Sustainability and Chemistry
CH5106: L2

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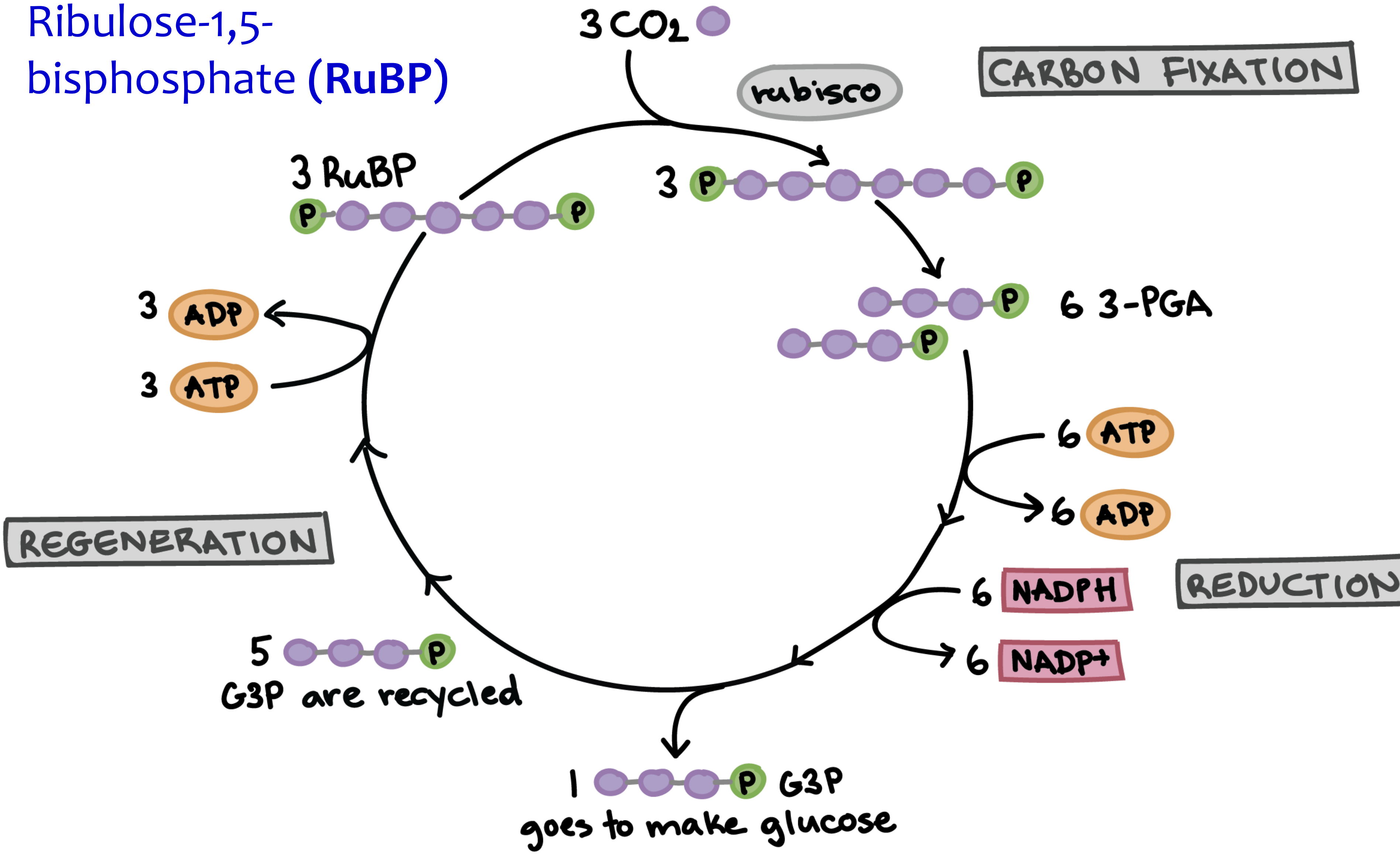
The expansion of grasslands contributed to the extinction of several large animals (chiefly herbivores), especially those dependent on woody vegetation for food and shelter. Although climate change and human activity were also influential, the transition from forests to grasslands particularly affected megafauna (the large mammals of a particular region) adapted to forested habitats.

Carbon Fixation
The process by which the inorganic CO_2 is integrated into an organic sugar (through photosynthesis) is called carbon fixation, and C_3 and C_4 plants "fix" the carbon in different manners.

C_3 Pathway (or Calvin Cycle): Woody plants primarily utilize the C3 photosynthetic pathway, also known as the Calvin cycle.

RuBisCO, or Ribulose-1,5-bisphosphate carboxylase/oxygenase, is a crucial enzyme in photosynthesis that facilitates the initial step of carbon fixation in the Calvin cycle. It's found in all plants and other photosynthetic organisms. RuBisCO's primary function is to catalyze the carboxylation of ribulose-1,5-bisphosphate (RuBP), a 5-carbon molecule, using carbon dioxide.

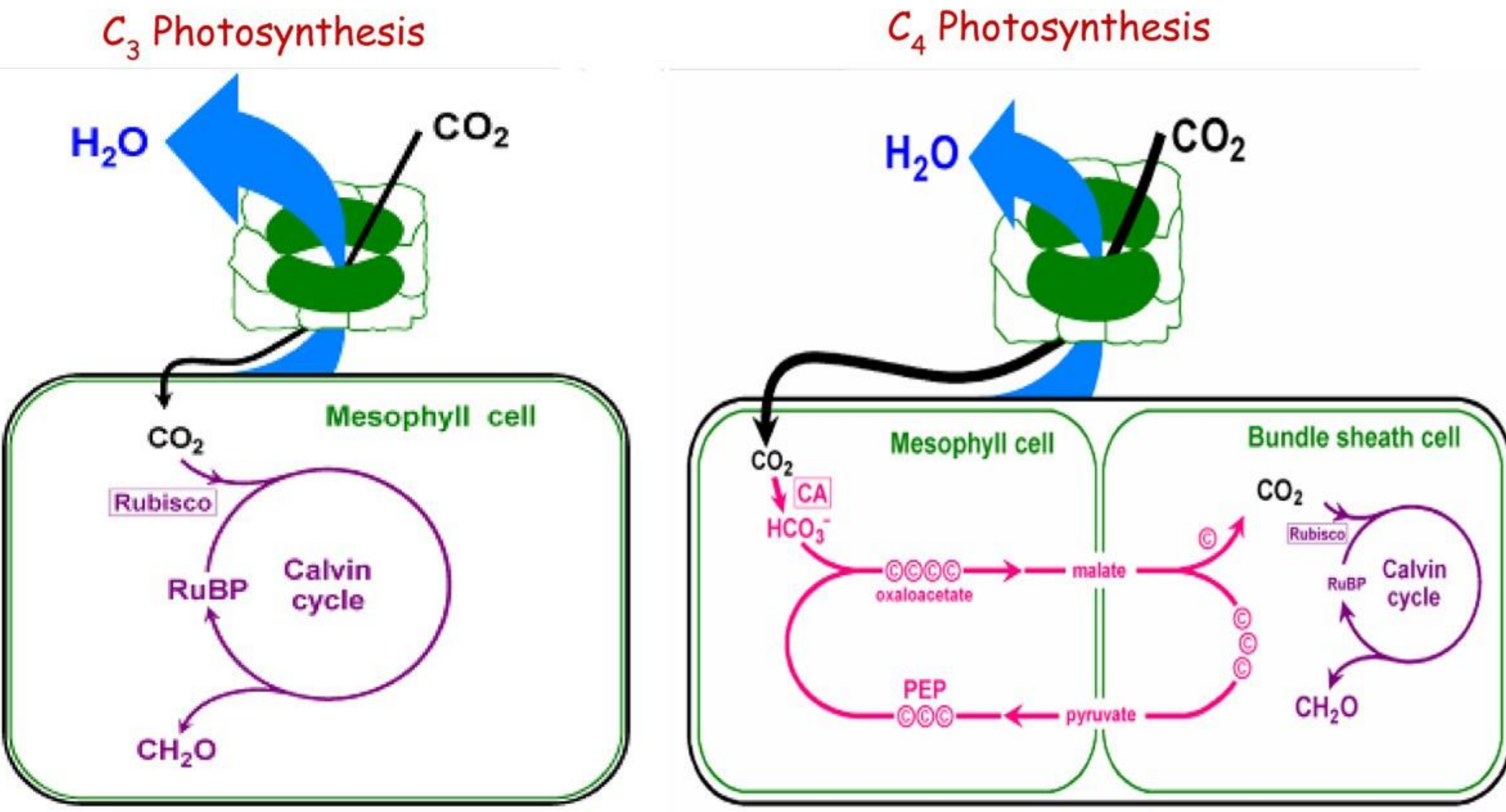
Ribulose-1,5-bisphosphate **(RuBP)**



https://www.khanacademy.org/science/ap-biology/cellular-energetics/photosynthesis/a/calvin-cycle

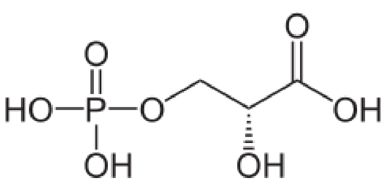
Hatch and Slack Pathway or C_4 pathway

BMC Syst Biol **6** (Suppl 2), S9 (2012)

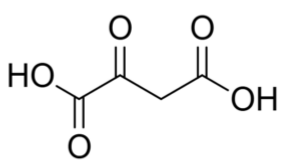


Mass spectrometry can distinguish between grassland/woodland and fossils by analysing the unique molecular compositions and stable isotope ratios within the samples. Fossils, especially those with preserved organic matter, will exhibit distinct molecular signatures compared to living plant material, due to degradation and fossilization processes.

Stable carbon isotope analysis ($^{12}C/^{13}C$) via mass spectrometry is a powerful tool for distinguishing between grassland (4C-chemical derivative) and woodland (3C Chemical Derivative) ecosystems in fossilized deposits. This approach exploits the difference associated with C3 or C$ chemicals associated with the photosynthetic pathways.



3-phosphoglyceric acid

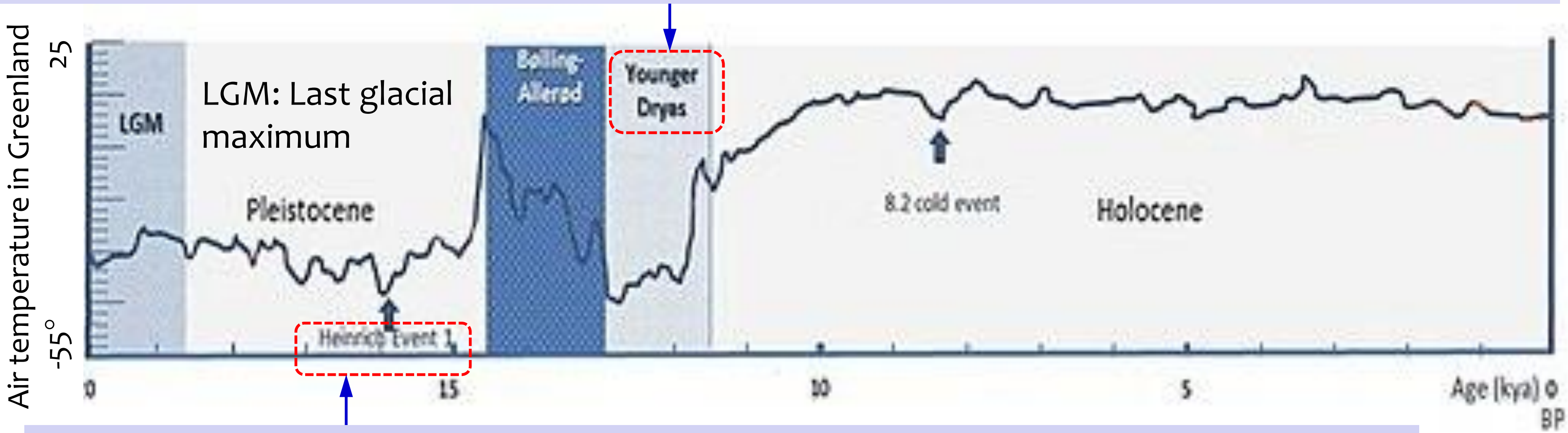


Oxaloacetate

C3 and C4 plants utilize different photosynthetic pathways. C3 plants (mostly woody plants) use the Calvin cycle directly to fix CO_2 into a C3-compound (3-phosphoglyceric acid or 3-phosphoglycerate). C4 plants (found mostly in grassland) have an initial step where CO_2 is fixed into a 4C-compound (oxaloacetate) in mesophyll cells, before being transferred to bundle sheath cells for the Calvin cycle. This process enhances efficiency in high-light, high-temperature, and dry conditions.

The Neolithic Revolution, or First Agricultural Revolution, marked a major shift in Afro-Eurasia during the Neolithic period, as many human societies transitioned from hunting and gathering to agriculture and permanent settlement. This change enabled population growth and allowed people to study plant growth, eventually leading to the domestication of crops.

Younger Dryas: A period of abrupt cooling (in the Northern Hemisphere) that interrupted the warming trend following the last glacial period, roughly 12,900 to 11,700 years ago.



Heinrich Event 1 (H1) was a significant climatic event during the last glacial period, specifically during the last deglaciation, approximately 16,000 years ago.

https://en.wikipedia.org/wiki/Neolithic_Revolution

Pleistocene epoch: The last ice age

The Pleistocene epoch is a geological time period that includes the last ice age. Also called the Pleistocene era, or simply the Pleistocene, this epoch began about 2.6 million years ago and ended 11,700 years ago, according to the International Commission on Stratigraphy.

Modern humans, or Homo sapiens, evolved during the Pleistocene and spread across most of Earth before the period ended, according to the University of California Museum of Paleontology. The Pleistocene epoch, known for its ice ages, was influenced by a combination of factors, including changes in Earth's orbit, atmospheric composition, and tectonic plate movements. These factors led to cyclical shifts between glacial (cold) and interglacial (warm) periods, with glaciers advancing and retreating.

1. Earth's Orbit (Milankovitch Cycles):

- The shape of Earth's orbit around the sun varies over long periods, affecting the amount of solar radiation reaching different parts of the planet.
- These variations, known as Milankovitch cycles, include changes in eccentricity (orbit shape), obliquity (tilt of Earth's axis), and precession (wobble of the axis).
- These cycles can trigger cooling periods, leading to the expansion of glaciers.

2. Atmospheric Composition:

- Changes in greenhouse gas concentrations, such as carbon dioxide and methane, can affect global temperatures.
- Lower levels of these gases can lead to cooling, contributing to glacial periods, while higher levels can cause warming, triggering interglacial periods.
- The Isthmus of Panama, a land bridge connecting North and South America, formed around 4.5 million years ago, possibly influencing ocean currents and precipitation patterns, which may have contributed to the last ice age.

3. Tectonic Plate Movements:

- The movement of tectonic plates can alter the position of continents, affecting ocean currents and wind patterns.
- Changes in landmass distribution can also influence the formation of glaciers and ice sheets.
- For example, the uplift of mountain ranges due to plate collisions can create conditions suitable for glacial formation.

What drove shifts in mammal communities over the past 7 million years?

One of the most well-documented changes is the expansion of grasslands throughout the past 4 million years. Many of the fossil megaherbivores preferred wooded environments, whereas ruminants (cattle, sheep, antelopes, deer, giraffes, etc.) thrive in the wide-open savannas that dominate parts of eastern Africa today. The fossil record of herbivores closely follows the shifting environments, with changes in the representation of these groups tracking long-term grassland expansion.

Around 1 million years ago, fossils show a shift in the mammal community's dietary structure that grassland expansion alone fails to explain. The non-ruminants that had dominated eastern African ecosystems fell into a sharp decline. This corresponds to marine dust records suggesting the region experienced pulses of climate drying that would have hit non-ruminants especially hard because they depend on reliable access to surface water, meaning that many species may have disappeared alongside the rivers and lakes they depended on. Additionally, the conveyor belt eating strategy of non-ruminants relies on accessing abundant vegetation, which would have declined during periods of drought.

https://attheu.utah.edu/facultystaff/ecosystems-of-early-human-evolution/

Ecosystems of early human evolution

To understand the environmental pressures that shaped human evolution, scientists must first piece together the details of the ancient plant and animal communities that our fossil ancestors lived in over the past 7 million years.

"For a long time, our field has been trying to pin down how environmental changes influenced human evolution, but we've got to be able to reconstruct past environments right in the first place," said lead author Tyler Faith, curator of archaeology at the Natural History Museum of Utah and assistant professor of anthropology at the Utah.

What drove shifts in mammal communities over the past 7 million years? One of the most well-documented changes is the expansion of grasslands throughout the past 4 million years.

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PNAS, 2019, 116 (43) 21478-21483

https://attheu.utah.edu/facultystaff/ecosystems-of-early-human-evolution/

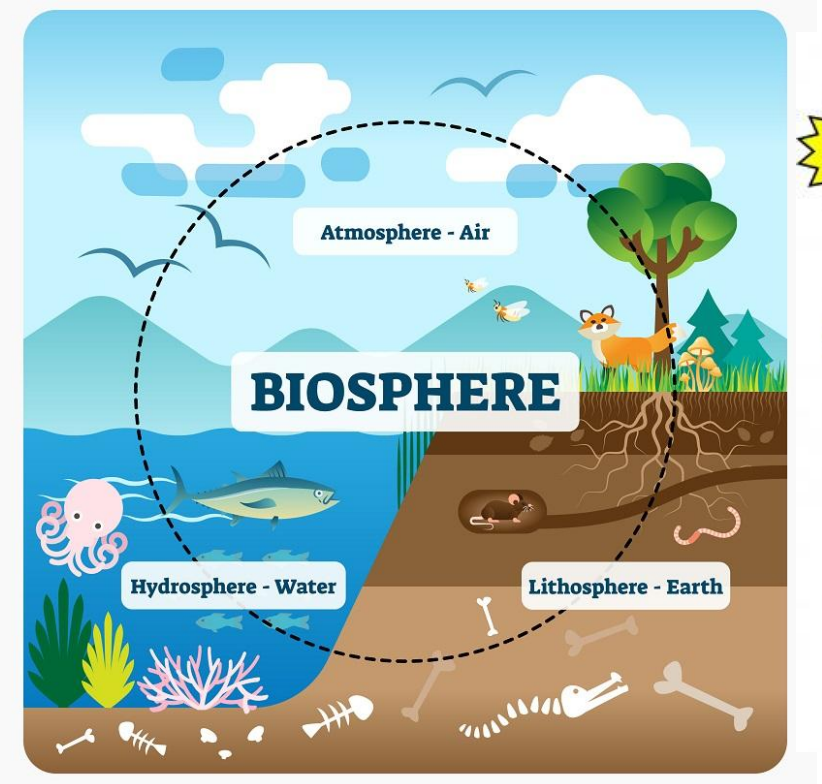
Over the course of human evolution, human ancestors increased their ability to cope with changing habitats rather than specializing on a single type of environment. How did hominins evolve the ability to respond to shifting surroundings and new environmental conditions?

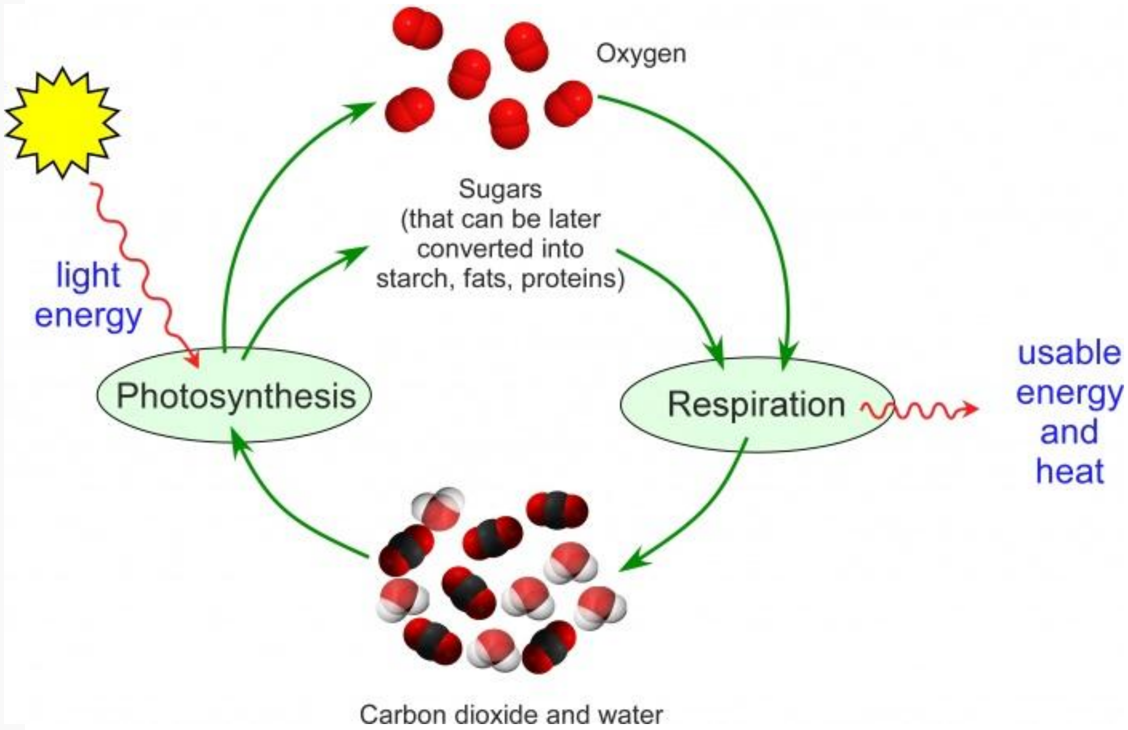
Organisms could cope with environmental fluctuations through genetic adaptation, wherein multiple alleles—different versions of a gene—exist within a population at varying frequencies. As conditions shift, **natural selection** favours the genetic version(s) best suited to the new environment. Additionally, genes that enable phenotypic plasticity—the ability to express different traits under different conditions—can further aid adaptation.

Another strategy involves evolving structures and behaviours that allow organisms to function across diverse environments. The selection of such traits in response to environmental instability is known as **variability selection**. Unlike hypotheses based on consistent environmental trends, which favour specialization, variability selection suggests that in highly unpredictable environments, flexibility and adaptability are more advantageous than specialization. It emphasises the survival benefits of behavioural and structural versatility.

https://humanorigins.si.edu/

Evidence suggests that biodiversity plays a pivotal role in ecosystem functioning. Consequently, diversity and heterogeneity are crucial for ecosystem adaptability, as ‘reduced biodiversity increases the risk of catastrophic change’.





Life on earth is possible because of the ability of plants to convert sunlight into biomass and thus store energy as O_2.

Ecosystem: An ecosystem is a community of living organisms (plants, animals, and microbes) that interact with one another and with their physical environment as a unified system. It comprises both biotic (living) and abiotic (non-living) components of a specific area, connected through nutrient cycles and energy flows.’

Key components: Biotic elements: Plants, animals, microorganisms.

Abiotic elements: Soil, water, air, sunlight, temperature.

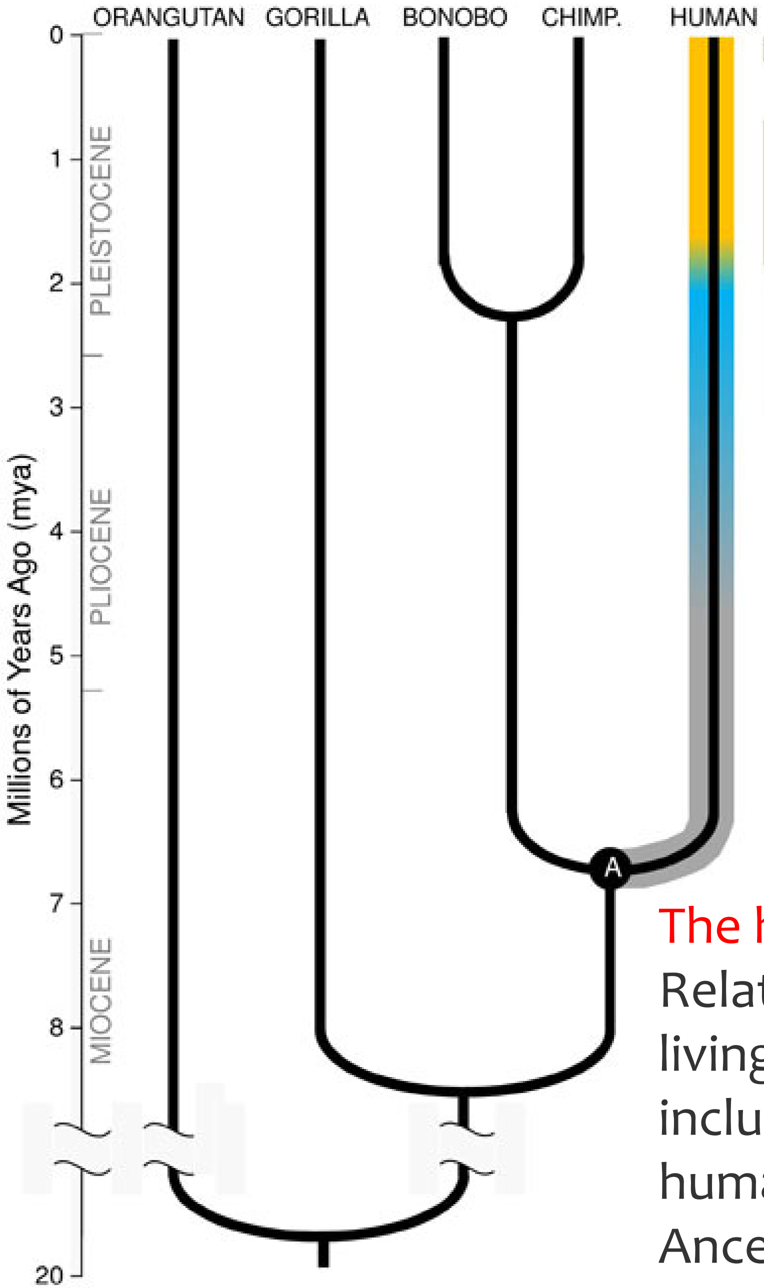
Two important ecosystem functions:

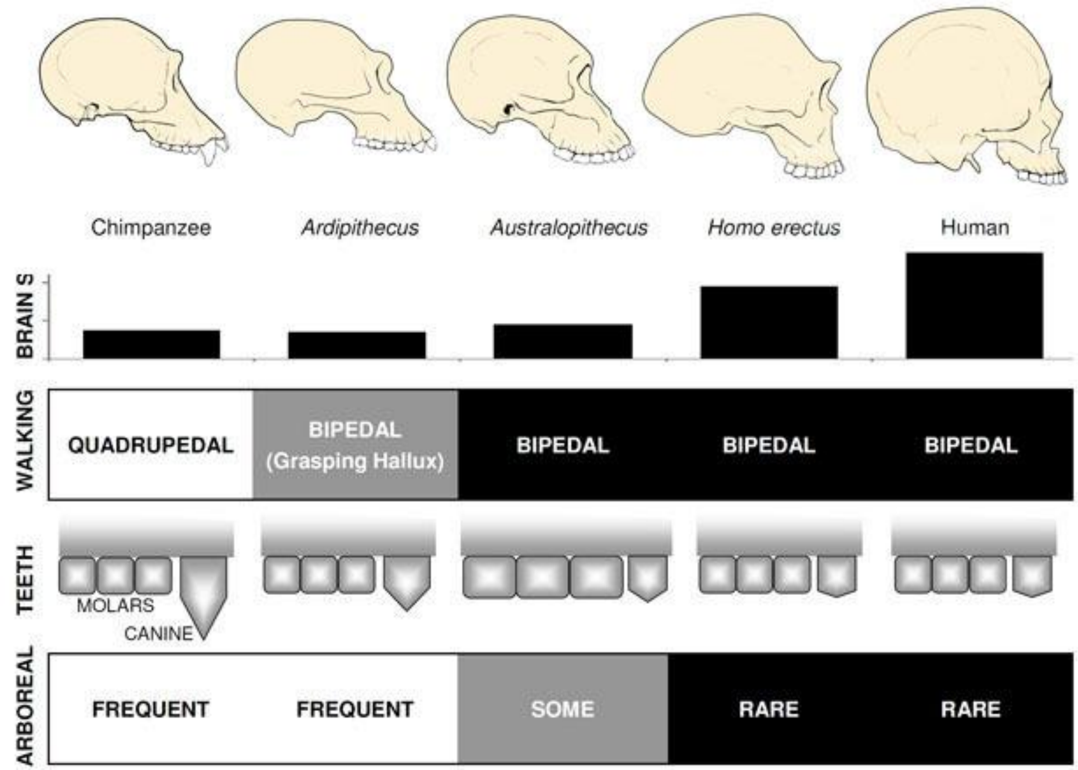
Biogeochemical cycling includes primary production (photosynthesis), nutrient and water cycling, and materials decomposition.

Flow of energy: The flow, storage, and transformation of materials and energy through the system are also influenced by processes that link organisms with each other, such as the food web, which consists of interlocking food chains.

In brief, An ecosystem functions through a web of interactions where each component influences others, making it a self-regulating system capable of sustaining life under varying conditions.

How did humans evolve into the big-brained, bipedal ape that we are today (fossil evidence of our 6-million-year evolution)?





Overview of Hominin Evolution. *Nat. Edu. Knowledge, 2012,* 3(10):8

The human evolutionary family tree.
Relationships and estimated divergence times of the living apes are shown. Hominins are all species, including side-branches and extinct species, on the human line (highlighted) after our Last Common Ancestor with chimpanzees & bonobos (marked “A”).

Materials Cycle: Biotic and Abiotic

Ecosystems involve strong interactions and networking between biotic and abiotic components.

The nature of these interactions plays a crucial role in an ecosystem's ability to be self-sustaining.

Biogeochemical (material) Cycles in Ecosystems:

In ecosystems, material cycles refer to the continuous movement of essential elements between the biotic (living) and abiotic (non-living) components of the environment. These are fundamental to sustaining life, regulating ecological balance, and maintaining ecosystem health.

Biotic Factors (Living Components): Producers (e.g., plants), consumers (e.g., animals), and decomposers (e.g., bacteria and fungi) are central to the cycling of matter through biological processes. They convert, assimilate, and transfer nutrients across trophic levels. **Nutrient Uptake and Release**: Living organisms absorb nutrients from their surroundings for growth, metabolism, and reproduction. These nutrients are returned to the environment via processes such as excretion, respiration, and decomposition, allowing for their reuse.

Abiotic Factors (Non-Living Components): Essential Physical Elements, such as water, air, soil, sunlight, temperature, and minerals, support and regulate life processes. They serve as the foundational medium for nutrient exchange and energy flow. **Elemental Reservoirs**: Abiotic elements act as storage pools for vital elements like carbon, nitrogen, oxygen, and phosphorus, which are cycled through biological and chemical processes.

Environmental Conditions: Factors such as temperature, humidity, and pH influence the rate and pathways of material cycling.

Material Cycles – Biotic

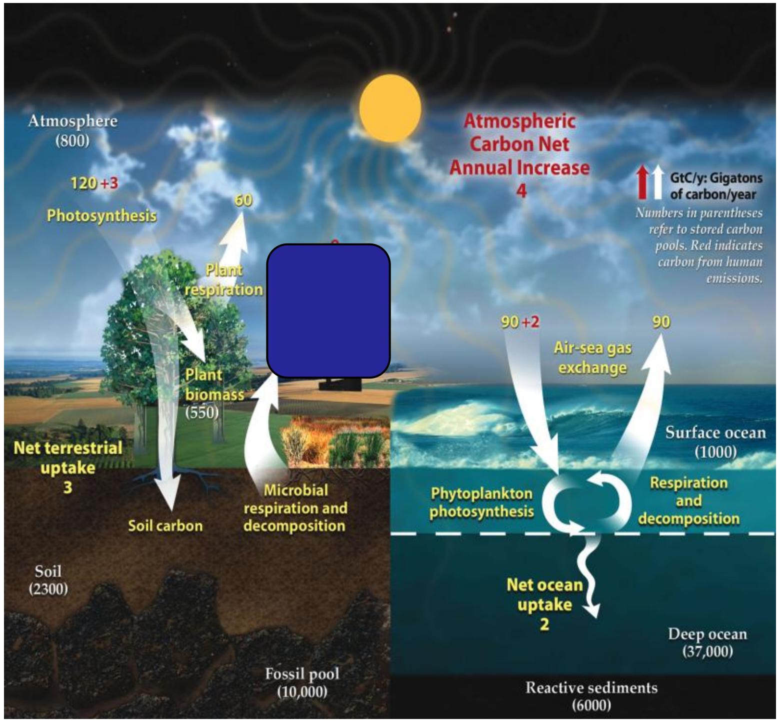
- Food webs consist of producers, consumers, decomposers
- *Producers* are green plants

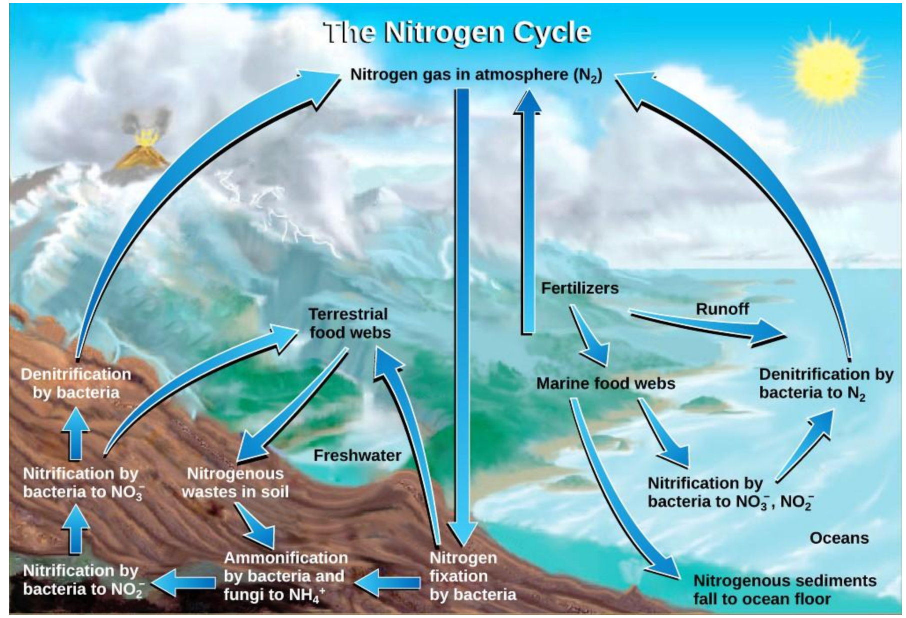
  $6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$ (photosynthesis)

  $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$ (respiration)
- *Consumers* are primary, secondary, and tertiary.
- *Decomposers* release nutrients from dead organisms for reuse by others
- *Mutualism* is also common

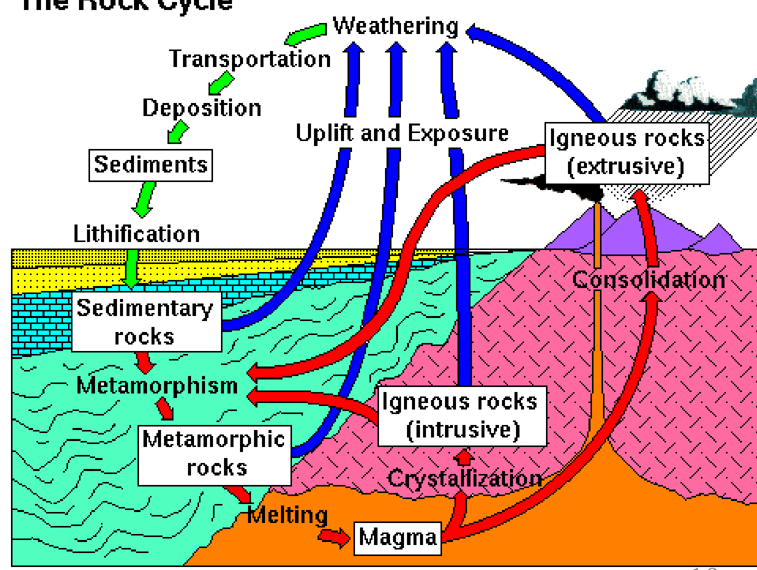
Mutualism is a type of relationship between the host and a symbiont (an organism living in symbiosis with another), where both organisms benefit and no one is harmed

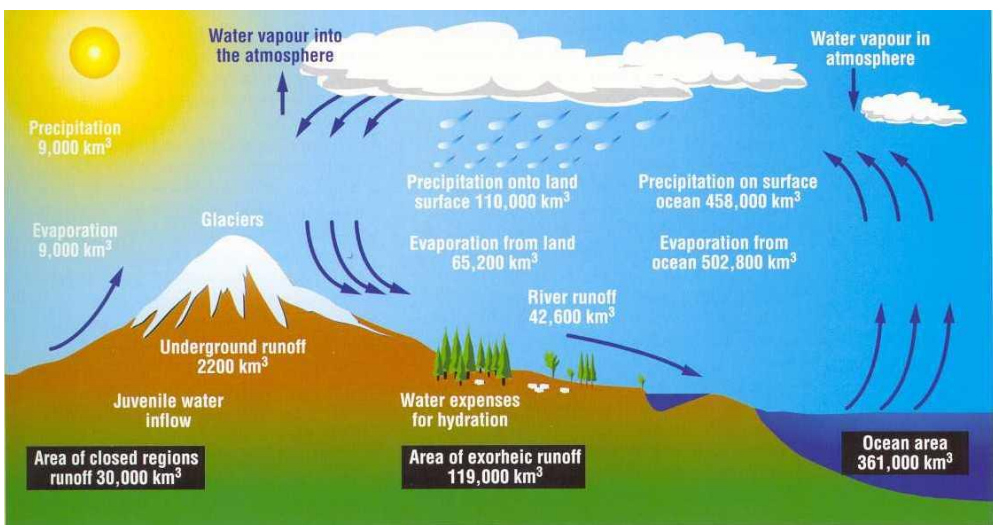
Natural Material Cycles



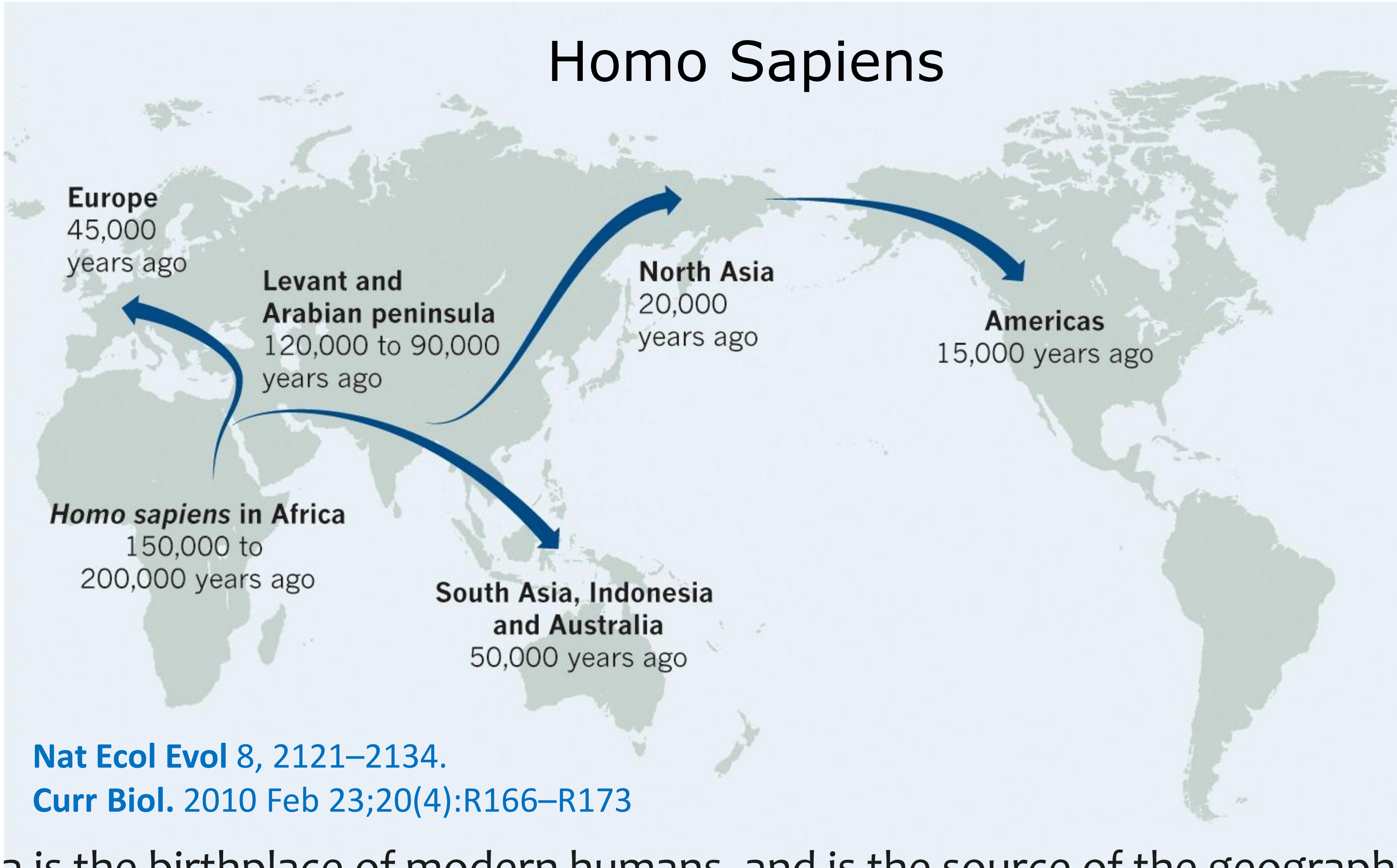


The Rock Cycle





Homo Sapiens



Nat Ecol Evol 8, 2121–2134.
Curr Biol. 2010 Feb 23;20(4):R166–R173

Africa is the birthplace of modern humans, and is the source of the geographic expansion of ancestral populations into other regions of the world. Indigenous Africans are characterized by high levels of genetic diversity within and between populations. The pattern of genetic variation in these populations has been shaped by demographic events occurring over the last 200,000 years. The dramatic variation in climate, diet, and exposure to infectious disease across the continent has also resulted in novel genetic and phenotypic adaptations in extant Africans.

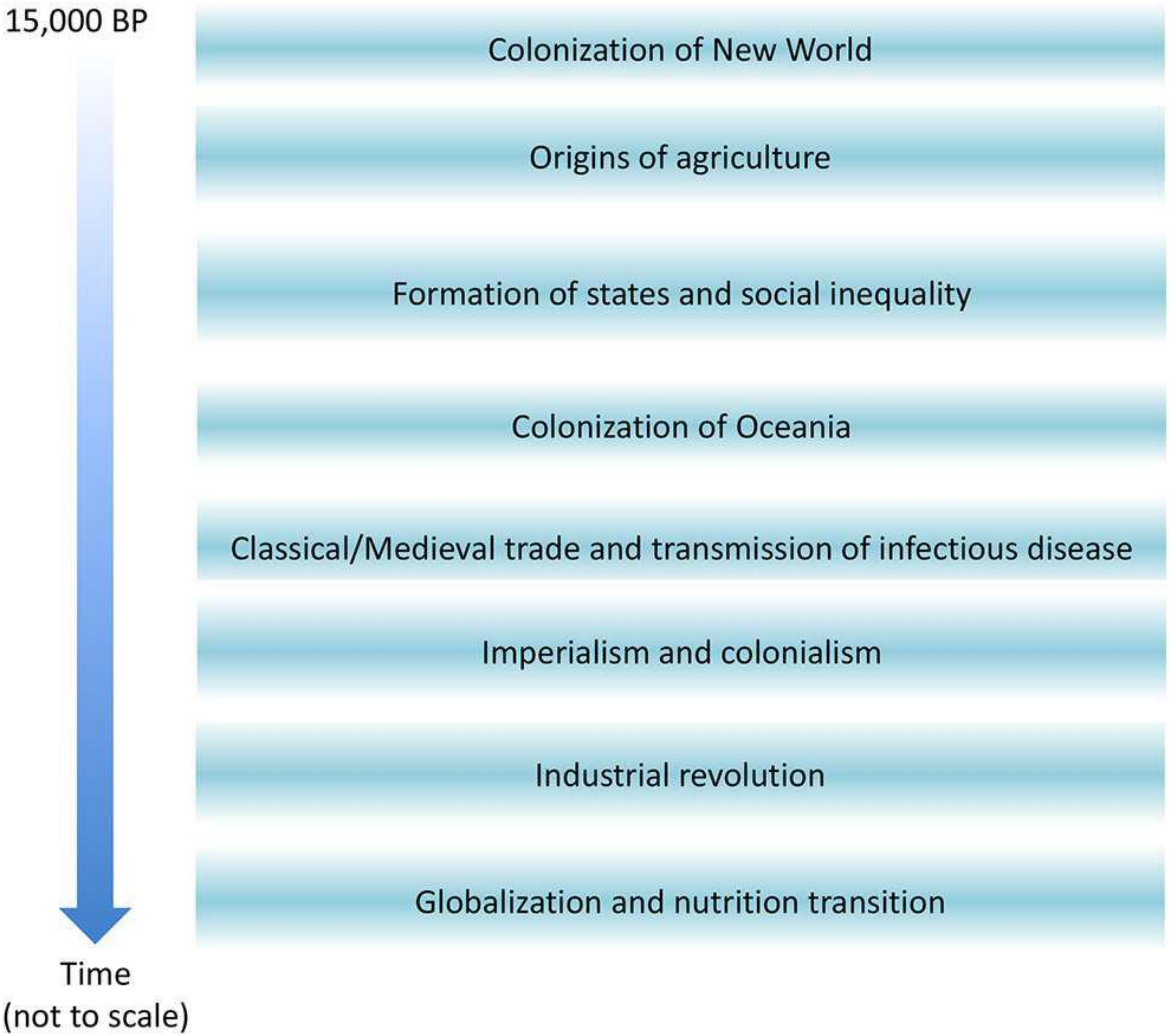
Human beings have existed on this earth for about 250,000 years, initially as hunter-gatherers for thousands of years, gathering wild plants and hunting animals. The hunter-gatherers dominated the scene across all continents until the end of the Pleistocene—a geological period that includes the last ice age, when glaciers covered huge parts of the globe. The Pleistocene began about 2.6 million years ago and ended 11,700 years ago [International Commission on Stratigraphy]. Hunter-gatherer culture is **a type of subsistence lifestyle that relies on hunting animals, fishing and foraging for wild vegetation and other nutrients like honey for food.**

The earliest fossils of *Homo sapiens* are located in Africa and date to the late Middle Pleistocene.

The Holocene Epoch is the current geologic period. Another term that is sometimes used is the Anthropocene Epoch because its primary characteristic is the global changes caused by human activity. During this period, food production based on the domestication of relatively few wild species (both plant and animal) took the center stage.

Neolithic Revolution: Traditional hunter-gatherer lifestyles, followed by humans since their evolution, were swept aside in favour of permanent settlements and a reliable food supply. Domestication, an accelerated evolutionary process driven by human intervention and natural selection, was a unique form of mutualism that developed between humans and the target plant or animal population and had strong selective advantages for both partners. During the domestication process, many traits in plants underwent dramatic modifications to meet human demands. After domestication, only favourable haplotypes were retained around selected genes, leading to the creation of a valley with extremely low genetic diversity.

450 yrs (BC/AC transition)
or



(Before Present) Dating uses 1950 as the reference point.

Therefore, 1500 BP would be 1500 years before 1950, which translates to 1950 - 1500 = 450 years before the year 0 (BC/AD transition).

Until the advent of agriculture and urbanization, the human population was largely limited by the same factors that limit other living organisms. Limiting factors in the environment, such as availability of food, water and shelter, evolutionary relationships like predator/prey ratios or the presence of pathogens provide natural balances to populations. A population will generally expand until it reaches the **carrying capacity**, the maximum number of individuals an environment can support without detrimental effects, at which time it will level off. Continued expansion beyond the carrying capacity generally results in a crash.

If enough genetic diversity remains, the population may recover; it may also become extinct.

Beginning of the first century A.D., humans began to sidestep these restraints. Agriculture had increased the number of people that could be supported by the environment; we were the first animals to increase the carrying capacity of our existing habitat. Science has continued to help us enhance the carrying capacity of the planet, but not the size of the planet.

https://www.livescience.com/28219-holocene-epoch.html

Why Harappan or Mohenjo-Daro civilization got extinct?

The reasons behind the decline and eventual abandonment of the Harappan or Indus Valley Civilization, including major cities like Mohenjo-Daro, are still debated by scholars, but several factors likely contributed to its demise around 1800 BCE.

Here are the main theories and reasons:

1. Climate Change and Environmental Factors

- Changes in monsoon patterns: Some studies suggest a weakening or eastward shift of the monsoons, leading to reduced rainfall and water scarcity for agriculture.
- Drying up of the Ghaggar-Hakra River: This river system (possibly the ancient Saraswati River), vital for many Harappan settlements, may have dried up due to tectonic activity or reduced monsoon rainfall, causing the abandonment of cities along its banks like Kalibangan and Banawali.
- Shifting River Courses: The Indus River, characterized by its instability, may have shifted its course away from Mohenjo-Daro, leading to water scarcity and forcing people to migrate.

2. Natural Disasters

- Floods: Evidence suggests repeated episodes of flooding in cities like Mohenjo-Daro, potentially caused by tectonic activity that created natural dams on the Indus River.
- Earthquakes: The Indus region is seismically active, and earthquakes may have caused significant damage to settlements and altered river courses.

3. Decline of Trade

- Weakening of Trade Networks: The Harappan Civilization relied heavily on trade with other regions, including Mesopotamia. The decline of Mesopotamia due to political problems or other factors might have negatively impacted Harappan trade and economy.
- Economic Instability: The reduction in trade, coupled with environmental challenges, could have led to economic hardship and a weakening of the civilization's overall stability.

Gradual Decline and Societal Shifts

- Urban Decay: Archaeological evidence indicates a decline in urban planning and construction standards towards the end of the civilization, suggesting a possible deterioration of social and economic infrastructure.
- Overpopulation and Strain on Resources: Some scholars propose that the growing population and cattle herds may have strained the environment, leading to deforestation, overgrazing, and soil exhaustion.
- Possible Internal Conflicts: While less emphasized than environmental factors, some scholars suggest that social unrest or conflicts might have contributed to the decline.

5. Aryan Invasion Theory (largely discredited)

- This theory suggested that the Harappan Civilization was invaded and conquered by the Aryans. However, this theory is now largely rejected by scholars due to a lack of convincing evidence.

It's important to remember that the decline of the Harappan Civilization was likely a complex process involving multiple interacting factors, rather than a single catastrophic event. The civilization didn't disappear suddenly but underwent a gradual de-urbanization, with many communities continuing to exist in a less organized form

The world has now entered the 'Anthropocene' an era in which human activities significantly impact Earth system functioning. The profound, and almost omnipresent, impact of agriculture on the environment is well documented (Science, 2005, 309, 5734:570-574, 10.1126/science.1111772, Science, 2012, 335(6066):289-290, 10.1126/science.1217941) and manifests itself via multiple interacting pathways, e.g., land-cover change, greenhouse gas emissions, excessive water use, and biodiversity impacts. https://www.worldhistory.org/article/9/agriculture-in-the-fertile-crescent--mesopotamia/

Carrying Capacity: One of the earliest concepts addressing the issue of scale is **carrying capacity**. In biology, carrying capacity is defined as the **maximum population of a given species that an environment can support indefinitely**, without degrading the ecosystem. Importantly, **carrying capacity is dynamic**—it changes over time as both the population and the characteristics of the habitat evolve.

In the context of human societies, carrying capacity refers to the **total demand placed on natural resource stocks and flows** relative to the **ecosystem's ability to regenerate those resources and maintain stability**. It provides a measure of whether human use of natural capital is within ecological limits or exceeding the planet's long-term capacity to support life.

Earth Overshoot Day 2025 is on July 24th. This means that by July 24th, humanity will have used up nature's entire year's worth of resources that Earth can regenerate.

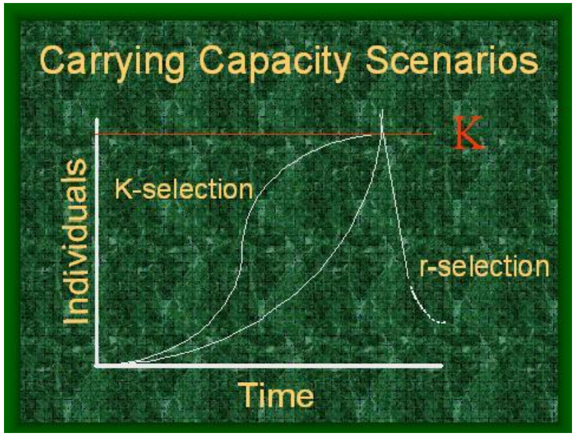
A natural experiment" of St. Matthew Island:

St. Matthew Island (Alaska, US) represents the southern limit of the range of polar bears in the Bering Sea. In 1944, 29 Reindeer were introduced to St. Matthew Island (Area: ~ 320 sq km) by the Coast Guard as an emergency food source, and the Coast Guard abandoned the island a few years later, leaving the reindeer. Its population increased to 6,000 in the summer of 1963, a drastic overshoot of the island's carrying capacity, causing a crash die-off the following winter to 42 animals. Based on the size of the island, recent estimates put the carrying capacity at about 1,670 animals [Klein, D. R. (n.d.). The Introduction, Increase, and Crash of Reindeer on St. Matthew Island. Retrieved May 25, 2016, https://web.archive.org/web/20110709032911/http://dieoff.org/page80.htm].

Ecologist **Garrett Hardin** cited the 'natural experiment' of St. Matthew Island of the reindeer population explosion and collapse as a model example of the consequences of overpopulation in his essay *An Ecolate View of the Human Predicament*.

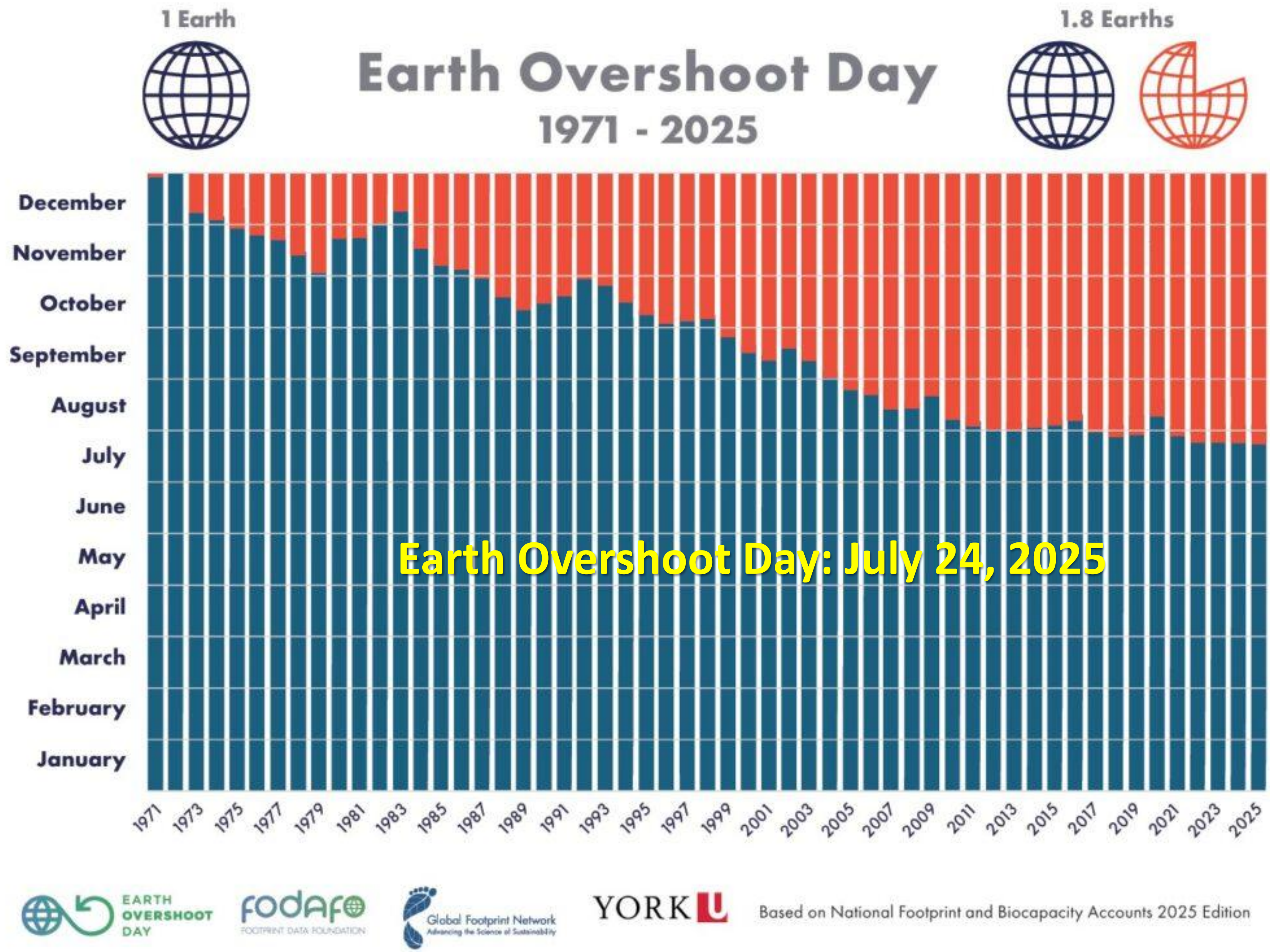
Two Patterns

Many animal species have been studied with respect to a specific area's carrying capacity. Starting from a low population level, there are two quite different patterns which describe how various species reach carrying capacity, the sigmoid and peak phenomena. Populations which exhibit the sigmoid pattern increase rapidly while food and habitat are abundant, and then slow down as regulatory factors such as lower birth rate and reduced food availability come into play. As the rate of population growth slows down to zero, the population reaches a fairly stable level. This pattern is referred to as ***K*** (for constant) selected species.



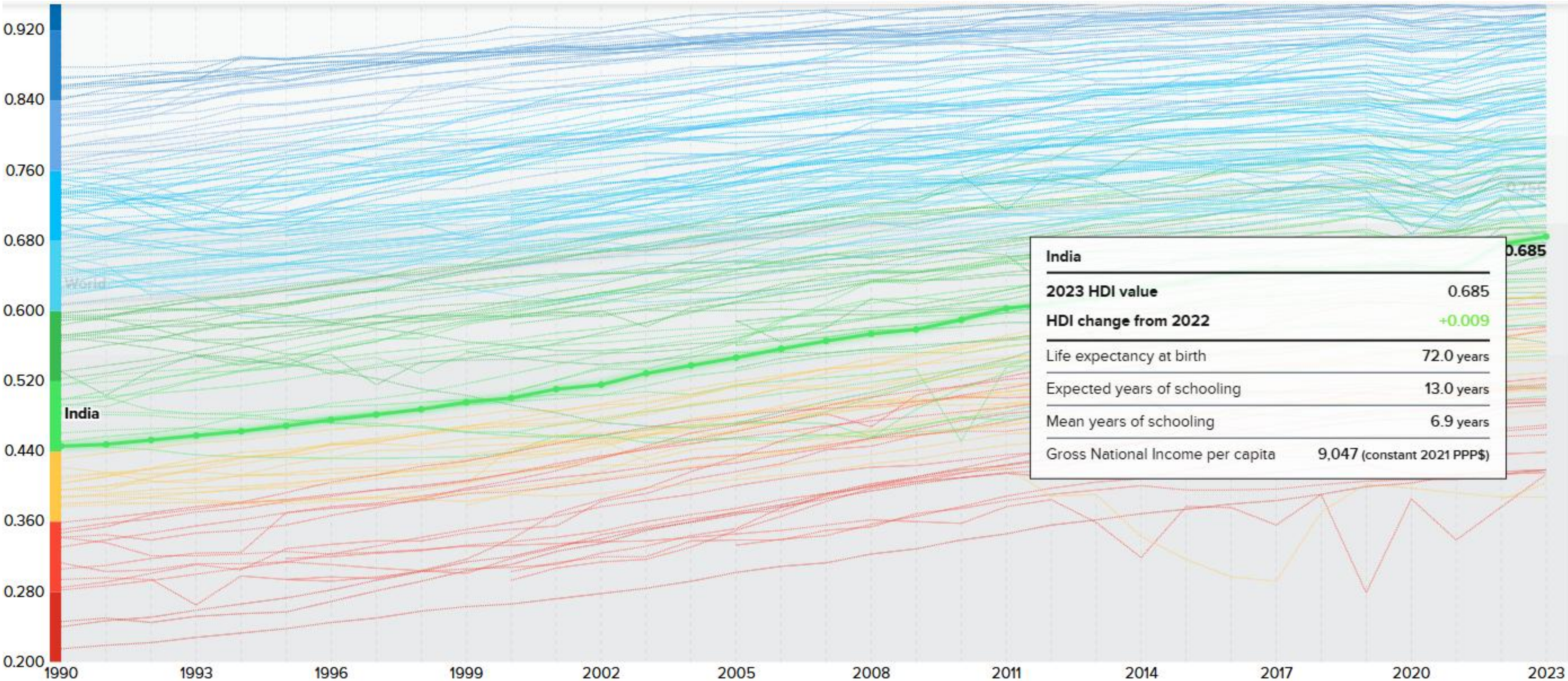
A natural experiment of St. Matthew Island

The other pattern, the same regulatory factors do not come into play, and the population increases rapidly to the point where it exhausts the resources upon which it depends. At this point, mortality becomes the primary regulatory factor, and the population collapses to a low level. When resources are replenished, the population begins to rise again; this process is repeated in a 'boom and bust' cycle. This is referred to as the ***"r-selected"*** species.



https://overshoot.footprintnetwork.org/newsroom/past-earth-overshoot-days/

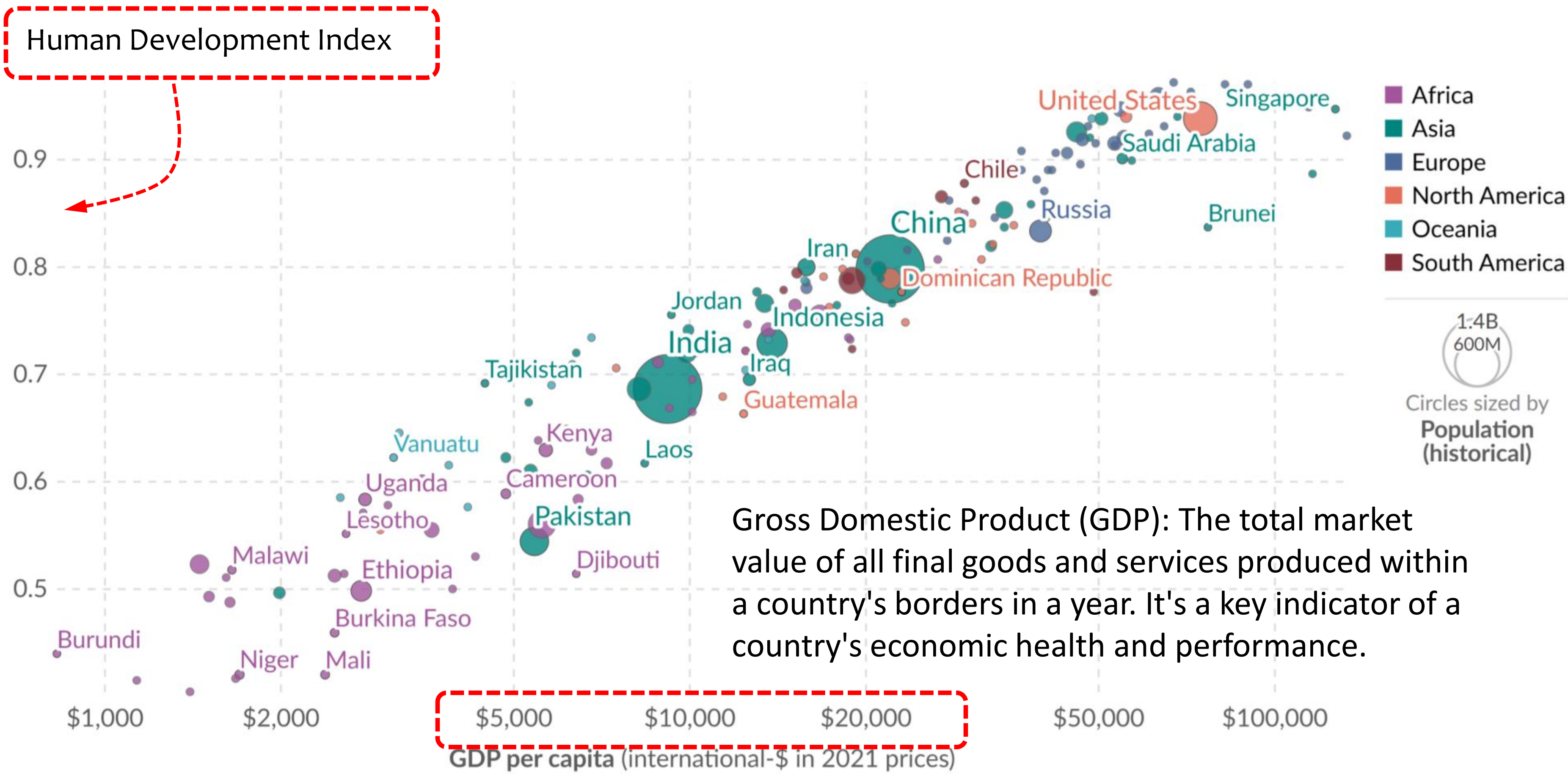
HDI Distribution 1990-2023



India is ranked 130th out of 193 countries.

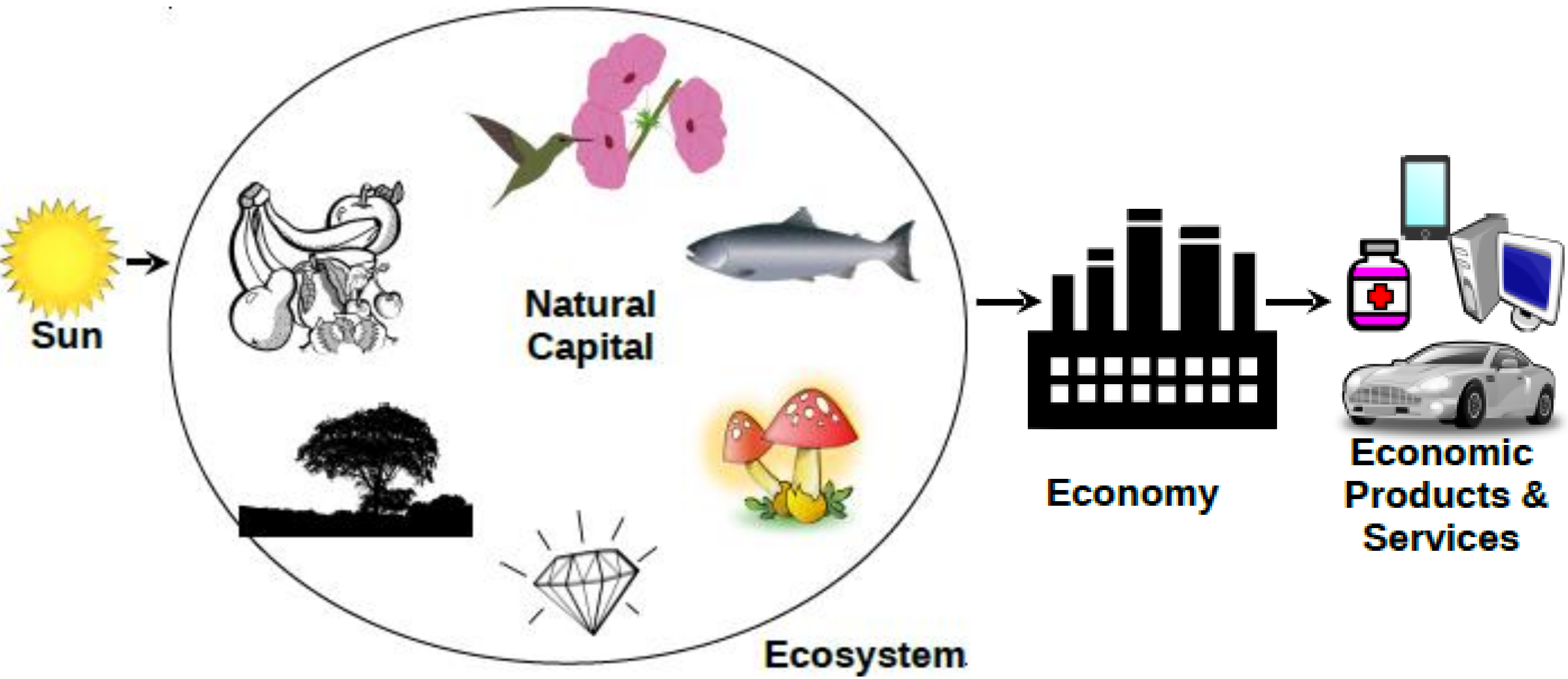
https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

The Human Development Index (HDI) 2023: A summary measure of key dimensions of human development: a long and healthy life, access to good education, and a decent standard of living. GDP per capita is adjusted for inflation and differences in living costs between countries.



Data source: UNDP, Human Development Report (2025); Eurostat, OECD, and World Bank (2025) – Learn more about this data; GDP per capita is expressed in international-$ at 2021 prices

Ecosystem and Economic Activities



Economic activities transform ecosystem goods and services into economic goods and services.

One of the most basic laws of physics is that it is impossible to create something from nothing. All economic products result from the transformation of raw materials provided by nature. Furthermore, it is impossible to create nothing from something. All human-made products eventually break down, wear out and fall apart, returning to the ecosystem as waste.

The transformation of raw material inputs into economic products and waste requires low-entropy energy, irreversibly converted through use into high-entropy waste. Finite stocks of fossil fuels account for nearly 86% of the total energy consumption, creating steady flows of CO_2 and other pollutants into the atmosphere. Society controls the rate at which fossil fuels are extracted, and hence the flow of waste into the ecosystem from their combustion.

Joshua Farley, Ecosystem services: The economics debate, Ecosystem Services, 2012, 1, 40-49

Entropy and Low-Entropy Energy in Material Transformation

Entropy is a measure of disorder or randomness in a system. In thermodynamics, **'low-entropy energy'** refers to energy that is **highly ordered and capable of performing useful work**. Examples of low-entropy energy include electricity, chemical energy stored in fuels, and sunlight.

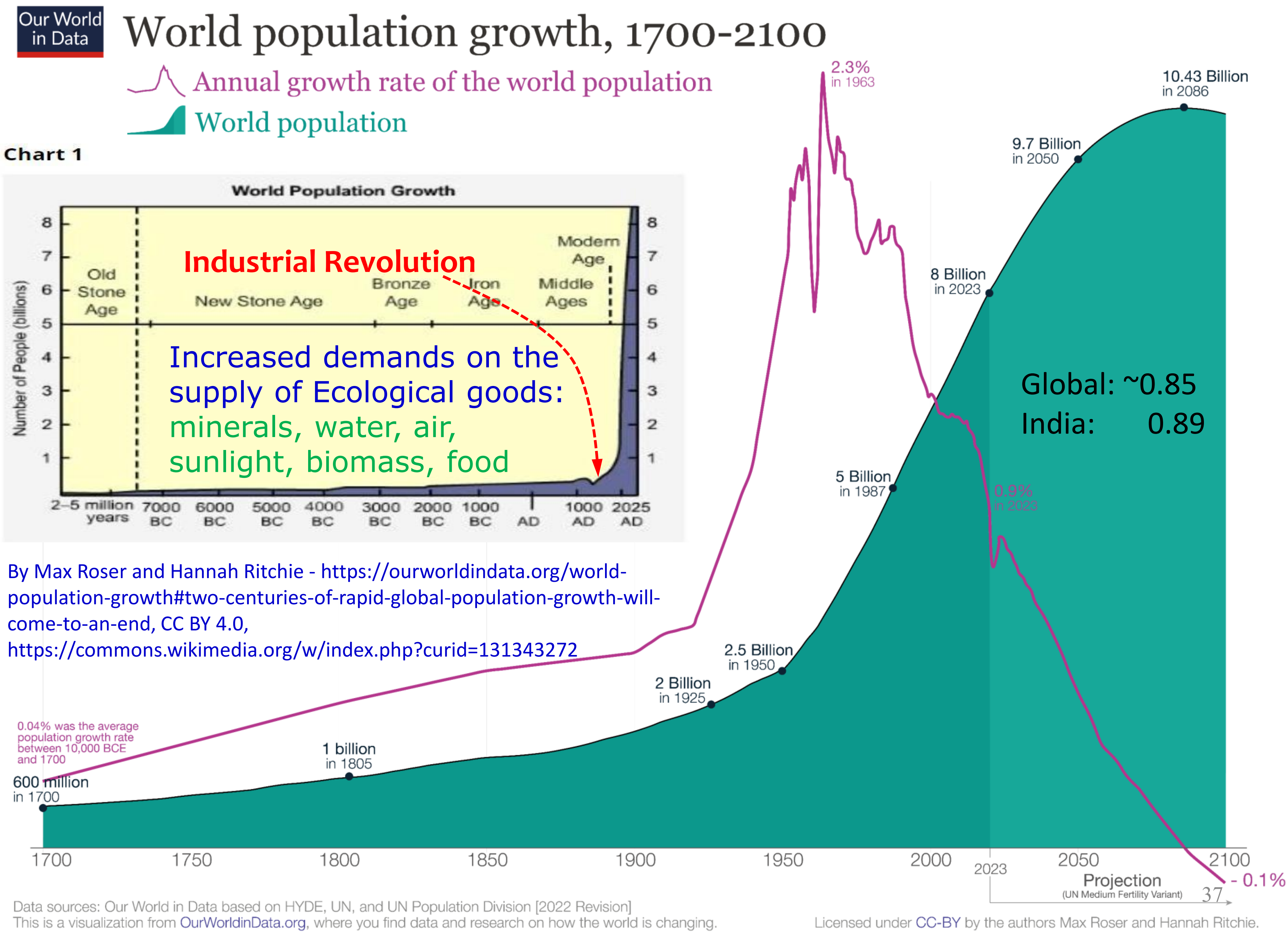
When raw materials are transformed into economic products—such as converting iron ore into steel—**energy is required to impose order and drive the necessary physical and chemical changes**. This restructuring depends on the input of low-entropy energy to organize matter, facilitate reactions, and power machinery.

However, during this transformation process, a portion of the low-entropy energy is **irreversibly degraded into high-entropy forms**, such as waste heat, which can no longer be efficiently reused. While localized order is created (in the form of the product), the overall entropy of the system—and the universe—increases.

The **Second Law of Thermodynamics** states that:

In any energy transformation, the total entropy of a closed system will increase.

Thus, while low-entropy energy enables economic production, its use inevitably contributes to the increase of global entropy.


Our World in Data
World population growth, 1700-2100
Annual growth rate of the world population
World population
Chart 1
World Population Growth
Number of People (billions)
Old Stone Age
New Stone Age
Bronze Age
Iron Age
Middle Ages
Modern Age
2–5 million years
7000 BC
6000 BC
5000 BC
4000 BC
3000 BC
2000 BC
1000 BC
AD
1000 AD
2025 AD
Industrial Revolution
Increased demands on the supply of Ecological goods:
minerals, water, air, sunlight, biomass, food
By Max Roser and Hannah Ritchie - https://ourworldindata.org/world-population-growth#two-centuries-of-rapid-global-population-growth-will-come-to-an-end, CC BY 4.0, https://commons.wikimedia.org/w/index.php?curid=131343272
2.3% in 1963
10.43 Billion in 2086
9.7 Billion in 2050
8 Billion in 2023
Global: ~0.85
India: 0.89
5 Billion in 1987
0.9% in 2023
2.5 Billion in 1950
2 Billion in 1925
1 billion in 1805
0.04% was the average population growth rate between 10,000 BCE and 1700
600 million in 1700
- 0.1%
1700
1750
1800
1850
1900
1950
2000
2023
2050
2100
Projection
(UN Medium Fertility Variant)
Data sources: Our World in Data based on HYDE, UN, and UN Population Division [2022 Revision]
This is a visualization from OurWorldinData.org, where you find data and research on how the world is changing.
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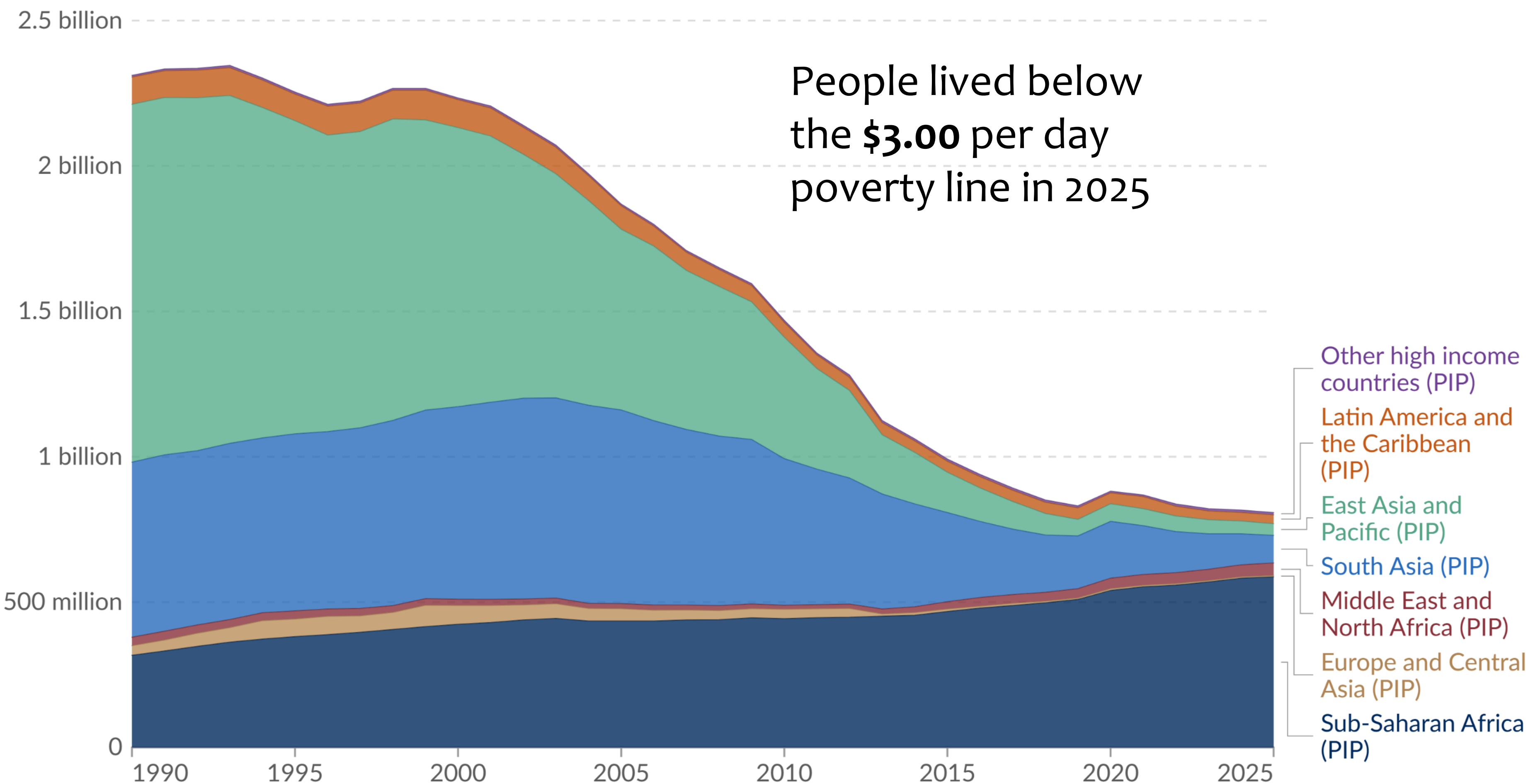
Total population living in extreme poverty by world region

Extreme poverty is defined as living below the International Poverty Line of $3 per day. This data is adjusted for inflation and for differences in living costs between countries.

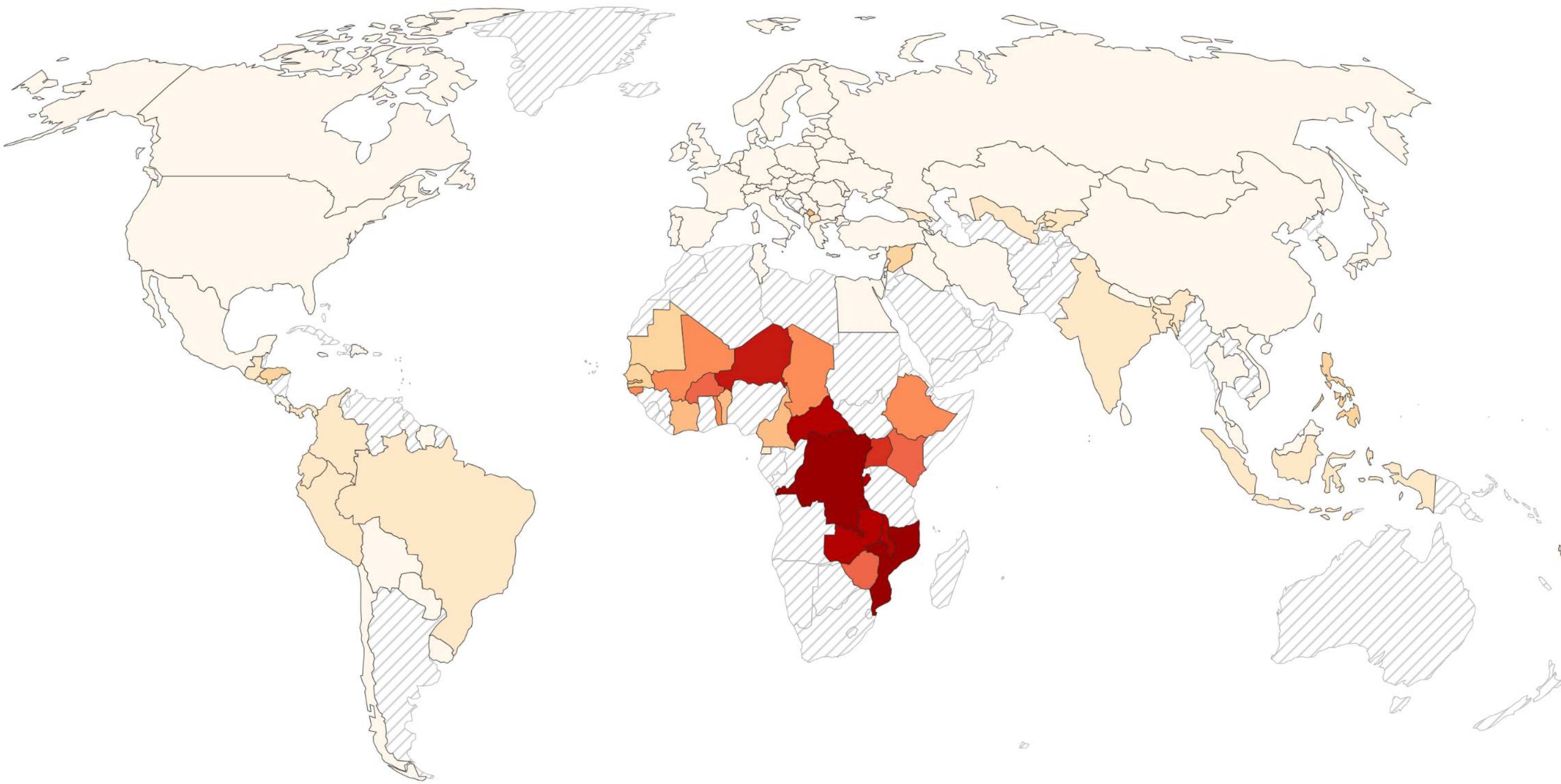


World Bank Poverty and Inequality Platform (2025) – Learn more about this data: OurWorldinData.org/poverty |

Note: This data is expressed in international-$ at 2021 prices. Depending on the country and year, it relates to income (measured after taxes and benefits) or to consumption, per capita.

Share of population living in extreme poverty, 2024

Extreme poverty is defined as living below the International Poverty Line of $3 per day. This data is adjusted for inflation and for differences in living costs between countries.



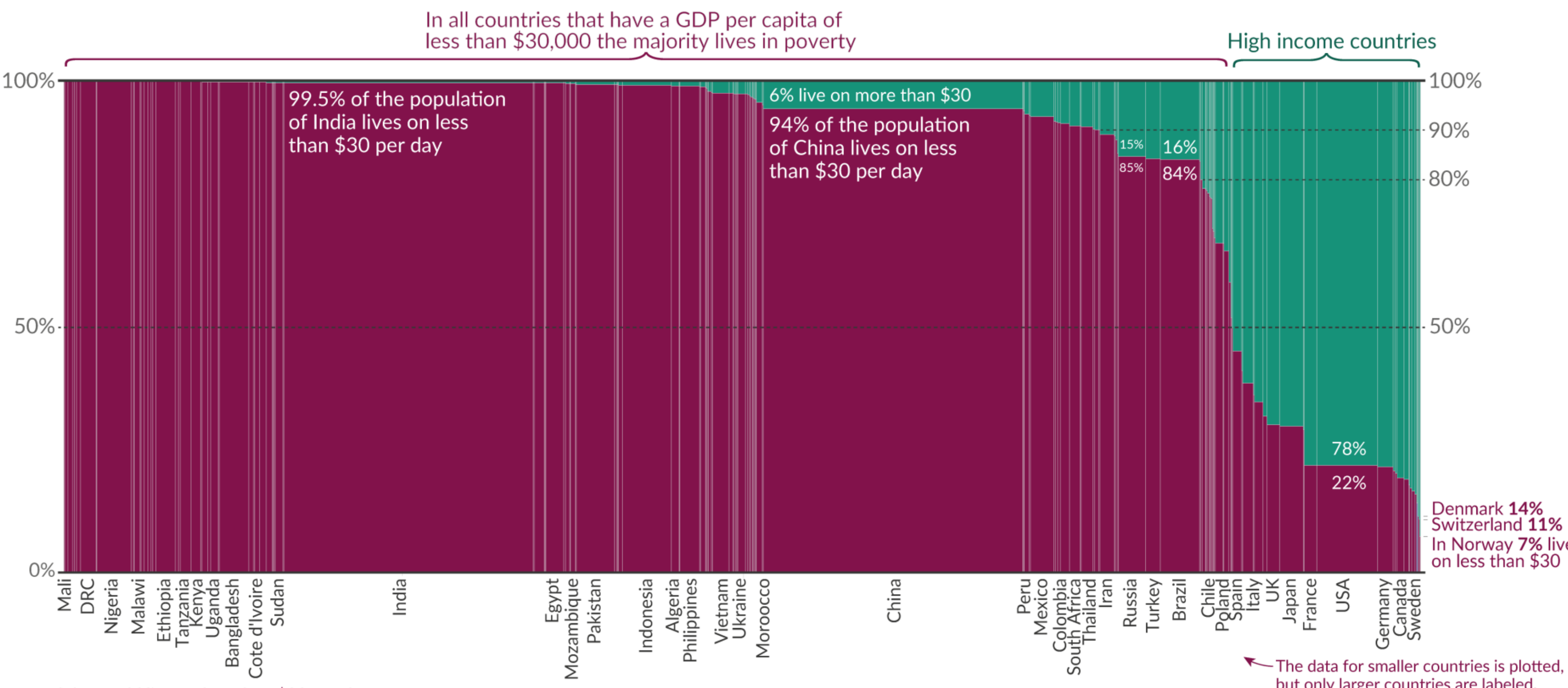
Data source: World Bank Poverty and Inequality Platform (2025) – Learn more about this data; **Note:** This data is expressed in international-$ at 2021 prices. Depending on the country and year, it relates to income (measured after taxes and benefits) or to consumption, per capita.

Global poverty: The share in each country living on less than $30 per day

Our World in Data

Adjusted for price differences: All incomes are adjusted for price differences between countries and expressed in international-dollars. One international-$ has the same purchasing power as one US-$ in the US. This means no matter where in the world a person is living on int.-$30, the value of the goods and services they can buy would cost US-$30 in the US.

How to read this chart: The width of each bar corresponds to the country's population size, the height of the purple bar shows the share in poverty, the area of each purple rectangle therefore represents the number of poor people in each country.

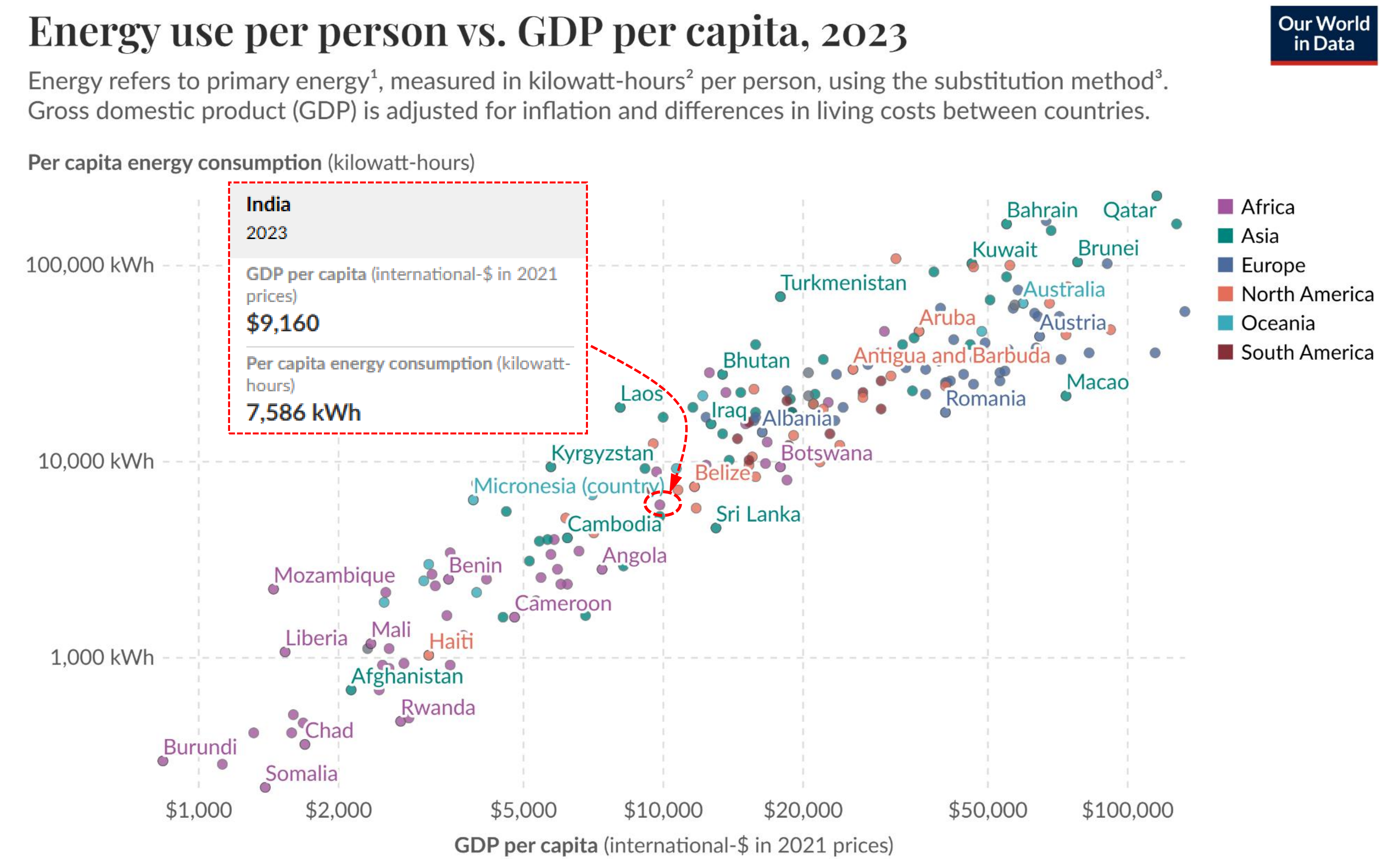


85% of the world live on less than $30 per day.

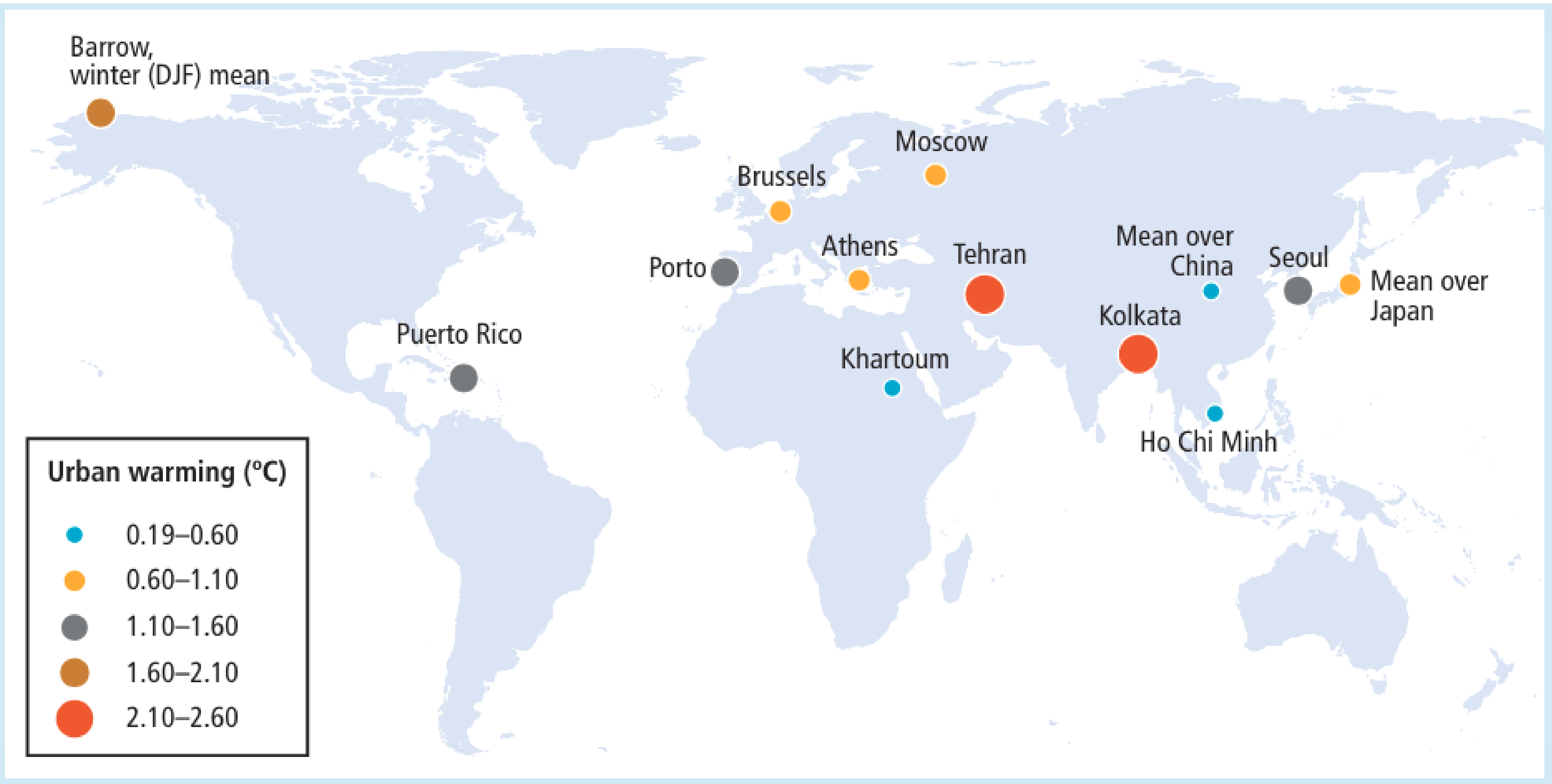
(Which means that those who live on more than $30 per day are among the richest 15%.)

Data source: World Bank (PovcalNet) 2017 data. Non-monetary sources of income (e.g. subsistence farming) are taken into account.

OurWorldinData.org – Research and data to make progress against the world's largest problems.

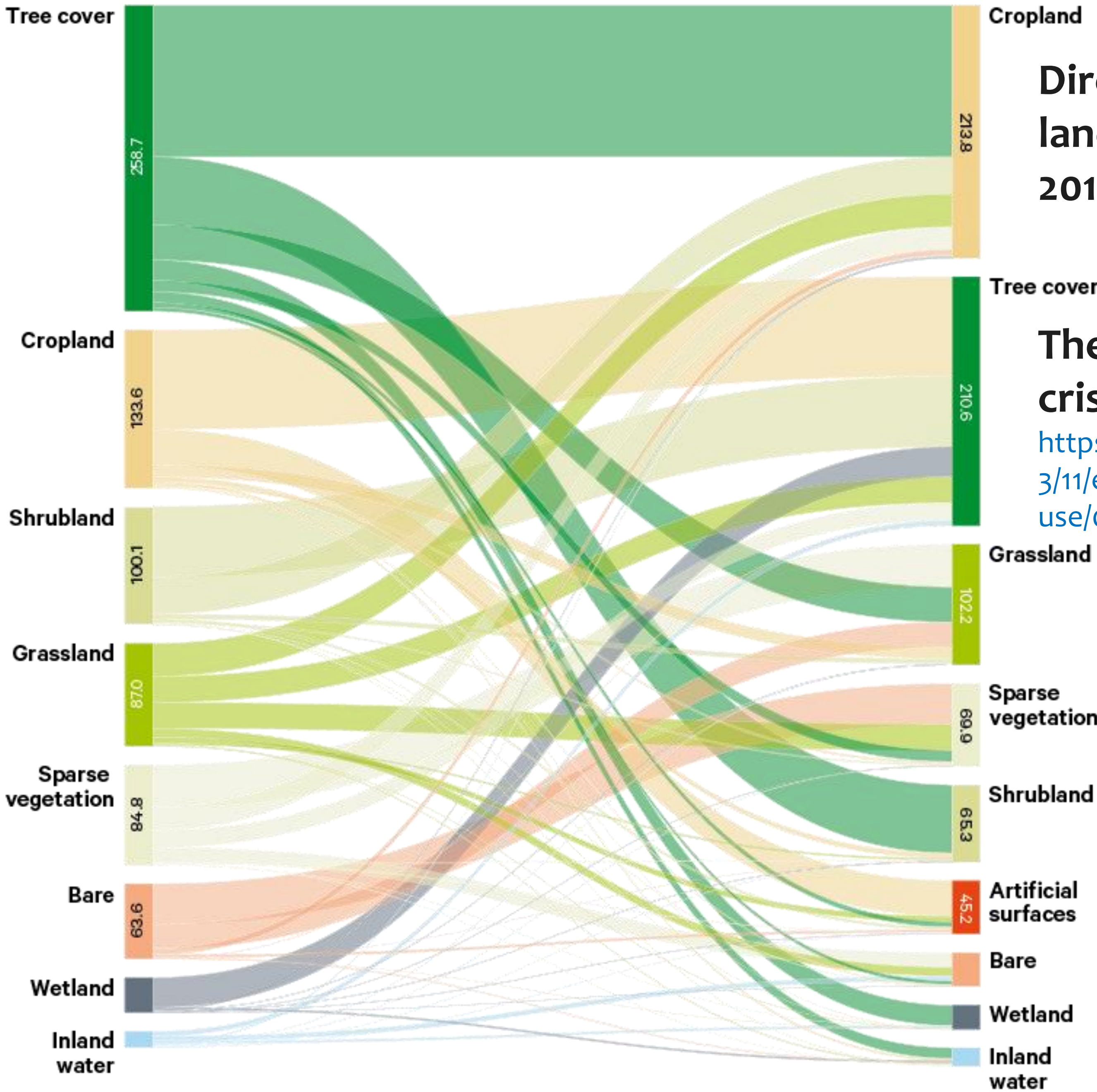


U.S. Energy Information Administration (2023); Energy Institute - Statistical Review of World Energy (2024); Population based on various sources (2023) – with major processing by Our World in Data



Change in annual mean surface air temperature resulting from urbanisation (°C). The colour and size of the circles refer to the magnitude of the change.

Land–climate interactions Coordinating Lead Authors: Gensuo Jia (China), Elena Shevliakova (The United States of America); https://doi.org/10.1017/9781009157988.004



Direct changes in global land cover types 1992–2019 (million ha):

The emerging global crisis of land use:
https://www.chathamhouse.org/2023/11/emerging-global-crisis-land-use/02-state-worlds-land-resources

Source: Calculated from OECD (2022), 'OECD.Stat > Land cover in countries and regions'.
https://stats.oecd.org/OECDStat_Metadata/ShowMetadata.ashx?Dataset=LAND_COVER (accessed 1 Jun. 2022).