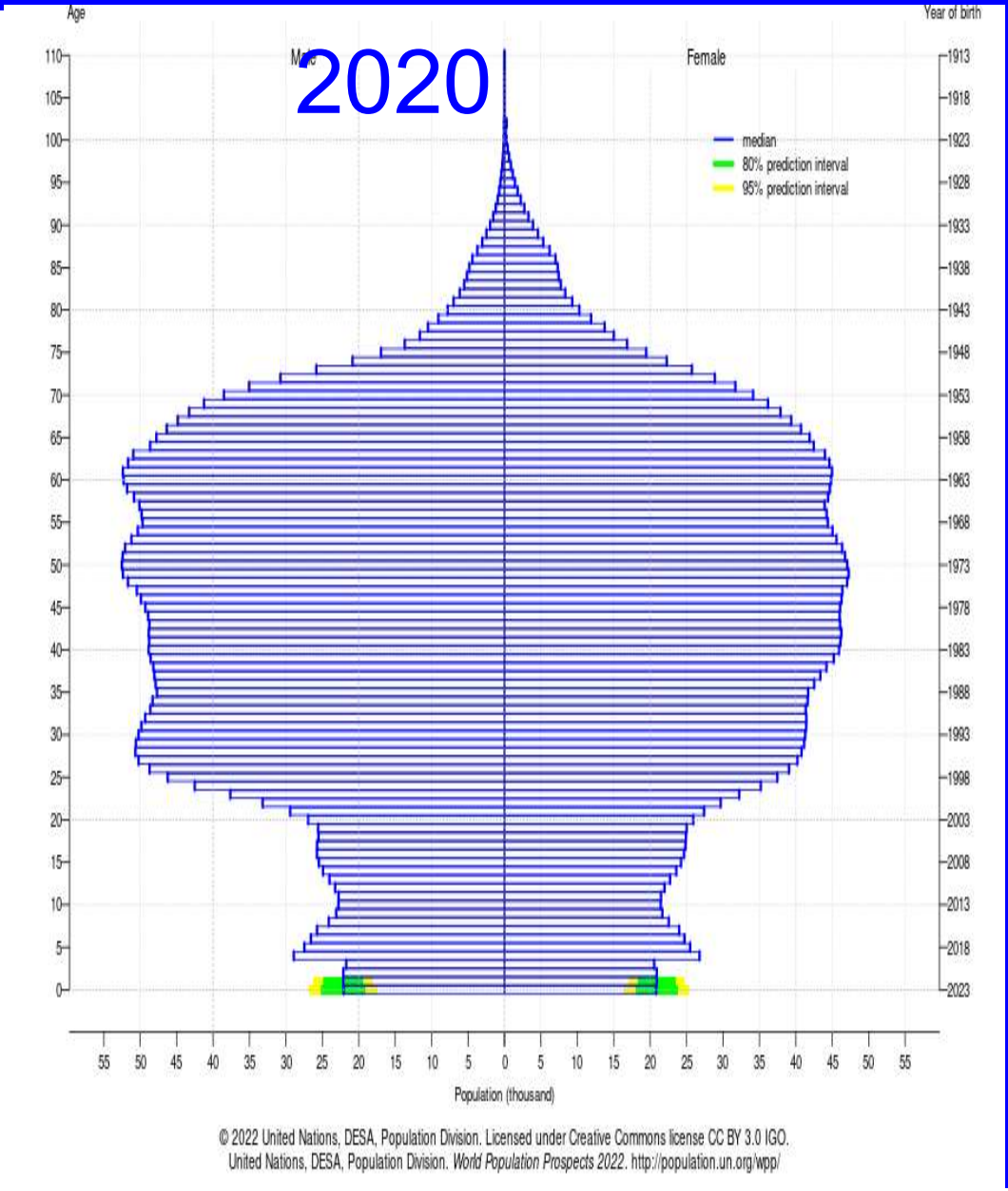
http://www.mortality.org/hmd/USA/STATS/bltper_5x5.txt

Singapore: low fertility, long life

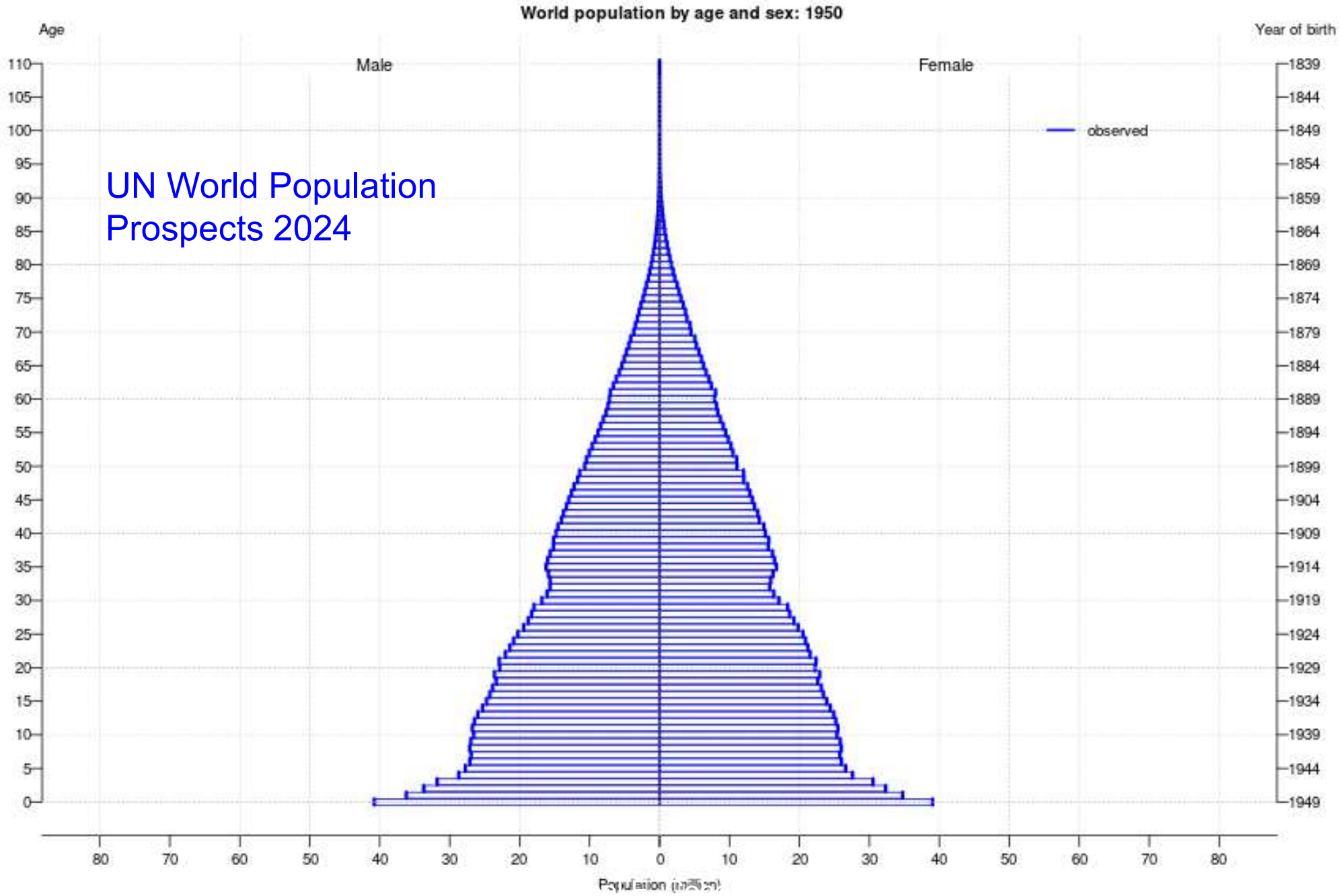
UN Population Division, *World Population Prospects 2022*

http://population.un.org/wpp



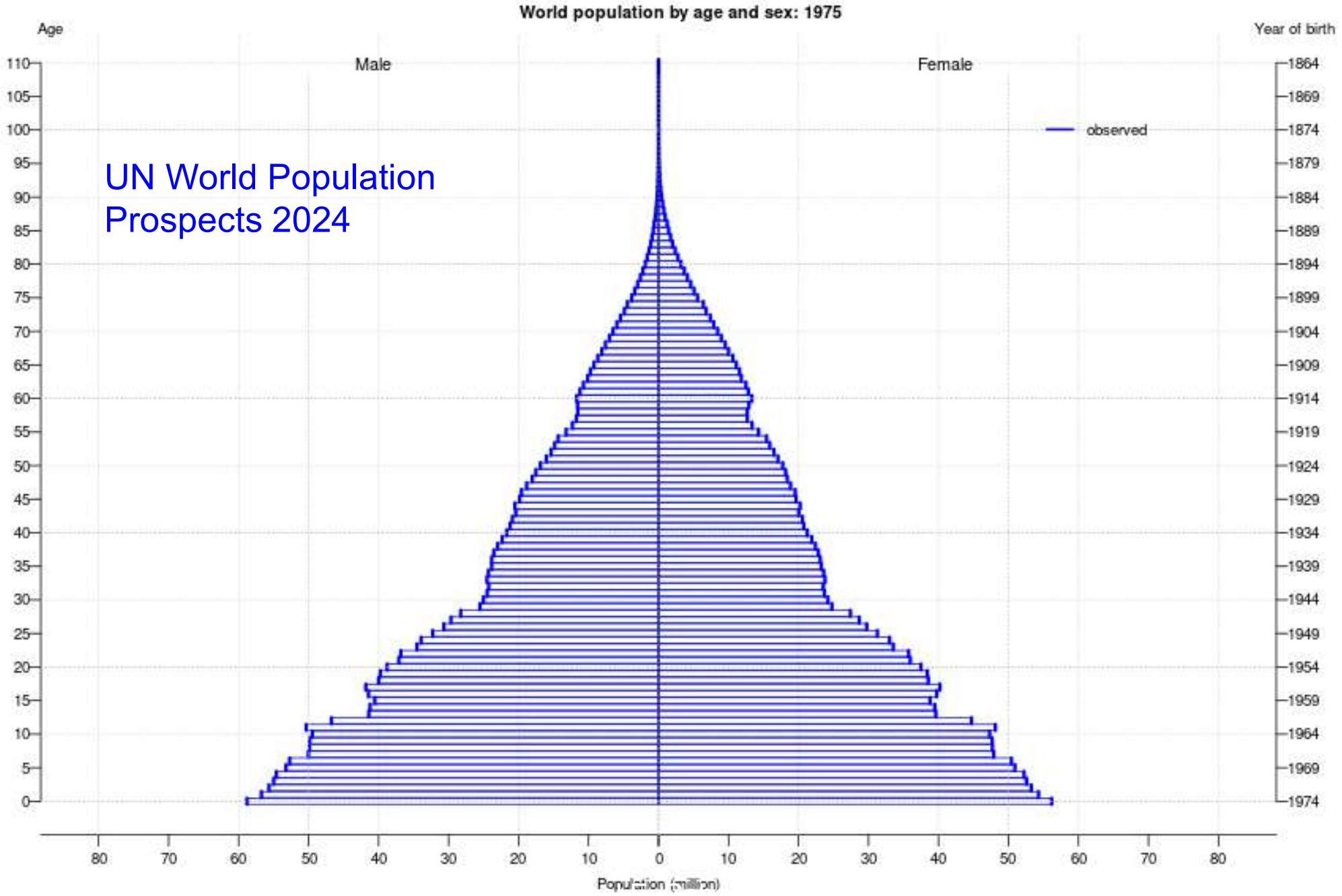


1950



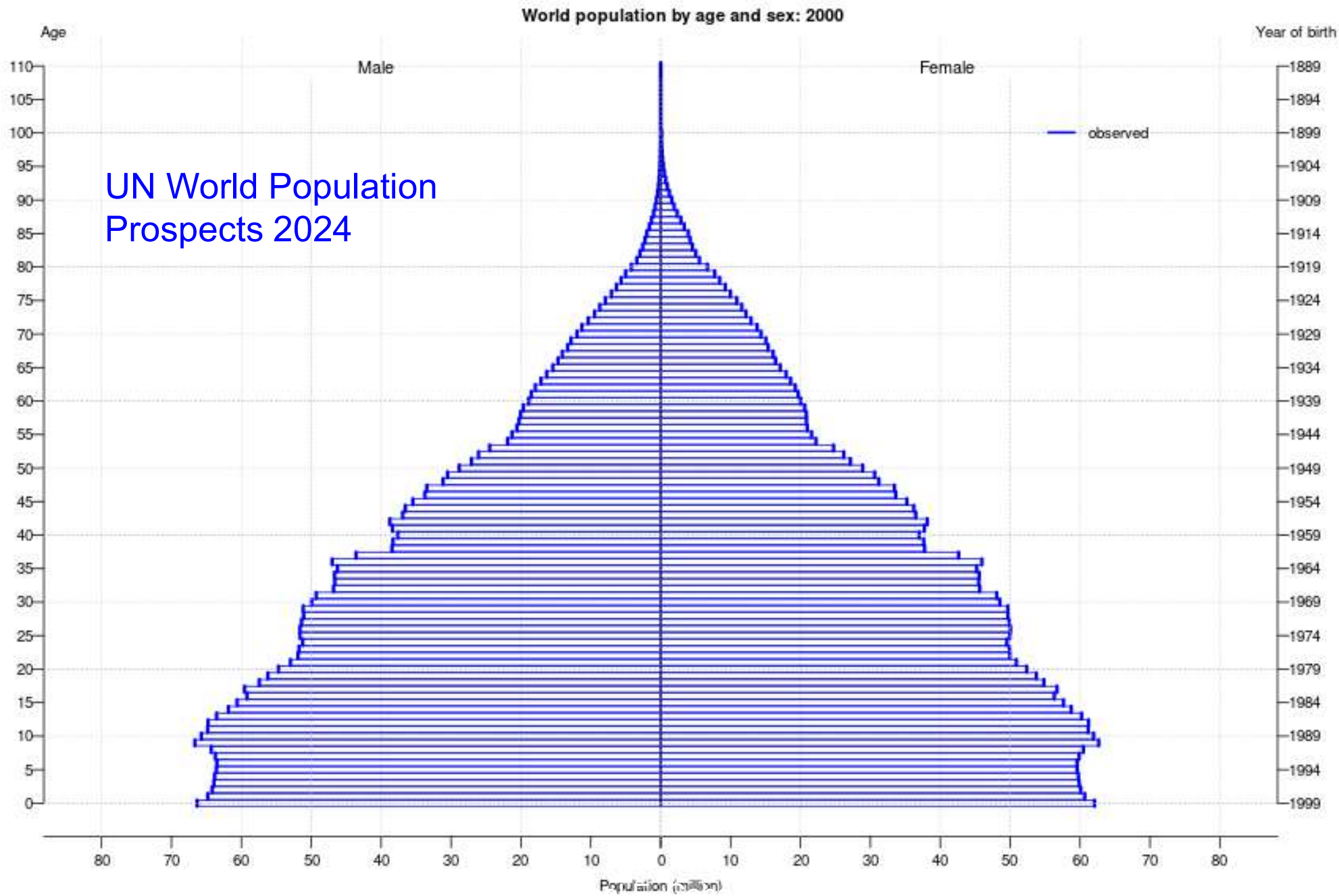
United Nations, DESA, Population Division. *World Population Prospects 2024*. http://population.un.org/wpp/

1975



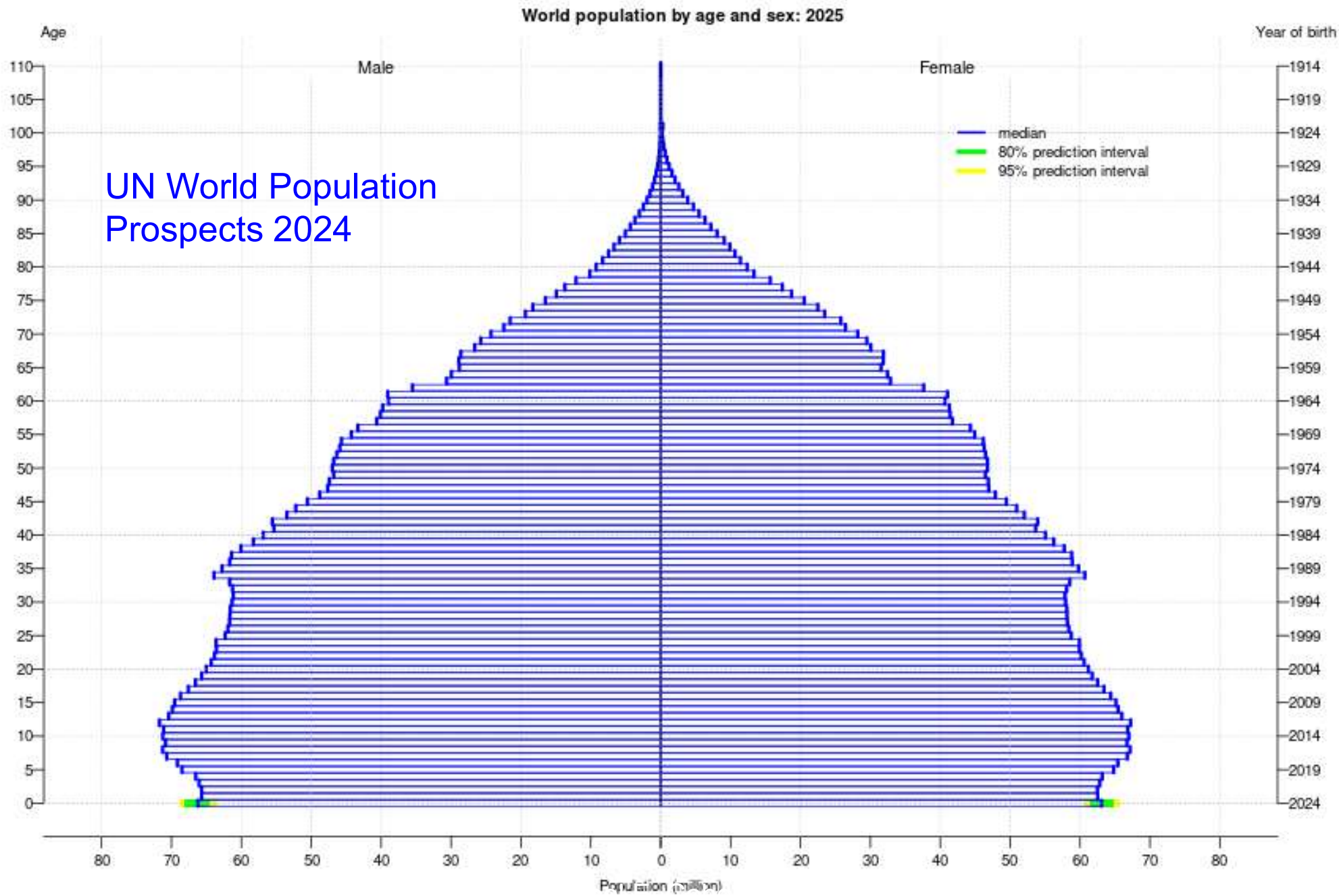
United Nations, DESA, Population Division. *World Population Prospects 2024*. http://population.un.org/wpp/

2000



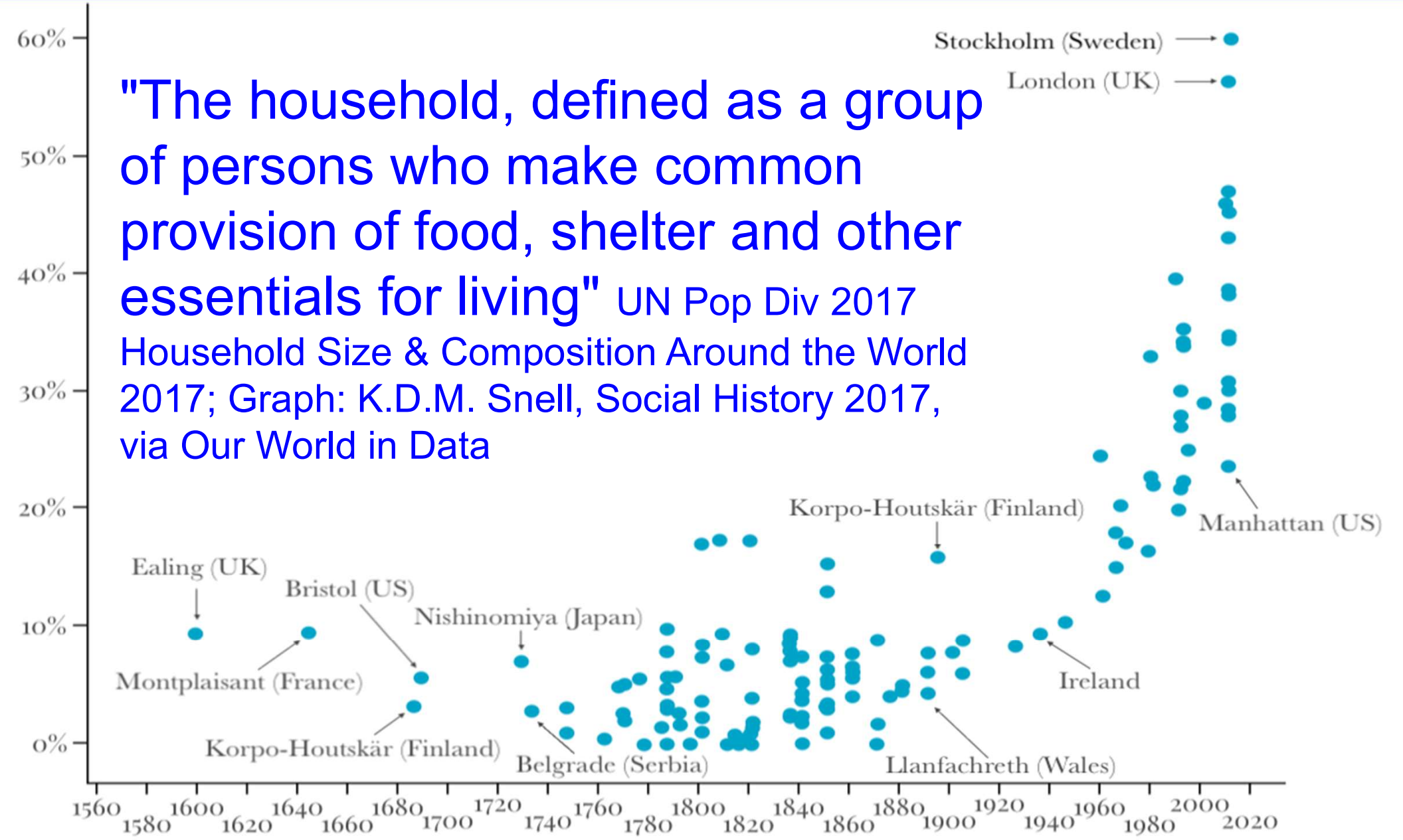
United Nations, DESA, Population Division. *World Population Prospects 2024*. http://population.un.org/wpp/

2025



United Nations, DESA, Population Division. *World Population Prospects 2024*. http://population.un.org/wpp/

% 1-person households in villages & cities, 1600-2017



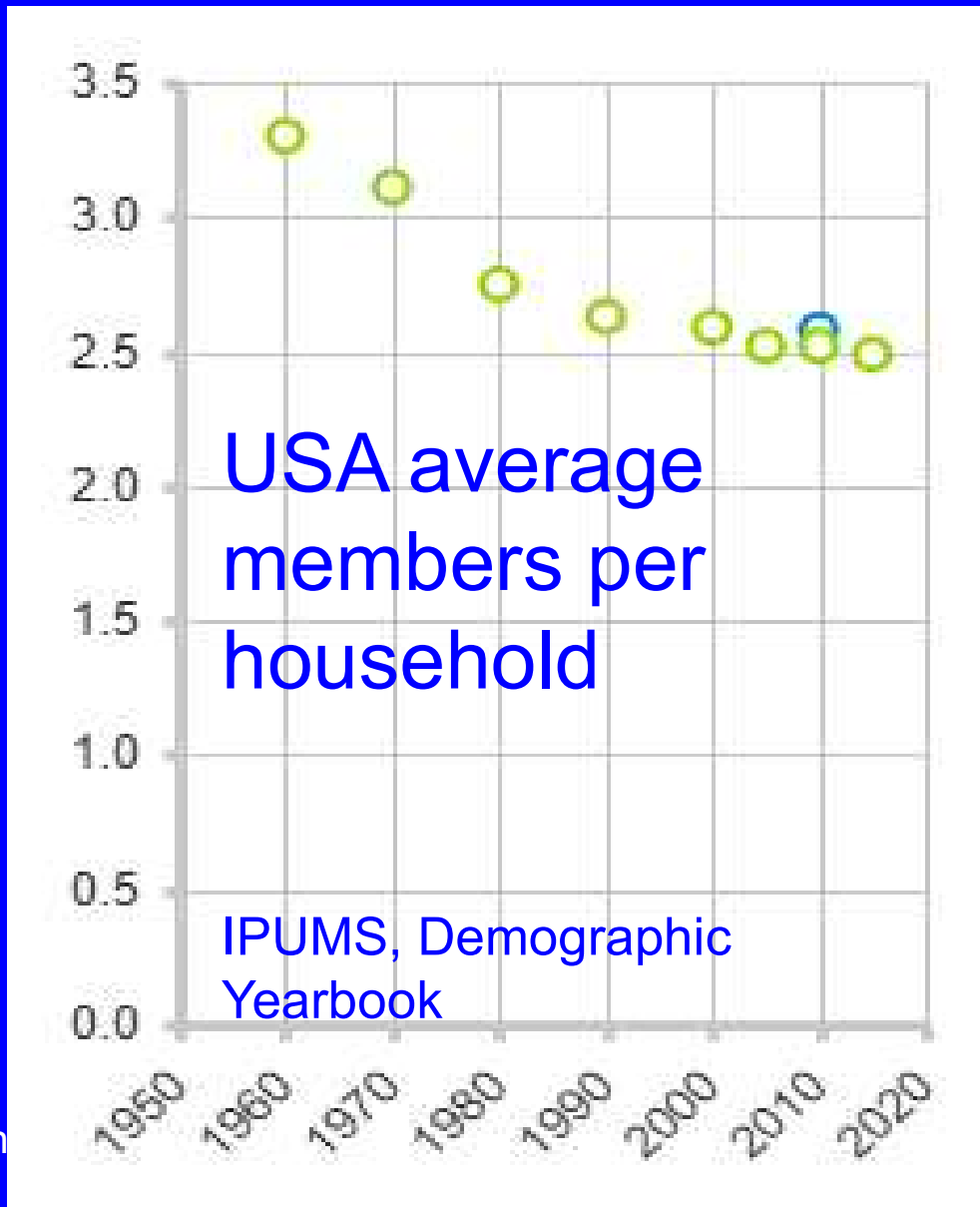
"The household, defined as a group of persons who make common provision of food, shelter and other essentials for living" UN Pop Div 2017

Household Size & Composition Around the World 2017; Graph: K.D.M. Snell, Social History 2017, via Our World in Data

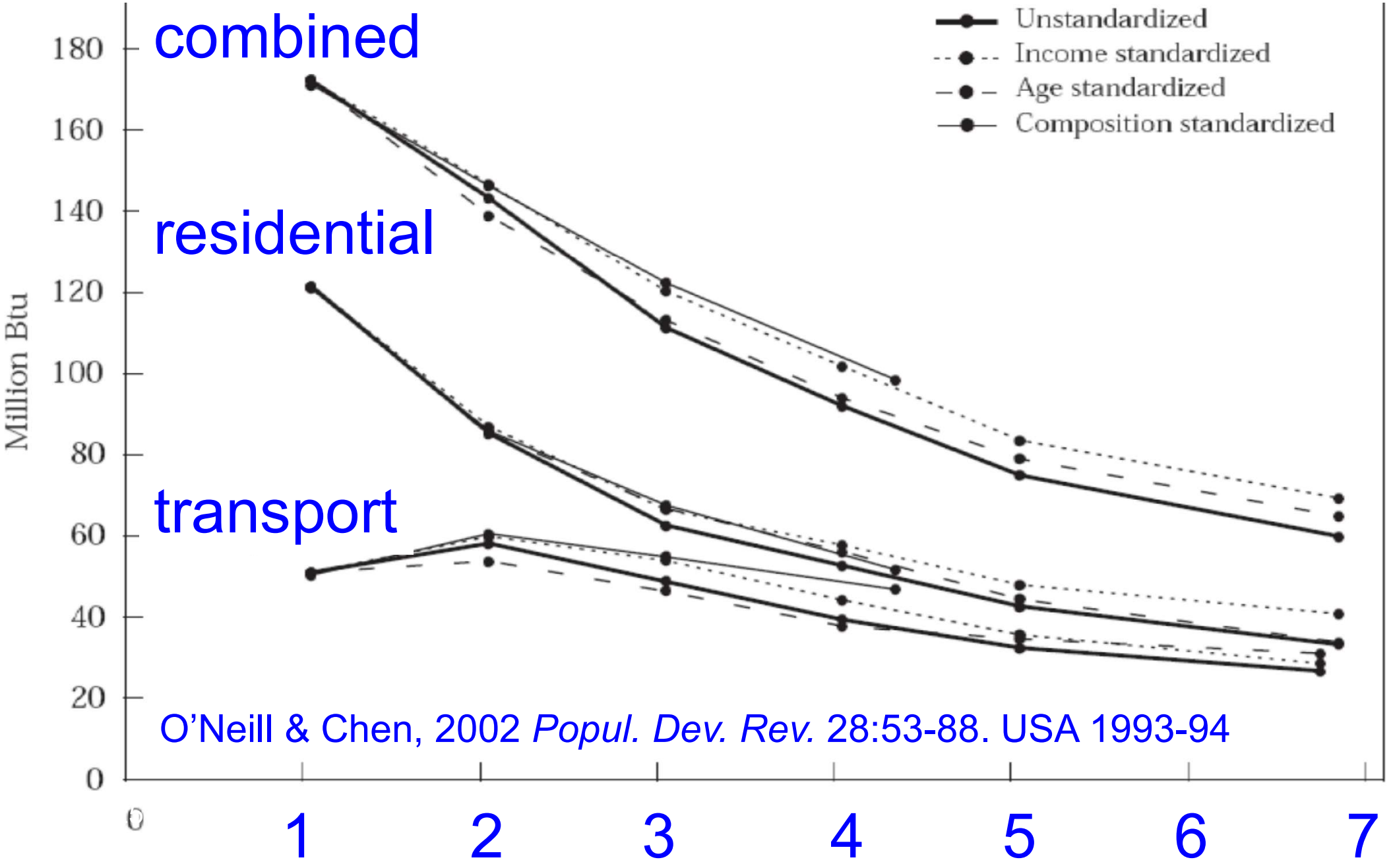
Number of households grew faster than number of people.

Average people per household 1970-2000 **fell** in less-developed countries, from 5.1 to 4.4, & in more-developed countries, from 3.2 to 2.5.

Why? lower fertility, greater longevity, later marriage, more divorce, rising wealth, changing preferences



Energy use per person was greater in U. S. households with fewer people.



O'Neill & Chen, 2002 *Popul. Dev. Rev.* 28:53-88. USA 1993-94


Shibuya, Tokyo, 2014-10-26
JEC
Cities
CINEMAS
2025-01-23
Joel E. Cohen
28

How many people are "urban"?

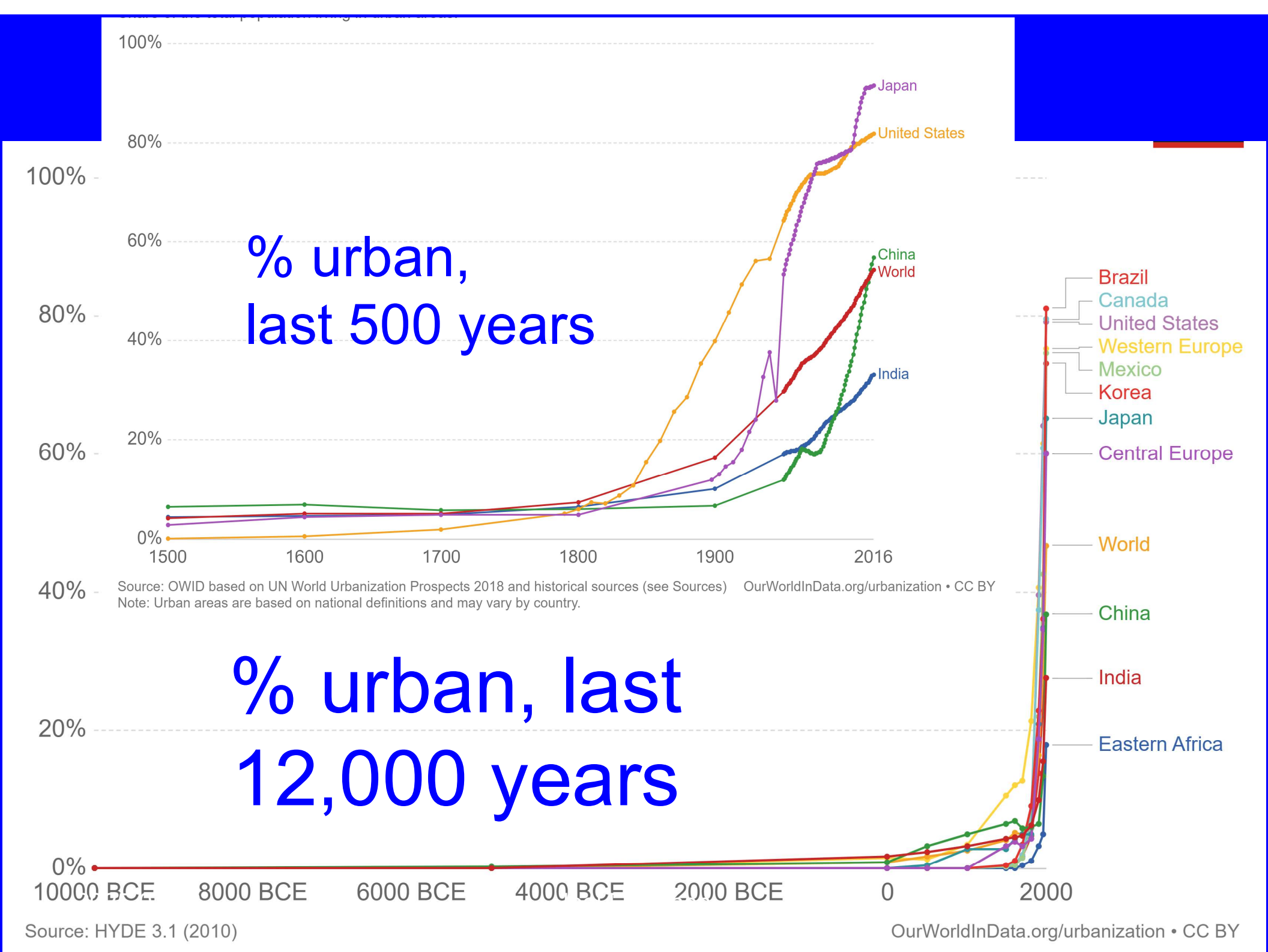
UN Population Division estimates about 55% of people live in urban areas.

UN Population Division, *World Urbanization Prospects 2018*

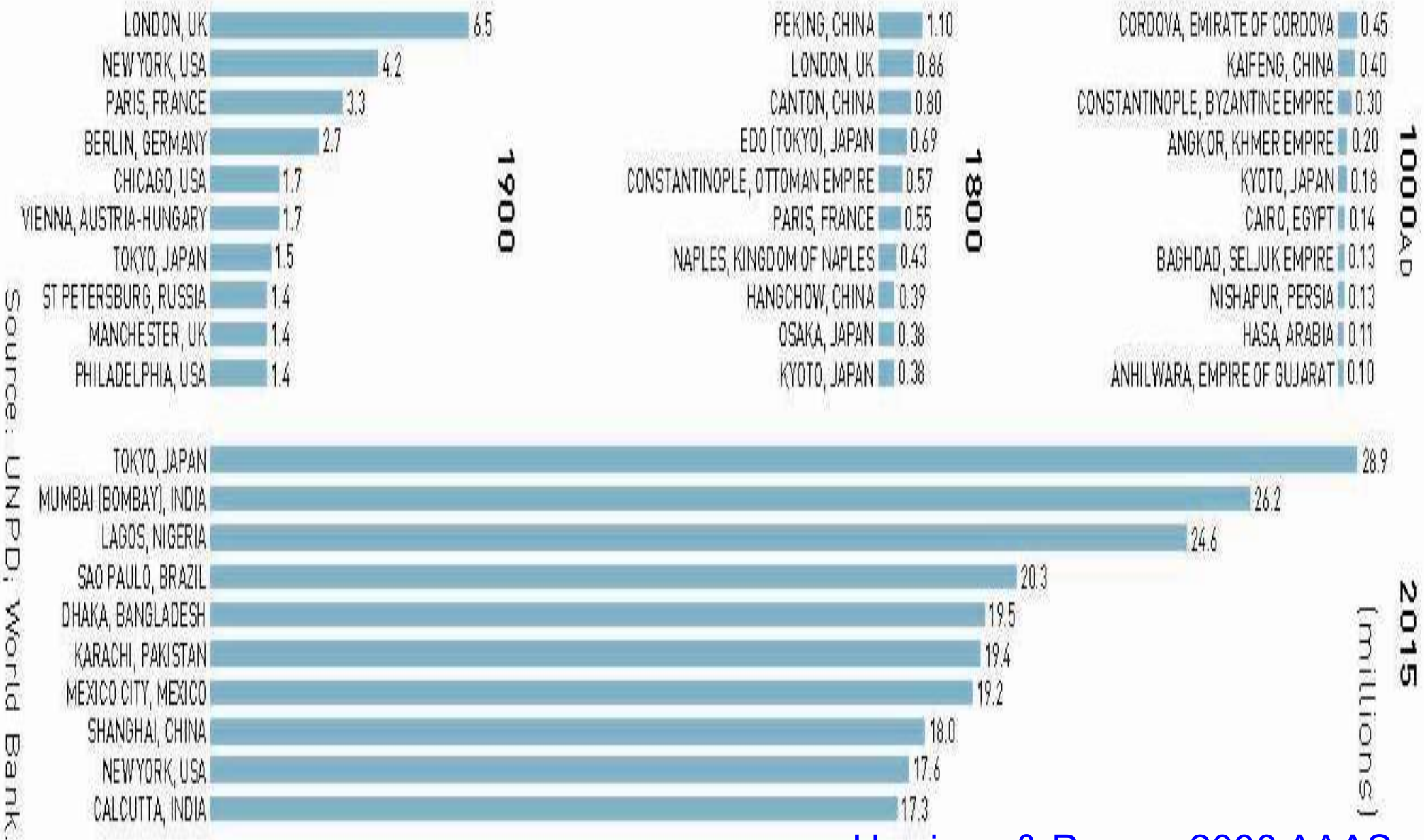
European Commission estimates about 85% of people live in urban areas.

Pesaresi, M., et al. (2016). Atlas of the human planet … *JRC103150. Publications Office of the European Union*

There is no international standard or consensus on the definition & measurement of "urban".


% urban,
last 500 years
100%
80%
60%
40%
20%
0%
1500
1600
1700
1800
1900
2016
Japan
United States
China
World
India
Source: OWID based on UN World Urbanization Prospects 2018 and historical sources (see Sources)
Note: Urban areas are based on national definitions and may vary by country.
OurWorldInData.org/urbanization • CC BY
% urban, last
12,000 years
100%
80%
60%
40%
20%
0%
10000 BCE
8000 BCE
6000 BCE
4000 BCE
2000 BCE
0
2000
Brazil
Canada
United States
Western Europe
Mexico
Korea
Japan
Central Europe
World
China
India
Eastern Africa
Source: HYDE 3.1 (2010)
OurWorldInData.org/urbanization • CC BY

10 cities with most people in year 1000 have no overlap with top 10 cities in 2015.

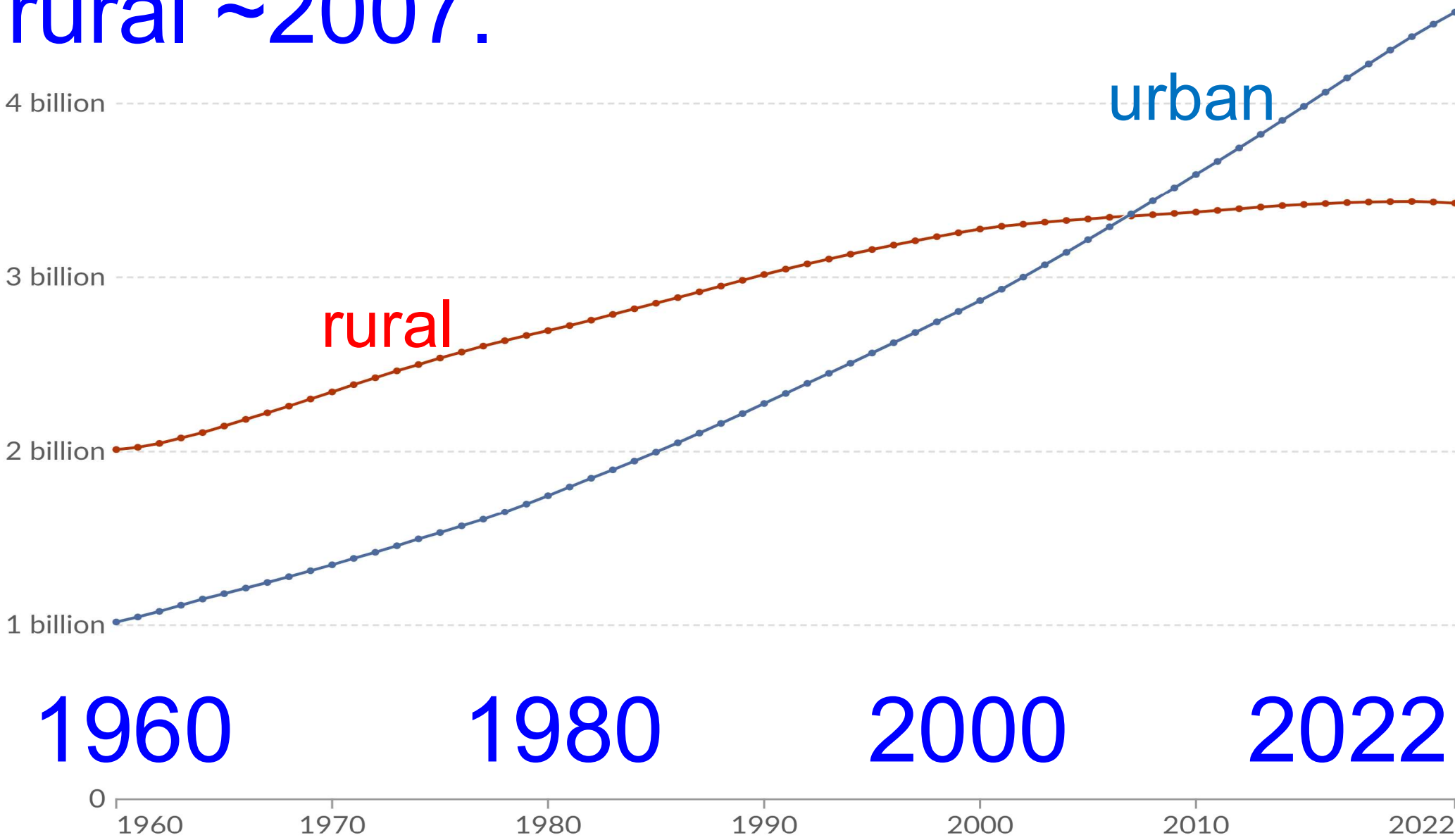


Harrison & Pearce 2000 AAAS

Cities grew in 20th century.

	1900	1950	2000
Urban population (billions)	0.21	0.75	2.87
% of total	13%	30%	47%
Number of cities with ≥10 million people	0	1	20
% of urban people living in cities with ≥10 million people	0	1.6	9.6

Urban populations surpassed rural ~2007.



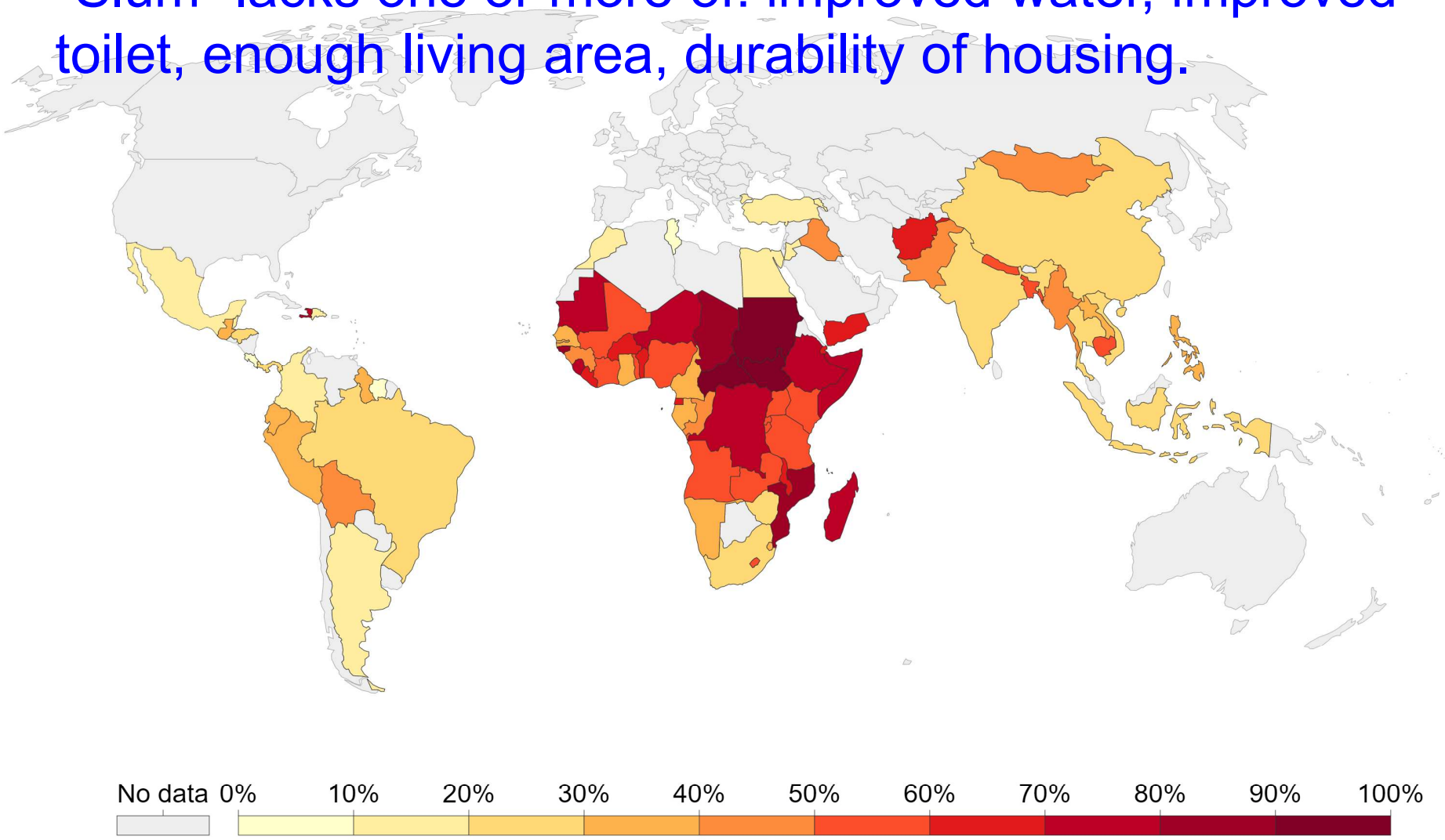
Data source: Multiple sources compiled by World Bank (2024) OurWorldinData.o

Note: Because the estimates of city and metropolitan areas are based on national definitions of what constitutes a area, cross-country comparisons should be made with caution.

1/3 of urban people live in "slums."

2018, UN Habitat via World Bank

"Slum" lacks one or more of: improved water, improved toilet, enough living area, durability of housing.



Source: UN HABITAT


Bangalore, India, JEC 2003-07-27
2003 7 27
2025-01-23
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Katrina, New Orleans, 2005-08-31

photo from Air Force One

2025-01-23

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Sandy, New York City, 2012-10-28/29

"largest hurricane ever recorded in the Atlantic basin"--Wikipedia

Storm surge at Battery Park of ~4.25 m (14 feet)

Urban expansion competes with surrounding farms.

Rice field, Fuji City, Japan 2006-01-22, Michiko Shimoda

Urban growth could affect food supply.

Many cities (~3% of land) are located on prime agricultural land (~10% of land).

If doubling of urban population leads to doubling of urban area, prime agricultural land could be removed from food production.

Food

Nearly a billion people are chronically hungry because they cannot compete economically for food with wealthier people, not because the world does not produce enough food to feed everyone well.

Engel's law

1857, International Statistical Institute Bulletin 1895

In human diets, food expenditures increase with income & family size, but the ratio of food expenditures to all expenditures decreases with increasing income.

Roughly, food expenditures ~ log(income), so food/total ~ log(income)/income falls as income rises.

➔The poorer people are, the bigger the share of the household budget taken by food.

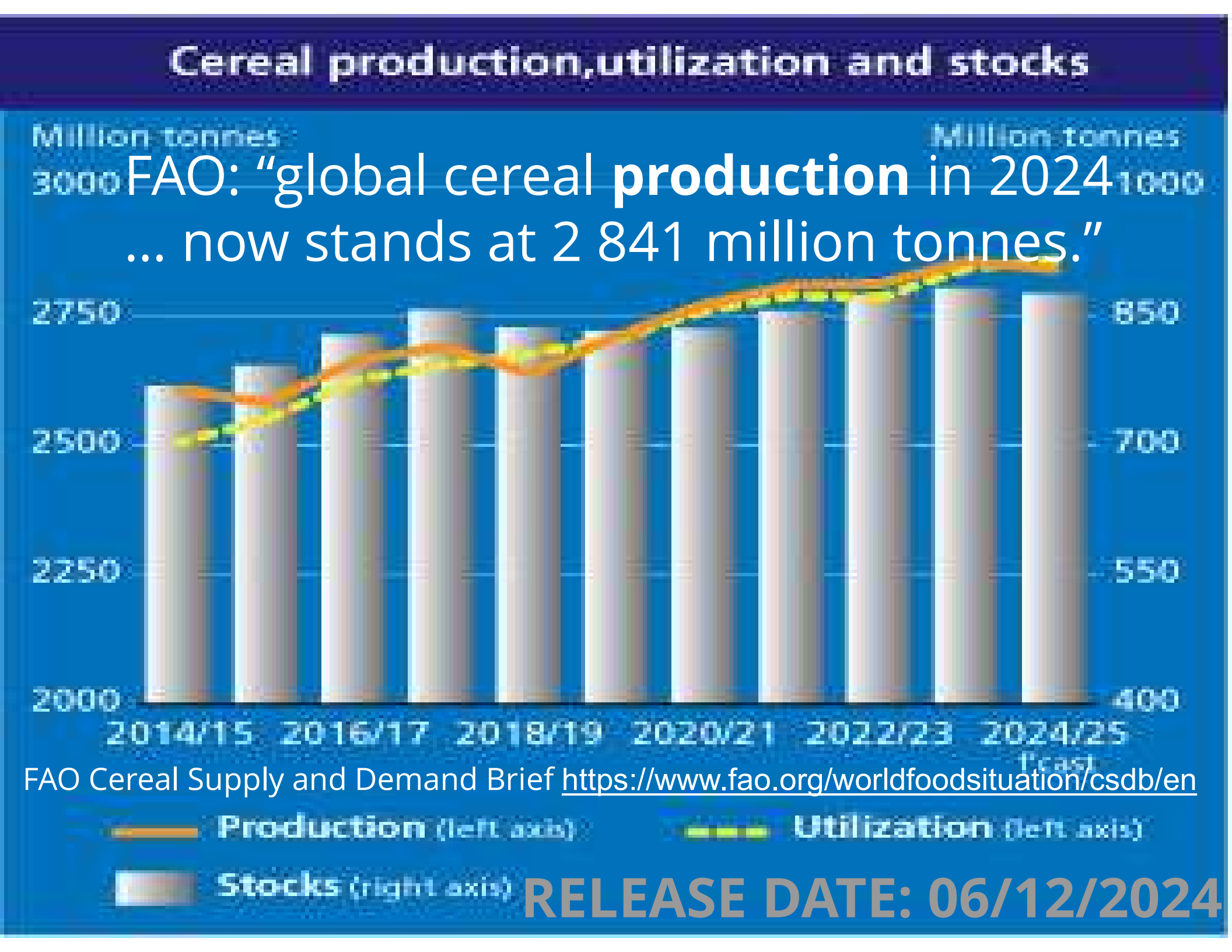
Bennett's law

Geographical Review 1941

In human diets, the ratio of calories derived from cereals (wheat, rye, rice, barley, oats, corn, millets, grain sorghums) & tubers (white potatoes, sweet potatoes, cassava) to all calories consumed is lower, the higher a household's or country's income.

➔Prices of cereals & tubers affect poor people more than they affect the rich.

➔Meat consumption rises as income rises.



FAO: "global cereal **production** in 2024 … now stands at 2 841 million tonnes."

FAO Cereal Supply and Demand Brief https://www.fao.org/worldfoodsituation/csdb/en

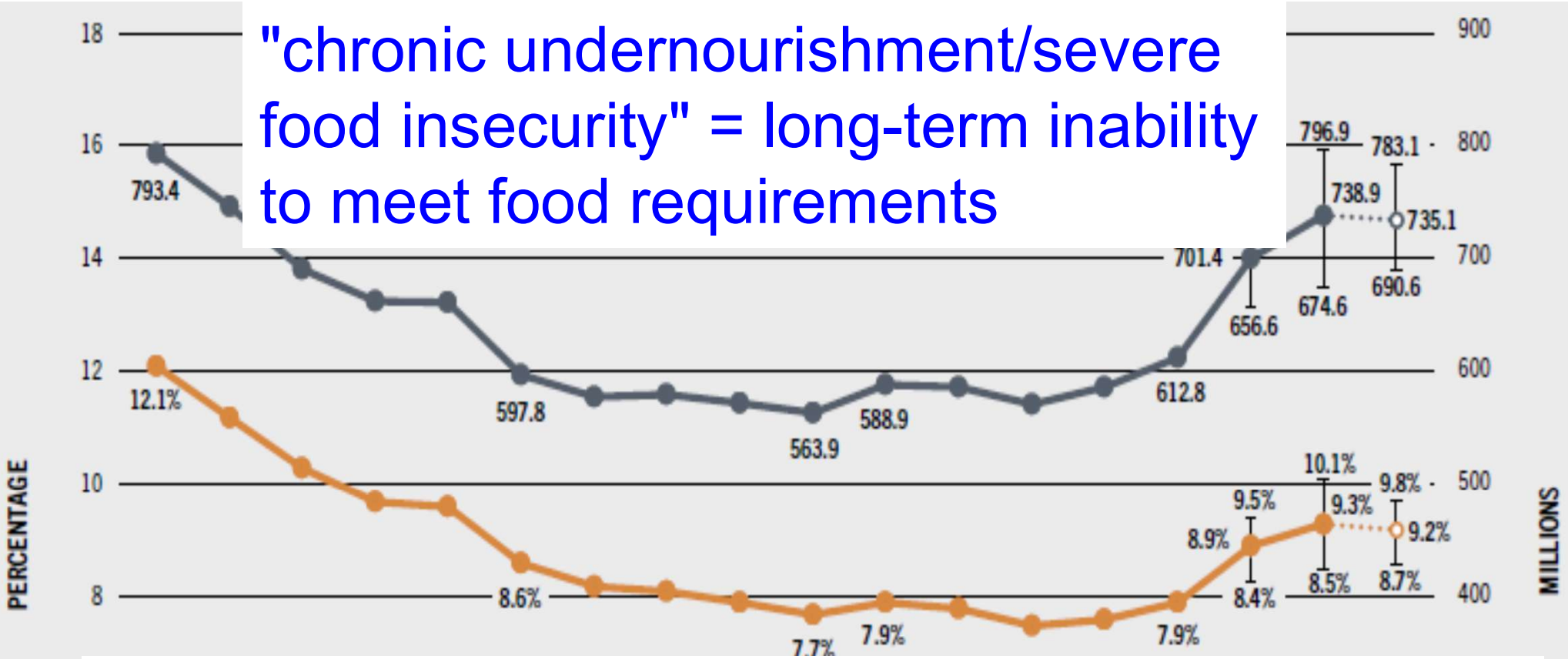
RELEASE DATE: 06/12/2024

1 tonne (1000 kg) of carbohydrate supplies enough energy for 4-5 people for 1 year.

200 kg of this grain provides	kilocalories per day for a year
Rice	2,000
Wheat pasta	2,032
Corn (maize)	1,984
Oatmeal	2,028

2.8 bln tonnes of cereals have enough calories for 11-14 billion people.

"chronic undernourishment/severe food insecurity" = long-term inability to meet food requirements



One person in ten is chronically hungry now.

Global number & % of chronically undernourished rose since 2014.

FAO, IFAD, UNICEF, WFP, WHO State of Food Security and Nutrition in the World 2023

2005 2010 2015 2022

People ate 1171 / 2778 = 42% of cereal grains used in 2020/21.

58% fed animals & machines.

2025-01-23

WORLD CEREAL MARKET AT A GLANCE
FAO Food Outlook June 2021, p. 1

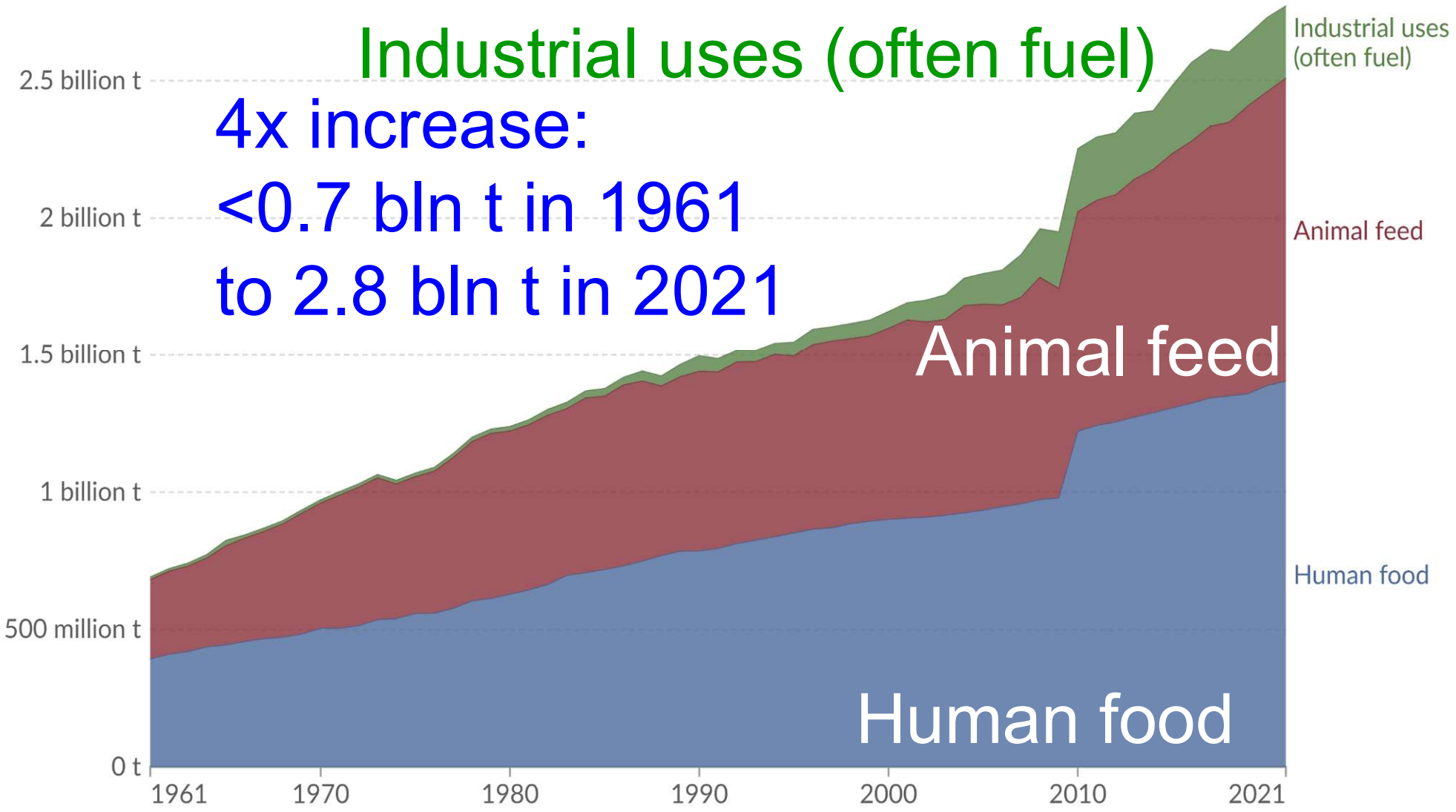
Gentrification of food

	2019/0	2020/21 *estim.*	2021/22 *f'cast*	Change: 2021/22 over 2020/21
		million tonnes		%
WORLD BALANCE				
Production	**2 710.7**	**2 768.6**	**2 820.9**	**1.9**
Trade[1]	**440.1**	**468.0**	**469.3**	**0.3**
Total utilization	**2 713.7**	**2 778.2**	**2 825.7**	**1.7**
Food	1 151.4	1 170.7	1 183.9	1.1
Feed	1 007.8	1 050.5	1 070.2	1.9
Other uses	554.5	557.0	571.6	2.6
Ending stocks[2]	**822.3**	**808.8**	**811.5**	**0.3**
SUPPLY AND DEMAND INDICATORS				
Per caput food consumption:				
World (kg/yr)	149.3	150.2	150.3	0.1
LIFDC (kg/yr)	152.3	153.7	153.4	-0.2

Cereals allocated to food, animal feed and fuel, World

Our World in Data

Cereal crops allocated to direct human consumption, used for animal feed, and other uses – mainly industrial uses such as biofuel production. This is based on domestic supply quantity for countries after correction for imports, exports and stocks.



Data source: Food and Agriculture Organization of the United Nations (2023)

OurWorldinData.org/land-use-diets | CC BY

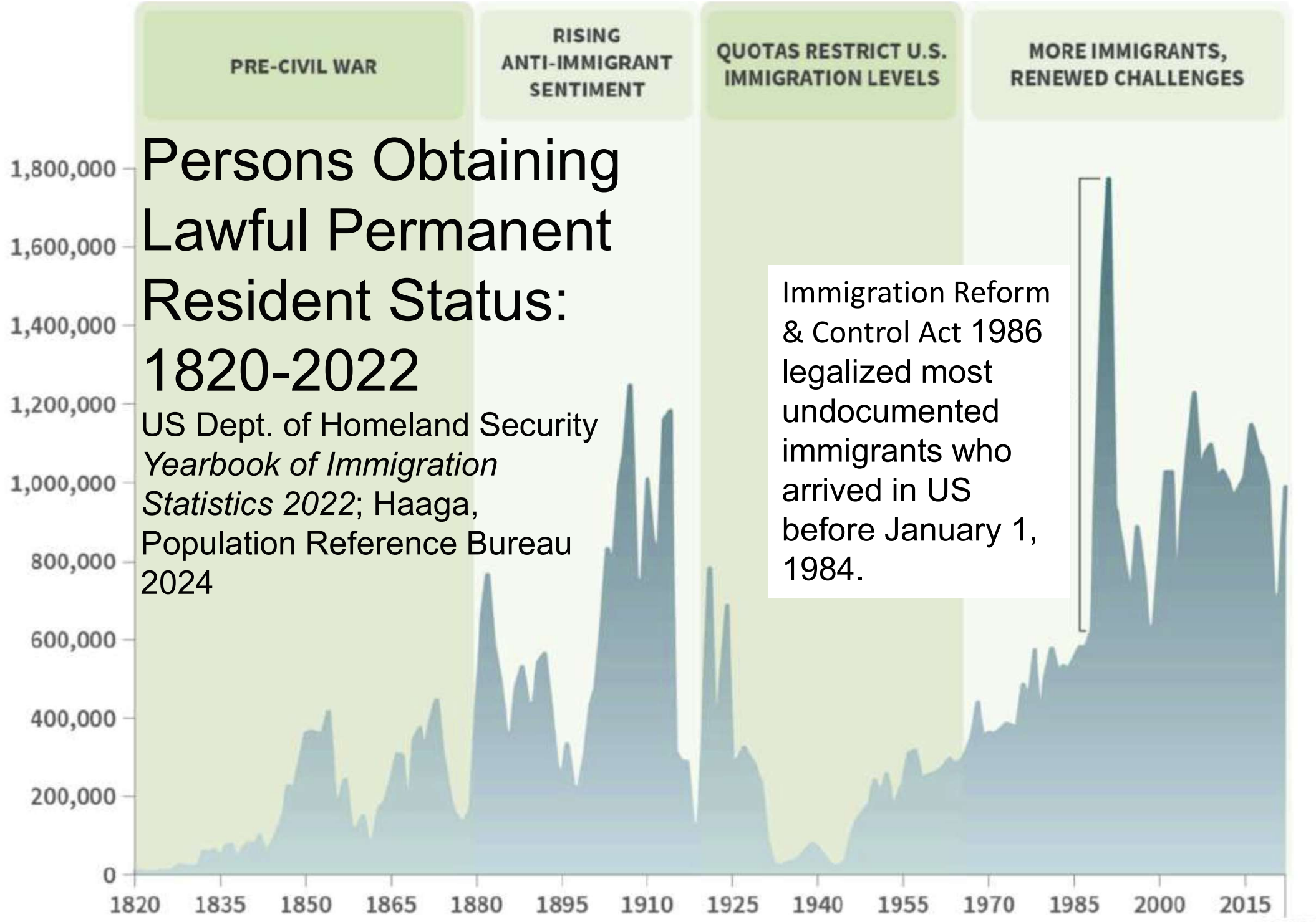
Note: The FAO apply a methodological change from the year 2010 onwards.

Hunger is economically invisible.

Chronically undernourished people exercise less demand (supported by customers' orders and capacity to pay) in world food markets than those who demand meat, biofuels, & other non-food uses of cereal grains.

Poor people, especially poor children, do not outbid rich people's demand to feed animals & machines.

Migration



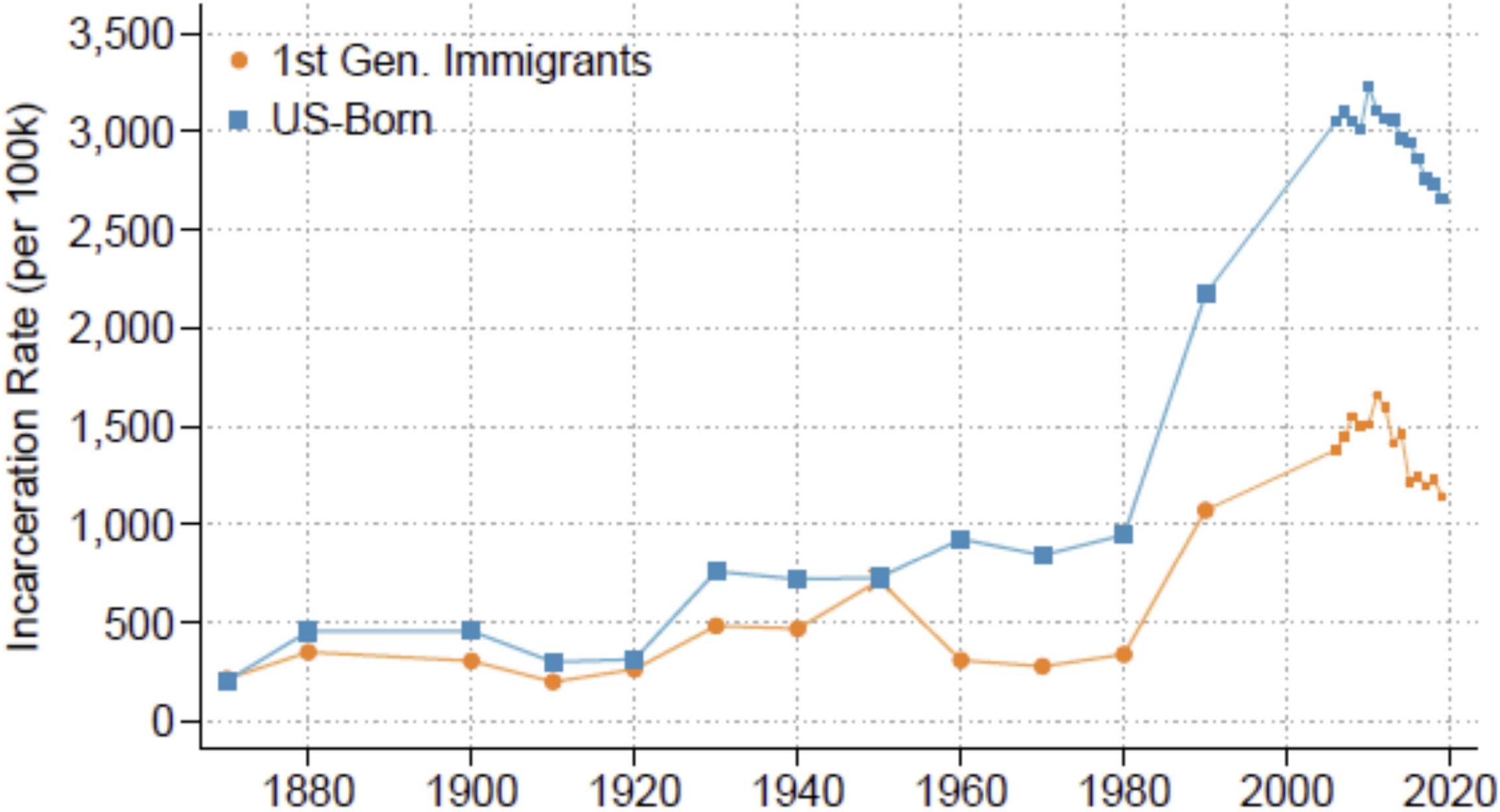
Persons Obtaining Lawful Permanent Resident Status: 1820-2022

US Dept. of Homeland Security *Yearbook of Immigration Statistics 2022*; Haaga, Population Reference Bureau 2024

Immigration Reform & Control Act 1986 legalized most undocumented immigrants who arrived in US before January 1, 1984.

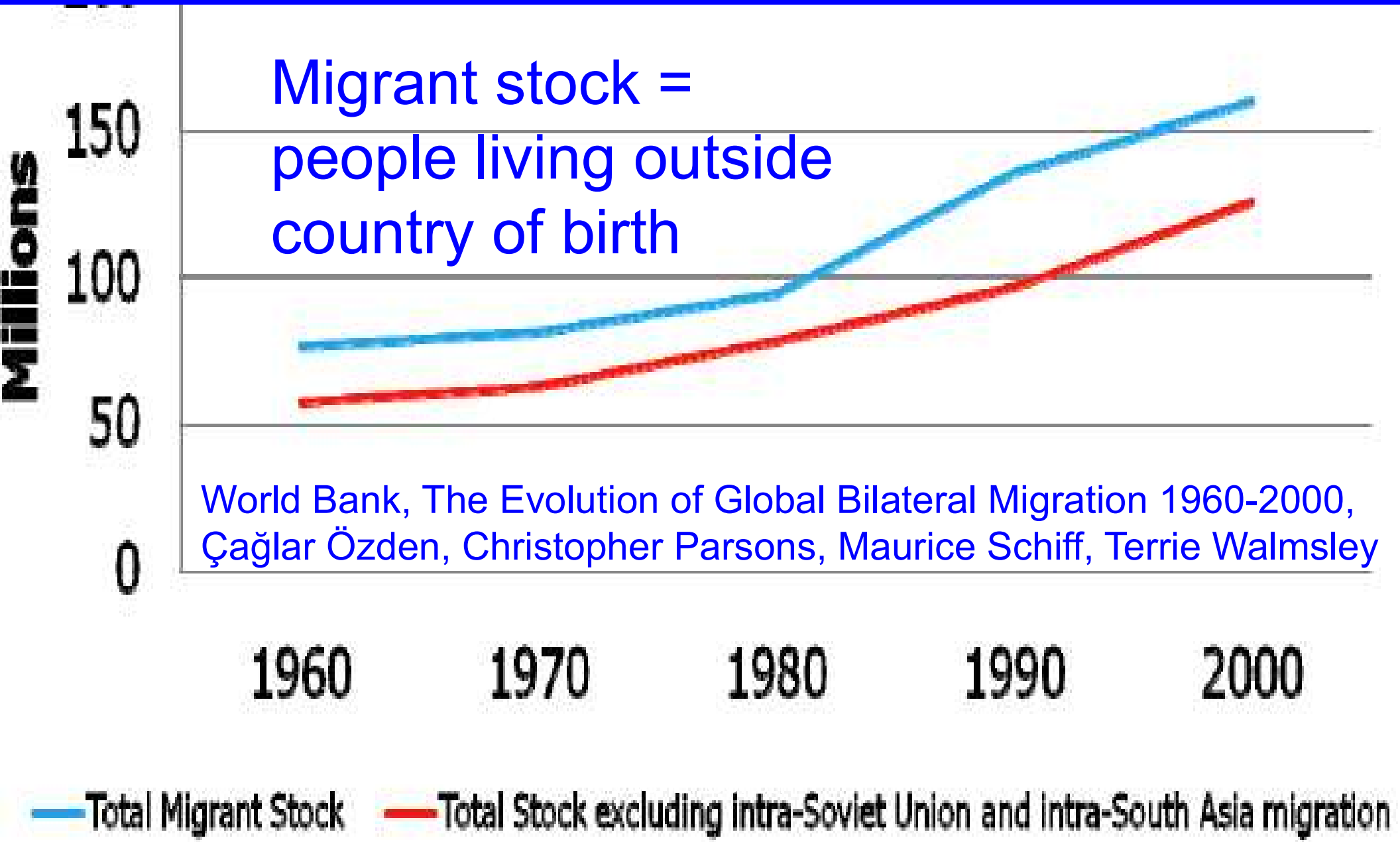
Haaga, Repeats and Rhymes: Lessons From 100 Years of U.S. Immigration Policy, Population Reference Bureau 2024

Incarceration rates of immigrants & US-born men,1870-2019: all immigrants



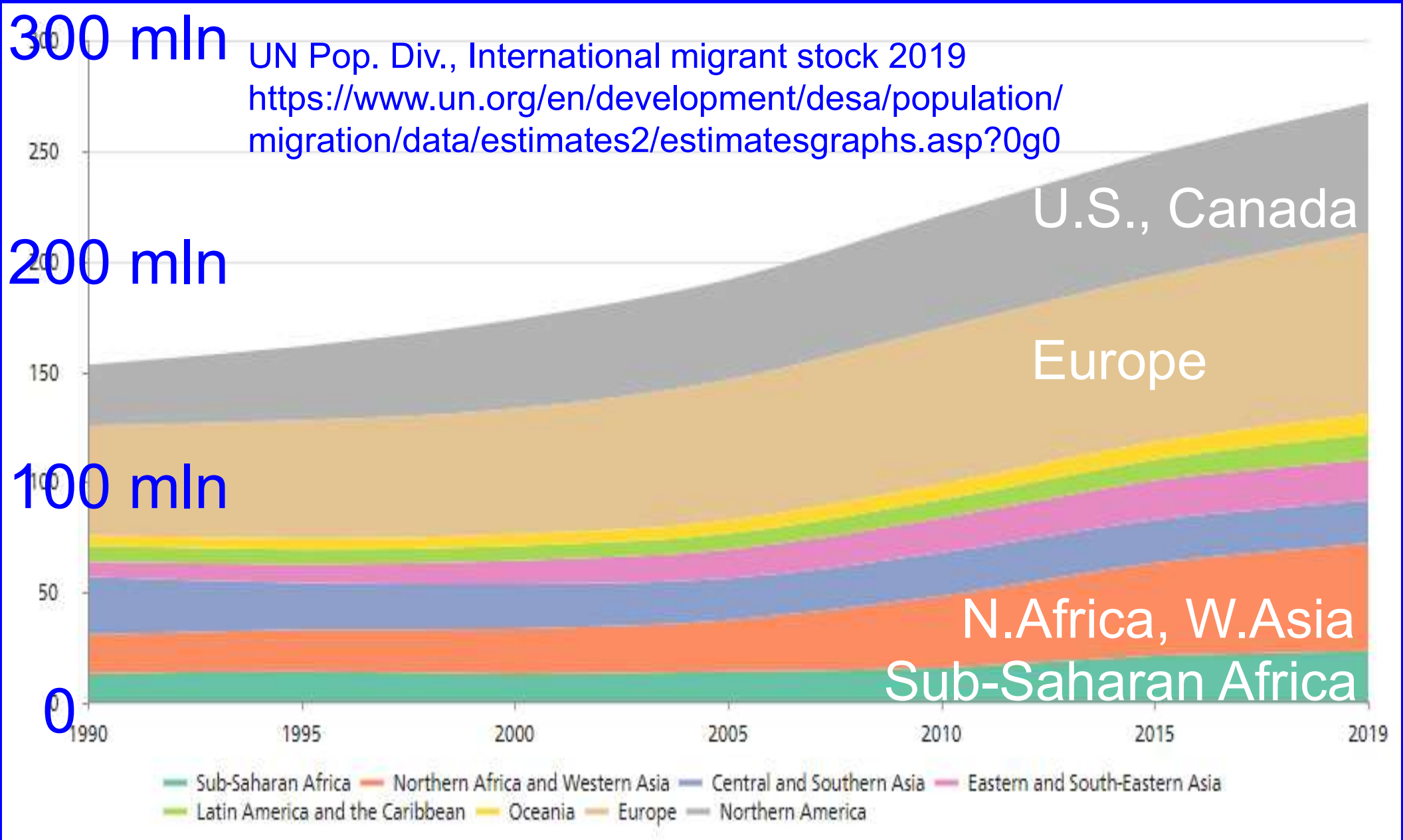
Abramitzky et al., "Law-Abiding Immigrants: The Incarceration Gap between Immigrants and the US-Born, 1870–2020."
American Economic Review: Insights, 6 (4): 453–71.

International migrant stock more than doubled, 1960-2000.



World Bank, The Evolution of Global Bilateral Migration 1960-2000, Çağlar Özden, Christopher Parsons, Maurice Schiff, Terrie Walmsley

Most migrant stock lived in North America & Europe, 1990-2019.



~750 million people (15% of adults) “desire to migrate permanently to another country.”

Gallup polls of 453,122 adults in 152 countries 2015-2017

"The one in six Americans (16%) in 2017 who said they would like to move to another country is the highest measure to date."

158 million → USA (312 million in 2010)
47 million → Canada (34 million 2010)
42 million → Germany (82 million in 2010)
36 million → France (63 million 2010)
36 million → Australia (22 million in 2010)