

A Brief History of Earth

As Earth cooled, oceans and continents formed and were followed by a chain of life that evolved from single celled organisms to Humans, who changed the world.

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Introduction

This essay presents a new History of life on Earth.

The evolution of life on Earth began long after the Sun and its planets were formed and it was not a smooth progression, for ninety-nine percent of all life forms that ever lived are now extinct.

Our first recognisable ancestors were small, warm-blooded, mouse like creatures, beneath the notice of the mighty dinosaurs. Their evolution eventually led to human beings who came to dominate the world during the last ten thousand years, a tiny speck of time compared to the age of Earth.

Following the development of civilisation and the rise of the world population, half of whom now live in vast sprawling cities, dependent on technology to provide electricity, clean water, regular food deliveries, and safe sewage disposal. Although this way of living is normal to us, it has only existed for less than a blink of an eye, compared to the age of Earth.

The lives of humans have frequently been disrupted by famine, epidemics, wars and now the explosion and acceleration of the human population in the last two hundred years. We rely on the availability of food as do all other living creatures. Recently, great famines have been prevented by increasing crop yields and already most land suitable for cultivation is in use.

The population growth of Eurasia has now peaked and is beginning to decline, so there may yet be food to spare. However, even this is under threat due to the expected rapid increase in the populations of Africa and South America during the rest of this century.

PART ONE

THE TIMELINE OF EARTH

Birth of the Sun	460,000,000,000 (460 billion years ago)
Earth & the other planets	454,000,000,000 (454 billion years ago)
<u>Life on Earth, an Unbroken Chain of Evolution</u>	
The first living organisms	370,000,000,000 (370 billion years)
Evolution of Multicellular Animals	541-485,000,000 (541-485 million years)
Fossils become part of Earth itself	200,000,000 (200 million years)
Tectonic Plates and the Movements of Continents	Continues to this today
Great Forests that Became Coal	358-289,000,000 (358-289 million years)
The Evolution of Life and the great extinctions	Ongoing
First animals on land	20-18,000,000 (20-18 million years)
The time of the dinosaurs	245-66,000,000 (245-66 million years)
Evolution of mammals & birds	65-53,000 (65-53 thousand years)
Hominidae, our ancestors	55,000 (55 thousand years)
Evolution of humans	11,000 (14-11 thousand years)
Modern humans	10,000 years to the present

PART TWO

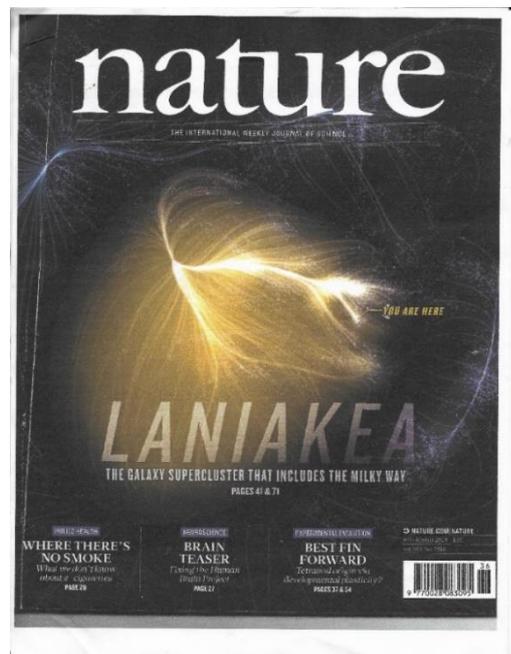
THE HUMAN IMPACT

The Progression of Evolution
The Proof that all Living Organisms, Including Humans are Related
Human Dominance on Earth
Food Shortages, Famines, Plagues and Wars
Half of the World's Population Live in Cities
Destruction of Forests, a Modern problem
Pollution of Earth and the Atmosphere
The Evolutions of Humans
The Near Future
The Human Population Explosion
Prosperity without Growth
Final observations

PART ONE

The Birth of the Sun.

The Sun became a fiery ball 460 billion years ago and is one of the smallest and brightest stars in the Milky Way, our galaxy of a hundred billion stars situated on the edge of the Laniakea Supercluster of stars, that has billions of Galaxies on one side, and a relative void on the other, as illustrated on the cover of Nature presented below. (*Nature Journal of Science*, 4th Sept. 2014. Vol 513. No. 7516.)

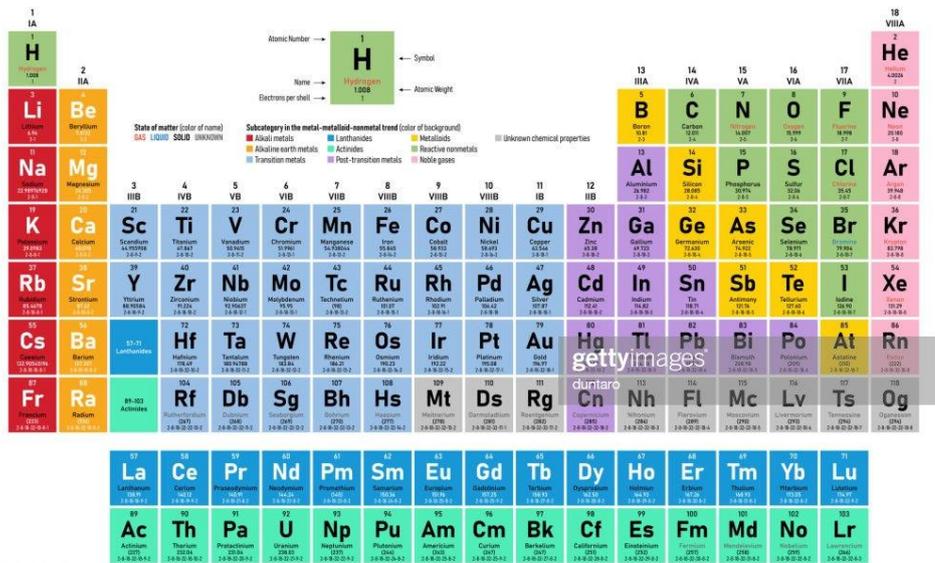


Our Sun, as with all-stars, condensed from a cloud of stellar dust, which was the debris from earlier stars that had died and disintegrated. This stellar dust gradually coalesced to reignite as our fiery Sun, with the planets of our universe circling around it. All stars are nuclear reactors, powered by fusing hydrogen into helium, then into carbon and oxygen and to a lesser extent all the rest of the elements shown in the periodic table below. These same elements are the substance of all stars and planets, throughout the Universe. The distance of Earth from the Sun is ideal, for it is the only planet in our solar system where water is found in all its states. These are as vapour in the atmosphere, as a liquid and as ice. The planets nearer the sun are dry and those beyond us are frozen and uninhabitable. In the future it might be possible for a small group of humans to survive on Mars, but that is unlikely.

The nearest star to the Sun is a red dwarf called Proxima Centauri four light-years away. This is the time it takes for a ray of light to reach Earth from over forty-billion kilometres away. These distances are so enormous that the human mind has difficulty in comprehending them, so in reality there is no possibility of humans reaching another solar system let alone one that could support life.

All living creatures that ever existed are on Earth, for no signs of life have yet been found in the cosmos and if space travel were ever possible it would take an unimaginable number of generations of humans before it could be reached. So, it essential that we look after our own planet. In antiquity, the Ancient Greeks thought that the sun was eternal, modern astronomers have calculated that another four-and-a half-billion years will pass before it fades. *Wonders of the Universe, By Professor Brian Cox, Harper Collins 2011.*

Periodic Table of the Elements



These elements are the substrate of the cosmos including all life on Earth.

Earth and the Moon.

Earth changed from a rocky mass to a fireball four-hundred-and-fifty billion years ago. It travels around the Sun in an elliptical orbit that averages 150 million kilometres away from it. Earth is two-thirds the age of the Sun and initially developed from rocks that coalesced, generating heat to become a fireball. Later another protoplanet crashed into it. This collision split the protoplanet into two, one half increased the size of the Earth and caused it to spin. The smaller portion became the Moon, circling Earth as its satellite planet. The Moon does not spin and always shows the same side towards Earth.



Above left there is a picture of the moon as seen from Earth, always showing the same side. Above right. Our beautiful spinning blue planet, photographed from 'Apollo 11 as it travelled towards the Moon on July 16th. 1969. (Pictures by NASA, The United States of America).

As the outer layer of lava on Earth's surface began to cool, areas hardened into a solid crust, forming the early proto- continents. As the number of volcanos decreased, those remaining have continued to spew molten lava. Earth's atmosphere was initially without oxygen, and this was the time that water precipitated to form the oceans.

The First Living Organisms.

It is not known how the first single celled organism evolved from inorganic matter and this will remain a mystery. The earliest living cells that have been identified, originated about 370-billion years ago and were the first fossils found in the oldest rocks on Earth. These simple life forms fed on carbon compounds in the early oceans. Over time, they evolved to photosynthesise, using sunlight, water, and carbon dioxide to produce oxygen and energy in the form of sugar. This was when oxygen accumulated in Earth's atmosphere for the first time.

Later, Stromatolites, as shown in the picture below, spread in the oceans and formed the first reefs. They consisted of colonies of single celled organisms living on top of on their dead forbears, hence the development of the structure on which they rest as shown in the photograph below. Stromatolites still exist on the Atlantic coast of Australia and elsewhere.



Stromatolites.

www.dmp.wa.gov.au >

Evolution of Multicellular Animals.

In 1886, the fossilised remains of the earliest and tiniest multicellular animals were discovered in a quarry in Canada. They had lived between 541 to 485 million years ago and were embedded and compressed in shale, a sedimentary rock that originally had been mud. Splitting open the shale revealed fossils of complex animals that indicated a great leap forward in life on Earth when compared to the first single celled organisms. For they were the ancestors of all subsequent animals that have evolved over millions of years to produce many distinct species, including humans. The proof of this ancestry is explained in Part Two of this essay.

(Geologic Time Scale by Wikipedia).



The animal above is less than a centimetre in length and was fossilised in a shale deposit in Canada, dating to the Cambrian Era, 541-485 million years ago. It is one of the oldest animals discovered and its bodily segmentation with multiple legs was typical of these early creatures.

Fossils become part of Earth itself



Photo by permission of Mrs Sara Maybury.

Half a million years ago, the fossils in the polished stone above, lived in the sea. These specimens were excavated from a quarry in Somerset, in the South of England. Land is not static on Earth and moves slowly. An example of this can be seen in the chalk cliffs, in the photograph below. These white cliffs consist of tiny shells that drifted down to the sea floor as their inhabitants died in their unnumbered trillions. This took place in warm seas to the south, 100 to 65 thousand years ago. As they died, the shells came to rest on the seafloor and formed chalk deposits up to a hundred meters deep. This seam of chalk was pushed up from the sea floor to expose the white cliffs formed from these shells. This demonstrates that the shells of these tiny sea creatures are now part of the fabric of Earth itself.



The white chalk cliffs shown in the photograph above are the ‘Seven Sisters.’ Looking westwards, beyond the cliffs is Seaford Bay with Brighton City in the distance. The cliffs are composed of trillions of shells of coccoliths, tiny sea creatures, which lived and died 65 to 100 million years ago. Their empty shells came to rest on the warm tropical seabed of that time, to form chalk deposits seventy to one hundred meters deep. It is remarkable that the tiny skeletons made by living creatures have become part of the actual structure of Earth itself. Photograph by the author.

Tectonic Plates and the Movements of Continents

We now return to earlier times, as fiery Earth began to cool, tectonic plates the earliest landmasses drifted on Earth’s red-hot lava. When two of these plates collided, the edge of one was pushed under the edge of the other and returned into Earth’s molten mantle. The overriding plate buckled upwards under immense pressure to create the first mountain ranges. The mechanism causing the movements of tectonic plates is unknown. However, the best examples are the development of the Rocky and Andes Mountains of North and South America. For the North and South American tectonic plates crashed and slid under the Pacific Oceanic plates. The immense pressure caused the edge of the Pacific oceanic plate to be pushed upwards, over the American plate, causing it to buckle, then as it rose it became the magnificent Rocky Mountains in the north and Andes in the south. This mechanism explains how seashells, formerly on the floor of the Pacific Ocean are now found at the top of these Mountains. The same process happened later, when the Indian tectonic plate crashed into the Eurasian land mass to form the Himalayas the highest mountains in the world and then the same process took place when Africa drifted north to collide with Europe, causing the Alps to be raised.

The slow movement of the great continents over the surface of Earth continues to this day. Early in the 20th century, the British Isles and Europe on the eastern side of the Atlantic, and the United States of America on the western side were discovered to be drifting apart by ten centimetres a year. This does not seem much, but over geological time, these small movements of the continents are significant. The Mid Atlantic rift is where the gradual separation of the continents has split the Atlantic Ocean plate from north to south, resulting in a line of new underwater volcanoes as the East and West Atlantic plates drift apart. As a result, the mountains will continue to be elevated along the western seaboard of the Americas, with repeated earthquakes until they no longer push against each other. Meanwhile tectonic drift will continue to slowly move the land masses around the surface of Earth.

Great Forests that Turned into Coal.

Great forests of primitive trees grew across the world three-hundred-and fifty million years ago. An artist's impression of such a forest is seen below. The forests covered the continents during the warm damp climate that then existed during the Middle Devonian Period. As trees died generation after generation during sixty-nine million years, their weight compressed the wood to fossilise them into coal.



An artist's impression of the early forests that became coal.

Two hundred and eighty million years later, the Industrial Revolution began in England in the 1760s. It rapidly gathered momentum and needed a source of fuel to boil water, to produce steam, that under pressure would power the new machinery of that age. As industrialization spread to other countries, ever increasing volumes of coal were mined. The burning of coal to power the machinery of industry, continues across the world to this day.

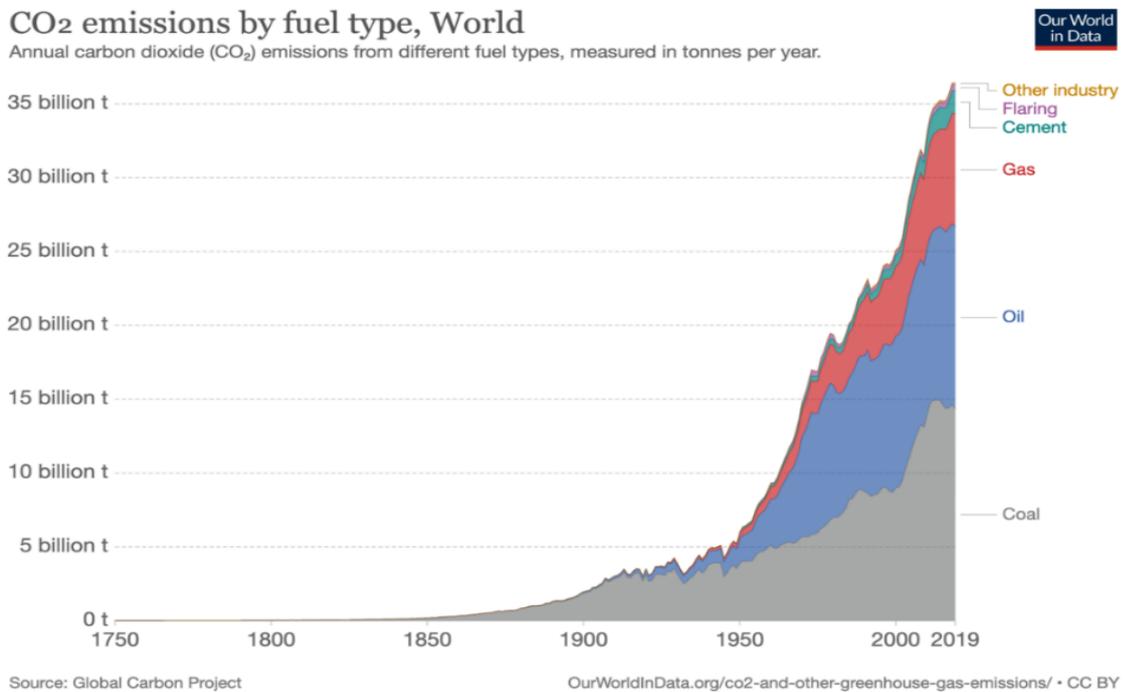
This explains how and why a great portion of the coal laid down sixty-nine million years ago are now ashes, having fuelled the industries of civilization. This has taken place during only three hundred years and during this brief time trillions of tons of coal has been burnt, releasing a similar volume of carbon dioxide (CO²) into the atmosphere. CO², with other toxic airborne components, derived from burning coal, have collected in Earth's upper atmosphere. There, the accumulating carbon dioxide creates a barrier preventing the previously normal radiation of Earth's heat into space by reflecting it back to Earth. This is important, because too little CO² in the stratosphere around Earth causes the world to freeze, while too much causes Earth to overheat.

In 2022 a heatwave in England recorded the highest temperature ever recorded at 39.1 degrees centigrade. Atmospheric heating has also caused the polar icecaps to melt, and the effect is measurable. For, on the nearest land, the Arctic tundra, the white spruce trees, 'Picea glauca' are now seeding and advancing in the

direction of the North Pole at the rate of four kilometres every ten years. This confirms that the surface of Earth is becoming hotter, as illustrated in the next chart. The rising temperature has also led to great storms and an increase in forest fires in recent years.

Industrial processes are beginning to be powered by nuclear, solar, and wind power, in the place of coal. Britain has commissioned fifteen small nuclear power installations to supplement the large nuclear power stations already functioning. The United States of America in 2021 was producing 20% of its electricity from coal, after reduced it from 39% in 2014. China is building nuclear power stations, but it will be years before they are functioning. Meanwhile, commissioning new coal burning plants continues. The result is that carbon-dioxide pollution of the atmosphere will increase for decades.

Professor Lord Martin Rees of Cambridge University, in his book ‘On the Future Prospects for Humanity’ is pessimistic and confirms that decarbonising industry will be slower than anticipated, as carbon will continue to be the principal source of power world-wide for many years. The diagram below shows the increasing level of carbon dioxide in the atmosphere up to 2019. The ongoing switch to solar power is encouraging, however it will be many decades before the increasing pollution of the atmosphere can be controlled.



The diagram above illustrates that less coal was burnt, between 2014 and 2019 in the most populous countries in the world. However, oil, gas and other flammable substances have been burnt instead, resulting in even more carbon being released into the atmosphere and so further increasing global warming.

The Evolution of Life and the Great Extinctions

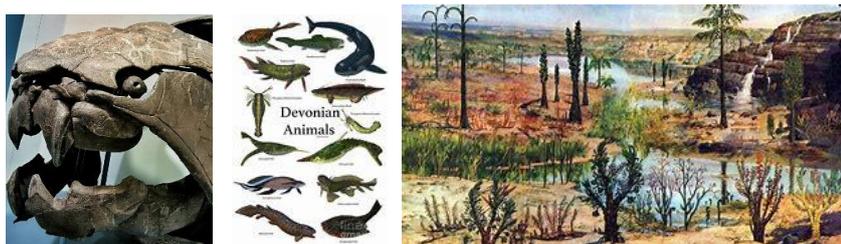
More than ninety-nine percent of all living organisms that have ever lived, excluding humans are now extinct. Once life was established on Earth, each period, going back millions of years, has ended in a mass extinction of most of life on Earth caused by different catastrophes. The exception is the current period, the Holocene dominated by humans. At the end of each of the earlier Periods, the organisms that survived passed on their DNA to their offspring. So over thousands to millions of years species gradually mutated to differ from their forebears. The major periods of near extinction of life on Earth are briefly presented below.

The first was during the **Ordovician-Silurian period**, beginning 440 million years ago. It was at the end of this period that 86% of all species died. This extinction event occurred when carbon-dioxide was virtually removed from the atmosphere by the great forests of trees that then existed. Then the lack of carbon-dioxide in the atmosphere caused Earth's heat to radiate into space, causing the temperature on Earth to fall to freezing, leading to an ice age, during which the oceans fell to their lowest level. The 14% of organisms to survive this mass extinction lived in the narrow ice-free belt round the Equator.



Seen above are typical examples of life forms that existed during the Ordovician-Silurian period.

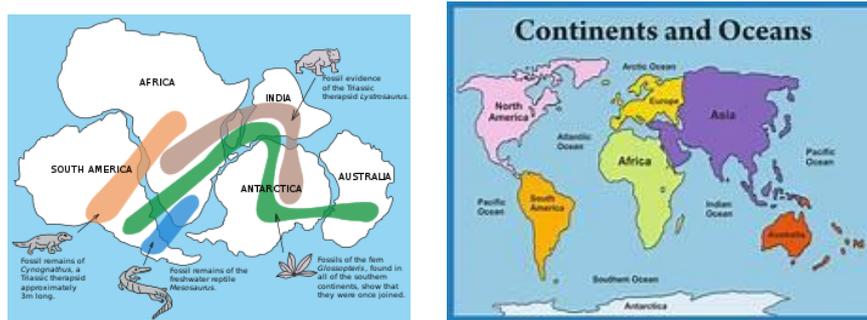
The **Late Devonian Period** followed about 364 million years ago, when the atmosphere lacked oxygen. This caused the nutrient rich water to bloom with algae, that in turn eventually depleted the seas of life and precipitated another massive extinction, causing 75% of species to die.



However, the animals and landscape during the early part of this period developed significant evolutionary advances, compared to the earlier Ordovician-Silurian Period

The **Permian–Triassic Period**, began 250 million years ago and lasted 110 million years. During this period life again evolved in abundance. This was when bacteria began to emit methane into the atmosphere, causing Earth to warm, and the oceans to rise with the melting of the ice, it also became acidic. In the first part of this period marine life of great complexity evolved. However, it ended in the greatest mass extinction event when 96% of all species died, caused by massive volcanic eruptions that filled the atmosphere with carbon dioxide.

Then came the **Triassic–Jurassic Period**, 214 million years ago that lasted for 135 million years. The diagram below on the left shows the separation of the great southern continent of Gondwana into the recognisable continents of today. This lengthened the coastline by fifty percent enabled colonisation by animals and plants to gather pace.



The diagram on the left above shows Gondwana, the great southern continent as it divided into separate continental plates. The diagram on the right is familiar and helps us understand how the continents following the division of Gondwana divided and moved to their current positions around the world. It was during this period that the dinosaurs evolved and reigned on Earth. They died after an asteroid hit Earth, causing the atmosphere to be filled with dust, blocking out the sunlight and causing floods and volcanic eruptions that were followed by the extinction of 96% of marine creatures and 70% of terrestrial life, including the dinosaurs and many of the early insects.



A selection of the animal that evolved and lived in the later Triassic period.

The **Cretaceous–Paleogene Period** began 65 million years ago when mammals evolved following the extinction of the dinosaurs. These ‘rat sized’ warm blooded creatures left their burrows and over millions of

years evolved into many distinct species, included mammoths, woolly rhinoceros's, giant beavers, giant ground-sloths, sabretooth tigers and giant armadillos and more. They were the megafauna that populated the planet until about 10,000 years ago, when they became extinct following the struggle for existence with early humans.



Eight-foot high Glyptons.



Sabre toothed tigers.



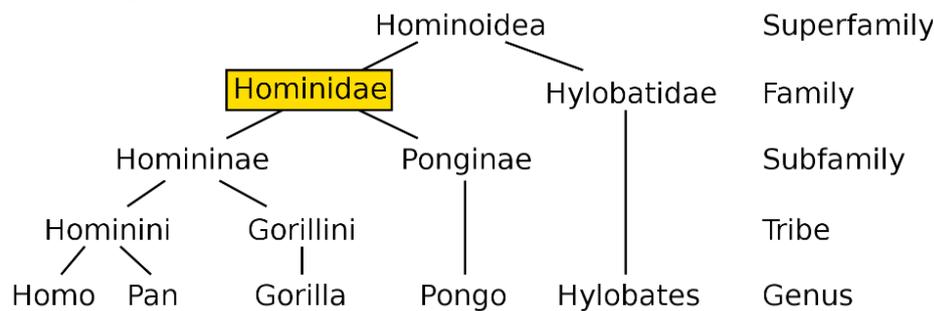
Giant Ground Sloth.

At this time bacteria began to emit methane into the atmosphere, causing Earth to warm, and the rising oceans to become acidic and marine life of great complexity evolved, as did birds from dinosaurs. The evidence for this was found in China, where the last of the dinosaurs grew some feathers and as land animals they did not fly, although their descendants did evolve into birds. It was also at this time that flowering plants evolved.



A pterosaur in flight.

In the same period bacteria began to emit methane into the atmosphere, causing Earth to warm, and the rising oceans to become acidic. It was during the first part of this period that marine life of great complexity evolved. In this same period 55,000 years ago, the Hominoidea evolved and were the common ancestors of all primates, including early humans as shown in the diagram below. Also in this group are Pan, the chimpanzees who are human's closest relatives; Gorillas are next; followed by Pongo that evolved into orangutans that are more distantly related to humans.



Homo is short for Homo sapiens, the Latin name for humans. Pan are chimpanzees, their full name being Pan troglodytes. The official Latin name for a gorilla is 'Gorilla gorilla.' Pongo (or orangutan) developed two subspecies, 'Pongo abelii' that live on the Island of Sumatra and Pongo pygmaeus that live in Borneo. Hylobates or tree monkeys are forest dwellers.

It took more than fifty-four thousand years for Homo to evolve from apes to become recognisably Human and in modern times we have given ourselves the Latin name 'Homo Sapiens' loosely translated as 'Wise or Knowledgeable People,' who began to make a significant impact on Earth 14,000 to 11,000 years ago.

Their impact began with the extinction of Mammoths in northern Russia, caused by climate change and human predation. The same applies to the extinction of the giant woolly rhinoceros, which died out about 14,000 years ago. Giant beavers, the largest rodents ever to exist were hunted to extinction by the Clovis people about 11,500 years ago, who were also the first humans to settle in the Americas. The pattern of extinction continued with Giant ground-sloths, Sabretooth tigers and Glyptodons, the massively armoured and tank sized forebears of modern armadillos, all became extinct at the hands of hunters.

Modern humans evolved about 10,000 years ago. This seems a long time, but if we imagine a clock measuring time in billions of years, starting with the first single celled organisms, then humans have only evolved one or two seconds before midnight. Our ancestors advanced from hunter-gatherers to farmers and later to become city dwellers, where most people live in the 21st century.

Although humans have been the dominant species on Earth for 10,000 years, it is only in the last three hundred years that they have physically change the face of Earth. This began when the power of steam was harnessed, causing the industrial revolution. This was later followed by the discovery of electricity then by nuclear power. This was the golden age of science and engineering.

Among other discoveries, were the number of species of bacteria and viruses that cause diseases that are now preventable. Also, from the middle of the twentieth century antibiotics have been available, these and other discoveries have resulted in most humans living longer than ever before. The greatest challenge now is the impact of humans on Earth, for in 2022 there were eight billion. The question is whether the human population will stabilise, or will increase, leading to the inevitable extinction of elephants, armadillos, lions, and cheetahs and not forgetting many species of insects that are at risk of extermination by insecticides.

The production of food in the United Kingdom for example, has reached the point where ninety percent of the arable land suitable for farming is already growing crops, leaving only a small margin for further expansion. The ten percent of uncultivated land is mostly of a poorer quality.

Photographs taken from space show where the world lights up at night. The Eastern United States of America, Western Europe, including England, and Japan, are the most densely populated countries, judging from their use of electricity. They are followed by the rest of Western and all Eastern Europe, India, and the Philippines. The overall picture confirms the increasing extent of human domination of our planet. Africa and South America are hardly light up. This will change when Africa's population has doubled by the end of this century to reach eight billion people.

PART TWO

The Progression of Evolution

As recently as the mid-19th century, it was believed that the world and all living things were created six- thousand years ago. This began to change when Sir Charles Lyell (1797-1875), the most famous geologist of the eighteenth century, and author of '*Principles of Geology*' published in 1830, recognised that landmasses on the surface of Earth were in slow and constant movement and that earthquakes can cause huge movements of the land and seafloor. He was the first to discover why fossil shells that had lived in the sea were now at the top of the highest mountain ranges. Meanwhile the cause of earthquakes was not known.

Shortly afterwards, Charles Darwin (1809-1882), embarked in 1831 on a five-year voyage round the world aboard HMS Beagle. He was the naturalist on the ship, so while the Beagle surveyed the coastline of South America for the Royal Navy, Darwin went ashore to explore the land and study animals and plants. His discoveries included the ancient skeletons of animals that had lived thousands of years ago and were especially common in Argentina and Chile. After returning home to England, Darwin analysed his findings and after further research published '*The Origin of Species*' in 1859. The book was revolutionary, well-documented, and provided a new and entirely original framework to describe the course of evolution. Darwin's book ran through several editions. His discoveries had now disproved the earlier belief that the world was only six thousand years old.

Before his voyage, Darwin had calculated that six thousand years was too short a time for animals and plants to noticeably change and even less so during a human lifetime. For he had also witnessed, while exploring the west coast of South America, an earthquake, when the land rose six feet in as many hours. From this he understood that powerful geological forces could alter the landscape through repeated earthquakes and over thousands to millions of years could raise the shells of ancient and fossilized sea creatures from the seafloor to the tops of mountains, as has been noted. These findings, when combined with his study of the skeletons of gigantic, extinct animals in Argentina and Chile, confirmed his belief that Earth was of great age.

This showed that there was time enough, for the slow process of evolution to take place over thousands of years. He was the first to prove that all species including humans change and evolve over time. For humans have a short lifespan, compared to the slow pace of evolution over unimaginable lengths of time, for it is simply not possible for humans during their lifetime to observe evolutionary changes in nature.

Darwin knew that in nature, all animals and birds breed with their own species. He then used a device learned from pigeon fanciers, who demonstrated how birds can change dramatically in appearance from one generation to the next by crossbreeding different varieties, as shown on the next page. There the pigeon on the left is one of the wild species '*Columba Livia*' while the pigeons on the right are the offspring of a variety of domesticated, crossbred 'fancy' pigeons. This was the proof that species could change in appearance.

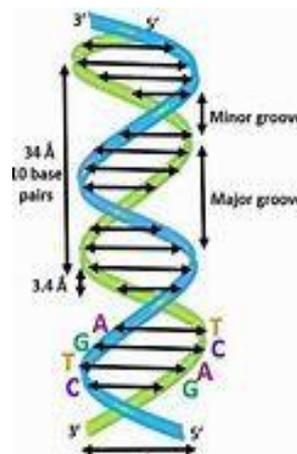
Darwin's thoughts, insights and intuition led to his discovery of evolution, making him one of the greatest scientists of all time



The Proof that all Living Organisms, Including Humans are Related.

In recent times it has been confirmed that all living organisms including, fruit flies, eagles, dinosaurs, and humans have evolved using DNA, the ‘tool-kit’ for the development of all forms of life. (The New Science of Evo-Devo. In Endless forms most Beautiful by Sean B. Carrol. 2005).

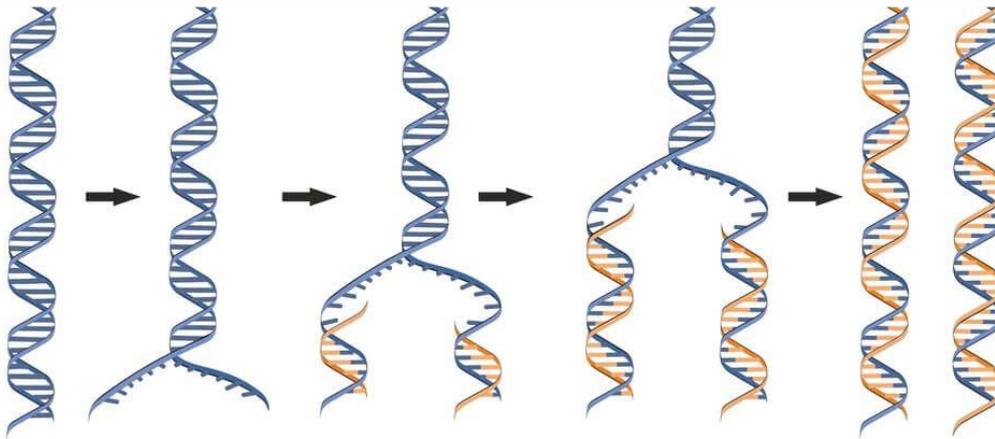
In 1953, Dr James Watson and Dr Francis Crick, at Cambridge University in England, identified the two-stranded double-helix of deoxyribonucleic acid, called DNA for short and illustrated below. For it shows both strands of the DNA helix are composed of nucleotides. These are the basic building blocks, common to all organisms. A different molecular patten of DNA has evolved for every organism and is carried on its helix. Each holds the biological information found in every cell, of that organism with specific information to reproduce itself. This applies for all organisms from bacteria to humans. These facts are the irrefutable evidence that the common origin of life began with DNA in single-celled organisms 63 billion years ago. All life forms known today have evolved from these organisms for they all possess the helix but have different attachments that defines each form of life, as illustrated below. Even viruses have attenuated DNA that can invade animal and plant cells, using the mechanisms of the cells invaded to replicate themselves into millions more of their kind. (Wikipedia).



The form of the double helix shown above was first understood and unravelled by Watson and Crick, who demonstrated the interlocking of DNA molecules, to form two strands connected by hydrogen bonds twisted helically. This framework is the basis of all living organisms. (www.biologydiscussion.com/dna/watson-and-cricks-model-of-double-helix-of-DNA-biochemistry/6507)

When a helix replicates itself, the information stored on it is copied as its two strands separate in opposite directions. This leads to the formation of two new helices as shown below. Each of them then forms a new cell. Every strand of DNA has attached to it four building blocks called nucleotides. These are – cytosine (C), guanine (G), adenine (A), or thiamine (T). These have their place in the DNA of the double helix and their arrangements differ for each species whether a single-celled organism, or a multi-celled one.

The diagram below, shows each polynucleotide chain uncoiling to form two separate identical double helices. These new helices store the same biological information.
(Wikipedia)



This discovery led to studies of the development of the different body parts to be found in animals as diverse as fruit flies, eagles, dinosaurs, and humans, who all started life using the same genes, or ‘tool-kit’ in their DNA, although all different forms of life have a different order in the attachments to their DNA. (The New Science of Evo-Devo. In Endless forms most Beautiful by Sean B. Carrol. 2005).

Humans possess over 25,000 genes in pairs following fertilization of an ovum by a sperm. These are the building blocks for the whole body. Chimpanzees share ninety-nine percent of the same genes as humans, while mice have slightly fewer. The word gene comes from the Greek word ‘genos’ meaning a group of people of the same family and with the same name and can be applied to the development of all living creatures.

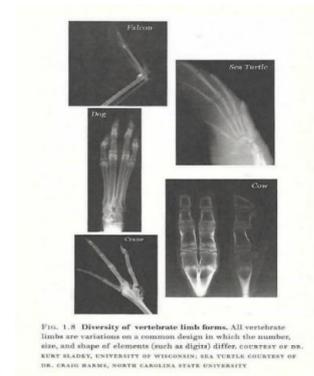


FIG. 1.8 Diversity of vertebrate limb forms. All vertebrate limbs are variations on a common design in which the number, size, and shape of elements (such as digits) differ. COURTESY OF DR. KEVIN BLAKES, UNIVERSITY OF WASHINGTON, SEA TURTLE COURTESY OF DR. CRAIG WARRIS, NORTH CAROLINA STATE UNIVERSITY

On the left is an X-ray of a human hand. On the right are x-rays of the digits on the fore limbs of different animals that are comparable to the human hand. It illustrates diversity, yet similarity, from their common origin as vertebrates.

Evolutionary changes take place in an organism when a tiny section of its DNA alters from that of its parents. Such a change is rare and occurs only when an error is made as a gene replicates itself, resulting in a single letter changing on the genetic helix. If this change is not compatible with life, the foetus does not survive. However, if the change is advantageous the organism survives. An example could be the development of a slight lengthening of the legs for example.

Such a change will enable that animal to run faster than its peers and make it more likely to escape predators, while the shorter-legged herd members are more likely to be caught. Even a slight change in leg length gives the owner of that genetic change an advantage. For some of its offspring will inherit the longer legs and over time are more likely to survive than those with shorter legs, who being slower are more likely to be caught by predators. The same type of process applies to all body parts.

These unexpected and occasionally useful changes in the DNA take place over hundreds to thousands of years, as can be seen in the timeline of the genus homo, as early ape ancestors evolved separately into humans, chimpanzees, gorillas, and monkeys.

The large brain, in relation to body size, has resulted in humans becoming the dominant form of life on Earth. Despite this we are still part of and will remain dependent on Earth's ecosystem for food and all the other necessities of life.

Another insurmountable consideration is that only Earth is habitable. Therefore, without other habitable planets in our solar system, coupled by the impossibility of reaching unknown planets like Earth, if they exist in distant galaxies, means we must take more care of our own planet, for we now know about the great extinctions in the past.

Debate among the scientific community tells us that Earth is now in an era of mass extinctions caused by humans. The world is officially in the Holocene or new era. However, many scientists prefer unofficially to emphasise humans' impact on Earth's ecosystems by renaming it the Anthropocene Era, which translates as the 'Age of the Man' because of human dominance of the planet.



This photograph shown the atomic bomb explosion on Bikini Atoll in 1946. It demonstrates the extraordinary destructive power humans now possess. (Photograph by the United States Navy.)

It is also true that plants and animals are becoming extinct at a faster rate than expected because of the impact caused by the rapid growth of the human population. The burning of fossil fuels has steadily increased and has triggered the warming of the world's climate, as the density of CO² in the atmosphere increases.

Human activity has also increased the extinction of other species, ten to a hundred times faster than would have happened in the past. The evidence now shows that Earth is already in the 6th mass extinction period, caused by the growing human population that displaces other creatures.



The picture above demonstrates the impact of the world becoming warmer.

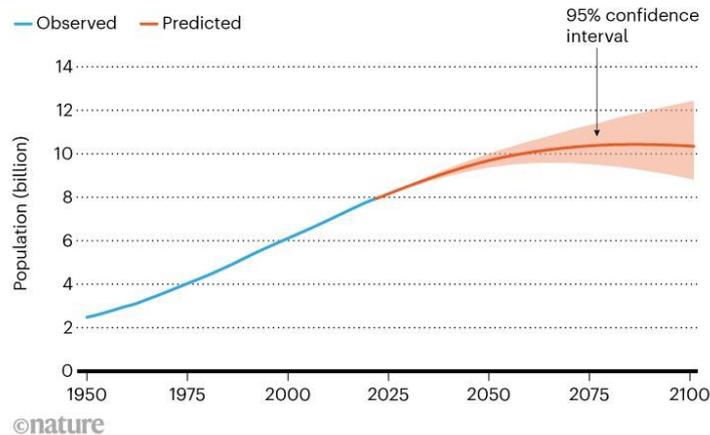
The Human Dominance of Earth.

The first multicellular creatures discovered, lived during the Cambrian Era, one thousand-seven-hundred-billion years ago and despite the repeated mass extinctions on Earth, some living organisms have always survived to pass on their DNA. It was ten-thousand years ago that our ape ancestors evolved into recognisable humans, when large brains and the ability to speak.

Humans now dominate life on Earth. A thousand years ago the human population was less than half a million people, this has grown to 8 billion in 2022 and may increase to over ten billion by 2060. The population growth is slowing down, for in 2022 the populations of China and India, the two most populous countries in the world, have stabilised. But even when a populations birth rate has stabilised the population will continue to rise for some decades.

PEOPLE OF THE WORLD

The United Nations expects the global population to reach 8 billion this week, and 10.4 billion by 2100.



The Graph above was produced by the United Nations, who expect the population of the World to peak at approximately 10.3 billion in 2075. (Nature Briefing' on the 15th of November 2022).

Food Shortages, Famines, Plagues and Wars

Looking back at the history of population growth, it was in 1797 that Robert Malthus, an English clergyman, wrote an '*Essay on Population*'. He was the first to identify the imbalance between the constant tendency for populations to increase more rapidly than food can be produced to feed them. This imbalance, when coupled with crop failure and other disasters has frequently led to famine and starvation in the past. History also shows that humans have always fought amongst themselves, from the time of small tribes to the great Wars of the Twentieth Century, for death, food scarcity and starvation follow in the wake of war.



World War II. 1939-1945, strict food rationing was necessary. An example from the UK.

It is now time to look more closely at the greatest famines from 1783 to the present. Only famines with more than a million deaths have been recorded. Humans like all living creatures, must eat or die, and starvation has caused the deaths of millions of people as shown below

Famines

Dates		Deaths
1783-1784	India	11,000,000
1810-1811 & 1886-1889	China	45,000,000
1845-1849	Ireland	1,000,00
1850-1873	China, Taiping rebellion	60,000,00
1899	India	15,000,0
1876-1879	India/China/Brazil/N. Africa	15-19,000,000
1888-1892	Ethiopia	1,000,00
1896-1902	India	2,000,00
1907-1911	China	25,000,1918-
1919	Iran	2,000,0
1921-1922	Russia	2,000,00
1928-1930	China	10 to 20,000,00
1932-1033	Russia, St Petersburg	5-7,000,00
1936	China	2-3,000,0
1942-1943	China	2-3,000,000
1942-1943	Iran	3,000,000

1946-1947	Soviet Union	15,000,000
1967-1970	Biafra, Nigeria	1,000,000
1968-1972	Sahal, N. Africa	1,000,000
1974	Bangladesh	1,500,000

Plagues

Plagues are equally deadly as famines. Only plagues with a death toll of more than a million are recorded. Humans are now aware of the high death toll caused by Covid-19 that began in 2000 and has a death toll worldwide of more than 7,000,000 people and it still increasing. It is amongst the most virulent of epidemics.

Date	Name	Disease	Deaths
165 AD	Antonine	Plague Smallpox/measles	5-10 million
541-549	Plague of Justinian	Bubonic Plague	15-100 million
735-737	Japan	Smallpox	2 million
1346-1358	Black Death	Bubonic Plague	75-200 million
1519-1520	Mexico	Smallpox	5-8 million
1545-1548	Cocoliztli epidemic	Unknown	5-15 million
1576	Cocoliztli Epidemic	Unknown	2-25 million
1629-1631	Italy	Bubonic plague	1 million
1656 16.	Naples	Bubonic plague	1.25 million
1772-1773	Persian plague	Bubonic plague	2 million
1848-1860	Pandemic	Cholera	1 million
1889-1890	Pandemic	Influenza	1 million
1918- 1922	Spanish Flu	Influenza	17-100 million
1918-1922	Russia	Typhus	2-3 million
1957-1958	Pandemic	Influenza	1-4 million
1968-1969	Hong Kong	Influenza	1-4 million
1980-	Pandemic	HIV/aids	36,3 million
2020-2023	Pandemic	Covid-19	6,225 million

The Spectre of Famine rose its head a century and a half after Malthus, when Norman Borlaug an American working in Mexico, produced a new variety of wheat in the 1960s. It has a heavier head of grain on a

shorter and stronger stalk, enabling it to withstand damage caused by high winds, it is also more resistant to disease. These advantages dramatically increased the yield of wheat.



The grain was ready for distribution in 1963, so, when in 1965 India and Pakistan were on the verge of famine due to the failure of their crops. This put millions in danger of dying from starvation but were saved by Borlaug's variety of high yielding wheat, that when grown and harvested in those countries saved billions from starvation. Since then, Pakistan and India have grown enough food to feed their growing populations.

Borlaug's process was named the 'Green Revolution,' for which he received a Nobel Peace Prize. The strong stalks of Borlaug wheat stems were able to carry a heavier head of wheat than in the past.

Borlaug's new variety of wheat increased the yield dramatically from 600 to 2,700 kilograms per hectare. In parts of India, it is possible to grow two and sometimes three crops a year. However, this high yield is heavily dependent on fertilizer and currently the yield is falling. (Wikipedia).

Half the World's Population Live in Cities.

In 1900, London was the largest city in the world with five million inhabitants. Although it has grown to ten million, even larger and more populous cities include Tokyo-Yokohama with thirty-eight million, Jakarta thirty million, and then Delhi and Manila have their millions. At present one-hundred-and twenty-three cities have populations greater than three and a half million.

Cities can be good places to live if the inhabitants have enough food and access to clean water, and safe sewage disposal. At present all are reliant on electricity produced by burning coal. This is still common in China, the USA, and India. This reminds us that burning coal, starting with the Industrial Revolution is now responsible for 89 % of global warming.

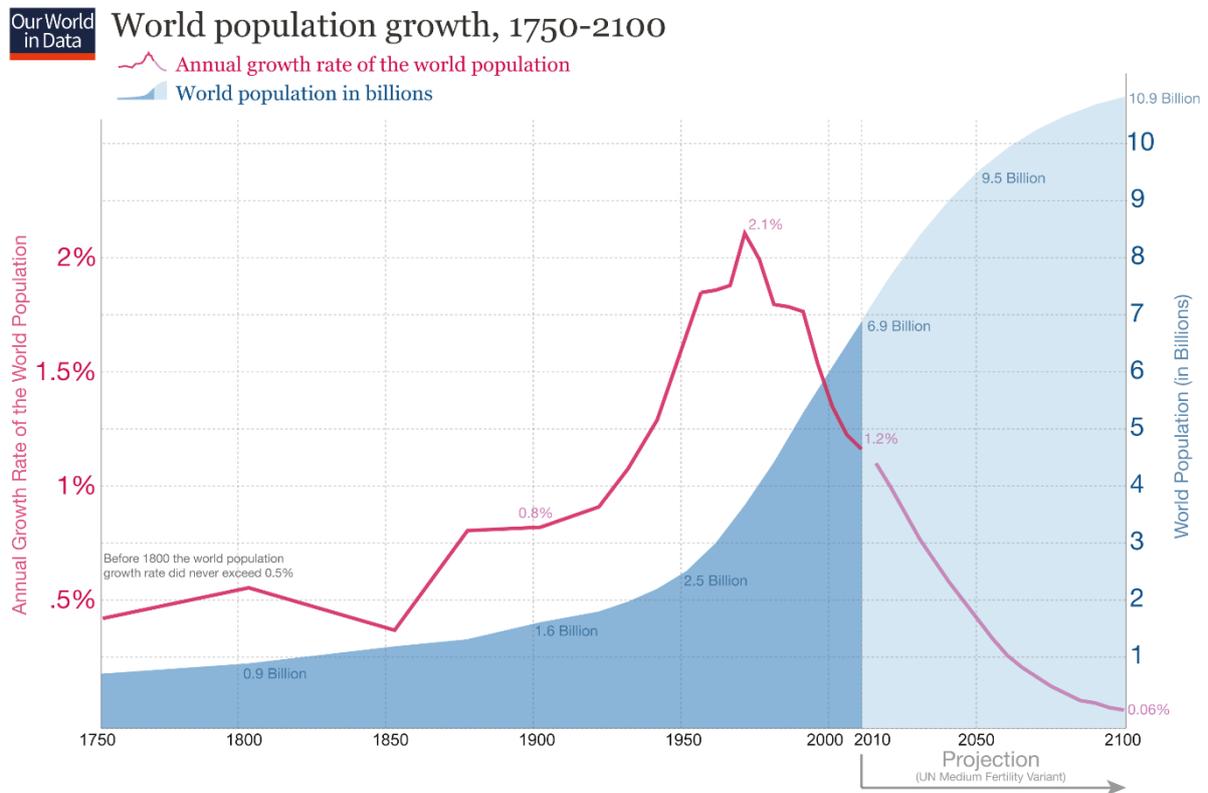
Medical care, especially immunisation, clean water and wholesome food have reduced infant mortality. This is a great good as is the availability and use of contraception to control a family's size. This advice is ignored in many parts of the world.

The figures below show the population growth in India following the introduction of the new wheat.

1960	500,000,000
2000	1,000,000,000
2022	1,393,000.000

An encouraging sign is that the birth rate in both India and China is falling. The population of China peaked in 2019 at 1,398 billion because millions of women are delaying having children while they work

outside the home. However, even when the birth rate of a country has stabilised, the population continues to rise as illustrated in the graph below.



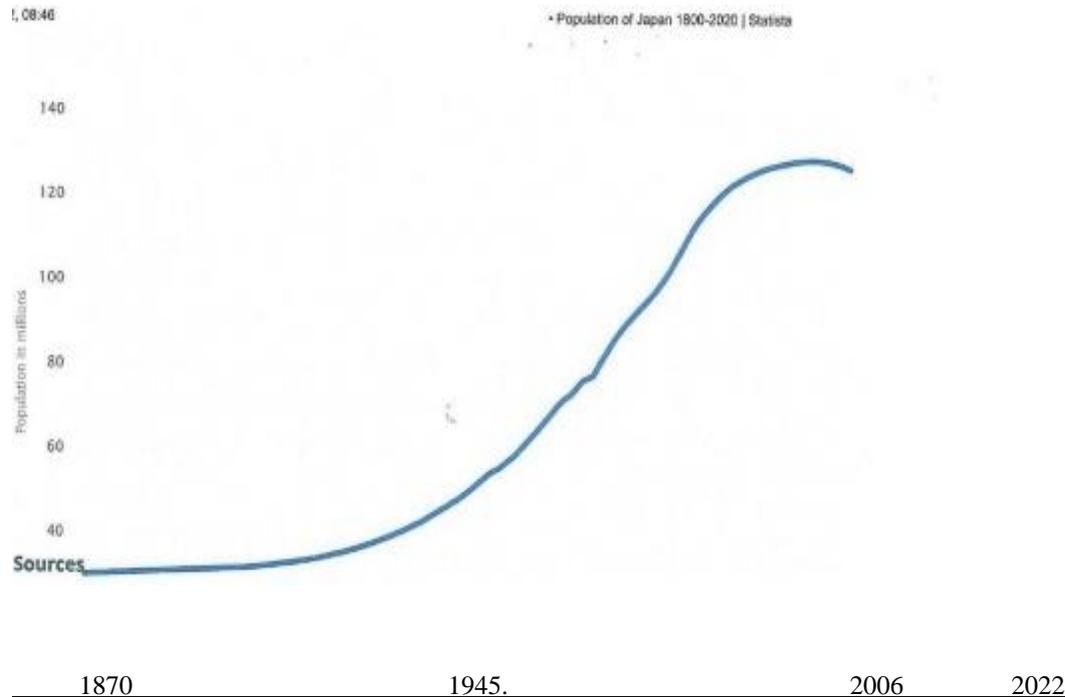
Data sources: Before 1940: Kremer (1993) – "Population Growth and Technological Change: One Million B.C. to 1990"; After: UN Population Division (2012), including population projection (medium variant). The data visualization is taken from OurWorldinData.org. There you find the raw data and more visualizations on this topic. Licensed under CC-BY-SA by the author Max Roser.

The red line in the graph above shows the annual growth rate of the population world-wide that peaked in the last century and is now in decline. While the actual population shown in light blue, will continues to grow to 10.9 billion people in 2200 and only then decline.

One nation, the Japanese, have deliberately and successfully controlled and reduced their population growth with the consent of their citizens. The 'Eugenics Protection Law' was passed by the Japanese Parliament at the end of World War II. This was necessary because five million soldiers and civilians had been rapidly repatriated, pushing the Japanese population close to starvation. The law permitted expectant mothers, with the consent of their husbands, to procure an abortion. A year later in 1949, 241,000 terminations took place, this number rose to over 1.2 million in 1955. Then in the following years, the number of terminations rapidly declined as effective contraception became available.

The Graph below shows that even when the birth rate was controlled, the population continued to grow from 77 million in 1945 to 127 million in 2006, sixty-one years after the passage of the law. Since then, the population has started to decline and there are now 125 million people. This illustrates that even after the birth-

rate has been stabilised, as shown in the graph below, the population continued to grow considerably before it peaked and is now gradually declining. There is no evidence that stabilising the population caused adverse problems, for the Japanese nation remain prosperous.



Populations 33 million. Birth rate control began at 77 m. It was controlled at 127m. & then declined to 125m.

This shows that it is possible to stabilise a population as demonstrated above. This stabilization has given the Japanese people one of the highest standards of living in the world. Another factor leading to the decline in the Japanese population. Meanwhile, in most countries the populations continue to grow. These facts are not now discussed and are unknown to the media. However it proves that a population can be stabilised through birth control, but takes time.

On a different note, current Economic Theory encourages population growth. Because Economists believe the prosperity of a nation can only be achieved with ever-increasing populations as has taken place in the UK and many other nations. This Economic theory now runs counter to the current explosion of the world population, as the economists theories originated two centuries ago, when populations were small leaving room for expansion. For the current increase in the worlds population will only begin to decline in 2075 according to the United Nations. However there is less and less new land suitable for agriculture increasing pressure to cut down forests which would be disasterous.

The United Nations have recently calculated that the population of the world will peak at just over ten billion in 2075. Feeding this number of people will be difficult and there will always be a risk of famine.

Destruction of Forests, a Modern Problem

Massive deforestation of the Amazon rainforest, the largest forest in the world covers 2.72 million square miles, that was the size of India. Forest destruction will increase the CO₂ in the atmosphere and as a result increase global warming. Also being lost are thousands of species of wildlife that reduces the diversity of life on Earth. The rate of destruction is beginning to cause the Amazonian water cycle to fail.

Recently an inventory of the trees of the worlds was undertaken by the International Union for Conservation of Nature (IUCN), who organized the largest conservation assessment in their history. Hundreds of conservationists searched rainforests, mountains, and strife-torn regions to produce an index of the trees. By 2021 they had recorded 58 thousand -species, of which 17 thousand are threatened with extinction.



The photograph above of Mount Mulanje in Malawi was the only natural home of the cypress *Widdringtonia whytei*. Only seven mature trees remained. To conserve them, half a million seeds were sown, this is repeatable with other species. (Morgan Trimble/Alamy)

Pollution of Earth and its Atmosphere

Earth's surface temperature has been rising as carbon dioxide and other pollutants are accumulating in the upper atmosphere. To prevent this from becoming worse, we should switch where possible to nuclear energy, until clean energy sources are available. In 2022 only 10% of the world's electricity was generated by 440 nuclear power reactors. Many more will be needed for at least another generation before they can be phased out, when renewable sources of energy replace them. People's fear of nuclear power disasters is concerning, however to date, the worst nuclear leaks were on Long Island in the USA, Chernobyl when it was part of the Soviet Union and is now in Ukraine, and in Japan.

In the USA and Japan there were no deaths. In the Soviet Union, at Chernobyl, over sixty people died. Their deaths were a tragedy, but in the same decade, the death toll in coal mining was over fifteen hundred or more. The diagram below shows all the sources of power used to generate electricity in 2019 and confirms that there is still a long way to go, before all the nations of the world have clean energy.

The sources of power in 2019.

- 36.7 % Coal
- 23 % Gas
- 16 % hydro-electric power
- 10 % Nuclear power
- 8 % Solar, Wind and Tidal Power
- 8 % Oil
- 2 % Other sources.

From the list above only hydro-electric power, nuclear power, solar, wind and tidal power produce clean energy. So only 34% of clean energy sources are presently functioning. There is much to be done before polluting energy sources can be eliminated. Meanwhile human waste causes massive pollution on land and sea as illustrated below. The Pollution of Earth has been growing steadily due to throw away plastics and other rubbish.



The photograph on the previous page, gives a glimpse of the millions of tons of plastics and other rubbish that ends up in the River Ganges in India as it flows to the ocean. Also shown is a poor scavenger searching for something useful. (www.theguardian.com)

Millions of tons of rubbish, including billions of plastic bags are dumped into the rivers and seas annually. Once in the sea, much of the plastic breaks down into molecular-sized particles, which are eaten and absorbed by fish, resulting in their being incorporated into their organs and tissues. When fish that have absorbed plastic molecules are eaten by humans, they become part of the human food chain. While plastic was the miracle of the 1950s, it is now a danger to us although to what extent is unknown.

The Evolution of Humans.

The evolution of humans is extraordinary, for as a species humans differ from all other animals including our ape ancestors in being able to talk lucidly and think abstractly. These abilities represent the most significant evolutionary advance in the chain of life from which we have evolved.

The progress of humans can be illustrated by the discovery of the world's oldest city, Catalhoyuk, discovered in the last century in modern Turkey and was inhabited 10,000-years ago. All the houses were underground and entered from a small opening in their roofs. The smoke from their fires also passed through their entry and exit in the roof. The excavation of such a house, is shown below, as is the statuette of their mother goddess.



As already mentioned, Earth itself was little disturbed by humans until the 'Industrial Revolution' that in the 18th century when fossil fuels, initially coal, began to be burnt in quantity. This released CO² into the upper atmosphere, where it created a barrier, preventing the heat from Earth drifting into space, so causing the present global warming. Fossil fuels are now very slowly being replaced by, solar, wind and nuclear power. This change has stalled for the present, for at the last 'Meeting of Nations' in 2022, the delegates could not come to an agreement and any action was deferred.

The Near Future.

However, efforts to ameliorate global warming have begun by building more nuclear power stations to develop clean electricity. The use of electric cars is already taking place in the USA. In time they will be

standard world-wide and exhaust emissions from cars will fall to zero. Meanwhile unfortunately, diesel will still fuel farm machines, trains, and ships, for it will be difficult to convert these to alternative clean power easily.

The combination of human activities, specifically mining and burning fossil fuels on one hand, combined with the rapid rise of the population, expected to peak at 9 to 10 billion people by the end of this century on the other hand the current pollution of Earth has steadily increased during the last 300 years. All the advances in technology already mentioned have contributed to our wellbeing, while many are at the same time detrimental to the wellbeing of Earth.

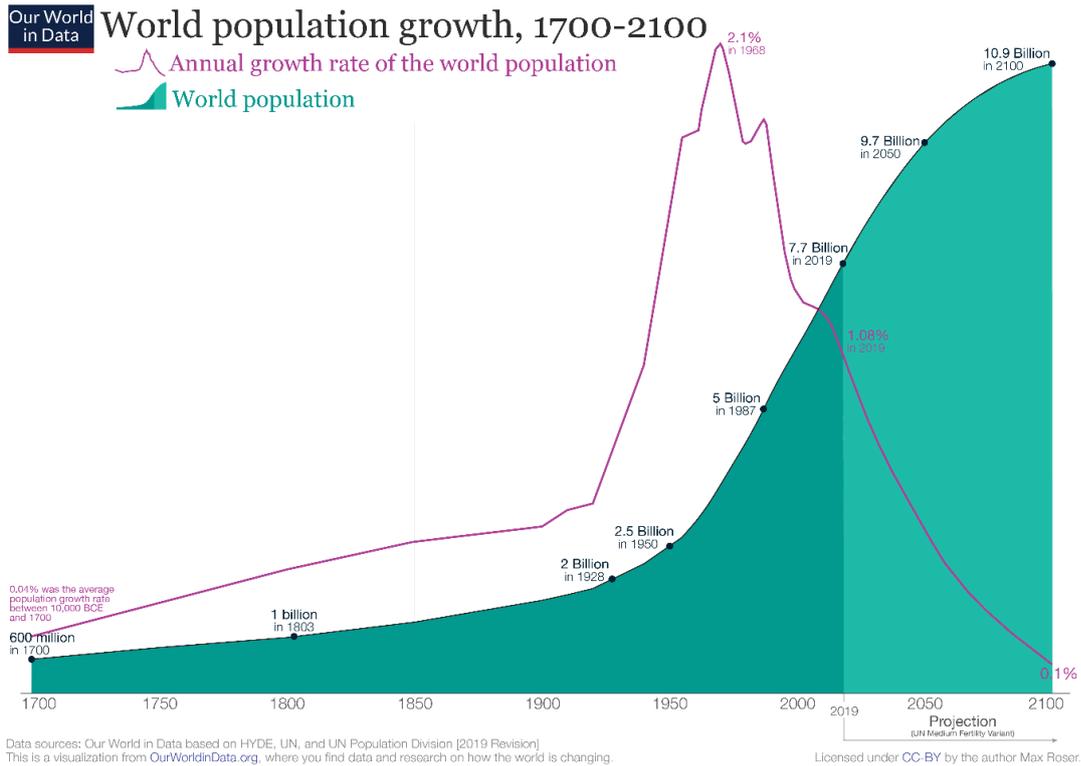
For human inventiveness has inadvertently led to trouble, by carelessly and unintentionally polluting Earth's seas, land, and the atmosphere. There may yet be time to prevent an increase of human pollution as solar and nuclear power are now increasingly available and expanding, while fossil fuel burning is beginning to decline. Once again, 'Action this Day', is urgently needed.

For our current aims may be achieved without conflict, for humans have always fought amongst themselves and between nations. Charles Darwin coined a phrase concerning wildlife, which can now also encapsulate human belligerence in '*The Struggle for Existence*'. What is extraordinary is that humans have become so powerful, that we are now in the 'Age of Man' designated as the 'Anthropocene' that acknowledges human dominance on Earth.

There is a warning, for when the 27th United Nations climate conference of 2022 ended. The final summary agreed to attempt to limit global warming to only 1.5 degrees above pre-industrial levels. To achieve this will require rapid, and sustained reductions of polluting gas emissions by 2030. The arguments among delegates failed to achieve an agreement over costs, so all decisions have been postponed, so pollution will continue.

The Human Population Explosion

We are now in 'interesting times' of uncertainty when the growth of the human population is accelerating. For the speed of change brought about by modern humans is accompanied by the population expanding to reach its greatest number at the end of this century. Details are in the graph below. It is expected that the world's population will peak, at the beginning of the next century, when there will be 10.9 billion people on Earth. This is an increase of a further three billion people above the population of 2019 as shown in the graph below.



It is now just possible that a population of about eleven billion people can live on Earth. This will create great challenges, one of the greatest being to prevent the great forests of the world from being cut down, for this would further pollute the atmosphere. At this stage in can be said, that Malthus's predictions of population growth outstripping the food available may take place with devastating results, so this must be avoided.

Prosperity without Growth.

The West has remained in an economic slump for some years, while Japan has prospered. Frank A Weil, an American economist visited Japan in 2022 and was surprised by their prosperity without economic growth. For Japan has for several decades has had high employment of its population who are 90% ethnic Japanese, for there has been minimal immigration.

Japan has long been considered an economic ‘basket case’ by some economists in the West because it manages its economy without inflation or by sacrificing stability for growth, an arrangement accepted by its citizens. Meanwhile, it must be noted that Western economists define economic success as involving everlasting growth. So how has Japan defied the odds and created its own steady prosperity in recent years, while avoiding the harmful excesses that come with the perpetual pursuit for growth that is the norm in the West. Savings in Japan are now strong, partly because they are free from worrying about paying interest to foreign lenders. So current Japanese success might stimulate constructive new thinking in the West, by the world's political and economic ‘gorillas’ and economists, concerning their fixation for the permeant necessity for growth in their economies. For the Japanese model underlines the view that perpetual economic growth as pursued in the West, is unsustainable and damaging to the planet. (Manuscript excerpts from Frank Weil, Chairman of Abacus and Associates, Inc., a private investment firm in New York).

In addition, ecosystems across Earth are being destroyed at an accelerating rate due to the stress caused by the increase of the world’s population. The life sciences are becoming the sciences of the dead with a million species threatened with extinction within decades. These include 10% of insects and 20% of plant species. Others not immediately threatened by extinction are in decline, caused by uncontrolled changes in land use, exploitative farming practices, overfishing, and fossil fuel emissions, all leading to extinctions of the creatures around us at an unprecedented speed.

These losses will accelerate climate change, for it is already know that greenhouse gas emissions from burning fossil fuels is rising and that deforestation continues. The latest report from the Intergovernmental Panel on Climate Change calculates that planet warming will exceed 2°C in this century and more recent estimates are higher. In addition, many places in the tropics have a strong possibility of being uninhabitable by humans over the next fifty years, creating swathes of the planet becoming too hot for humans. Should this happen, there will be mass displacements of millions of people. (Nov 7, 2022, <https://doi.org/10.7554/eLife.83292>).

Observations

So, what is to be done. In a quotation from ‘*On the Future Prospects for Humanity*’, Professor Martin Rees of Cambridge wrote: ‘Although we live under the shadow of unfamiliar and potentially catastrophic hazards, there seem to be no scientific impediment to achieve a sustainable and secure world, where we all enjoy a lifestyle better than those in the West today. We can be technological optimists, even though the balance of effort in technology needs redirection. Risks can be minimised by a culture of ‘responsible innovation’ especially in the fields like biotech, advanced ‘artificial intelligence’, and geoeengineering, and by reprioritising the thrust of the world’s technological effort. We should remain upbeat about science and technology – we should not put the brakes on new thinking and action.

As already noted, one of the greatest obstacles is that the Economy of all western countries is directed by professional economists, who for two centuries have dominated this sphere through their advice to governments at the highest level. The problem is that they believe in the everlasting growth of economies and populations to maintain prosperity. This might have been satisfactory in the 18th and 19th centuries but not now with the expected growth of the world's human population.

With hard-work, ingenuity, and goodwill, we must prove ourselves clever enough to avoid another great extinction event as has happened at the end of every Era in the past. With the world's population unchecked it can be expected that it will grow to ten billion people by the end of this century, after which it will decline. It will also involve significant changes in agriculture to feed the growing population.

There are signs of a shift in thought and ideas and action is being taken. Farming can concentrate on cereals and vegetables. Cars will be electric. Ships and trains will also need electric power produced by nuclear reactors in the first instance. Plastics will need to be phased out. There is much more to be done but with good will between nations this is possible. Intense farming was possible in the high Andes Mountains as shown by the terraces on mountain sides shown in the photographs below.

APPENDIX

On Farming. Copy the Incas in the Mountains of Peru,

Sacred Valley of the Incas, or Urubamba ion Peru. Further north, and higher up into the mountains from where our image was taken, stand the ruins of an ancient city. And while Machu Picchu is the most renowned cultural site in the region, the Sacred Valley of the Incas is full of other extraordinary archaeological sites and magnificent landscapes. Ollantaytambo and Pisac are just two of the valley locations with extensive Inca ruins.

Also called Urubamba Valley, the area's fertile soils have been farmed for thousands of years, and evidence of this is seen not only across the valley's small amount of level ground, but also quilted atop rolling hills, and even climbing the steep Andean foothills. These ancient hillside agricultural terraces are called 'andenes', and today are the most prolific physical evidence of the mighty Inca Empire. Could their farming of terraces be used once more.

Photos of farming in the Inca Empire could be copied on other mountains.

