WHERE DO WE COME FROM?
WHAT ARE WE?
WHERE ARE WE GOING?

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Contents

Chapter 1

GAUGUIN'S PAINTING AND QUESTIONS

1.1 The Bishop of Orléans' catechism

When he was between the ages of 11 and 16, Paul Gauguin[1] attended a Catholic boarding school in France. At the school, the Bishop Dupanloup of Orléans himself taught the class in liturgy. The bishop had devised a catechism in which three main questions were asked: "Where does humanity come from? Where is it going? How do we proceed?"

1.2 Gauguin's painting and attempted suicide

It is possible that these questions influenced Gauguin when, many years later, he began an enormous painting whose title asked very similar questions. By this time Gauguin had become an influential post-impressionist artist, the leader of the symbolist movement. Gauguin was admired by a small circle of artists but, like his close friend Vincent van Gogh, he was unrecognized by the larger public until after his death.[2]

In 1891, when he began the the huge painting, Gauguin was living on the island of Tahiti, where he had gone in search of a society free from European prejudices. Dogged by failing health and financial worries, he planned to commit suicide after finishing what he regarded as his best painting. He

[1](1848-1903)

[2]Gauguin's prices reached a new peak in February 2015 when the New York Times revealed that his Nafea Faa Ipoipo (Quand te maries-tu ?) had been acquired in a private deal for $300 million. At the time, the painting was part of a Paul Gauguin retrospective at the Beyeler Foundation. Sold by the artist for FF 500 in 1895, the painting suddenly became the most expensive artwork in the world!

did, indeed, attempt suicide by taking an overdose of arsenic, but the attempt failed, and he lived until 1903.

1.3 Answers from both religion and science

Gauguin's famous painting can symbolize the questions that humans throughout the ages have asked. Is there a purpose to life? What is our place in nature? Is the earth the center of the universe? What will happen in the future? Are humans special, or are the similar to other animals? Is human nature good or evil? Why do we sometimes act with loving care, and at other times commit genocides? Can war be eliminated?

Both science and religion have proposed answers to these central questions. Since I am a scientist, this book will approach the central problems of human existence by looking at the gradual development of scientific knowledge about our place in the universe. However, religious ethics have played an enormously important role, as will be discussed in Chapters 7, 10 and 11.

Most thoughtful observers today believe that human civilization is entering a period of crisis. As all indices move exponentially upward, including population, industrial production, scientific development and the power of technology over nature, the problem of achieving a stable and peaceful world remains serious, challenging and unsolved.

Can humanity and the biosphere survive the todays explosive growth of population and industry? Can we escape the twin threats of catastrophic climate change and thermonuclear war? Can we avoid a large-scale famine caused by population growth, climate change and the end of the fossil fuel era? Where do we come from? What are we? Where are we going?

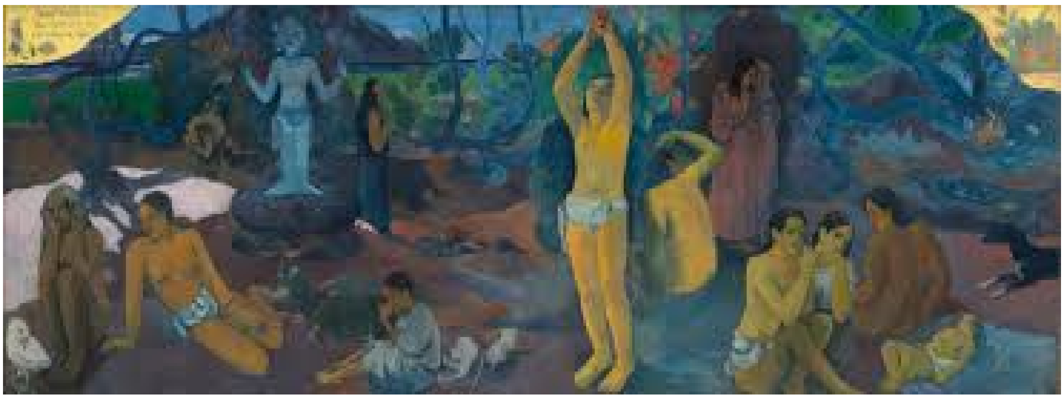

Figure 1.1: **D'où Venons Nous - Que Sommes Nous - Où Allons Nous.**

Figure 1.2: **Where do we come from?**

Figure 1.3: **What are we?**

Figure 1.4: **Where are we going?**

Figure 1.5: **Both religion and science have attempted to answer these questions.**

Figure 1.6: **A self-portrait by Gauguin with his painting, *The Yellow Christ.***

Chapter 2

LOST IN THE STARS

2.1 Introduction

From prehistoric times until the present, every culture has tried to explain the origin of the universe, the sun, moon and stars, and the earth, with its humans, plants and animals. In the earliest of these creation myths, imaginative poetical images predominate. The myths of creation were handed down orally, and to hold the attention of listeners, the stories had to be dramatic and entertaining.

Gradually, over many thousands of years, astronomy developed, and the earth began to loose its privileged position as the center of the universe. During the Hellenistic Era, (323 B.C.-31 B.C.), Aristarchus of Samos developed a sun-centered cosmology, which was forgotten during the Middle Ages, but rediscovered and further developed during the Renaissance by Copernicus, Tycho Brahe, Galileo and Kepler. The work of Isaac Newton brought order and universal natural laws into our picture of the solar system.

Finally, in modern times, the discoveries of Einstein, Hubble, Penzias and Wilson have given us a picture of an almost indescribably vast universe, in which our solar system appears only as an insignificant speck. Today we are "lost in the stars". Our planet no longer seems to be the center of the universe, about which everything else revolves. The meaning of human existence has become less clear. Where do we come from? What are we? Where are we going?

An apology

I must apologize to readers for putting forward my own point of view. I am, after all, a scientist, and readers with other backgrounds may be offended by my overly mechanistic ideas, for example, looking at emotions as phenomena involving not only the central nervous system but also hormones and neurotransmitters. I would not by any means deny that there are other ways of looking at human nature and human destiny, and I do not wish to force my own opinions on others. However, the problems which the world faces today are so serious that authors have a duty to report their opinions concerning these problems in a completely honest way, even at the risk of offending others.

Readers who wish to see more books and articles that I have written about the present precarious state of the world can find many of them on the following links:

http://eacpe.org/about-john-scales-avery/

https://human-wrongs-watch.net/2016/03/15/peace/

Regardless of whether the earth has a special importance when viewed on the scale of our fathomless universe, it is certainly important to us, and to the plants and animals with which we share the gift of life. None of us would wish to see a fatally damaged earth or a dystopian future. We give loving care to our children, but it makes no sense to do so if we neglect to do all that is within our power to give them a future in which they and their descendants can survive.

Most thoughtful people agree that we live today at a moment of crisis for human civilization and the biosphere. We face the twin threats of catastrophic climate change and an all-destroying thermonuclear war. Furthermore, the threat that population growth, climate change and the end of the fossil fuel era will combine to produce a very widespread global famine should not be neglected. The beginnings of this famine can already be seen in vulnerable parts of the world.

None of us asked to be born into an age of crisis, but history has given an enormous responsibility to our generation. In addition to the ordinary work that we do in order to put bread on the table and pay the rent, each of us has another job: We must work with dedication to save the future.

2.2 Mesopotamia, 4000 BC

In the imagination of the early Mesopotamians (the Sumerians, Elamites, Babylonians and Assyrians), the earth was a flat disc, surrounded by a rim of mountains and floating on an ocean of sweet water. Resting on these mountains was the hemispherical vault of the sky, across which moved the stars, the planets, the sun and the moon. Under the earth was another hemisphere containing the spirits of the dead. The Mesopotamians visualized the whole spherical world-universe as being immersed like a bubble in a limitless ocean of salt water.

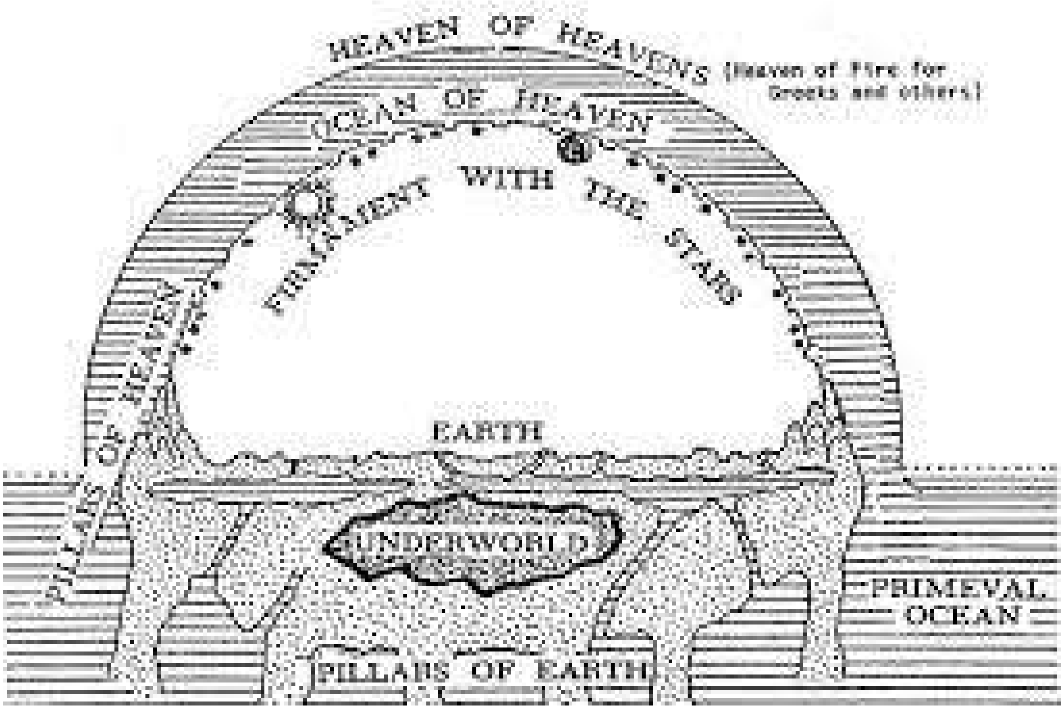

Figure 2.1: **Mesopotamian cosmology**

2.3 Ancient Egypt

The prosperity of ancient Egypt was based partly on its rich agriculture, nourished by the Nile, and partly on gold. Egypt possessed by far the richest gold deposits of the Middle East. They extended the whole length of the eastern desert, where more than a hundred ancient mines have been found; and in the south, Nubia was particularly rich in gold. The astonishing treasure found in the tomb of Tutankhamen, who was certainly not the most powerful of the pharaohs, gives us a pale idea of what the tombs of greater rulers must have been like before they were plundered.

In the religion of ancient Egypt, the distinction between the gods and the pharaohs was never very clear. Living pharaohs were considered to be gods, and they traced their ancestry back to the sun-god, Ra. Since all of the pharaohs were thought to be gods, and since, before the unification of Egypt, there were very many local gods, the Egyptian religion was excessively complicated. A list of gods found in the tomb of Thuthmosis III enumerates no fewer than seven hundred and forty! The extreme conservatism of Egyptian art (which maintained a consistent style for several thousand years) derives from the religious function played by painting and sculpture.

The famous gods, Osiris, Isis, Horus and Set probably began their existence as real people, and their story, which we know both from hieroglyphic texts and from Pliny, depicts an actual historical event - the first unification of Egypt: Osiris, the good ruler of the lower Nile, was murdered and cut to pieces by his jealous brother Set; but the pieces of Osiris' body were collected by his faithful wife Isis, who performed the first mummification and thus made Osiris immortal. Then Horus, the son of Osiris and Isis, like an Egyptian Hamlet, avenged the murder of his father by tracking down his wicked uncle Set, who attempted to escape by turning into various animals. However, in the end Horus killed Set, and thus Horus became the ruler of all of Egypt, both the lower Nile and the upper Nile.

This first prehistoric unification of Egypt left such a strong impression on the national consciousness that when a later pharaoh named Menes reunified Egypt in 3,200 B.C., he did so in the name of Horus. Like the Mesopotamian story of the flood, and like the epics of Homer, the story of the unification of Egypt by Horus probably contains a core of historical fact, blended with imaginative poetry. At certain points in the story, the characters seem to be real historical people - for example, when Osiris is described as being "handsome, dark-skinned and taller than other men". At other times, imagination seems to predominate. For example, the goddess Nut, who was the mother of Osiris, was thought to be the sky, while her husband Geb was the earth. The long curved body of Nut was imagined to be arched over the world so that only the tips of her toes and fingers touched the earth, while the stars and moon moved across her belly. Meanwhile her husband Geb lay prostrate, with all the vegetation of the earth growing out of his back.

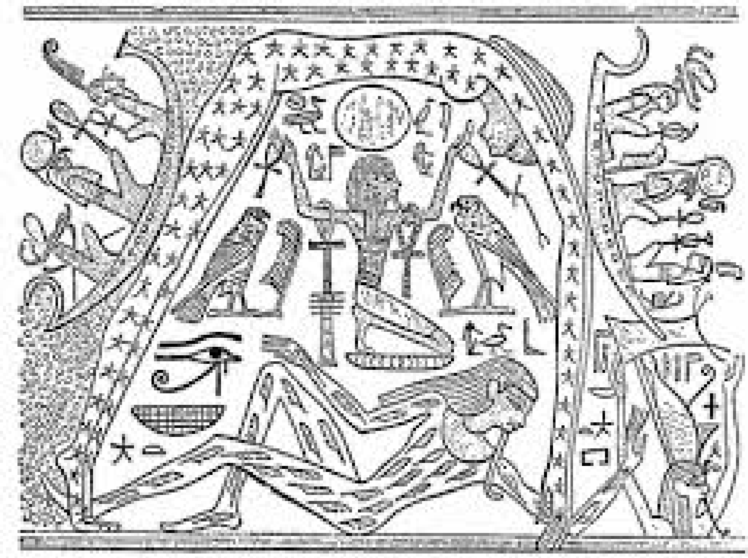

Figure 2.2: **In the imagery of the ancient Egyptians, the goddess Nut represented the sky, while her husband, Geb, was the earth.**

Figure 2.3: **The Nordic myth of the creation of the universe: "Thawing frost then became a cow called Audhumla. Four rivers of milk ran from her teats, and she fed Ymir. The cow licked salty ice blocks. After one day of licking, she freed a man's hair from the ice. After two days, his head appeared. On the third day the whole man was there. His name was Buri, and he was tall, strong, and handsome."**

Figure 2.4: **Ancient Nordic cosmology: “As all informed people know, the gods built a bridge from earth to heaven called Bifröst. Some call it the rainbow. It has three colors and is very strong, made with more skill and cunning than other structures. But strong as it is, it will break when the sons of Muspell ride out over it. The gods are not to blame that this structure will then break. Bifröst is a good bridge, but there is nothing in this world that can be relied on when the sons of Muspell are on the warpath. The chief sanctuary of the gods is by the ash tree Yggdrasil. There they hold their daily court. Yggdrasil is the best and greatest of all trees. Its branches spread out over the whole world and reach up over heaven.”**

2.4 Eratosthenes

Eratosthenes (276 B.C. - 196 B.C.), the director of the library at Alexandria, was probably the most cultured man of the Hellenistic Era. His interests and abilities were universal. He was an excellent historian, in fact the first historian who ever attempted to set up an accurate chronology of events. He was also a literary critic, and he wrote a treatise on Greek comedy. He made many contributions to mathematics, including a study of prime numbers and a method for generating primes called the "sieve of Eratosthenes".

As a geographer, Eratosthenes made a map of the world which, at that time, was the most accurate that had ever been made. The positions of various places on Eratosthenes' map were calculated from astronomical observations. The latitude was calculated by measuring the angle of the polar star above the horizon, while the longitude probably was calculated from the apparent local time of lunar eclipses.

As an astronomer, Eratosthenes made an extremely accurate measurement of the angle between the axis of the earth and the plane of the sun's apparent motion; and he also prepared a map of the sky which included the positions of 675 stars.

Eratosthenes' greatest achievement however, was an astonishingly precise measurement of the radius of the earth. The value which he gave for the radius was within 50 miles of what we now consider to be the correct value! To make this remarkable measurement, Eratosthenes of course assumed that the earth is spherical, and he also assumed that the sun is so far away from the earth that rays of light from the sun, falling on the earth, are almost parallel. He knew that directly south of Alexandria there was a city called Seyne, where at noon on a midsummer day, the sun stands straight overhead. Given these facts, all he had to do to find the radius of the earth was to measure the distance between Alexandria and Seyne. Then, at noon on a midsummer day, he measured the angle which the sun makes with the vertical at Alexandria. From these two values, he calculated the circumference of the earth to be a little over 25,000 miles. This was so much larger than the size of the known world that Eratosthenes concluded (correctly) that most of the earth's surface must be covered with water; and he stated that "If it were not for the vast extent of the Atlantic, one might sail from Spain to India along the same parallel."

2.5 Aristarchus

The Hellenistic astronomers not only measured the size of the earth - they also measured the sizes of the sun and the moon, and their distances from the earth. Among the astronomers who worked on this problem was Aristarchus (c. 320 B.C. - c. 250 B.C.). Like Pythagoras, he was born on the island of Samos, and he may have studied in Athens under Strato. However, he was soon drawn to Alexandria, where the most exciting scientific work of the time was being done.

Aristarchus calculated the size of the moon by noticing the shape of the shadow of the earth thrown on the face of the moon during a solar eclipse. From the shape of the earth's shadow, he concluded that the diameter of the moon is about a third the diameter of the earth. (This is approximately correct).

From the diameter of the moon and the angle between its opposite edges when it is seen from the earth, Aristarchus could calculate the distance of the moon from the earth. Next he compared the distance from the earth to the moon with the distance from the earth to the sun. To do this, he waited for a moment when the moon was exactly half-illuminated. Then the earth, moon and sun formed a right triangle, with the moon at the corner corresponding to the right angle. Aristarchus, standing on the earth, could measure the angle between the moon and the sun. He already knew the distance from the earth to the moon, so now he knew two angles and one side of the right triangle. This was enough to allow him to calculate the other sides, one of which was the sun-earth distance. His value for this distance was not very accurate, because small errors in measuring the angles were magnified in the calculation.

Aristarchus concluded that the sun is about twenty times as distant from the earth as the moon, whereas in fact it is about four hundred times as distant. Still, even the underestimated distance which Aristarchus found convinced him that the sun is enormous! He calculated that the sun has about seven times the diameter of the earth, and three hundred and fifty times the earth's volume. Actually, the sun's diameter is more than a hundred times the diameter of the earth, and its volume exceeds the earth's volume by a factor of more than a million!

Even his underestimated value for the size of the sun was enough to convince Aristarchus that the sun does not move around the earth. It seemed ridiculous to him to imagine the enormous sun circulating in an orbit around the tiny earth. Therefore he proposed a model of the solar system in which the earth and all the planets move in orbits around the sun, which remains motionless at the center; and he proposed the idea that the earth spins about its axis once every day.

Although it was the tremendous size of the sun which suggested this model to Aristarchus, he soon realized that the heliocentric model had many calculational advantages: For example, it made the occasional retrograde motion of certain planets much easier to explain. Unfortunately, he did not work out detailed table for predicting the positions of the planets. If he had done so, the advantages of the heliocentric model would have been so obvious that it might have been universally adopted almost two thousand years before the time of Copernicus, and the history of science might have been very different.

Aristarchus was completely right, but being right does not always lead to popularity. His views were not accepted by the majority of astronomers, and he was accused of impiety by the philosopher Cleanthes, who urged the authorities to make Aristarchus suffer for his heresy. Fortunately, the age was tolerant and enlightened, and Aristarchus was never brought to trial.

The model of the solar system on which the Hellenistic astronomers finally agreed was not that of Aristarchus but an alternative (and inferior) model developed by Hipparchus (c. 190 B.C. - c. 120 B.C.). Hipparchus made many great contributions to astronomy and mathematics. For example, he was the first person to calculate and publish tables of trigonometric functions. He also invented many instruments for accurate naked-eye observations. He discovered the "precession of equinoxes", introduced a classification of stars according to their apparent brightness, and made a star-map which far outclassed the earlier star-map of Eratosthenes. Finally, he introduced a model of the solar system which allowed fairly accurate calculation of the future positions of the planets, the sun and the moon.

In English, we use the phrase "wheels within wheels" to describe something excessively complicated. This phrase is derived from the model of the solar system introduced by Hipparchus! In his system, each planet has a large wheel which revolves with uniform speed about the earth (or in some cases, about a point near to the earth). Into this large wheel was set a smaller wheel, called the "epicycle", which also revolved with uniform speed. A point on the smaller wheel was then supposed to duplicate the motion of the planet. In some cases, the model of Hipparchus needed still more "wheels within wheels" to duplicate the planet's motion.. The velocities and sizes of the wheels were chosen in such a way as to "save the appearances".

The model of Hipparchus was popularized by the famous Egyptian astronomer, Claudius Ptolemy (c. 75 A.D. - c. 135 A.D.), in a book which dominated astronomy up to the time of Copernicus. Ptolemy's book was referred to by its admirers as *Megale Mathematike Syntaxis* (The Great Mathematical Composition). During the dark ages which followed the fall of Rome, Ptolemy's book was preserved and translated into Arabic by the civilized Moslems, and its name was shortened to *Almagest* (The Greatest). It held the field until, in the 15th century, the brilliant heliocentric model of Aristarchus was rescued from oblivion by Copernicus.

Figure 2.5: **A map of the known world by Eratosthenes, surrounded by spheres on which moved the sun, moon and stars.**

Figure 2.6: **A statue of Aristarchus. In the background we see his sun-centered picture of planetary motion.**

2.6 Copernicus

The career of Leonardo da Vinci illustrates the first phase of the "information explosion" which has produced the modern world: Inexpensive paper was being manufactured in Europe, and it formed the medium for Leonardo's thousands of pages of notes. His notes and sketches would never have been possible if he had been forced to use expensive parchment as a medium. On the other hand, the full force of Leonardo's genius and diligence was never felt because his notes were not printed.

Copernicus, who was a younger contemporary of Leonardo, had a much greater effect on the history of ideas, because his work was published. Thus, while paper alone made a large contribution to the information explosion, it was printing combined with paper which had an absolutely decisive and revolutionary impact: The modern scientific era began with the introduction of printing.

Nicolas Copernicus (1473-1543) was orphaned at the age of ten, but fortunately for science he was adopted by his uncle, Lucas Watzelrode, the Prince-Bishop of Ermland (a small semi-independent state which is now part of Poland). Through his uncle's influence, Copernicus was made a Canon of the Cathedral of Frauenberg in Ermland at the age of twenty-three. He had already spent four years at the University of Krakow, but his first act as Canon was to apply for leave of absence to study in Italy.

At that time, Italy was very much the center of European intellectual activity. Copernicus stayed there for ten years, drawing a comfortable salary from his cathedral, and wandering from one Italian University to another. He studied medicine and church law at Padua and Bologna, and was made a Doctor of Law at the University of Ferrara. Thus, thanks to the influence of his uncle, Copernicus had an education which few men of his time could match. He spent altogether fourteen years as a student at various universities, and he experienced the bracing intellectual atmosphere of Italy at the height of the Renaissance.

In 1506, Bishop Lucas recalled Copernicus to Ermland, where the young Canon spent the next six years as his uncle's personal physician and administrative assistant. After his uncle's death, Copernicus finally took up his duties as Canon at the cathedral-fortress of Frauenberg on the Baltic coast of Ermland; and he remained there for the rest of his life, administering the estates of the cathedral, acting as a physician to the people of Ermland, and working in secret on his sun-centered cosmology.

Even as a student in Krakow, Copernicus had thought about the problem of removing the defects in the Ptolomeic system. In Italy, where the books of the ancient philosophers had just become available in the original Greek,

Figure 2.7: **Nicolas Copernicus (1473-1543).**

Copernicus was able to search among their writings for alternative proposals. In Ptolemy's system, not all the "wheels within wheels" turn with a uniform velocity, although it is possible to find a point of observation called the *"punctum equans"* from which the motion seems to be uniform. Concerning this, Copernicus wrote:

"A system of this sort seems neither sufficiently absolute, nor sufficiently pleasing to the mind... Having become aware of these defects, I often considered whether there could be found a more reasonable arrangement of circles, in which everything would move uniformly about its proper center, as the rule of absolute motion requires.."

While trying to remove what he regarded as a defect in the Ptolemeic system by rearranging the wheels, Copernicus rediscovered the sun-centered cosmology of Aristarchus. However, he took a crucial step which went beyond Aristarchus: What Copernicus did during the thirty-one years which he spent in his isolated outpost on the Baltic was to develop the heliocentric model into a complete system, from which he calculated tables of planetary positions.

The accuracy of Copernicus' tables was a great improvement on those calculated from the Ptolemeic system, and the motions of the planets followed in a much more natural way. The inner planets, Mercury and Venus, stayed close to the sun because of the smallness of their orbits, while the occasional apparently retrograde motion of the outer planets could be explained in a very natural way by the fact that the more rapidly-moving earth sometimes overtook and passed one of the outer planets. Furthermore, the speed of the planets diminished in a perfectly regular way according to their distances from the sun.

According the the Copernican cosmology, the earth moves around the sun in an orbit whose radius is ninety-three million miles. As the earth moves in its enormous orbit, it is sometimes closer to a particular star, and sometimes farther away. Therefore the observed positions of the stars relative to each other ought to change as the earth moves around its orbit. This effect, called "stellar parallax", could not be observed with the instruments which were available in the 16th century.

The explanation which Copernicus gave for the absence of stellar parallax was that "Compared to the distance of the fixed stars, the earth's distance from the sun is neglegibly small!" If this is true for the nearest stars, then what about the distance to the farthest stars?

Vast and frightening chasms of infinity seemed to open under the feet of those who understood the implications of the Copernican cosmology. Humans were no longer rulers of a small, tidy universe especially created for themselves. They were suddenly "lost in the stars", drifting on a tiny speck of earth through unimaginably vast depths of space. Hence the cry of Blaise Pascal: *"Le silence eternal de ce éspaces infinis m'effraie!"*, "The eternal silence of these infinite spaces terrifies me!"

2.7 Tycho Brahe

The next step in the Copernican revolution was taken by two men who presented a striking contrast to one another. Tycho Brahe (1546-1601) was a wealthy and autocratic Danish nobleman, while Johannes Kepler (1571-1630) was a neurotic and poverty-stricken teacher in a provincial German school. Nevertheless, in spite of these differences, the two men collaborated for a time, and Johannes Kepler completed the work of Tycho Brahe.

At the time when Tycho was born, Denmark included southern Sweden; and ships sailing to and from the Baltic had to pay a toll as they passed through the narrow sound between Helsingør (Elsinore) in Denmark, and Helsingborg in what is now Sweden. On each side of the sound was a castle, with guns to control the sea passage. Tycho Brahe's father, a Danish nobleman, was Governor of Helsingborg Castle.

Tycho's uncle was also a military man, a Vice-Admiral in the navy of the Danish king, Frederik II. This uncle was childless, and Tycho's father promised that the Vice-Admiral could adopt one of his own children. By a fortunate coincidence, twins were born to the Governor's wife. However, when one of the twins died, Tycho's father was unwilling to part with the survivor (Tycho). The result was that, in the typically high-handed style of the Brahe family, the Vice-Admiral kidnapped Tycho. The Governor at first threatened murder, but soon calmed down and accepted the situation with good grace.

The adoption of Tycho Brahe by his uncle was as fortunate for science as the adoption of Copernicus by Bishop Watzelrode, because the Vice-Admiral soon met his death in an heroic manner which won the particular gratitude of the Danish Royal Family:

Admiral Brahe, returning from a battle against the Swedes, was crossing a bridge in the company of King Frederik II. As the king rode across the bridge, his horse reared suddenly, throwing him into the icy water below. The king would have drowned if Admiral Brahe had not leaped into the water and saved him. However, the Admiral saved the king's life at the cost of his own. He caught pneumonia and died from it. The king's gratitude to Admiral Brahe was expressed in the form of special favor shown to his adopted son, Tycho, who had in the meantime become an astronomer (against the wishes of his family).

As a boy of fourteen, Tycho Brahe had witnessed a partial eclipse of the sun, which had been predicted in advance. It struck him as "something divine that men could know the motions of the stars so accurately that they were able a long time beforehand to predict their places and relative positions". Nothing that his family could say would dissuade him from studying astronomy, and he did so not only at the University of Copenhagen, but also at Leipzig, Wittenberg, Rostock, Basel and Augsberg.

During this period of study, Tycho began collecting astronomical instruments. His lifelong quest for precision in astronomical observation dated from his seventeenth year, when he observed a conjunction of Saturn and Jupiter. He found that the best tables available were a month in error in predicting this event. Tycho had been greatly struck by the fact that (at least as far as the celestial bodies were concerned), it was possible to predict the future; but here the prediction was in error by a full month! He resolved to do better.

Tycho first became famous among astronomers through his observations on a new star, which suddenly appeared in the sky in 1572. He used the splendid instruments in his collection to show that the new star was very distant from the earth - certainly beyond the sphere of the moon - and that it definitely did not move with respect to the fixed stars. This was, at the time, a very revolutionary conclusion. According to Aristotle, (who was still regarded as the greatest authority on matters of natural philosophy), all generation and decay should be confined to the region beneath the sphere of the moon. Tycho's result meant that Aristotle could be wrong!

Tycho thought of moving to Basel. He was attracted by the beauty of the town, and he wanted to be nearer to the southern centers of culture. However, in 1576 he was summoned to appear before Frederik II. Partly in recognition of Tycho's growing fame as an astronomer, and partly to repay the debt of gratitude which he owed to Admiral Brahe, the king made Tycho the ruler of Hven, an island in the sound between Helsingborg and Helsingør. Furthermore, Frederik granted Tycho generous funds from his treasury to construct an observatory on Hven.

With these copious funds, Tycho Brahe constructed a fantastic castle-observatory which he called Uraniborg. It was equipped not only with the most precise astronomical instruments the world had ever seen, but also with a chemical laboratory, a paper mill, a printing press and a dungeon for imprisoning unruly tenants.

Tycho moved in with a retinue of scientific assistants and servants. The only thing which he lacked was his pet elk. This beast had been transported from the Brahe estate at Knudstrup to Landskrona Castle on the Sound, and it was due to be brought on a boat to the island of Hven. However, during the night, the elk wandered up a stairway in Landskrona Castle and found a large bowl of beer in an unoccupied room. Like its master, the elk was excessively fond of beer, and it drank so much that, returning down the stairway, it fell, broke its leg, and had to be shot.

Tycho ruled his island in a thoroughly autocratic and grandiose style, the effect of which was heightened by his remarkable nose. In his younger days, Tycho had fought a duel with another student over the question of who was the better mathematician. During the duel, the bridge of Tycho's nose had been sliced off. He had replaced the missing piece by an artificial bridge which he had made of gold and silver alloy, and this was held in place by means of a sticky ointment which he always carried with him in a snuff box.

Tycho entertained in the grandest possible manner the stream of scholars who came to Hven to see the wonders of Uraniborg. Among his visitors were King James VI of Scotland (who later ascended the English throne as James I), and the young prince who later became Christian IV of Denmark.

With the help of his numerous assistants, Tycho observed and recorded the positions of the sun, moon, planets and stars with an accuracy entirely unprecedented in the history of astronomy. He corrected both for atmospheric refraction and for instrumental errors, with the result that his observations were accurate to within two minutes of arc. This corresponds to the absolute limit of what can be achieved without the help of a telescope.

Not only were Tycho's observations made with unprecedented accuracy - they were also made *continuously* over a period of 35 years. Before Tycho's time, astronomers had haphazardly recorded an observation every now and then, but no one had thought of making systematic daily records of the positions of each of the celestial bodies. Tycho was able to make a "motion picture" record of the positions of the planets because he could divide the work among his numerous assistants.

Figure 2.8: *Tycho Brahe. Public domain, Wikimedia Commons*

Figure 2.9: **Johannes Kepler**

All went well with Tycho on the island of Hven for twelve years. Then, in 1588, Frederik II died (of alcoholism), and his son ascended the throne as Christian IV. Frederik II had been especially grateful to Admiral Brahe for saving his life, and he treated the Admiral's adopted son, Tycho, with great indulgence. However, Christian IV was unwilling to overlook the increasingly scandalous and despotic way in which Tycho was ruling Hven; and he reduced the subsidies which Tycho Brahe had been receiving from the royal treasury. The result was that Tycho, feeling greatly insulted, dismantled his instruments and moved them to Prague, together with his retinue of family, scientific assistants, servants and jester.

In Prague, Tycho became the Imperial Mathematician of the Holy Roman Emperor, Rudolph II. (We should mention in passing that royal patrons such as Rudolph were more interested in astrology than in astronomy: The chief duty of the Imperial Mathematician was to cast horoscopes for the court!) After the move to Prague, one of Tycho's senior scientific assistants became dissatisfied and left. To replace him, Tycho recruited a young German mathematician named Johannes Kepler.

2.8 Johannes Kepler

Two thousand years before the time of Kepler, Pythagoras had dreamed of finding mathematical harmony in the motions of the planets. Kepler and Newton were destined to fulfil his dream. Kepler was also a true follower of Pythagoras in another sense: Through his devotion to philosophy, he transcended the personal sufferings of a tortured childhood and adolescence. He came from a family of misfits whose neurotic quarrelsomeness was such that Kepler's father narrowly escaped being hanged, and his mother was accused of witchcraft by her neighbors. She was imprisoned, and came close to being burned.

At the age of 4, Kepler almost died of smallpox, and his hands were badly crippled. Concerning his adolescence, Kepler wrote: "I suffered continually from skin ailments, often severe sores, often from the scabs of chronic putrid wounds in my feet, which healed badly and kept breaking out again. On the middle finger of my right hand, I had a worm, and on the left, a huge sore."

Kepler's mental strength compensated for his bodily weakness. His brilliance as a student was quickly recognized, and he was given a scholarship to study theology at the University of Tübingen. He was agonizingly lonely and unpopular among his classmates.

Kepler distinguished himself as a student at Tübingen, and shortly before his graduation, he was offered a post as a teacher of mathematics and astronomy at the Protestant School in Graz. With the post went the title of "Mathematician of the Provence of Styria". (Gratz was the capital of Styria, a province of Austria).

Johannes Kepler was already an ardent follower of Copernicus; and during the summer of his first year in Graz, he began to wonder why the speed of the planets decreased in a regular way according to their distances from the sun, and why the planetary orbits had the particular sizes which Copernicus assigned to them.

On July 9, 1595, in the middle of a lecture which he was giving to his class, Kepler was electrified by an idea which changed the entire course of his life. In fact, the idea was totally wrong, but it struck Kepler with such force that he thought he had solved the riddle of the universe with a single stroke!

Kepler had drawn for his class an equilateral triangle with a circle circumscribed about it, so that the circle passed through all three corners of the triangle. Inside, another circle was inscribed, so that it touched each side of the triangle. It suddenly struck Kepler that the ratio between the sizes of the two circles resembled the ratio between the orbits of Jupiter and Saturn. His mercurial mind immediately leaped from the two-dimensional figure which he had drawn to the five regular solids of Pythagoras and Plato.

In three dimensions, only five different completely symmetrical many-sided figures are possible: the tetrahedron, cube, octahedron, icosahedron and the dodecahedron. There the list stops. As Euclid proved, it is a peculiarity of three-dimensional space that there are only five possible regular polyhedra. These five had been discovered by Pythagoras, and they had been popularized by Plato, the most famous of the Pythagorean philosophers. Because Plato made so much of the five regular solids in his dialogue *Timaeus*, they became known as the "Platonic solids".

In a flash of (completely false) intuition, Kepler saw why there had to be exactly six planets: The six spheres of the planetary orbits were separated by the five Platonic solids! This explained the sizes of the orbits too: Each sphere except the innermost and the outermost was inscribed in one solid and circumscribed about another!

Kepler, who was then twenty-three years old, was carried away with enthusiasm. He immediately wrote a book about his discovery and called it *Mysterium Cosmigraphicum*, "The Celestial Mystery". The book begins with an introduction strongly supporting the Copernican cosmology. After that comes the revelation of Kepler's marvelous (and false) solution to the cosmic mystery by means of the five Platonic solids. Kepler was unable to make the orbit of Jupiter fit his model, but he explains naively that "nobody will wonder at it, considering the great distance". The figures for the other planets did not quite fit either, but Kepler believed that the distances given by Copernicus were inaccurate.

Finally, after the mistaken ideas of the book, comes another idea, which comes close to the true picture of gravitation. Kepler tries to solve the problem of why the outer planets move more slowly than the inner ones, and he says:

"If we want to get closer to the truth and establish some correspondence in the proportions, then we must choose between these two assumptions: Either the souls of the planets are less active the farther they are from the sun, or there exists only one moving soul in the center of the orbits, that is the sun, which drives the planets the more vigorously the closer the planet is, but whose force is quasi-exhausted when acting on the outer planets, because of the long distance and the weakening of the force which it entails."

In *Mysterium Cosmigraphicum*, Kepler tried to find an exact mathematical relationship between the speeds of the planets and the sizes of their orbits; but he did not succeed in this first attempt. He finally solved this problem many years later, towards the end of his life.

Kepler sent a copy of his book to Tycho Brahe with a letter in which he called Tycho "the prince of mathematicians, not only of our time, but of all time". Tycho was pleased with this "fan letter"; and he recognized the originality of Kepler's book, although he had reservations about its main thesis.

Meanwhile, religious hatred had been deepening and Kepler, like all other Protestants, was about to be expelled from Catholic Austria. He appealed to Tycho for help, and Tycho, who was in need of a scientific assistant, wrote to Kepler from the castle of Benatek near Prague:

"You have no doubt already been told that I have most graciously been called here by his Imperial Majesty and that I have been received in a most friendly and benevolent manner. I wish that you would come here, not forced by the adversity of fate, but rather of your own will and desire for common study. But whatever your reason, you will find in me your friend, who will not deny you his advice and help in adversity"

To say that Kepler was glad for this opportunity to work with Tycho Brahe is to put the matter very mildly. The figures of Copernicus did not really fit Kepler's model, and his great hope was that Tycho's more accurate observations would give a better fit. In his less manic moments, Kepler also recognized that his model might not be correct after all, but he hoped that Tycho's data would allow him to find the true solution.

Kepler longed to get his hands on Tycho's treasure of accurate data, and concerning these he wrote:

"Tycho possesses the best observations, and thus so-to-speak the material for building the new edifice. He also has collaborators, and everything else he could wish for. He only lacks the architect who would put all this to use according to his own design. For although he has a happy disposition and real architectural skill, he is nevertheless obstructed in his progress by the multitude of the phenomena, and by the fact that the truth is deeply hidden in them. Now old age is creeping upon him, enfeebling his spirit and his forces"

In fact, Tycho had only a short time to live. Kepler arrived in Prague in 1600, and in 1601 he wrote:

"On October 13, Tycho Brahe, in the company of Master Minkowitz, had dinner at the illustrious Rosenborg's table, and held back his water beyond the demands of courtesy. When he drank more, he felt the tension in his bladder increase, but he put politeness before health. When he got home, he was scarcely able to urinate.. After five sleepless nights, he could still only pass water with the greatest pain, and even so the passage was impeded. The insomnia continued, with internal fever gradually leading to delirium; and the food which he ate, from which he could not be kept, exacerbated the evil... On his last night, he repeated over and over again, like someone composing a poem: 'Let me not seem to have lived in vain'."

A few days after Tycho's death, Kepler was appointed to succeed him as Imperial Mathematician of the Holy Roman Empire. Kepler states that the problem of analyzing Tycho's data took such a hold on him that he nearly went out of his mind. With a fanatic diligence rarely equaled in the history of science, he covered thousands of pages with calculations. Finally, after many years of struggle and many false starts, he wrung from Tycho's data three precise laws of planetary motion:

1) The orbits of the planets are ellipses, with the sun at one focal point.

2) A line drawn from the sun to any one of the planets sweeps out equal areas in equal intervals of time.

3) The square of the period of a planet is proportional to the cube of the mean radius of its orbit.

Thanks to Kepler's struggles, Tycho certainly had not lived in vain. Kepler's three laws were to become the basis for Newton's great universal laws of motion and gravitation. Kepler himself imagined a universal gravitational force holding the planets in their orbits around the sun, and he wrote:

"If two stones were placed anywhere in space, near to each other, and outside the reach of force of any other material body, then they would come together after the manner of magnetic bodies, at an intermediate point, each approaching the other in proportion to the other's mass... "

"If the earth ceased to attract the waters of the sea, the seas would rise up and flow to the moon... If the attractive force of the moon reaches down to the earth, it follows that the attractive force of the earth, all the more, extends to the moon, and even farther... "

"Nothing made of earthly substance is absolutely light; but matter which is less dense, either by nature or through heat, is relatively lighter... Out of the definition of lightness follows its motion; for one should not believe that when lifted up it escapes to the periphery of the world, or that it is not attracted to the earth. It is merely less attracted than heavier matter, and is therefore displaced by heavier matter."

Kepler also understood the correct explanation of the tides. He explained them as being produced primarily by the gravitational attraction of the moon, while being influenced to a lesser extent by the gravitational field of the sun.

Unfortunately, when Kepler published these revolutionary ideas, he hid them in a tangled jungle of verbiage and fantasy which repelled the most important of his readers, Galileo Galilei. In fact, the English were the first to appreciate Kepler. King James I (whom Tycho entertained on Hven) invited Kepler to move to England, but he declined the invitation. Although the skies of Europe were darkened by the Thirty Years War, Kepler could not bring himself to leave the German cultural background where he had been brought up and where he felt at home.

2.9 Newton

On Christmas day in 1642 (the year in which Galileo died), a recently widowed woman named Hannah Newton gave birth to a premature baby at the manor house of Woolsthorpe, a small village in Lincolnshire, England. Her baby was so small that, as she said later, "he could have been put into a quart mug", and he was not expected to live. He did live, however, and lived to achieve a great scientific synthesis, uniting the work of Copernicus, Brahe, Kepler, Galileo and Descartes.

When Isaac Newton was four years old, his mother married again and went to live with her new husband, leaving the boy to be cared for by his grandmother. This may have caused Newton to become more solemn and introverted than he might otherwise have been. One of his childhood friends remembered him as "a sober, silent, thinking lad, scarce known to play with the other boys at their silly amusements".

As a boy, Newton was fond of making mechanical models, but at first he showed no special brilliance as a scholar. He showed even less interest in running the family farm, however; and a relative (who was a fellow of Trinity College) recommended that he be sent to grammar school to prepare for Cambridge University.

When Newton arrived at Cambridge, he found a substitute father in the famous mathematician Isaac Barrow, who was his tutor. Under Barrow's guidance, and while still a student, Newton showed his mathematical genius by inventing the binomial theorem.

In 1665, Cambridge University was closed because of an outbreak of the plague, and Newton returned for two years to the family farm at Woolsthorpe. He was then twenty-three years old. During the two years of isolation, Newton developed his binomial theorem into the beginnings of differential calculus.

Newton's famous experiments in optics also date from these years. The sensational experiments of Galileo were very much discussed at the time, and Newton began to think about ways to improve the telescope. Writing about his experiments in optics, Newton says:

"In the year 1666 (at which time I applied myself to the grinding of optic glasses of other figures than spherical), I procured me a triangular prism, to try therewith the celebrated phenomena of colours. And in order thereto having darkened my chamber, and made a small hole in the window shuts to let in a convenient quantity of the sun's light, I placed my prism at its entrance, that it might thereby be refracted to the opposite wall."

"It was at first a very pleasing divertisment to view the vivid and intense colours produced thereby; but after a while, applying myself to consider them more circumspectly, I became surprised to see them in an oblong form, which, according to the received laws of refraction I expected should have been circular."

Newton then describes his crucial experiment. In this experiment, the beam of sunlight from the hole in the window shutters was refracted by two prisms in succession. The first prism spread the light into a rainbow-like band of colors. From this spectrum, he selected a beam of a single color, and allowed the beam to pass through a second prism; but when light of a single color passed through the second prism, the color did not change, nor was the image spread out into a band. No matter what Newton did to it, red light always remained red, once it had been completely separated from the other colors; yellow light remained yellow, green remained green, and blue remained blue.

Newton then measured the amounts by which the beams of various colors were bent by the second prism; and he discovered that red light was bent the least. Next in sequence came orange, yellow, green, blue and finally violet, which was deflected the most. Newton recombined the separated colors, and he found that together, they once again produced white light.

Concluding the description of his experiments, Newton wrote:

"...and so the true cause of the length of the image (formed by the first prism) was detected to be no other than that light is not similar or homogenial, but consists of *deform rays, some of which are more refrangible than others*."

"As rays of light differ in their degrees of refrangibility, so they also differ in their disposition to exhibit this or that particular colour... To the same degree of refrangibility ever belongs the same colour, and to the same colour ever belongs the same degree of refrangibility."

"...The species of colour and the degree of refrangibility belonging to any particular sort of rays is not mutable by refraction, nor by reflection from natural bodies, nor by any other cause that I could yet observe. When any one sort of rays hath been well parted from those of other kinds, it hath afterwards obstinately retained its colour, notwithstanding my utmost endeavours to change it."

During the plague years of 1665 and 1666, Newton also began the work which led to his great laws of motion and universal gravitation. Referring to the year 1666, he wrote:

"I began to think of gravity extending to the orb of the moon; and having found out how to estimate the force with which a globe revolving within a sphere presses the surface of the sphere, from Kepler's rule of the periodical times of the planets being in a sesquialternate proportion of their distances from the centres of their orbs, I deduced that the forces which keep the planets in their orbs must be reciprocally as the squares of the distances from the centres about which they revolve; and thereby compared the force requisite to keep the moon in her orb with the force of gravity at the surface of the earth, and found them to answer pretty nearly."

"All this was in the plague years of 1665 and 1666, for in those days I was in the prime of my age for invention, and minded mathematics and philosophy more than at any time since."

Galileo had studied the motion of projectiles, and Newton was able to build on this work by thinking of the moon as a sort of projectile, dropping towards the earth, but at the same time moving rapidly to the side. The combination of these two motions gives the moon its nearly-circular path.

From Kepler's third law, Newton had deduced that the force with which the sun attracts a planet must fall off as the square of the distance between the planet and the sun. With great boldness, he guessed that this force is *universal*, and that every object in the universe attracts every other object with a gravitational force which is directly proportional to the product of the two masses, and inversely proportional to the square of the distance between them.

Newton also guessed correctly that in attracting an object outside its surface, the earth acts as though its mass were concentrated at its center. However, he could not construct the proof of this theorem, since it depended on integral calculus, which did not exist in 1666. (Newton himself invented integral calculus later in his life.)

In spite of the missing proof, Newton continued and "...compared the force requisite to keep the moon in her orb with the force of gravity at the earth's surface, and found them to answer pretty nearly". He was not satisfied with this incomplete triumph, and he did not show his calculations to anyone. He not only kept his ideas on gravitation to himself, (probably because of the missing proof), but he also refrained for many years from publishing his work on the calculus. By the time Newton published, the calculus had been invented independently by the great German mathematician and philosopher, Gottfried Wilhelm Leibniz (1646-1716); and the result was a bitter quarrel over priority. However, Newton did publish his experiments in optics, and these alone were enough to make him famous.

In 1669, Newton's teacher, Isaac Barrow, generously resigned his post as Lucasian Professor of Mathematics so that Newton could have it. Thus, at the age of 27, Newton became the head of the mathematics department at Cambridge. He was required to give eight lectures a year, but the rest of his time was free for research.

Newton's prism experiments had led him to believe that the only possible way to avoid blurring of colors in the image formed by a telescope was to avoid refraction entirely. Therefore he designed and constructed the first reflecting telescope. In 1672, he presented a reflecting telescope to the newly-formed Royal Society, which then elected him to membership.

Meanwhile, the problems of gravitation and planetary motion were increasingly discussed by the members of the Royal Society. In January, 1684, three members of the Society were gathered in a London coffee house. One of them was Robert Hooke (1635-1703), author of *Micrographia* and Professor of Geometry at Gresham College, a brilliant but irritable man. He had begun his career as Robert Boyle's assistant, and had gone on to do important work in many fields of science. Hooke claimed that he could calculate the motion of the planets by assuming that they were attracted to the sun by a force which diminished as the square of the distance.

Listening to Hooke were Sir Christopher Wren (1632-1723), the designer of St. Paul's Cathedral, and the young astronomer, Edmund Halley (1656-1742). Wren challenged Hooke to produce his calculations; and he offered to present Hooke with a book worth 40 shillings if he could prove his inverse square force law by means of rigorous mathematics. Hooke tried for several months, but he was unable to win Wren's reward.

Meanwhile, in August, 1684, Halley made a journey to Cambridge to talk with Newton, who was rumored to know very much more about the motions of the planets than he had revealed in his published papers. According to an almost-contemporary account, what happened then was the following:

"Without mentioning his own speculations, or those of Hooke and Wren, he (Halley) at once indicated the object of his visit by asking Newton what would be the curve described by the planets on the supposition that gravity diminished as the square of the distance. Newton immediately answered: an

Ellipse. Struck with joy and amazement, Halley asked how he knew it? 'Why', replied he, 'I have calculated it'; and being asked for the calculation, he could not find it, but promised to send it to him."

Newton soon reconstructed the calculation and sent it to Halley; and Halley, filled with enthusiasm and admiration, urged Newton to write out in detail all of his work on motion and gravitation. Spurred on by Halley's encouragement and enthusiasm, Newton began to put his research in order. He returned to the problems which had occupied him during the plague years, and now his progress was rapid because he had invented integral calculus. This allowed him to prove rigorously that terrestrial gravitation acts as though all the earth's mass were concentrated at its center. Newton also had available an improved value for the radius of the earth, measured by the French astronomer Jean Picard (1620-1682). This time, when he approached the problem of gravitation, everything fell into place.

By the autumn of 1684, Newton was ready to give a series of lectures on dynamics, and he sent the notes for these lectures to Halley in the form of a small booklet entitled *On the Motion of Bodies*. Halley persuaded Newton to develop these notes into a larger book, and with great tact and patience he struggled to keep a controversy from developing between Newton, who was neurotically sensitive, and Hooke, who was claiming his share of recognition in very loud tones, hinting that Newton was guilty of plagiarism.

Newton reacted by striking out from his book every single reference to Robert Hooke. The Royal Society at first offered to pay for the publication costs of Newton's book, but because a fight between Newton and Hooke seemed possible, the Society discretely backed out. Halley then generously offered to pay the publication costs himself, and in 1686 Newton's great book was printed. It is entitled *Philosophae Naturalis Principia Mathematica*, (The Mathematical Principles of Natural Philosophy), and it is divided into three sections.

The first book sets down the general principles of mechanics. In it, Newton states his three laws of motion, and he also discusses differential and integral calculus (both invented by himself).

In the second book, Newton applies these methods to systems of particles and to hydrodynamics. For example, he calculates the velocity of sound in air from the compressibility and density of air; and he treats a great variety of other problems, such as the problem of calculating how a body moves when its motion is slowed by a resisting medium, such as air or water.

The third book is entitled *The System of the World*. In this book, Newton sets out to derive the entire behavior of the solar system from his three laws of motion and from his law of universal gravitation. From these, he not only derives all three of Kepler's laws, but he also calculates the periods of the planets and the periods of their moons; and he explains such details as the

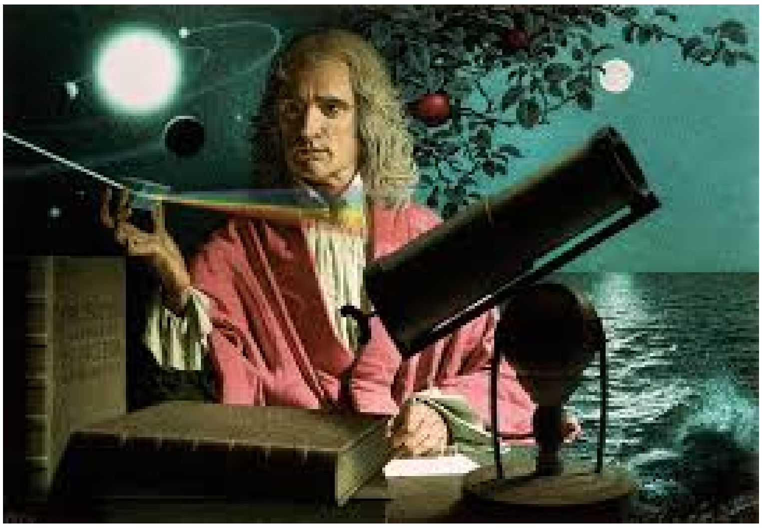

Figure 2.10: **Newton: "I do not know what I may appear to the world, but to myself I seem to have been only like a boy playing on the seashore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me."**

flattened, non-spherical shape of the earth, and the slow precession of its axis about a fixed axis in space. Newton also calculated the irregular motion of the moon resulting from the combined attractions of the earth and the sun; and he determined the mass of the moon from the behavior of the tides.

Newton's *Principia* is generally considered to be one of the greatest scientific works of all time. To present a unified theory explaining such a wide variety of phenomena with so few assumptions was a magnificent and unprecedented achievement; and Newton's contemporaries immediately recognized the importance of what he had done.

The great Dutch physicist, Christian Huygens (1629-1695), inventor of the pendulum clock and the wave theory of light, travelled to England with the express purpose of meeting Newton. Voltaire, who for reasons of personal safety was forced to spend three years in England, used the time to study Newton's *Principia*; and when he returned to France, he persuaded his mistress, Madame du Chatelet, to translate the *Principia* into French; and Alexander Pope, expressing the general opinion of his contemporaries, wrote a famous couplet, which he hoped would be carved on Newton's tombstone:

"Nature and Nature's law lay hid in night.

God said: 'Let Newton be!', and all was light!"

2.10 Albert Einstein

Newton's laws of gravitation and motion stood unchallenged until the 20th century, when Einstein showed that they were only approximately correct. Albert Einstein was born in Ulm, Germany, in 1879. He was the son of middle-class, irreligious Jewish parents, who sent him to a Catholic school. Einstein was slow in learning to speak, and at first his parents feared that he might be retarded; but by the time he was eight, his grandfather could say in a letter: "Dear Albert has been back in school for a week. I just love that boy, because you cannot imagine how good and intelligent he has become."

Remembering his boyhood, Einstein himself later wrote: "When I was 12, a little book dealing with Euclidean plane geometry came into my hands at the beginning of the school year. Here were assertions, as for example the intersection of the altitudes of a triangle in one point, which, though by no means self-evident, could nevertheless be proved with such certainty that any doubt appeared to be out of the question. The lucidity and certainty made an indescribable impression on me."

When Albert Einstein was in his teens, the factory owned by his father and uncle began to encounter hard times. The two Einstein families moved to Italy, leaving Albert alone and miserable in Munich, where he was supposed to finish his course at the gymnasium. Einstein's classmates had given him the nickname "Beidermeier", which means something like "Honest John"; and his tactlessness in criticizing authority soon got him into trouble. In Einstein's words, what happened next was the following: "When I was in the seventh grade at the Lutpold Gymnasium, I was summoned by my home-room teacher, who expressed the wish that I leave the school. To my remark that I had done nothing wrong, he replied only, 'Your mere presence spoils the respect of the class for me'."

Einstein left gymnasium without graduating, and followed his parents to Italy, where he spent a joyous and carefree year. He also decided to change his citizenship. "The over-emphasized military mentality of the German State was alien to me, even as a boy", Einstein wrote later. "When my father moved to Italy, he took steps, at my request, to have me released from German citizenship, because I wanted to be a Swiss citizen."

The financial circumstances of the Einstein family were now precarious, and it was clear that Albert would have to think seriously about a practical career. In 1896, he entered the famous Zürich Polytechnic Institute with the intention of becoming a teacher of mathematics and physics. However, his undisciplined and nonconformist attitudes again got him into trouble. His mathematics professor, Hermann Minkowski (1864-1909), considered Einstein to be a "lazy dog"; and his physics professor, Heinrich Weber, who originally had gone out of his way to help Einstein, said to him in anger and exasperation: "You're a clever fellow, but you have one fault: You won't let anyone tell you a thing! You won't let anyone tell you a thing!"

Einstein missed most of his classes, and read only the subjects which interested him. He was interested most of all in Maxwell's theory of electromagnetism, a subject which was too "modern" for Weber. There were two major examinations at the Zürich Polytechnic Institute, and Einstein would certainly have failed them had it not been for the help of his loyal friend, the mathematician Marcel Grossman.

Grossman was an excellent and conscientious student, who attended every class and took meticulous notes. With the help of these notes, Einstein managed to pass his examinations; but because he had alienated Weber and the other professors who could have helped him, he found himself completely unable to get a job. In a letter to Professor F. Ostwald on behalf of his son, Einstein's father wrote: "My son is profoundly unhappy because of his present joblessness; and every day the idea becomes more firmly implanted in his mind that he is a failure, and will not be able to find the way back again."

From this painful situation, Einstein was rescued (again!) by his friend Marcel Grossman, whose influential father obtained for Einstein a position at the Swiss Patent Office: Technical Expert (Third Class). Anchored at last in a safe, though humble, position, Einstein married one of his classmates. He learned to do his work at the Patent Office very efficiently; and he used the remainder of his time on his own calculations, hiding them guiltily in a drawer when footsteps approached.

In 1905, this Technical Expert (Third Class) astonished the world of science with five papers, written within a few weeks of each other, and published in the Annalen der Physik. Of these five papers, three were classics: One of these was the paper in which Einstein applied Planck's quantum hypothesis to the photoelectric effect. The second paper discussed "Brownian motion", the zig-zag motion of small particles suspended in a liquid and hit randomly by the molecules of the liquid. This paper supplied a direct proof of the validity of atomic ideas and of Boltzmann's kinetic theory. The third paper was destined to establish Einstein's reputation as one of the greatest physicists of all time. It was entitled "On the Electrodynamics of Moving Bodies", and in this paper, Albert Einstein formulated his special theory of relativity. Essentially, this theory maintained that all of the fundamental laws of nature exhibit a symmetry with respect to rotations in a 4-dimensional space-time continuum.

Gradually, the importance of Einstein's work began to be realized, and he was much sought after. He was first made Assistant Professor at the University of Zürich, then full Professor in Prague, then Professor at the Zürich

Polytechnic Institute; and finally, in 1913, Planck and Nernst persuaded Einstein to become Director of Scientific Research at the Kaiser Wilhelm Institute in Berlin. He was at this post when the First World War broke out

While many other German intellectuals produced manifestos justifying Germany's invasion of Belgium, Einstein dared to write and sign an anti-war manifesto. Einstein's manifesto appealed for cooperation and understanding among the scholars of Europe for the sake of the future; and it proposed the eventual establishment of a League of Europeans. During the war, Einstein remained in Berlin, doing whatever he could for the cause of peace, burying himself unhappily in his work, and trying to forget the agony of Europe, whose civilization was dying in a rain of shells, machine-gun bullets, and poison gas.

The work into which Einstein threw himself during this period was an extension of his theory of relativity. He already had modified Newton's equations of motion so that they exhibited the space-time symmetry required by his Principle of Special Relativity. However, Newton's law of gravitation. remained a problem.

Obviously it had to be modified, since it disagreed with his Special Theory of Relativity; but how should it be changed? What principles could Einstein use in his search for a more correct law of gravitation? Certainly whatever new law he found would have to give results very close to Newton's law, since Newton's theory could predict the motions of the planets with almost perfect accuracy. This was the deep problem with which he struggled.

In 1907, Einstein had found one of the principles which was to guide him, the Principle of Equivalence of inertial and gravitational mass. After turning Newton's theory over and over in his mind, Einstein realized that Newton had used mass in two distinct ways: His laws of motion stated that the force acting on a body is equal to the mass of the body multiplied by its acceleration; but according to Newton, the gravitational force on a body is also proportional to its mass. In Newton's theory, gravitational mass, by a coincidence, is equal to inertial mass; and this holds for all bodies. Einstein decided to construct a theory in which gravitational and inertial mass necessarily have to be the same.

He then imagined an experimenter inside a box, unable to see anything outside it. If the box is on the surface of the earth, the person inside it will feel the pull of the earth's gravitational field. If the experimenter drops an object, it will fall to the floor with an acceleration of 32 feet per second per second. Now suppose that the box is taken out into empty space, far away from strong gravitational fields, and accelerated by exactly 32 feet per second per second. Will the enclosed experimenter be able to tell the difference between these two situations? Certainly no difference can be detected by dropping an object, since in the accelerated box, the object will fall to the floor in exactly the same way as before.

With this "thought experiment" in mind, Einstein formulated a general Principle of Equivalence: He asserted that no experiment whatever can tell an observer enclosed in a small box whether the box is being accelerated, or whether it is in a gravitational field. According to this principle, gravitation and acceleration are locally equivalent, or, to say the same thing in different words, gravitational mass and inertial mass are equivalent.

Einstein soon realized that his Principle of Equivalence implied that a ray of light must be bent by a gravitational field. This conclusion followed because, to an observer in an accelerated frame, a light beam which would appear straight to a stationary observer, must necessarily appear very slightly curved. If the Principle of Equivalence held, then the same slight bending of the light ray would be observed by an experimenter in a stationary frame in a gravitational field.

Another consequence of the Principle of Equivalence was that a light wave propagating upwards in a gravitational field should be very slightly shifted to the red. This followed because in an accelerated frame, the wave crests would be slightly farther apart than they normally would be, and the same must then be true for a stationary frame in a gravitational field. It seemed to Einstein that it ought to be possible to test experimentally both the gravitational bending of a light ray and the gravitational red shift.

This seemed promising; but how was Einstein to proceed from the Principle of Equivalence to a formulation of the law of gravitation? Perhaps the theory ought to be modeled after Maxwell's electromagnetic theory, which was a field theory, rather than an "action at a distance" theory. Part of the trouble with Newton's law of gravitation was that it allowed a signal to be propagated instantaneously, contrary to the Principle of Special Relativity. A field theory of gravitation might cure this defect, but how was Einstein to find such a theory? There seemed to be no way.

From these troubles Albert Einstein was rescued (a third time!) by his staunch friend Marcel Grossman. By this time, Grossman had become a professor of mathematics in Zürich, after having written a doctoral dissertation on tensor analysis and non-Euclidean geometry, the very things that Einstein needed. The year was then 1912, and Einstein had just returned to Zürich as Professor of Physics at the Polytechnic Institute. For two years, Einstein and Grossman worked together; and by the time Einstein left for Berlin in 1914, the way was clear. With Grossman's help, Einstein saw that the gravitational field could be expressed as a curvature of the 4-dimensional space-time continuum.

In 1919, a British expedition, headed by Sir Arthur Eddington, sailed to a small island off the coast of West Africa. Their purpose was to test Einstein's prediction of the bending of light in a gravitational field by observing stars close to the sun during a total eclipse. The observed bending agreed exactly with Einstein's predictions; and as a result he became world-famous. The general public was fascinated by relativity, in spite of the abstruseness of the theory (or perhaps because of it). Einstein, the absent-minded professor, with long, uncombed hair, became a symbol of science. The world was tired of war, and wanted something else to think about.

In its original version, Einstein's theory of relativity predicted an expansion of the universe. However. since the universe was then thought to be static, Einstein later added to his equations a "cosmological constant" that led to a static non-expanding universe. Later, in 1929, when the discoveries of Edwin Hubble showed that the universe is indeed expanding, Einstein said that he considered his cosmological constant to be the biggest blunder of his life.

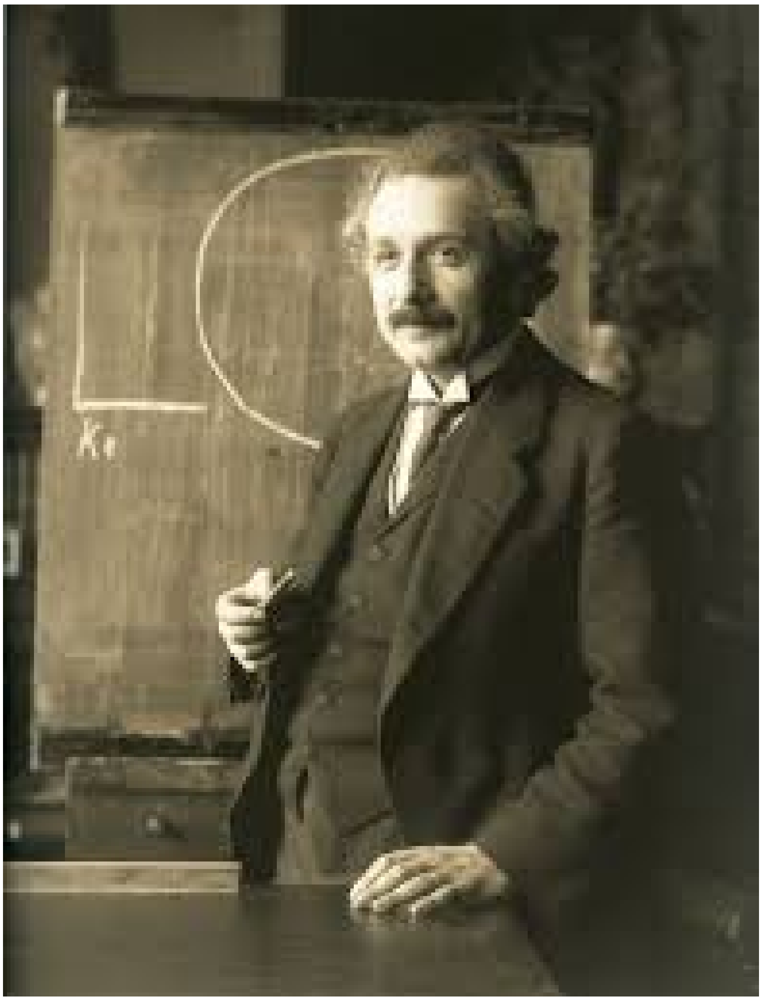

Figure 2.11: **Albert Einstein (1879-1955).**

2.11 Edwin Hubble

Edwin Hubble's father wanted him to become a lawyer, and following his father's dying request, he studied law, first at the University of Chicago, and then at Oxford University. However, his true passion was astronomy. During his Oxford law studies, he managed to take a number of science course. After the end of World War I, he became a student at Cambridge University, this time abandoning law and studying astronomy full-time.

In 1919, Hubble was offered a position at the Mount Wilson Observatory in Pasadena California, a position which he held until his death in 1953. Just as Hubble arrived, the Mount Wilson Observatory acquired the 100 inch Hooker telescope. At that time it was the world's largest, and it helped Hubble to make his important discoveries.

Hubble's special attention was drawn to the Chephiad variable stars, whose brightness varied with a characteristic period. A relationship between the period of Cephiad variable stars and their luminosity had been discovered in 1908 by Henrietta Swan Levitt. Her discovery allowed astronomers to calculate the distance of a variable star by comparing its period with its apparent brightness. Using this relationship, Hubble was able to show that some of the variable stars which he could observe with the Hooker telescope were too far away to be part of our own galaxy. His studies of the Andromeda nebula, which had previously been thought to be a cloud of gas within our own galaxy, proved that it was in fact an entire galaxy very similar to our own Milky Way.

Edwin Hubble used the Doppler effect to make a second extremely important discovery. When a star is moving away from the earth, the light from the star is shifted to the red. In other words each colour of light has a longer wave length than it would have if the star were stationary or moving towards us. This is similar to the effect that we can notice when the sound of the whistle of an approaching railway train falls in pitch as the train passes us and moves away. Hubble discovered that the red shift due to the Doppler effect is greatest for the galaxies that are farthest from the earth. This discovery, which is known as Hubble's Law, is interpreted by most astronomers as indicating that our universe as a whole is expanding.

In 1924, Edwin Hubble, who was then 35 years old, announced his epoch-making discoveries in the New York Times. In January, 1925, he followed this announcement with a formal paper, presented to a meeting of the American Astronomical Society.

Hubble's name is perhaps best known to the public because of the space telescope named after him. Why put a telescope into space? The reason is that for telescopes on even the highest of mountains, fluctuations in the density of air above them limits the resolution that they can achieve. Since the Hubble

Figure 2.12: **Edwin Hubble (1889-1953).**

Figure 2.13: **The Andromeda spiral nebula.**

Figure 2.14: **The Hubble space telescope**

space telescope is completely above the earth's atmosphere, it has been able to send us remarkable images of our universe.

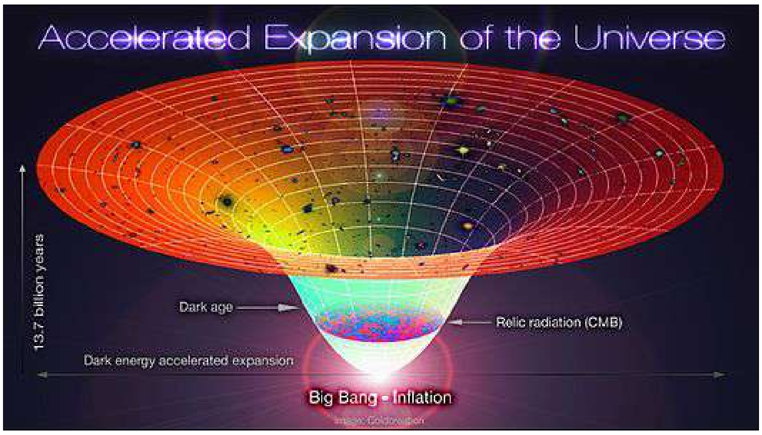

Figure 2.15: **The standard model of our universe.**

Figure 2.16: **Arno Penzias and Robert Woodrow Wilson, discoverers of the echo of the Big Bang.**

2.12 The Big Bang

If the Universe is expanding, as Hubble's Law suggests, then it is logical to extrapolate backward in time, and to suppose that the Universe expanded outward from one place. According to this model this model, which is called the *Standard Model* of cosmology, or *Big Bang Theory*, the Universe exploded outward from an extremely hot and dense initial state, gradually cooling as it expanded.[1]

The Standard Model was first proposed 1927 by Georges Lemaitre and Alexander Friedmann on the basis of their solutions to Einstein's general relativistic equations. In 1929 the model was supported by Hubble's discoveries. Until the late 1950's, there were competing models, such as the Steady State Cosmology proposed by Fred Hoyle. However in more recent times, very strong evidence has accumulated to support the Standard Model. This evidence includes the large-scale structure of the Universe, the abundances of elements.

Crucial evidence supporting the Standard Model was discovered by accident in 1964. Working at the Bell Laboratories in New Jersey, Arno Penzias and Robert Woodrow Wilson were experimenting with a super-sensitive 6 meter microwave horn antenna designed to pick up the signals from radio waves bounced off Echo balloon satellites. They tried to remove all the interfering signals from radar and radio broadcasts by cooling their receiver with liquid helium. However, despite their efforts, they could not get rid of a mysterious microwave background radiation that seemed to be coming equally from all directions, both day and night. They had no idea of what was causing this mysterious background.

Meanwhile, at Princeton University, only sixty miles away, astrophysicists Robert H. Dicke, Jim Peebls and David Wilkinson, building on the earlier work of George Gamow, had written a paper on the cosmic background radiation that they thought should be present on theoretical grounds. During the expansion and cooling of the Universe, a moment occurred when atoms formed, and the radiation characteristic of the temperature at that time was suddenly free to propagate outward. By now, the Princeton group calculated, this radiation should be red shifted so far that it would now lie in the microwave region.

As it happened, Bernard F. Burke of MIT knew of both the Bell Labs experiments and the Princeton group's theoretical work. He brought them all together, and a joint publication was arranged. In 1978, Penzias and Wilson were awarded a Nobel Prize on Physics for their experimental discovery of what might be called "the echo of the Big Bang". This was the crucial piece of evidence supporting the Standard Model.

[1]Today this initial state is believed to have been infinitely hot and infinitely dense, i.e. a *singularity*.

Today, our Universe is believed to be 13.72 billion years old. When it cooled enough for atoms to form, only hydrogen extremely small amounts of helium were present. The heavier elements are thought to have been synthesized through nuclear reactions in the interior of stars.

The Wikipedia article on stellar evolution states that *all stars are born from collapsing clouds of gas and dust... Over the course of millions of years, these protostars settle down into a state of equilibrium, becoming what is known as a main-sequence star.*

Nuclear fusion powers a star for most of its life. Initially the energy is generated by the fusion of hydrogen atoms at the core of the main-sequence star. Later, as the preponderance of atoms at the core becomes helium, stars like the Sun begin to fuse hydrogen along a spherical shell surrounding the core. This process causes the star to gradually grow in size, passing through the subgiant stage until it reaches the red giant phase. Stars with at least half the mass of the Sun can also begin to generate energy through the fusion of helium at their core, whereas more-massive stars can fuse heavier elements along a series of concentric shells. Once a star like the Sun has exhausted its nuclear fuel, its core collapses into a dense white dwarf and the outer layers are expelled as a planetary nebula. Stars with around ten or more times the mass of the Sun can explode in a supernova as their inert iron cores collapse into an extremely dense neutron star or black hole. Although the universe is not old enough for any of the smallest red dwarfs to have reached the end of their lives, stellar models suggest they will slowly become brighter and hotter before running out of hydrogen fuel and becoming low-mass white dwarfs.

Our local star, the sun, is middle-sized and middle-aged. It was formed an estimated 4.6 billion years ago, and will last another 5 billion years or so before expanding into a red giant. At the moment it lies of the main sequence in the temperature-luminosity diagram. Evidence from abundances of radioactive elements and their decay products indicates that our earth was formed soon after the sun, roughly 4.54 billion years ago.

Modern astronomy has shown the Universe to be almost unimaginably large. Wikipedia states that: "The size of the Universe is unknown; it may be infinite. The region visible from Earth (the observable universe) is a sphere with a radius of about 46 billion light years, based on where the expansion of space has taken the most distant objects observed. For comparison, the diameter of a typical galaxy is 30,000 light-years, and the typical distance between two neighboring galaxies is 3 million light-years. As an example, the Milky Way Galaxy is roughly 100,000 light years in diameter, and the nearest sister galaxy to the Milky Way, the Andromeda Galaxy, is located roughly 2.5 million light years away. There are probably more than 100 billion (10^{11}) galaxies in the observable Universe.Typical galaxies range from dwarfs with as few as ten million (10^7) stars up to giants with one trillion(10^{12}) stars, all orbiting the galaxy's center of mass. A 2010 study by astronomers estimated that the observable Universe contains 300 sextillion (3×10^{23}) stars."

Among this incredibly vast number of stars it is believed that there are innumerable stars that have planets similar to the Earth and hence able to support life. We also now know that given conditions that are favorable to life, it will almost certainly develop and evolve. The Earth seems to be only of extremely minor importance on the scale of the Universe. Given these facts, and given that the fundamental laws of nature are mathematical, it is difficult to maintain that the entire Universe and the laws that govern it were arranged for the benefit of humans, especially since humans have only existed for a brief instant on the time-scale of the Universe. If asked where the Universe came from and why, the scientist must answer with honesty, "I don't know".

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Chapter 3

LIFE ON EARTH

3.1 Formation of the Sun and the Earth

Our local star, the Sun, was formed from molecular clouds in interstellar space, which had been produced by the explosion of earlier stars. Our Sun contains mainly hydrogen and a little helium, with very small amounts of heavier elements. The vast amounts of energy produced by the sun come mainly from a nuclear reaction in which hydrogen is converted into helium.

There were clouds of containing not only hydrogen and helium, but also heavier elements left swirling around the infant Sun. Gradually, over many millions of years, these condensed through a process of collision and accretion, to form the planets. In the four relatively small inner planets, Mercury, Venus, Earth and Mars, heavy elements predominate, while in the giants, Jupiter, Saturn, Uranus and Neptune, we find lighter elements.

The Sun accounts for 99.86% of the solar system's mass, while the four giant planets contain 99% of the remaining mass.

One *astronomical unit* (1 AU) is, by definition, the average distance of the earth from the sun, i.e. approximately 93 million miles or 150 million kilometers. In terms of this unit, the average distances of the planets from the sun are as follows: Mercury, 0.387 AU; Venus, 0.722 AU; Earth, 1.000 AU; Mars, 1.52 AU; Jupiter, 5.20 AU; Saturn, 9.58 AU; Uranus, 19.2 AU; Neptune, 30.1 AU.

The Solar System also includes the asteroid belt, which lies between the orbits of Mars and Jupiter; the Kuiper belt and scattered disc, which are populations of trans-Neptunian objects; the dwarf planets, Ceres, Pluto and Eris; and the comets. Many of the bodies in the solar system, including six of the planets, have natural satellites or moons. The Earth's moon was produced by collision with a Mars-sized body, soon after the formation of the Earth.

Of the four inner planets, the Earth is the only one that has large amounts

Figure 3.1: **Much experimental evidence supports the Standard Model of cosmology, according to which our Universe began in an enormously hot and dense state 15.72 billion years ago, from which it is exploding outward. By 10 billion years before the present it had cooled enough for the first stars to form. Our own local star, the Sun, was formed 4.54 billion years ago from dust clouds left when earlier stars exploded.**

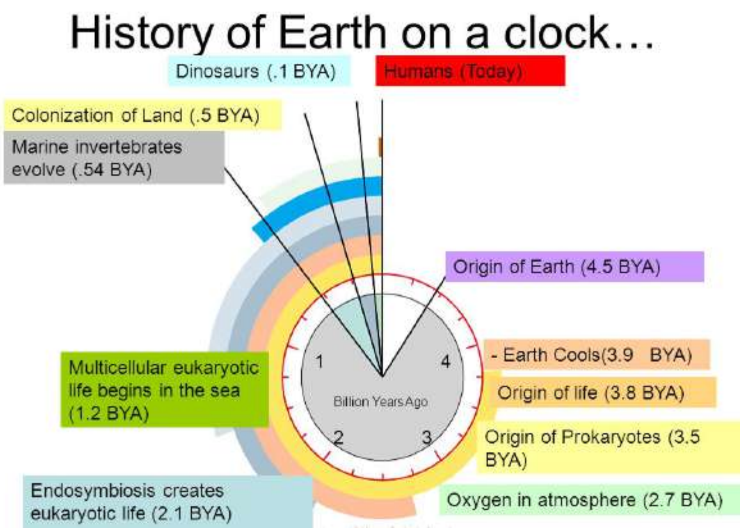

Figure 3.2: **The Earth was formed 4.54 billion years ago. Life on earth originated approximately 3.8 billion years ago (3.8 BYA).**

Figure 3.3: **This figure shows the relative sizes of the planets. Closest to the Sun are the relatively small terrestrial planets, Mercury, Venus, Earth and Mars, composed of metals and rock. Farther out are two gas giants, Jupiter and Saturn, which are composed mainly of hydrogen and helium. Still farther out are two ice giants, Uranus and Neptune, which are composed mainly of frozen water, frozen ammonia and frozen methane. The distances of the planets from the Sun shown in this figure are not realistic. The planetary orbits lie in roughly in the same plane, which is called the ecliptic, and all the planets circle the Sun in the same direction.**

of liquid water on its surface. When the Earth cooled sufficiently after the violent collision that gave us our Moon, oceans began to form, and life is believed to have originated in the oceans, approximately 3.8 billion years before the present.

3.2 The history of evolutionary theories

Before discussing modern theories of the origin and evolution of life on Earth, we will the ides of some early pioneers of this field.

Aristotle, (384 BC - 322 BC)

Aristotle was a very great organizer of knowledge, and his writings almost form a one-man encyclopedia. His best work was in biology, where he studied and classified more than five hundred animal species, many of which he also dissected. In Aristotle's classification of living things, he shows an awareness of the interrelatedness of species. This interrelatedness was much later used by Darwin as evidence for the theory of evolution. One cannot really say that Aristotle developed a theory of evolution, but he was groping towards the idea. In his history of animals, he writes:

"Nature proceeds little by little from lifeless things to animal life, so that it is impossible to determine either the exact line of demarcation, or on which side of the line an intermediate form should lie. Thus, next after lifeless things in the upward scale comes the plant. Of plants, one will differ from another as to its apparent amount of vitality. In a word, the whole plant kingdom, whilst devoid of life as compared with the animal, is yet endowed with life as compared with other corporeal entities. Indeed, there is observed in plants a continuous scale of ascent towards the animal."

Aristotle's classification of living things, starting at the bottom of the scale and going upward, is as follows: Inanimate matter, lower plants and sponges, higher plants, jellyfish, zoophytes and ascidians, molluscs, insects, jointed shellfish, octopuses and squids, fish and reptiles, whales, land mammals and man. The acuteness of Aristotle's observation and analysis can be seen from the fact that he classified whales and dolphins as mammals (where they belong) rather than as fish (where they superficially seem to belong, and where many ancient writers placed them).

Among Aristotle's biological writings, there appears a statement that clearly foreshadows the principle of natural selection, later independently discovered by Darwin and Wallace and fully developed by Darwin. Aristotle wrote: "Wheresoever, therefore... all parts of one whole happened like as if they were made for something, these were preserved, having been appropriately constituted by an internal spontaneity; and wheresoever things were not thus constituted, they perished, and still perish".

Averröes

During the Middle Ages, Aristotle's evolutionary ideas were revived and extended in the writings of the Islamic philosopher Averröes[1], who lived in Spain from 1126 to 1198. His writings had a great influence on western thought. Averroes shocked both his Moslem and his Christian readers by his thoughtful commentaries on the works of Aristotle, in which he maintained that the world was not created at a definite instant, but that it instead evolved over a long period of time, and is still evolving.

Like Aristotle, Averröes seems to have been groping towards the ideas of evolution which were later developed in geology by Lyell and in biology by Darwin and Wallace. Much of the scholastic philosophy written at the University of Paris during the 13th century was aimed at refuting the doctrines of Averroes; but nevertheless, his ideas survived and helped to shape the modern picture of the world.

The mystery of fossils

During the lifetime of Leonardo da Vinci (1452-1519) the existence of fossil shells in the rocks of high mountain ranges was recognized and discussed. "...the shells in Lombardy are at four levels", Leonardo wrote, "and thus it is everywhere, having been made at various times...The stratified stones of the mountains are all layers of clay, deposited one above the other by the various floods of the rivers." Leonardo had no patience with the explanation given by some of his contemporaries, that the shells had been carried to mountain tops by the deluge described in the Bible. "If the shells had been carried by the muddy waters of the deluge", he wrote, "they would have been mixed up, and separated from each other amidst the mud, and not in regular steps and layers." Nor did Leonardo agree with the opinion that the shells somehow grew within the rocks: "Such an opinion cannot exist in a brain of much reason", he wrote, "because here are the years of their growth, numbered on their shells, and there are large and small ones to be seen, which could not have grown without food, and could not have fed without motion...and here they could not move."

Leonardo believed that the fossil shells were once part of living organisms, that they were buried in strata under water, and much later lifted to the tops of

[1] Abul Walid Mahommed Ibn Achmed, Ibn Mahommed Ibn Rosched

mountains by geological upheavals. However his acute observations had little influence on the opinions of his contemporaries because they appear among the 4000 or so pages of notes which he wrote for himself but never published.

It was left to the Danish scientist Niels Stensen (1638-1686) (usually known by his Latinized name, Steno) to independently rediscover and popularize the correct interpretation of fossils and of rock strata. Steno, who had studied medicine at the University of Leiden, was working in Florence, where his anatomical studies attracted the attention of the Grand Duke of Tuscany, Ferdinand II. When an enormous shark was caught by local fishermen, the Duke ordered that its head be brought to Steno for dissection. The Danish anatomist was struck by shape of the shark's teeth, which reminded him of certain curiously shaped stones called glossopetrae that were sometimes found embedded in larger rocks. Steno concluded that the similarity of form was not just a coincidence, and that the glossopetrae were in fact the teeth of once-living sharks which had become embedded in the muddy sediments at the bottom of the sea and gradually changed to stone. Steno used the corpuscular theory of matter, a forerunner of atomic theory, to explain how the composition of the fossils could have changed while their form remained constant. Steno also formulated a law of strata, which states that in the deposition of layers of sediment, later converted to rock, the oldest layers are at the bottom.

In England, the brilliant and versatile experimental scientist Robert Hooke (1635-1703) added to Steno's correct interpretation of fossils by noticing that some fossil species are not represented by any living counterparts. He concluded that "there have been many other Species of Creatures in former Ages, of which we can find none at present; and that 'tis not unlikely also but that there may be divers new kinds now, which have not been from the beginning."

Similar observations were made by the French naturalist, Georges-Louis Leclerc, Comte de Buffon (1707-1788), who wrote: "We have monuments taken from the bosom of the Earth, especially from the bottom of coal and slate mines, that demonstrate to us that some of the fish and plants that these materials contain do not belong to species currently existing." Buffon's position as keeper of the Jardin du Roi, the French botanical gardens, allowed him time for writing, and while holding this post he produced a 44-volume encyclopedia of natural history. In this enormous, clearly written, and popular work, Buffon challenged the theological doctrines which maintained that all species were created independently, simultaneously and miraculously, 6000 years ago. As evidence that species change, Buffon pointed to vestigial organs, such as the lateral toes of the pig, which may have had a use for the ancestors of the pig. He thought that the donkey might be a degenerate relative of the horse. Buffon believed the earth to be much older than the 6000 years allowed by the Bible, but his estimate, 75,000 years, greatly underestimated the true age of the earth.

The great Scottish geologist James Hutton (1726-1797) had a far more realistic picture of the true age of the earth. Hutton observed that some rocks seemed to have been produced by the compression of sediments laid down under water, while other rocks appeared to have hardened after previous melting. Thus he classified rocks as being either igneous or else sedimentary. He believed the features of the earth to have been produced by the slow action of wind, rain, earthquakes and other forces which can be observed today, and that these forces never acted with greater speed than they do now. This implied that the earth must be immensely old, and Hutton thought its age to be almost infinite. He believed that the forces which turned sea beds into mountain ranges drew their energy from the heat of the earth's molten core. Together with Steno, Hutton is considered to be one of the fathers of modern geology. His uniformitarian principles, and his belief in the great age of the earth were later given wide circulation by Charles Darwin's friend and mentor, Sir Charles Lyell (1797-1875), and they paved the way for Darwin's application of uniformitarianism to biology. At the time of his death, Hutton was working on a theory of biological evolution through natural selection, but his manuscripts on this subject remained unknown until 1946

Linnaeus, Lamarck and Erasmus Darwin

During the 17th and 18th centuries, naturalists had been gathering information on thousands of species of plants and animals. This huge, undigested heap of information was put into some order by the great Swedish naturalist, Carl von Linné (1707-1778), who is usually called by his Latin name, Carolus Linnaeus.

Linnaeus reclassified all living things, and he introduced a binomial nomenclature, so that each plant or animal became known by two names - the name of its genus, and the name of its species. In the classification of Linnaeus, the species within a given genus resemble each other very closely. Linnaeus also grouped related genera into classes, and related classes into orders. Later, the French anatomist, Cuvier (1769-1832), grouped related orders into phyla.

In France, the Chevalier J.B. de Lamarck (1744-1829), was struck by the close relationships between various animal species; and in 1809 he published a book entitled *Philosophie Zoologique*, in which he tried to explain this interrelatedness in terms of a theory of evolution. Lamarck explained the close similarity of the species within a genus by supposing these species to have evolved from a common ancestor. However, the mechanism of evolution which he postulated was seriously wrong, since he believed that acquired characteristics could be inherited.

Lamarck believed, for example, that giraffes stretched their necks slightly by reaching upward to eat the leaves of high trees. He believed that these slightly-stretched necks could be inherited; and in this way, Lamarck thought, the necks of giraffes have gradually become longer over many generations. Although his belief in the inheritability of acquired characteristics was a serious mistake, Lamarck deserves much credit for correctly maintaining that the close similarity between the species of a genus is due to their descent from a common ancestral species.

Meanwhile, in England, the brilliant physician-poet, Erasmus Darwin (1731-1802), who was considered by Coleridge to have "...a greater range of knowledge than any other man in Europe", had published *The Botanic Garden* and *Zoonomia* (1794). Darwin's first book, *The Botanic Garden*, was written in verse, and in the preface he stated that his purpose was "...to inlist imagination under the banner of science.." and to call the reader's attention to "the immortal works of the celebrated Swedish naturalist, Linnaeus". This book was immensely popular during Darwin's lifetime, but modern readers might find themselves wishing that he had used prose instead of poetry.

Darwin's second book, *Zoonomia*, is more interesting, since it contains a clear statement of the theory of evolution:

"...When we think over the great changes introduced into various animals", Darwin wrote, "as in horses, which we have exercised for different purposes of strength and swiftness, carrying burthens or in running races; or in dogs, which have been cultivated for strength and courage, as the bull-dog; or for acuteness of his sense of smell, as in the hound and spaniel; or for the swiftness of his feet, as the greyhound; or for his swimming in the water, or for drawing snow-sledges, as the rough-haired dogs of the north... and add to these the great change of shape and colour which we daily see produced in smaller animals from our domestication of them, as rabbits or pigeons;... when we revolve in our minds the great similarity of structure which obtains in all the warm-blooded animals, as well as quadrupeds, birds and amphibious animals, as in mankind, from the mouse and the bat to the elephant and whale; we are led to conclude that they have alike been produced from a similar living filament."

Erasmus Darwin's son, Robert, married Suzannah Wedgwood, the pretty and talented daughter of the famous potter, Josiah Wedgwood; and in 1809, (the same year in which Lamarck published his *Philosophie Zoologique*), she became the mother of Charles Darwin.

Charles Darwin

As a boy, Charles Darwin was fond of collecting and hunting, but he showed no special ability in school. His father, disappointed by his mediocre performance, once said to him: "You care for nothing but shooting, dogs and rat-catching;

and you will be a disgrace to yourself, and to all your family."

Robert Darwin was determined that his son should not turn into an idle, sporting man, as he seemed to be doing, and when Charles was sixteen, he was sent to the University of Edinburgh to study medicine. However, Charles Darwin had such a sensitive and gentle disposition that he could not stand to see operations (performed, in those days, without chloroform). Besides, he had found out that his father planned to leave him enough money to live on comfortably; and consequently he didn't take his medical studies very seriously. However, some of his friends were scientists,and through them, Darwin became interested in geology and zoology.

Robert Darwin realized that his son did not want to become a physician, and, as an alternative, he sent Charles to Cambridge to prepare for the clergy. At Cambridge, Charles Darwin was very popular because of his cheerful, kind and honest character; but he was not a very serious student. Among his many friends, however, there were a few scientists, and they had a strong influence on him. The most important of Darwin's scientific friends were John Stevens Henslow, the Professor of Botany at Cambridge, and Adam Sedgwick, the Professor of Geology.

Remembering the things which influenced him at that time, Darwin wrote:

"During my last year at Cambridge, I read with care and profound interest Humboldt's *Personal Narrative of Travels to the Equinoctial Regions of America*. This work, and Sir J. Herschel's *Introduction to the Study of Natural Philosophy*, stirred up in me a burning desire to add even the most humble contribution to the noble structure of Natural Science. No one of a dozen books influenced me nearly so much as these. I copied out from Humboldt long passages about Teneriffe, and read them aloud to Henslow, Ramsay and Dawes... and some of the party declared that they would endeavour to go there; but I think they were only half in earnest. I was, however, quite in earnest, and got an introduction to a merchant in London to enquire about ships."

During the summer of 1831, Charles Darwin went to Wales to help Professor Sedgwick, who was studying the extremely ancient rock formations found there. When he returned to his father's house after this geological expedition, he found a letter from Henslow. This letter offered Darwin the post of unpaid naturalist on the *Beagle*, a small brig which was being sent by the British government to survey the coast of South America and to carry a chain of chronological measurements around the world.

Darwin was delighted and thrilled by this offer. He had a burning desire both to visit the glorious, almost-unknown regions described by his hero, Alexander von Humboldt, and to "add even the most humble contribution to the noble structure of Natural Science". His hopes and plans were blocked,

Figure 3.4: **Erasmus Darwin (1731-1802), the grandfather of Charles Darwin, proposed a theory of evolution, but did not support it with enough experimental evidence to satisfy the naturalists of the time.**

however, by the opposition of his father, who felt that Charles was once again changing his vocation and drifting towards a life of sport and idleness. “If you can find any man of common sense who advises you to go”, Robert Darwin told his son, “I will give my consent”.

Deeply depressed by his father’s words, Charles Darwin went to visit the estate of his uncle, Josiah Wedgwood, at Maer, where he always felt more comfortable than he did at home. In Darwin’s words what happened next was the following:

“...My uncle sent for me, offering to drive me over to Shrewsbury and talk with my father, as my uncle thought that it would be wise in me to accept the offer. My father always maintained that my uncle was one of the most sensible men in the world, and he at once consented in the kindest possible manner. I had been rather extravagant while at Cambridge, and to console my father, I said that ‘I should be deuced clever to spend more than my allowance whilst on board the *Beagle*’, but he answered with a smile, ‘But they tell me you are very clever!’.”

Thus, on December 27, 1831, Charles Darwin started on a five-year voyage around the world. Not only was this voyage destined to change Darwin’s life, but also, more importantly, it was destined to change man’s view of his place in nature.

Lyell’s hypothesis

As the *Beagle* sailed out of Devonport in gloomy winter weather, Darwin lay in his hammock, 22 years old, miserably seasick and homesick, knowing that

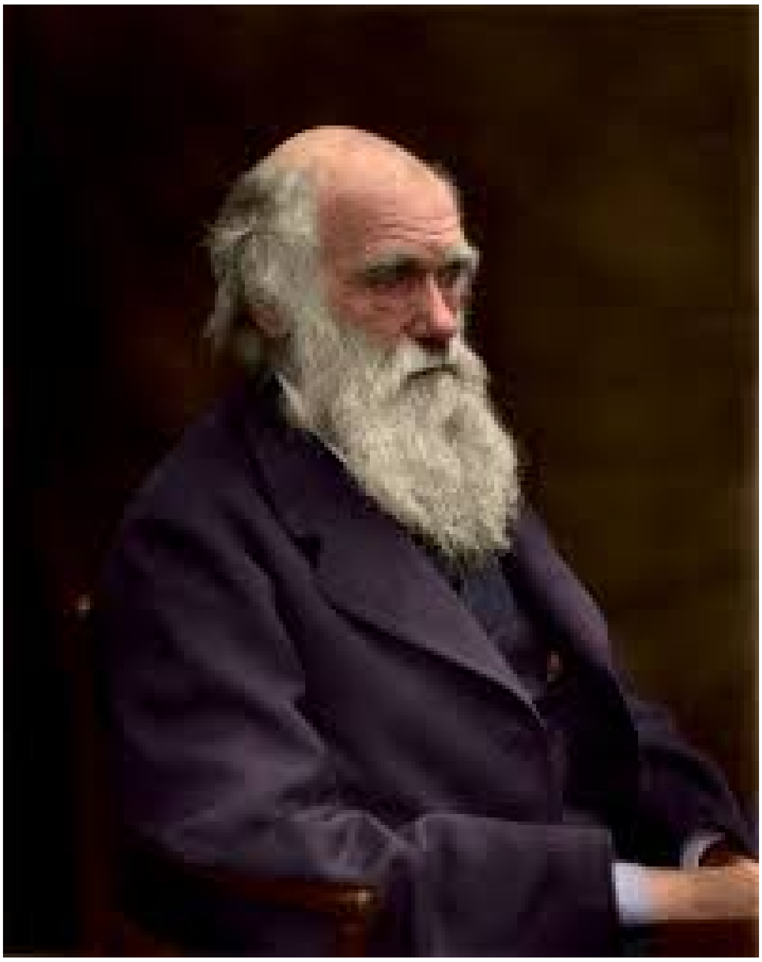

Figure 3.5: **Charles Darwin (1809-1882) as an old man,**

he would not see his family and friends for many years. To take his mind away from his troubles, Darwin read a new book, which Henslow had recommended: Sir Charles Lyell's *Principles of Geology.* "Read it by all means", Henslow had written, "for it is very interesting; but do not pay any attention to it except in regard to facts, for it is altogether wild as far as theory goes."

Reading Lyell's book with increasing excitement and absorption, Darwin could easily see what Henslow found objectionable: Lyell, a follower of the great Scottish geologist, James Hutton (1726-1797), introduced a revolutionary hypothesis into geology. According to Lyell, "No causes whatever have, from the earliest times to which we can look back, to the present, ever acted, but those now acting; and they have never acted with different degrees of energy from those which they now exert".

This idea seemed dangerous and heretical to deeply religious men like Henslow and Sedgwick. They believed that the earth's geology had been shaped by Noah's flood, and perhaps by other floods and catastrophes which had occurred before the time of Noah. The great geological features of the earth, its mountains, valleys and planes, they viewed as marks left behind by the various catastrophes through which the earth had passed.

All this was now denied by Lyell. He believed the earth to be enormously old - thousands of millions of years old. Over this vast period of time, Lyell believed, the long-continued action of slow forces had produced the geological features of the earth. Great valleys had been carved out by glaciers and by the slow action of rain and frost; and gradual changes in the level of the land, continued over enormous periods of time, had built up towering mountain ranges.

Lyell's belief in the immense age of the earth, based on geological evidence, made the evolutionary theories of Darwin's grandfather suddenly seem more plausible. Given such vast quantities of time, the long-continued action of small forces might produce great changes in biology as well as in geology!

By the time the *Beagle* had reached San Thiago in the Cape Verde Islands, Darwin had thoroughly digested Lyell's book, with its dizzying prospects. Looking at the geology of San Thiago, he realized "the wonderful superiority of Lyell's manner of treating geology". Features of the island which would have been incomprehensible on the basis of the usual Catastrophist theories were clearly understandable on the basis of Lyell's hypothesis.

As the *Beagle* slowly made its way southward along the South American coast, Darwin went on several expeditions to explore the interior. On one of these trips, he discovered some fossil bones in the red mud of a river bed. He carefully excavated the area around them, and found the remains of nine huge extinct quadrupeds. Some of them were as large as elephants, and yet in structure they seemed closely related to living South American species. For example, one of the extinct animals which Darwin discovered resembled an armadillo except for its gigantic size.

The *Beagle* rounded Cape Horn, lashed by freezing waves so huge that it almost floundered. After the storm, when the brig was anchored safely in the channel of Tierra del Fuego, Darwin noticed how a Fuegan woman stood for hours and watched the ship, while sleet fell and melted on her naked breast, and on the new-born baby she was nursing. He was struck by the remarkable degree to which the Fuegans had adapted to their frigid environment, so that they were able to survive with almost no shelter, and with no clothes except a few stiff animal skins, which hardly covered them, in weather which would have killed ordinary people.

In 1835, as the *Beagle* made its way slowly northward, Darwin had many chances to explore the Chilean coast - a spectacularly beautiful country, shadowed by towering ranges of the Andes. One day, near Concepcion Bay, he experienced the shocks of a severe earthquake.

"It came on suddenly, and lasted two minutes", Darwin wrote, "The town of Concepcion is now nothing more than piles and lines of bricks, tiles and timbers."

Measurements which Darwin made showed him that the shoreline near Concepcion had risen at least three feet during the quake; and thirty miles away, Fitzroy, the captain of the *Beagle*, discovered banks of mussels ten feet above the new high-water mark. This was dramatic confirmation of Lyell's theories! After having seen how much the level of the land was changed by a single earthquake, it was easy for Darwin to imagine that similar events, in the course of many millions of years, could have raised the huge wall of the Andes mountains.

In September, 1835, the *Beagle* sailed westward to the Galapagos Islands, a group of small rocky volcanic islands off the coast of Peru. On these islands, Darwin found new species of plants and animals which did not exist anywhere else in the world. In fact, he discovered that each of the islands had its own species, similar to the species found on the other islands, but different enough to be classified separately.

The Galapagos Islands contained thirteen species of finches, found nowhere else in the world, all basically alike in appearance, but differing in certain features especially related to their habits and diet. As he turned these facts over in his mind, it seemed to Darwin that the only explanation was that the thirteen species of Galapagos finches were descended from a single species, a few members of which had been carried to the islands by strong winds blowing from the South American mainland.

"Seeing this gradation and diversity of structure in one small, intimately related group of birds", Darwin wrote, "one might really fancy that from an original paucity of birds in this archipelago, one species had been taken and modified for different ends... Facts such as these might well undermine the stability of species."

As Darwin closely examined the plants and animals of the Galapagos Islands, he could see that although they were not quite the same as the corresponding South American species, they were so strongly similar that it seemed most likely that all the Galapagos plants and animals had reached the islands from the South American mainland, and had since been modified to their present form.

The idea of the gradual modification of species could also explain the fact, observed by Darwin, that the fossil animals of South America were more closely related to African and Eurasian animals than were the living South American species. In other words, the fossil animals of South America formed a link between the living South American species and the corresponding animals of Europe, Asia and Africa. The most likely explanation for this was that the animals had crossed to America on a land bridge which had since been lost, and that they had afterwards been modified.

The Beagle continued its voyage westward, and Darwin had a chance to study the plants and animals of the Pacific Islands. He noticed that there were no mammals on these islands, except bats and a few mammals brought by sailors. It seemed likely to Darwin that all the species of the Pacific Islands had reached them by crossing large stretches of water after the volcanic islands had risen from the ocean floor; and this accounted for the fact that so many classes were missing. The fact that each group of islands had its own particular species, found nowhere else in the world, seemed to Darwin to be strong evidence that the species had been modified after their arrival. The strange marsupials of the isolated Australian continent also made a deep impression on Darwin.

The Origin of Species

Darwin had left England on the Beagle in 1831, an immature young man of 22, with no real idea of what he wanted to do with his life. He returned from the five-year voyage in 1836, a mature man, confirmed in his dedication to science, and with formidable powers of observation, deduction and generalization. Writing of the voyage, Darwin says:

"I have always felt that I owe to the voyage the first real education of my mind... Everything about which I thought or read was made to bear directly on what I had seen, or was likely to see, and this habit was continued during the five years of the voyage. I feel sure that it was this training which has enabled me to do whatever I have done in science."

Darwin returned to England convinced by what he had seen on the voyage that plant and animal species had not been independently and miraculously created, but that they had been gradually modified to their present form over millions of years of geological time.

Darwin was delighted to be home and to see his family and friends once again. To his uncle, Josiah Wedgwood, he wrote:

"My head is quite confused from so much delight, but I cannot allow my sister to tell you first how happy I am to see all my dear friends again... I am most anxious once again to see Maer and all its inhabitants."

In a letter to Henslow, he said:

"My dear Henslow, I do long to see you. You have been the kindest friend to me that ever man possessed. I can write no more, for I am giddy with joy and confusion."

In 1837, Darwin took lodgings at Great Marlborough Street in London, where he could work on his geological and fossil collections. He was helped in his work by Sir Charles Lyell, who became Darwin's close friend. In 1837 Darwin also began a notebook on *Transmutation of Species*. His *Journal of researches into the geology and natural history of the various countries visited by the H.M.S. Beagle* was published in 1839, and it quickly became a best-seller. It is one of the most interesting travel books ever written, and since its publication it has been reissued more than a hundred times.

These were very productive years for Darwin, but he was homesick, both for his father's home at the Mount and for his uncle's nearby estate at Maer, with its galaxy of attractive daughters. Remembering his many happy visits to Maer, he wrote:

"In the summer, the whole family used often to sit on the steps of the old portico, with the flower-garden in front, and with the steep, wooded bank opposite the house reflected in the lake, with here and there a fish rising, or a water-bird paddling about. Nothing has left a more vivid picture in my mind than these evenings at Maer."

In the summer of 1838, tired of his bachelor life in London, Darwin wrote in his diary:

"My God, it is intolerable to think of spending one's whole life like a neuter bee, working, working, and nothing after all! Imagine living all one's days in smoky, dirty London! Only picture to yourself a nice soft wife on a sofa with a good fire, and books and music perhaps.. Marry! Marry! Marry! Q.E.D."

Having made this decision, Darwin went straight to Maer and proposed to his pretty cousin, Emma Wedgwood, who accepted him at once, to the joy of both families. Charles and Emma Darwin bought a large and pleasant country house at Down, fifteen miles south of London; and there, in December, 1839, the first of their ten children was born.

Darwin chose this somewhat isolated place for his home because he was beginning to show signs of a chronic illness, from which he suffered for the rest of his life. His strength was very limited, and he saved it for his work by avoiding social obligations. His illness was never accurately diagnosed during his own lifetime, but the best guess of modern doctors is that he had Chagas' disease, a trypanasome infection transmitted by the bite of a South American blood-sucking bug.

Darwin was already convinced that species had changed over long periods of time, but what were the forces which caused this change? In 1838 he found the answer:

"I happened to read for amusement Malthus on *Population*", he wrote, "and being well prepared to appreciate the struggle for existence which everywhere goes on from long-continued observation of the habits of animals and plants, it at once struck me that under these circumstances favorable variations would tend to be preserved, and unfavorable ones destroyed. The result would be the formation of new species"

"Here, then, I had at last got a theory by which to work; but I was so anxious to avoid prejudice that I determined not for some time to write down even the briefest sketch of it. In June, 1842, I first allowed myself the satisfaction of writing a very brief abstract of my theory in pencil in 33 pages; and this was enlarged during the summer of 1844 into one of 230 pages".

All of Darwin's revolutionary ideas were contained in the 1844 abstract, but he did not publish it! Instead, in an incredible Copernicus-like procrastination, he began a massive treatise on barnacles, which took him eight years to finish! Probably Darwin had a premonition of the furious storm of hatred and bigotry which would be caused by the publication of his heretical ideas.

Finally, in 1854, he wrote to his friend, Sir Joseph Hooker (the director of Kew Botanical Gardens), to say that he was at last resuming his work on the origin of species. Both Hooker and Lyell knew of Darwin's work on evolution, and for many years they had been urging him to publish it. By 1835, he had written eleven chapters of a book on the origin of species through natural selection; but he had begun writing on such a vast scale that the book might have run to four or five heavy volumes, which could have taken Darwin the rest of his life to complete.

Fortunately, this was prevented by the arrival at Down House of a bombshell in the form of a letter from a young naturalist named Alfred Russell Wallace. Like Darwin, Wallace had read Malthus' book *On Population*, and in a flash of insight during a period of fever in Malaya, he had arrived at a theory of evolution through natural selection which was precisely the same as the theory on which Darwin had been working for twenty years! Wallace enclosed with his letter a short paper entitled *On the Tendency of Varieties to Depart Indefinitely From the Original Type.* It was a perfect summary of

Darwin's theory of evolution!

"I never saw a more striking coincidence", the stunned Darwin wrote to Lyell, "If Wallace had my MS. sketch, written in 1842, he could not have made a better short abstract! Even his terms now stand as heads of my chapters... I should be extremely glad now to publish a sketch of my general views in about a dozen pages or so; but I cannot persuade myself that I can do so honourably... I would far rather burn my whole book than that he or any other man should think that I have behaved in a paltry spirit."

Both Lyell and Hooker acted quickly and firmly to prevent Darwin from suppressing his own work, as he was inclined to do. In the end, they found a happy solution: Wallace's paper was read to the Linnean Society together with a short abstract of Darwin's work, and the two papers were published together in the proceedings of the society. The members of the Society listened in stunned silence. As Hooker wrote to Darwin the next day, the subject was "too novel and too ominous for the old school to enter the lists before armouring."

Lyell and Hooker then persuaded Darwin to write a book of moderate size on evolution through natural selection. As a result, in 1859, he published *The Origin of Species*, which ranks, together with Newton's *Principia* as one of the two greatest scientific books of all time. What Newton did for physics, Darwin did for biology: He discovered the basic theoretical principle which brings together all the experimentally-observed facts and makes them comprehensible; and he showed in detail how this basic principle can account for the facts in a very large number of applications.

3.3 Modern theories of the origin of life

Molecular biology

Charles Darwin postulated that natural selection acts on small inheritable variations in the individual members of a species. His opponents objected that these slight variations would be averaged away by interbreeding. Darwin groped after an answer to this objection, but he did not have one. However, unknown to Darwin, the answer had been uncovered several years earlier by an obscure Augustinian monk, Gregor Mendel, who was born in Silesia in 1822, and who died in Bohemia in 1884.

Mendel loved both botany and mathematics, and he combined these two interests in his hobby of breeding peas in the monastery garden. Mendel carefully self-pollinated his pea plants, and then wrapped the flowers to prevent pollination by insects. He kept records of the characteristics of the plants and their offspring, and he found that dwarf peas always breed true - they invariably produce other dwarf plants. The tall variety of pea plants, pollinated with themselves, did not always breed true, but Mendel succeeded in isolating a strain of true-breeding tall plants which he inbred over many generations.

Next he crossed his true-breeding tall plants with the dwarf variety and produced a generation of hybrids. All of the hybrids produced in this way were tall. Finally Mendel self-pollinated the hybrids and recorded the characteristics of the next generation. Roughly one quarter of the plants in this new generation were true-breeding tall plants, one quarter were true-breeding dwarfs, and one half were tall but not true-breeding.

Gregor Mendel had in fact discovered the existence of dominant and recessive genes. In peas, dwarfism is a recessive characteristic, while tallness is dominant. Each plant has two sets of genes, one from each parent. Whenever the gene for tallness is present, the plant is tall, regardless of whether it also has a gene for dwarfism. When Mendel crossed the pure-breeding dwarf plants with pure-breeding tall ones, the hybrids received one type of gene from each parent. Each hybrid had a tall gene and a dwarf gene; but the tall gene was dominant, and therefore all the hybrids were tall. When the hybrids were self-pollinated or crossed with each other, a genetic lottery took place. In the next generation, through the laws of chance, a quarter of the plants had two dwarf genes, a quarter had two tall genes, and half had one of each kind.

Mendel published his results in the *Transactions of the Brünn Natural History Society* in 1865, and no one noticed his paper[2]. At that time, Austria was being overrun by the Prussians, and people had other things to think about. Mendel was elected Abbot of his monastery; he grew too old and fat to bend over and cultivate his pea plants; his work on heredity was completely forgotten, and he died never knowing that he would one day be considered to be the founder of modern genetics.

In 1900 the Dutch botanist named Hugo de Vries, working on evening primroses, independently rediscovered Mendel's laws. Before publishing, he looked through the literature to see whether anyone else had worked on the subject, and to his amazement he found that Mendel had anticipated his great discovery by 35 years. De Vries could easily have published his own work without mentioning Mendel, but his honesty was such that he gave Mendel full credit and mentioned his own work only as a confirmation of Mendel's laws. Astonishingly, the same story was twice repeated elsewhere in Europe during the same year. In 1900, two other botanists (Correns in Berlin and Tschermak in Vienna) independently rediscovered Mendel's laws, looked through the literature, found Mendel's 1865 paper, and gave him full credit for the discovery.

Besides rediscovering the Mendelian laws for the inheritance of dominant and recessive characteristics, de Vries made another very important discovery:

[2] Mendel sent a copy of his paper to Darwin; but Darwin, whose German was weak, seems not to have read it.

He discovered genetic mutations - sudden unexplained changes of form which can be inherited by subsequent generations. In growing evening primroses, de Vries found that sometimes, but very rarely, a completely new variety would suddenly appear, and he found that the variation could be propagated to the following generations. Actually, mutations had been observed before the time of de Vries. For example, a short-legged mutant sheep had suddenly appeared during the 18th century; and stock-breeders had taken advantage of this mutation to breed sheep that could not jump over walls. However, de Vries was the first scientist to study and describe mutations. He noticed that most mutations are harmful, but that a very few are beneficial, and those few tend in nature to be propagated to future generations.

After the rediscovery of Mendel's work by de Vries, many scientists began to suspect that chromosomes might be the carriers of genetic information. The word "chromosome" had been invented by the German physiologist, Walther Flemming, to describe the long, threadlike bodies which could be seen when cells were stained and examined through, the microscope during the process of division. It had been found that when an ordinary cell divides, the chromosomes also divide, so that each daughter cell has a full set of chromosomes.

The Belgian cytologist, Edouard van Benedin, had shown that in the formation of sperm and egg cells, the sperm and egg receive only half of the full number of chromosomes. It had been found that when the sperm of the father combines with the egg of the mother in sexual reproduction, the fertilized egg again has a full set of chromosomes, half coming from the mother and half from the father. This was so consistent with the genetic lottery studied by Mendel, de Vries and others, that it seemed almost certain that chromosomes were the carriers of genetic information.

The number of chromosomes was observed to be small (for example, each normal cell of a human has 46 chromosomes); and this made it obvious that each chromosome must contain thousands of genes. It seemed likely that all of the genes on a particular chromosome would stay together as they passed through the genetic lottery; and therefore certain characteristics should always be inherited together.

This problem had been taken up by Thomas Hunt Morgan, a professor of experimental zoology working at Colombia University. He found it convenient to work with fruit flies, since they breed with lightning-like speed and since they have only four pairs of chromosomes.

Morgan found that he could raise enormous numbers of these tiny insects with almost no effort by keeping them in gauze-covered glass milk bottles, in the bottom of which he placed mashed bananas. In 1910, Morgan found a mutant white-eyed male fly in one of his milk-bottle incubators. He bred this fly with a normal red-eyed female, and produced hundreds of red-eyed hybrids. When he crossed the red-eyed hybrids with each other, half of the next generation were red-eyed females, a quarter were red-eyed males, and a quarter were white-eyed males. There was not one single white-eyed female! This indicated that the mutant gene for white eyes was on the same chromosome as the gene for the male sex.

As Morgan continued his studies of genetic linkages, however, it became clear that the linkages were not absolute. There was a tendency for all the genes on the same chromosome to be inherited together; but on rare occasions there were "crosses", where apparently a pair of chromosomes broke at some point and exchanged segments. By studying these crosses statistically, Morgan and his "fly squad" were able to find the relative positions of genes on the chromosomes. They reasoned that the probability for a cross to separate two genes should be proportional to the distance between the two genes on the chromosome. In this way, after 17 years of work and millions of fruit flies, Thomas Hunt Morgan and his coworkers were able to make maps of the fruit fly chromosomes showing the positions of the genes.

This work had been taken a step further by Hermann J. Muller, a member of Morgan's "fly squad", who exposed hundreds of fruit flies to X-rays. The result was a spectacular outbreak of man-made mutations in the next generation.

"They were a motley throng", recalled Muller. Some of the mutant flies had almost no wings, others bulging eyes, and still others brown, yellow or purple eyes; some had no bristles, and others curly bristles. Muller's experiments indicated that mutations can be produced by radiation-induced physical damage; and he guessed that such damage alters the chemical structure of genes.

In spite of the brilliant work by Morgan and his collaborators, no one had any idea of what a gene really was.

The structure of DNA

Until 1944, most scientists had guessed that the genetic message was carried by the proteins of the chromosome. In 1944, however, O.T. Avery and his co-workers at the laboratory of the Rockefeller Institute in New York performed a critical experiment, which proved that the material which carries genetic information is not protein, but deoxyribonucleic acid (DNA) - a giant chain-like molecule which had been isolated from cell nuclei by the Swiss chemist, Friedrich Miescher.

Avery had been studying two different strains of pneumococci, the bacteria which cause pneumonia. One of these strains, the S-type, had a smooth coat, while the other strain, the R-type, lacked an enzyme needed for the manufacture of a smooth carbohydrate coat. Hence, R-type pneumococci had a rough appearance under the microscope. Avery and his co-workers were able to show that an extract from heat-killed S-type pneumococci could convert the living R-type species permanently into S-type; and they also showed that this extract consisted of pure DNA.

In 1947, the Austrian-American biochemist, Erwin Chargaff, began to study the long, chainlike DNA molecules. It had already been shown by Levine and Todd that chains of DNA are built up of four bases: adenine (A), thymine (T), guanine (G) and cytosine (C), held together by a sugar-phosphate backbone. Chargaff discovered that in DNA from the nuclei of living cells, the amount of A always equals the amount of T; and the amount of G always equals the amount of C.

When Chargaff made this discovery, neither he nor anyone else understood its meaning. However, in 1953, the mystery was completely solved by Rosalind Franklin and Maurice Wilkins at Kings College, London, together with James Watson and Francis Crick at Cambridge University. By means of X-ray diffraction techniques, Wilkins and Franklin obtained crystallographic information about the structure of DNA. Using this information, together with Linus Pauling's model-building methods, Crick and Watson proposed a detailed structure for the giant DNA molecule.

The discovery of the molecular structure of DNA was an event of enormous importance for genetics, and for biology in general. The structure was a revelation! The giant, helical DNA molecule was like a twisted ladder: Two long, twisted sugar-phosphate backbones formed the outside of the ladder, while the rungs were formed by the base pairs, A, T, G and C. The base adenine (A) could only be paired with thymine (T), while guanine (G) fit only with cytosine (C). Each base pair was weakly joined in the center by hydrogen bonds - in other words, there was a weak point in the center of each rung of the ladder - but the bases were strongly attached to the sugar-phosphate backbone. In their 1953 paper, Crick and Watson wrote:

"It has not escaped our notice that the specific pairing we have postulated suggests a possible copying mechanism for genetic material". Indeed, a sudden blaze of understanding illuminated the inner workings of heredity, and of life itself.

If the weak hydrogen bonds in the center of each rung were broken, the ladderlike DNA macromolecule could split down the center and divide into two single strands. Each single strand would then become a template for the formation of a new double-stranded molecule.

Because of the specific pairing of the bases in the Watson-Crick model of DNA, the two strands had to be complementary. T had to be paired with A, and G with C. Therefore, if the sequence of bases on one strand was (for example) TTTGCTAAAGGTGAACCA... , then the other strand necessarily had to have the sequence AAACGATTTCCACTTGGT... The Watson-Crick model of DNA made it seem certain that all the genetic information needed for producing a new individual is coded into the long, thin, double-stranded DNA molecule of the cell nucleus, written in a four-letter language whose letters are the bases, adenine, thymine, guanine and cytosine.

The solution of the DNA structure in 1953 initiated a new kind of biology - molecular biology. This new discipline made use of recently-discovered physical techniques - X-ray diffraction, electron microscopy, electrophoresis, chromatography, ultracentrifugation, radioactive tracer techniques, autoradiography, electron spin resonance, nuclear magnetic resonance and ultraviolet spectroscopy. In the 1960's and 1970's, molecular biology became the most exciting and rapidly-growing branch of science.

Hypothermophiles

Comparison of the base sequences of RNA and DNA from various species has proved to be a powerful tool for establishing evolutionary relationships. Figure 3.6 shows the universal philogenetic tree established in this way by Iwabe, Woese and their coworkers.[3]

In Figure 3.6, all presently living organisms are divided into three main kingdoms, Eukaryotes, Eubacteria, and Archaebacteria. Carl Woese, who proposed this classification on the basis of comparative sequencing, wished to call the three kingdoms "Eucarya, Bacteria and Archaea". However, the most widely accepted terms are the ones shown in capital letters on the figure. Before the comparative RNA sequencing work, which was performed on the ribosomes of various species, it had not been realized that there are two types of bacteria, so markedly different from each other that they must be classified as belonging to separate kingdoms. One example of the difference between archaebacteria and eubacteria is that the former have cell membranes which contain ether lipids, while the latter have ester lipids in their cell membranes. Of the three kingdoms, the eubacteria and the archaebacteria are "prokaryotes", that is to say, they are unicellular organisms having no cell nucleus. Most of the eukaryotes, whose cells contain a nucleus, are also unicellular, the exceptions being plants, fungi and animals.

One of the most interesting features of the philogenetic tree shown in Figure 3.6 is that the deepest branches - the organisms with shortest pedigrees - are all hyperthermophiles, i.e. they live in extremely hot environments such as hot springs or undersea hydrothermal vents. The shortest branches represent the

[3] "Phylogeny" means "the evolutionary development of a species". "Ontogeny" means "the growth and development an individual, through various stages, for example, from fertilized egg to embryo, and so on." Ernst Haeckel, a 19th century follower of Darwin, observed that, in many cases, "ontogeny recapitulates phylogeny."

most extreme hyperthermophiles. The group of archaebacteria indicated by (1) in the figure includes **Thermofilum, Thermoproteus, Pyrobaculum, Pyrodictium, Desulfurococcus**, and **Sulfolobus** - all hypothermophiles[4]. Among the eubacteria, the two shortest branches, Aquifex and Thermatoga are both hyperthermophiles[5]

The philogenetic evidence for the existence of hyperthermophiles at a very early stage of evolution lends support to a proposal put forward in 1988 by the German biochemist Günter Wächterhäuser. He proposed that the reaction for pyrite formation,

$$FeS + H_2S \rightarrow FeS_2 + 2H + +2e^-$$

which takes place spontaneously at high temperatures, supplied the energy needed to drive the first stages of chemical evolution towards the origin of life. Wächterhäuser pointed out that the surface of the mineral pyrite (FeS_2) is positively charged, and he proposed that, since the immediate products of carbon-dioxide fixation are negatively charged, they would be attracted to the pyrite surface. Thus, in Wächterhäuser's model, pyrite formation not only supplied the reducing agent needed for carbon-dioxide fixation, but also the pyrite surface aided the process. Wächterhäuser further proposed an archaic autocatylitic carbon-dioxide fixation cycle, which he visualized as resembling the reductive citric acid cycle found in present-day organisms, but with all reducing agents replaced by FeS + H_2S, with thioester activation replaced by thioacid activation, and carbonyl groups replaced by thioenol groups. The interested reader can find the details of Wächterhäuser's proposals in his papers, which are listed at the end of this chapter.

A similar picture of the origin of life has been proposed by Michael J. Russell and Alan J. Hall in 1997. In this picture "...(i) life emerged as hot, reduced, alkaline, sulphide-bearing submarine seepage waters interfaced with colder, more oxidized, more acid, Fe^{2+} >>Fe^{3+}-bearing water at deep (*ca.* 4km) floors of the Hadean ocean *ca.* 4 Gyr ago; (ii) the difference in acidity, temperature and redox potential provided a gradient of pH (*ca.* 4 units), temperature (*ca.* 60°C) and redox potential (*ca.* 500 mV) at the interface of those waters that was sustainable over geological time-scales, providing the continuity of conditions conducive to organic chemical reactions needed for the origin of life..." [6]. Russell, Hall and their coworkers also emphasize the role

[4] Group (2) in Figure 3.7 includes **Methanothermus**, which is hyperthermophilic, and Methanobacterium, which is not. Group (3) includes **Archaeoglobus**, which is hyperthermophilic, and Halococcus, Halobacterium, Methanoplanus, Methanospirilum, and Methanosarcina, which are not.

[5] Thermophiles are a subset of the larger group of extremophiles.

[6]See W. Martin and M.J. Russell, *On the origins of cells: a hypothesis for the evolutionary*

that may have been played by spontaneously-formed 3-dimensional mineral chambers (bubbles). They visualize these as having prevented the reacting molecules from diffusing away, thus maintaining high concentrations.

Evidence from layered rock formations called "stromatolites", produced by colonies of photosynthetic bacteria, show that photoautotrophs (or phototrophs) appeared on earth at least 3.5 billion years ago. The geological record also supplies approximate dates for other events in evolution. For example, the date at which molecular oxygen started to become abundant in the earth's atmosphere is believed to have been 2.0 billion years ago, with equilibrium finally being established 1.5 billion years in the past. Multi-cellular organisms appeared very late on the evolutionary and geological time-scale - only 600 million years ago. By collecting such evidence, the Belgian cytologist Christian de Duve has constructed the philogenetic tree shown in Figure 3.7, showing branching as a function of time. One very interesting feature of this tree is the arrow indicating the transfer of "endosymbionts" from the eubacteria to the eukaryotes. In the next section, we will look in more detail at this important event, which took place about 1.8 billion years ago.

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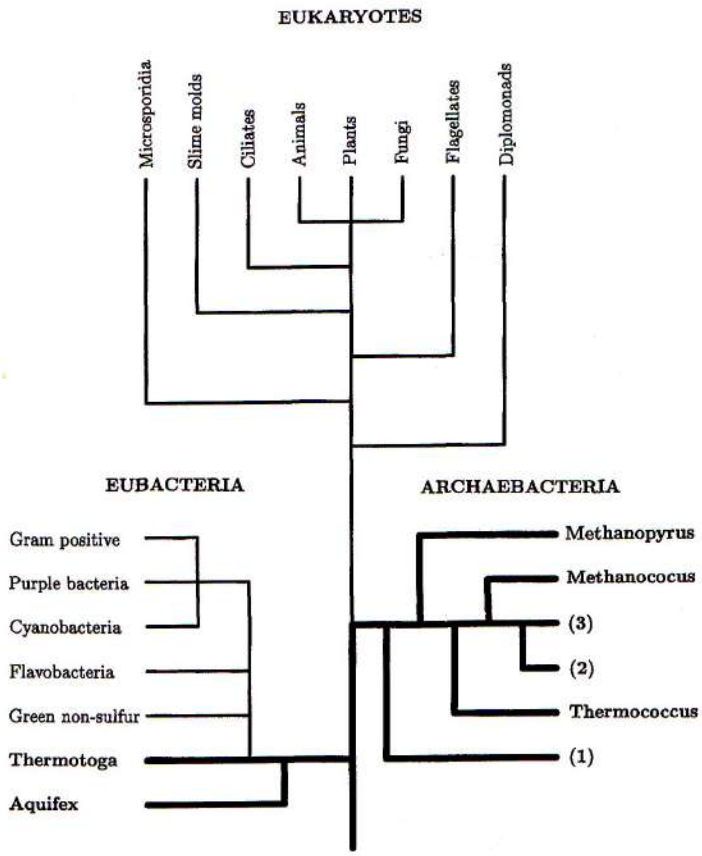

Figure 3.6: **At the root of the universal philogenetic tree are the hypothermophiles, a fact that indicates that life on earth may have originated at hot undersea vents, at which mineral-laden water, heated by volcanism, met the colder water of the primitive ocean.**

3.4 Life elsewhere in the universe

On December 18, 2017, scientists from the University of California published an article in *Science News* entitled *Ancient fossil microorganisms indicate that life in the universe is common.* According to the article:

"A new analysis of the oldest known fossil microorganisms provides strong evidence to support an increasingly widespread understanding that life in the universe is common.

"The microorganisms, from Western Australia, are 3.465 billion years old. Scientists from UCLA and the University of Wisconsin-Madison report today in the journal Proceedings of the National Academy of Sciences that two of the species they studied appear to have performed a primitive form of photosynthesis, another apparently produced methane gas, and two others appear to have consumed methane and used it to build their cell walls.

"The evidence that a diverse group of organisms had already evolved extremely early in the Earth's history, combined with scientists' knowledge of the vast number of stars in the universe and the growing understanding that planets orbit so many of them, strengthens the case for life existing elsewhere in the universe because it would be extremely unlikely that life formed quickly on Earth but did not arise anywhere else."

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Chapter 4

OUR ANCESTORS

4.1 Timeline for the evolution of life on the Earth

The dates shown here are taken from the Wikipedia article entitled *Timeline of the evolutionary history of life*. The unit BYA means "Billion years ago", while MYA means "Million years ago".

- 4.540 BYA. Earliest Earth
- 4.404 BYA, First appearance of water on Earth.
- 4.280 BYA. Earliest appearance of life on Earth.[1]
- 3.900 BYA, Cells resembling prokaryotes appear. These first organisms use CO_2 as a source of carbon, and obtain energy by oxidizing inorganic materials.
- 3.500 BYA, Lifetime of the last universal common ancestor. The split between bacteria and archae occurs.
- 3.000 BYA, Photosynthetic cyanobacteria evolved. They used water as a reducing agent and produced oxygen as a waste product.
- 2.800 BYA, Earliest evidence of microbial life on land.
- 2.500 BYA, Great Oxygenation Event, produced by cyanobacteria's oxogenic photosynthesis.

[1] This date for the first appearance of life on earth is earlier than previously thought possible. It is based on the ratio of carbon isotopes in zircon rocks recently found in Australia.

- 1.850 BYA, Eukaryotic cells appear. They probably evolved from cooperative assemblages of prokaryotes (phagocytosis and symbiosis).
- 1.200 BYA, Sexual reproduction first appears in the fossil records. It may have existed earlier.
- 0.800 BYA, First multicellular organisms.
- 0.600 BYA, The ozone layer is formed, making landbased life more possible.
- 0.580-0.500 BYA, The Cambrian Explosion. Biodiversity quickly increases and most modern phyla of animals appear in the fossil record.
- 0.560 BYA, Fungi appear.
- 0.550 BYA, Comb jellies, sponges, sea anemones and corals evolved.
- 0.530 BYA, The first known fossilized footprints on land.
- 0.485 BYA, Jawless fishes.
- 0.434 BYA, The first primitive plants move onto land, accompanied by fungi which may have helped them.
- 0.420 BYA, Ray-finned fishes, arachnids, and land scorpions.
- 0.410 BYA, First signs of teeth in fish.
- 0.395 BYA, First lichens, stonewarts, harvestmen and springtails. The first known tracks of four-legged animals on land.
- 0.363 BYA, The Carboniferous Period starts. Insects appear on land and soon learn to fly. Seed-bearing plants and forests cover the land.
- 0.360 BYA, First crabs and ferns. Land flora dominated by ferns.
- 0.350 BYA, Large sharks, ratfishes and hagfish.
- 0.320 BYA, The precursors of mammals separate from the precursors to reptiles.
- 0.280 BYA, Earliest beetles, seed plants and conifers diversify.
- 0.2514 BYA, The Permian-Triassic extinction event eliminates 90-95% of marine species, and 70% of terrestrial vertebrates.[2]

[2]Today, there is a danger that human use of fossil fuels will initiate a very similar extinction event. This danger will be discussed in a later chapter.

- 0.245 BYA, Earliest icthyosaurs (i.e. seagoing dinosaurs).
- 0.225 BYA, Earliest dinosaurs and conifers. First mammals.
- 0.220 BYA, Seed-producing forests dominate the land. Herbivours grow to huge sizes. First flies and turtles.
- 0.155 BYA, First bloodsucking insects. Archaeopteryx, a possible ancestor of birds, appears.
- 0.130 BYA, Rise of the flowering plants. Coevolution of plants and their pollinators.
- 0.115 BYA, First monotreme (egg-laying) mammals.
- 0.110 BYA, Toothed diving birds.
- 0.100 BYA, Earliest bees.
- 0.090 BYA, Probable origin of placental mammals. However, the first undisputed fossil evidence is from 0.066 BYA.
- 0.080 BYA, First ants.
- 0.066 BYA, The Cretaceous-Paleogene extinction event wipes out about half of all animal species, including all of the dinosaurs except the birds. Afterwards, mammals become the dominant animal species. Conifers dominate northern forests.
- 0.060 BYA, Earliest true primates. Diversification of large, flightless birds. The ancestors of carnivorous mammals had appeared.
- 0.055 BYA, Diversification of birds. First songbirds, parrots, loons, swifts, and woodpeckers. First whale.
- 0.052 BYA, First bats appear in the fossil record.
- 0.050 BYA, Tapirs, rhinoceroses and camels appear. Diversification of primates.
- 0.040 BYA, Modern-type moths and butterflies were alive.
- 0.035 BYA, Grasses diversify. Many modern mammal groups appear.
- 0.030 BYA, Earliest pigs and cats.
- 0.025 BYA, First deer.

- 0.020 BYA, Giraffes, hyenas, bears, and giant anteaters appear. Birds increase in diversity.
- 0.015 BYA, First mastodons. Australian megafauna diversify. Kangaroos appear.
- 0.010 BYA, Grasslands and savannahs are established. Major diversification of grassland animals and snakes. Insects diversify, especially ants and termites.
- 0.0095 BYA = 9.50 MYA, Great American Interchange occurs. Armadillos, opossums, hummingbirds, "terror birds", and ground sloths were among the species that migrated from South America to North America after a land bridge formed between the previously isolated continents. Species moving in the opposite direction included horses, tapirs, saber-toothed cats, jaguars, bears, coaties, ferrets, otters, skunks and deer.
- 6.50 MYA, First homanins (our human ancestors diverging from the apes).
- 6.00 MYA, Australopithecines (extinct close relatives of humans after the split with chimpanzees) diversify.
- 5.00 MYA, First tree sloths and hippopotami. Diversification of grazing and carnivorous mammals.
- 4.00 MYA, Diversification of Australopithecines. The first modern elephants, giraffes, zebras, lions, rhinoceros and gazelles.
- 2.80 MYA, Appearance of a species intermediate between the Anthropithecines and Homo Habilis.
- 2.10 MYA, First member of the genus *Homo* appears, Homo habilis.

4.2 Early ancestors of humans

In his *Systema Naturae*, published in 1735, Carolus Linnaeus correctly classified humans as mammals associated with the anthropoid apes. However, illustrations of possible ancestors of humans in a later book by Linnaeus, showed one with a manlike head on top of a long-haired body, and another with a tail. A century later, in 1856, light was thrown on human ancestry by the discovery of some remarkable bones in a limestone cave in the valley of Neander, near Düsseldorf - a skullcap and some associated long bones. The skullcap was clearly manlike, but the forehead was low and thick, with massive ridges over the eyes. The famous pathologist Rudolf Virchow dismissed the find as a relatively recent pathological idiot. Other authorities thought that it was "one of the Cossacks who came from Russia in 1814". Darwin knew of the "Neanderthal man", but he was too ill to travel to Germany and examine the bones. However, Thomas Huxley examined them, and in his 1873 book, Zoological Evidences of Man's Place in Nature, he wrote: "Under whatever aspect we view this cranium... we meet with apelike characteristics, stamping it as the most pithecoid (apelike) of human crania yet discovered."

"In some older strata," Huxley continued, "do the fossilized bones of an ape more anthropoid, or a man more pithecoid, than any yet known await the researches of some unborn paleontologist?" Huxley's question obsessed Eugène Dubois, a young Dutch physician, who reasoned that such a find would be most likely in Africa, the home of chimpanzees and gorillas, or in the East Indies, where orang-outangs live. He was therefore happy to be appointed to a post in Sumatra in 1887. While there, Dubois heard of a site in Java where the local people had discovered many ancient fossil bones, and at this site, after much searching, he uncovered a cranium which was much too low and flat to have belonged to a modern human. On the other hand it had features which proved that it could not have belonged to an ape. Near the cranium, Dubois found a leg bone which clearly indicated upright locomotion, and which he (mistakenly) believed to belong to the same creature. In announcing his find in 1894, Dubois proposed the provocative name "Pithecanthropus erectus", i.e. "upright-walking ape-man"

Instead of being praised for this discovery, Dubois was denounced. His attackers included not only the clergy, but also many scientists (who had expected that an early ancestor of man would have an enlarged brain associated with an apelike body, rather than apelike head associated with upright locomotion). He patiently exhibited the fossil bones at scientific meetings throughout Europe, and gave full accounts of the details of the site where he had unearthed them. When the attacks nevertheless continued, Dubois became disheartened, and locked the fossils in a strongbox, out of public view, for the next 28 years. In 1923, however, he released a cast of the skull, which showed that the brain volume was about 900 cm^3 - well above the range of apes, but below the 1200-1600 cm^3 range which characterizes modern man. Thereafter he again began to exhibit the bones at scientific meetings.

The fossil bones of about 1000 hominids, intermediate between apes and humans, have now been discovered. The oldest remains have been found in Africa. Many of these were discovered by Raymond Dart and Robert Broom, who worked in South Africa, and by Louis and Mary Leaky and their son Richard, who made their discoveries at the Olduvai Gorge in Tanzania and at

Lake Rudolph in Kenya.

One can deduce from biochemical evidence that the most recent common ancestor of the anthropoid apes and of humans lived in Africa between 5 and 10 million years before the present. Although the community of palaeoanthropologists is by no means unanimous, there is reasonably general agreement that while A. africanus is probably an ancestor of H. habilis and of humans, the "robust" species, A. aethiopicus, A. robustus and A. boisei1[3] represent a side-branch which finally died out. "Pithecanthropus erectus", found by Dubois, is now classified as a variety of Homo erectus, as is "Sinanthropus pekinensis" ("Peking man"), discovered in 1929 near Beijing, China.

Footprints 3.7 million years old showing upright locomotion have been discovered near Laetoli in Tanzania. The Laetoli footprints are believed to have been made by A. afarensis, which was definitely bipedal, but upright locomotion is thought to have started much earlier. There is even indirect evidence which suggests that A. ramidus may have been bipedal. Homo habilis was discovered by Mary and Louis Leakey at the Olduvai Gorge, among beds of extremely numerous pebble tools. The Leakeys gave this name (meaning "handy man") to their discovery in order to call special attention to his use of tools. The brain of H. habilis is more human than that of A. africanus, and in particular, the bulge of Broca's area, essential for speech, can be seen on one of the skull casts. This makes it seem likely that H. habilis was capable of at least rudimentary speech.

Homo erectus was the first species of hominid to leave Africa, and his remains are found not only there, but also in Europe and Asia. "Peking man", who belonged to this species, probably used fire. The stone tools of H. erectus were more advanced than those of H. habilis; and there is no sharp line of demarcation between the most evolved examples of H. erectus and early fossils of archaic H. sapiens.

Homo sapiens neanderthalensis lived side by side with Homo sapiens sapiens (modern man) for a hundred thousand years; but in relatively recent times, only 30,000 years ago, Neanderthal man disappeared. Did modern man outcompete him? Do present-day humans carry any Neanderthal genes? To what extent was modern man influenced by Neanderthal cultural achievements? Future research may tell us the answers to these questions, but for the moment they are mysteries.

The hominid species shown in Table 4.1 show an overall progression in various characteristics: Their body size and brain size grew. They began to mature more slowly and to live longer. Their tools and weapons increased in

[3] A. boisei was originally called "Zinjanthropus boisei" by Mary and Louis Leakey who discovered the fossil remains at the Olduvai Gorge. Charles Boise helped to finance the Leakey's expedition.

Table 4.1: **Hominid species**

genus and species	years before present	brain volume
Ardipithicus ramidus	4.35 to 4.45 million	300 to 350 cm^2
Australopithecus anamensis	4.2 to 3.9 million	
Australopithecus afarensis	3.9 to 3.0 million	375 to 550 cm^3
Australopithecus africanus	3 to 2 million	420 to 500 cm^3
Australopithecus aethiopicus	2.6 to 2.3 million	410 cm^3
Paranthropus robustus	2 to 1.5 million	410 to 530 cm^3
Australopithecus boisei	2.1 to 1.1 million	530 cm^3
Homo habilis	2.1 to 1.5 million	550 to 687 cm^3
Homo erectus	1.9 to 0.143 million	750 to 1225 cm^3
Homo sapiens (archaic)	0.5 to 0.2 million	1200 cm^3
Homo sapiens neand.	0.23 to 0.04 million	1450 cm^3
Homo sapiens sapiens	0.12 mil. to present	1350 cm^3

Table 4.2: **Paleolithic cultures**

name	years before present	characteristics
Oldowan	2.4 to 1.5 million	Africa, flaked pebble tools
Choukoutien	1.2 to 0.5 million	chopper tool culture of east Asia
Abbevillian	500,000 to 450,000	crude stone handaxes
		Africa, Europe, northeast Asia
Mousterian	70,000 to 20,000	produced by Neanderthal man,
		retouched core and flake tools,
		wooden spears, fire, burial of dead
Aurignacian	50,000 to 20,000	western Europe, fine stone blades,
		pins and awls of bone, fire, cave art
Solutrian	20,000 to 17,000	France and central Europe,
		long, pressure-flaked bifacial blades
Magdalenian	17,000 to 10,000	western Europe, reindeer hunting
		awls and needles of bone and antler

sophistication. Meanwhile their teeth became smaller, and their skeletons more gracile - less heavy in proportion to their size. What were the evolutionary forces which produced these changes? How were they rewarded by a better chance of survival?

4.3 Ardipithicus ramidus

17 bone fragments belonging to our distant ancestor, A. ramidus, were discovered in 1992-1993 by a research team headed by Tim White. The discovery was made in the Afar Depression of the Middle Awash river valley of Ethiopia. In 1994, more fragments were discovered, amounting finally to 45% of a complete skeleton. On the basis of the age of the stratum in which the bones were found, A. ramidus is thought to have lived between 4.35 and 4.45 years ago. This hominid walked upright, but had foot with a thumblike big toe which could grasp tree branches. A. ramidus had a small brain, only 300-350 $cm.^3$, which is smaller than a modern female chimpanzee. Nevertheless, the upright locomotion of the species identifies it as a human ancestor rather than an ape.

4.4 Australopithecus

Australopithecus afarensis ("Lucy")

Several hundred fossil bone fragments belonging to A. afarensis were discovered in 1974 in the Awash valley of Ethiopia, not far from the site where A. ramidus was discovered in 1992-1994. Although discovered earlier, the bones belong to one of our ancestors who lived at a later period, 3.2 million years before the present. The bones belong to a young female who was given the fanciful nickname "Lucy", after the popular Beetles song "Lucy in the Sky With Diamonds" which was being played loudly and repeatedly at the campsite of the discoverers[4].

Lucy was 1.1 meters tall, (3 feet and 7 inches), with a brain-size comparable to a modern chimpanzee, but her upright locomotion marked her as a human ancestor rather than an ape. She had long arms in relation to the length of her legs, although not so long as those of a chimpanzee.

Homo habilis ("handy man")

Louis Leakey (father of Richard Leakey), and his wife, Mary Leakey, found the first trace of H. habilis in 1955: two hominin teeth. These were later

[4]Donald Johanson, Mary Leaky, Yves Coppens and their team.

classified as "milk teeth", and therefore considered difficult to link to taxa, unlike permanent teeth. However, in 1959, Mary Leakey recovered the cranium of a young adult that had a small brain, large face, tiny canines and massive chewing teeth. The remains were associated with stone tools of the Oldowan type. In 1964 the fossils were identified as a separate species and given the name Homo habilis.

Short in stature, with disproportionately long arms compared with H. sapiens, and a brain about half the size of that of modern humans, H. habilis was very apelike, and many palaeoanthropologists believe that the species ought to be classified with the Australopithicenes. On the other hand, the relatively advances stone tools and omnivorous diet of H. habilis support the classification of the species within the genus Homo.

Homo erectus

As mentioned above, the first fossil remains of H. erectus were discovered in Sumatra in 1857 by the young Dutch physician, Eugène Dubois. Most paleoanthropologists believe that H. erectus evolved in Africa, and was the first hominin to leave that continent, during a period when the climates of Africa and the Middle East were more favorable to migration then they later became. However, there is a minority school of thought that maintains that H. erectus evolved in Asia. In any case the species survived in Asia until only 143,000 years before the present, and was able to use fire.

Homo neanderthalensis

The species H. neandrithalensis ("Neanderthal Man") takes its name from the mountain valley near to Düsseldorf where fossil remains were discovered in 1856.[5] The presence in the Middle East of this successful and physically powerful species is probably the reason why the first attempts of H. sapiens to leave Africa failed.

The Wikipedia article on Homo heidelbergensis states that "Neanderthals, Denisovans, and modern humans are all considered to have descended from Homo heidelbergensis that appeared around 700,000 years ago in Africa. Fossils have been recovered in Ethiopia, Namibia and South Africa. Between 400,000 and 300,000 years ago a group of Homo heidelbergensis migrated into Europe and West Asia via yet unknown routes and eventually evolved into Neanderthals."

[5]Earlier fossils of H. neanderthalensis were discovered in Belgium in 1829, and in Gibraltar in 1848, but the importance of these discoveries was not recognized.

Figure 4.1: **Australopithecus afarensis. One famous member of this species, nicknames "Lucy", was 1.1 meters tall and lived 3.2 million years ago.**

Denisovans are eastern cousin of the Neanderthals, and the genes of both species have been sequenced by Prof. Svante Pääbo and his colleagues at the Max Planck Institute for Evolutionary Anthropology. The results of these studies show that the genomes of modern humans outside of Africa contain an appreciable amount of genetic information derived from interbreeding with Neanderthals and Denisovans.

Figure 4.2: **Australopithecus afarensis: a hunting scene. Males of the species are seen here using weapons and cooperative tactics.**

Figure 4.3: **Homo habilis, "handy man", was very apelike in size and appearance, but used a more advanced toolkit than previous hominins.**

Figure 4.4: **Homo habilis is seen here making and using tools.**

Figure 4.5: **Homo erectus left Africa, and spread throughout Eurasia, as far as Georgia, Armenia, India, Sri Lanka, China and Indonesia.**

Figure 4.6: **Homo erectus using fire.**

4.5 Y-chromosomal DNA and mitochondrial DNA

Recent DNA studies have cast much light on human prehistory, and especially on the story of how a small group of anatomically and behaviorally modern humans left Africa and populated the remainder of the world. Two types of DNA have been especially useful - Y-chromosomal DNA and mitochondrial DNA.

When we reproduce, the man's sperm carries either an X chromosome or a Y chromosome. It is almost equally probable which of the two it carries. The waiting egg of the mother has an X chromosome with complete certainty. When the sperm and egg unite to form a fertilized egg and later an embryo, the YX combinations become boys while the XX combinations become girls. Thus every male human carries a Y chromosome inherited from his father, and in fact this chromosome exists in every cell of a male's body.

Humans have a total of 23 chromosomes, and most of these participate in what might be called the "genetic lottery" - part of the remaining 22 chromosomes come from the father, and part from the mother, and it is a matter of chance which parent contributes which chromosome. Because of this genetic lottery, no two humans are genetically the same, except in the case of identical twins. This diversity is a great advantage, not only because it provides natural selection variation on which to act, but also it because prevents parasites from mimicking our cell-surface antigens and thus outwitting our immune systems. In fact the two advantages of diversity just mentioned are so great that sexual reproduction is almost universal among higher animals and plants.

Because of its special role in determining the sex of offspring, the Y chromosome is exempted from participation in the genetic lottery. This makes it an especially interesting object of study because the only changes that occur in Y chromosomes as they are handed down between generations are mutations. These mutations are not only infrequent but they also happen at a calculable rate. Thus by studying Y-chromosomal lineages, researchers have been able not only to build up prehistoric family trees but also to assign dates to events associated with the lineages.

The mutation M168 seems to have occurred just before the ancestral population of anatomically and behaviorally modern humans left Africa, roughly 60,000 years ago. All of the men who left Africa at that time carried this mutation. The descendents of this small group, probably a single tribe, were destined to populate the entire world outside Africa.

After M168, further mutations occurred, giving rise to the Y-chromosomal groups C, D, E and F-R. Men carrying Y chromosomes of type C migrated to Central Asia, East Asia and Australia/New Guinea. The D group settled in Central Asia, while men carrying Y chromosomes of type E can be found today in East Asia, Sub-Saharan Africa, the Middle East, West Eurasia, and Central Asia. Populations carrying Y chromosomes of types F-R migrated to all parts of the world outside Africa. Those members of population P who found their way to the Americas carried the mutation M242. Only indigenous men of the Americas have Y chromosomes with M242.

Mitochondrial DNA is present in the bodies of both men and women, but is handed on only from mother to daughter. The human family tree constructed from mutations in mitochondrial DNA is closely parallel to the tree constructed by studying Y chromosomes. In both trees we see that only a single small group left Africa, and that the descendents of this small group populated the remainder of the world. The mitochondrial groups L1a, L1b, and L2 are confined to Sub-Saharan Africa, but by following the lineage L3 we see a path leading out of Africa towards the population of the remainder of the world, as is shown in the next figure.

While the unmutated L3 lineage remained in Africa, a slightly changed group of people found their way out. It seems to have been a surprisingly small group, perhaps only a single tribe. Their descendents populated the remainder of the the world. The branching between the N and M lineages occurred after their exodus from Africa. All women in Western Eurasia are daughters of the N line, while in Eastern Eurasia women are descended from both the N and M lineages. Daughters of both N and M reached the Americas.

Mitochondrial DNA is also exempted from participation in the genetic lottery, but for a different reason. Mitochondria were once free-living eubacteria of a type called alpha-proteobacteria. These free-living bacteria were able perform oxidative phosphorylation, i.e. they could couple the combustion of glucose to the formation of the high-energy phosphate bond in ATP. When photosynthesis evolved, the earth's atmosphere became rich in oxygen, which was a deadly poison to most of the organisms alive at the time. Two billion years ago, when atmospheric oxygen began to increase in earnest, many organisms retreated into anaerobic ecological niches, while others became extinct; but some survived the oxygen crisis by incorporating alpha-proteobacteria into their cells and living with them symbiotically. Today, mitochondria living as endosymbionts in all animal cells, use oxygen constructively to couple the burning of food with the synthesis of ATP. As a relic of the time when they were free-living bacteria, mitochondria have their own DNA, which contained within them rather than within the cell nuclei.

When a sperm and an egg combine, the sperm's mitochondria are lost; and therefore all of the mitochondria in the body of a human child come from his or her mother. Just as Y-chromosomal DNA is passed essentially unchanged between generations in the male lines of a family tree, mitochondrial DNA is passed on almost without change in the female lines. The only changes in both cases are small and infrequent mutations. By estimating the frequency of these mutations, researchers can assign approximate dates to events in human prehistory.

On the female side of the human family tree, all lines lead back to a single woman, whom we might call "Mitochondrial Eve". Similarly, all the lines of the male family tree lead back to a single man, to whom we can give the name "Y-Chromosomal Adam". ("Eve" and "Adam" were not married, however; they were not even contemporaries!)

But why do the female and male and family trees both lead back to single individuals? This has to do with a phenomenon called "genetic drift". Sometimes a man will have no sons, and in that case, his male line will end, thus reducing the total number of Y-chromosomes in the population. Finally, after many generations, all Y-chromosomes will have dropped away through the ending of male lines except those that can be traced back to a single individual. Similar considerations hold for female lines.

When did Y-Chromosomal Adam walk the earth? Peter Underhill and his colleagues at Stanford University calculate that, on the basis of DNA evidence, Adam lived between 40,000 and 140,000 years before the present (BP). However, on the basis of other evidence (for example the dating of archaeological sites in Australia) 40,000 years BP can be ruled out as being much too recent. Similar calculations on the date of Mitochondrial Eve find that she lived very approximately 150,000 years BP, but again there is a wide error range.

Table 4.3: **Events leading up to the dispersal of fully modern humans from Africa (a model proposed by Sir Paul Mellars).**

Years before present	Event
150,000-200,000 BP	Initial emergence of anatomically modern populations in Africa
110,000-90,000 BP	Temporary dispersal of anatomically modern populations (with Middle Paleolithic technology) from Africa to southwest Asia, associated with clear symbolic expression
80,000-70,000 BP	Rapid climatic and environmental changes in Africa
80,000-70,000 BP	Major technological, economic and social changes in south and east Africa
70,000-60,000 BP	Major population expansion in Africa from small source area
ca. 60,000 BP	Dispersal of modern populations from Africa to Eurasia

Figure 4.7: **Homo neandrithalensis. In 1997, Prof. Dr. Svante Pääbo and his colleagues at the Max Planck Institute for Evolutionary Anthropology reported their successful sequencing of Neanderthal mitochondrial DNA. Later they sequenced the DNA of Denisovans, the eastern cousins of the Neanderthals. They were also able to show that 3-5% of the DNA of humans living outside Africa is shared with Neanderthals and Denisovans, indicating intermarriage, or at least interbreeding.**

Figure 4.8: **Homo neandrithalensis working happily in front of his dwelling. The brain size of Neanderthals was larger than that of modern humans, but their linguistic abilities may have been inferior to those of H. sapiens sapiens. The Neanderthals survived in Spain until 40,000 years ago. They are, in a sense, alive today, since their genes have been mixed with those of modern humans.**

4.6 Exodus: Out of Africa

A model for the events leading up to the exodus of fully modern humans from Africa has been proposed by Sir Paul Mellars of Cambridge University, and it is shown in Table 4.3. In the article on which this table is based, Mellars calls our attention to archaeological remains of anatomically modern humans at the sites of Skhul and Qafzeh in what is now northern Israel. The burials have been dated as having taken place 110,000-90,000 BP, and they show signs of cultural development, including ceremonial arrangement with arms folded, and sacrificial objects such as pierced shell ornaments. This early exodus was short-lived, however, probably because of competition with the long-established Neanderthal populations in the region.

In Mellars' model, rapid climatic and environmental changes took place in Africa during the period 80,000-70,000 BP. According to the Toba Catastrophe Theory[6] the climatic changes in Mellers' model were due to the eruption of a supervolcano at the site of what is now Lake Toba in Indonesia. This eruption, one of the largest known to us, took place ca. 73,000 BP, and plunged the earth into a decade of extreme cold, during which the population of our direct ancestors seem to have been reduced to a small number, perhaps as few as 10,000 individuals[7].

The survivors of the Toba Catastrophe may have been selected for improved linguistic ability, which gave them a more advanced culture than their contemporaries. Mellers points to archaeological and genetic evidence that a major population expansion of the L2 and L3 mitochondrial lineages took place in Africa 70,000-60,000 BP, starting from a small source region in East Africa, and spreading west and south. The expanding L2 and L3 populations were characterized by advanced cultural features such as upper paleolithic technology, painting and body ornaments.

All researchers agree that it was a small group of the L3 mitochondrial lineage that made the exodus from Africa, but there is some disagreement about the date of this event. These differences reflect the intrinsic inaccuracy of the genetic dating methods, but all researchers agree that the group passing out of Africa was remarkably small, especially when we reflect that the entire population of the remainder of the world is descended from them.

The small group of modern humans leaving Africa probably crossed the Red

[6]The Toba Catastrophe Theory is supported by such authors as Ann Gibons, Michael R. Rampino and Steven Self

[7]Additional support to the Toba Catastrophe Theory comes from DNA studies of mammals, such as chimpanzees, orangutans, macques, cheetahs, tigers and gorillas. These mammals also seem, on the basis of DNA studies, to have been reduced to very small populations at the time of the Toba eruption.

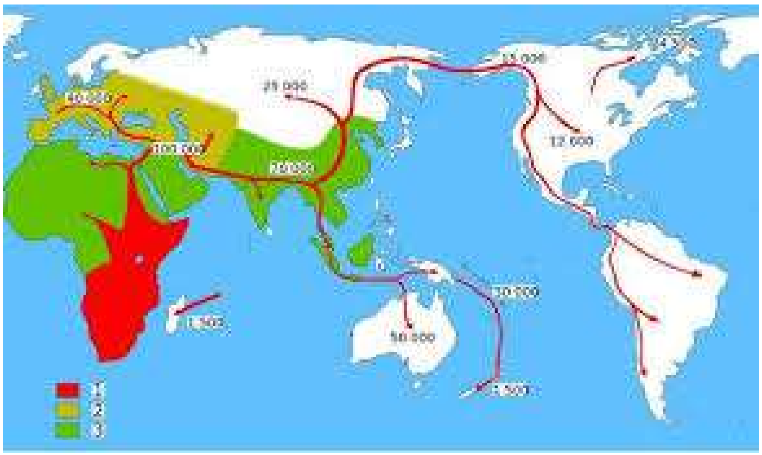

Figure 4.9: **The spread of Homo sapiens**

Sea at a its narrowest point[8]. The men in this tiny but brave group of explorers carried with them the Y-chromosomal mutation M168, while the women were of the mitochondrial lineage L3. Shortly after they crossed the Red Sea (like Moses and his followers), a mutation occurred and two new mitochondrial lineages were established, M and N. All women today in Western Eurasia are daughters of the N lineage[9], while the M lineage spread to the entire world outside Africa. The mitochondrial lineages M and N had further branches, and daughters of the A, B, C, D and X lineages passed over a land bridge which linked Siberia to Alaska during the period 22,000-7,000 BP, thus reaching the Americas.

[8]Today this narrow place is sometimes called "Gate of Grief" because many shipwrecks take place there.

[9]Of course, this broad statement does not take into account the movements of peoples that have taken place during historic times.

Figure 4.10: **Domestication of the dog**

Figure 4.11: **Paleolithic cave paintings as old as 40,000 years before the present have been found in many parts of the world. Those shown here are from the Dordogne region of France. Perhaps these paintings were made to ensure the success of hunts for the animals shown.**

Figure 4.12: **Another painting from the same cave in France.**

Figure 4.13: **Cave paintings made using human hands as stencils. The artist's mouth was filled with paint, and this was blown onto the rock.**

Figure 4.14: **Cave paintings showing the use of bows and arrows in hunting.**

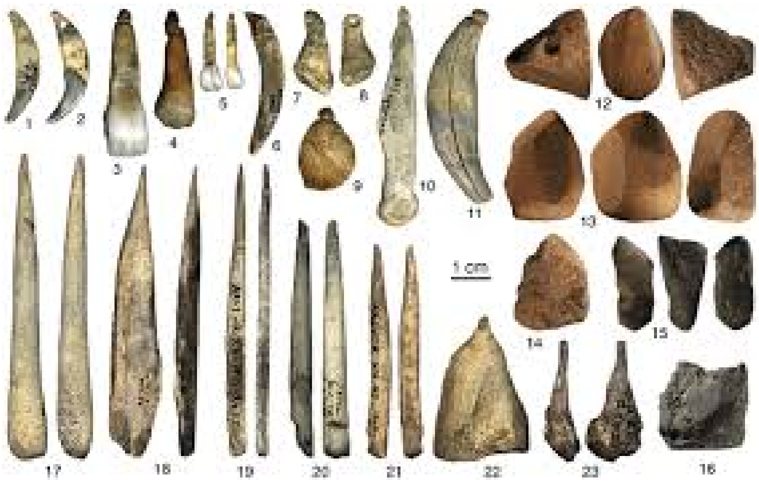

Figure 4.15: **Paleolithic stone tools**

Figure 4.16: **Neolithic stone tools were more advanced. Stone axes were highly polished and had holes to accommodate the hafts.**

Figure 4.17: **A Neolithic scene.**

Figure 4.18: **About 10,000 years ago, during a period of exceptional climatic stability, agriculture was invented independently in several parts of the world. It spread rapidly, revolutionizing human life, and making much larger population densities possible. Here we see agriculture in ancient Egypt. It also supported advanced civilizations in Mesopotamia, China and India, as well as in Central and South America.**

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Chapter 5

EMOTIONS

5.1 Ethology

In the long run, because of the terrible weapons that have already been produced through the misuse of science, and because of the even more terrible weapons that are likely to be invented in the future, the only way in which we can ensure the survival of civilization is to abolish the institution of war. But is this possible? Or are the emotions that make war possible so much a part of human nature that we cannot stop humans from fighting any more than we can stop cats and dogs from fighting? Can biological science throw any light on the problem of why our supposedly rational species seems intent on choosing war, pain and death instead of peace, happiness and life? To answer this question, we need to turn to the science of ethology - the study of inherited emotional tendencies and behavior patterns in animals and humans.

5.2 Darwin's book on emotions

In *The Origin of Species*, Charles Darwin devoted a chapter to the evolution of instincts, and he later published a separate book on *The Expression of the Emotions in Man and Animals*. Because of these pioneering studies, Darwin is considered to be the founder of ethology.

Behind Darwin's work in this field is the observation that instinctive behavior patterns are just as reliably inherited as morphological characteristics. Darwin was also impressed by the fact that within a given species, behavior patterns have some degree of uniformity, and the fact that the different species within a family are related by similarities of instinctive behavior, just as they are related by similarities of bodily form. For example, certain elements of cat-like behavior can be found among all members of the cat family; and certain elements of dog-like or wolf-like behavior can be found among all members of the dog family. On the other hand, there are small variations in instinct among the members of a given species. For example, not all domestic dogs behave in the same way.

"Let us look at the familiar case of breeds of dogs", Darwin wrote in *The Origin of Species*, "It cannot be doubted that young pointers will sometimes point and even back other dogs the very first time they are taken out; retrieving is certainly in some degree inherited by retrievers; and a tendency to run round, instead of at, a flock of sheep by shepherd dogs. I cannot see that these actions, performed without experience by the young, and in nearly the same manner by each individual, and without the end being known - for the young pointer can no more know that he points to aid his master than the white butterfly knows why she lays her eggs on the leaf of the cabbage - I cannot see that these actions differ essentially from true instincts..."

"How strongly these domestic instincts habits and dispositions are inherited, and how curiously they become mingled, is well shown when different breeds of dogs are crossed. Thus it is known that a cross with a bulldog has affected for many generations the courage and obstinacy of greyhounds; and a cross with a greyhound has given to a whole family of shepherd dogs a tendency to hunt hares..."

Darwin believed that in nature, desirable variations of instinct are propagated by natural selection, just as in the domestication of animals, favorable variations of instinct are selected and propagated by kennelmen and stock breeders. In this way, according to Darwin, complex and highly developed instincts, such as the comb-making instinct of honey-bees, have evolved by natural selection from simpler instincts, such as the instinct by which bumble bees use their old cocoons to hold honey and sometimes add a short wax tube.

In the introduction of his book, *The Expression of the Emotions in Man and Animals*, Darwin says "I thought it very important to ascertain whether the same expressions and gestures prevail, as has often been asserted without much evidence, with all the races of mankind, especially with those who have associated but little with Europeans. Whenever the same movements of the features or body express the same emotions in several distinct races of man, we may infer with much probability, that such expressions are true ones, - that is, are innate or instinctive."

To gather evidence on this point, Darwin sent a printed questionnaire on the expression of human emotions and sent it to missionaries and colonial administrators in many parts of the world. There were 16 questions to be answered:

1. *Is astonishment expressed by the eyes and mouth being opened wide, and by the eyebrows being raised?*

2. *Does shame excite a blush when the colour of the skin allows it to be visible? and especially how low down on the body does the blush extend?*

3. *When a man is indignant or defiant does he frown, hold his body and head erect, square his shoulders and clench his fists?*

4. *When considering deeply on any subject, or trying to understand any puzzle, does he frown, or wrinkle the skin beneath the lower eyelids?*

and so on.

Darwin received 36 replies to his questionnaire, many coming from people who were in contact with extremely distinct and isolated groups of humans. The results convinced him that our emotions and the means by which they are expressed are to a very large extent innate, rather than culturally determined, since the answers to his questionnaire were so uniform and so independent of both culture and race. In preparation for his book, he also closely observed the emotions and their expression in very young babies and children, hoping to see inherited characteristics in subjects too young to have been greatly influenced by culture. Darwin's observations convinced him that in humans, just as in other mammals, the emotions and their expression are to a very large extent inherited universal characteristics of the species.

The study of inherited behavior patterns in animals (and humans) was continued in the 20th century by such researchers as Karl von Frisch (1886-1982), Nikolaas Tinbergen (1907-1988), and Konrad Lorenz (1903-1989), three scientists who shared a Nobel Prize in Medicine and Physiology in 1973.

Karl von Frisch, the first of the three ethologists who shared the 1973 prize, is famous for his studies of the waggle-dance of honeybees. Bees guide each other to sources of food by a genetically programmed signaling method - the famous waggle dance, deciphered in 1945 by von Frisch. When a worker bee has found a promising food source, she returns to the hive and performs a complex dance, the pattern of which indicates both the direction and distance of the food. The dancer moves repeatedly in a pattern resembling the Greek letter Θ. If the food-discoverer is able to perform her dance on a horizontal flat surface in view of the sun, the line in the center of the pattern points in the direction of the food. However, if the dance is performed in the interior of the hive on a vertical surface, gravity takes the place of the sun, and the angle between the central line and the vertical represents the angle between the food source and the sun.

The central part of the dance is, in a way, a re-enactment of the excited forager's flight to the food. As she traverses the central portion of the pattern, she buzzes her wings and waggles her abdomen rapidly, the number of waggles indicating the approximate distance to the food [1]. After this central portion of the dance, she turns alternately to the left or to the right, following one or the other of the semicircles, and repeats the performance. Studies of the accuracy with which her hive-mates follow these instructions show that the waggle dance is able to convey approximately 7 bits of information - 3 bits concerning distance and 4 bits concerning direction. After making his initial discovery of the meaning of the dance, von Frisch studied the waggle dance in many species of bees. He was able to distinguish species-specific dialects, and to establish a plausible explanation for the evolution of the dance.

Among the achievements for which Tinbergen is famous are his classic studies of instinct in herring gulls. He noticed that the newly-hatched chick of a herring gull pecks at the beak of its parent, and this signal causes the parent gull to regurgitate food into the gaping beak of the chick. Tinbergen wondered what signal causes the chick to initiate this response by pecking at the beak of the parent gull. Therefore he constructed a series of models of the parent in which certain features of the adult gull were realistically represented while other features were crudely represented or left out entirely. He found by trial and error that the essential signal to which the chick responds is the red spot on the tip of its parent's beak. Models which lacked the red spot produced almost no response from the young chick, although in other respects they were realistic models; and the red spot on an otherwise crude model would make the chick peck with great regularity.

In other experiments, Tinbergen explored the response of newly-hatched chicks of the common domestic hen to models representing a hawk. Since the chicks were able to recognize a hawk immediately after hatching, he knew that the response must be genetically programmed. Just as he had done in his experiments with herring gulls, Tinbergen experimented with various models, trying to determine the crucial characteristic that was recognized by the chicks, causing them to run for cover. He discovered that a crude model in the shape of the letter T invariable caused the response if pulled across the sky with the wings first and tail last. (Pulled backwards, the T shape caused no response.)

In the case of a newly-hatched herring gull chick pecking at the red spot on the beak of its parent, the program in the chick's brain must be entirely genetically determined, without any environmental component at all. Learning cannot play a part in this behavioral pattern, since the pattern is present in the young chick from the very moment when it breaks out of the egg. On the other hand (Tinbergen pointed out) many behavioral patterns in animals and in man have both an hereditary component and an environmental component. Learning is often very important, but learning seems to be built on a foundation

[1] The number of waggles is largest when the source of food is near, and for extremely nearby food, the bees use another dance, the "round dance".

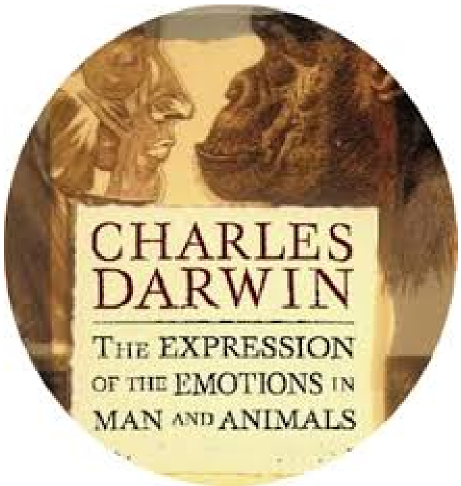

Figure 5.1: **Charles Darwin discussed inherited behaviour patterns in *The Origin of Species.* He later published a separate book on this subject entitled *The Expression of Emotions in Man and Animals.***

of genetic predisposition.

To illustrate this point, Tinbergen called attention to the case of sheep-dogs, whose remote ancestors were wolves. These dogs, Tinbergen tells us, can easily be trained to drive a flock of sheep towards the shepherd. However, it is difficult to train them to drive the sheep away from their master. Tinbergen explained this by saying that the sheep-dogs regard the shepherd as their "pack leader"; and since driving the prey towards the pack leader is part of the hunting instinct of wolves, it is easy to teach the dogs this maneuver. However, driving the prey away from the pack leader would not make sense for wolves hunting in a pack; it is not part of the instinctive makeup of wolves, nor is it a natural pattern of behavior for their remote descendants, the sheep-dogs.

As a further example of the fact that learning is usually built on a foundation of genetic predisposition, Tinbergen mentions the ease with which human babies learn languages. The language learned is determined by the baby's environment; but the astonishing ease with which a human baby learns to speak and understand implies a large degree of genetic predisposition.

Figure 5.2: **A baby crying, one of the illustrations in *The Expression of Emotions in Man and Animals.***

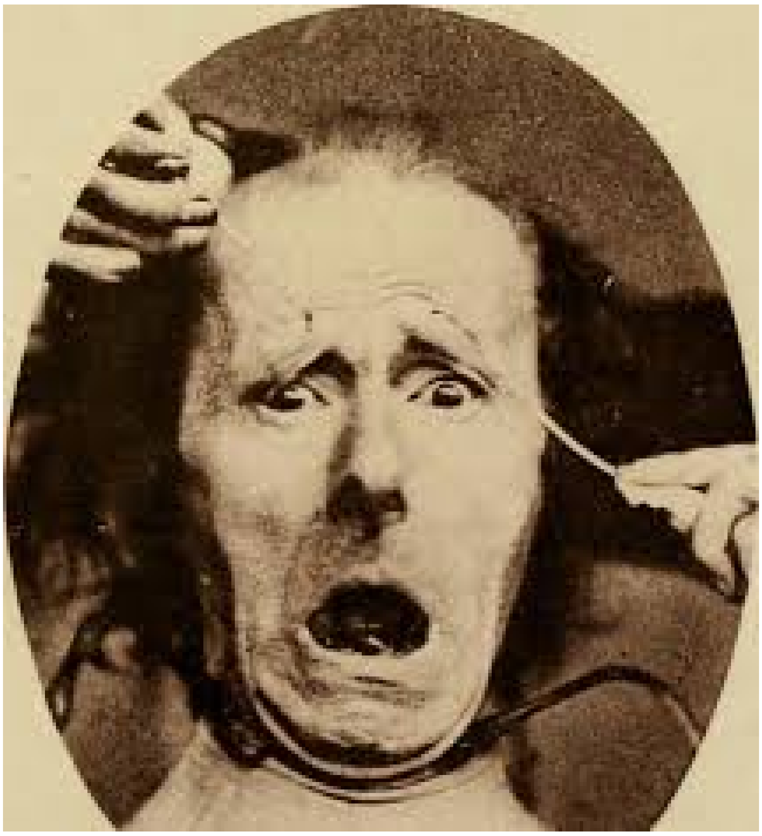

Figure 5.3: **Another illustration in Darwin's book, *The Expression of Emotions in Man and Animals* shows an expression of horror on the face of a man. This expression was induced by an electrical shock, showing the human facial musculature is capable of forming the expression of horror automatically, if properly induced.**

Figure 5.4: **Another illustration in Darwin's book shows a dog's face expressing threat when confronting an enemy.**

Figure 5.5: **Here we see a cat's response to an enemy. The cat arches her back and raises her fur to make herself seem larger and more dangerous than she actually is. This illustration is also taken from Darwin's book on the expression of emotions.**

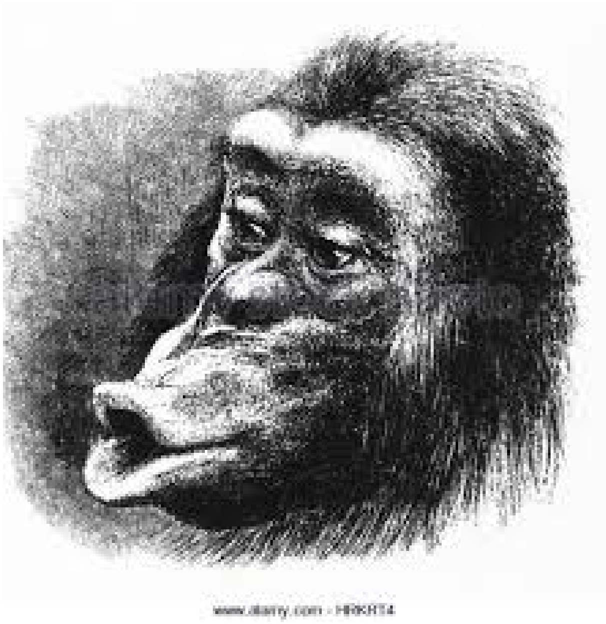

Figure 5.6: **An ape expressing affection.**

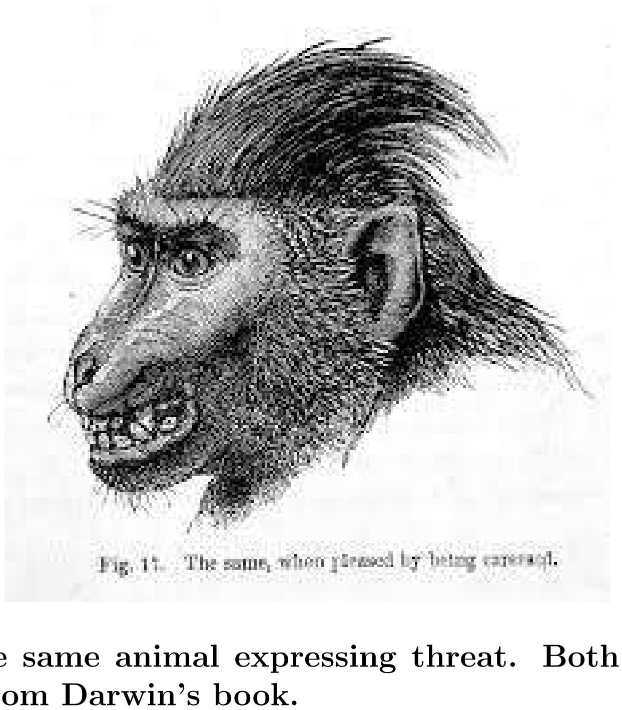

Figure 5.7: **The same animal expressing threat. Both drawings are illustrations from Darwin's book.**

5.3 Brain chemistry

Emotions in humans and in animals have an extremely long evolutionary history. Chemicals that affect behaviour are present in even the most primitive forms of multicellular organisms, even in slime molds, which are at the exact borderline between single-celled multicellular organisms. Cyclic AMP has been shown to be the molecule that expresses slime mold unhappiness!

Not only do cells communicate by touching each other and recognizing each other's cell surface antigens - they also communicate by secreting and absorbing transmitter molecules. For example, the group behavior of slime mold cells is coordinated by the cyclic adenosine monophosphate molecules, which the cells secrete when distressed.

Within most multicellular organisms, cooperative behavior of cells is coordinated by molecules such as hormones - chemical messengers. These are recognized by "receptors", the mechanism of recognition once again depending on complementarity of charge distributions and shape. Receptors on the surfaces of cells are often membrane-bound proteins which reach from the exterior of the membrane to the interior. When an external transmitter molecule is bound to a receptor site on the outside part of the protein, it causes a conformational change which releases a bound molecule of a different type from a site on the inside part of the protein, thus carrying the signal to the cell's interior. In other cases the messenger molecule passes through the cell membrane.

In this way the individual cell in a society of cells (a multicellular organism) is told when to divide and when to stop dividing, and what its special role will be in the economy of the cell society (differentiation). For example, in humans, follicle-stimulating hormone, lutenizing hormone, prolactin, estrogen and progesterone are among the chemical messengers which cause the cell differentiation needed to create the secondary sexual characteristics of females.

Another role of chemical messengers in multicellular organisms is to maintain a reasonably constant internal environment in spite of drastic changes in the external environment of individual cells or of the organism as a whole (homeostasis). An example of such a homeostatic chemical messenger is the hormone insulin, which is found in humans and other mammals. The rate of its release by secretory cells in the pancreas is increased by high concentrations of glucose in the blood. Insulin carries the news of high glucose levels to target cells in the liver, where the glucose is converted to glycogen, and to other target cells in the muscles, where the glucose is burned.

5.4 Nervous systems

Hormones require a considerable amount of time to diffuse from the cells where they originate to their target cells; but animals often need to act very quickly, in fractions of seconds, to avoid danger or to obtain food. Because of the need for quick responses, a second system of communication has evolved - the system of neurons.

Neurons have a cell bodies, nuclei, mitochondria and other usual features of eukaryotic cells, but in addition they possess extremely long and thin tubelike extensions called axons and dendrites. The axons function as informational output channels, while the dendrites are inputs. These very long extensions of neurons connect them with other neurons which can be at distant sites, to which they are able to transmit electrical signals. The complex network of neurons within a multicellular organism, its nervous system, is divided into three parts. A sensory or input part brings in signals from the organism's interior or from its external environment. An effector or output part produces a response to the input signal, for example by initiating muscular contraction.

Between the sensory and effector parts of the nervous system is a message-processing (internuncial) part, whose complexity is not great in the jellyfish or the leech. However, the complexity of the internuncial part of the nervous system increases dramatically as one goes upward in the evolutionary order of animals, and in humans it is truly astonishing.

5.5 Chemical synapses

The small button-like connections between neurons are called synapses. When an electrical signal propagating along an axon reaches a synapse, it releases a chemical transmitter substance into the tiny volume between the synapse and the next neuron (the post-synaptic cleft). Depending on the nature of the synapse, this chemical messenger may either cause the next neuron to "fire" (i.e., to produce an electrical pulse along its axon) or it may inhibit the firing of the neuron. Furthermore, the question of Neuron whether a neuron will or will not fire depends on the past history of its synapses. Because of this feature, the internuncial part of an animal's nervous system is able to learn. There many kinds of synapses and many kinds of neurotransmitters, and the response of synapses is sensitive to the concentration of various molecules in the blood, a fact which helps to give the nervous systems of higher animals extraordinary subtlety and complexity.

5.6 Neurotransmitters

The first known neurotransmitter molecule, acetylcholine, was discovered jointly by Sir Henry Dale in England and by Otto Loewi in Germany. In 1921 Loewi was able to show that nerve endings transmit information to muscles by means of this substance.

The idea for the critical experiment occurred to him in a dream at 3 am. Otto Loewi woke up and wrote down the idea; but in the morning he could not read what he had written. Luckily he had the same dream the following night. This time he took no chances. He got up, drank some coffee, and spent the whole night working in his laboratory. By morning he had shown that nerve cells separated from the muscle of a frog's heart secrete a chemical substance when stimulated, and that this substance is able to cause contractions of the heart of another frog.

Sir Henry Dale later showed that Otto Loewi's transmitter molecule was identical to acetylcholine, which Dale had isolated from the ergot fungus in 1910. The two men shared a Nobel Prize in 1936. Since that time, a large variety of neurotransmitter molecules have been isolated. Among the excitatory neurotransmitters (in addition to acetylcholine) are noradrenalin, norepinephrine, serotonin, dopamine, and glutamate, while gamma-amino-butyric acid is an example of an inhibitory neurotransmitter.

Some important neurotransmitters

- **Glutamate**: This is the most abundant neurotransmitter in humans, used by about half of the neurons in the human brain. It is the primary excitatory transmitter in the central nervous system. One of its functions is to help form memories.

- **GABA**: The name GABA is an acronym for Gamma-aminobutyric acid. GABA is the primary inhibitory transmitter in the vertebrate brain. It helps to control anxiety, and it is sometimes used medically to treat anxiety and the associated sleeplessness.

- **Glycine**: This neurotransmitter is a single amino acid. It is the main inhibitory neurotransmitter in the vertebrate spinal cord. Glycine is important in the central nervous system, especially in the spinal cord, brainstem, and retina.

- **Acetylcholine**: An ester (the organic analogue of a salt) formed from the reaction between choline and acetic acid, acetylcholine stimulates muscles, functions in the autonomic nervous system and sensory neurons, and is associated with REM sleep. Alzheimer's disease is associated with a significant drop in acetylcholine levels.

- **Norepinepherine**: Also known as noradrenaline, norepinephorine increases heart rate and blood pressure. It is part of the body's "fight or flight" system. Norepinephrine is also needed to form memories. Stress depletes stores of this neurotransmitter.

- **Dopamine**: Dopamine is also synthesized in plants and most animals. It is an inhibitory transmitter associated with the reward center of the brain. Low dopamine levels are associated with social anxiety and Parkinson's disease, while excess dopamine is related to schizophrenia. The brain includes several distinct dopamine pathways, one of which plays a major role in reward-motivated behavior. Most types of rewards increase the level of dopamine in the brain, and many addictive drugs increase dopamine neuronal activity.

- **Serotonin**: Biochemically derived from the amino acid tryptophanis, serotonin an inhibitory neurotransmitter involved in mood, emotion, and perception. Low serotonin levels can lead to depression, suicidal tendencies, anger management issues, difficulty sleeping, migraines, and an increased craving for carbohydrates. It's functions include the regulation of mood, appetite, and sleep. Serotonin also has some cognitive functions, including memory and learning.

- **Endorphins**: The name of this class of neurotransmitters means "a class of a morphine-like substance originating from within the body". are a class of molecules similar to opioids (e.g., morphine, heroin) in terms of structure and function. The word "endorphin" is short for "endogenous morphine." Endorphins are inhibitory transmitters associated with pleasure and pain relief. In other animals, these chemicals slow metabolism and permit hibernation. The treatment of pain by means of acupuncture functions by releasing endorphines.

Pleasure versus happiness

Pleasure is fleeting. Happiness lasts. Pleasure is addictive, but happiness is not. Pleasure craves more and more of everything. Happiness can be content with very little. These characteristics make happiness a better goal than pleasure. Interestingly, the neurotransmitter dopamine is associated with pleasure, while serotonin is associated with happiness.[2]

[2]See, for example, https://gobeyondlifestyle.com/happiness-vs-pleasure-root-addiction/

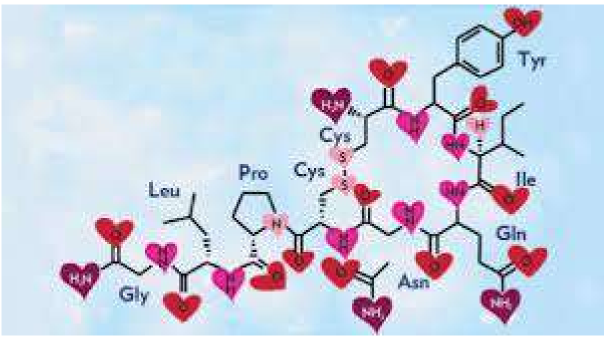

Figure 5.8: **An artist's impression of the structure of oxytocin**

5.7 Oxytocin, the "love hormone"

Besides discovering acetylcholine, Sir Henry Dale also discovered, in 1906. the peptide hormone Oxytocin, which has sometimes been called the "love hormone". Oxytocin plays a role in social bonding and sexual reproduction in both sexes. During childbirth, Oxytocin is released into the bloodstream of women in response to stretching of the curvex and uterus during labour, and also in response to breastfeeding. The hormone then facilitates the bonding between mother and child. Oxytocin is also present in men and its concentration in their bloodstream increases in response to romantic attachments and social bonding.

A very similar hormone, with similar functions, is also present in other mammals besides humans.

5.8 Mother love and rage

We can recognize many of our own emotions in other mammals. Among these are mother love and rage. Interestingly these two emotions are associated respectively with oxytocin and testosterone.

One of the most beautiful emotions is the love that women exhibit towards their children. We must all be grateful that women are willing to undergo the danger and pain of childbirth. We must be grateful for the devotion that they show to their children and families.

Both humans and most other animals compete for dominance and mating rights. In humans, mating displays and struggles for dominance lead to what the economist Thorstein Veblen called “conspicuous consumption”. Overconsumption in industrialized nations is one of the factors driving the world towards an ecological catastrophe.

Figure 5.9: **Mother love: One of the most beautiful emotions.**

Figure 5.10: **Mother love.**

Figure 5.11: **Mother love**

Figure 5.12: **Mother love:**

Figure 5.13: **Mother love**

Figure 5.14: **Mother love**

Figure 5.15: **Mother love**

Figure 5.16: **Mother love: Although we recognize the emotions of mammals most clearly as being similar to our own, animals less closely related to ourselves also exhibit emotions that we can recognize. For example, birds are devoted to their young and make great sacrifices to help and protect them.**

Figure 5.17: **Male animals fighting for dominance and mating rights**

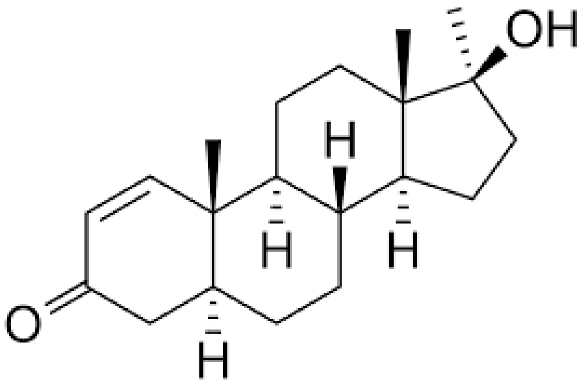

Figure 5.18: **Testosterone is a hormone present in large quantities in males and much smaller amounts in females. It is involved in rank-determining fights and mating.**

Figure 5.19: **Male lions fighting for dominance and mating rights.**

Figure 5.20: **In Shakespeare's poetic tragedy, *Romeo and Juliet*, we see many human emotions on display: males fighting for dominance and mating rights (testosterone), romantic attachment (oxytocin), and tribalism (Montagues versus Capulets). The dangers of tribalism in an age of genocidal and potentially omnicidal thermonuclear weapons will be discussed in the next chapter.**

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Chapter 6

TRIBALISM. NATIONALISM AND WAR

6.1 Rank-determining conflicts compared with group conflicts

In Chapter 5, we discussed struggles for dominance and mating rights. Rank-determining conflicts occur both in humans and in animals. However, it is important to distinguish between rank-determining conflicts and conflicts between groups.

In his famous but controversial book *On Aggression* the Nobel Laureate ethologist Konrad Lorenz makes a distinction between intergroup aggression and intragroup aggression. Among animals, he points out, rank-determining fights are seldom fatal. Thus, for example, the fights that determine leadership within a wolf pack end when the loser makes a gesture of submission. By contrast, fights between groups of animals are often fights to the death, examples being wars between ant colonies, or of bees against intruders, or the defense of a rat pack against strange rats.

Many animals, humans included, seem willing to kill or be killed in defense of the communities to which they belong. Lorenz calls this behavioral tendency a "communal defense response". He points out that the "holy shiver" - the tingling of the spine that humans experience when performing a heroic act in defense of their communities - is related to the prehuman reflex for raising the hair on the back of an animal as it confronts an enemy - a reflex that makes the animal seem larger than it really is.

It seems probable that the communal defense response discussed by Lorenz will prove to be a correct and useful concept. The communal defense mechanism can be thought of as the aspect of human emotions which makes it natural for soldiers to kill or be killed in defense of their countries. In the era before nuclear weapons made war prohibitively dangerous, such behavior was considered to be the greatest of virtues. Generations of schoolboys have learned the Latin motto: "Dulce et decorum est pro patria mori" - it is both sweet and proper to die for one's country. Even in today's world, death in battle in defense of country and religion is still praised by nationalists. However, because of the development of weapons of mass destruction, both nationalism and narrow patriotism have become dangerous anachronisms.

In thinking of violence and war, we must be extremely careful not to confuse the behavioral patterns that lead to wife-beating or bar-room brawls with those that lead to episodes like the trench warfare of the First World War, or to the nuclear bombing of Hiroshima and Nagasaki. The first type of aggression is similar to the rank-determining fights of animals, while the second is more akin to the team-spirit exhibited by a football side. Heroic behavior in defense of one's community has been praised throughout the ages, but the tendency to such behavior has now become a threat to the survival of civilization, since tribalism makes war possible, and war with thermonuclear weapons threatens civilization with catastrophe.

In an essay entitled *The Urge to Self-Destruction* [1], Arthur Koestler says:

"Even a cursory glance at history should convince one that individual crimes, committed for selfish motives, play a quite insignificant role in the human tragedy compared with the numbers massacred in unselfish love of one's tribe, nation, dynasty, church or ideology... Wars are not fought for personal gain, but out of loyalty and devotion to king, country or cause..."

"We have seen on the screen the radiant love of the Führer on the faces of the Hitler Youth... They are transfixed with love, like monks in ecstasy on religious paintings. The sound of the nation's anthem, the sight of its proud flag, makes you feel part of a wonderfully loving community. The fanatic is prepared to lay down his life for the object of his worship, as the lover is prepared to die for his idol. He is, alas, also prepared to kill anybody who represents a supposed threat to the idol." The emotion described here by Koestler is the same as the communal defense mechanism ("militant enthusiasm") described in biological terms by Lorenz.

In *On Aggression*, Konrad Lorenz gives the following description of the emotions of a hero preparing to risk his life for the sake of the group:

"In reality, militant enthusiasm is a specialized form of communal aggression, clearly distinct from and yet functionally related to the more primitive forms of individual aggression. Every man of normally strong emotions knows, from his own experience, the subjective phenomena that go hand in hand with

[1] in *The Place of Value in a World of Facts*, A. Tiselius and S. Nielsson editors, Wiley, New York, (1970)

the response of militant enthusiasm. A shiver runs down the back and, as more exact observation shows, along the outside of both arms. One soars elated, above all the ties of everyday life, one is ready to abandon all for the call of what, in the moment of this specific emotion, seems to be a sacred duty. All obstacles in its path become unimportant; the instinctive inhibitions against hurting or killing one's fellows lose, unfortunately, much of their power. Rational considerations, criticisms, and all reasonable arguments against the behavior dictated by militant enthusiasm are silenced by an amazing reversal of all values, making them appear not only untenable, but base and dishonorable. Men may enjoy the feeling of absolute righteousness even while they commit atrocities. Conceptual thought and moral responsibility are at their lowest ebb. As the Ukrainian proverb says: 'When the banner is unfurled, all reason is in the trumpet'."

"The subjective experiences just described are correlated with the following objectively demonstrable phenomena. The tone of the striated musculature is raised, the carriage is stiffened, the arms are raised from the sides and slightly rotated inward, so that the elbows point outward. The head is proudly raised, the chin stuck out, and the facial muscles mime the 'hero face' familiar from the films. On the back and along the outer surface of the arms, the hair stands on end. This is the objectively observed aspect of the shiver!"

"Anybody who has ever seen the corresponding behavior of the male chimpanzee defending his band or family with self-sacrificing courage will doubt the purely spiritual character of human enthusiasm. The chimp, too, sticks out his chin, stiffens his body, and raises his elbows; his hair stands on end, producing a terrifying magnification of his body contours as seen from the front. The inward rotation of the arms obviously has the purpose of turning the longest-haired side outward to enhance the effect. The whole combination of body attitude and hair-raising constitutes a bluff. This is also seen when a cat humps its back, and is calculated to make the animal appear bigger and more dangerous than it really is. Our shiver, which in German poetry is called a 'heiliger Schauer', a 'holy' shiver, turns out to be the vestige of a prehuman vegetative response for making a fur bristle which we no longer have. To the humble seeker for biological truth, there cannot be the slightest doubt that human militant enthusiasm evolved out of a communal defense response of our prehuman ancestor."

Lorenz goes on to say, "An impartial visitor from another planet, looking at man as he is today - in his hand the atom bomb, the product of his intelligence - in his heart the aggression drive, inherited from his anthropoid ancestors, which the same intelligence cannot control - such a visitor would not give mankind much chance of survival."

Population genetics

If we examine altruism and aggression in humans, we notice that members of our species exhibit great altruism towards their own children. Kindness towards close relatives is also characteristic of human behavior, and the closer the biological relationship is between two humans, the greater is the altruism they tend to show towards each other. This profile of altruism is easy to explain on the basis of Darwinian natural selection since two closely related individuals share many genes and, if they cooperate, the genes will be more effectively propagated.

To explain from an evolutionary point of view the communal defense mechanism discussed by Lorenz - the willingness of humans to kill and be killed in defense of their communities - we have only to imagine that our ancestors lived in small tribes and that marriage was likely to take place within a tribe rather than across tribal boundaries. Under these circumstances, each tribe would tend to consist of genetically similar individuals. The tribe itself, rather than the individual, would be the unit on which the evolutionary forces of natural selection would act. The idea of group selection in evolution was proposed in the 1930's by J.B.S. Haldane and R.A. Fisher, and more recently it has been discussed by W.D. Hamilton.

According to the group selection model, a tribe whose members showed altruism towards each other would be more likely to survive than a tribe whose members cooperated less effectively. Since several tribes might be in competition for the same territory, intertribal aggression might, under some circumstances, increase the chances for survival of one's own tribe. Thus, on the basis of the group selection model, one would expect humans to be kind and cooperative towards members of their own group, but at the same time to sometimes exhibit aggression towards members of other groups, especially in conflicts over territory. One would also expect intergroup conflicts to be most severe in cases where the boundaries between groups are sharpest - where marriage is forbidden across the boundaries.

6.2 The accelerating speed of cultural evolution

An acceleration of human cultural development seems to have begun approximately 70,000 years ago. The first art objects date from that period, as do migrations that ultimately took modern man across the Bering Strait to the western hemisphere. A land bridge extending from Siberia to Alaska is thought to have been formed approximately 70,000 years ago, disappearing again roughly 10,000 years before the present. Cultural and genetic studies indicate that migrations from Asia to North America took place during this period. Shamanism,[2] which is found both in Asia and the new world, as well as among the Sami (Lapps) of northern Scandinavia, is an example of the cultural links between the hunting societies of these regions.

Before the acceleration of human cultural development just mentioned, genetic change and cultural change went hand in hand, but during the last 70,000 years, the constantly accelerating rate of information-accumulation and cultural evolution has increasingly outdistanced the rate of genetic change in humans. Genetically we are almost identical with our hunter-gatherer ancestors of 70,000 years ago, but cultural evolution has changed our way of life beyond recognition.

As we start the 21st century, our scientific and technological civilization seems to be entering a period of crisis. Today, for the first time in history, science has given to humans the possibility of a life of comfort, free from hunger and cold, and free from the constant threat of infectious disease. At the same time, science has given us the power to destroy civilization through thermonuclear war, as well as the power to make our planet uninhabitable through pollution, overpopulation and climate change. The question of which of these alternatives we choose is a matter of life or death to ourselves and our children. Scientists and engineers have a special responsibility for ensuring that their work is used in a way that benefits human civilization and the biosphere, rather than harmfully.

Genetically we are almost identical with our Neolithic ancestors; but their world has been replaced by a world of quantum theory, relativity, supercomputers, antibiotics, genetic engineering and space telescopes - unfortunately also a world of nuclear weapons and nerve-gas. Because of the slowness of genetic evolution in comparison to the rapid and constantly-accelerating rate of cultural change, our bodies and emotions are not adapted to our new way of life. They still reflect the way of life of our hunter-gatherer ancestors.

In addition to the contrast between the slow pace of genetic evolution when compared with the rapid and constantly accelerating rate of cultural evolution, we can also notice a contrast between rapidly- and slowly-moving aspects of cultural change: Social institutions and structures seem to change slowly when compared with the lightning-like pace of scientific and technological innovation. Thus, tensions and instability characterize our information-driven contemporary society, not only because the human nature we have inherited from our ancient ancestors is not appropriate to our present way of life, but also because

[2] A shaman is a special member of a hunting society who, while in a trance, is thought to be able pass between the upper world, the present world, and the lower world, to cure illnesses, and to insure the success of a hunt.

science and technology change so much more rapidly than institutions, laws, and attitudes.

Space-age science and stone-age politics make an extraordinarily dangerous mixture. It seems probable that in the future, the rapidity of scientific and technological change will produce ethical dilemmas and social tensions even more acute than those we experience today. It is likely that the fate of our species (and the fate of the biosphere) will be made precarious by the astonishing speed of scientific and technological change unless this progress is matched by the achievement of far greater ethical and political maturity than we have yet attained.

Science and technology have shown themselves to be double-edged, capable of doing great good or of producing great harm, depending on the way in which we use the enormous power over nature, which science has given to us. For this reason, ethical thought is needed now more than ever before. The wisdom of the world's religions, the traditional wisdom of humankind, can help us as we try to insure that our overwhelming material progress will be beneficial.

The crisis of civilization, which we face today, has been produced by the rapidity with which science and technology have developed. Our institutions and ideas adjust too slowly to the change. The great challenge which history has given to our generation is the task of building new international political structures, which will be in harmony with modern technology. At the same time, we must develop a new global ethic, which will replace our narrow loyalties by loyalty to humanity as a whole.

Tribal markings; ethnicity; pseudospeciation

In biology, a species is defined to be a group of mutually fertile organisms. Thus all humans form a single species, since mixed marriages between all known races will produce children, and subsequent generations in mixed marriages are also fertile. However, although there is never a biological barrier to marriages across ethnic and racial boundaries, there are often very severe cultural barriers.

Irenäus Eibl-Ebesfeldt, a student of Konrad Lorenz, introduced the word *pseudospeciation* to denote cases where cultural barriers between two groups of humans are so strongly marked that marriages across the boundary are difficult and infrequent. In such cases, he pointed out, the two groups function as though they were separate species, although from a biological standpoint this is nonsense. When two such groups are competing for the same land, the same water, the same resources, and the same jobs, the conflicts between them can become very bitter indeed. Each group regards the other as being "not truly human".

In his book *The Biology of War and Peace*, Eibl-Eibesfeldt discusses the "tribal markings" used by groups of humans to underline their own identity and to clearly mark the boundary between themselves and other groups. One of the illustrations in the book shows the marks left by ritual scarification on the faces of the members of certain African tribes. These scars would be hard to counterfeit, and they help to establish and strengthen tribal identity. Seeing a photograph of the marks left by ritual scarification on the faces of African tribesmen, it is impossible not to be reminded of the dueling scars that Prussian army officers once used to distinguish their caste from outsiders.

Surveying the human scene, one can find endless examples of signs that mark the bearer as a member of a particular group - signs that can be thought of as "tribal markings": tattoos; piercing; bones through the nose or ears; elongated necks or ears; filed teeth; Chinese binding of feet; circumcision, both male and female; unique hair styles; decorations of the tongue, nose, or naval; peculiarities of dress, fashions, veils, chadors, and headdresses; caste markings in India; use or nonuse of perfumes; codes of honor and value systems; traditions of hospitality and manners; peculiarities of diet (certain foods forbidden, others preferred); giving traditional names to children; knowledge of dances and songs; knowledge of recipes; knowledge of common stories, literature, myths, poetry or common history; festivals, ceremonies, and rituals; burial customs, treatment of the dead and ancestor worship; methods of building and decorating homes; games and sports peculiar to a culture; relationship to animals, knowledge of horses and ability to ride; systems of belief.

By far the most important marks of ethnic identity are religion and language, Within a particular language, dialect and accent. If the only purpose of language were communication, it would be logical for the people of a small country to stop speaking their own tongue and go over to a more universally-understood international language such as English. However, language has another function in addition to communication: It is also a mark of identity. It establishes the boundary of the group. Within a particular language, dialects and accents mark the boundaries of subgroups.

Figure 6.1: **Tribal markings: Ritual scarification has marked this African woman for life as a member of a small in-group.**

Figure 6.2: **Tribal markings: Looking at the dueling scars that Prussian army officers once used as a mark of group identity, it is impossible not to be reminded of the ritual scarification used for the same purpose by African tribes.**

Figure 6.3: **Tribal markings: Tattoos are also a form of tribal marking. They lead to what Irenäus Eibl-Ebesfeldt called "pseudospeciation".**

6.3 War threatens human survival

In the long run, because of the enormously destructive weapons, which have been produced through the misuse of science, the survival of civilization can only be insured if we are able to abolish the institution of war.

Modern warfare has become prohibitively dangerous and destructive because of the enormously powerful weapons that scientists and engineers have developed. The institution of war could not continue without their cooperation. Thus, scientists and engineers throughout the world have a special responsibility.

Wars are driven by the collective paranoia of voters, who are willing to allow colossal sums to be spent by ' 'Defense Departments". But are civilians really defended? Absolutely not!

We can see this most clearly if we think of nuclear war. Nations threaten each other with "Mutually Assured Destruction", which has the very appropriate acronym MAD. What does this mean? Does it mean that civilians are being protected? Not at all. Instead they are threatened with complete destruction. Civilians here play the role of hostages in the power games of their leaders. Those leaders' goal is not protection of ordinary people, but rather protection of the gargantuan profits of the military-industrial complex. As the Indian writer Arundhati Roy put it, "Once weapons were manufactured to fight wars. Now wars are manufactured to sell weapons."

If a thermonuclear war occurs, it will be the end of human civilization and much of the biosphere. This will definitely happen in the future unless the world rids itself of nuclear weapons, since, in the long run, the finite chance of accidental nuclear war happening due to a technical or human failure during a given year will gradually build up into a certainty of disaster. Scientists and engineers must not sell their knowledge and talents to this march towards the precipice.

The direct and indirect costs of war

The costs of war, both direct and indirect, are so enormous that they are almost beyond comprehension. We face a direct threat because a thermonuclear war may destroy human civilization and much of the biosphere, and an indirect threat because the institution of war interferes seriously with the use of tax money for constructive and peaceful purposes.

Today, despite the end of the Cold War, the world spends roughly 1.7 trillion (i.e. 1.7 million million) US dollars each year on armaments. This colossal flood of money could have been used instead for education, famine relief, development of infrastructure, or on urgently needed public health measures.

The World Health Organization lacks funds to carry through an antimalarial program on as large a scale as would be desirable, but the entire program could be financed for less than our military establishments spend in a single day. Five hours of world arms spending is equivalent to the total cost of the 20-year WHO campaign that resulted in the eradication of smallpox. For every 100,000 people in the world, there are 556 soldiers, but only 85 doctors. Every soldier costs an average of $20,000 per year, while the average spent on education is only $380 per school-aged child. With a diversion of funds consumed by three weeks of military spending, the world could create a sanitary water supply for all its people, thus eliminating the cause of almost half of all human illness.

A new drug-resistant form of tuberculosis has recently become widespread in Asia and in the former Soviet Union. In order to combat this new and highly dangerous form of tuberculosis and to prevent its spread, WHO needs $500 million, an amount equivalent to 1.2 hours of world arms spending.

Today's world is one in which roughly ten million children die every year from starvation or from diseases related to poverty. Besides this enormous waste of young lives through malnutrition and preventable disease, there is a huge waste of opportunities through inadequate education. The rate of illiteracy in the 25 least developed countries is 80%, and the total number of illiterates in the world is estimated to be 800 million. Meanwhile every 60 seconds the world spends $6.5 million on armaments.

It is plain that if the almost unbelievable sums now wasted on the institution of war were used constructively, most of the pressing problems of humanity could be solved, but today the world spends more than 20 times as much on war as it does on development.

Medical and psychological consequences; loss of life

While in earlier epochs it may have been possible to confine the effects of war mainly to combatants, in the 20th century the victims of war were increasingly civilians, and especially children. For example, according to Quincy Wright's statistics, the First and Second World Wars cost the lives of 26 million soldiers, but the toll in civilian lives was much larger: 64 million.

Since the Second World War, despite the best efforts of the UN, there have been over 150 armed conflicts; and, if civil wars are included, there are on any given day an average of 12 wars somewhere in the world. In the conflicts in Indo-China, the proportion of civilian victims was between 80% and 90%, while in the Lebanese civil war some sources state that the proportion of civilian casualties was as high as 97%.

Civilian casualties often occur through malnutrition and through diseases that would be preventable in normal circumstances. Because of the social disruption caused by war, normal supplies of food, safe water and medicine are interrupted, so that populations become vulnerable to famine and epidemics.[3]

Effects of war on children

According to UNICEF figures, 90% of the casualties of recent wars have been civilians, and 50% children. The organization estimates that in recent years, violent conflicts have driven 20 million children from their homes. They have become refugees or internally displaced persons within their own countries.

During the last decade 2 million children have been killed and 6 million seriously injured or permanently disabled as the result of armed conflicts, while 1 million children have been orphaned or separated from their families. Of the ten countries with the highest rates of death of children under five years of age, seven are affected by armed conflicts. UNICEF estimates that 300,000 child soldiers are currently forced to fight in 30 armed conflicts throughout the world. Many of these have been forcibly recruited or abducted.

Even when they are not killed or wounded by conflicts, children often experience painful psychological traumas: the violent death of parents or close relatives, separation from their families, seeing family members tortured, displacement from home, disruption of ordinary life, exposure to shelling and other forms of combat, starvation and anxiety about the future.[4]

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[3]http://www.cadmusjournal.org/article/volume-2/issue-2-part-3/lessons-world-war-i
http://www.truth-out.org/opinion/item/27201-the-leading-terrorist-state

[4]http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2080482/

Refugees

Human Rights Watch estimates that in 2001 there were 15 million refugees in the world, forced from their countries by war, civil and political conflict, or by gross violations of human rights. In addition, there were an estimated 22 million internally displaced persons, violently forced from their homes but still within the borders of their countries.

In 2001, 78% of all refugees came from ten areas: Afghanistan, Angola, Burma, Burundi, Congo-Kinshasa, Eritria, Iraq, the Palestinian territories, Somalia and Sudan. A quarter of all refugees are Palestinians, who make up the world's oldest and largest refugee population. 45% of the world's refugees have found sanctuaries in Asia, 30% in Africa, 19% in Europe and 5% in North America.

Refugees who have crossed an international border are in principle protected by Article 14 of the Universal Declaration of Human Rights, which affirms their right "to seek and to enjoy in other countries asylum from persecution". In 1950 the Office of the High Commissioner for Refugees was created to implement Article 14, and in 1951 the Convention Relating to the Status of Refugees was adopted by the UN. By 2002 this legally binding treaty had been signed by 140 nations. However the industrialized countries have recently adopted a very hostile and restrictive attitude towards refugees, subjecting them to arbitrary arrests, denial of social and economic rights, and even forcible return to countries in which they face persecution.

The status of internally displaced persons is even worse than that of refugees who have crossed international borders. In many cases the international community simply ignores their suffering, reluctant to interfere in the internal affairs of sovereign states. In fact, the United Nations Charter is self-contradictory in this respect, since on the one hand it calls for non-interference in the internal affairs of sovereign states, but on the other hand, people everywhere are guaranteed freedom from persecution by the Charter's Universal Declaration of Human Rights.[5]

Damage to infrastructure

Most insurance policies have clauses written in fine print exempting companies from payment of damage caused by war. The reason for this is simple. The damage caused by war is so enormous that insurance companies could never come near to paying for it without going bankrupt.

We mentioned above that the world spends 1.7 trillion dollars each year on preparations for war. A similarly colossal amount is needed to repair the

[5]https://www.hrw.org/topic/refugees

damage to infrastructure caused by war. Sometimes this damage is unintended, but sometimes it is intentional.

During World War II, one of the main aims of air attacks by both sides was to destroy the industrial infrastructure of the opponent. This made some sense in a war expected to last several years, because the aim was to prevent the enemy from producing more munitions. However, during the Gulf War of 1990, the infrastructure of Iraq was attacked, even though the war was expected to be short. Electrical generating plants and water purification facilities were deliberately destroyed with the apparent aim of obtaining leverage over Iraq after the war.

In general, because war has such a catastrophic effect on infrastructure, it can be thought of as the opposite of development. War is the greatest generator of poverty.[6]

Ecological damage

Warfare during the 20th century has not only caused the loss of 175 million lives (primarily civilians) - it has also caused the greatest ecological catastrophes in human history. The damage takes place even in times of peace. Studies by Joni Seager, a geographer at the University of Vermont, conclude that "a military presence anywhere in the world is the single most reliable predictor of ecological damage".

Modern warfare destroys environments to such a degree that it has been described as an "environmental holocaust." For example, herbicides use in the Vietnam War killed an estimated 6.2 billion board-feet of hardwood trees in the forests north and west of Saigon, according to the American Association for the Advancement of Science. Herbicides such as Agent Orange also made enormous areas of previously fertile land unsuitable for agriculture for many years to come. In Vietnam and elsewhere in the world, valuable agricultural land has also been lost because land mines or the remains of cluster bombs make it too dangerous for farming.

During the Gulf War of 1990, the oil spills amounted to 150 million barrels, 650 times the amount released into the environment by the notorious Exxon Valdez disaster. During the Gulf War an enormous number of shells made of depleted uranium were fired. When the dust produced by exploded shells is inhaled it often produces cancer, and it will remain in the environment of Iraq

[6] https://www.wsws.org/en/articles/2002/11/iraq-n04.html
http://www.globalresearch.ca/crimes-against-humanity-the-destruction-of-iraqs-electricity-infrastructure-the-social-economic-and-environmental-impacts/5355665
http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/00157630-EN-ERP-48.PDF

for decades.

Radioactive fallout from nuclear tests pollutes the global environment and causes many thousands of cases of cancer, as well as birth abnormalities. Most nuclear tests have been carried out on lands belonging to indigenous peoples. Agent Orange also produced cancer, birth abnormalities and other serious forms of illness both in the Vietnamese population and among the foreign soldiers fighting in Vietnam[7]

The threat of nuclear war

As bad as conventional arms and conventional weapons may be, it is the possibility of a catastrophic nuclear war that poses the greatest threat to humanity. There are today roughly 16,000 nuclear warheads in the world. The total explosive power of the warheads that exist or that could be made on short notice is approximately equal to 500,000 Hiroshima bombs.

To multiply the tragedy of Hiroshima by a factor of half a million makes an enormous difference, not only quantitatively, but also qualitatively. Those who have studied the question believe that a nuclear catastrophe today would inflict irreversible damage on our civilization, genetic pool and environment.

Thermonuclear weapons consist of an inner core where the fission of uranium-235 or plutonium takes place. The fission reaction in the core is able to start a fusion reaction in the next layer, which contains isotopes of hydrogen. It is possible to add a casing of ordinary uranium outside the hydrogen layer, and under the extreme conditions produced by the fusion reaction, this ordinary uranium can undergo fission. In this way, a fission-fusion-fission bomb of almost limitless power can be produced. For a victim of severe radiation exposure, the symptoms during the first week are nausea, vomiting, fever, apathy, delirium, diarrhoea, oropharyngeal lesions and leukopenia. Death occurs during the first or second week.

We can perhaps be helped to imagine what a nuclear catastrophe means in human terms by reading the words of a young university professor, who was 2,500 meters from the hypocenter at the time of the bombing of Hiroshima: "Everything I saw made a deep impression: a park nearby covered with dead bodies... very badly injured people evacuated in my direction... Perhaps most impressive were girls, very young girls, not only with their clothes torn off, but their skin peeled off as well. ... My immediate thought was that this was like the hell I had always read about. ... I had never seen anything which resembled it before, but I thought that should there be a hell, this was it."

[7]http://www.dailymail.co.uk/news/article-2401378/Agent-Orange-Vietnamese-children-suffering-effects-herbicide-sprayed-US-Army-40-years-ago.html

One argument that has been used in favor of nuclear weapons is that no sane political leader would employ them. However, the concept of deterrence ignores the possibility of war by accident or miscalculation, a danger that has been increased by nuclear proliferation and by the use of computers with very quick reaction times to control weapons systems.

Recent nuclear power plant accidents remind us that accidents frequently happen through human and technical failure, even for systems which are considered to be very "safe." We must also remember the time scale of the problem. To assure the future of humanity, nuclear catastrophe must be avoided year after year and decade after decade. In the long run, the safety of civilization cannot be achieved except by the abolition of nuclear weapons, and ultimately the abolition of the institution of war.

In 1985, International Physicians for the Prevention of Nuclear War received the Nobel Peace Prize. IPPNW had been founded in 1980 by six physicians, three from the Soviet Union and three from the United States. Today, the organization has wide membership among the world's physicians. Professor Bernard Lowen of the Harvard School of Public Health, one of the founders of IPPNW, said in a recent speech:

"...No public health hazard ever faced by humankind equals the threat of nuclear war. Never before has man possessed the destructive resources to make this planet uninhabitable... Modern medicine has nothing to offer, not even a token benefit, in the event of nuclear war..."

"We are but transient passengers on this planet Earth. It does not belong to us. We are not free to doom generations yet unborn. We are not at liberty to erase humanity's past or dim its future. Social systems do not endure for eternity. Only life can lay claim to uninterrupted continuity. This continuity is sacred."

The danger of a catastrophic nuclear war casts a dark shadow over the future of our species. It also casts a very black shadow over the future of the global environment. The environmental consequences of a massive exchange of nuclear weapons have been treated in a number of studies by meteorologists and other experts from both East and West. They predict that a large-scale use of nuclear weapons would result in fire storms with very high winds and high temperatures, which would burn a large proportion of the wild land fuels in the affected nations. The resulting smoke and dust would block out sunlight for a period of many months, at first only in the northern hemisphere but later also in the southern hemisphere.

Temperatures in many places would fall far below freezing, and much of the earth's plant life would be killed. Animals and humans would then die of starvation. The nuclear winter effect was first discovered as a result of the Mariner 9 spacecraft exploration of Mars in 1971. The spacecraft arrived in the middle of an enormous dust-storm on Mars, and measured a large temperature drop at the surface of the planet, accompanied by a heating of the upper atmosphere. These measurements allowed scientists to check their theoretical models for predicting the effect of dust and other pollutants distributed in planetary atmospheres.

Using experience gained from the studies of Mars, R.P. Turco, O.B. Toon, T. Ackerman, J.B. Pollack and C. Sagan made a computer study of the climatic effects of the smoke and dust that would result from a large-scale nuclear war. This early research project is sometimes called the TTAPS Study, after the initials of the authors.

In April 1983, a special meeting was held in Cambridge, Massachusetts, where the results of the TTAPS Study and other independent studies of the nuclear winter effect were discussed by more than 100 experts. Their conclusions were presented at a forum in Washington, D.C., the following December, under the chairmanship of U.S. Senators Kennedy and Hatfield. The numerous independent studies of the nuclear winter effect all agreed of the following main predictions:

High-yield nuclear weapons exploded near the earth's surface would put large amounts of dust into the upper atmosphere. Nuclear weapons exploded over cities, forests, oilfields and refineries would produce fire storms of the type experienced in Dresden and Hamburg after incendiary bombings during the Second World War. The combination of high-altitude dust and lower altitude soot would prevent sunlight from reaching the earth's surface, and the degree of obscuration would be extremely high for a wide range of scenarios.

A baseline scenario used by the TTAPS study assumes a 5,000-megaton nuclear exchange, but the threshold for triggering the nuclear winter effect is believed to be much lower than that. After such an exchange, the screening effect of pollutants in the atmosphere might be so great that, in the northern and middle latitudes, the sunlight reaching the earth would be only 1% of ordinary sunlight on a clear day, and this effect would persist for many months. As a result, the upper layers in the atmosphere might rise in temperature by as much as 100 °C, while the surface temperatures would fall, perhaps by as much a 50 °C.

The temperature inversion produced in this way would lead to superstability, a condition in which the normal mixing of atmospheric layers is suppressed. The hydrological cycle (which normally takes moist air from the oceans to a higher and cooler level, where the moisture condenses as rain) would be strongly suppressed. Severe droughts would thus take place over continental land masses. The normal cleansing action of rain would be absent in the atmosphere, an effect which would prolong the nuclear winter.

In the northern hemisphere, forests would die because of lack of sunlight, extreme cold, and drought. Although the temperature drop in the southern hemisphere would be less severe, it might still be sufficient to kill a large portion of the tropical forests, which normally help to renew the earth's oxygen.

The oxygen content of the atmosphere would then fall dangerously, while the concentration of carbon dioxide and oxides of nitrogen produced by firestorms would remain high. The oxides of nitrogen would ultimately diffuse to the upper atmosphere, where they would destroy the ozone layer.

Thus, even when the sunlight returned after an absence of many months, it would be sunlight containing a large proportion of the ultraviolet frequencies which are normally absorbed by the ozone in the stratosphere, and therefore a type of light dangerous to life. Finally, after being so severely disturbed, there is no guarantee that the global climate would return to its normal equilibrium.

Even a nuclear war below the threshold of nuclear winter might have climatic effects very damaging to human life. Professor Paul Ehrlich, of Stanford University, has expressed this in the following words:

"...A smaller war, which set off fewer fires and put less dust into the atmosphere, could easily depress temperatures enough to essentially cancel grain production in the northern hemisphere. That in itself would be the greatest catastrophe ever delivered upon Homo Sapiens, just that one thing, not worrying about prompt effects. Thus even below the threshold, one cannot think of survival of a nuclear war as just being able to stand up after the bomb has gone off."[8]

[8] http://www.voanews.com/content/pope-francis-calls-for-nuclear-weapons-ban/2909357.html
http://www.cadmusjournal.org/article/issue-4/flaws-concept-nuclear-deterrance
http://www.countercurrents.org/avery300713.htm
https://www.wagingpeace.org/author/john-avery/
http://www.commondreams.org/news/2015/08/06/70-years-after-bombing-hiroshima-calls-abolish-nuclear-weapons
http://www.informationclearinghouse.info/article42488.htm
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http://www.cadmusjournal.org/article/issue-4/flaws-concept-nuclear-deterrance
http://www.cadmusjournal.org/article/issue-6/arms-trade-treaty-opens-new-possibilities-u

Nuclear weapons are criminal! Every war is a crime!

War was always madness, always immoral, always the cause of unspeakable suffering, economic waste and widespread destruction, and always a source of poverty, hate, barbarism and endless cycles of revenge and counter-revenge. It has always been a crime for soldiers to kill people, just as it is a crime for murderers in civil society to kill people. No flag has ever been wide enough to cover up atrocities.

But today, the development of all-destroying modern weapons has put war completely beyond the bounds of sanity and elementary humanity.

Today, war is not only insane, but also a violation of international law. Both the United Nations Charter and the Nuremberg Principles make it a crime to launch an aggressive war. According to the Nuremberg Principles, every soldier is responsible for the crimes that he or she commits, even while acting under the orders of a superior officer.

Nuclear weapons are not only insane, immoral and potentially omnicidal, but also criminal under international law. In response to questions put to it by WHO and the UN General Assembly, the International Court of Justice ruled in 1996 that “the threat and use of nuclear weapons would generally be contrary to the rules of international law applicable in armed conflict, and particularly the principles and rules of humanitarian law.” The only possible exception to this general rule might be “an extreme circumstance of self-defense, in which the very survival of a state would be at stake”. But the Court refused to say that even in this extreme circumstance the threat or use of nuclear weapons would be legal. It left the exceptional case undecided. In addition, the Court added unanimously that “there exists an obligation to pursue in good faith and bring to a conclusion negotiations leading to nuclear disarmament in all its aspects under strict and effective international control.”

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http://eruditio.worldacademy.org/issue-6/article/remember-your-humanity

http://www.informationclearinghouse.info/article42568.htm

https://firstlook.org/theintercept/2014/09/23/nobel-peace-prize-fact-day-syria-7th-country-bombed-obama/

http://www.informationclearinghouse.info/article42577.htm

http://www.informationclearinghouse.info/article42580.htm

http://human-wrongs-watch.net/2015/08/06/us-unleashing-of-atomic-weapons-against-civilian-populations-was-a-criminal-act-of-the-first-order/

http://human-wrongs-watch.net/2015/08/06/hiroshima-and-nagasaki-remembering-the-power-of-peace/

http://human-wrongs-watch.net/2015/08/04/atomic-bombing-hear-the-story-setsuko-thurlow/

http://human-wrongs-watch.net/2015/08/04/atomic-bombing-hear-the-story-yasuaki-yamashita/

http://human-wrongs-watch.net/2015/08/03/why-nuclear-weapons/

Can we not rid ourselves of both nuclear weapons and the institution of war itself? We must act quickly and resolutely before everything that we love in our beautiful world is reduced to radioactive ashes.

6.4 Nationalism: a dangerous anachronism

The enlargement of the fundamental political and social unit has been made necessary and possible by improved transportation and communication, and by changes in the techniques of warfare. In Europe, for example, the introduction of cannons in warfare made it possible to destroy castles, and thus the power of central monarchs was increased at the expense of feudal barons. At the same time, improved roads made merchants wish to trade freely over larger areas. Printing allowed larger groups of people to read the same books and newspapers, and thus to experience the same emotions. Therefore the size of the geographical unit over which it was possible to establish social and political cohesion became enlarged.

The tragedy of our present situation is that the same forces that made the nation-state replace the tribe as the fundamental political and social unit have continued to operate with constantly increasing intensity. For this reason, the totally sovereign nation-state has become a dangerous anachronism. Although the world now functions as a single unit because of modern technology, its political structure is based on fragments, on absolutely sovereign nation-states - large compared to tribes, but too small for present-day technology, since they do not include all of mankind. Gross injustices mar today's global economic interdependence, and because of the development of ther- monuclear weapons, the continued existence of civilization is threatened by the anarchy that exists today at the international level.

6.5 The devil's dynamo

Why is the military-industrial complex sometimes called "The Devil's Dynamo"?

The military-industrial complex involves a circular flow of money. The money flows like the electrical current in a dynamo, driving a diabolical machine. Money from immensely rich corporate oligarchs buys the votes of politicians and the propaganda of the mainstream media. Numbed by the propaganda, citizens allow the politicians to vote for obscenely bloated military budgets, which further enrich the corporate oligarchs, and the circular flow continues.

The Industrial Revolution and Colonialism

The devil's dynamo of today has lead to a modern version of colonialism and empire. It is therefore interesting to look at the first global era of colonialism: In the 18th and 19th centuries, the continually accelerating development of science and science-based industry began to affect the whole world. As the factories of Europe poured out cheap manufactured goods, a change took place in the patterns of world trade: Before the Industrial Revolution, trade routes to Asia had brought Asian spices, textiles and luxury goods to Europe. For example, cotton cloth and fine textiles, woven in India, were imported to England. With the invention of spinning and weaving machines, the trade was reversed. Cheap cotton cloth, manufactured in England, began to be sold in India, and the Indian textile industry withered, just as the hand-loom industry in England itself had done a century before.

The rapid development of technology in the west also opened an enormous gap in military strength between the industrialized nations and the rest of the world. Taking advantage of their superior weaponry, the advanced industrial nations rapidly carved the remainder of the world into colonies, which acted as sources of raw materials and food, and as markets for manufactured goods. Throughout the American continent, the native Indian population had proved vulnerable to European diseases, such as smallpox, and large numbers of them had died. The remaining Indians were driven westward by streams of immigrants arriving from Europe.

The sometimes genocidal wars waged by industrial nations against the inhabitants of Asia, Africa and the Western Hemisphere often involved almost unimaginable cruelty. We can think, for example of the atrocities committed by the army of Leopold II in Belgian Congo, where more than ten million people were killed out of a total population of 20 million. (In Leopold's Congo human hands became a sort of currency. This was because the men in Leopold's army were ordered to cut off the hands of their victims to prove that they had not wasted bullets.) We can also think of distribution of smallpox-infected blankets to the Amerinds, or the unbelievable treachery and cruelty of Conquistadors in Central America and South South America.

Often the industrialized nations made their will felt by means of naval bombardments: In 1854, Commodore Perry forced Japan to accept foreign traders by threatening to bombard Tokyo. In 1856, British warships bombarded Canton in China to punish acts of violence against Europeans living in the city. In 1864, a force of European and American warships bombarded Choshu in Japan, causing a revolution. In 1882, Alexandria was bombarded, and in 1896, Zanzibar.

Much that was beautiful and valuable was lost, as mature traditional cultures collapsed, overcome by the power and temptations of modern industrial civilization. For the Europeans and Americans of the late 19th century and early 20th century, progress was a religion, and imperialism was its crusade.

Between 1800 and 1875, the percentage of the earth's surface under European rule increased from 35percent to 67 percent. In the period between 1875 and 1914, there was a new wave of colonial expansion, and the fraction of the earth's surface under the domination of colonial powers (Europe, the United States and Japan) increased to 85 percent, if former colonies are included.

The unequal (and unfair) contest between the industrialized countries, armed with modern weapons, and the traditional cultures with their much more primitive arms, was summarized by the English poet Hilaire Belloc in a sardonic couplet: "Whatever happens, we have got The Maxim gun, and they have not."

The Maxim gun was one of the world's first automatic machine guns. It was invented in the United States in 1884 by Hiram S. Maxim. The explorer and colonialist Henry Morton Stanley (1841-1904) was extremely enthusiastic about Maxim's machine gun, and during a visit to the inventor he tried firing it, demonstrating that it really could fire 600 rounds per minute. Stanley commented that the machine gun would be "a valuable tool in helping civilization to overcome barbarism".

During the period between 1880 and 1914, British industrial and colonial dominance began to be challenged. Industrialism had spread from Britain to Belgium, Germany and the United States, and, to a lesser extent, to France, Italy, Russia and Japan. By 1914, Germany was producing twice as much steel as Britain, and the United States was producing four times as much. . New techniques in weaponry were introduced, and a naval armaments race began among the major industrial powers. The English found that their old navy was obsolete, and they had to rebuild. Thus, the period of colonial expansion between 1880 and 1914 was filled with tensions, as the industrial powers raced to arm themselves in competition with each other, and raced to seize as much as possible of the rest of the world.

The English economist and Fabian, John Atkinson Hobson (1858-1940), offered a famous explanation of the colonial era in his book "Imperialism: A Study" (1902). According to Hobson, the basic problem that led to colonial expansion was an excessively unequal distribution of incomes in the industrialized countries. The result of this unequal distribution was that neither the rich nor the poor could buy back the total output of their society. The incomes of the poor were insufficient, and rich were too few in number. The rich had finite needs, and tended to reinvest their money. As Hobson pointed out, reinvestment in new factories only made the situation worse by increasing output.

Hobson had been sent as a reporter by the Manchester Guardian to cover the Second Boer War. His experiences had convinced him that colonial wars have an economic motive. Such wars are fought, he believed, to facilitate investment of the excess money of the rich in African or Asian plantations and mines, and to make possible the overseas sale of excess manufactured goods. Hobson believed imperialism to be immoral, since it entails suffering both among colonial peoples and among the poor of the industrial nations. The cure that he recommended was a more equal distribution of incomes in the manufacturing countries.

Outlawing war

Industrial and colonial rivalry contributed to the outbreak of the First World War, to which the Second World War can be seen as a sequel. The Second World War was terrible enough to make world leaders resolve to end the institution of war once and for all, and the United Nations was set up for this purpose. Article 2 of the UN Charter requires that "All members shall refrain in their international relations from the threat or use of force against the territorial integrity or political independence of any state."

The Nuremberg principles, which were used in the trial of Nazi leaders after World War II, explicitly outlawed "Crimes against peace: (i) Planning, preparation, initiation or waging of war of aggression or a war in violation of international treaties, agreements or assurances; (ii) Participation in a common plan or conspiracy for the accomplishment of any of the acts mentioned under (i)."

With the founding of the United Nations at the end of the Second World War, a system of international law was set up to replace the rule of military force. Law is a mechanism for equality. Under law, the weak and the powerful are in principle equal. The basic purpose of the United Nations is to make war illegal, and if war is illegal, the powerful and weak are on equal footing, much to the chagrin of the powerful. How can one can one construct or maintain an empire if war is not allowed? It is only natural that powerful nations should be opposed to international law, since it is a curb on their power. However, despite opposition, the United Nations was quite successful in ending the original era of colonialism, perhaps because of the balance of power between East and West during the Cold War. One by one, former colonies regained their independence. But it was not to last. The original era of colonialism was soon replaced by neocolonialism.

The military-industrial complex

The two world wars of the 20th Century involved a complete reordering of the economies of the belligerent countries, and a dangerous modern phenomenon was created - the military-industrial complex.

In his farewell address (January 17, 1961) US President Dwight David Eisenhower warned of the dangers of the war-based economy that World War II had forced his nation to build: "...We have been compelled to create an armaments industry of vast proportions", Eisenhower said, "...Now this conjunction of an immense military establishment and a large arms industry is new in American experience. The total influence - economic, political, even spiritual - is felt in every city, every state house, every office in the federal government. ...We must not fail to comprehend its grave implications. Our toil, resources and livelihood are all involved; so is the very structure of our society. ... We must stand guard against the acquisition of unwarranted influence, whether sought or unsought, by the military-industrial complex. The potential for the disastrous rise of misplaced power exists and will persist. We must never let the weight of this combination endanger our democratic processes. We should take nothing for granted."

This farsighted speech by Eisenhower deserves to be studied by everyone who is concerned about the future of human civilization and the biosphere. As the retiring president pointed out, the military-industrial complex is a threat both to peace and to democracy. It is not unique to the United States but exists in many countries. The world today spends roughly 1.7 trillion (i.e. 1.7 million million) US dollars each year on armaments.

It is obvious that very many people make their living from war, and therefore it is correct to speak of war as a social, political and economic institution. The military-industrial complex is one of the main reasons why war persists, although everyone realizes that war is the cause of much of the suffering of humanity.

Figure 6.4: **War: A woodcut by the German artist Käthe Kollwitz, used as an illustration in the book *Keieg dem Kriege!* (*Fight Against War!*).**

Figure 6.5: **War: Another woodcut by Käthe Kollwitz. It is one of a long series of images which she produced as a protest against the horrors of World War I, in the hope that the institution of war would be abolished.**

Figure 6.6: **War: This photograph shows a terrified child during the Vietnam War (1954-1975).**

Figure 6.7: **War: One of a series of 82 prints entitled *Los desastros de la guerra* (*The disasters of war*), created by the Spanish artist Francisco Goya between 1810 and 1820.**

Figure 6.8: **War: The famous painting *Guernica* was created by Pablo Picasso in 1937 as a protest against the terror bombing of civilians, mainly women and children, in the Basque town of Guernica by Fascist Italian and Nazi German aircraft.**

Figure 6.9: **War: The Nanking Massacre, a 1937 episode of mass murder and mass rape committed by Japanese troops against the residents of Nanking (or Nanjing), which was then the capital of China. It is estimated that as many as 300,000 deaths resulted. Almost all of the victims were civilians.**

Figure 6.10: **War: A victim of the U.S. nuclear attacks on Hiroshima and Nagasaki in 1945. There is evidence that the purpose of the attacks was not to end the war with already-defeated Japan, but rather to intimidate the Soviet Union.**

Figure 6.11: **Nationalism: Today, nationalism is a dangerous anachronism. War can be eliminated only through the development of effective and just international governance and international law.**

Figure 6.12: **Nationalism: The vindictive Versailles Treaty at the end of World War I set the stage for World War II.**

Figure 6.13: **Nationalism: The 19th century German nationalist movement resulted in Nazi atrocities.**

Figure 6.14: **Nationalism: Fascism disappeared in Italy with the death of Mussolini, only to reappear in the United States after the 2016 presidential election.**

Figure 6.15: **Nationalism: A photograph of Donald Trump, who was elected in 2016 on an openly racist platform. The legality of his activities as well as his mental stability have been questioned. His war of words with Kim Jong-un threatens to plunge the world into a catastrophic thermonuclear war.**

Figure 6.16: **Nationalism: North Korea's dictator, Kim-Jong-un. The doctrine of nuclear deterrence rests on the assumption that no sane political leader would use nuclear weapons, an assumption that seems very uncertain in the case of the U.S.-North Korean conflict.**

Figure 6.17: **Nationalism: Soldiers "serving their nation" become automatons. The individual conscience is replaced by blind obedience.**

Figure 6.18: **Nationalism: Soldiers goosesteping like automatons. However, according to the Nuremberg Principles, soldiers must follow their individual consciences, and refrain from committing atrocities even if ordered to do so by their superior officers.**

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Chapter 7

THE BIRTH OF ETHICS

7.1 Ethics can overwrite tribalism!

After the invention of agriculture, roughly 10,000 years ago, humans began to live in progressively larger groups, which were sometimes multi-ethnic. In order to make towns, cities and finally nations function without excessive injustice and violence, both ethical and legal systems were needed. Today, in an era of global economic interdependence, instantaneous worldwide communication and all-destroying thermonuclear weapons, we urgently need new global ethical principles and a just and enforcible system of international laws.

The very long childhood of humans allows learned behavior to overwrite instinctive behavior. A newborn antelope is able to stand on its feet and follow the herd almost immediately after birth. By contrast, a newborn human is totally helpless. With cultural evolution, the period of dependence has become progressively longer. Today, advanced education often requires humans to remain dependent on parental or state support until they are in their middle 20's!

Humans are capable of tribalistic inter-group atrocities such as genocides and wars, but they also have a genius for cooperation. Cultural evolution implies inter-group exchange of ideas and techniques. It is a cooperative enterprise in which all humans participate. It is cultural evolution that has given our special dominance. But cultural evolution depends on overwriting destructive tribalism with the principles of law, ethics and politeness. The success of human cultural evolution demonstrates that this is possible. Ethics can overwrite tribalism!

What is law?

The principles of law, ethics, politeness and kindness function in slightly different ways, but all of these behavioral rules help human societies to function in a cohesive and trouble-free way. Law is the most coarse. The mesh is made finer by ethics, while the rules of politeness and kindness fill in the remaining gaps.

Legal systems began at a time at a time when tribal life was being replaced by life in villages, towns and cities. One of the oldest legal documents that we know of is a code of laws enacted by the Babylonian king Hammurabi in about 1754 BC. It consists of 282 laws, with scaled punishments, governing household behavior, marriage, divorce, paternity, inheritance, payments for services, and so on. An ancient 2.24 meter stele inscribed with Hammurabi's Code can be seen in the Louvre. The laws are written in the Akkadian language, using cuneiform script.

Humanity's great ethical systems also began during a period when the social unit was growing very quickly. It is an interesting fact that many of history's greatest ethical teachers lived at a time when the human societies were rapidly increasing in size. One can think, for example of Moses, Confucius, Lao-Tzu, Gautama Buddha, the Greek philosophers, and Jesus. Muhammad came slightly later, but he lived and taught at a time when tribal life was being replaced by city life in the Arab world. During the period when these great teachers lived, ethical systems had become necessary to over-write raw inherited human emotional behavior patterns in such a way that increasingly large societies could function in a harmonious and cooperative way, with a minimum of conflicts.

Figure 7.1: **Hammurabi's code**

Figure 7.2: **Hammurabi's code**

7.2 The Ten Commandments

Here is a description of the Ten Commandments, as given in the chapter Exodus 20 of the King James Version of the Bible:

And God spake all these words, saying,

I am the Lord thy God, which have brought thee out of the land of Egypt, out of the house of bondage.

Thou shalt have no other gods before me.

Thou shalt not make unto thee any graven image, or any likeness of any thing that is in heaven above, or that is in the earth beneath, or that is in the water under the earth.

Thou shalt not bow down thyself to them, nor serve them: for I the Lord thy God am a jealous God, visiting the iniquity of the fathers upon the children unto the third and fourth generation of them that hate me;

And showing mercy unto thousands of them that love me, and keep my commandments.

Thou shalt not take the name of the Lord thy God in vain; for the Lord will not hold him guiltless that taketh his name in vain.

Remember the sabbath day, to keep it holy.

Six days shalt thou labor, and do all thy work:

But the seventh day is the sabbath of the Lord thy God: in it thou shalt not do any work, thou, nor thy son, nor thy daughter, thy manservant, nor thy maidservant, nor thy cattle, nor thy stranger that is within thy gates:

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested the seventh day: wherefore the Lord blessed the sabbath day, and hallowed it.

Honor thy father and thy mother: that thy days may be long upon the land which the Lord thy God giveth thee.

Thou shalt not kill.

Thou shalt not commit adultery.

Thou shalt not steal.

Thou shalt not bear false witness against thy neighbor.

Thou shalt not covet thy neighbor's house, thou shalt not covet thy neighbor's wife, nor his manservant, nor his maidservant, nor his ox, nor his ass, nor any thing that is thy neighbor's.

And all the people saw the thunderings, and the lightnings, and the noise of the trumpet, and the mountain smoking: and when the people saw it, they removed, and stood afar off.

And they said unto Moses, Speak thou with us, and we will hear: but let not God speak with us, lest we die.

And Moses said unto the people, Fear not: for God is come to prove you, and that his fear may be before your faces, that ye sin not.

And the people stood afar off, and Moses drew near unto the thick darkness where God was.

And the Lord said unto Moses, Thus thou shalt say unto the children of Israel, Ye have seen that I have talked with you from heaven.

Ye shall not make with me gods of silver, neither shall ye make unto you gods of gold.

An altar of earth thou shalt make unto me, and shalt sacrifice thereon thy burnt offerings, and thy peace offerings, thy sheep, and thine oxen: in all places where I record my name I will come unto thee, and I will bless thee.

And if thou wilt make me an altar of stone, thou shalt not build it of hewn stone: for if thou lift up thy tool upon it, thou hast polluted it.

Neither shalt thou go up by steps unto mine altar, that thy nakedness be not discovered thereon.

Figure 7.3: **The Ten Commandments**

7.3 The life and message of Gautama Buddha

Evidence of a very early river-valley civilization in India has been found at a site called Mohenjo-Daro. However, in about 2,500 B.C., this early civilization was destroyed by some great disaster, perhaps a series of floods; and for the next thousand years, little is known about the history of India. During this dark period between 2,500 B.C. and 1,500 B.C., India was invaded by the Indo-Aryans, who spoke Sanskrit, a language related to Greek. The Indo-Aryans partly drove out and partly enslaved the smaller and darker native Dravidians. However, there was much intermarriage between the groups, and to prevent further intermarriage, the Indo-Aryans introduced a caste system sanctioned by religion.

According to Hindu religious belief, the soul of a person who has died is reborn in another body. If, throughout his life, the person has faithfully performed the duties of his caste, then his or her soul may be reborn into a higher caste. Finally, after existing as a Brahman, the soul may be so purified that it can be released from the cycle of death and rebirth.

In the 6th century B.C., Gautama Buddha founded a new religion in India. Gautama Buddha was convinced that all the troubles of humankind spring from attachment to earthly things. He felt that the only escape from sorrow is through the renunciation of earthly desires. He also urged his disciples to follow a high ethical code, the Eightfold Way. Among the sayings of Buddha are the following:

"Hatred does not cease by hatred at any time; hatred ceases by love."

"Let a man overcome anger by love; let him overcome evil by good."

"All men tremble at punishment. All men love life. Remember that you are like them, and do not cause slaughter."

One of the early converts to Buddhism was the emperor Ashoka Maurya, who reigned in India between 273 B.C. and 232 B.C.. During one of his wars of conquest, Ashoka Maurya became so sickened by the slaughter that he resolved never again to use war as an instrument of policy. He became one of the most humane rulers in history, and he also did much to promote the spread of Buddhism throughout Asia.

Under the Mauryan dynasty (322 B.C. - 184 B.C.), the Gupta dynasty (320 B.C. - 500 A.D.) and also under the rajah Harsha (606 A.D. - 647 A.D.), India had periods of unity, peace and prosperity. At other times, the country was divided and upset by internal wars. The Gupta period especially is regarded as the golden age of India's classical past. During this period, India led the world in such fields as medicine and mathematics.

The Guptas established both universities and hospitals. According to the Chinese Buddhist pilgrim, Fa-Hsien, who visited India in 405 A.D., "The nobles and householders have founded hospitals within the city to which the poor of all countries, the destitute, crippled and diseased may go. They receive every kind of help without payment."

Indian doctors were trained in cleansing wounds, in using ointments and in surgery. They also developed antidotes for poisons and for snakebite, and they knew some techniques for the prevention of disease through vaccination.

When they had completed their training, medical students in India took an oath, which resembled the Hippocratic oath: "Not for yourself, not for the fulfillment of any earthly desire or gain, but solely for the good of suffering humanity should you treat your patients."

In Indian mathematics, algebra and trigonometry were especially highly developed. For example, the astronomer Brahmagupta (598 A.D. - 660 A.D.) applied algebraic methods to astronomical problems. The notation for zero and the decimal system were invented in India, probably during the 8th or 9th century A.D.. These mathematical techniques were later transmitted to Europe by the Arabs.

Many Indian techniques of manufacture were also transmitted to the west by the Arabs. Textile manufacture in particular was highly developed in India, and the Arabs, who were the middlemen in the trade with the west, learned to duplicate some of the most famous kinds of cloth. One kind of textile which they copied was called "quttan" by the Arabs, a word which in English has become "cotton". Other Indian textiles included cashmere (Kashmir), chintz

Figure 7.4: **Buddha**

and calico (from Calcutta, which was once called Calicut). Muslin derives its name from Mosul, an Arab city where it was manufactured, while damask was made in Damascus.

Indian mining and metallurgy were also highly developed. The Europeans of the middle ages prized fine laminated steel from Damascus; but it was not in Damascus that the technique of making steel originated. The Arabs learned steelmaking from the Persians, and Persia learned it from India.

The Noble Eightfold Path

1. **Right understanding**. *And what is right understanding? There are fruits, and results of good and bad actions. There is this world and the next world. There is mother and father. There are spontaneously reborn beings; there are contemplatives and Brahmans who faring rightly and practicing rightly, proclaim this world and the next after having directly known and realized it for themselves.' This is the right view with effluents, siding with merit, resulting in acquisitions*

2. **Right resolve**. *And what is right resolve? Being resolved on renunciation, on freedom from ill will, on harmlessness: This is called right resolve.*

3. **Right speech**. *And what is right speech? Abstaining from lying, from divisive speech, from abusive speech, and from idle chatter: This is called right speech.*

4. **Right action**. *And what is right action? Abstaining from killing, abstaining from stealing, abstaining from sexual misconduct. This is called right action.*

5. **Right livelihood**. *And what is right livelihood? Not possessing more than is strictly necessary. Avoiding causing suffering to sentient beings by cheating them, or harming or killing them in any way.*

6. **Right effort**. *And what is right effort? Here the monk arouses his will, puts forth effort, generates energy, exerts his mind, and strives to prevent the arising of evil and unwholesome mental states that have not yet arisen. He arouses his will... and strives to eliminate evil and unwholesome mental states that have already arisen, to keep them free of delusion, to develop, increase, cultivate, and perfect them. This is called right effort.*

7. **Right mindfulness**. *And what is right mindfulness? Here the monk remains contemplating the body as body, resolute, aware and mindful, having put aside worldly desire and sadness; he remains contemplating feelings as feelings; he remains contemplating mental states as mental states; he remains contemplating mental objects as mental objects, resolute, aware and mindful, having put aside worldly desire and sadness; This is called right mindfulness.*

8. **Right concentration**. *And what is right concentration? [i] Here, the monk, detached from sense-desires, detached from unwholesome states, enters and remains in the first jhana (level of concentration, in which there is applied and sustained thinking, together with joy and pleasure born of detachment; [ii] And through the subsiding of applied and sustained thinking, with the gaining of inner stillness and oneness of mind, he enters and remains in the second jhana, which is without applied and sustained thinking, and in which there are joy and pleasure born of concentration; [iii] And through the fading of joy, he remains equanimous, mindful and aware, and he experiences in his body the pleasure of which the Noble Ones say: "equanimous, mindful and dwelling in pleasure", and thus he enters and remains in the third jhana; [iv] And through the giving up of pleasure and pain, and through the previous disappearance of happiness and sadness, he enters and remains in the fourth jhana, which*

is without pleasure and pain, and in which there is pure equanimity and mindfulness. This is called right concentration.

Some of the sayings of Gautama Buddha

In the end, only three things matter: How much you loved, how gently you lived, and how gracefully you let go of things not meant for you.

Buddha was asked, "What have you gained from mediation?" He replied NOTHING! However let me tell you what i have lost: anger, anxiety, depression, insecurity, fear of old age and death.

When the student is ready, the teacher will appear.

The less you respond to negative people, the more peaceful your life will become.

Health is the greatest gift, contentment is the greatest wealth, A trusted friend is the best relative, liberated mind is the greatest bliss.

The thought manifests as the word: the word manifests as the deed: the deed develops into character. So watch the thought and its ways with care, and let it spring from love born out of concern for all beings.

Do not learn how to react learn how to respond.

If your compassion does not include yourself, It is incomplete.

Everything that has a beginning has an ending. Make your peace with that and all will be well.

If anything is worth doing, do it with all your heart.

Your worst enemy cannot harm you as much as your own unguarded thoughts.

The root of suffering is attachment.

Holding onto anger is like drinking poison and expecting the other person to die.

All that we are is the result of what we have thought.

Do not dwell in the past, do not dream of the future, concentrate the mind on the present moment.

What you think you become, what you feel, you attract. what you imagine, you create.

Nothing can harm you as much as your own thoughts unguarded.

The trouble is you think you have time.

Your work is to discover your world and then with all your heart give yourself to it.

Believe nothing, no matter where you read it or who has said it, not even if i have said it. Unless it agrees with your own reason and your own common sense.

On the long journey of human life, Faith is the best of companions.

To understand everything is to forgive everything.

No one saves us but ourselves. No one can and no one may. We ourselves must walk the past.

There is no path to happiness: Happiness is the path.

No matter how hard the past, you can always begin again.

If you want to fly, give up everything that weighs you down.

You only lose what you cling to.

When we meet real tragedy in life, we can react in two ways- Either by losing hope and falling into self-destructive habits or by using the challenge to find our inner strength.

Don't rush anything. When the time is right, it will happen.

The whole secret of existence is to have no fear.

Be kind to all creatures; this is the true religion.

Those who are free of resentful thoughts surely find peace.

It is during our darkest moments that we must focus to see the light

Quiet the mind, and the soul will speak.

Each morning we are born again. What we do today is what matters most.

A man who conquers himself is greater than one who conquers a thousand men in a battle.

All human unhappiness comes from not facing reality squarely, exactly as it is.

It is better to be hated for what you are than to be loved for what you are not.

He who does not understand your silence will probably not understand your words.

You will not be punished for your anger, you will be punished by your anger.

Whatever befalls you, walk on untouched, unattached.

7.4 Confucius and Chinese civilization

After the fall of Rome in the 5th century A.D., Europe became a culturally backward area. However, the great civilizations of Asia and the Middle East continued to flourish, and it was through contact with these civilizations that science was reborn in the west.

During the dark ages of Europe, a particularly high level of civilization existed in China. The art of working in bronze was developed in China during the Shang dynasty (1,500 B.C. - 1,100 B.C.) and it reached a high pitch of excellence in the Chou dynasty (1,100 B.C. - 250 B.C.). " In the Chou period, many of the cultural characteristics which we recognize as particularly Chinese were developed. During this period, the Chinese evolved a code of behavior based on politeness and ethics. Much of this code of behavior is derived from the teachings of K'ung Fu-tzu (Confucius), a philosopher and government official who lived between 551 B.C. and 479 B.C.. In his writings about ethics and politics, K'ung Fu-tzu advocated respect for tradition and authority, and the effect of his teaching was to strengthen the conservative tendencies in Chinese civilization. He was not a religious leader, but a moral and political philosopher, like the philosophers of ancient Greece. He is traditionally given credit for the compilation of the Five Classics of Chinese Literature, which include books of history, philosophy and poetry, together with rules for religious ceremonies.

Some sayings of Confucius

By three methods we may learn wisdom: First, by reflection, which is noblest; Second, by imitation, which is easiest; and third by experience, which is the bitterest.

Everything has beauty, but not everyone sees it.

Wheresoever you go, go with all your heart.

It does not matter how slowly you go as long as you do not stop.

Life is really simple, but we insist on making it complicated.

If you make a mistake and do not correct it, this is called a mistake.

The man who moves a mountain begins by carrying away small stones.

The funniest people are the saddest ones.

Before you embark on a journey of revenge, dig two graves.

To be wronged is nothing, unless you continue to remember it.

Respect yourself and others will respect you.

Silence is a true friend who never betrays.

You cannot open a book without learning something.

When you see a good person, think of becoming like her/him. When you see someone not so good, reflect on your own weak points.

Attack the evil that is within yourself, rather than attacking the evil that is in others.

The man who asks a question is a fool for a minute, the man who does not ask is a fool for life.

What the superior man seeks is in himself; what the small man seeks is in others.

I hear and I forget. I see and I remember. I do and I understand.

Music produces a kind of pleasure which human nature cannot do without.

The hardest thing of all is to find a black cat in a dark room, especially if there is no cat.

It is not the failure of others to appreciate your abilities that should trouble you, but rather your failure to appreciate theirs.

The man of wisdom is never of two minds; the man of benevolence never worries; the man of courage is never afraid.

The gem cannot be polished without friction, nor man perfected without trials.

Give a bowl of rice to a man and you will feed him for a day. Teach him how to grow his own rice and you will save his life.

Only the wisest and stupidest of men never change.

It is more shameful to distrust our friends than to be deceived by them.

Real knowledge is to know the extent of one's ignorance.

And remember, no matter where you go, there you are.

Hold faithfulness and sincerity as first principles.

If what one has to say is not better than silence, then one should keep silent.

Forget injuries, never forget kindnesses.

When it is obvious that the goals cannot be reached, don't adjust the goals, adjust the action steps.

Better a diamond with a flaw than a pebble without.

To put the world in order, we must first put the nation in order; to put the nation in order, we must first put the family in order; to put the family in order; we must first cultivate our personal life; we must first set our hearts right.

A lion chased me up a tree, and I greatly enjoyed the view from the top.

To be wealthy and honored in an unjust society is a disgrace.

In a country well governed, poverty is something to be ashamed of. In a country badly governed, wealth is something to be ashamed of.

If your plan is for one year plant rice. If your plan is for ten years plant trees. If your plan is for one hundred years educate children.

Don't do unto others what you don't want done unto you.

Education breeds confidence. Confidence breeds hope. Hope breeds peace.

To see what is right and not do it is the worst cowardice.

Time flows away like the water in the river.

The superior man thinks always of virtue; the common man thinks of comfort.

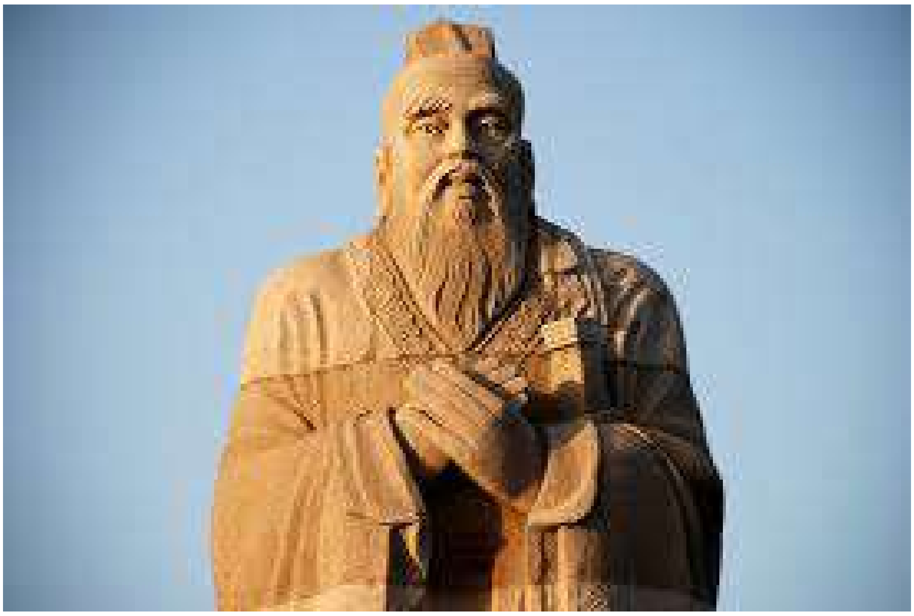

Figure 7.5: **Confucius**

7.5 Lao Tzu: Unity with nature

The rational teachings of K'ung Fu-tzu were complemented by the more mystical and intuitive doctrines of Lao-tzu and his followers. Lao-tzu lived at about the same time as K'ung Fu-tzu, and he founded the Taoist religion. The Taoists believed that unity with nature could be achieved by passively blending oneself with the forces of nature.

On the whole, politicians and scholars followed the practical teachings of K'ung Fu-tzu, while poets and artists became Taoists. The intuitive sensitivity to nature inspired by Taoist beliefs allowed these artists and poets to achieve literature and art of unusual vividness and force with great economy of means. The Taoist religion has much in common with Buddhism, and its existence in China paved the way for the spread of Buddhism from India to China and Japan.

From 800 B.C. onwards, the central authority of the Chou dynasty weakened, and China was ruled by local landlords. This period of disunity was ended in 246 B.C. by Shih Huang Ti, a chieftain from the small northern state of Ch'in, who became the first real emperor of China. (In fact, China derives its name from the state of Ch'in).

Shih Huang Ti was an effective but ruthless ruler. It was during his reign (246 B.C. -210 B.C.) that the great wall of China was built. This wall, built to protect China from the savage attacks of the mounted Mongolian hordes, is one of the wonders of the world. It runs 1,400 miles, over all kinds of terrain, marking a rainfall boundary between the rich agricultural land to the south and the arid steppes to the north.

In most places, the great wall is 25 feet high and 15 feet thick. To complete this fantastic building project, Shih Huang Ti carried absolutism to great extremes, uprooting thousands of families and transporting them to the comfortless north to work on the wall. He burned all the copies of the Confucian classics which he could find, since his opponents quoted these classics to show that his absolutism had exceeded proper bounds.

Soon after the death of Shih Huang Ti, there was a popular reaction to the harshness of his government, and Shih's heirs were overthrown. However, Shih Huang Ti's unification of China endured, although the Ch'in dynasty (250 B.C. - 202 B.C.) was replaced by the Han dynasty (202 B.C. -220 A.D.). The Han emperors extended the boundaries of China to the west into Turkestan, and thus a trade route was opened, through which China exported silk to Persia and Rome.

During the Han period, China was quite receptive to foreign ideas, and was much influenced by the civilization of India. For example, the Chinese pagoda was inspired by the Buddhist shrines of India. The Han emperors adopted Confucianism as the official philosophy of China, and they had the Confucian classics recopied in large numbers. The invention of paper at the end of the first century A.D. facilitated this project, and it greatly stimulated scholarship and literature.

The Han emperors honored scholarship and, in accordance with the political ideas of K'ung Fu-tzu, they made scholarship a means of access to high governmental positions. During the Han dynasty, the imperial government carried through many large-scale irrigation and flood-control projects. These projects were very successful. They increased the food production of China, and gave much prestige to the imperial government.

Like the Roman Empire, the Han dynasty was ended by attacks of barbarians from the north. However, the Huns who overran northern China in 220 A.D. were quicker to adopt civilization than were the tribes which conquered Rome. Also, in the south, the Chinese remained independent; and therefore the dark ages of China were shorter than the European dark ages.

In 581 A.D., China was reunited under the Sui dynasty, whose emperors expelled most of the Huns, built a system of roads and canals, and constructed huge granaries for the prevention of famine. These were worthwhile projects, but in order to accomplish them, the Sui emperors used very harsh methods. The result was that their dynasty was soon overthrown and replaced by the T'ang dynasty (618 A.D. - 906 A.D.).

The T'ang period was a brilliant one for China. Just as Europe was sinking further and further into a mire of superstition, ignorance and bloodshed, China entered a period of peace, creativity and culture. During this period, China included Turkestan, northern Indochina and Korea. The T'ang emperors re-established and strengthened the system of civil-service examinations which had been initiated during the Han dynasty.

Some sayings of Lau Tzu

Being deeply loved by someone gives you strength, while loving someone deeply gives you courage.

Simplicity, patience, compassion. These three are your greatest treasures. Simple in actions and thoughts, you return to the source of being. Patient with both friends and enemies, you accord with the way things are. Compassionate toward yourself, you reconcile all beings in the world.

The journey of a thousand miles begins with a single step."

Knowing others is intelligence; knowing yourself is true wisdom.
Mastering others is strength; mastering yourself is true power.

A good traveler has no fixed plans and is not intent on arriving.

Life is a series of natural and spontaneous changes. Don't resist them; that only creates sorrow. Let reality be reality. Let things flow naturally forward in whatever way they like.

Those who know do not speak. Those who speak do not know.

When you are content to be simply yourself and don't compare or compete, everyone will respect you.

The truth is not always beautiful, nor beautiful words the truth

When I let go of what I am, I become what I might be.

Time is a created thing. To say 'I don't have time,' is like saying, 'I don't want to.

Because one believes in oneself, one doesn't try to convince others. Because one is content with oneself, one doesn't need others' approval. Because one *accepts oneself, the whole world accepts him or her.*

A man with outward courage dares to die; a man with inner courage dares to live.

Care about what other people think and you will always be their prisoner.

If you are depressed you are living in the past. If you are anxious you are living in the future. If you are at peace you are living in the present.

Be careful what you water your dreams with. Water them with worry and fear and you will produce weeds that choke the life from your dream. Water them with optimism and solutions and you will cultivate success. Always be on the lookout for ways to turn a problem into an opportunity for success. Always be on the lookout for ways to nurture your dream.

Be content with what you have; rejoice in the way things are. When you realize there is nothing lacking, the whole world belongs to you.

Nature does not hurry, yet everything is accomplished.

Silence is a source of Great Strength.

Do you have the patience to wait until your mud settles and the water is clear?

If you understand others you are smart. If you understand yourself you are illuminated. If you overcome others you are powerful. If you overcome yourself you have strength. If you know how to be satisfied you are rich. If you can act with vigor, you have a will. If you don't lose your objectives you can be long-lasting. If you die without loss, you are eternal.

Kindness in words creates confidence. Kindness in thinking creates profoundness. Kindness in giving creates love.

Manifest plainness, Embrace simplicity, Reduce selfishness, Have few desires.

The flame that burns Twice as bright burns half as long.

Music in the soul can be heard by the universe.

Respond intelligently even to unintelligent treatment.

Figure 7.6: **Lao Tzu**

Act without expectation.

7.6 Socrates and Plato: Dialogues on ethics

The Sophists and Socrates

Since Athens was a democracy, the citizens often found themselves speaking at public meetings. Eloquence could be turned into influence, and the wealthy Athenians imported teachers to help them master the art of rhetoric. These teachers, called "Sophists" (literally "wisdomists"), besides teaching rhetoric, also taught a form of philosophy which denied the existence of absolute truth, absolute beauty and absolute justice. According to the Sophists, "man is the measure of all things", all truths are relative, "beauty is in the eye of the beholder", and justice is not divine or absolute but is a human institution.

Opposed to the Sophists was the philosopher Socrates, who believed passionately in the existence of the absolutes which the Sophists denied. According to Socrates, a beautiful object would be beautiful whether or not there were any humans to observe it. Socrates adopted from the Sophists a method of conducting arguments by asking questions which made people see for themselves the things which Socrates wanted them to see.

The Sophists talked about moral and political questions, rather than about the nature of the universe. Socrates was an opponent of the Sophists, but like them he also neglected the study of nature and concentrated on the moral and political problems of man, "the measure of all things".The Sophists, together with Socrates and his pupil Plato, exerted a great influence in causing a split between moral philosophy and natural philosophy.

The beginning of the end of classical Greek civilization came in 431 B.C., when Athens, pushing her aggressive commercial policy to an extreme, began to expel Corinthian merchants from markets around the Aegean. Corinth reacted by persuading the Peloponesian League to declare war on Athens. This was the beginning of a long war which ruined Greece.

Realizing that they could not resist the Spartan land forces, the Athenians abandoned the farmland outside their city, and took refuge inside the walls. The Athenians continued their prosperous foreign trade, and they fed their population with grain imported from the east. Ships bringing grain also brought the plague. A large part of the population of Athens died of the plague, including the city's great leader, Pericles. No leader of equal stature was found to replace him, and the democratic Athenian government degenerated into mob rule.

In 404 B.C., when the fleet of Athens was destroyed in a disastrous battle, the city surrendered to the Spartans. However, the Spartans remembered that without Athens, they would be unable to resist the Persian Empire. Therefore they did not destroy Athens totally, but were content to destroy the walls of Athens, reducing the city to the status of a satellite of Sparta.

Looking for scapegoats on whom to blame this disaster, the Athenian mobs seized Socrates (one of the few intellectuals who remained alive after the Peloponesian War), and they condemned him to death for failing to believe in the gods of the city.

For a short period, Sparta dominated the Greek world; but soon war broke out again, and the political scene degenerated into a chaos of wars between the city states.

Plato

Darkness was falling on the classical Greek world, but the light of civilization had not quite gone out. Socrates was dead, but Plato, the student of Socrates, kept his memory alive by writing dialogues in which Socrates appeared as a character.

Plato (427 B.C. - 317 B.C.) was an Athenian aristocrat, descended from the early kings of Athens. His real name was Aristocles, but he was called by his nickname, Platon (meaning "broad") because of his broad shoulders. After the

Figure 7.7: **Socrates**

death of Socrates, Plato left Athens, saying that the troubles of the city would never end until a philosopher became king. (He may have had himself in mind!) He travelled to Italy and studied under the Pythagoreans. In 387 he returned to Athens and founded a school, which was called the Academy because it stood on ground which had once belonged to a Greek named Academus.

Plato developed a philosophy which was based on the idealism of the Pythagoreans. In Pythagorean philosophy, a clear distinction was made between mathematical ideas and their physical expression. For example, geometry was considered to deal, not with real physical objects, but with idealized figures, constructed from lines of perfect straightness and infinite thinness. Plato developed and exaggerated the idealism of Pythagoras. In Plato's philosophy, the real world is corruptible and base, but the world of ideas is divine and eternal. A real table, for example, is an imperfect expression of the idea of a table. Therefore we ought to turn our eyes away from the real world and live in the world of ideas.

Plato's philosophy was just what the Athenians wanted! All around them, their world was crumbling. They gladly turned their backs on the unpleasantness of the real world, and accepted Plato's invitation to live in the world of ideas, where nothing decays and where the golden laws of mathematics rule eternally.

By all accounts, Plato was an excellent mathematician, and through his influence mathematics obtained a permanent place in education.

According to Plato, Socrates thought that knowledge is of the utmost importance because, since no man sins wittingly, only knowledge is needed to make men and women perfectly virtuous.

Figure 7.8: **Plato**

7.7 The ethical message of Greek drama

In ancient Greece, drama was an essential part of ethical culture. Performances of the plays of great dramatists, such as Sophocles, Aeschylus and Euripides, allowed the public to debate questions of morality. A recurring theme was the punishment of *hubris* (excessive pride) by *nemesis* (the revenge of the gods). Hubris is arrogance in word, deed and thought. For example, hubris is having or maintaining stubbornly an attitude which goes against or ignores, say, the prophecies, counsel or pronouncements of the Delphic Oracle. The central meaning of hubris is doing deeds and thinking thoughts more than a mere mortal human should do and think, thereby showing impiety towards the gods.

Starting in approximately 500 B.C., drama flourished in the Greek city-states, especially in Athens, which was an important cultural center. The presentation of dramas was part of a festival dedicated to the god Dionysus. Masks were used by the actors, and by members of the chorus. The chorus commented on the action, and often pointed to the moral that could be drawn from it.

The Trojan Women, by Euripides

An example of a Greek tragedy with ethical implications, *The Trojan Women* follows the fate of the women of Troy after all their husbands and sons had been slaughtered by the conquering Greeks. The play makes it clear to the audience that the conquering Greeks were guilty of *hubris*.

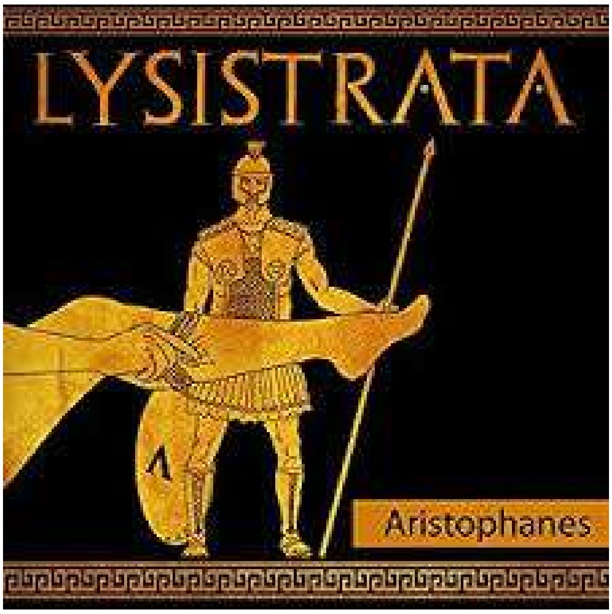

Figure 7.9: **Lysistrata**

Lysistrata, by Aristophanes

Although *The Trojan Women* protested against the atrocities and horrors of war, the play did not attack the institution of war itself. However, in *Lysistrata*. an comedy by Aristophanes first performed in Athens in 411 B.C., war as an institution is attacked. In the play, the women of all parts of Greece are persuaded to withhold sex from their husbands and lovers until the painfully long Peloponesian Wars are ended. After much comic struggle, the men, of course, give in and agree to peace, since their overpowering desire for sex is greater than their addiction to fighting.

7.8 Christian ethics

The three Abrahamic religions, Judaism, Christianity and Islam, have a total of 4 billion followers today, of which 2.4 billion are Christian. At its start, the Christian religion can be seen as a reform of Jewish traditions, a protest against the overly legalistic teachings of the Pharisees and a revelation of a new. more powerful and more universal system of ethics. Later, Saint Paul saw it as his mission to bring Christianity to the Gentiles (i.e. non-Jews).

If Christian ethics were really followed, war would be impossible, but wars have nevertheless persisted, and many of the most brutal wars have been fought in the name of Christianity. In the words the American poet, Edna St. Vincent Millay,[1]

Up goes the man of God before the crowd.
With voice of honey and with eyes of steel
He drones your humble Gospel to the proud.
Nobody listens, less than the wind that blows
Are all your words to us you died to save.
Oh Prince of Peace! O Sharon's dewy Rose!
How mute you lie within your vaulted grave!
The stone the angel rolled away with tears
Is back upon your mouth these thousand years.

The Seven Deadly Sins

Here is a list of important human failings as recognized by Christianity. They are rooted in emotions which we share with our animal ancestors. Today these emotions are inappropriate for civilized human society, and they must be overwritten by ethical principles.

1. **LUST** Regarding lust, Schopenhauer wrote: *Lust is the ultimate goal of almost all human endeavor, exerts an adverse influence on the most important affairs, interrupts the most serious business, sometimes for a while confuses even the greatest minds, does not hesitate with its trumpery to disrupt the negotiations of statesmen and the research of scholars, has the knack of slipping its love-letters and ringlets even into ministerial portfolios and philosophical manuscripts.*

2. **GLUTTONY** Saint Thomas Aquinas argued that gluttony could include, besides eating too much, an obsessive anticipation of meals, and the constant eating of delicacies and excessively costly foods. He even proposed five categories of Gluttony: *1. Laute: eating too expensively. 2. Studiose: eating too daintily. 3. Nimis: eating too much. 4. Praepropere: eating too soon. 5. Ardenter: eating too eagerly.*

3. **GREED** As defined outside Christian writings, greed is an inordinate desire to acquire or possess more than one needs, especially with respect to material wealth. Like pride, it can lead to not just some, but all evil. Saint Thomas Aquinas wrote: *Greed is a sin against God, just as all mortal sins, in as much as man condemns things eternal for the sake of temporal things.* In the New Testament, we can find many passages

[1]from her poem. *To Jesus, on His Birthday*

condemning greed, for example: *For the love of money is the root of all evil: which while some coveted after, they have erred from the faith, and pierced themselves through with many sorrows.* Timothy 6:10, and *Lay not up for yourselves treasures upon earth, where moth and rust doth corrupt, and where thieves break through and steal.* Mathew 6:19

4. **SLOTH** Unlike the other deadly sins, Sloth is characterized by sins of omission. In his play Per Gynt, Henrik Ibsen portrays his protagonist as hearing voices which tell him: *We are the tears you should have shed. That cutting ice, which all hearts dread, we could have melted, but now its dart is frozen into a stubborn heart. Our power is lost. We are the deeds you should have done, strangled by doubt, spoiled e're begun. At the judgement day, we will be there to tell our tale. How will you fare?* Per Gynt answers: *You can't condemn a man for what he has not done!*, but Ibsen's message is: Yes, you can condemn a person for sins of omission. They too are deadly sins.

5. **WRATH** According to the Catholic Church, *Hatred is the sin of desiring that someone else may suffer misfortune or evil, and is a mortal sin when one desires grave harm.* The Catholic Church also states that *If anger reaches the point of a deliberate desire to kill or seriously wound a neighbor, it is gravely against charity; it is a mortal sin.* We can also remember the words of Gautama Buddha, *Hatred does not cease by hatred at any time; hatred ceases by love.*

6. **ENVY** Envy can be directly related to the Ten Commandments, specifically, *Neither shall you covet... anything that belongs to your neighbor.* If we are free from envy, our happiness is greatly increased, since we can derive pleasure from the success and happiness of others.

7. **PRIDE** C.S. Lewis wrote that *Unchastity, anger, greed, drunkenness, and all that, are mere fleabites in comparison: it was through Pride that the devil became the devil: Pride leads to every other vice: it is the complete anti-God state of mind.* In ancient Greece, both philosophers and dramatists considered excessive pride, which they called *hubris*, to be a sin against the gods, which always led to punishment. According to Wikipedia, *Hubris means extreme pride or arrogance. Hubris often indicates a loss of contact with reality, and an overestimation of one's own competence or capabilities, especially when the person exhibiting it is in a position of power.... The word is also used to describe actions of those who challenged the gods or their laws, especially in Greek tragedy, resulting in the protagonist's fall.* We can think, for example of the

Titanic. The invention and use of nuclear weapons can also be thought of as an example of *hubris*.

Excerpts from *The Sermon on the Mount*

Many of the important ethical principles of Christianity are contained in the Sermon on the Mount. Here is the first part of the sermon, as given by the Gospel According to Mathew, Chapter 6:

And seeing the multitudes, he went up into a mountain: and when he was set, his disciples came unto him: And he opened his mouth, and taught them, saying,

Blessed are the poor in spirit: for theirs is the kingdom of heaven.

Blessed are they that mourn: for they shall be comforted.

Blessed are the meek: for they shall inherit the earth.

Blessed are they which do hunger and thirst after righteousness: for they shall be filled.

Blessed are the merciful: for they shall obtain mercy.

Blessed are the pure in heart: for they shall see God.

Blessed are the peacemakers: for they shall be called the children of God.

Blessed are they which are persecuted for righteousness' sake: for theirs is the kingdom of heaven.

Blessed are ye, when men shall revile you, and persecute you, and shall say all manner of evil against you falsely, for my sake.

Rejoice, and be exceeding glad: for great is your reward in heaven: for so persecuted they the prophets which were before you.

Ye are the salt of the earth: but if the salt have lost his savour, wherewith shall it be salted? it is thenceforth good for nothing, but to be cast out, and to be trodden under foot of men.

Ye are the light of the world. A city that is set on an hill cannot be hid. Neither do men light a candle, and put it under a bushel, but on a candlestick; and it giveth light unto all that are in the house.

Let your light so shine before men, that they may see your good works, and glorify your Father which is in heaven.

Think not that I am come to destroy the law, or the prophets: I am not come to destroy, but to fulfil.

For verily I say unto you, Till heaven and earth pass, one jot or one tittle shall in no wise pass from the law, till all be fulfilled.

Whosoever therefore shall break one of these least commandments, and shall teach men so, he shall be called the least in the kingdom of heaven: but whosoever shall do and teach them, the same shall be called great in the kingdom of heaven.

For I say unto you, That except your righteousness shall exceed the righteousness of the scribes and Pharisees, ye shall in no case enter into the kingdom of heaven.

Ye have heard that it was said by them of old time, Thou shalt not kill; and whosoever shall kill shall be in danger of the judgment:

But I say unto you, That whosoever is angry with his brother without a cause shall be in danger of the judgment: and whosoever shall say to his brother, Raca, shall be in danger of the council: but whosoever shall say, Thou fool, shall be in danger of hell fire.

Therefore if thou bring thy gift to the altar, and there rememberest that thy brother hath ought against thee;

Leave there thy gift before the altar, and go thy way; first be reconciled to thy brother, and then come and offer thy gift.

Agree with thine adversary quickly, whiles thou art in the way with him; lest at any time the adversary deliver thee to the judge, and the judge deliver thee to the officer, and thou be cast into prison.

Verily I say unto thee, Thou shalt by no means come out thence, till thou *hast paid the uttermost farthing. Ye have heard that it was said by them of old time, Thou shalt not commit adultery:*

But I say unto you, That whosoever looketh on a woman to lust after her hath committed adultery with her already in his heart.

And if thy right eye offend thee, pluck it out, and cast it from thee: for it is profitable for thee that one of thy members should perish, and not that thy whole body should be cast into hell.

And if thy right hand offend thee, cut if off, and cast it from thee: for it is profitable for thee that one of thy members should perish, and not that thy whole body should be cast into hell.

It hath been said, Whosoever shall put away his wife, let him give her a writing of divorcement: But I say unto you, That whosoever shall put away his wife, saving for the cause of fornication, causeth her to commit adultery: and whosoever shall marry her that is divorced committeth adultery.

Again, ye have heard that it hath been said by them of old time, Thou shalt not forswear thyself, but shalt perform unto the Lord thine oaths:

But I say unto you, Swear not at all; neither by heaven; for it is God's throne:

Nor by the earth; for it is his footstool: neither by Jerusalem; for it is the city of the great King. Neither shalt thou swear by thy head, because thou canst not make one hair white or black. But let your communication be, Yea, yea; Nay, nay: for whatsoever is more than these cometh of evil. Ye have heard that it hath been said, An eye for an eye, and a tooth for a tooth:

But I say unto you, That ye resist not evil: but whosoever shall smite thee on thy right cheek, turn to him the other also.

And if any man will sue thee at the law, and take away thy coat, let him have thy cloke also.

And whosoever shall compel thee to go a mile, go with him twain.

Give to him that asketh thee, and from him that would borrow of thee turn not thou away.

Ye have heard that it hath been said, Thou shalt love thy neighbour, and hate thine enemy.

But I say unto you, Love your enemies, bless them that curse you, do good to them that hate you, and pray for them which despitefully use you, and persecute you;

That ye may be the children of your Father which is in heaven: for he maketh his sun to rise on the evil and on the good, and sendeth rain on the just and on the unjust.

For if ye love them which love you, what reward have ye? do not even the publicans the same?

And if ye salute your brethren only, what do ye more than others? do not even the publicans so?

Be ye therefore perfect, even as your Father which is in heaven is perfect.

Notice particularly that Christians are required to love their enemies and to do good to those who have wronged them. This seemingly impractical advice is in fact very practical. Endless escalating cycles of revenge and counter-revenge can only be prevented by unilateral acts of kindness.

But do the governments of supposedly Christian countries follow this commandment? Absolutely not! As Edna St. Vincent Millay says, “Nobody listens. Less than the winds that blow are all your words to us you died to save.”

Contrast the duty to love and do good to one’s enemies with the doctrine of massive retaliation which is built into the concept of nuclear deterrence. In a nuclear war, the hudreds of millions, or even billions, of victims in every country of the world, also neutral countries, would include people of every kind: women, men, old people, children and infants, completely irrespective of any degree of guilt that they might have. This type of killing has to be classified as genocide.

If Christians were true to their beliefs, not only nuclear war, but every kind of war would be forbidden to them.

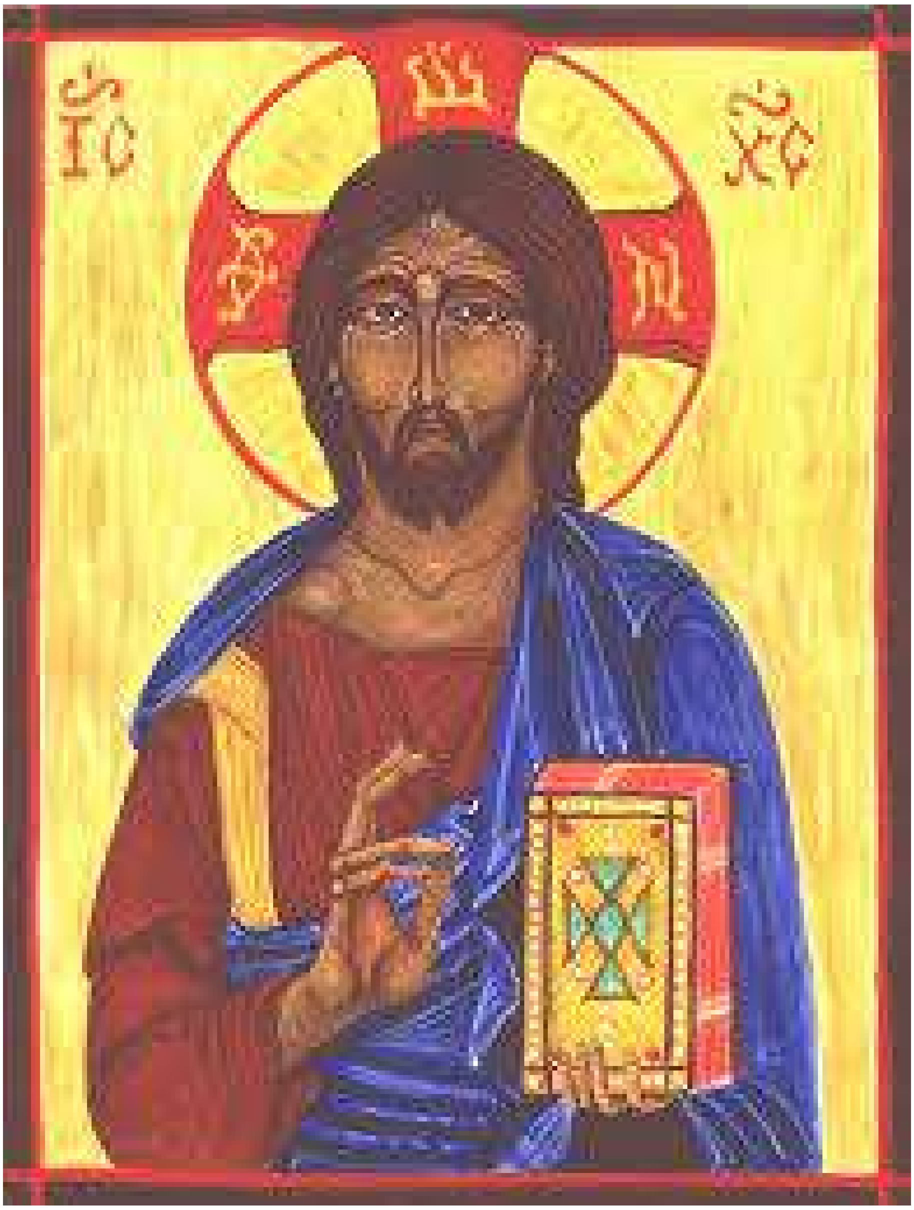

Figure 7.10: **An ikon depicting Jesus**

The Parable of the Good Samaritan

All of the major religions of humanity contain some form of the Golden Rule. Christianity offers an especially clear statement of this central ethical principle: According to the Gospel of Luke, after being told that he must love his neighbor as much as he loves himself, a man asks Jesus, "Who is my neighbor?". Jesus then replies with the Parable of the Good Samaritan, in which we are told that our neighbor need not be a member of our own tribe, but can live far away and can belong to a completely different nation or ethnic group. Nevertheless, that person is still our neighbor, and deserves our love and care.

And, behold, a certain lawyer stood up, and tempted him, saying, Master, what shall I do to inherit eternal life?

He said unto him, What is written in the law? how readest thou?

And he answering said, Thou shalt love the Lord thy God with all thy heart, and with all thy soul, and with all thy strength, and with all thy mind; and thy neighbour as thyself.

And he said unto him, Thou hast answered right: this do, and thou shalt live.

But he, willing to justify himself, said unto Jesus, And who is my neighbour?

And Jesus answering said, A certain man went down from Jerusalem to Jericho, and fell among thieves, which stripped him of his raiment, and wounded him, and departed, leaving him half dead.

And by chance there came down a certain priest that way: and when he saw him, he passed by on the other side.

And likewise a Levite, when he was at the place, came and looked on him, and passed by on the other side.

But a certain Samaritan, as he journeyed, came where he was: and when he saw him, he had compassion on him,

And went to him, and bound up his wounds, pouring in oil and wine, and set him on his own beast, and brought him to an inn, and took care of him.

And on the morrow when he departed, he took out two pence, and gave them to the host, and said unto him, Take care of him; and whatsoever thou spendest more, when I come again, I will repay thee.

Which now of these three, thinkest thou, was neighbour unto him that fell among the thieves?

And he said, He that shewed mercy on him. Then said Jesus unto him, Go, and do thou likewise.

Saint Paul's letter to the Corinthians

If I speak in the tongues of men or of angels, but do not have love, I am only a resounding gong or a clanging cymbal. If I have the gift of prophecy and can fathom all mysteries and all knowledge, and if I have a faith that can move mountains, but do not have love, I am nothing. If I give all I possess to the poor and give over my body to hardship that I may boast, but do not have love, I gain nothing.

Love is patient, love is kind. It does not envy, it does not boast, it is not proud. It does not dishonor others, it is not self-seeking, it is not easily angered, it keeps no record of wrongs. Love does not delight in evil but rejoices with the truth. It always protects, always trusts, always hopes, always perseveres. Love never fails. But where there are prophecies, they will cease; where there are tongues, they will be stilled; where there is knowledge, it will pass away. For we know in part and we prophesy in part, but when completeness comes, what is in part disappears. When I was a child, I talked like a child, I thought like a child, I reasoned like a child. When I became a man, I put the ways of childhood behind me. For now we see only a reflection as in a mirror; then we shall see face to face. Now I know in part; then I shall know fully, even as I am fully known.

And now these three remain: faith, hope and love. But the greatest of these is love.

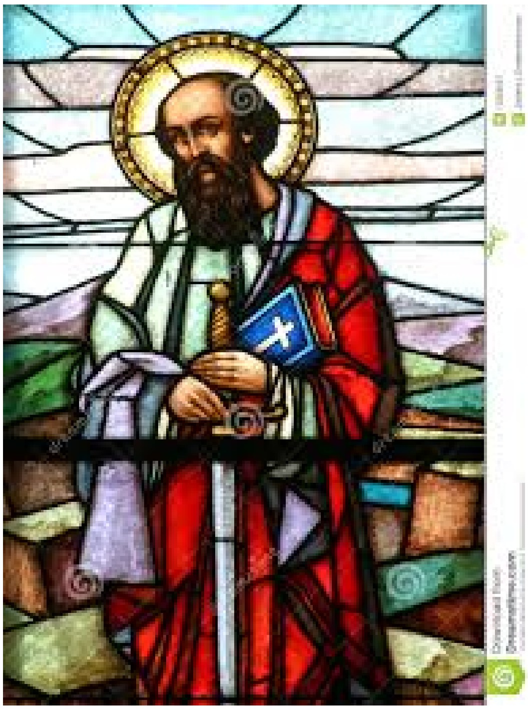

Figure 7.11: **Saint Paul**

Figure 7.12: **Saint Francis, in a painting by Giotto, preaching to the birds. Today Pope Francis I carries to us the message of Saint Francis. Pope Francis tells us that the true interpretation of Christianity includes respect for nature, social justice and opposition to the institution of war.**

7.9 The ethical message of Islam

Some Islamic contributions to civilization

In the 5th century A.D., there was a split in the Christian church of Byzantium;and the Nestorian church, separated from the official Byzantine church. The Nestorians were bitterly persecuted by the Byzantines, and therefore they migrated, first to Mesopotamia, and later to south-west Persia. (Some Nestorians migrated as far as China.)

During the early part of the middle ages, the Nestorian capital at Gondisapur was a great center of intellectual activity. The works of Plato, Aristotle, Hippocrates, Euclid, Archimedes, Ptolemy, Hero and Galen were translated into Syriac by Nestorian scholars, who had brought these books with them from Byzantium.

Among the most distinguished of the Nestorian translators were the members of a family called Bukht-Yishu (meaning "Jesus hath delivered"), which produced seven generations of outstanding scholars. Members of this family were fluent not only in Greek and Syriac, but also in Arabic and Persian.

In the 7th century A.D., the Islamic religion suddenly emerged as a conquering and proselytizing force. Inspired by the teachings of Mohammad (570 A.D. - 632 A.D.), the Arabs and their converts rapidly conquered western Asia, northern Africa, and Spain. During the initial stages of the conquest, the Islamic religion inspired a fanaticism in its followers which was often hostile to learning. However, this initial fanaticism quickly changed to an appreciation of the ancient cultures of the conquered territories; and during the middle ages, the Islamic world reached a very high level of culture and civilization.

Thus, while the century from 750 to 850 was primarily a period of translation from Greek to Syriac, the century from 850 to 950 was a period of translation from Syriac to Arabic. It was during this latter century that Yuhanna Ibn Masawiah (a member of the Bukht-Yishu family, and medical advisor to Caliph Harun al-Rashid) produced many important translations into Arabic.

The skill of the physicians of the Bukht-Yishu family convinced the Caliphs of the value of Greek learning; and in this way the family played an extremely important role in the preservation of the western cultural heritage. Caliph al-Mamun, the son of Harun al-Rashid, established at Baghdad a library and a school for translation, and soon Baghdad replaced Gondisapur as a center of learning.

The English word "chemistry" is derived from the Arabic words *"al-chimia"*, which mean "the changing". The earliest alchemical writer in Arabic was Jabir (760-815), a friend of Harun al-Rashid. Much of his writing deals with the occult, but mixed with this is a certain amount of real chemical knowledge. For example, in his *Book of Properties*, Jabir gives the following recipe for making what we now call lead hydroxycarbonate (white lead), which is used in painting and pottery glazes: "Take a pound of litharge, powder it well and heat it gently with four pounds of vinegar until the latter is reduced to half its original volume. The take a pound of soda and heat it with four pounds of fresh water until the volume of the latter is halved. Filter the two solutions until they are quite clear, and then gradually add the solution of soda to that of the litharge. A white substance is formed, which settles to the bottom. Pour off the supernatant water, and leave the residue to dry. It will become a salt as white as snow."

Another important alchemical writer was Rahzes (c. 860 - c. 950). He was born in the ancient city of Ray, near Teheran, and his name means "the man from Ray". Rhazes studied medicine in Baghdad, and he became chief physician at the hospital there. He wrote the first accurate descriptions of smallpox and measles, and his medical writings include methods for setting broken bones with casts made from plaster of Paris. Rahzes was the first person to classify substances into vegetable, animal and mineral. The word *"al-kali"*, which appears in his writings, means "the calcined" in Arabic. It is the source of our word "alkali", as well as of the symbol K for potassium.

The greatest physician of the middle ages, Avicenna, (Abu-Ali al Hussain Ibn Abdullah Ibn Sina, 980-1037), was also a Persian, like Rahzes. More than a hundred books are attributed to him. They were translated into Latin in the 12th century, and they were among the most important medical books used in Europe until the time of Harvey. Avicenna also wrote on alchemy, and he is important for having denied the possibility of transmutation of elements.

In mathematics, one of the most outstanding Arabic writers was al-Khwarizmi (c. 780 - c. 850). The title of his book, *Ilm al-jabr wa'd muqabalah*, is the source of the English word "algebra". In Arabic *al-jabr* means "the equating". Al-Khwarizmi's name has also become an English word, "algorism", the old word for arithmetic. Al-Khwarizmi drew from both Greek and Hindu sources, and through his writings the decimal system and the use of zero were transmitted to the west.

One of the outstanding Arabic physicists was al-Hazen (965-1038). He made the mistake of claiming to be able to construct a machine which could regulate the flooding of the Nile. This claim won him a position in the service of the Egyptian Caliph, al-Hakim. However, as al-Hazen observed Caliph al-Hakim in action, he began to realize that if he did not construct his machine *immediately*, he was likely to pay with his life! This led al-Hazen to the rather desperate measure of pretending to be insane, a ruse which he kept up for many years. Meanwhile he did excellent work in optics, and in this field he went far beyond anything done by the Greeks.

Al-Hazen studied the reflection of light by the atmosphere, an effect which makes the stars appear displaced from their true positions when they are near the horizon; and he calculated the height of the atmospheric layer above the earth to be about ten miles. He also studied the rainbow, the halo, and the reflection of light from spherical and parabolic mirrors. In his book, *On the Burning Sphere*, he shows a deep understanding of the properties of convex lenses. Al-Hazen also used a dark room with a pin-hole opening to study the image of the sun during an eclipses. This is the first mention of the *camera obscura*, and it is perhaps correct to attribute the invention of the *camera obscura* to al-Hazen.

Another Islamic philosopher who had great influence on western thought was Averröes, who lived in Spain from 1126 to 1198. His writings took the form of thoughtful commentaries on the works of Aristotle. He shocked both his Moslem and his Christian readers by maintaining that the world was not created at a definite instant, but that it instead evolved over a long period of time, and is still evolving.

Like Aristotle, Averröes seems to have been groping towards the ideas of evolution which were later developed in geology by Steno, Hutton and Lyell and in biology by Darwin and Wallace. Much of the scholastic philosophy which developed at the University of Paris during the 13th century was aimed at refuting the doctrines of Averröes; but nevertheless, his ideas survived and helped to shape the modern picture of the world.

A few verses from the Quran

1. THE OPENING:
All praise is due to Allah, the Lord of the Worlds.
The Beneficent, the Merciful.
Master of the Day of Judgment.
Thee do we serve and Thee do we beseech for help.
Keep us on the right path.
The path of those upon whom Thou hast bestowed favors.
Not (the path) of those upon whom Thy wrath is brought down, nor of those who go astray.

107. ALMS
In the name of Allah, the Beneficent, the Merciful.
Have you considered him who calls the judgment a lie?
That is the one who treats the orphan with harshness,
And does not urge (others) to feed the poor.
So woe to the praying ones,

Who are unmindful of their prayers,
Who do (good) to be seen,
And withhold the necessaries of life.

109. THE DISBELIEVERS
In the name of Allah, the Beneficent, the Merciful.
Say: O unbelievers!
I do not serve that which you serve,
Nor do you serve Him Whom I serve:
Nor am I going to serve that which you serve,
Nor are you going to serve Him Whom I serve:
You shall have your religion and I shall have my religion.

112. THE UNITY
In the name of Allah, the Beneficent, the Merciful.
Say: He, Allah, is One.
Allah is He on Whom all depend.
He begets not, nor is He begotten.
And none is like Him.

113. THE DAWN
In the name of Allah, the Beneficent, the Merciful.
Say: I seek refuge in the Lord of the dawn,
From the evil of what He has created,
And from the evil of the utterly dark night when it comes,
And from the evil of those who blow on knots,
And from the evil of the envious when he envies.

114. THE PEOPLE
In the name of Allah, the Beneficent, the Merciful.
Say: I seek refuge in the Lord of men,
The King of men,
The God of men,
From the evil of the whisperings of the slinking (Shaitan),
Who whispers into the hearts of men,
From among the jinn and the men.

Figure 7.13: **Mosaics at the Alhambra**

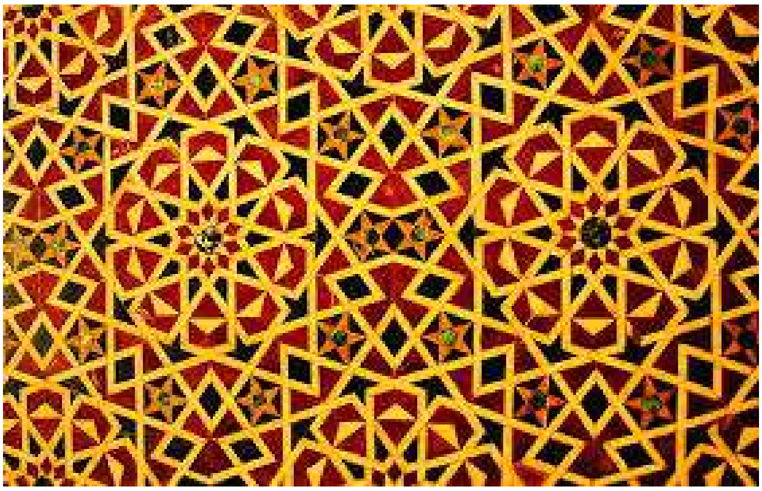

Figure 7.14: **Mosaics at the Alhambra**

Figure 7.15: **The interior of the great mosque at Isfahan**

7.10 East-West exchanges in Toledo

In the 12th century, parts of Spain, including the city of Toledo, were reconquered by the Christians. Toledo had been an Islamic cultural center, and many Muslim scholars, together with their manuscripts, remained in the city when it passed into the hands of the Christians. Thus Toledo became a center for the exchange of ideas between east and west; and it was in this city that many of the books of the classical Greek and Hellenistic philosophers were translated from Arabic into Latin.

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In the 12th century, the translation was confined to books of science and philosophy. Classical Greek literature was forbidden by both the Christian and Moslem religions; and the beautiful poems and dramas of Homer, Sophocles and Euripides were not translated into Latin until the time of the Renaissance Humanists.

It is interesting and inspiring to visit Toledo. A tourist there can see ample evidence of a period of tolerance and enlightenment, when members of the three Abrahamic religions, Christianity, Judaism and Islam , lived side by side in harmony and mutual respect, exchanging important ideas which were to destined to become the foundations of our modern civilization. One can also

Figure 7.16: **A view of Toledo**

see a cathedral, a mosque and a synagogue, in each of which craftsmen from all three faiths worked cooperatively to produce a beautiful monument to human solidarity.

7.11 Tolstoy, Gandhi and non-violence

Leo Tolstoy was born in 1828. While he was still a child, his parents died, and he became Count Tolstoy, with responsibility for the family estate at Yasnaya Polyana. As a young man, he was attracted to the gay and worldly social life of Moscow, but his diary during this period shows remorse over his pursuit of sensual pleasures. Disgusted with himself, he entered the army, and during idle periods he began his career as a writer. While still a soldier, he published a beautiful nostalgic work entitled "Childhood" as well as a number of skillful stories describing army life.

Schools and textbooks for peasants

At the age of 28, Tolstoy left the army and spent a brief period as a literary idol in St. Petersburg. He then became concerned about lack of education among Russian peasants, and he traveled widely in Europe, studying educational theory and methods. Returning to Yasnaya Polyana, he established schools for the peasants, published an educational magazine and compiled a number of textbooks whose simplicity and attractiveness anticipated modern teaching methods.

Tolstoy's great novels

Tolstoy married in 1862 at the age of 34. His wife, Sonya Bers, shared his wide intellectual interests, and they had a happy family life with thirteen children1 . During this period, Tolstoy managed his estate with much success, and he produced his great literary masterpieces "War and Peace" and "Anna Karenina". He modeled the characters in "War and Peace" after members of his own family. For example, Tolstoy's famous heroine, Natassia, is modeled after his sister-in-law, Tanya Bers. Pierre in "War and Peace" and Levin in "Anna Karenina" reflect Tolstoy's own efforts to understand the meaning of life, his concern with the misery of the Russian peasants, and his ultimate conclusion that true happiness and peace of mind can only be found in a simple life devoted to the service of others.

Search for life's meaning

By the time Tolstoy had finished "Anna Karenina", he had become very dissatisfied with the life that he was leading. Despite having achieved in great measure all of the goals for which humans usually strive, he felt that his existence lacked meaning; and in 1879 he even contemplated suicide. He looked for life's purpose by systematically studying the writings of scientists and philosophers, but he could not find an answer there that satisfied him.

Finally Tolstoy found inspiration in the humble and devout lives of the peasants. He decided that the teachings of Jesus, as recorded in the New Testament, could provide the answer for which he was searching. Tolstoy published an account of his spiritual crisis in a book entitled "A Confession", in which he says:

"I searched for enlightenment everywhere in the hard-won accumulated knowledge of mankind. I searched passionately and long, not in a lazy way, but with my whole soul, day and night. I searched like a drowning man looking for safety - and found nothing. I searched all the sciences, and not only did I find nothing, but I also came to the conclusion that everyone who, like myself, had searched in the sciences for life's meaning had also found nothing."

"I then diligently studied the teachings of Buddhism and Islam in the holy books of those religions; but most of all I studied Christianity as I met it in the holy Scriptures and in the living Christians around me..."

Love for the poor

"I began to approach the believers among the poor, simple ignorant people: pilgrims, monks and peasants... The whole life of Christians of our own circle seemed to be a contradiction of their faith. By contrast, the whole life of

Christians of the peasant class was an affirmation of the view of life which their religious faith gave to them. I looked more and more deeply into the faith of these people, and the more deep my insight became, the more I became convinced that they had a genuine belief, that their faith was essential to them, and that it was their faith alone which gave their life a meaning and made it possible for them to live... I developed a love for these simple people."

Moved by the misery of the urban poor whom he encountered in the slums of Moscow, Tolstoy wrote: "Between us, the rich and the poor, there is a wall of false education, and before we can help the poor, we must first tear down that wall. I was forced to the conclusion that our own wealth is the true cause of the misery of the poor."

What Then Must We Do?

Tolstoy's book, "What Then Must We Do?", tells of his experiences in the slums and analyses the causes of poverty. Tolstoy felt that the professed Christian belief of the Czarist state was a thin cosmetic layer covering a structure that was fundamentally built on violence. Violence was used to maintain a huge gap between the rich and the poor, and violence was used in international relations. Tolstoy felt especially keenly the contradiction between Christianity and war. In a small book entitled "The Kingdom of God is Within Us" he wrote:

The contradiction between Christianity and war

"All other contradictions are insignificant compared with the contradiction which now faces humankind in international relations, and which cries out for a solution, since it brings the very existence of civilization into danger. This is the contradiction between the Christian conscience and war."

"All of the Christian peoples of the world, who all follow one and the same spiritual life, so that any good and fruitful thought which is put forward in any corner of the world is immediately communicated to all of Christiandom, where it arouses feelings of pride and happiness in us regardless of our nationality; we who simply love the thinkers, humanitarians, and poets of other countries; we who not only admire their achievements, but also feel delight in meeting them and greet them with friendly smiles; we will all be forced by the state to participate in a murderous war against these same people, a war which if it does not break out today will do so tomorrow."

"...The sharpest of all contradictions can be seen between the government's professed faith in the Christian law of the brotherhood of all humankind, and the military laws of the state, which force each young man to prepare himself for enmity and murder, so that each must be simultaneously a Christian and a gladiator."

Banned and excommunicated

Tolstoy's writings on Christianity and on social questions were banned by the public censor, and he was excommunicated from the Russian Orthodox Church. However, his universally recognized stature as one of the world's greatest writers was undiminished, and his beliefs attracted many followers, both inside and outside of Russia.

Tolstoy and Gandhi

In 1894, the young Indian lawyer, Mohandas K. Gandhi, (who was then working for the civil rights of Indians in South Africa), read Tolstoy's books on Christianity and was greatly influenced by them. Gandhi wrote a review of "The Kingdom of God is Within Us", and in 1909 he sent Tolstoy an account of the activities of the civil rights movement in South Africa. He received a reply in which Tolstoy said:

"...The longer I live, and especially now, when I vividly feel the nearness of death, the more I want to tell others what I feel so particularly clearly and what to my mind is of great importance, namely that which is called passive resistance, but which is in reality nothing else but the teaching of love, uncorrupted by false interpretations. That love, i.e. the striving for the union of human souls and the activity derived from that striving, is the highest and only law of human life, and in the depth of his soul every human being knows this (as we most clearly see in children); he knows this until he is entangled in the false teachings of the world. This law was proclaimed by all, by the Indian as by the Chinese, Hebrew, Greek and Roman sages of the world. I think that this law was most clearly expressed by Christ, who plainly said that in this alone is all the law and the prophets..."

"...The peoples of the Christian world have solemnly accepted this law, while at the same time they have permitted violence and built their lives on violence; and that is why the whole life of the Christian peoples is a continuous contradiction between what they profess, and the principles on which they order their lives - a contradiction between love accepted as the law of life, and violence which is recognized and praised, acknowledged even as a necessity in different phases of life, such as the power of rulers, courts, and armies..."

"This year, in the spring, at a Scripture examination in a girls' high school in Moscow, the teacher and the bishop present asked the girls questions on the Commandments, and especially on the sixth. After a correct answer, the bishop generally put another question, whether murder was always in all cases forbidden by God's law; and the unhappy young ladies were forced by previous instruction to answer 'not always' - that murder was permitted in war and in the execution of criminals. Still, when one of these unfortunate young ladies (what I am telling is not an invention, but a fact told to me by an eye witness) after her first answer, was asked the usual question, if killing was always sinful, she, agitated and blushing, decisively answered 'Always', and to all the usual sophisms of the bishop, she answered with decided conviction that killing always was forbidden in the Old Testament and forbidden by Christ, not only killing, but every wrong against a brother. Notwithstanding all his grandeur and arts of speech, the bishop became silent and the girl remained victorious."

Nonviolent resistance to governmental violence

Tolstoy believed that violence can never under any circumstances be justified, and that therefore an individual's resistance to governmental violence must be passive and non-violent. He also believed that each individual ought to reduce his needs to a minimum in order to avoid exploiting the labor of others.

Tolstoy gave up meat, alcohol, tobacco, and hunting. He began to clean his own room, wore simple peasant clothes, worked in the fields, and made his own boots. He participated in famine relief, and he would have liked to give away all of his great wealth to feed the poor, but bowing to the protests of his family, he gave his wealth to them instead. Because he had been unable to convert his family to his beliefs, Tolstoy left home secretly on a November night in 1910, accompanied, like King Lear, by his youngest daughter. He died of pneumonia a few days later at a remote railway junction.

Figure 7.17: **Count Leo Tolstoy**

Figure 7.18: **Mahatma Gandhi firmly rejected the pernicious doctrine that "the end justifies the mens". Gandhi said: "They say 'means are after all means'. I would say 'means are after all everything'. As the means so the end...... There is no wall of separation between means and end. Indeed the Creator has given us control (and that too very limited) over means, none over the end... The means may be likened to a seed, the end to a tree, and there is just the same inviolable connection between the means and the end as there is between the seed and the tree."**

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Chapter 8

THE INFORMATION EXPLOSION

8.1 The invention of writing

Mesopotamia

In Mesopotamia (which in Greek means "between the rivers"), the settled agricultural people of the Tigris and Euphrates valleys evolved a form of writing. Among the earliest Mesopotamian writings are a set of clay tablets found at Tepe Yahya in southern Iran, the site of an ancient Elamite trading community halfway between Mesopotamia and India.

The Elamite trade supplied the Sumarian civilization of Mesopotamia with silver, copper, tin, lead, precious gems, horses, timber, obsidian, alabaster and soapstone. The practical Sumerians and Elamites probably invented writing as a means of keeping accounts.

The tablets found at Tepe Yahya are inscribed in proto-Elamite, and radiocarbon dating of organic remains associated with the tablets shows them to be from about 3,600 B.C.. The inscriptions on these tablets were made by pressing the blunt and sharp ends of a stylus into soft clay. Similar tablets have been found at the Sumerian city of Susa at the head of the Tigris River.

In about 3,100 B.C. the cuneiform script was developed, and later Mesopotamian tablets are written in cuneiform, which is a phonetic script where the symbols stand for syllables.

Egypt

The Egyptian hieroglyphic (priest writing) system began its development in about 4,000 B.C.. At that time, it was pictorial rather than phonetic. However,

Figure 8.1: **Sumerian writing**

Figure 8.2: **The Phoenician alphabet**

Figure 8.3: **Hieroglyphics**

the Egyptians were in contact with the Sumerian civilization of Mesopotamia, and when the Sumerians developed a phonetic system of writing in about 3,100 B.C., the Egyptians were quick to adopt the idea. In the cuneiform writing of the Sumerians, a character stood for a syllable. In the Egyptian adaptation of this idea, most of the symbols stood for combinations of two consonants, and there were no symbols for vowels. However, a few symbols were purely alphabetic, i.e. they stood for sounds which we would now represent by a single letter. This was important from the standpoint of cultural history, since it suggested to the Phoenicians the idea of an alphabet of the modern type.

In Sumer, the pictorial quality of the symbols was lost at a very early stage, so that in the cuneiform script the symbols are completely abstract. By contrast, the Egyptian system of writing was designed to decorate monuments and to be impressive even to an illiterate viewer; and this purpose was best served by retaining the elaborate pictographic form of the symbols.

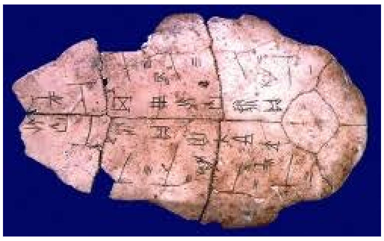

Figure 8.4: **Very early Chinese writing on a bone**

China

Writing was developed at a very early stage in Chinese history, but the system remained a pictographic system, with a different character for each word. A phonetic system of writing was never developed.

The failure to develop a phonetic system of writing had its roots in the Chinese imperial system of government. The Chinese empire formed a vast area in which many different languages were spoken. It was necessary to have a universal language of some kind in order to govern such an empire. The Chinese written language solved this problem admirably.

Suppose that the emperor sent identical letters to two officials in different districts. Reading the letters aloud, the officials might use entirely different words, although the characters in the letters were the same. Thus the Chinese written language was a sort of "Esperanto" which allowed communication between various language groups, and its usefulness as such prevented its replacement by a phonetic system.

The disadvantages of the Chinese system of writing were twofold: First, it was difficult to learn to read and write; and therefore literacy was confined to a small social class whose members could afford a prolonged education. The system of civil-service examinations made participation in the government dependant on a high degree of literacy; and hence the old, established scholar-gentry families maintained a long-term monopoly on power, wealth and education. Social mobility was possible in theory, since the civil service examinations were open to all, but in practice, it was nearly unattainable.

The second great disadvantage of the Chinese system of writing was that it was unsuitable for printing with movable type. An "information explosion" occurred in the west following the introduction of printing with movable type, but this never occurred in China. It is ironical that although both paper and printing were invented by the Chinese, the full effect of these immensely important inventions bypassed China and instead revolutionized the west.

Figure 8.5: **Chinese writing in a later form**

Figure 8.6: **Mayan writing.**

The Americas

The Mayan system of writing is thought to have been invented in about 700 B.C., and this invention is believed to be entirely independent of the invention of writing elsewhere. Some of the Mayan glyphs represented entire words, but the could also represent syllables.

Knotted string systems of keeping records were used by the Andean peoples of South America, especially by the Inca civilization. In the Incan language collections of knotted strings were known as *quipus* or talking knots. Quipus could have only a few, or as many as 2000 knotted strings.

Belts made from shell beads (*wampum*) were used by the natives peoples of North America, both as currency and as a means of recording events

8.2 The invention of paper

The ancient Egyptians were the first to make books. As early as 4,000 B.C., they began to make books in the form of scrolls by cutting papyrus reeds into thin strips and pasting them into sheets of double thickness. The sheets were glued together end to end, so that they formed a long roll. The rolls were sometimes very long indeed. For example, one roll, which is now in the British Museum, is 17 inches wide and 135 feet long.

(Paper of the type which we use today was not invented until 105 A.D.. This enormously important invention was made by a Chinese eunuch named Tsai Lun. The kind of paper invented by Tsai Lun could be made from many things: for example, bark, wood, hemp, rags, etc.. The starting material was made into a pulp, mixed together with water and binder, spread out on a cloth to partially dry, and finally heated and pressed into thin sheets. The art of paper-making spread slowly westward from China, reaching Baghdad in 800 A.D.. It was brought to Europe by the crusaders returning from the Middle East. Thus paper reached Europe just in time to join with Gütenberg's printing press to form the basis for the information explosion which has had such a decisive effect on human history.)

Figure 8.7: **Papyrus**

Figure 8.8: **Paper is a Chinese invention**

8.3 Printing

It was during the T'ang period that the Chinese made an invention of immense importance to the cultural evolution of mankind. This was the invention of printing. Together with writing, printing is one of the key inventions which form the basis of human cultural evolution.

Printing was invented in China in the 8th or 9th century A.D., probably by Buddhist monks who were interested in producing many copies of the sacred texts which they had translated from Sanskrit. The act of reproducing prayers was also considered to be meritorious by the Buddhists.

The Chinese had for a long time followed the custom of brushing engraved official seals with ink and using them to stamp documents. The type of ink which they used was made from lamp-black, water and binder. In fact, it was what we now call "India ink". However, in spite of its name, India ink is a Chinese invention, which later spread to India, and from there to Europe.

We mentioned that paper of the type which we now use was invented in China in the first century A.D.. Thus, the Buddhist monks of China had all the elements which they needed to make printing practical: They had good ink, cheap, smooth paper, and the tradition of stamping documents with ink-covered engraved seals. The first block prints which they produced date from the 8th century A.D.. They were made by carving a block of wood the size of a printed page so that raised characters remained, brushing ink onto the block, and pressing this onto a sheet of paper.

The oldest known printed book, the "Diamond Sutra", is dated 868 A.D.., and it consists of only six printed pages. In was discovered in 1907 by an English scholar who obtained permission from Buddhist monks in Chinese Turkestan to open some walled-up monastery rooms, which were said to have been sealed for 900 years. The rooms were found to contain a library of about 15,000 manuscripts, among which was the Diamond Sutra.

Block printing spread quickly throughout China, and also reached Japan, where woodblock printing ultimately reached great heights in the work of such artists as Hiroshige and Hokusai. The Chinese made some early experiments with movable type, but movable type never became popular in China, because the Chinese written language contains 10,000 characters. However, printing with movable type was highly successful in Korea as early as the 15th century A.D..

The unsuitability of the Chinese written language for the use of movable type was the greatest tragedy of the Chinese civilization. Writing had been developed at a very early stage in Chinese history, but the system remained a pictographic system, with a different character for each word. A phonetic system of writing was never developed.

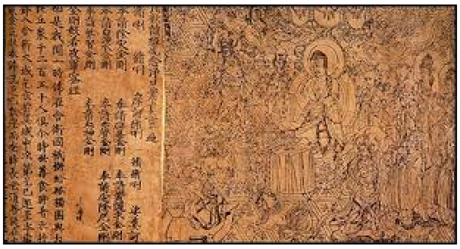

Figure 8.9: **The Diamond Sutra was the first printed book**

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The invention of block printing during the T'ang dynasty had an enormously stimulating effect on literature, and the T'ang period is regarded as the golden age of Chinese lyric poetry. A collection of T'ang poetry, compiled in the 18th century, contains 48,900 poems by more than 2,000 poets.

Figure 8.10: **Gutenberg's printing press**

8.4 The Industrial Revolution

The development of printing in Europe produced a brilliant, chainlike series of scientific discoveries. During the 17th century, the rate of scientific progress gathered momentum, and in the 18th and 19th centuries, the practical applications of scientific knowledge revolutionized the methods of production in agriculture and industry.

The changes produced by the Industrial Revolution at first resulted in social chaos - enormous wealth in some classes of society, and great suffering in other classes; but later, after the appropriate social and political adjustments had been made, the improved methods of production benefited all parts of society in a more even way.

The Industrial Revolution marked the start of massive human use of fossil fuels. The stored energy from several hundred million years of plant growth began to be used at roughly a million times the rate at which it had been formed. The effect on human society was like that of a narcotic. There was a euphoric (and totally unsustainable) surge of growth of both population and industrial production. Meanwhile, the carbon released into the atmosphere from the burning of fossil fuels began to duplicate the conditions which led to the 5 geologically-observed mass extinctions, during each of which more than half of all living species disappeared forever.

Figure 8.11: **And was Jerusalem builded here, among these dark Satanic mills?**

8.5 A revolution in communication

The modern communication revolution began with the prediction of electromagnetic waves by James Clerk Maxwell, their discovery by Heinrich Hertz, Marconi's wireless telegraph messages across the Atlantic, and the invention of the telephone by Alexander Graham Bell. Radio and television programs were quick to follow. Today cell phones and Skype allow us to talk across vast distances with little effort and almost no expense. The Internet makes knowledge universally and instantly available.

Electromagnetism: Faraday, Maxwell and Hertz

The experimental discoveries of Galvani, Volta, Ørsted and Faraday, demonstrated that electricity and magnetism were two faces of a larger phenomenon: electromagnetism.

During the nine years from 1864 to 1873, the great Scottish mathematician James Clerk Maxwell worked on the problem of putting Faraday's laws of electricity and magnetism into mathematical form. In 1873, he published *A Treatise on Electricity and Magnetism*, one of the truly great scientific classics. Maxwell achieved a magnificent synthesis by expressing in a few simple equations the laws governing electricity and magnetism in all its forms. His electromagnetic equations have withstood the test of time; and now, a century later, they are considered to be among the most fundamental laws of physics.

Maxwell's equations not only showed that visible light is indeed and electromagnetic wave, as Faraday had suspected, but they also predicted the existence of many kinds of in- visible electromagnetic waves, both higher and lower in frequency than visible light. We now know that the spectrum of electromagnetic radiation includes (starting at the low- frequency end) radio waves, microwaves, infra-red radiation, visible light, ultraviolet rays, X-rays and gamma rays. All these types of radiation are fundamentally the same, except that their frequencies and wave lengths cover a vast range. They all are oscillations of the electromagnetic field; they all travel with the speed of light; and they all are described by Maxwell's equations.

Maxwell's book opened the way for a whole new category of inventions, which have had a tremendous impact on society. However, when it was published, very few scientists could understand it. Part of the problem was that the scientists of the 19th century would have liked a mechanical explanation of electromagnetism.

The German physicist Hermann von Helmholtz (1821-1894), tried hard to understand Maxwell's theory in mechanical terms, and ended by accepting Maxwell's equations without ever feeling that he really understood them. In 1883, the struggles of von Helmholtz to understand Maxwell's theory produced a dramatic proof of its correctness: Helmholtz had a brilliant student named Heinrich Hertz (1857-1894), whom he regarded almost as a son. In 1883, the Berlin Academy of Science offered a prize for work in the field of electromagnetism; and von Helmholtz suggested to Hertz that he should try to win the prize by testing some of the predictions of Maxwell's theory.

Hertz set up a circuit in which a very rapidly oscillating electrical current passed across a spark gap. He discovered that electromagnetic waves were indeed produced by this rapidly-oscillating current, as predicted by Maxwell! The waves could be detected with a small ring of wire in which there was a gap. As Hertz moved about the darkened room with his detector ring, he could see a spark flashing across the gap, showing the presence of electromagnetic waves, and showing them to behave exactly as predicted by Maxwell.

Marconi

The waves detected by Hertz were, in fact, radio waves; and it was not long before the Italian engineer, Guglielmo Marconi (1874-1937), turned the discovery into a practical means of communication. In 1898, Marconi used radio signals to report the results of the boat races at the Kingston Regatta, and on

December 12, 1901, using balloons to lift the antennae as high as possible, he sent a signal across the Atlantic Ocean from England to Newfoundland.

In 1904, a demonstration of a voice-carrying radio apparatus developed by Fessenden was the sensation of the St. Louis World's Fair; and in 1909, Marconi received the Nobel Prize in physics for his development of radio communications. In America, the inventive genius of Alexander Graham Bell (1847-1922) and Thomas Alva Edison (1847-1931) turned the discoveries of Faraday and Maxwell into the telephone, the electric light, the cinema and the phonograph.

Alexander Graham Bell

Alexander Graham Bell (1847-1922) is credited with inventing the first workable telephone, but in addition, his inventions and scientific work reached many other fields. Bell was born in Edinburgh, Scotland, where his father. Professor Alexander Melville Bell, worked in phonetics, a branch of linguistics that studies the sounds of human speech and their physical properties. Alexander Graham Bell's grandfather and his two brothers also worked in this field.

At the age of 12, Alexander Graham Bell invented a dehusking machine that was used for many years to prepare grain to be milled into flour. As a reward, the local mill owner and gave young Bell the materials and workshop that he needed to work on other inventions.

Motivated not only by the fact that so many of his family members worked in phonetics but also by his mother's gradually increasing deafness, Bell began experiments on the mechanical reproduction of sound. When he was 19, a report on Bell's work in this field was sent to Alexander Ellis[1]. Ellis informed Bell that very similar work had been done in Germany by Herman von Helmholtz. Unable to read German, Bell studied a French translation of the work of von Helmholtz. He later said:

"Without knowing much about the subject, it seemed to me that if vowel sounds could be produced by electrical means, so could consonants, so could articulate speech. I thought that Helmholtz had done it ... and that my failure was due only to my ignorance of electricity. It was a valuable blunder ... If I had been able to read German in those days, I might never have commenced my experiments!"

When Bell was 23, he and his family moved to Canada because several family members were threatened with tuberculosis[2]. They hoped that Canada's climate would help their struggles with the disease. Two years later Bell moved

[1] later portrayed as Henry Higgens in Shaw's play *Pygmalion*

[2] Both of Bell's brothers eventually died of tuberculosis.

to Boston, Massachusetts, where he opened his School of Vocal Physiology and Mechanics of Speech. Among his numerous students was Helen Keller.

Because the late nights and overwork resulting from combining electrical voice transmission experimentation with teaching was affecting his health, Bell decided to keep only two students, 6 year old Georgie Sanders and 15 year old Mable Hubbard. Georgie Sanders' wealthy father provided Bell with free lodging and a laboratory. Mable was a bright and attractive girl, ten years younger than Bell, and she later became his wife.

At that time, in 1874, the telegraph was becoming more and more commercially important, and William Orton, the President of the Western Union telegraph company had hired Thomas Edison and Elisha Gray to invent a method for sending multiple messages over the same wire. When Bell confided to the wealthy fathers of his two pupils that he was working on a method to send multiple voice messages over the same wire, the two fathers supported Bell's race with Edison and Gray to be first with a practical method and a patent.

In the same year, Bell happened to meet Thomas A. Watson, an experienced designer of electrical machines. With the financial help of Sanders and Hubbard, Bell hired Watson as his assistant. In 1876, Bell spoke the first intelligible words over his newly invented telephone: "Mr. Watson, come here. I need you." That same year U.S. and U.K patents were granted to Bell, but a somewhat similar patent application from Elisha Gray had arrived almost simultaneously, initiating a controversy over priority.

Bell and his supporters offered to sell another patent which covered their method for sending multiple messages over the same telegraph wire to Western Union for $100,000, but the offer was refused. Two years later the President of Western Union said that if he could obtain the patent for $25,000,000, he would consider it a bargain, but by that time, the Bell Telephone Company no longer wished to sell.

Although Bell is best known for the telephone, his interests were very wide According to Wikipedia,

Bell's work ranged "unfettered across the scientific landscape" and he often went to bed voraciously reading the Encyclopedia Britannica, scouring it for new areas of interest.[135] The range of Bell's inventive genius is represented only in part by the 18 patents granted in his name alone and the 12 he shared with his collaborators. These included 14 for the telephone and telegraph, four for the photophone, one for the phonograph, five for aerial vehicles, four for "hydroairplanes", and two for selenium cells. Bell's inventions spanned a wide range of interests and included a metal jacket to assist in breathing, the audiometer to detect minor hearing problems, a device to locate icebergs, investigations on how to separate salt from seawater, and work on finding alternative *fuels.*

Bell worked extensively in medical research and invented techniques for teaching speech to the deaf. During his Volta Laboratory period, Bell and his associates considered impressing a magnetic field on a record as a means of reproducing sound. Although the trio briefly experimented with the concept, they could not develop a workable prototype. They abandoned the idea, never realizing they had glimpsed a basic principle which would one day find its application in the tape recorder, the hard disc and floppy disc drive, and other magnetic media.

Bell's own home used a primitive form of air conditioning, in which fans blew currents of air across great blocks of ice. He also anticipated modern concerns with fuel shortages and industrial pollution. Methane gas, he reasoned, could be produced from the waste of farms and factories. At his Canadian estate in Nova Scotia, he experimented with composting toilets and devices to capture water from the atmosphere. In a magazine interview published shortly before his death, he reflected on the possibility of using solar panels to heat houses.

As of today, the Bell Laboratories, funded by the Bell Telephone Company, has produced 13 Nobel Prize winners. Most notably, the 1956 Nobel Prize in Physics was shared by Bell Laboratory scientists John Bardeen, Walter Brattain, and William Shockley for the invention of the transistor, a device that has made the astonishing modern stages of the information explosion possible.

Skype

Skype is the name of a telecommunications software that was developed in 2003 by a Swede, Niklas Zennström a Dane, Janus Friis, and three Estonians, Ahti Heinla, Priit Kasesalu, and Jaan Tallinn. Skype allows users to use the Internet for voice and video communication. For Skype to Skype conversations, the service is free, but users are charged for conversations connecting Skype to telephones.

At the end of 2010 there were 660 million Skype users worldwide, i.e 8.8% of the world's population. In May, 2011, Microsoft bought Skype for $8.5 billion. Skype's division headquarters are in Luxembourg, but 44% of the technical development team are located in Estonia. During 2016 and 2017, Microsoft redesigned Skype for Windows, iOS, Android, Mac and Linux. iOS (formerly iPhone OS) is a mobile operating system created and developed by Apple Inc. exclusively for its hardware. It is the operating system that presently powers many of the company's mobile devices, including the iPhone, iPad, and iPod Touch. It is the second most popular mobile operating system globally after Android.

Figure 8.12: **The invention of the telegraph**

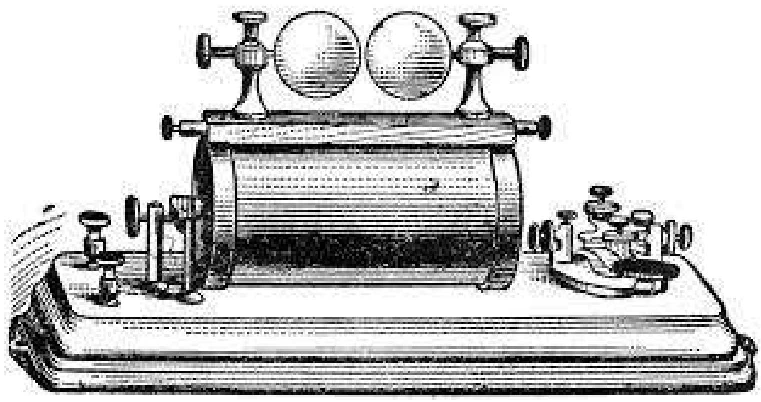

Figure 8.13: **Marconi's wireless telegraph**

In a 1964 BBC special entitled *Horizon*, the famous science-fiction writer Arthur C. Clark predicted that in 50 years, satellites would "make possible a world where we can be in instant contact with each other, wherever we may be." Today, we must acknowledge the striking correctness of this prediction.

8.6 The invention of computers

The first computers

If civilization survives, historians in the distant future will undoubtedly regard the invention of computers as one of the most important steps in human cultural evolution - as important as the invention of writing or the invention of printing. The possibilities of artificial intelligence have barely begun to be explored, but already the impact of computers on society is enormous.

The first programmable universal computers were completed in the mid-1940's; but they had their roots in the much earlier ideas of Blaise Pascal (1623-1662), Gottfried Wilhelm Leibniz (1646-1716), Joseph Marie Jacquard (1752-1834) and Charles Babbage (1791-1871).

In 1642, the distinguished French mathematician and philosopher Blaise Pascal completed a working model of a machine for adding and subtracting. According to tradition, the idea for his "calculating box" came to Pascal when, as a young man of 17, he sat thinking of ways to help his father (who was a tax collector). In describing his machine, Pascal wrote: "I submit to the public a small machine of my own invention, by means of which you alone may, without any effort, perform all the operations of arithmetic, and may be relieved of the work which has often times fatigued your spirit when you have worked with the counters or with the pen."

Pascal's machine worked by means of toothed wheels. It was much improved by Leibniz, who constructed a mechanical calculator which, besides adding and subtracting, could also multiply and divide. His first machine was completed in 1671; and Leibniz' description of it, written in Latin, is preserved in the Royal Library at Hanover: "There are two parts of the machine, one designed for addition (and subtraction), and the other designed for multiplication (and division); and they should fit together. The adding (and subtracting) machine coincides completely with the calculating box of Pascal. Something, however, must be added for the sake of multiplication..."

"The wheels which represent the multiplicand are all of the same size, equal to that of the wheels of addition, and are also provided with ten teeth which, however, are movable so that at one time there should protrude 5, at another 6 teeth, etc., according to whether the multiplicand is to be represented five times or six times, etc."

"For example, the multiplicand 365 consists of three digits, 3, 6, and 5. Hence the same number of wheels is to be used. On these wheels, the multiplicand will be set if from the right wheel there protrude 5 teeth, from the middle wheel 6, and from the left wheel 3."

By 1810, calculating machines based on Leibniz' design were being manufactured commercially; and mechanical calculators of a similar (if much improved) design could be found in laboratories and offices until the 1960's. The idea of a programmable universal computer is due to the English mathematician, Charles Babbage, who was the Lucasian Professor of Mathematics at Cambridge University. (In the 17th century, Isaac Newton held this post, and in the 20th century, P.A.M. Dirac and Stephen Hawking also held it.)

In 1812, Babbage conceived the idea of constructing a machine which could automatically produce tables of functions, provided that the functions could be approximated by polynomials. He constructed a small machine, which was able to calculate tables of quadratic functions to eight decimal places, and in 1832 he demonstrated this machine to the Royal Society and to representatives of the British government.

The demonstration was so successful that Babbage secured financial support for the construction of a large machine which would tabulate sixth-order polynomials to twenty decimal places. The large machine was never completed, and twenty years later, after having spent seventeen thousand pounds on the project, the British government withdrew its support. The reason why Babbage's large machine was never finished can be understood from the following account by Lord Moulton of a visit to the mathematician's laboratory:

"One of the sad memories of my life is a visit to the celebrated mathematician and inventor, Mr. Babbage. He was far advanced in age, but his mind was still as vigorous as ever. He took me through his workrooms."

"In the first room I saw the parts of the original Calculating Machine, which had been shown in an incomplete state many years before, and had even been put to some use. I asked him about its present form. 'I have not finished it, because in working at it, I came on the idea of my Analytical Machine, which would do all that it was capable of doing, and much more. Indeed, the idea was so much simpler that it would have taken more work to complete the Calculating Machine than to design and construct the other in its entirety; so I turned my attention to the Analytical Machine.'"

"After a few minutes talk, we went into the next workroom, where he showed me the working of the elements of the Analytical Machine. I asked if I could see it. 'I have never completed it,' he said, 'because I hit upon the idea of doing the same thing by a different and far more effective method, and this rendered it useless to proceed on the old lines.'"

"Then we went into a third room. There lay scattered bits of mechanism, but I saw no trace of any working machine. Very cautiously I approached the subject, and received the dreaded answer: 'It is not constructed yet, but I am working at it, and will take less time to construct it altogether than it would have taken to complete the Analytical Machine from the stage in which I left it.' I took leave of the old man with a heavy heart."

Babbage's first calculating machine was a special-purpose mechanical computer, designed to tabulate polynomial functions; and he abandoned this design because he had hit on the idea of a universal programmable computer. Several years earlier, the French inventor Joseph Marie Jacquard had constructed an automatic loom in which large wooden "punched cards" were used to control the warp threads. Inspired by Jacquard's invention, Babbage planned to use

Figure 8.14: **Pascal's calculator**

punched cards to program his universal computer. (Jacquard's looms could be programmed to weave extremely complex patterns: A portrait of the inventor, woven on one of his looms in Lyon, hung in Babbage's drawing room.)

One of Babbage's frequent visitors was Augusta Ada[3], Countess of Lovelace (1815-1852), the daughter of Lord and Lady Byron. She was a mathematician of considerable ability, and it is through her lucid descriptions that we know how Babbage's never-completed Analytical Machine was to have worked.

The next step towards modern computers was taken by Herman Hollerith, a statistician working for the United States Bureau of the Census. He invented electromechanical machines for reading and sorting data punched onto cards. Hollerith's machines were used to analyze the data from the 1890 United States Census. Because the Census Bureau was a very limited market, Hollerith branched out and began to manufacture similar machines for use in business and administration. His company was later bought out by Thomas J. Watson, who changed its name to International Business Machines.

In 1937, Howard Aiken, of Harvard University, became interested in combining Babbage's ideas with some of the techniques which had developed from Hollerith's punched card machines. He approached the International Business Machine Corporation, the largest manufacturer of punched card equipment, with a proposal for the construction of a large, automatic, programmable calculating machine.

Aiken's machine, the Automatic Sequence Controlled Calculator (ASCC), was completed in 1944 and presented to Harvard University. Based on geared wheels, in the Pascal-Leibniz-Babbage tradition, ASCC had more than three quarters of a million parts and used 500 miles of wire. ASCC was unbelievably

[3] The programming language ADA is named after her.

Figure 8.15: **Jacquard's loom**

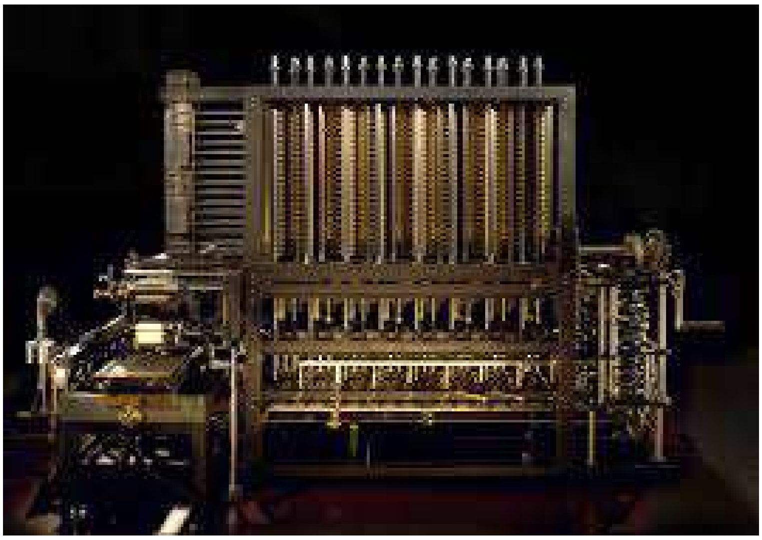

Figure 8.16: **Babbage's analytical engine**

slow by modern standards - it took three-tenths of a second to perform an addition - but it was one of the first programmable general-purpose digital computers ever completed. It remained in continuous use, day and night, for fifteen years.

In the ASCC, binary numbers were represented by relays, which could be either on or off. The on position represented 1, while the off position represented 0, these being the only two digits required to represent numbers in the binary (base 2) system. Electromechanical calculators similar to ASCC were developed independently by Konrad Zuse in Germany and by George R. Stibitz at the Bell Telephone Laboratory.

Electronic digital computers

In 1937, the English mathematician A.M. Turing published an important article in the Proceedings of the London Mathematical Society in which envisioned a type of calculating machine consisting of a long row of cells (the "tape"), a reading and writing head, and a set of instructions specifying the way in which the head should move the tape and modify the state and "color" of the cells on the tape. According to a hypothesis which came to be known as the "Church-Turing hypothesis", the type of computer proposed by Turing was capable of performing every possible type of calculation. In other words, the Turing machine could function as a universal computer.

In 1943, a group of English engineers, inspired by the ideas of Alan Turing and those of the mathematician M.H.A. Newman, completed the electronic digital computer Colossus. Colossus was the first large-scale electronic computer. It was used to break the German Enigma code; and it thus affected the course of World War II.

In 1946, ENIAC (Electronic Numerical Integrator and Calculator) became operational. This general-purpose computer, designed by J.P. Eckert and J.W. Mauchley of the University of Pennsylvania, contained 18,000 vacuum tubes, one or another of which was often out of order. However, during the periods when all its vacuum tubes were working, an electronic computer like Colossus or ENIAC could shoot ahead of an electromechanical machine (such as ASCC) like a hare outdistancing a tortoise.

During the summer of 1946, a course on "The Theory and Techniques of Electronic Digital Computers" was given at the University of Pennsylvania. The ideas put forward in this course had been worked out by a group of mathematicians and engineers headed by J.P. Eckert, J.W. Mauchley and John von Neumann, and these ideas very much influenced all subsequent computer design.

Microelectronics

The problem of unreliable vacuum tubes was solved in 1948 by John Bardeen, William Shockley and Walter Brattain of the Bell Telephone Laboratories. Application of quantum theory to solids had led to an understanding of the electronic properties of crystals. Like atoms, crystals were found to have allowed and forbidden energy levels.

The allowed energy levels for an electron in a crystal were known to form bands; i.e., some energy ranges with a quasi-continuum of allowed states (allowed bands), and other energy ranges with none (forbidden bands). The lowest allowed bands were occupied by electrons, while higher bands were empty. The highest filled band was called the valence band, and the lowest empty band was called the conduction band.

According to quantum theory, whenever the valence band of a crystal is only partly filled, the crystal is a conductor of electricity; but if the valence band is completely rilled with electrons, the crystal is an electrical insulator. (A completely filled band is analogous to a room so packed with people that none of them can move.)

In addition to explaining conductors and insulators, quantum theory yielded an understanding of semiconductors - crystals where the valence band is completely filled with electrons, but where the energy gap between the conduction band and the valence band is relatively small. For example, crystals of the elements silicon and germanium are semiconductors. For such a crystal, thermal energy is sometimes enough to lift an electron from the valence band to the conduction band.

Bardeen, Shockley and Brattain found ways to control the conductivity of germanium crystals by injecting electrons into the conduction band, or alternatively by removing electrons from the valence band. They could do this by forming junctions between crystals "doped" with appropriate impurities, and by injecting electrons with a special electrode. The semi-conducting crystals whose conductivity was controlled in this way could be used as electronic valves, in place of vacuum tubes.

By the 1960's, replacement of vacuum tubes by transistors in electronic computers had led not only to an enormous increase in reliability and a great reduction in cost, but also to an enormous increase in speed. It was found that the limiting factor in computer speed was the time needed for an electrical signal to propagate from one part of the central processing unit to another. Since electrical impulses propagate with the speed of light, this time is extremely small; but nevertheless, it is the limiting factor in the speed of electronic computers.

In order to reduce the propagation time, computer designers tried to make the central processing units very small; and the result was the development of integrated circuits and microelectronics. (Another motive for miniaturization of electronics came from the requirements of space exploration.)

Integrated circuits were developed, in which single circuit elements were not manufactured separately, but instead the whole circuit was made at one time. An integrated circuit is a multilayer sandwich-like structure, with conducting, resisting and insulating layers interspersed with layers of germanium or silicon, "doped" with appropriate impurities. At the start of the manufacturing process, an engineer makes a large drawing of each layer. For example, the drawing of a conducting layer would contain pathways which fill the role played by wires in a conventional circuit, while the remainder of the layer would consist of areas destined to be etched away by acid.

The next step is to reduce the size of the drawing and to multiply it photographically. The pattern of the layer is thus repeated many times, like the design on a piece of wallpaper. The multiplied and reduced drawing is then focused through a reversed microscope onto the surface to be etched. Successive layers are built up by evaporating or depositing thin films of the appropriate substances onto the surface of a silicon or germanium wafer. If the layer being made is to be conducting, the surface might consist of an extremely thin layer of copper, covered with a photosensitive layer called a "photoresist". On those portions of the surface receiving light from the pattern, the photoresist becomes insoluble, while on those areas not receiving light, the photoresist can be washed away.

The surface is then etched with acid, which removes the copper from those areas not protected by photoresist. Each successive layer of a wafer is made in this way, and finally the wafer is cut into tiny "chips", each of which corresponds to one unit of the wallpaper-like pattern. Although the area of a chip may be much smaller than a square centimeter, the chip can contain an extremely complex circuit.

In 1965, only four years after the first integrated circuits had been produced, Dr. Gordon E. Moore, one of the founders of Intel, made a famous prediction which has come to be known as "Moore's Law". He predicted that the number of transistors per integrated circuit would double every two years, and that this trend would continue through 1975. In fact, the general trend predicted by Moore has continued for a much longer time. Although the number of transistors per unit area has not continued to double every two years, the logic density (bits per unit area) has done so, and thus a modified version of Moore's law still holds today. How much longer the trend can continue remains to be seen. Physical limits to miniaturization of transistors of the present type will soon be reached; but there is hope that further miniaturization can be achieved through "quantum dot" technology, molecular switches, and autoassembly.

As a result of miniaturization and parallelization, the speed of computers

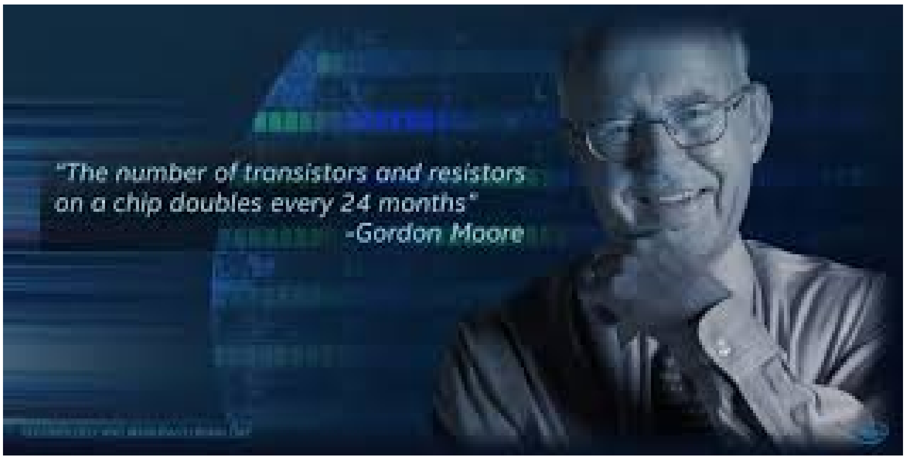

Figure 8.17: **In 1965, George E. Moore, one of the co-founders of Intel, predicted that the number of transistors that could be placed on an integrated circuit would double every two years, and that this trend would continue until 1975. In fact, as is shown by the figure, the trend has continued much longer than that. In 2011, the number of transistors per chip reached 2.6 billion. (After Wgsimon, Wikimedia Commons)**

rose exponentially. In 1960, the fastest computers could perform a hundred thousand elementary operations in a second. By 1970, the fastest computers took less than a second to perform a million such operations. In 1987, a massively parallel computer, with 566 parallel processors, called GFll was designed to perform 11 billion floating-point operations per second (flops). By 2002 the fastest computer performed 40 at teraflops, making use of 5120 parallel CPU's.

Computer disk storage has also undergone a remarkable development. In 1987, the magnetic disk storage being produced could store 20 million bits of information per square inch; and even higher densities could be achieved by optical storage devices. Storage density has until followed a law similar to Moore's law.

In the 1970's and 1980's, computer networks were set up linking machines in various parts of the world. It became possible (for example) for a scientist in Europe to perform a calculation interactively on a computer in the United States just as though the distant machine were in the same room; and two or more computers could be linked for performing large calculations. It also became possible to exchange programs, data, letters and manuscripts very rapidly through the computer networks.

The exchange of large quantities of information through computer networks was made easier by the introduction of fiber optics cables. By 1986, 250,000

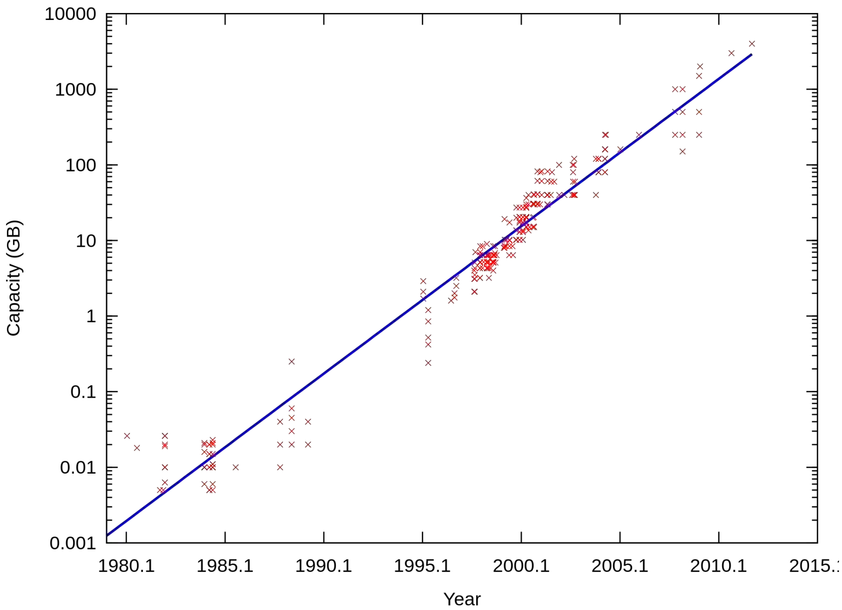

Figure 8.18: **A logarithmic plot of the increase in PC hard-drive capacity in gigabytes. An extrapolation of the rate of increase predicts that the individual capacity of a commercially available PC will reach 10,000 gigabytes by 2015, i.e. 10,000,000,000,000 bytes. (After Hankwang and Rentar, Wikimedia Commons)**

miles of such cables had been installed in the United States. If a ray of light, propagating in a medium with a large refractive index, strikes the surface of the medium at a grazing angle, then the ray undergoes total internal reflection. This phenomenon is utilized in fiber optics: A light signal can propagate through a long, hairlike glass fiber, following the bends of the fiber without losing intensity because of total internal reflection. However, before fiber optics could be used for information transmission over long distances, a technological breakthrough in glass manufacture was needed, since the clearest glass available in 1940 was opaque in lengths more than 10 m. Through studies of the microscopic properties of glasses, the problem of absorption was overcome. By 1987, devices were being manufactured commercially that were capable of transmitting information through fiber-optic cables at the rate of 1.7 billion bits per second.

The history of the Internet and World Wide Web

The history of the Internet began in 1961, when Leonard Kleinrock, a student at MIT, submitted a proposal for Ph.D. thesis entitled "Information Flow in Large Communication Nets". In his statement of the problem, Kleinrock wrote: "The nets under consideration consist of nodes, connected to each other by links. The nodes receive, sort, store, and transmit messages that enter and leave via the links. The links consist of one-way channels, with fixed capacities. Among the typical systems which fit this description are the Post Office System, telegraph systems, and satellite communication systems." Kleinrock's theoretical treatment of package switching systems anticipated the construction of computer networks which would function on a principle analogous to a post office rather than a telephone exchange: In a telephone system, there is a direct connection between the sender and receiver of information. But in a package switching system, there is no such connection - only the addresses of the sender and receiver on the package of information, which makes its way from node to node until it reaches its destination.

Further contributions to the concept of package switching systems and distributed communications networks were made by J.C.R. Licklider and W. Clark of MIT in 1962, and by Paul Baran of the RAND corporation in 1964. Licklider visualized what he called a "Galactic Network", a globally interconnected network of computers which would allow social interactions and interchange of data and software throughout the world. The distributed computer communication network proposed by Baran was motivated by the desire to have a communication system that could survive a nuclear war. The Cold War had also provoked the foundation (in 1957) of the Advanced Research Projects Agency (ARPA) by the U.S. government as a response to the successful Russian satellite "Sputnik".

In 1969, a 4-node network was tested by ARPA. It connected computers at the University of California divisions at Los Angeles and Santa Barbara with computers at the Stanford Research Institute and the University of Utah. Describing this event, Leonard Kleinrock said in an interview: "We set up a telephone connection between us and the guys at SRI. We typed the L and we asked on the phone 'Do you see the L?' 'Yes we see the L', came the response. We typed the 0 and we asked 'Do you see the 0?' 'Yes we see the O.' Then we typed the G and the system crashed." The ARPANET (with 40 nodes) performed much better in 1972 at the Washington Hilton Hotel where the participants at a Conference on Computer Communications were invited to test it.

Although the creators of ARPANET visualized it as being used for long-distance computations involving several computers, they soon discovered that social interactions over the Internet would become equally important if not more so. An electronic mail system was introduced in the early 1970's, and in 1976 Queen Elizabeth II of the United Kingdom became one of the increasing number of e-mail users.

In September, 1973, Robert F. Kahn and Vinton Cerf presented the basic ideas of the Internet at a meeting of the International Network Working Group at the University Sussex in Brighton, England. Among these principles was the rule that the networks to be connected should not be changed internally. Another rule was that if a packet did not arrive at its destination, it would be retransmitted from its original source. No information was to be retained by the gateways used to connect networks; and finally there was to be no global control of the Internet at the operations level.

Computer networks devoted to academic applications were introduced in the 1970's and 1980's, both in England, the United States and Japan. The Joint Academic Network (JANET) in the U.K. had its counterpart in the National Science Foundation's network (NSFNET) in America and Japan's JUNET (Japan Unix Network). Internet traffic is approximately doubling each year,[4] and it is about to overtake voice communication in the volume of information transferred.

In March, 2011, there were more than two billion Internet users in the world. In North America they amounted to 78.3 % of the total population, in Europe 58.3 % and worldwide, 30.2 %. Another index that can give us an impression of the rate of growth of digital data generation and exchange is the "digital universe", which is defined to be the total volume of digital information that human information technology creates and duplicates in a year. In 2011 the

[4] In the period 1995-1996, the rate of increase was even faster - a doubling every four months

Table 8.1: **Historical total world Internet traffic (after Cisco Visual Networking Index Forecast). 1 terrabyte =1,000,000,000,000 bytes**

year	terabytes per month
1990	1
1991	2
1992	4
1993	10
1994	20
1995	170
1996	1,800
1997	5,000
1998	11,000
1999	26,000
2000	75,000
2001	175,000
2002	358,000
2003	681,000
2004	1,267,000
2005	2,055,000
2006	3,339,000
2007	5,219,000
2008	7,639,000
2009	10,676,000
2010	14,984,000

digital universe reached 1.2 zettabytes, and it is projected to quadruple by 2015. A zettabyte is 10^{21} bytes, an almost unimaginable number, equivalent to the information contained in a thousand trillion books, enough books to make a pile that would stretch twenty billion kilometers.

Self-reinforcing information accumulation

Humans have been living on the earth for roughly two million years (more or less, depending on where one draws the line between our human and prehuman ancestors, Table 6.1). During almost all of this,time, our ancestors lived by hunting and food-gathering. They were not at all numerous, and did not stand out conspicuously from other animals. Then, suddenly, during the brief space of ten thousand years, our species exploded in numbers from a few million to seven billion (Figure 6.1), populating all parts of the earth, and even setting foot on the moon. This population explosion, which is still going on, has been the result of dramatic cultural changes. Genetically we are almost identical with our hunter-gatherer ancestors, who lived ten thousand years ago, but cultural evolution has changed our way of life beyond recognition.

Beginning with the development of speech, human cultural evolution began to accelerate. It started to move faster with the agricultural revolution, and faster still with the invention of writing and printing. Finally, modern science has accelerated the rate of social and cultural change to a completely unprecedented speed.

The growth of modern science is accelerating because knowledge feeds on itself. A new idea or a new development may lead to several other innovations, which can in turn start an avalanche of change. For example, the quantum theory of atomic structure led to the invention of transistors, which made high-speed digital computers possible. Computers have not only produced further developments in quantum theory; they have also revolutionized many other fields.

The self-reinforcing accumulation of knowledge - the information explosion - which characterizes modern human society is reflected not only in an explosively-growing global population, but also in the number of scientific articles published, which doubles roughly every ten years. Another example is Moore's law - the doubling of the information density of integrated circuits every two years. Yet another example is the explosive growth of Internet traffic shown in Table 8.1.

8.7 The collective human consciousness

The Internet itself is the culmination of a trend towards increasing societal information exchange - the formation of a collective human consciousness. This collective consciousness preserves the observations of millions of eyes, the experiments of millions of hands, the thoughts of millions of brains; and it does not die when the individual dies.

Culture, education, and human solidarity

Cultural and educational activities have a small ecological footprint, and therefore are more sustainable than pollution-producing, fossil-fuel-using jobs in industry. Furthermore, since culture and knowledge are shared among all nations, work in culture and education leads societies naturally towards internationalism and peace.

Economies based on a high level of consumption of material goods are unsustainable and will have to be abandoned by a future world that renounces the use of fossil fuels in order to avoid catastrophic climate change, a world where non-renewable resources such as metals will become increasingly rare and expensive. How then can full employment be maintained?

The creation of renewable energy infrastructure will provide work for a large number of people; but in addition, sustainable economies of the future will need to shift many workers from jobs in industry to jobs in the service sector.

Within the service sector, jobs in culture and education are particularly valuable because they will help to avoid the disastrous wars that are currently producing enormous human suffering and millions of refugees, wars that threaten to escalate into an all-destroying global thermonuclear war.

Human nature has two sides: It has a dark side, to which nationalism and militarism appeal; but our species also has a genius for cooperation, which we can see in the growth of culture.

Our modern civilization has been built up by means of a worldwide exchange of ideas and inventions. It is built on the achievements of many ancient cultures. China, Japan, India, Mesopotamia, Egypt, Greece, the Islamic world, Christian Europe, and the Jewish intellectual traditions all have contributed. Potatoes, corn, squash, vanilla, chocolate, chili peppers, and quinine are gifts from the American Indians.

We are taught that our own country is always heroic and in the right. We urgently need to replace this indoctrination in chauvinism by a reformed view of history, where the slow development of human culture is described, giving credit to all who have contributed.

When we teach history, it should not be about power struggles. It should be about how human culture was gradually built up over thousands of years by the patient work of millions of hands and minds.

Our common global culture, the music, science, literature and art that all of us share, should be presented as a precious heritage - far too precious to be risked in a thermonuclear war.

We have to extend our loyalty to the whole of the human race, and to work for a world not only free from nuclear weapons, but free from war.

A war-free world is not utopian but very practical, and not only practical but necessary. It is something that we can achieve and must achieve.

Today there are large regions, such as the European Union, where war would be inconceivable. What is needed is to extend these.

Nor is a truly sustainable economic system utopian or impossible. To achieve it, we should begin by shifting jobs to the creation of renewable energy infrastructure, and to the fields of culture and education.

By so doing we will support human solidarity and avoid the twin disasters of catastrophic war and climate change.

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Chapter 9

SMALL IS BEAUTIFUL

9.1 The warning voice of Malthus

A debate between father and son

T.R. Malthus' *Essay on The Principle of Population*, the first edition of which was published in 1798, was one of the the first systematic studies of the problem of population in relation to resources. Earlier discussions of the problem had been published by Boterro in Italy, Robert Wallace in England, and Benjamin Franklin in America. However Malthus' *Essay* was the first to stress the fact that, in general, powerful checks operate continuously to keep human populations from increasing beyond their available food supply. In a later edition, published in 1803, he buttressed this assertion with carefully collected demographic and sociological data from many societies at various periods of their histories.

The publication of Malthus' *Essay* coincided with a wave of disillusionment which followed the optimism of the Enlightenment. The utopian societies predicted by the philosophers of the Enlightenment were compared with reign of terror in Robespierre's France and with the miseries of industrial workers in England; and the discrepancy required an explanation.

The optimism which preceded the French Revolution, and the disappointment which followed a few years later, closely paralleled the optimistic expectations of our own century, in the period after the Second World War, when it was thought that the transfer of technology to the less developed parts of the world would eliminate poverty, and the subsequent disappointment when poverty persisted.

Science and technology developed rapidly in the second half of the twentieth century, but the benefits which they conferred were just as rapidly consumed by a global population which today is increasing at the rate of one billion people every fourteen years. Because of the close parallel between the optimism and disappointments of Malthus' time and those of our own, much light can be thrown on our present situation by rereading the debate between Malthus and his contemporaries.

Thomas Robert Malthus (1766-1834) came from an intellectual family: His father, Daniel Malthus, was a moderately well-to-do English country gentleman, an enthusiastic believer in the optimistic ideas of the Enlightenment, and a friend of the philosophers Henry Rousseau, David Hume and William Godwin. The famous book on population by the younger Malthus grew out of conversations with his father.

In 1793, Robert Malthus was elected a fellow of Jesus College, and he also took orders in the Anglican Church. He was assigned as Curate to Okewood Chapel in Surrey. This small chapel stood in a woodland region, and Malthus' illiterate parishioners were so poor that the women and children went without shoes. They lived in low thatched huts made of woven branches plastered with mud. The floors of these huts were of dirt, and the only light came from tiny window openings. Malthus' parishioners diet consisted almost entirely of bread. The children of these cottagers developed late, and were stunted in growth. Nevertheless, in spite of the harsh conditions of his parishioners' lives, Malthus noticed that the number of births which he recorded in the parish register greatly exceeded the number of deaths. It was probably this fact which first turned his attention to the problem of population.

Robert Malthus lived with his parents at Albury, about nine miles from Oakwood, and it was here that the famous debates between father and son took place. As Daniel Malthus talked warmly about Godwin, Condorcet, and the idea of human progress, the mind of his son, Robert, turned to the unbalance between births and deaths which he had noticed among his parishioners at Okewood Chapel. He pointed out to his father that no matter what benefits science might be able to confer, they would soon be eaten up by population growth.

Regardless of technical progress, the condition of the lowest social class would remain exactly the same: The poor would continue to live, as they always had, on the exact borderline between survival and famine, clinging desperately to the lower edge of existence. For them, change for the worse was impossible since it would loosen their precarious hold on life; their children would die and their numbers would diminish until they balanced the supply of food. But any change for the better was equally impossible, because if more nourishment should become available, more of the children of the poor would survive, and the share of food for each of them would again be reduced to the precise minimum required for life.

Observation of his parishioners at Okewood had convinced Robert Malthus that this sombre picture was a realistic description of the condition of the poor in England at the end of the 18th century. Techniques of agriculture and industry were indeed improving rapidly; but among the very poor, population was increasing equally fast, and the misery of society's lowest class remained unaltered.

Publication of the first essay in 1798

Daniel Malthus was so impressed with his son's arguments that he urged him to develop them into a small book. Robert Malthus' first essay on population, written in response to his father's urging, was only 50,000 words in length. It was published anonymously in 1798, and its full title was *An Essay on the Principle of Population, as it affects the future improvement of society, with remarks on the speculations of Mr. Godwin, M. Condorcet, and other writers.* Robert Malthus' *Essay* explored the consequences of his basic thesis: that "the power of population is indefinitely greater than the power in the earth to produce subsistence for man".

"That population cannot increase without the means of subsistence", Robert Malthus wrote, "is a proposition so evident that it needs no illustration. That population does invariably increase, where there are means of subsistence, the history of every people who have ever existed will abundantly prove. And that the superior power cannot be checked without producing misery and vice, the ample portion of these two bitter ingredients in the cup of human life, and the continuance of the physical causes that seem to have produced them, bear too convincing a testimony."

In order to illustrate the power of human populations to grow quickly to enormous numbers if left completely unchecked, Malthus turned to statistics from the United States, where the population had doubled every 25 years for a century and a half. Malthus called this type of growth "geometrical" (today we would call it "exponential"); and, drawing on his mathematical education, he illustrated it by the progression1,2,4,8,16,32,64,128,256,..etc. In order to show that, in the long run, no improvement in agriculture could possibly keep pace with unchecked population growth, Malthus allowed that, in England, agricultural output might with great effort be doubled during the next quarter century; but during a subsequent 25-year period it could not again be doubled. The growth of agricultural output could at the very most follow an arithmetic (linear) progression, 1,2,3,4,5,6,...etc.

Because of the overpoweringly greater numbers which can potentially be generated by exponential population growth, as contrasted to the slow linear progression of sustenance, Malthus was convinced that at almost all stages of human history, population has not expanded freely, but has instead pressed painfully against the limits of its food supply. He maintained that human numbers are normally held in check either by "vice or misery". (Malthus classified both war and birth control as forms of vice.) Occasionally the food supply increases through some improvement in agriculture, or through the opening of new lands; but population then grows very rapidly, and soon a new equilibrium is established, with misery and vice once more holding the population in check.

Like Godwin's *Political Justice*, Malthus' *Essay on the Principle of Population* was published at exactly the right moment to capture the prevailing mood of England. In 1793, the mood had been optimistic; but by 1798, hopes for reform had been replaced by reaction and pessimism. Public opinion had been changed by Robespierre's Reign of Terror and by the threat of a French invasion. Malthus' clear and powerfully written essay caught the attention of readers not only because it appeared at the right moment, but also because his two contrasting mathematical laws of growth were so striking.

One of Malthus' readers was William Godwin, who recognized the essay as the strongest challenge to his utopian ideas that had yet been published. Godwin several times invited Malthus to breakfast at his home to discuss social and economic problems. (After some years, however, the friendship between Godwin and Malthus cooled, the debate between them having become more acrimonious.)

In 1801, Godwin published a reply to his critics, among them his former friends James Mackintosh and Samuel Parr, by whom he recently had been attacked. His *Reply to Parr* also contained a reply to Malthus: Godwin granted that the problem of overpopulation raised by Malthus was an extremely serious one. However, Godwin wrote, all that is needed to solve the problem is a change of the attitudes of society. For example we need to abandon the belief "that it is the first duty of princes to watch for (i.e. encourage) the multiplication of their subjects, and that a man or woman who passes the term of life in a condition of celibacy is to be considered as having failed to discharge the principal obligations owed to the community".

"On the contrary", Godwin continued, "it now appears to be rather the man who rears a numerous family that has to some degree transgressed the consideration he owes to the public welfare". Godwin suggested that each marriage should be allowed only two or three children or whatever number might be needed to balance the current rates of mortality and celibacy. This duty to society, Godwin wrote, would surely not be too great a hardship to be endured, once the reasons for it were thoroughly understood.

The second essay, published in 1803

Malthus' small essay had captured public attention in England, and he was anxious to expand it with empirical data which would show his principle of population to be valid not only in England in his own day, but in all societies and all periods. He therefore traveled widely, collecting data. He also made use of the books of explorers, such as Cook and Vancouver.

Malthus' second edition, more than three times the length of his original essay on population, was ready in 1803. Book I and Book II of the 1803 edition of Malthus' *Essay* are devoted to a study of the checks to population growth which have operated throughout history in all the countries of the world for which he possessed facts.

In his first chapter, Malthus stressed the potentially enormous power of population growth contrasted the slow growth of the food supply. He concluded that strong checks to the increase of population must almost always be operating to keep human numbers within the bounds of sustenance. He classified the checks as either preventive or positive, the preventive checks being those which reduce fertility, while the positive checks are those which increase mortality. Among the positive checks, Malthus listed "unwholesome occupations, severe labour and exposure to the seasons, extreme poverty, bad nursing of children, great towns, excesses of all kinds, the whole train of common diseases and epidemics, wars, plague, and famine".

In the following chapters of Books I, Malthus showed in detail the mechanisms by which population is held at the level of sustenance in various cultures. He first discussed primitive hunter-gatherer societies, such as the inhabitants of Tierra del Fuego, Van Diemens Land and New Holland, and those tribes of North American Indians living predominantly by hunting. In hunting societies, he pointed out, the population is inevitably very sparse: "The great extent of territory required for the support of the hunter has been repeatedly stated and acknowledged", Malthus wrote, "...The tribes of hunters, like beasts of prey, whom they resemble in their mode of subsistence, will consequently be thinly scattered over the surface of the earth. Like beasts of prey, they must either drive away or fly from every rival, and be engaged in perpetual contests with each other...The neighboring nations live in a perpetual state of hostility with each other. The very act of increasing in one tribe must be an act of aggression against its neighbors, as a larger range of territory will be necessary to support its increased numbers. The contest will in this case continue, either till the equilibrium is restored by mutual losses, or till the weaker party is exterminated or driven from its country... Their object in battle is not conquest but destruction. The life of the victor depends on the death of the enemy". Malthus concluded that among the American Indians of his time, war was the predominant check to population growth, although famine, disease and infanticide each played a part.

In Book II, Malthus turned to the nations of Europe, as they appeared at the end of the 18th century, and here he presents us with a different picture. Although in these societies poverty, unsanitary housing, child labour, malnutrition and disease all took a heavy toll, war produced far less mortality than in hunting and pastoral societies, and the preventive checks, which lower fertility, played a much larger roll.

Malthus painted a very dark panorama of population pressure and its consequences in human societies throughout the world and throughout history: At the lowest stage of cultural development are the hunter-gatherer societies, where the density of population is extremely low. Nevertheless, the area required to support the hunters is so enormous that even their sparse and thinly scattered numbers press hard against the limits of sustenance. The resulting competition for territory produces merciless intertribal wars.

The domestication of animals makes higher population densities possible; and wherever this new mode of food production is adopted, human numbers rapidly increase; but very soon a new equilibrium is established, with the population of pastoral societies once more pressing painfully against the limits of the food supply, growing a little in good years, and being cut back in bad years by famine, disease and war.

Finally, agricultural societies can maintain extremely high densities of population; but the time required to achieve a new equilibrium is very short. After a brief period of unrestricted growth, human numbers are once more crushed against the barrier of limited resources; and if excess lives are produced by overbreeding, they are soon extinguished by deaths among the children of the poor.

Malthus was conscious that he had drawn an extremely dark picture of the human condition. He excused himself by saying that he has not done it gratuitously, but because he was convinced that the dark shades really are there, and that they form an important part of the picture. He did allow one ray of light, however: By 1803, his own studies of Norway, together with personal conversations with Godwin and the arguments in Godwin's *Reply to Parr*, had convinced Malthus that "moral restraint" should be included among the possible checks to population growth. Thus he concluded Book II of his 1803 edition by saying that the checks which keep population down to the level of the means of subsistence can all be classified under the headings of "moral restraint, vice and misery". (In his first edition he had maintained that vice and misery are the only possibilities).

Replies to Malthus

The second edition of Malthus' *Essay* was published in 1803. It provoked a storm of controversy, and a flood of rebuttals. In 1803 England's political situation was sensitive. Revolutions had recently occurred both in America and in France; and in England there was much agitation for radical change, against which Malthus provided counter-arguments. Pitt and his government had taken Malthus' first edition seriously, and had abandoned their plans for extending the Poor Laws. Also, as a consequence of Malthus' ideas, England's first census was taken in 1801. This census, and subsequent ones, taken in 1811, 1821 and 1831, showed that England's population was indeed increasing rapidly, just as Malthus had feared. (The population of England and Wales more than doubled in 80 years, from an estimated 6.6 million in 1750 to almost 14 million in 1831.) In 1803, the issues of poverty and population were at the center of the political arena, and articles refuting Malthus began to stream from the pens of England's authors.

William Coleridge planned to write an article against Malthus, and he made extensive notes in the margins of his copy of the *Essay*. In one place he wrote: "Are Lust and Hunger both alike Passions of physical Necessity, and the one equally with the other independent of the Reason and the Will? Shame upon our race that there lives an individual who dares to ask the Question." In another place Coleridge wrote: "Vice and Virtue subsist in the agreement of the habits of a man with his Reason and Conscience, and these can have but one moral guide, Utility, or the virtue and Happiness of Rational Beings". Although Coleridge never wrote his planned article, his close friend Robert Southey did so, using Coleridge's notes almost verbatim. Some years later Coleridge remarked: "Is it not lamentable - is it not even marvelous - that the monstrous practical sophism of Malthus should now have gained complete possession of the leading men of the kingdom! Such an essential lie in morals - such a practical lie in fact it is too! I solemnly declare that I do not believe that all the heresies and sects and factions which ignorance and the weakness and wickedness of man have ever given birth to, were altogether so disgraceful to man as a Christian, a philosopher, a statesman or citizen, as this abominable tenet."

In 1812, Percy Bysshe Shelley, who was later to become William Godwin's son-in-law, wrote: "Many well-meaning persons... would tell me not to make people happy for fear of over-stocking the world... War, vice and misery are undoubtedly bad; they embrace all that we can conceive of temporal and eternal evil. Are we to be told that these are remedyless, because the earth would in case of their remedy, be overstocked?" A year later, Shelley called Malthus a "priest, eunuch, and tyrant", and accused him, in a pamphlet, of proposing that ".. after the poor have been stript naked by the tax-gatherer and reduced to bread and tea and fourteen hours of hard labour by their masters.. the last tie by which Nature holds them to benignant earth (whose plenty is garnered up in the strongholds of their tyrants) is to be divided... They are required to abstain from marrying under penalty of starvation... whilst the rich are permitted to add as many mouths to consume the products of the poor as they please"

Godwin himself wrote a long book (which was published in 1820) entitled *Of Population, An Enquiry Concerning the Power and Increase in the Number of Mankind, being an answer to Mr. Malthus.* One can also view many of the books of Charles Dickens as protests against Malthus' point of view. For example, *Oliver Twist* gives us a picture of a workhouse "administered in such a way that the position of least well-off independent workers should not be worse than the position of those supported by parish assistance."

Among the 19th century authors defending Malthus was Harriet Martineau, who wrote: "The desire of his heart and the aim of his work were that domestic virtue and happiness should be placed within the reach of all... He found that a portion of the people were underfed, and that one consequence of this was a fearful mortality among infants; and another consequence the growth of a recklessness among the destitute which caused infanticide, corruption of morals, and at best, marriage between pauper boys and girls; while multitudes of respectable men and women, who paid rates instead of consuming them, were unmarried at forty or never married at all. Prudence as to time of marriage and for making due provision for it was, one would think, a harmless recommendation enough, under the circumstances."

The Irish Potato Famine of 1845

Meanwhile, in Ireland, a dramatic series of events had occurred, confirming the ideas of Malthus. Anti-Catholic laws prevented the Irish cottagers from improving their social position; and instead they produced large families, fed almost exclusively on a diet of milk and potatoes. The potato and milk diet allowed a higher density of population to be supported in Ireland than would have been the case if the Irish diet had consisted primarily of wheat. As a result, the population of Ireland grew rapidly: In 1695 it had been approximately one million, but by 1821 it had reached 6,801,827. By 1845, the population of Ireland was more than eight million; and in that year the potato harvest failed because of blight. All who were able to do so fled from the country, many emigrating to the United States; but two million people died of starvation. As the result of this shock, Irish marriage habits changed, and late marriage became the norm, just as Malthus would have wished. After the Potato Famine of 1845, Ireland maintained a stable population of roughly four million.

Malthus continued a life of quiet scholarship, unperturbed by the heated public debate which he had caused. At the age of 38, he married a second cousin. The marriage produced only three children, which at that time was considered to be a very small number. Thus he practiced the pattern of late marriage which he advocated. Although he was appointed rector of a church in Lincolnshire, he never preached there, hiring a curate to do this in his place. Instead of preaching, Malthus accepted an appointment as Professor of History and Political Economy at the East India Company's College at Haileybury. This appointment made him the first professor of economics in England, and probably also the first in the world. Among the important books which he wrote while he held this post was *Principles of Political Economy, Considered with a View to their Practical Application*. Malthus also published numerous revised and expanded editions of his *Essay on the Principle of Population*. The third edition was published in 1806, the fourth in 1807, the fifth in 1817, and the sixth in 1826.

In the societies that Malthus describes, we can see a clear link not only between population pressure and poverty, but also between population pressure and war. Undoubtedly this is why the suffering produced by poverty and war saturates so much of human history. Stabilization of population through birth control offers a key to eliminating this suffering.

Population stabilization and sustainability

Does the contrast between the regions of our contemporary world mean that Malthus has been "proved wrong" in some regions and "proved right" in others? To answer this question, let us re-examine the basic assertion which Malthus puts forward in Books I and II of the 1803 version of his *Essay*. His basic thesis is that the maximum natural fertility of human populations is greatly in excess of replacement fertility. This being so, Malthus points out, human populations would always increase exponentially if they were not prevented from doing so by powerful and obvious checks.

In general, Malthus tells us, populations cannot increase exponentially because the food supply increases slowly, or is constant. Therefore, he concludes, in most societies and almost all periods of history, checks to population growth are operating. These checks may be positive, or they may be preventive, the positive checks being those which raise the death rate, while the preventive checks lower the birth rate. There are, however, Malthus says, exceptional periods of history when the populations of certain societies do actually increase exponentially because of the opening of new lands or because of the introduction of new methods of food production. As an example, he cites the growth of the population of the United States, which doubled every 25 years over a period of 150 years.

We can see, from this review of Malthus' basic thesis, that his demographic model is flexible enough to describe all of the regions of our contemporary world: If Malthus were living today, he would say that in countries with low birth and death rates and stable populations, the checks to population growth are primarily preventive, while in countries with high death rates, the positive checks are important. Finally, Malthus would describe our rapidly-growing global population as the natural result of the introduction of improved methods of food production in the developing countries. We should notice, however, that the flexibility of Malthus' demographic model first appears in the 1803 version of his *Essay*: In the 1798 version, he maintained "..that population does invariably increase, where there are means of subsistence.." and "that the superior power (of population) cannot be checked without producing misery and vice.." This narrower model of population did not agree with Malthus' own observations in Norway in 1799, and therefore in his 1803 *Essay* he allowed more scope for preventive checks, which included late marriage and moral restraint as well as birth control (which he classified under the heading of "vice").

Today we are able to estimate the population of the world at various periods in history, and we can also make estimates of global population in prehistoric times. Looking at the data, we can see that the global population of humans has not followed an exponential curve as a function of time, but has instead followed a hyperbolic trajectory. At the time of Christ, the population of the world is believed to have been approximately 220 million. By 1500, the earth contained 450 million people, and by 1750, the global population exceeded 700 million. As the industrial and scientific revolution has accelerated, global population has responded by increasing at a break-neck speed: In 1930, the population of the world reached two billion; in 1958 three billion; in 1974 four billion; in 1988 five billion, and in 1999, six billion.

Today, roughly a billion people are being added to the world's population every decade. But our food supply cannot keep increasing at this rate. On the contrary, the amount of food available to us is threatened by water shortages, climate change and the end of petroleum-supported high-yield agriculture. Thus, facing the threat of an extremely large-scale global famine, we need to listen to the warning voice of Malthus.

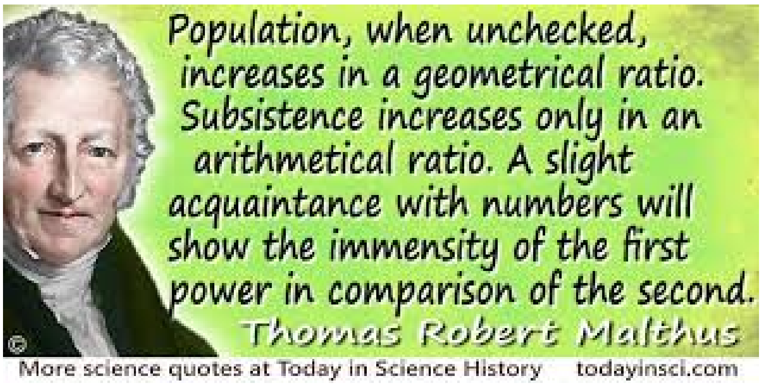

Figure 9.1: **Thomas Robert Malthus was the first person to maintain that population always presses painfully against the limits imposed by nature. The result has usually been famine, disease and war.**

9.2 Growth cannot continue forever

The Industrial Revolution marked the start of massive human use of fossil fuels. The stored energy from several hundred million years of plant growth began to be used at roughly a million times the rate at which it had been formed. The effect on human society was like that of a narcotic. There was a euphoric (and totally unsustainable) surge of growth of both population and industrial production. Meanwhile, the carbon released into the atmosphere from the burning of fossil fuels began to duplicate the conditions which led to the 5 geologically-observed mass extinctions, during each of which more than half of all living species disappeared forever.

Economists (with a few notable exceptions, such as Nicholas Georgescu-Roegen, Herman Daly and Aurelio Peccei) have long behaved as though growth were synonymous with economic health. If the gross national product of a country increases steadily by 4% per year, most economists express approval and say that the economy is healthy. If the economy could be made to grow still faster (they maintain), it would be still more healthy. If the growth rate should fall, economic illness would be diagnosed.

However, it is obvious that on a finite Earth, neither population growth nor economic growth can continue indefinitely. A 4% rate of growth corresponds to an increase by a factor of 50 every century. No one can maintain that this is sustainable in the long run except by refusing to look more than a short distance into the future.

Of course, it is necessary to distinguish between industrial growth, and growth of culture and knowledge, which can and should continue to grow. Qualitative improvements in human society are possible and desirable, but resource-using and pollution-producing industrial growth is reaching its limits, both because of ecological constraints and because of the exhaustion of petroleum, natural gas and other non-renewable resources, such as metals. The threat of catastrophic climate change makes it imperative for us to stop using fossil fuels within very few decades.

Today, as economic growth falters, the defects and injustices of our banking system have come sharply into focus, and light has also been thrown onto the much-too-cozy relationship between banking and government. The collapse of banks during the sub-prime mortgage crisis of 2008 and their subsequent bailout by means of the taxpayer's money can give us an insight into both phenomena, the faults of our banking system and its infiltration into the halls of government. The same can be said of the present national debt crisis in the Euro zone and elsewhere.

One feature of banking that cries out for reform is "fractional reserve banking", i.e. the practice whereby private banks keep only a tiny fraction of the money entrusted to them by their depositors, and lend out all the remaining amount. By doing so, the banks are in effect coining their own money and putting it into circulation, a prerogative that ought to be reserved for governments. Under the system of fractional reserve banking, profits from any expansion of the money supply go to private banks rather than being used by the government to provide social services. This is basically unjust; the banks are in effect issuing their own counterfeit money.

When the economy contracts instead of expanding, the effect of fractional reserve banking is still worse. In that case the depositors ask the banks for their money, which it is their right to do. But the banks do not have the money; they have lent it out, and thus they fail. However, the bankers have insured themselves against this eventuality by buying the votes of government officials. Thus the banks are bailed out and the taxpayers are left with the bill, as in the recent example in which the US Federal Reserve secretly gave 7.7 trillion of the taxpayers' dollars to bail out various banks.

In a later section (on entropy and economics) we will discuss in detail Frederick Soddy's criticisms of the fractional reserve banking system, and his proposals for monetary reform.

The fact that our fractional reserve banking system is stable when the economy is expanding, but collapses when the economy contracts explains, in part, the irrational and almost religious belief of governments and economists in perpetual growth. Also contributing to growth-worship are the unearned profits that investors reap when they own property in growing cities, or shares of growing businesses. But growth cannot continue forever. It is destroying the earth.

Pope Francis has called for economic reform. Our battered earth calls for

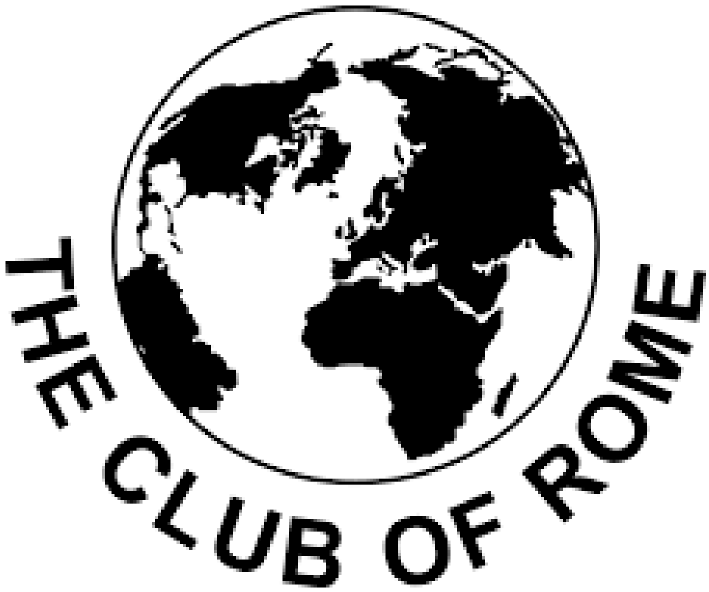

Figure 9.2:

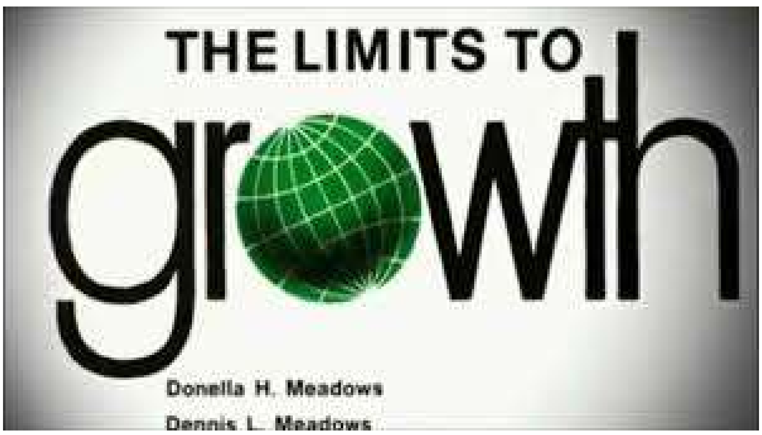

Figure 9.3:

Figure 9.4: **Aurelio Peccei (1908-1984), main founder of the Club of Rome. Concerning our present economic system, he wrote: "The only way we have devised to meet the surging waves of our rampant militarism and consumerism is to draw increasingly on the natural environment and to exploit, indiscriminately, the most accessible mineral and fuel deposits and all living resources we can lay our hands on. Such actions irreversibly impoverish our unique, irreplaceable, world, whose bounty and generosity are not infinite. Even if all the other adverse situations we find ourselves in today were to be alleviated, in itself, our high-handed treatment of Nature can bring about our doom." Photograph by Koen Suyk/Anefo (Nationaal Archif), CC BY-SA 3.0, Wikimedia Commons**

Figure 9.5: **Today the distinguished economist Herman Daly warns us strongly of the urgent need for a steady state economic system.**

it. The case of Greece shows clearly that our present economic system is not working; it is destroying nature and at the same time producing human misery. We need to replace our present economic system by one that has both an ecological conscience and a social conscience.[1]

The Club of Rome

In 1968 Aurelio Peccei, Thorkil Kristensen and others founded the Club of Rome, an organization of economists and scientists devoted to studying the predicament of human society. One of the first acts of the organization was to commission an MIT study of future trends using computer models. The result

[1]http://eruditio.worldacademy.org/issue-5/article/urgent-need-renewable-energy
http://www.theguardian.com/environment/2015/jul/08/exxon-climate-change-1981-climate-denier-funding
http://human-wrongs-watch.net/2015/06/25/militarisms-hostages/
http://www.commondreams.org/news/2015/07/13/pope-calls-world-youth-rise-against-global-capitalism
https://www.transcend.org/tms/2015/07/tpp-ttip-tisa-a-tipping-edge-from-democracy/
http://dissidentvoice.org/2015/05/secrecy-and-democracy-are-incompatible/
http://www.countercurrents.org/roberts100715.htm
http://eruditio.worldacademy.org/issue-6/article/institutional-and-cultural-inertia
http://human-wrongs-watch.net/2015/07/04/will-the-real-issues-be-discussed-in-2016/
https://www.youtube.com/watch?v=AjZaFjXfLec
http://www.theguardian.com/environment/video/2012/oct/25/david-attenborough-climate-change-video

was a book entitled "Limits to Growth", published in 1972. From the outset the book was controversial, but it became a best-seller. It was translated into many languages and sold 30 million copies. The book made use of an exponential index for resources, i.e. the number of years that a resource would last if used at an exponentially increasing rate.

Today the more accurate Hubbert Peak model is used instead to predict rate of use of a scarce resource as a function of time. Although the specific predictions of resource availability in "Limits to Growth" lacked accuracy, its basic thesis, that unlimited industrial growth on a finite planet is impossible, was indisputably correct. Nevertheless the book was greeted with anger and disbelief by the community of economists, and these emotions still surface when it is mentioned.

9.3 Schumacher's book

Ernst Frederich Schumacher was born in 1911 in Bohn, Germany, where his father was a professor of political economy. He studied in both Bohn and Berlin before going to Oxford, England, as a Rhodes Scholar.

When Hitler came to power, the anti-Nazi Schumacher moved permanently to England, only to be interned as an "enemy alien" at the start of World War II. Using time stolen from his farm duties, the interned Schumacher wrote a paper entitled *Multilateral Clearing*, which attracted the attention of the great political economist John Maynard Keynes; who arranged for the young German not only to be released from internment but also to be employed by Oxford University.

After the end of World War II, Schumacher worked as an economic advisor to the British commission that was charged with rebuilding of Germany. Then, between 1950 and 1970 he held the position of Chief Economic Advisor to the British Coal Board. This was a position of great responsibility, since the Coal Board controlled the activities of 800,000 workers. Schumacher believed that that the British economy ought to rely on coal rather than oil for energy, since oil reserves were not only more limited but also located in politically unstable parts of the world. He also called attention to the dangers of nuclear power generation.

n 1955 Schumacher travelled to Burma as an economic consultant. While there, he developed the set of principles he called "Buddhist economics", based on the belief that individuals need good work for proper human development. He also proclaimed that "production from local resources for local needs is the most rational way of economic life." He travelled throughout many Third World countries, encouraging local governments to create self-reliant

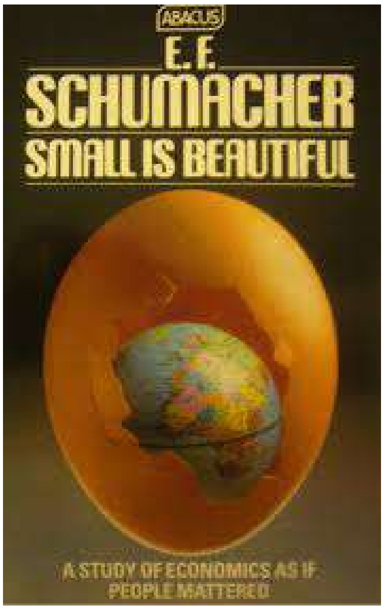

Figure 9.6: **Schumacher's book: Published in 1973, a year after *Limits to Growth*, *Small is Beautiful* also called attention to the problem of exhaustion of non-renewable resources.**

economies. During his travels, he was greatly influenced by the economic thinking of Mahatma Gandhi.

In 1973, Schumacher published his influential book, *Small is Beautiful: Economics As If People Mattered*.[2] In this book, he points out that our present economic system is unsustainable, partly because it is based on non-renewable resources, which will ultimately be exhausted, and partly because there are limits on the amount of pollution that can be absorbed by the global environment. Not only is our present economic system unsustainable; it is also unsuited to human psychological needs. People need meaningful work rather than blind pursuit of material goods. We must also develop the idea of "enoughness", Schumacher tells us.

9.4 The economics of happiness

Happiness is a better goal than pleasure

Let us start by repeating a few words from Chapter 5: Pleasure is fleeting. Happiness lasts. Pleasure is addictive, but happiness is not. Pleasure craves

[2]The title phrase "Small is be beautiful" was originated by Schumacher's former teacher, Leopold Kahr (1909-1994).

more and more of everything. Happiness can be content with very little. These characteristics make happiness a better goal than pleasure.

William Morris and John Ruskin

Together with John Ruskin (1819-1900) and others in the Arts and Crafts Movement, Morris criticized the Industrial Revolution and division of labor for destroying craftsmanship, traditions of design, traditional skills, and pride in work. His Utopian book, "News from Nowhere", is a plea for a return to cooperative workshops where good design and craftsmanship would flourish. Ruskin's Book, "Unto This Last" (which later greatly influenced Gandhi), points out that the pleasure of warm friendships with coworkers in small co-operative communities is not given sufficient weight by the economic systems of industrial societies.

Helena Norberg-Hodge

Helena Norberg-Hodge was born in Sweden in 1946. She was educated in Sweden, Germany, Austria, England and the United States, eventually specializing in linguistics under Professor Noam Chomsky at MIT. As a result of her linguistic studies, she speaks seven languages fluently.

After completing her education, Norberg-Hodge lived and studied in several countries with varying degrees of industrialization, and she became convinced that increased material wealth often leads to a decrease in happiness. One of the countries that she visited was Ladakh, a remote Himalayan country which is part of India, but which more closely resembles Tibet.

Because of border disputes with both China and Pakistan, the government of India kept Ladakh as a buffer zone, not allowing tourism. However, in 1962 the first road to Ladakh was built, and in 1975 the Indian government decided to open the country to tourism and "development". Helena Norberg-Hodge described the effect of this decision in the following words:

When I first arrived in Leh, the capital of 5,000 inhabitants, cows were the most likely cause of congestion and the air was crystal clear. Within five minutes' walk in any direction from the town centre were barley fields, dotted with large farmhouses. For the next twenty years I watched Leh turn into an urban sprawl. The streets became choked with traffic, and the air tasted of diesel fumes. 'Housing colonies' of soulless, cement boxes spread into the dusty desert. The once pristine streams became polluted, the water undrinkable. For the first time, there were homeless people. The increased economic pressures led to unemployment and competition. Within a few years, friction between *different communities appeared. All of these things had not existed for the previous 500 years.*

Many of the changes were psychological:

In one of my first years in Ladakh, I was in this incredibly beautiful village. All the houses were three stories high and painted white. And I was just amazed. So out of curiosity I asked a young man from that village to show me the poorest house. He thought for a bit, and then he said, 'We don't have any poor houses.' The same person I heard eight years later saying to a tourist, 'Oh, if you could only help us Ladakhis, we're so poor!' And what had happened is that in the intervening eight years he had been bombarded with all these one-dimensional images of life in the West. He'd seen people with fast cars, you know, looking as though they never worked, and with lots of money. And suddenly by comparison his culture seemed backward and primitive and poor.

These experiences led Helena Norberg-Hodge to found the *International Society for Ecology and Culture*, an organization whose name was later changed to *Local Futures*. In 1991, she published an important book entitled *Ancient Futures*, which was described as "an inspirational classic" by the London Times and as "one of the most important books of our time" by author Sisan George. In 2011 her award-winning film *The Economics of Happiness* was released. The film was hailed as a key ideological statement by the Transition Towns movement.

Wikipedia describes the recognition of Norbert-Hodge in the following words:

Norberg-Hodge lectures extensively in English, Swedish, German, French, Spanish, Italian and Ladakhi. Over the years, lecture tours have brought her to universities, government agencies and private institutions. She has made presentations to parliamentarians in Germany, Sweden, and England; at the White House and the US Congress; to UNESCO, the World Bank and the IMF; and at Cambridge, Oxford, Harvard, Cornell and numerous other universities. She also teaches regularly at Schumacher College in England. She frequently lectures and gives workshops for community groups around the world working on localization issues.

Over the years, Norberg-Hodge has received support from many world leaders, including H.R.H. Prince Charles, Prince Sadruddin Aga Khan, H.H. the Dalai Lama, and Indian Prime Ministers Indira and Rajiv Gandhi. In 1986, she received the Right Livelihood Award as recognition for her work with LEDeG.

In 1993, she was named one of the world's 'Ten Most Interesting Environmentalists' by the Earth Journal. Her work has been the subject of more than 250 articles in over a dozen countries.

In Carl McDaniel's book Wisdom for a Liveable Planet (Trinity University Press, 2005), she was profiled as one of eight visionaries changing the world today.

On 25 November 2012, she received the 2012 Goi Peace Award from the Goi Peace Foundation in Japan, "in recognition of her pioneering work in the new economy movement to help create a more sustainable and equitable world."

The case of Bhutan

Before the doors of Bhutan were cautiously opened to visitors in 1974, the country remained aloof from the modern world. One of the most striking characteristics of the ancient Bhutanese culture was that most of the actions of its citizens were done from a sense of duty and tradition, rather than for economic reasons. The citizens of Bhutan derived great happiness from these actions. For example, caring for the elderly was to them not only a duty but also a great source of pleasure. Bhutan is notable for introducing Gross National Happiness as a measure of the success of the country's economy. In 1999, the Bhutanese government lifted bans on television and the Internet, but warned that misuse of television could erode the country's traditional values. Today, Bhutan also encourages tourism, and between 1960 and 2005, the population of the country increased from 224,000 to 650,000. It is doubtful whether population growth, tourism, television and modernization will increase the happiness of the Bhutanese.

An immense forest covers 72% of Bhutan's area[3], and for this reason the country is CO_2-neutral. The forest absorbs all of the CO_2 that the country produces. Bhutan also exports renewable energy in the form of hydroelectric power.

Wikipedia states that *...According to the Swiss-based International Union for Conservation of Nature, Bhutan is viewed as a model for proactive conservation initiatives. The Kingdom has received international acclaim for its commitment to the maintenance of its biodiversity. This is reflected in the decision to maintain at least sixty percent of the land area under forest cover, to designate more than 40% of its territory as national parks, reserves and other protected areas, and most recently to identify a further nine percent of land area as biodiversity corridors linking the protected areas. All of Bhutan's protected land is connected to one another through a vast network of biological corridors, allowing animals to migrate freely throughout the country. Environmental conservation has been placed at the core of the nation's development strategy, the middle path. It is not treated as a sector but rather as a set of concerns that must be mainstreamed in Bhutan's overall approach to development planning and to be buttressed by the force of law. The country's constitution mentions*

[3]The king of Bhutan once visited Albertslund, Denmark, the community where my family and I live, in order to study the very large nearby forest which had been planted on land formerly used for agriculture.

environment standards in multiple sections

Tim Jackson

Professor Tim Jackson is the Economics Commissioner for Britain's Sustainable Development Commission. In March, 2009, he published a book entitled "Prosperity without growth? The transition to a sustainable economy". 'Questioning growth' is deemed the act of lunatics, idealists and revolutionaries", Jackson states, "But question it we must. The myth of growth has failed us. It has failed the billion people who still live on less than $2 a day. It has failed the fragile ecological systems on which we depend for survival. It has failed spectacularly, in its own terms, to provide economic stability and to secure people's jobs."

Jackson lists the challenges facing the world today - the end of the era of cheap oil; the degradation of forests, lakes and soils; the challenge of stabilizing concentrations of carbon in the atmosphere - and he says: "We face these challenges with an economy that is fundamentally broken, in desperate need of renewal." Nevertheless, his book is optimistic, and it offers solutions to the problem of recasting our economic system so that it will be able to achieve prosperity without growth.

9.5 Gandhian economics

In his autobiography, Mahatma Gandhi says: "Three moderns have left a deep impression on my life and captivated me: Raychandbhai (the Indian philosopher and poet) by his living contact; Tolstoy by his book 'The Kingdom of God is Within You'; and Ruskin by his book 'Unto This Last'." Ruskin's book, "Unto This Last", which Gandhi read in 1904, is a criticism of modern industrial society. Ruskin believed that friendships and warm interpersonal relationships are a form of wealth that economists have failed to consider. He felt that warm human contacts are most easily achieved in small agricultural communities, and that therefore the modern tendency towards centralization and industrialization may be a step backward in terms of human happiness. While still in South Africa, Gandhi founded two religious Utopian communities based on the ideas of Tolstoy and Ruskin, Phoenix Farm (1904) and Tolstoy Farm (1910).

Gandhi later put these principles into practice when he introduced spinning and weaving in the home as a means for eliminating the unemployment that had been produced by the importation of factory-made cloth into India. Similarly, the Transition Towns movement, which is rapidly gaining momentum today, emphasizes local self-sufficiency and restoration of traditional craftsmanship, as well as local production of food. The word "Transition" enters the name of the movement because the towns involved have decided to start making the transition to conditions as they will be after oil and natural gas have become prohibitively expensive.

Because of his growing fame as the leader of the Indian civil rights movement in South Africa, Gandhi was persuaded to return to India in 1914 and to take up the cause of Indian home rule. In order to re-acquaint himself with conditions in India, he travelled tirelessly, now always going third class as a matter of principle.

During the next few years, Gandhi worked to reshape the Congress Party into an organization which represented not only India's Anglicized upper middle class but also the millions of uneducated villagers who were suffering under an almost intolerable burden of poverty and disease. In order to identify himself with the poorest of India's people, Gandhi began to wear only a white loincloth made of rough homespun cotton. He traveled to the remotest villages, recruiting new members for the Congress Party, preaching non-violence and "firmness in the truth", and becoming known for his voluntary poverty and humility. The villagers who flocked to see him began to call him "Mahatma" (Great Soul).

Disturbed by the spectacle of unemployment and poverty in the villages, Gandhi urged the people of India to stop buying imported goods, especially cloth, and to make their own. He advocated the reintroduction of the spinning wheel into village life, and he often spent some hours spinning himself. The spinning wheel became a symbol of the Indian independence movement, and was later incorporated into the Indian flag.

The movement for boycotting British goods was called the "Swadeshi movement". The word Swadeshi derives from two Sanskrit roots: Swa, meaning self, and Desh, meaning country. Gandhi described Swadeshi as "a call to the consumer to be aware of the violence he is causing by supporting those industries that result in poverty, harm to the workers and to humans or other creatures."

Gandhi tried to reconstruct the crafts and self-reliance of village life that he felt had been destroyed by the colonial system. "I would say that if the village perishes, India will perish too", he wrote, "India will be no more India. Her own mission in the world will get lost. The revival of the village is only possible when it is no more exploited. Industrialization on a mass scale will necessarily lead to passive or active exploitation of the villagers as problems of competition and marketing come in. Therefore we have to concentrate on the village being self-contained, manufacturing mainly for use. Provided this character of the village industry is maintained, there would be no objection to villagers using even the modern machines that they can make and can afford to use. Only they should not be used as a means of exploitation by others."

"You cannot build nonviolence on a factory civilization, but it can be built on self-contained villages... Rural economy as I have conceived it, eschews exploitation altogether, and exploitation is the essence of violence... We have to make a choice between India of the villages that are as ancient as herself and India of the cities which are a creation of foreign domination..."

"Machinery has its place; it has come to stay. But it must not be allowed to displace necessary human labour. An improved plow is a good thing. But if by some chances, one man could plow up, by some mechanical invention of his, the whole of the land of India, and control all the agricultural produce, and if the millions had no other occupation, they would starve, and being idle, they would become dunces, as many have already become. There is hourly danger of many being reduced to that unenviable state."

In these passages we see Gandhi not merely as a pioneer of nonviolence; we see him also as an economist. Faced with misery and unemployment produced by machines, Gandhi tells us that social goals must take precedence over blind market mechanisms. If machines are causing unemployment, we can, if we wish, and use labor-intensive methods instead. With Gandhi, the free market is not sacred; we can do as we wish, and maximize human happiness, rather than maximizing production and profits.

Mahatma Gandhi was assassinated by a Hindu extremist on January 30, 1948. After his death, someone collected and photographed all his worldly goods. These consisted of a pair of glasses, a pair of sandals, a pocket watch and a white homespun loincloth. Here, as in the Swadeshi movement, we see Gandhi as a pioneer of economics. He deliberately reduced his possessions to an absolute minimum in order to demonstrate that there is no connection between personal merit and material goods. Like Veblen, Mahatma Gandhi told us that we must stop using material goods as a means of social competition. We must start to judge people not by what they have, but by what they are.[4]

Gandhi's vision of an "India of villages" rather than an "India of cities" has much in common with the Transition Town movement, which we will discuss next.

[4]https://en.wikipedia.org/wiki/Gandhian_economics
http://bollier.org/blog/gandhian-economics-and-commons
http://caravan.squat.net/ICC-en/Krrs-en/ghandi-econ-en.htm
http://www.mkgandhi.org/ebks/untothislast.pdf
https://en.wikipedia.org/wiki/Unto_This_Last
http://www.efm.bris.ac.uk/het/ruskin/ruskin

9.6 The threat of catastrophic climate change

Quick change is needed to save the long-term future.

The central problem which the world faces in its attempts to avoid catastrophic climate change is a contrast of time scales. In order to save human civilization and the biosphere from the most catastrophic effects of climate change we need to act immediately, Fossil fuels must be left in the ground. Forests must be saved from destruction by beef or palm oil production.

These vitally necessary actions are opposed by powerful economic interests, by powerful fossil fuel corporations desperate to monetize their underground "assets", and by corrupt politicians receiving money from the beef or palm oil industries.

However, although some disastrous effects climate change are already visible, the worst of these calamities lie in the distant future. Therefor it is difficult to mobilize the political will for quick action. We need to act immediately, because of the danger of passing tipping points beyond which climate change will become irreversible despite human efforts to control it.

Tipping points are associated with feedback loops, such as the albedo effect and the methane hydrate feedback loop. The albedo effect is important in connection with whether the sunlight falling on polar seas is reflected or absorbed. While ice remains, most of the sunlight is reflected, but as areas of sea surface become ice-free, more sunlight is absorbed, leading to rising temperatures and further melting of sea ice, and so on, in a loop.

The methane hydrate feedback loop involves vast quantities of the powerful greenhouse gas methane, CH_4, frozen in a crystalline form surrounded by water molecules. 10,000 gigatons of methane hydrates are at present locked in Arctic tundra or the continental shelves of the world's oceans. Although oceans warm very slowly because of thermal inertia, the long-term dangers from the initiation of a methane-hydrate feedback loop are very great. There is a danger that a very large-scale anthropogenic extinction event could be initiated unless immediate steps are taken to drastically reduce the release of greenhouse gases.

Scientists have long been aware of the dangers

Scientists have long been aware that CO_2 and other greenhouse gases released into the earth's atmosphere through human activities can cause dangerous climate change. László Szombatfalvy's important book. "The Greatest Challenges of Our Time", (Ekerlids, 2010), gives the following history of our knowledge of the link between greenhouse gases and climate change:

"As far back as 100 years ago, Swedish scientists observed that human activities could affect the climate. Arvid Högbom, professor of geology in Stockholm, warned in 1895 that anthracite burning would increase carbon dioxide content in the air. The following year, Svante Arrhenius, professor of physics and Nobel Prize Laureate, estimated that doubling of the content of carbon dioxide in the atmosphere would lead to an increase of the earth's average temperature by 5-6 degrees C. However, with the low emissions at that time, the process would take several thousand years.

"In 1938, measurements by Guy S. Callendar, an English researcher, confirmed theories that the amount of carbon dioxide in the atmosphere had actually increased since the previous century. His report made little impact since attention at that time was focused on the outbreak of World War II.

"During the 1950s and 1960s, several research reports were published supporting Svante Arrhenius's calculation of carbon dioxide emissions' warming effects. But the time perspective in these reports has been reduced considerably.

"In the 1970s, it was discovered that emissions of several other greenhouse gases from human activities heightened carbon dioxide's effects.

"In 1988, the International Panel on Climate Control, IPCC, was organized. Every fourth or fifth year since 1990, the IPCC has published climate change reports that are increasingly more extensive and ominous.

"In December 1997, the first international agreement to limit emissions of greenhouse gases was signed in Japan. Known as the Kyoto Protocol, the agreement's goal is that industrialized nations reduce emissions of greenhouse gases by 5.2 percent by 2012, compared with 1990 levels. The Protocol has been hitherto ratified by 176 countries, but unfortunately not by the most important country in this matter: USA."

More recently, on December 12, 2015, the Paris Agreement was adopted by consensus by the 196 parties of the United Nations Framework Convention on Climate Change. As of June, 2017, 195 UNFCC members have signed the Agreement, and 153 nations have ratified it.

The Paris Agreement aims at "Holding the increase in the global average temperature to well below 2^{o}C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5^{o}C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."

A warning from the World Bank

In 2012, the World Bank issued a report warning that without quick action to curb CO_2 emissions, global warming is likely to reach 4 °C during the 21st century. This is dangerously close to the temperature which initiated the

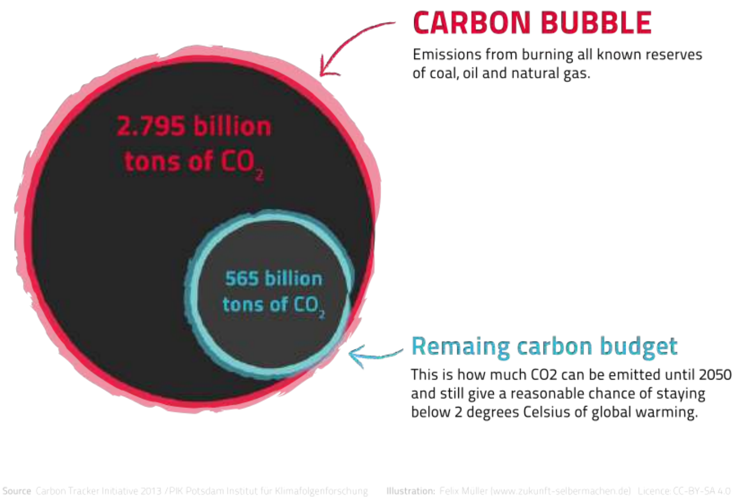

Figure 9.7: **If we are to avoid catastrophic climate change, almost all of the known fossil fuel reserves must be left in the ground.**

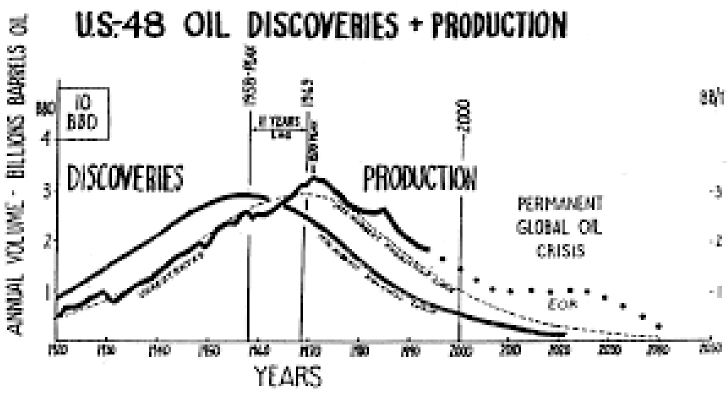

Figure 9.8: **The Hubbert peak model for exhaustion of nonrenewable resources as a function of time. The model was first proposed in 1956 by the American geophysicist M.K. Hubbert, who predicted the the extraction and use of oil in the 48 contiguous US states would reach a peak in 1970 and would afterwards decline, following a approximately bell-shaped curve. The prediction was at first disbelieved, but when it turned out to be astonishingly accurate, Hubbert became famous. His model is now applied to every nonrenewable resource. The prediction is that the production and use of the resource will reach a peak when reserves are approximately half-exhausted.**

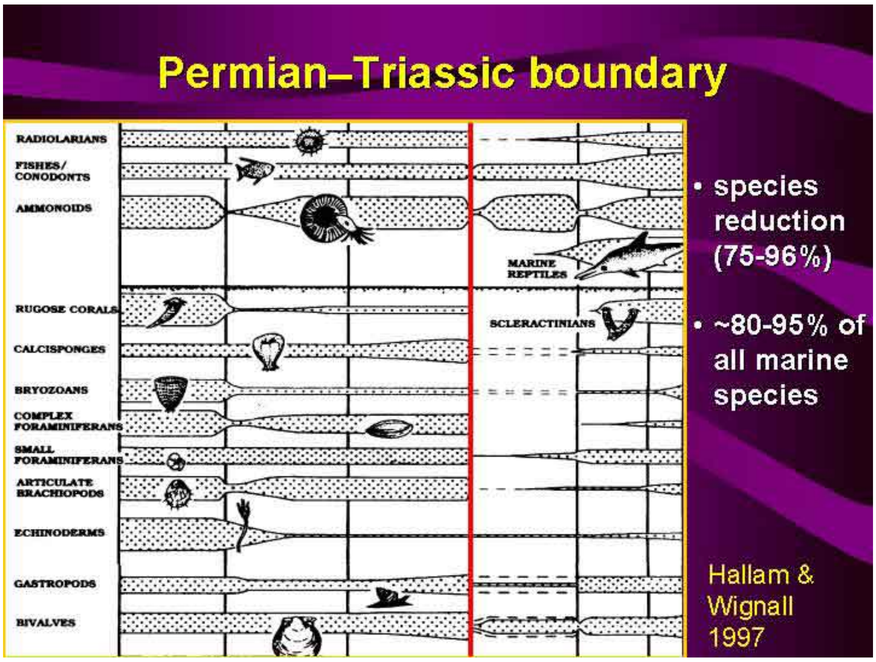

Figure 9.9: **Loss of species caused by the Permian-Triassic extinction event. Unless quick steps are taken to lower our greenhouse gas emissions, we may cause a similar extinction event, which will threaten the survival of our own species. Source: Australian Frontiers of Science, www.sciencearchive.org.au**

Permian-Triassic extinction event: 6 °C above normal. During the Permian-Triassic extinction event, which occurred 252 million years ago, 96% of all marine species were wiped out, as well as 70% of all terrestrial vertebrates.[5]

The 4^{o}C scenarios are devastating: the inundation of coastal cities; increasing risks for food production potentially leading to higher malnutrition rates; many dry regions becoming dryer, wet regions wetter; unprecedented heat waves in many regions, especially in the tropics; substantially exacerbated water scarcity in many regions; increased frequency of high-intensity tropical cyclones; and irreversible loss of biodiversity, including coral reef systems.

And most importantly, a 4^{o}C world is so different from the current one that it comes with high uncertainty and new risks that threaten our ability to anticipate and plan for future adaptation needs. The lack of action on climate change not only risks putting prosperity out of reach of millions of people in the developing world, it threatens to roll back decades of sustainable development. It is clear that we already know a great deal about the threat before us. The science is unequivocal that humans are the cause of global warming, and major changes are already being observed: global mean warming is 0.8^{o}C above pre industrial levels; oceans have warmed by 0.09^{o}C since the 1950s and are acidifying; sea levels rose by about 20 cm since pre-industrial times and are now rising at 3.2 cm per decade; an exceptional number of extreme heat waves occurred in the last decade; major food crop growing areas are increasingly affected by drought.

Despite the global community's best intentions to keep global warming below a 2^{o}C increase above pre-industrial climate, higher levels of warming are increasingly likely. Scientists agree that countries' cur- rent United Nations Framework Convention on Climate Change emission pledges and commitments would most likely result in 3.5 to 4^{o}C warming. And the longer those pledges remain unmet, the more likely a 4^{o}C world becomes.

Data and evidence drive the work of the World Bank Group. Science reports, including those produced by the Intergovernmental Panel on Climate Change, informed our decision to ramp up work on these issues, leading to, a World Development Report on climate change designed to improve our understanding of the implications of a warming planet; a Strategic Framework on Development and Climate Change, and a report on Inclusive Green Growth. The World Bank is a leading advocate for ambitious action on climate change, not only because it is a moral imperative, but because it makes good economic sense.

But what if we fail to ramp up efforts on mitigation? What are the implica-

[5] http://science.nationalgeographic.com/science/prehistoric-world/permian-extinction/ http://www.worldbank.org/en/news/feature/2012/11/18/Climate-change-report-warns-dramatically-warmer-world-this-century

tions of a 4^{o}C world? We commissioned this report from the Potsdam Institute for Climate Impact Research and Climate Analytics to help us understand the state of the science and the potential impact on development in such a world.

It would be so dramatically different from today's world that it is hard to describe accurately; much relies on complex projections and interpretations. We are well aware of the uncertainty that surrounds these scenarios and we know that different scholars and studies sometimes disagree on the degree of risk. But the fact that such scenarios cannot be discarded is sufficient to justify strengthening current climate change policies. Finding ways to avoid that scenario is vital for the health and welfare of communities around the world. While every region of the world will be affected, the poor and most vulnerable would be hit hardest. A 4^{o}C world can, and must, be avoided.

The World Bank Group will continue to be a strong advocate for international and regional agreements and increasing climate financing. We will redouble our efforts to support fast growing national initiatives to mitigate carbon emissions and build adaptive capacity as well as support inclusive green growth and climate smart development. Our work on inclusive green growth has shown that, through more efficiency and smarter use of energy and natural resources, many opportunities exist to drastically reduce the climate impact of development, without slowing down poverty alleviation and economic growth.

This report is a stark reminder that climate change affects everything. The solutions don't lie only in climate finance or climate projects. The solutions lie in effective risk management and ensuring all our work, all our thinking, is designed with the threat of a 4^{o}C degree world in mind. The World Bank Group will step up to the challenge.

Permian-Triassic extinction event

The geological record shows five major extinction events.

- Ordovician-Silurian Extinction. around 439 million years ago.
- Late Devonian Extinction. 375-360 million years ago.
- Permian-Triassic extinction. 352 million years ago.
- Triassic-Jurassic extinction, 201 million years ago.
- Cretaceous-Paleogene extinction, 66 million years ago.

The most devastating of these was the Permian-Triassic extinction, which occurred 252 million years ago.[6] In the Permian-Triassic extinction, 96% of all marine specias and 76% of all terrestrial vertebrates disappeared forever. The cause of this extremely severe event is disputed, but according to one of the most plausible theories it was triggered by a massive volcanic eruption in Siberia, which released enormous amounts of CO_2 into the earth's atmosphere.

The region where massive volcanic eruptions are known to have occurred 252 million years ago called the "Siberian Traps". (The "Traps" part of the name comes from the fact that many of the volcanic rock formations in the region resemble staircases. The Swedish word for staircase is "trappe".) The eruptions continued for about a million years.

Today the area covered is about 2 million square kilometers, roughly equal to western Europe in land area. Estimates of the original coverage are as high as 7 million square kilometers. The original volume of lava is estimated to range from 1 to 4 million cubic kilometers.

The CO_2 released by the Siberian Traps eruption is believed to have caused a global temperature increase of 6^oC, and this was enough to trigger the methane-hydrate feedback loop, which will be discussed below, The earth's temperature is thought to have continued to rise for 85,000 years, finally reaching 15^o above normal.

The Holocene (Anthropocene) extinction

We are now living in the midst of a sixth, human-caused, mass extinction. How severe it becomes is up to us.

Recently a group of scientists stated that the scope of human impact on planet Earth is so great that the *Anthropocene* warrants a formal place in the Geological Time Scale.

In a statement issued by University of Leicester Press Office on 2 October 2017, professor Jan Zalasiewicz from the University of Leicester's School of Geography, Geology, and the Environment said: "Our findings suggest that the Anthropocene should follow on from the Holocene Epoch that has seen 11.7 thousand years of relative environmental stability, since the retreat of the last Ice Age, as we enter a more unstable and rapidly evolving phase of our

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[6] https://www.thomhartmann.com/bigpicture/last-hours-climate-change
The Last Hours of Humanity: Warming the World To Extinction (book), by Thom Hartmann
https://www.amazon.com/Last-Hours-Humanity-Warming-Extinction/dp/1629213640
http://www.mediaite.com/online/leonardo-dicaprio-boosts-thom-hartmann-apocalyptic-global-warming-film-last-hours/

planet's history,"[7]

"We conclude that human impact has now grown to the point that it has changed the course of Earth history by at least many millennia, in terms of the anticipated long-term climate effects (e.g. postponement of the next glacial maximum: see Ganopolski et al., 2016; Clark et al., 2016), and in terms of the extensive and ongoing transformation of the biota, including a geologically unprecedented phase of human-mediated species invasions, and by species extinctions which are accelerating (Williams et al., 2015, 2016)."

The report stated that defining characteristics of the period include "marked acceleration of rates of erosion and sedimentation; large-scale chemical perturbations to the cycles of carbon, nitrogen, phosphorus and other elements; the inception of significant change in global climate and sea level; and biotic changes including unprecedented levels of species invasions across the Earth. Many of these changes are geologically long-lasting, and some are effectively irreversible."

Loss of biodiversity

Tropical rain forests are the most biologically diverse places in the world. This is because they have not been affected by the periods of glaciation that have periodically destroyed the forests of temperate and boreal regions. The destruction of species-rich tropical rain forests is one of the mechanisms driving the present high rate of species loss.

According to a recent article published in *The Guardian*[8] "Conservation experts have already signalled that the world is in the grip of the "sixth great extinction" of species, driven by the destruction of natural habitats, hunting, the spread of alien predators and disease, and climate change.

"The IUCN[9] created shock waves with its major assessment of the world's biodiversity in 2004, which calculated that the rate of extinction had reached 100-1,000 times that suggested by the fossil records before humans.

"No formal calculations have been published since, but conservationists agree the rate of loss has increased since then, and Stuart said it was possible that the dramatic predictions of experts like the renowned Harvard biologist E O Wilson, that the rate of loss could reach 10,000 times the background rate in two decades, could be correct."

A recent article by Profs. Gerardo Ceballos, Paul R. Ehrlich and Rodolfo Dirzo in the *Proceedings of the National Academy of Sciences* was entitles

[7]http://www2.le.ac.uk/offices/press/press-releases/2017/october/significant-scale-of-human-impact-on-planet-has-changed-course-of-earth2019s-history-scientists-suggest

[8]https://www.theguardian.com/environment/2010/mar/07/extinction-species-evolve

[9]International Union for the Conservation of Nature

"Biological Annihilation via the Ongoing Sixth Mass Extinction Signaled by Vertebrate Population Losses and Declines".

The Abstract of the paper reads as follows: "The population extinction pulse we describe here shows, from a quantitative viewpoint, that Earth's sixth mass extinction is more severe than perceived when looking exclusively at species extinctions. Therefore, humanity needs to address anthropogenic population extirpation and decimation immediately. That conclusion is based on analyses of the numbers and degrees of range contraction (indicative of population shrinkage and/or population extinctions according to the International Union for Conservation of Nature) using a sample of 27,600 vertebrate species, and on a more detailed analysis documenting the population extinctions between 1900 and 2015 in 177 mammal species. We find that the rate of population loss in terrestrial vertebrates is extremely high, even in 'species of low concern.' In our sample, comprising nearly half of known vertebrate species, 32% (8,851/27,600) are decreasing; that is, they have decreased in population size and range. In the 177 mammals for which we have detailed data, all have lost 30% or more of their geographic ranges and more than 40% of the species have experienced severe population declines (80% range shrinkage). Our data indicate that beyond global species extinctions Earth is experiencing a huge episode of population declines and extirpations, which will have negative cascading consequences on ecosystem functioning and services vital to sustaining civilization. We describe this as a 'biological annihilation' to highlight the current magnitude of Earth's ongoing sixth major extinction event."

9.7 Transition Towns

The Transition Town Movement of today is a grassroots response to the end of the fossil fuel era, the threat of catastrophic climate change, and the threat of economic collapse. It can be thought of as a modern branch of the Cooperative Movement. In 2006, the Transition Town of Totnes in Devon, England was the first to use this name, which implied a transition from globalism, consumerism and growth to a sustainable, local and self-sufficient economy. The ideal was to produce locally all the necessary food for the town, and as much of other necessities as possible. In this way, the energy expenditures involved in transportation could be avoided.

Today there are more than 1400 Transition Towns or Transition Initiatives, and they are located in at least 50 countries. Many of them have local currencies which are legal tender within the town. If the pioneers of this movement are right in saying that this is the only sustainable model for the future, we may

Figure 9.10: **The Transition Town movement visualizes the world after the end of the fossil fuel era. The towns in this movement try to make the necessary lifestyle adjustments today.**

wonder whether mega-cities will be able to survive in the long-term future.[10]

One of the important founders of the Transition Initiative movement was Rob Hopkins, who was born London in 1968. Starting in 1988, Hopkins spent two and a half years working as house manager at a Tibetan Buddhist monastery in Italy. He then spent a year travelling in India (where he met his future wife), Pakistan, China, Tibet and Hong Kong. Returning to England, he obtained a degree in Environmental Quality and Resource Management at the University of the West of England.

In 2001, Rob Hopkins started teaching at the Kinsale Further Education College in Ireland, where he taught a course on Practical Sustainability. In 2004, Hopkins set his students the task of applying permaculture principles to the concept of peak oil. In response to this challenge, his students produced the Kinsale Energy Descent Action Plan[11], which they placed on the Internet. To their surprise, the report was downloaded by people from all over the world. Hopkins afterwards moved to Totnes, England, where. in 2006, he founded the first Transition Town. The movement spread rapidly and is still growing.

[10]https://en.wikipedia.org/wiki/Degrowth
http://commondreams.org/views/2015/07/31/we-are-all-greece
http://www.localfutures.org/
http://www.powells.com/biblio/7-9780871566430-2

[11]http://transitionus.org/sites/default/files/KinsaleEnergyDescentActionPlan.pdf

Figure 9.11: **The problem of supplying large cities with food may become very accute in the future.**

9.8 Human society as a superorganism

A completely isolated human being would find it as difficult to survive for a long period of time as would an isolated ant or bee or termite. Therefore it seems correct to regard human society as a superorganism. In the case of humans, the analog of the social insects' nest is the enormous and complex material structure of civilization. It is, in fact, what we call the human economy. It consists of functioning factories, farms, homes, transportation links, water supplies, electrical networks, computer networks and much more.

Almost all of the activities of modern humans take place through the medium of these external "exosomatic" parts of our social superorganism. The terms "exosomatic" and "endosomatic" were coined by the American scientist Alfred Lotka (1880-1949). A lobster's claw is endosomatic; it is part of the lobster's body. The hammer used by a human is exosomatic, like a detachable claw. Lotka spoke of "exosomatic evolution", including in this term not only cultural evolution but also the building up of the material structures of civilization.

The economy associated with the human superorganism "eats" resources and free energy. It uses these inputs to produce local order, and finally excretes them as heat and waste. The process is closely analogous to food passing through the alimentary canal of an individual organism. The free energy and resources that are the inputs of our economy drive it just as food drives the processes of our body, but in both cases, waste products are finally excreted in a degraded form.

Almost all of the free energy that drives the human economy came originally from the sun's radiation, the exceptions being geothermal energy which originates in the decay of radioactive substances inside the earth, and tidal energy, which has its origin in the slowing of the motions of the earth-moon system. However, since the start of the Industrial Revolution, our economy has been using the solar energy stored in of fossil fuels. These fossil fuels were formed over a period of several hundred million years. We are using them during a few hundred years, i.e., at a rate approximately a million times the rate at which they were formed.

The present rate of consumption of fossil fuels is more than 13 terawatts and, if used at the present rate, fossil fuels would last less than a century. However, because of the very serious threats posed by climate change, human society would be well advised to stop the consumption of coal, oil and natural gas well before that time.

The rate of growth of of new renewable energy sources is increasing rapidly. These sources include small hydro, modern biomass, solar, wind, geothermal, wave and tidal energy. There is an urgent need for governments to set high taxes on fossil fuel consumption and to shift subsidies from the petroleum and nuclear industries to renewables. These changes in economic policy are needed to make the prices of renewables more competitive.

The shock to the global economy that will be caused by the end of the fossil fuel era will be compounded by the scarcity of other non-renewable resources, such as metals. While it is true (as neoclassical economists emphasize) that "matter and energy can neither be created nor destroyed", free energy can be degraded into heat, and concentrated deposits of minerals can be dispersed. Both the degradation of free energy into heat and the dispersal of minerals involve increases of entropy.

Economic activity is usually divided into two categories, 1) production of goods and 2) provision of services. It is the rate of production of goods that will be limited by the carrying capacity of the global environment. Services that have no environmental impact will not be constrained in this way. Thus a smooth transition to a sustainable economy will involve a shift of a large fraction the work force from the production of goods to the provision of services.

In his recent popular book "The Rise of the Creative Class" the economist Richard Florida points out that in a number of prosperous cities, for example Stockholm, a large fraction of the population is already engaged in what might be called creative work, a type of work that uses few resources, and produces few waste products, work which develops knowledge and culture rather than producing material goods. For example, producing computer software requires few resources and results in few waste products. Thus it is an activity with a very small ecological footprint.

Similarly, education, research, music, literature and art are all activities that do not weigh heavily on the carrying capacity of the global environment. Furthermore, cultural activities lead in a natural way to global cooperation and internationalism, since cultural achievements are shared by the people of the entire world. Indeed, the shared human inheritance of culture and knowledge is growing faster than ever before.

Florida sees this as a pattern for the future, and maintains that everyone is capable of creativity. He visualizes the transition to a sustainable future economy as one in which a large fraction of the work force moves from industrial jobs to information-related work. Meanwhile, as Florida acknowledges, industrial workers feel uneasy and threatened by such trends.[12]

Biological Carrying capacity and Economics

Classical economists pictured the world as largely empty of human activities. According to the empty-world picture of economics, the limiting factors in the production of food and goods are shortages of human capital and labor. The land, forests, fossil fuels, minerals, oceans filled with fish, and other natural resources upon which human labor and capital operate, are assumed to be present in such large quantities that they are not limiting factors. In this picture, there is no naturally-determined upper limit to the total size of the human economy. It can continue to grow as long as new capital is accumulated, as long as new labor is provided by population growth, and as long as new technology replaces labor by automation.

Biology, on the other hand, presents us with a very different picture. Biologists remind us that if any species, including our own, makes demands on its environment which exceed the environment's carrying capacity, the result is a catastrophic collapse both of the environment and of the population which it supports. Only demands which are within the carrying capacity are sustainable. For example, there is a limit to regenerative powers of a forest.

It is possible to continue to cut trees in excess of this limit, but only at the cost of a loss of forest size, and ultimately the collapse and degradation of the forest. Similarly, cattle populations may for some time exceed the carrying capacity of grasslands, but the ultimate penalty for overgrazing will be degradation or desertification of the land. Thus, in biology, the concept of the carrying capacity of an environment is extremely important; but in economic theory this concept has not yet been given the weight which it deserves.

Exponential growth of human population and economic activity have brought us, in a surprisingly short time, from the empty-world situation to a full-world situation. In today's world, we are pressing against the absolute limits of

[12]http://www.clubofrome.org/?p=326
http://www.donellameadows.org/wp-content/userfiles/Limits-to-Growth-digital-scan-version.pdf
http://www.donellameadows.org/archives/a-synopsis-limits-to-growth-the-30-year-update/

the earth's carrying capacity, and further growth carries with it the danger of future collapse.

Full-world economics, the economics of the future, will no longer be able to rely on industrial growth to give profits to stockbrokers or to solve problems of unemployment or to alleviate poverty. In the long run, neither the growth of industry nor that of population is sustainable; and we have now reached or exceeded the sustainable limits.

The limiting factors in economics are no longer the supply of capital or human labor or even technology. The limiting factors are the rapidly vanishing supplies of petroleum and metal ores, the forests damaged by acid rain, the diminishing catches from over-fished oceans, and the cropland degraded by erosion or salination, or lost to agriculture under a cover of asphalt.

Neoclassical economists have maintained that it is generally possible to substitute man-made capital for natural resources; but a closer examination shows that there are only very few cases where this is really practical. (See G.E. Tverberg, "Thoughts on why energy use and CO_2 emissions are rising as fast as GDP", www.ourfiniteworld.com, November 30, 2011.)

The size of the human economy is, of course, the product of two factors the total number of humans, and the consumption per capita. If we are to achieve a sustainable global society in the future, a society whose demands are within the carrying capacity of of the global environment, then both these factors must be reduced.

The responsibility for achieving sustainability is thus evenly divided between the North and the South: Where there is excessively high consumption per capita, it must be reduced; and this is primarily the responsibility of the industrialized countries. High birth rates must also be reduced; and this is primarily the responsibility of the developing countries. Both of these somewhat painful changes are necessary for sustainability; but both will be extremely difficult to achieve because of the inertia of institutions, customs and ways of thought which are deeply embedded in society, in both the North and the South.

9.9 Population and food supply

Let us look first at the problem of high birth rates: The recent spread of modern medical techniques throughout the world has caused death rates to drop sharply; but since social customs and attitudes are slow to change, birth rates have remained high. As a result, between 1930 and 2011, the population of the world increased with explosive speed from two billion to seven billion.

During the last few decades, the number of food-deficit countries has lengthened; and it now reads almost like a United Nations roster. The food-importing

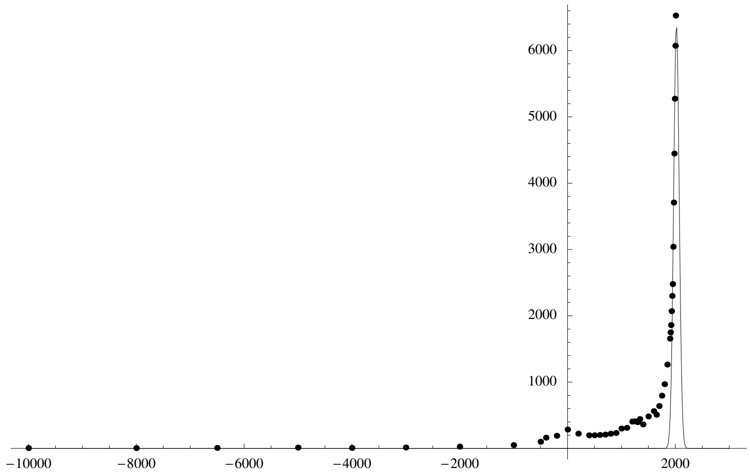

Figure 9.12: **When global population and fossil fuel use are plotted on the same graph over a period of several thousand years, the burning of fossil fuels appears as a sharp spike, rising from almost nothing to a high value over a period of a few hundred years and then falling abruptly to almost zero again. Recent population growth appears to be simultaneous with, and perhaps driven by, fossil fuel use. This raises the question of whether population of humans is headed for a crash when the fossil fuel era inevitably ends.**

nations are dependent, almost exclusively, on a single food-exporting region, the grain belt of North America. In the future, this region may be vulnerable to droughts produced by global warming.

An analysis of the global ratio of population to cropland shows that we probably already have exceeded the sustainable limit of population through our dependence on petroleum: Between 1950 and 1982, the use of cheap petroleum-derived fertilizers increased by a factor of 8, and much of our present agricultural output depends their use. Furthermore, petroleum-derived synthetic fibers have reduced the amount of cropland needed for growing natural fibers, and petroleum-driven tractors have replaced draft animals which required cropland for pasturage. Also, petroleum fuels have replaced fuelwood and other fuels derived for biomass. The reverse transition, from fossil fuels back to renewable energy sources, will require a considerable diversion of land from food production to energy production.

As population increases, the cropland per person will continue to fall, and we will be forced to make still heavier use of fertilizers to increase output per hectare. Also marginal land will be used in agriculture, with the probable result that much land will be degraded through erosion or salination.

Reserves of oil are likely to be exhausted by the middle of this century. Thus there is a danger that just as global population reaches the unprecedented level of 9 billion or more, the agricultural base for supporting it may suddenly collapse. The resulting catastrophe, possibly compounded by war and other disorders, could produce famine and death on a scale unprecedented in history, a disaster of unimaginable proportions, involving billions rather than millions of people. The present tragic famine in Africa is to this possible future disaster what Hiroshima is to the threat of thermonuclear war a tragedy of smaller scale, whose horrors should be sufficient, if we are wise, to make us take steps to avoid the larger catastrophe.

At present a child dies from starvation every six seconds. Five million children die from hunger every year. Over a billion people in today's world are chronically undernourished. There is a threat that unless prompt and well-informed action is taken by the international community, the tragic loss of life that is already being experienced will increase to unimaginable proportions.

As glaciers melt in the Himalayas, threatening the summer water supplies of India and China; as ocean levels rise, drowning the fertile rice-growing river deltas of Asia; as aridity begins to decrease the harvests of Africa, North America and Europe; as populations grow; as aquifers are overdrawn; as cropland is lost to desertification and urban growth; and as energy prices increase, the billion people who now are undernourished but still survive, might not survive. They might become the victims of a famine whose proportions could exceed anything that the world has previously experienced.

It is vital for the world to stabilize its population, not only because of the threat of a catastrophic future famine, but also because rapid population growth is closely linked with poverty. Today, a large fraction of the world's people live in near-poverty or absolute poverty, lacking safe water, sanitation, elementary education, primary health care and proper nutrition. Governments struggling to solve these problems, and to provide roads, schools, jobs and medical help for all their citizens, find themselves defeated by the rapid doubling times of populations. For example, in Liberia, the rate of population growth is 4% per year, which means that the population of Liberia doubles in size every eighteen years.

Under such circumstances, despite the most ambitious development programs, the infrastructure per capita decreases. Also, since new jobs must be found for the new millions added to the population, the introduction of efficient modern methods in industry and agriculture aggravates the already-serious problem of unemployment.

Education of women and higher status for women are vitally important measures, not only for their own sake, but also because in many countries these social reforms have proved to be strongly correlated with lower birth rates. Religious leaders who oppose programs for the education of women and for family planning on "ethical" grounds should think carefully about the scope and consequences of the catastrophic global famine which will undoubtedly occur within the next 50 years if population is allowed to increase unchecked.

One of the most important keys to controlling the global population explosion is giving women better education and equal rights. These goals are desirable for the sake of increased human happiness, and for the sake of the uniquely life-oriented point of view which women can give us; but in addition, education and improved status for women have shown themselves to be closely connected with lowered birth rates.

When women lack education and independent careers outside the home, they can be forced into the role of baby-producing machines by men who do not share in the drudgery of cooking, washing and cleaning; but when women have educational, legal, economic, social and political equality with men, experience has shown that they choose to limit their families to a moderate size.

Sir Partha Dasgupta of Cambridge University has pointed out that the changes needed to break the cycle of overpopulation and poverty are all desirable in themselves. Besides education and higher status for women, they include state-provided social security for old people, provision of water supplies near to dwellings, provision of health services to all, abolition of child labor and general economic development.[13]

9.10 Sustainable future populations

In an important and detailed study entitled *Will Limited Land, Water, and Energy Control Human Population Numbers in the Future?*, David Pimentel et al. [14] discuss the problem of agriculture and global population in the post fossil fuel era. Here are some quotations from the article:

"Nearly 60% of the world's human population is malnourished and the numbers are growing. Shortages of basic foods related to decreases in per capita cropland, water, and fossil energy resources contribute to spreading malnutrition and other diseases. The suggestion is that in the future only a smaller number of people will have access to adequate nourishment. In about 100 years, when it is reported that the planet will run out of fossil energy, we suggest that a world population of about two billion might be sustainable if it relies on renewable energy technologies and also reduces per capita use of the earth's natural resources.

"Developed and developing nations need to provide a good quality life for their people while coping with rapid population growth, but 'Population is

[13]http://www.poverties.org/famine-in-africa.html

[14]D. Pimentel et al., Human Ecology DOI 10.1007/s10745-010-9346-y, (2010)

the issue no one wants to touch' (Meadows 2000). The current world population is about 6.8 billion. Based on the present growth rate of 1.2% per year, the population is projected to double in approximately 58 years (Chiras 2006; PRB 2008). Because population growth cannot continue indefinitely, society can either voluntarily control its numbers or let natural forces such as disease, malnutrition, and other disasters limit human numbers (Bartlett 1997-98; Pimentel et al. 1999). Increasing human numbers especially in urban areas, and increasing pollution of food, water, air, and soil by pathogenic disease organisms and chemicals, are causing a rapid increase in the prevalence of disease and human mortality (Murray and Lopez 1996; Pimentel et al. 2007). Currently, more than 3.7 billion humans are malnourished worldwide - the largest number ever (WHO 2005a, b).

"The planet's numerous environmental problems highlight the urgent need to evaluate available land, water, and energy resources and how they relate to the requirements of a rapidly growing human population (Pimentel and Pimentel 2008). In this article we assess the carrying capacity of the Earth's natural resources, and suggest that humans should voluntarily limit their population growth, rather than letting natural forces control their numbers (Ferguson 1998; Pimentel et al. 1999). In addition, we suggest appropriate policies and technologies that would improve standards of living and quality of life worldwide...

"In 1960, when the world population numbered about 3 billion, approximately 0.5 ha of cropland was available per capita worldwide. This half a hectare is needed to provide a diverse, healthy, nutritious diet of plant and animal products..."

Pimentel et al. state that worldwide, the average cropland per capita has now fallen to 0.22 hectares. This number will continue to fall because global population is increasing at the rate of almost one billion people per decade, while the global area available for cropland is not increasing. On the contrary, it is decreasing because of desertification, erosion, salination and urban sprawl. Pimentel et al.state that cropland is being degraded and lost at a rate of more than 20 million hectares per year.

The current cropland per capita in the United States is 0.56 hectares, and thus still quite large, but in China, the figure is dangerously low: only 0.1 hectares. China will soon be unable to feed its population and will have to buy grain on the world market. As Lester Brown pointed out in a Copenhagen lecture, China will be able to import grain because of its strong economy, but this will raise food prices and will cause widespread famine in other parts of the world.

Added to the agricultural and environmental problems, are problems of finance and distribution. Famines can occur even when grain is available somewhere in the world, because those who are threatened with starvation may not be able to pay for the grain, or for its transportation. The economic laws of supply and demand are not able to solve this type of problem. One says that there is no "demand" for the food (meaning demand in the economic sense), even though people are in fact starving.

What is the optimum population of the world? It is certainly not the maximum number that can be squeezed onto the globe by eradicating every species of plant and animal that cannot be eaten. The optimum global population is one that can be supported in comfort, equality and dignity - and with respect for the environment.

In 1848 (when there were just over one billion people in the world), John Stuart Mill described the optimal global population in the following words:

The density of population necessary to enable mankind to obtain, in the greatest degree, all the advantages of cooperation and social intercourse, has, in the most populous countries, been attained. A population may be too crowded, although all be amply supplied with food and raiment.

... Nor is there much satisfaction in contemplating the world with nothing left to the spontaneous activity of nature; with every rood of land brought into cultivation, which is capable of growing food for human beings; every flowery waste or natural pasture plowed up, all quadrupeds or birds which are not domesticated for man's use exterminated as his rivals for food, every hedgerow or superfluous tree rooted out, and scarcely a place left where a wild shrub or flower could grow without being eradicated as a weed in the name of improved agriculture. If the earth must lose that great portion of its pleasantness which it owes to things that the unlimited increase of wealth and population would extirpate from it, for the mere purpose of enabling it to support a larger, but not better or happier population, I sincerely hope, for the sake of posterity, that they will be content to be stationary, long before necessity compels them to it.[15]

Dennis Meadows, one of the authors of **Limits to Growth**, stated recently that the optimum human population in the distant future may be about 2 billion people.

But what about the near future? Will the global population of humans crash catastrophically after having exceeded the carrying capacity of the environment? There is certainly a danger that this will happen - a danger that the 21st century will bring very large scale famines to vulnerable parts of the world, because modern energy-intensive agriculture will be dealt a severe blow by prohibitively high petroleum prices. At present, there are only a few major food-exporting countries, notably the United States, Canada, Australia and Argentina. There is a danger that within a few decades, the United States will

[15] John Stuart Mill, *Principles of Political Economy, With Some of Their Applications to Social Philosophy*, (1848).

no longer be able to export food because of falling production and because of the demands of a growing population. We should be aware of these serious future problems if we are to have a chance of avoiding them.

Today we are able to estimate the population of the world at various periods in history, and we can also make estimates of global population in prehistoric times. Looking at the data, we can see that the global population of humans has not followed an exponential curve as a function of time, but has instead followed an information-driven and technology-driven hyperbolic trajectory. At the time of Christ, the population of the world is believed to have been approximately 220 million. By 1500, the earth contained 450 million people, and by 1750, the global population exceeded 700 million. As the industrial and scientific revolution has accelerated, global population has responded by increasing at a break-neck speed: In 1930, the population of the world reached two billion; in 1958 three billion; in 1974 four billion; in 1988 five billion, and in 1999, six billion.

Almost a billion people are currently being added to the world's population every decade. But our food supply cannot keep increasing at this rate. On the contrary, the amount of food available to us is threatened by water shortages, climate change and the end of petroleum-supported high-yield agriculture. Thus, facing the threat of an extremely large-scale global famine, we need to listen to the warning voice of Malthus.

9.11 Population stabilization today

The phrase "developing countries" is more than a euphemism; it expresses the hope that with the help of a transfer of technology from the industrialized nations, all parts of the world can achieve prosperity. Some of the forces that block this hope have just been mentioned. Another factor that prevents the achievement of worldwide prosperity is population growth.

In the words of Dr. Halfdan Mahler, former Director General of the World Health Organization, "Country after country has seen painfully achieved increases in total output, food production, health and educational facilities and employment opportunities reduced or nullified by excessive population growth."

The growth of population is linked to excessive urbanization, infrastructure failures and unemployment. In rural districts in the developing countries, family farms are often divided among a growing number of heirs until they can no longer be subdivided. Those family members who are no longer needed on the land have no alternative except migration to overcrowded cities, where the infrastructure is unable to cope so many new arrivals. Often the new migrants are forced to live in excrement-filled makeshift slums, where dysentery, hepatitis and typhoid are endemic, and where the conditions for human life sink to the lowest imaginable level. In Brazil, such shanty towns are called "favelas".

If modern farming methods are introduced in rural areas while population growth continues, the exodus to cities is aggravated, since modern techniques are less labor-intensive and favor large farms. In cities, the development of adequate infrastructure requires time, and it becomes a hopeless task if populations are growing rapidly. Thus, population stabilization is a necessary first step for development.

It can be observed that birth rates fall as countries develop. However, development is sometimes blocked by the same high birth rates that economic progress might have prevented. In this situation (known as the "demographic trap"), economic gains disappear immediately because of the demands of an exploding population.

For countries caught in the demographic trap, government birth control programs are especially important, because one cannot rely on improved social conditions to slow birth rates. Since health and lowered birth rates should be linked, it is appropriate that family-planning should be an important part of programs for public health and economic development.

A recent study conducted by Robert F. Lapham of Demographic Health Surveys and W. Parker Maudlin of the Rockefeller Foundation has shown that the use of birth control is correlated both with socio-economic setting and with the existence of strong family-planning programs. The implication of this study is that even in the absence of increased living standards, family-planning programs can be successful, provided they have strong government support.

China, the world's most populous nation, has adopted the somewhat draconian policy of allowing only one child for families in living in towns and cities (35.9% of the population). Chinese leaders obtained popular support for their one-child policy by means of an educational program which emphasized future projections of diminishing water resources and diminishing cropland per person if population increased unchecked. Like other developing countries, China has a very young population, which will continue to grow even when fertility has fallen below the replacement level because so many of its members are contributing to the birth rate rather than to the death rate. China's present population is 1.4 billion. Its projected population for the year 2025 is 1.6 billion. China's one-child policy is supported by 75% of the country's people, but the methods of enforcement are sometimes criticized, and it has led to a M/F sex ratio of 1.17/1.00. The natural baseline for the sex ratio ranges between 1.03/1.00 and 1.07/1.00.

Education of women and higher status for women are vitally important measures, not only for their own sake, but also because in many countries these social reforms have proved to be the key to lower birth rates. Religious leaders who oppose programs for the education of women and for family planning on "ethical" grounds should think carefully about the scope and consequences of the catastrophic global famine which will undoubtedly occur within the next 50 years if population is allowed to increase unchecked. Do these leaders really wish to be responsible for the suffering and death from starvation of hundreds of millions of people?

At the United Nations Conference on Population and Development, held in Cairo in September, 1994, a theme which emerged very clearly was that one of the most important keys to controlling the global population explosion is giving women better education and equal rights. These goals are desirable for the sake of increased human happiness, and for the sake of the uniquely life-oriented point of view which women can give us; but in addition, education and improved status for women have shown themselves to be closely connected with lowered birth rates. When women lack education and independent careers outside the home, they can be forced into the role of baby-producing machines by men who do not share in the drudgery of cooking, washing and cleaning; but when women have educational, legal, economic, social and political equality with men, experience has shown that they choose to limit their families to a moderate size.

Sir Partha Dasgupta of Cambridge University has pointed out that the changes needed to break the cycle of overpopulation and poverty are all desirable in themselves. Besides education and higher status for women, they include state-provided social security for old people, provision of water supplies near to dwellings, provision of health services to all, abolition of child labor and general economic development.

9.12 Refugees from climate change

Populations displaced by drought and famine

Climate change could produce a refugee crisis that is "unprecedented in human history", Barack Obama has warned as he stressed global warming was the most pressing issue of the age.

Speaking at an international food conference in Milan, the former US President said rising temperatures were already making it more difficult to grow crops and rising food prices were "leading to political instability".

If world leaders put aside "parochial interests" and took action to reduce greenhouse gas emissions by enough to restrict the rise to one or two degrees

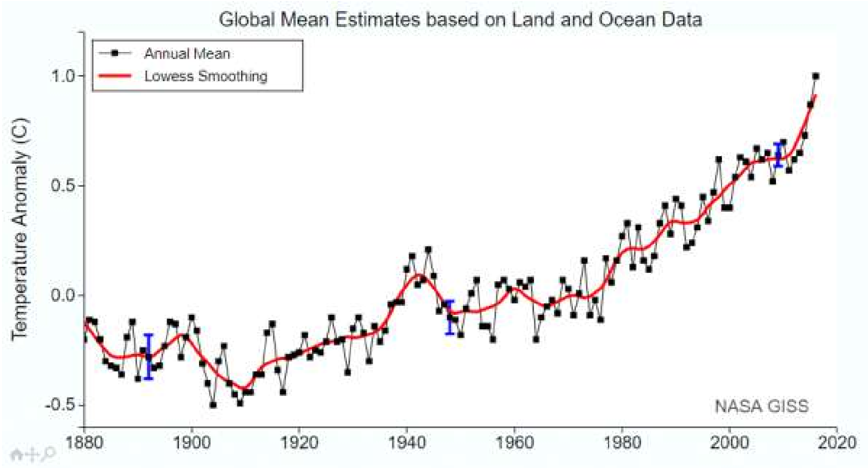

Figure 9.13: **This figure shows an alarming upward turn in the average global temperature**

Celsius, then humanity would probably be able to cope.

Failing to do this, Mr Obama warned, increased the risk of "catastrophic" effects in the future, "not only real threats to food security, but also increases in conflict as a consequence of scarcity and greater refugee and migration patterns".

"If you think about monsoon patterns in the Indian subcontinent, maybe half a billion people rely on traditional rain patterns in those areas,"

Populations displaced by rising temperatures

A new study published in Nature: Climate Change has warned that up to 75% of the world's population could face deadly heat waves by 2100 unless greenhouse gas emissions are rapidly controlled.[16]. The following is an excerpt from the article:

"Here we conducted a global analysis of documented lethal heat events to identify the climatic conditions associated with human death and then quantified the current and projected occurrence of such deadly climatic conditions worldwide. We reviewed papers published between 1980 and 2014, and found 783 cases of excess human mortality associated with heat from 164 cities in 36 countries.

"Based on the climatic conditions of those lethal heat events, we identified a global threshold beyond which daily mean surface air temperature and relative humidity become deadly. Around 30% of the world's population is currently

[16]Mora, C. et al., *Global risk of deadly heat*, Nature: Climate Change, 19 June 2017

exposed to climatic conditions exceeding this deadly threshold for at least 20 days a year.

"By 2100, this percentage is projected to increase to 48% under a scenario with drastic reductions of greenhouse gas emissions and 74% under a scenario of growing emissions. An increasing threat to human life from excess heat now seems almost inevitable, but will be greatly aggravated if greenhouse gases are not considerably reduced." [17]

Populations displaced by war

A recent article in *The Guardian*[18] discusses the relationship between climate change and war, Here are some excerpts from the article:

"Climate change is set to cause a refugee crisis of 'unimaginable scale', according to senior military figures, who warn that global warming is the greatest security threat of the 21st century and that mass migration will become the 'new normal'.

"The generals said the impacts of climate change were already factors in the conflicts driving a current crisis of migration into Europe, having been linked to the Arab Spring, the war in Syria and the Boko Haram terrorist insurgency.

"Military leaders have long warned that global warming could multiply and accelerate security threats around the world by provoking conflicts and migration. They are now warning that immediate action is required.

"'Climate change is the greatest security threat of the 21st century,' said Maj Gen Muniruzzaman.

"Muniruzzaman, chairman of the Global Military Advisory Council on climate change and a former military adviser to the president of Bangladesh. He said one meter of sea level rise will flood 20% of his nation. 'We're going to see refugee problems on an unimaginable scale, potentially above 30 million people.'

"Previously, Bangladesh's finance minister, Abul Maal Abdul Muhith, called on Britain and other wealthy countries to accept millions of displaced people.

"Brig Gen Stephen Cheney, a member of the US Department of State's foreign affairs policy board and CEO of the American Security Project, said: 'Climate change could lead to a humanitarian crisis of epic proportions. We're already seeing migration of large numbers of people around the world because of food scarcity, water insecurity and extreme weather, and this is set to become the new normal'.

[17]See also https://phys.org/news/2017-08-deadly-south-asia-century.html and https://cleantechnica.com/2017/09/28/extreme-heatwaves-like-recent-lucifer-heatwave-become-normal-europe-2050s/

[18]Thursday, 1 December, 2016

9.13 Social values and levels of consumption

Let us next turn to the problem of reducing the per-capita consumption in the industrialized countries. The whole structure of western society seems designed to push its citizens in the opposite direction, towards ever-increasing levels of consumption. The mass media hold before us continually the ideal of a personal utopia filled with material goods. Every young man in a modern industrial society feels that he is a failure unless he fights his way to the "top"; and in recent years, women too have been drawn into this competition.

Of course not everyone can reach the top; there would not be room for everyone; but society urges all us to try, and we feel a sense of failure if we do not reach the goal. Thus, modern life has become a struggle of all against all for power and possessions.

One of the central problems in reducing consumption is that in our present economic and social theory, consumption has no upper bound; there is no definition of what is enough; there is no concept of a state where all of the real needs of a person have been satisfied. In our growth-oriented present-day economics, it is assumed that, no matter how much a person earns, he or she is always driven by a desire for more.

The phrase "conspicuous consumption" was invented by the Norwegian-American economist Thorstein Veblen (1857-1929) in order to describe the way in which our society uses economic waste as a symbol of social status. In "The Theory of the Leisure Class", first published in 1899, Veblen pointed out that it wrong to believe that human economic behavior is rational, or that it can be understood in terms of classical economic theory. To understand it, Veblen maintained, one might better make use of insights gained from anthropology, psychology, sociology, and history.

The sensation caused by the publication of Veblen's book, and the fact that his phrase, "conspicuous consumption", has become part of our language, indicate that his theory did not completely miss its mark. In fact, modern advertisers seem to be following Veblen's advice: Realizing that much of the output of our economy will be used for the purpose of establishing the social status of consumers, advertising agencies hire psychologists to appeal to the consumer's longing for a higher social position.

When possessions are used for the purpose of social competition, demand has no natural upper limit; it is then limited only by the size of the human ego, which, as we know, is boundless. This would be all to the good if unlimited economic growth were desirable. But today, when further industrial growth implies future collapse, western society urgently needs to find new values to replace our worship of power, our restless chase after excitement, and our admiration of excessive consumption.

Figure 9.14: **Growth-centered theories of economics have become a religion.**

The values which we need, both to protect nature from civilization and to protect civilization from itself, are perhaps not new: Perhaps it would be more correct to say that we need to rediscover ethical values which once were part of human culture, but which were lost during the process of industrialization, when technology allowed us to break traditional environmental constraints.

9.14 The transition to a sustainable economy

The Worldwatch Institute, Washington D.C., lists the following steps as necessary for the transition to sustainability[19]:

1. Stabilizing population
2. Shifting to renewable energy
3. Increasing energy efficiency
4. Recycling resources
5. Reforestation

[19]L.R. Brown and P. Shaw, 1982.

6. Soil Conservation

All of these steps are labor-intensive; and thus, wholehearted governmental commitment to the transition to sustainability can help to solve the problem of unemployment.

In much the same spirit that Roosevelt (with Keynes' approval) used governmental powers to end the great depression, we must now urge our governments to use their powers to promote sustainability and to reduce the trauma of the transition to a steady-state economy. For example, an increase in the taxes on fossil fuels could make a number of renewable energy technologies economically competitive; and higher taxes on motor fuels would be especially useful in promoting the necessary transition from private automobiles to bicycles and public transportation. Tax changes could also be helpful in motivating smaller families.

Governments already recognize their responsibility for education. In the future, they must also recognize their responsibility for helping young people to make a smooth transition from education to secure jobs. If jobs are scarce, work must be shared, in a spirit of solidarity, among those seeking employment; hours of work (and if necessary, living standards) must be reduced to insure a fair distribution of jobs. Market forces alone cannot achieve this. The powers of government are needed.

Economic activity is usually divided into two categories, 1) production of goods and 2) provision of services. It is the rate of production of goods that will be limited by the carrying capacity of the global environment. Services that have no environmental impact will not be constrained in this way. Thus a smooth transition to a sustainable economy will involve a shift of a large fraction the work force from the production of goods to the provision of services.

In his recent popular book *The Rise of the Creative Class*, the economist Richard Florida points out that in a number of prosperous cities - for example Stockholm - a large fraction of the population is already engaged in what might be called creative work - a type of work that uses few resources, and produces few waste products - work which develops knowledge and culture rather than producing material goods. For example, producing computer software requires few resources and results in few waste products. Thus it is an activity with a very small ecological footprint. Similarly, education, research, music, literature and art are all activities that do not weigh heavily on the carrying capacity of the global environment. Florida sees this as a pattern for the future, and maintains that everyone is capable of creativity. He visualizes the transition to a sustainable future economy as one in which a large fraction of the work force moves from industrial jobs to information-related work. Meanwhile, as Florida acknowledges, industrial workers feel uneasy and threatened by such trends.

Figure 9.15: **Renewable energy can support a modest life-style for a limited global population, but not the high-energy society that economists visualize. A transition to electric vehicles is not enough. We also must have fewer vehicles.**

9.15 Population and goods per capita

In the distant future, the finite carrying capacity of the global environment will impose limits on the amount of resource-using and waste-generating economic activity that it will be possible for the world to sustain. The consumption of goods per capita will be equal to this limited total economic activity divided by the number of people alive at that time. Thus, our descendants will have to choose whether they want to be very numerous and very poor, or less numerous and more comfortable, or very few and very rich. Perhaps the middle way will prove to be the best.

Given the fact that environmental carrying capacity will limit the sustainable level of resource-using economic activity to a fixed amount, average wealth in the distant future will be approximately inversely proportional to population over a certain range of population values.[20]

[20]Obviously, if the number of people is reduced to such an extent that it approaches zero, the average wealth will not approach infinity, since a certain level of population is needed to maintain a modern economy. However, if the global population becomes extremely large, the average wealth will indeed approach zero.

The Titanic as an allegory

*"Oh the ship set out from England, and they were not far from shore.
When the rich refused to associate with the poor,
So they put them down below, where they'd be the first to go,
It was sad when that great ship went down."* (folksong)

On April 15, 1912, the RMS Titanic sank on her maiden voyage, after colliding with an iceberg in the North Atlantic. She carried 2,223 passagers, among whom were some of the wealthiest people in the world, accommodated in unbelievable luxury in the upper parts of the ship. Available for the pleasure of the first class passengers were a gymnasium, swimming pool, libraries, luxurious restaurants and opulent cabins. Meanwhile, below, crammed on the lower decks below the water line, were about a thousand emigrants from England, Ireland and Scandinavia, seeking a new life in North America. The Titanic carried only lifeboats enough for 1178 people, but the ship had so many advanced safety features that it was thought to be unsinkable.

Why does the story of the Titanic fascinate us? Why was an enormously expensive film made about it? Why has a cruise ship recently retraced the Titanic's route? I think that the reason for our fascination with the story of the Titanic is that it serves as a symbol for the present state of modern society. We are all in the great modern ship together. On top are the enormously rich, enjoying a life of unprecedented luxury, below the poor. But rich and poor alike are in the same boat, headed for disaster - surrounded by the miracles of our technology, but headed for a disastrous collision with environmental forces, the forces of nature that we have neglected in our pride and arrogance.

The ancient Greeks were very conscious of the sin of pride - "hubris", and it played a large role in their religion and literature. What the Greeks meant can be seen by looking in Wikipedia where the following words appear:

"Hubris means extreme pride or arrogance. Hubris often indicates a loss of contact with reality, and an overestimation of one's own competence or capabilities, especially when the person exhibiting it is in a position of power.... The word is also used to describe actions of those who challenged the gods or their laws, especially in Greek tragedy, resulting in the protagonist's fall."

"...loss of contact with reality, and overestimation of one's own competence or capabilities, especially when the person exhibiting it is in a position of power..." Can we recognize this today? I think that we can.

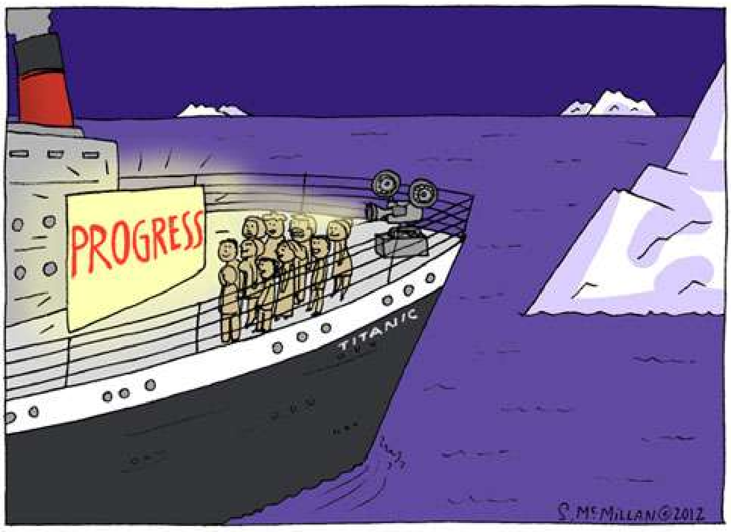

Figure 9.16: **The sinking of the Titanic can symbolize human overestimation of the power of technology and underestimation of the power of nature (hubris).**

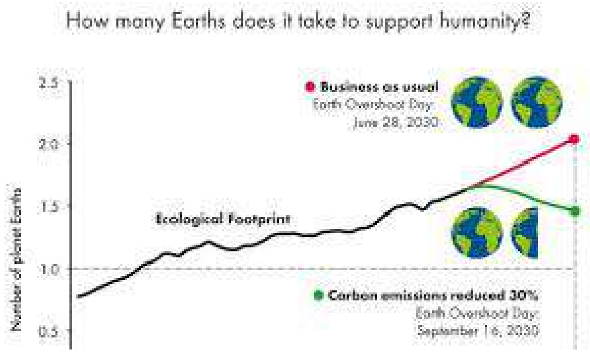

Figure 9.17: **We are already exceeding the carrying capacity of the earth by a factor of 1.6.**

Figure 9.18: **Overpopulation and overconsumption are destroying the global environment.**

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Chapter 10

RESPECT FOR NATURE

Hubris has replaced respect

Hunter-gatherers traditionally respected nature. However, when the agricultural revolution allowed humans to live in larger groups, respect for nature was forgotten, and and humankind began to be seen as the ruler of the natural world, rather as a part of it. We can see this attitude in the following excerpt from *Antigone*, by Aristophanes (c. 446 - c. 386 BC):

Numberless are the world's wonders, but none
More wonderful than man; the storm-gray sea
Yields to his prows, the huge crests bear him high;
Earth, holy and inexhaustible, is graven
With shining furrows where his plows have gone
Year after year, the timeless labor of stallions.
The light-boned birds and beasts that cling to cover,
The lithe fish lighting their reaches of dim water,
All are taken, tamed in the net of his mind;
The lion on the hill, the wild horse windy-maned,
Resign to him; and his blunt yoke has broken
The sultry shoulders of the mountain bull.
Words also, and thought as rapid as air,
He fashions to his good use; statecraft is his
And his the skill that deflects the arrows of snow...

Figure 10.1: **We must be the friend of nature. We must respect nature.**

10.1 Learning to live in harmony

New goals for education

Good education ought to make students well adapted to live in their environment. In the largest sense,"environment" means not only the family setting but also the political, economic and natural environments that surround young people as they grow up today. These environments have changed almost beyond recognition during the last few centuries; in fact, they have changed enormously during the last few decades, and consequently traditional education is in great need of revision. When Samuel Johnson visited the Birmingham factory where James Watt's newly-invented steam engines were being manufactured during the first stages of the Industrial Revolution, the owner proudly said to him, "I sell here, Sir, what all the world desires to have - Power!" Power, Growth, Dominance and Profit have been the traditional ideals of industrial society. However, it is doubtful whether they are appropriate ideals for the present and the future. In this section we will discuss the reasons why Harmony is a much better ideal and a better goal for education in the world of today.

Figure 10.2: **We are not the rulers of nature. We are a part of nature, on equal footing with plants and animals.**

Figure 10.3: **We must learn to derive more of our happiness from enjoyment of the beauty of the natural world.**

Figure 10.4: **Even the humblest living creature is worthy of our respect and wonder. This is what Albert Schweitzer meant when he spoke of "reverence for life".**

Loss of biodiversity

Tropical forests are being destroyed at an alarming rate, with a catastrophic loss of biodiversity. The burning of fossil fuels and the destruction of tropical forests have produced an increase of carbon dioxide in the earth's atmosphere and a steadily increasing average global temperature. Tropical rain forests are thought to be the habitat of more than half of the world's species of plants, animals and insects; and their destruction is accompanied by an alarming rate of extinction of species. The Harvard biologist, E.O. Wilson, estimates that the rate of extinction resulting from deforestation in the tropics may now exceed 4,000 species per year - 10,000 times the natural background rate (*Scientific American*, September, 1989).

The enormous biological diversity of tropical rain forests has resulted from their stability. Unlike northern forests, which have been affected by glacial epochs, tropical forests have existed undisturbed for millions of years. As a result, complex and fragile ecological systems have had a chance to develop. Professor Wilson expresses this in the following words: *Fragile superstructures of species build up when the environment remains stable enough to support their evolution during long periods of time. Biologists now know that biotas, like houses of cards, can be brought tumbling down by relatively small perturbations in the physical environment. They are not robust at all.*

The number of species which we have until now domesticated or used in medicine is very small compared with the number of potentially useful species still waiting in the world's tropical rain forests. When we destroy them, we damage our future. But we ought to regard the annual loss of thousands of species as a tragedy, not only because biological diversity is potential wealth for human society, but also because every form of life deserves our respect and protection.

Every year, more than 100,000 square kilometers of rain forest are cleared and burned, an area which corresponds to that of Switzerland and the Netherlands combined. Almost half of the world's tropical forests have already been destroyed. Ironically, the land thus cleared often becomes unsuitable for agriculture within a few years.

Tropical soils may seem to be fertile when covered with luxuriant vegetation, but they are usually very poor in nutrients because of leeching by heavy rains. The nutrients which remain are contained in the vegetation itself; and when the forest cover is cut and burned, they are rapidly leached away. Often the remaining soil is rich in aluminum oxide and iron oxide. When such soils are exposed to oxygen and sun-baking, a rocklike substance called laterite is formed. The temples of Angkor Wat in Cambodia are built of laterite; and it is thought that the Khmer civilization, which built these temples a thousand years ago, disappeared because of laterization of the soil.

The mathematical properties of exponential growth

Our economists, whose education is based on the assumptions of Adam Smith and other economic thinkers of the early Industrial Revolution, still continue to regard Growth as the Holy Grail. A 5% rate of growth is considered to be the mark of a healthy economy. This blind faith in growth can only be maintained by ignoring not only the rapid approach of the global economy to limits imposed by the carrying capacity of the earth's environment, but also by ignoring the mathematical properties of exponential growth. Economists apparently refuse to look more than a decade or so into the future. What they would see, if they looked a little farther, is that a 5 percent rate of growth implies that whatever is growing will double in 14 years, grow by a factor of 132 in a century, by a factor of 17,292 in two centuries, by a factor of 2,273,996 in three centuries, and so on. Thus, in the long run, economic growth cannot possibly be sustainable; nor can population growth be sustainable, as can be seen from the mathematics of any type of exponential growth.

The goals of education, especially the education of economists, need to be changed in such a way as to include a realistic picture of today's world. All students, especially economists, must learn the fact that in the long run neither population growth nor economic growth is sustainable. A new kind of economics should be taught - not "empty world" economics but "full world" economics; not the economics of growth but the economics of equilibrium and stability.

The social impact of science

Let us consider some other ways in which the world is changing, all of which imply a need for new goals in education. Science and technology have developed extremely rapidly in recent decades, and they will undoubtedly continue to do so in the future. The result has been that humans now have an unprecedented and constantly increasing power over nature, which can be used for both good and evil. Science has given us the possibility of a life free from hunger and free from the constant threat of death through infectious disease. At the same time, however, our constantly accelerating technology has given us the possibility of destroying civilization in a thermonuclear war.

Since it is almost impossible to prevent science from making new discoveries that can be used both constructively and disastrously, one of the new goals of education must be to give voters the knowledge needed to choose wisely the among ways in which our enormous new powers over nature can to be used. This implies that some familiarity with science is needed even for students who specialize in the humanities. A study of the history and social impact of science ought to be part of the education of both scientists and humanists. This should include discussions of global problems and ethical dilemmas related to scientific and technological progress. Scientists also need some background in the humanities in order to see their work as part of a larger picture.

Global ethics

Traditional education has always tried to produce patriotism in its students. This may once have been a reasonable goal, but today a broader view than narrow nationalism is needed. Global interdependence and communication have increased to such an extent that the absolutely sovereign nation-state has become a dangerous anachronism. If the disaster of a third world war is to be avoided, structures of government and law must be built up at an international level. One of the new goals for education should be to prepare students for this great task. Today's students need a global ethic - a loyalty to humanity as a whole, rather that a narrowly nationalistic loyalty.

History has traditionally been taught in such a way that ones own nation is seen as being heroic and always in the right. History textbooks also emphasizes power, dominance and military conflicts. A reformed teaching of history might instead be a chronicle of the gradual cultural advances of humankind as a whole, giving adequate recognition to the contributions of all nations and peoples, and giving weight to constructive achievements rather than to power struggles and conflicts.

10.2 Learning from pre-industrial cultures

The era of colonialism has left the industrialized countries with a rather arrogant attitude towards other cultures. Although formal political colonialism has almost entirely vanished, many of the assumptions of the colonial era persist and are strongly supported by the mainstream mass media. It is assumed by many people in the industrialized North that if the developing countries would only learn mass production, modern farming techniques and a modern lifestyle, all would be well. However, a sustainable global future may require a transfer of knowledge, techniques and attitudes in precisely the opposite direction - from pre-industrial societies to highly industrialized ones. The reason for this is that the older societies have cultures that allow them to live in harmony with nature, and this is exactly what the highly industrial North must learn to do.

Industrialism and the rapid development of science and technology have given some parts of the world a 200-year period of unbroken expansion and growth, but today this growth is headed for a collision with a wall-like barrier - limits set by the carrying capacity of the global environment and by the exhaustion of non-renewable resources. Encountering these limits is a new experience for the the industrialized countries. By contrast, pre-industrial societies have always experienced limits. The industrialized world must soon replace the economics of growth with equilibrium economics. Pre-industrial societies have already learned to live in equilibrium - in harmony with nature.

Like biodiversity, cultural diversity is an extremely valuable resource, and for similar reasons. A large genetic pool gives living organisms the flexibility needed to adapt to changes in the environment. Similarly, cultural diversity can give humans the flexibility needed to cope with change. In the changed world of today (changed by the invention of thermonuclear weapons and by the extraordinary growth of global population and commerce) we urgently need to learn to live in harmony, in harmony with ourselves, in harmony with nature, and in harmony with other members of our species. We can do this if we draw on the full human heritage of cultural diversity. We can draw not only on the knowledge and wisdom of presently existing societies, but also on the experiences and ideas of societies of the past

- **The Pythagorean concept of harmony**: In the ancient world, the concept of harmony was developed to a high level by the Pythagoreans. The Pythagoreans used the idea of harmony to understand medicine, music, mathematics and ethics.

- **The concept of harmony in Chinese civilization**: Chinese civilization is very ancient, and it has made many extremely important contributions to the cultural heritage of the world - for example, the invention of paper, ink, printing and the magnetic compass. Agriculture began in China as early as 6,000 B.C. The art of working in bronze was developed in China during the Shang dynasty (1,500 B.C. - 1,100 B.C.) and it reached a high pitch of excellence in the Chou dynasty (1,100 B.C. - 250 B.C.).

Taoist and Confucian teachings each emphasized a particular aspect of harmony. Taoism emphasized harmony with nature, while Confucianism taught harmonious relationships between humans. Thus in China, harmony became an ideal advocated by both traditions. The Chinese respect for harmony as an ideal can be seen, for example, in the beautiful Temple of Divine Harmony in Beijing.

- **India**: Both Hindu and Buddhist traditions emphasize the unity of all life on earth. Hindus regard killing an animal as a sin, and many try to avoid accidentally stepping on insects as they walk. (The Hindu and Buddhist picture of the relatedness of all life on earth has been confirmed by modern biological science. We now know that all living organisms have the same fundamental biochemistry, based on DNA, RNA, proteins and polysaccharides, and we know that our own human genomes are more similar to than different from the genomes of our close relations in the animal world.)

  The peoples of the industrialized nations urgently need to acquire a non-anthropocentric element in their ethics, similar to reverence for all life found in the Hindu and Buddhist traditions, as well as in the teachings of Saint Francis of Assisi and Albert Schweitzer. We need to learn to value other species for their own sakes, and not because we expect to use them for our own economic goals.

  The Buddhist concept of karma has great value in human relations. The word "karma" means simply "action". In Buddhism, one believes that actions return to the actor. Good actions will be returned, and bad actions will also be returned. This is obviously true in social relationships. If we behave with kindness and generosity to our neighbors, they will return our kindness. Conversely, a harmful act may lead to a vicious circle of revenge and counter-revenge which can only be broken by returning good for evil. However the concept of karma has a broader and more abstract validity beyond the direct return of actions to the actor.

  When we perform a good action, we increase the total amount of good karma in the world. If all people similarly behave well, the the world as a whole will become more pleasant and more safe. Human nature seems to have a built-in recognition of this fact, and we are rewarded by inner happiness when we perform good and kind actions. In his wonderful book, "Ancient Wisdom, Modern World", the Dalai Lama says that good actions lead to happiness and bad actions to unhappiness even if our neighbors do not return these actions. Inner peace, he tells us, is incompatible with bad karma and can be achieved only through good karma, i.e. good actions.

- **Harmony with nature in the Native American culture**: The attitude towards nature of the Sioux can be seen from the following quotations from Land of the Spotted Eagle by the Lakota (Western Sioux) chief, Standing Bear (ca. 1834 - 1908):

  The Lakota was a true lover of Nature. He loved the earth and all things of the earth... From Waken Tanka (the Great Spirit) there came a great unifying life force that flowered in and through all things - the flowers of the plains, blowing winds, rocks, trees, birds, animals - and was the same force that had been breathed into the first man. Thus all things were kindred and were brought together by the same Great Mystery.

  The animal had rights - the right of man's protection, the right to live, the right to multiply, the right to freedom, and the right to man's indebtedness - and in recognition of these rights the Lakota never enslaved the animal, and spared all life that was not needed for food and clothing.

  This concept of life was humanizing and gave to the Lakota an abiding love. It filled his being with the joy and mystery of things; it gave him reverence for all life; it made a place for all things in the scheme of existence with equal importance to all. The Lakota could despise no creature, for all were one blood, made by the same hand, and filled with the essence of the Great Mystery.

  A similar attitude towards nature can be found in traditional Inuit cultures.

- **St. Francis of Assisi (1181-1226) and Mahatma Gandhi (1869-1948)**: There are similarities between the doctrines of these two great ethical teachers. Both came from wealthy families, but during the course of their lives they acquired strong sympathy with the poor and rejected excessive attachment to worldly goods. Both dressed in the simplest possible rough homespun clothes. (Gandhi said, "Live simply that others may simply live.") Both taught peace between humans and kindness to all life. St. Francis is said to have preached sermons to the birds; Gandhi personally took care of sick animals in his ashram.

- **Respect for nature in African cultures**: In some parts of Africa, a man who plans to cut down a tree offers a prayer of apology, telling the tree why necessity has forced him to harm it. This pre-industrial attitude is something from which the industrialized North could learn. In industrial societies, land “belongs” to some one, and the owner has the “right” to ruin the land or to kill the communities of creatures living on it if this happens to give some economic advantage, in much the same way that a Roman slaveowner was thought to have the “right” to kill his slaves. Pre-industrial societies have a much less rapacious and much more custodial attitude towards the land and towards its non-human inhabitants.

- **Preservation of the land for future generations**: Many traditional agricultural societies have an ethical code that requires them to preserve the fertility of the land for future generations. This recognition of a duty towards the distant future is in strong contrast to the shortsightedness of modern economists. For example, John Maynard Keynes has been quoted as saying “In the long run, we will all be dead”, meaning that we need not look that far ahead. By contrast, members of traditional agricultural societies recognize that their duties extend far into the distant future, since their descendants will still be alive.

The pre-industrial societies and ethical teachers mentioned above have much to tell us about how to achieve harmony with ourselves, harmony with nature, and harmony with other members of our own species. Of course is is necessary to learn from the best aspects of each culture and not the worst. Also we must remember that the population of the world is now so large that a complete return to a pre-industrial way of life would not be possible. However, some of the values and attitudes of pre-industrial cultures can help us to an awareness of what it will take to achieve a truly sustainable global society.

The advertising-driven orgies of consumerism that characterize modern market economies cannot be extended into the distant future because of limitations that will be imposed by exhaustion of non-renewable resources and by the limited carrying capacity of the global environment. Therefore we need to stop using material goods as a measure of merit. Gandhi deliberately reduced his possessions to a minimum in order to demonstrate that merit and goods are not synonymous. St. Francis did the same. We can learn from them, and from the values of pre-industrial societies, to stop worshiping the false ideals, **Power, Dominance, Growth**, and **Profit**. Instead we must learn to live in **Harmony**.

10.3 The earth is our mother

The World People's Conference on Climate Change and the Rights of Mother Earth

This conference took place in Tiquipaya, just outside the city of Cochabamba, Bolivia, from April 19-22, 2010. The event was attended by around 30,000 people from over 100 countries. It was hosted by the Bolivian government, and the proceedings were transmitted online by the organizations OneClimate and Global Campaign for Climate Action.

One of the outstanding results of the conference was the drafting of a Universal Declaration of the Rights of Mother Earth, modeled on the United Nations' Universal Declaration of Human Rights. Both Declarations might be criticized for being unrealistic,[1] but both have great normative value. They define the goals towards which we ought to be striving.

Proposed Universal Declaration of the Rights of Mother Earth[2]

Preamble

We, the peoples and nations of Earth:

- *considering that we are all part of Mother Earth, an indivisible, living community of interrelated and interdependent beings with a common destiny;*
- *gratefully acknowledging that Mother Earth is the source of life, nourishment and learning and provides everything we need to live well;*
- *recognizing that the capitalist system and all forms of depredation, exploitation, abuse and contamination have caused great destruction, degradation and disruption of Mother Earth, putting life as we know it today at risk through phenomena such as climate change;*
- *convinced that in an interdependent living community it is not possible to recognize the rights of only human beings without causing an imbalance within Mother Earth;*

[1] https://www.transcend.org/tms/2012/12/human-rights-a-letter-to-santa-claus/

[2] https://www.theguardian.com/environment/2011/apr/10/bolivia-enshrines-natural-worlds-rights
https://pwccc.wordpress.com

- *affirming that to guarantee human rights it is necessary to recognize and defend the rights of Mother Earth and all beings in her and that there are existing cultures, practices and laws that do so;*

- *conscious of the urgency of taking decisive, collective action to transform structures and systems that cause climate change and other threats to Mother Earth;*

- *proclaim this Universal Declaration of the Rights of Mother Earth, and call on the General Assembly of the United Nation to adopt it, as a common standard of achievement for all peoples and all nations of the world, and to the end that every individual and institution takes responsibility for promoting through teaching, education, and consciousness raising, respect for the rights recognized in this Declaration and ensure through prompt and progressive measures and mechanisms, national and international, their universal and effective recognition and observance among all peoples and States in the world.*

Article 1: Mother Earth

1. *Mother Earth is a living being.*

2. *Mother Earth is a unique, indivisible, self-regulating community of interrelated beings that sustains, contains and reproduces all beings.*

3. *Each being is defined by its relationships as an integral part of Mother Earth.*

4. *The inherent rights of Mother Earth are inalienable in that they arise from the same source as existence.*

5. *Mother Earth and all beings are entitled to all the inherent rights recognized in this Declaration without distinction of any kind, such as may be made between organic and inorganic beings, species, origin, use to human beings, or any other status.*

6. *Just as human beings have human rights, all other beings also have rights which are specific to their species or kind and appropriate for their role and function within the communities within which they exist.*

7. *The rights of each being are limited by the rights of other beings and any conflict between their rights must be resolved in a way that maintains the integrity, balance and health of Mother Earth.*

Article 2. Inherent Rights of Mother Earth

1. *Mother Earth and all beings of which she is composed have the following inherent rights:*

    (a) *the right to life and to exist;*

    (b) *the right to be respected;*

    (c) *the right to regenerate its bio-capacity and to continue its vital cycles and processes free from human disruptions;*

    (d) *the right to maintain its identity and integrity as a distinct, self-regulating and interrelated being;*

    (e) *the right to water as a source of life;*

    (f) *the right to clean air;*

    (g) *the right to integral health;*

    (h) *the right to be free from contamination, pollution and toxic or radioactive waste;*

    (i) *the right to not have its genetic structure modified or disrupted in a manner that threatens it integrity or vital and healthy functioning;*

    (j) *the right to full and prompt restoration the violation of the rights recognized in this Declaration caused by human activities;*

2. *Each being has the right to a place and to play its role in Mother Earth for her harmonious functioning.*

3. *Every being has the right to wellbeing and to live free from torture or cruel treatment by human beings.*

Article 3. Obligations of human beings to Mother Earth

1. *Every human being is responsible for respecting and living in harmony with Mother Earth.*

2. *Human beings, and all States guarantee peace and eliminate nuclear, chemical and biological weapons;*

    (a) *act in accordance with the rights and obligations recognized in this Declaration;*

    (b) *recognize and promote the full implementation and enforcement of the rights and obligations recognized in this Declaration;*

Figure 10.5: **The earth is our mother.**

(c) *promote and participate in learning, analysis, interpretation and communication about how to live in harmony with Mother Earth in accordance with this Declaration;*

(d) *ensure that the pursuit of human wellbeing contributes to the wellbeing of Mother Earth, now and in the future;*

(e) *establish and apply effective norms and laws for the defense, protection and conservation of the rights of Mother Earth;*

(f) *respect, protect, conserve and where necessary, restore the integrity, of the vital ecological cycles, processes and balances of Mother Earth;*

(g) *guarantee that the damages caused by human violations of the inherent rights recognized in this Declaration are rectified and that those responsible are held accountable for restoring the integrity and health of Mother Earth;*

(h) *empower human beings and institutions to defend the rights of Mother Earth and of all beings;*

(i) *establish precautionary and restrictive measures to prevent human activities from causing species extinction, the destruction of ecosystems or the disruption of ecological cycles;*

(j) *guarantee peace and eliminate nuclear, chemical and biological weapons;*

(k) *promote and support practices of respect for Mother Earth and all beings, in accordance with their own cultures, traditions and customs;*

(l) *promote economic systems that are in harmony with Mother Earth and in accordance with the rights recognized in this Declaration.*

Article 4: Definitions

1. *The term "being" includes ecosystems, natural communities, species and all other natural entities which exist as part of Mother Earth.*

2. *Nothing in this Declaration restricts the recognition of other inherent rights of all beings or specified beings.*

Figure 10.6: **Love and respect Mother Earth.**

Figure 10.7: **We need reverence for all life, and even reverence for inanimate nature. We need respect and love for Mother Earth. She will return out love.**

10.4 Crimes against indigenous peoples

Our older brothers can help us today

The distinguished English author Anne Baring describes the indigenous peoples of the world as our "older brothers". They are anxious to give their "younger brothers" (us) advice about how to preserve the earth, rather than destroying it. But we do not listen. Instead, we murder them because of greed, because we want to take their land.

Genocides in the Americas

Instances of genocide stain much of human history. Readers of Charles Darwin's book describing "The Voyage of the Beagle" will remember his horrifying account of General Rosas' genocidal war against the Amerind population of Argentina. Similar genocidal violence has been experienced by indigenous peoples throughout South and Central America, and indeed throughout the world.

In general, the cultures of indigenous peoples require much land, and greed for this land is the motive for violence against them. However, the genetic and cultural heritage of indigenous peoples can potentially be of enormous value to humanity, and great efforts should be made to protect them.

In North America, we can recall that military commanders, such as Lord Jeffrey Amherst, deliberately innoculated the Indians with smallpox by giving them blankets from smallpox hospitals. Amherst wrote to his associate, Colonel Henry Bouquet "You will do well to try to inoculate the Indians, by means of blankets, as well as to try every other method that can serve to extirpate this execrable race." This is clearly an instance of genocide, as well as being an example of the use of biological weapons.

The website of the Holocaust Museum Houston states that "Civil war existed in Guatemala since the early 1960s due to inequalities existing in the economic and political life. In the 1970s, the Maya began participating in protests against the repressive government, demanding greater equality and inclusion of the Mayan language and culture. In 1980, the Guatemalan army instituted "Operation Sophia," which aimed at ending insurgent guerrilla warfare by destroying the civilian base in which they hid. This program specifically targeted the Mayan population, who were believed to be supporting the guerilla movement. Over the next three years, the army destroyed 626 villages, killed or 'disappeared' more than 200,000 people and displaced an additional 1.5 million, while more than 150,000 were driven to seek refuge in Mexico. Forced disappearance policies included secretly arresting or abducting people,

Figure 10.8: **The atrocities they committed by the "conquistadors" over the course of three centuries are far too many to be listed here, but there are some that stand out. In the Caribbean, most of the native populations were completely wiped out due to Spanish rapine and diseases. In Mexico, Hernan Cortes and Pedro de Alvarado ordered the Cholula Massacre and the Temple Massacre respectively, killing thousands of unarmed men, women and children. In Peru, Francisco Pizarro captured Emperor Atahualpa in the midst of an unprovoked bloodbath at Cajamarca. Wherever the conquistadors went, death and misery for the natives followed.**

who were often killed and buried in unmarked graves."

Persistent effects of colonialism

Part of the extreme economic inequality that exists in today's world is due to colonial and neocolonial wars.

The Industrial Revolution opened up an enormous gap in military strength between the industrialized nations and the rest of the world. Taking advantage of their superior weaponry, Europe, the United States and Japan rapidly carved up the remainder of the world into colonies, which acted as sources of raw materials and food, and as markets for manufactured goods. Between 1800 and 1914, the percentage of the earth under the domination of colonial powers increased to 85 percent, if former colonies are included.

The English economist and Fabian, John Atkinson Hobson (1858-1940), offered a famous explanation of the colonial era in his book "Imperialism: A Study" (1902). According to Hobson, the basic problem that led to colonial expansion was an excessively unequal distribution of incomes in the industrialized countries. The result of this unequal distribution was that neither the rich nor the poor could buy back the total output of their society. The incomes of the poor were insufficient, and rich were too few in number. The rich had finite needs, and tended to reinvest their money. As Hobson pointed out, reinvestment in new factories only made the situation worse by increasing output.

Hobson had been sent as a reporter by the Manchester Guardian to cover the Second Boer War. His experiences had convinced him that colonial wars have an economic motive. Such wars are fought, he believed, to facilitate investment of the excess money of the rich in African or Asian plantations and mines, and to make possible the overseas sale of excess manufactured goods. Hobson believed imperialism to be immoral, since it entails suffering both among colonial peoples and among the poor of the industrial nations. The cure that he recommended was a more equal distribution of incomes in the manufacturing countries.

Neocolonialism?

In his book, *Neocolonialism, The Last Stage of Imperialism* (Thomas Nielsen, London, 1965), Kwami Nkrumah defined neocolonialism with the following words: "The essence of neocolonialism is that the State which is subject to it is, in theory independent, and has all the outward trappings of international sovereignty. In reality its economic system and thus its political policy is directed from the outside. The methods and form of this direction can take various shapes. For example, in an extreme case, the troops of the imperial power may garrison the territory of the neocolonial State and control the government of it. More often, however, neocolonial control is exercised through monetary means... The struggle against neocolonialism is not aimed at excluding the capital of the developed world from operating in less developed countries. It is aimed at preventing the financial power of the developed countries from being used in such a way as to impoverish the less developed."

The resource curse

The way in which the industrialized countries maintain their control over less developed nations can be illustrated by the "resource curse", i.e. the fact that resource-rich developing countries are no better off economically than those that lack resources, but are cursed with corrupt and undemocratic governments. This is because foreign corporations extracting local resources under unfair agreements exist in a symbiotic relationship with corrupt local officials.

One might think that taxation of foreign resource-extracting firms would provide developing countries with large incomes. However, there is at present no international law governing multinational tax arrangements. These are usually agreed to on a bilateral basis, and the industrialized countries have stronger bargaining powers in arranging the bilateral agreements.

Racism, colonialism and exceptionalism

It seems to be possible for nations, and the majority of their citizens, to commit the worst imaginable atrocities, including torture, murder and genocide, while feeling that what they are doing is both noble and good. Some understanding of how this is possible can be gained by watching the 3-part BBC documentary, "The History of Racism".

The series was broadcast by BBC Four in March 2007. and videos of the broadcasts are available on the Internet. Watching this eye-opening documentary can give us much insight into the link between racism and colonialism. We can also begin to see how both racism and colonialism are linked to exceptionalism and neocolonialism.

Looking at the BBC documentary we can see how often in human history economic greed and colonial exploitation have been justified by racist theories. The documentary describes almost unbelievable cruelties committed against the peoples of the Americas and Africa by Europeans. For example, in the Congo, a vast region which King Leopold II of Belgium claimed as his private property, the women of villages were held as hostages while the men were forced to gather rubber in the forests. Since neither the men nor the women could produce food under these circumstances, starvation was the result.

Leopold's private army of 90,000 men were issued ammunition, and to make sure that they used it in the proper way, the army was ordered to cut off the hands of their victims and send them back as proof that the bullets had not been wasted. Human hands became a kind of currency, and hands were cut off from men, women and children when rubber quotas were not fulfilled. Sometimes more than a thousand human hands were gathered in a single day. During the rule of Leopold, roughly 10,000,000 Congolese were killed, which was approximately half the population of the region.

According to the racist theories that supported these atrocities, it was the duty of philanthropic Europeans like Leopold to bring civilization and the Christian religion to Africa. Similar theories were used to justify the genocides committed by Europeans against the native inhabitants of the Americas. Racist theories were also used to justify enormous cruelties committed by the

British colonial government in India. For example, during the great famine of 1876-1878, in which ten million people died, the Viceroy, Lord Lytton, oversaw the export from India to England of a record 6.4 million hundredweight of wheat.

Meanwhile, in Europe, almost everyone was proud of the role which they were playing in the world. All that they read in newspapers and in books or heard from the pulpits of their churches supported the idea that they were serving the non-Europeans by bringing them the benefits of civilization and Christianity. Kipling wrote: "Take up the White Man's burden, Send forth the best ye breed, Go bind your sons to exile, To serve your captives' need; To wait in heavy harness, On fluttered folk and wild, Your new-caught, sullen peoples, Half-devil and half-child." On the whole, the mood of Europe during this orgy of external cruelty and exploitation, was self-congratulatory.

Can we not see a parallel with the self-congratulatory mood of nations of today that export violence, murder, torture and neocolonialism to the whole world, and justify it by thinking of themselves as "exceptional"?

10.5 Realities of climate change

Predictions of drought in the Stern Review

According to a report presented to the Oxford Institute of Economic Policy by Sir Nicholas Stern on 31 January, 2006, areas likely to lose up to 30% of their rainfall by the 2050's because of climate change include much of the United States, Brazil, the Mediterranean region, Eastern Russia and Belarus, the Middle East, Southern Africa and Southern Australia. Meanwhile rainfall is predicted to increase up to 30% in Central Africa, Pakistan, India, Bangladesh, Siberia, and much of China.

Stern and his team point out that "We can... expect to see changes in the Indian monsoon, which could have a huge impact on the lives of hundreds of millions of people in India, Pakistan and Bangladesh. Most climate models suggest that the monsoon will change, although there is still uncertainty about exactly how. Nevertheless, small changes in the monsoon could have a huge impact. Today, a fluctuation of just 10% in either direction from average monsoon rainfall is known to cause either severe flooding or drought. A weak summer monsoon, for example, can lead to poor harvests and food shortages among the rural population - two-thirds of India's almost 1.1 billion people. Heavier-than-usual monsoon downpours can also have devastating consequences..."

In some regions, melting of glaciers can be serious from the standpoint of dry-season water supplies. For example, melts from glaciers in the Hindu Kush and the Himalayas now supply much of Asia, including China and India, with a dry-season water supply. Complete melting of these glacial systems would cause an exaggerated runoff for a few decades, after which there would be a drying out of some of the most densely populated regions of the world.

Ocean current changes and failure of monsoons

It is expected that climate change will affect ocean currents, and hence also affect monsoon rainfall. We are already experiencing a diversion of the Gulf Stream due to southward currents of cold water from melting ice in the Arctic. This has caused what is known as the *North Atlantic Anomaly.* While most regions of the world are experiencing rising temperatures, the North Atlantic and several northern European countries are exceptions to this rule, and have cooled. Complete failure of the Gulf Stream would lead to much colder temperatures in Europe.

Changes in ocean currents have already lead to the failure of the West African Monsoon, and this has already produced severe food insecurity in West Africa.

In the future, climate-changed ocean currents may lead to failures of monsoons in South-east Asia, and thus damage the food supply of almost two billion people.

Falling water tables around the world

Under many desert areas of the world are deeply buried water tables formed during glacial periods when the climate of these regions was wetter. These regions include the Middle East and large parts of Africa. Water can be withdrawn from such ancient reservoirs by deep wells and pumping, but only for a limited amount of time.

In oil-rich Saudi Arabia, petroenergy is used to drill wells for ancient water and to bring it to the surface. Much of this water is used to irrigate wheat fields, and this is done to such an extent that Saudi Arabia exports wheat. The country is, in effect, exporting its ancient heritage of water, a policy that it may, in time, regret. A similarly short-sighted project is Muammar Qaddafi's enormous pipeline, which will bring water from ancient sub-desert reservoirs to coastal cities.

In the United States, the great Ogallala aquifer is being overdrawn. This aquifer is an enormous stratum of water-saturated sand and gravel under-lying parts of northern Texas, Oklahoma, New Mexico, Kansas, Colorado, Nebraska, Wyoming and South Dakota. The average thickness of the aquifer is about

70 meters. The rate of water withdrawal from the aquifer exceeds the rate of recharge by a factor of eight.

Thus we can see that in many regions, the earth's present population is living on its inheritance of water, rather than its income. This fact, coupled with rapidly increasing populations and climate change, may contribute to a very serious food crisis partway through the 21st century.

Glacial melting and summer water supplies

The summer water supplies of both China and India are threatened by the melting of glaciers. The Gangotri glacier, which is the principle glacier feeding India's great Ganges River, is reported to be melting at an accelerating rate, and it could disappear within a few decades. If this happens,the Ganges could become seasonal, flowing only during the monsoon season. Chinese agriculture is also threatened by disappearing Himalayan glaciers, in this case those on the Tibet-Quinghai Plateau. The respected Chinese glaciologist Yao Tandong estimates that the glaciers feeding the Yangtze and Yellow Rivers are disappearing at the rate of 7% per year.[3]

Loss of Arctic sea ice

The melting of Arctic sea ice is taking place far more rapidly than was predicted by IPCC reports. David Wasdell, Director of the Apollo-Gaia Project, points out that the observed melting has been so rapid that within less than five years, the Arctic may be free of sea ice at the end of each summer. It will, of course continue to re-freeze during the winters, but the thickness and extent of the winter ice will diminish.

For January 2016, the satellite based data showed the lowest overall Arctic sea ice extent of any January since records begun in 1979. Bob Henson from *Wundergrund* commented: "Hand in hand with the skimpy ice cover, temperatures across the Arctic have been extraordinarily warm for midwinter. Just before New Year's, a slug of mild air pushed temperatures above freezing to within 200 miles of the North Pole. That warm pulse quickly dissipated, but it was followed by a series of intense North Atlantic cyclones that sent very mild air poleward, in tandem with a strongly negative Arctic Oscillation during the first three weeks of the month."

During some periods, Arctic temperatures have been 50^{o}C above normal for the time of year. Equally alarming is the fact that plumes of methane several

[3]http://www.commondreams.org/news/2015/08/04/global-glaciers-melting-three-times-rate-20th-century

km^2 in area have been observed bubbling up from the sea floor in the shallow ice-free seas north of Russia.[4]

Temperature and CO_2 in ice cores

Ice cores from the Greenland and Antarctic ice sheets and from glaciers have yielded valuable data on climate changes as far back as 800,000 years in the past. The ice cores show that there is a close correlation between global temperatures and the CO_2 content of the atmosphere. The cores also show that climatic changes can take place with great rapidity.

An article by Richard B. Alley in the Proceedings of the National Academy of Science (US) [5] Here is an excerpt from the article:

"Ice-core records show that climate changes in the past have been large, rapid, and synchronous over broad areas extending into low latitudes, with less variability over historical times. These ice-core records come from high mountain glaciers and the polar regions, including small ice caps and the large ice sheets of Greenland and Antarctica.

"As the world slid into and out of the last ice age, the general cooling and warming trends were punctuated by abrupt changes. Climate shifts up to half as large as the entire difference between ice age and modern conditions occurred over hemispheric or broader regions in mere years to decades. Such abrupt changes have been absent during the few key millennia when agriculture and industry have arisen. The speed, size, and extent of these abrupt changes required a reappraisal of climate stability. Records of these changes are especially clear in high-resolution ice cores. Ice cores can preserve histories of local climate (snowfall, temperature), regional (wind-blown dust, sea salt, etc.), and broader (trace gases in the air) conditions, on a common time scale, demonstrating synchrony of climate changes over broad regions."

Short-term sea level rise

The *National Geographic* recently published an article by Laura Parker entitled "Sea Level Rise Will Flood Hundreds of Cities in the Near Future+."[6] Here are a few excerpts from the article:

"Sea level rise caused by global warming is usually cast as a doomsday scenario that will play out so far into the future, it's easy to ignore. Just ask

[4] N. Shakhova et al., *Methane release on the Arctic East Siberian shelf* , Geophysical Research Abstracts, Vol.**9**, 01071, 2007

[5] Proc Natl Acad Sci U S A. 2000 Feb 15; 97(4): 1331-1334. PMCID: PMC34297

[6] http://news.nationalgeographic.com/2017/07/sea-level-rise-flood-global-warming-science/

anyone in South Florida, where new construction proceeds apace. Yet already, more than 90 coastal communities in the United States are battling chronic flooding, meaning the kind of flooding that's so unmanageable it prompts people to move away.

"That number is expected to roughly double to more than 170 communities in less than 20 years.

"Those new statistics, compiled in the first comprehensive mapping of the entire coastline of the Lower 48 states, paint a troubling picture, especially for the East and Gulf coasts, which are home to some of the nation's most populated areas.

"By the end of the century, chronic flooding will be occurring from Maine to Texas and along parts of the West Coast. It will affect as many as 670 coastal communities, including Cambridge, Massachusetts; Oakland, California; Miami and St. Petersburg, Florida; and four of the five boroughs of New York City. The magnitude of the coming calamity is so great, the ripple effects will reach far into the interior."

Just as an iceberg the size of Delaware broke away from an ice shelf in Antarctica Wednesday, July 12, 2017, scientists released findings that up to 668 U.S. communities could face chronic flooding from rising sea levels by the end of the century.

The Union of Concerned Scientists recently published a report entitled "When Rising Seas Hit Home: Hard Choices Ahead for Hundreds of US Coastal Communities"[7] The report states that "Chronic inundation will dramatically alter the landscape and the livability rise of just three feet would submerge the Maldives and make them uninhabitable of many coastal communities." rise of just three feet would submerge the Maldives and make them uninhabitable

Island nations threatened by rising oceans

The US National Academy of Sciences predictions from 2009 suggest that by 2100, sea level could increase by anywhere from 16 inches to 56 inches, depending how the Earth responds to changing climate.

The Maldives, consisting of over 1,100 islands to the west of India, is the world's lowest-lying nation. On average the islands are only 1.3 meters above sea level. The 325,000 (plus 100,000 expatriate workers who are not counted in the census) residents of the islands are threatened by rising sea levels. A rise of just three feet would submerge the Maldives and make them uninhabitable. Many island nations in the Pacific are also severely threatened by sea level rise.

[7]http://www.ucsusa.org/sites/default/files/attach/2017/07/when-rising-seas-hit-home-full-report.pdf

Displacement of populations in Southeast Asia

A World Bank press release has stated that "Bangladesh will be among the most affected countries in South Asia by an expected 2^{o}C rise in the world's average temperatures in the next decades, with rising sea levels and more extreme heat and more intense cyclones threatening food production, livelihoods, and infrastructure as well as slowing the reduction on poverty, according to a new scientific report released today by the World Bank Group.

" 'Bangladesh faces particularly severe challenges with climate change threatening its impressive progress in overcoming poverty,' said Johannes Zutt, World Bank Country Director for Bangladesh and Nepal. 'Bangladesh has demonstrated itself as a leader in moving the climate change agenda forward'"

"In Bangladesh, 40% of productive land is projected to be lost in the southern region of Bangladesh for a 65cm sea level rise by the 2080s. About 20 million people in the coastal areas of Bangladesh are already affected by salinity in drinking water. Rising sea levels and more intense cyclones and storm surges could intensify the contamination of groundwater and surface water causing more diarrhea outbreak."

Important rice-growing river delta regions of Viet Nam will also be lost during the present century.

Effects on the Netherlands, Danish islands, and Venice

Although the Netherlands, the Danish islands and Venice have had many years of experience in coping with floods due to high sea levels and storm surges, these European areas may have difficulties during the present century.

Greenland's icecap is melting much faster than was predicted by the IPCC, and sea level rise may exceed 100 cm. before 2100. Hurricanes are also becoming more severe, as has already been shown by Katrina and Sandy. Future hurricanes hitting Europe's Atlantic coasts will produce dangerous storm surges. In Venice, the danger from hurricanes is less severe, but Venice already experiences severe flooding and the rise of sea levels during the present century may endanger the priceless cultural monuments of the famous ancient city.

Long-term sea level rise

A 2012 article by Jevrejeva, S., Moore, J. C. and Grinsted, A. in the in the Journal of Global and Planetary Change[8] deals with sea level rise until 2500. Of course, the long-term future runs over hundreds of millennia, but nev-

[8]Volumes 80-81, January 2012, Pages 14.20

ertheless, the article, entitled "Sea level projections to AD2500 with a new generation of climate change scenarios" is of interest.

The article states that "Sea level rise over the coming centuries is perhaps the most damaging side of rising temperature. The economic costs and social consequences of coastal flooding and forced migration will probably be one of the dominant impacts of global warming. To date, however, few studies on infrastructure and socio-economic planning include provision for multi-century and multi-meter rises in mean sea level...

"We estimate sea level rise of 0.57 - 1.10 m by 2100 with four new RCP scenarios. Sea level will continue to rise for several centuries reaching 1.84 - 5.49 m by 2500. Due to long response time most rise is expected after stabilization of forcing. 200-400 years will require dropping the rate to the 1.8 mm/yr- 20th century average."

According to an article published by the Potsdam Institute for Climate Impact Research [9] "The Greenland ice sheet is likely to be more vulnerable to global warming than previously thought. The temperature threshold for melting the ice sheet completely is in the range of 0.8 to 3.2 degrees Celsius global warming, with a best estimate of 1.6 degrees above pre-industrial levels, shows a new study by scientists from the Potsdam Institute for Climate Impact Research (PIK) and the Universidad Complutense de Madrid. Today, already 0.8 degrees global warming has been observed. Substantial melting of land ice could contribute to long-term sea-level rise of several meters and therefore it potentially affects the lives of many millions of people.

"The time it takes before most of the ice in Greenland is lost strongly depends on the level of warming. 'The more we exceed the threshold, the faster it melts,' says Alexander Robinson, lead-author of the study now published in Nature Climate Change. In a business-as-usual scenario of greenhouse-gas emissions, in the long run humanity might be aiming at 8 degrees Celsius of global warming. This would result in one fifth of the ice sheet melting within 500 years and a complete loss in 2000 years, according to the study. 'This is not what one would call a rapid collapse,' says Robinson. 'However, compared to what has happened in our planet's history, it is fast. And we might already be approaching the critical threshold.'

"In contrast, if global warming would be limited to 2 degrees Celsius, complete melting would happen on a timescale of 50.000 years. Still, even within this temperature range often considered a global guardrail, the Greenland ice sheet is not secure. Previous research suggested a threshold in global temperature increase for melting the Greenland ice sheet of a best estimate of 3.1 degrees, with a range of 1.9 to 5.1 degrees. The new study's best estimate

[9]https://www.pik-potsdam.de/news/press-releases/archive/2012/gronlands-eismassen-konnten-komplett-schmelzen-bei-1-6-grad-globaler-erwarmung

indicates about half as much.

"'Our study shows that under certain conditions the melting of the Greenland ice sheet becomes irreversible. This supports the notion that the ice sheet is a tipping element in the Earth system,' says team-leader Andrey Ganopolski of PIK. 'If the global temperature significantly overshoots the threshold for a long time, the ice will continue melting and not re-grow - even if the climate would, after many thousand years, return to its preindustrial state- This is related to feedbacks between the climate and the ice sheet: The ice sheet is over 3000 meters thick and thus elevated into cooler altitudes. When it melts its surface comes down to lower altitudes with higher temperatures, which accelerates the melting. Also, the ice reflects a large part of solar radiation back into 'Our study shows that under certain conditions the melting of the Greenland ice sheet becomes irreversible. This supports the notion that the ice sheet is a tipping element in the Earth system,' says team-leader Andrey Ganopolski of PIK.'If the global temperature significantly overshoots the threshold for a long time, the ice will continue melting and not re-grow - even if the climate would, after many thousand years, return to its preindustrial state.' This is related to feedbacks between the climate and the ice sheet: The ice sheet is over 3000 meters thick and thus elevated into cooler altitudes. When it melts its surface comes down to lower altitudes with higher temperatures, which accelerates the melting. Also, the ice reflects a large part of solar radiation back into space. When the area covered by ice decreases, more radiation is absorbed and this adds to regional warming.space. When the area covered by ice decreases, more radiation is absorbed and this adds to regional warming."

Global warming and atmospheric water vapor

A feedback loop is a self-re-enforcing trend. One of the main positive feedback loops in global warming is the tendency of warming to increase the atmospheric saturation pressure for water vapor, and hence amount of water vapor in the atmosphere, which in turn leads to further warming, since water vapor is a greenhouse gas.

Wikipedia's article on greenhouse gases states that, "Water vapor accounts for the largest percentage of the greenhouse effect, between 36% and 66% for clear sky conditions and between 66% and 85% when including clouds."

The albedo effect

Albedo is defined to be the fraction of solar energy (shortwave radiation) reflected from the Earth back into space. It is a measure of the reflectivity of the earth's surface. Ice, especially with snow on top of it, has a high albedo:

most sunlight hitting the surface bounces back towards space.

Feedback from loss of sea ice

Especially in the Arctic and Antarctic regions, there exists a dangerous feedback loop involving the albedo of ice and snow. Arctic sea ice is rapidly disappearing. It is predicted that during the summers, the ice covering arctic seas may disappear entirely during the summers. As a consequence, incoming sunlight will encounter dark light-absorbing water surfaces rather than light-reflecting ice and snow.

This effect is self-re-enforcing. In other words, it is a feedback loop. The rising temperatures caused by the absorption of more solar radiation cause the melting of more ice, and hence even more absorption of radiation rather than reflection, still higher temperatures, more melting, and so on.

The feedback loop is further strengthened by the fact that water vapor acts like a greenhouse gas. As polar oceans become exposed, more water vapor enters the atmosphere, where it contributes to the greenhouse effect and rising temperatures.

Darkened snow on Greenland's icecap

Greenland's icecap is melting, and as it melts, the surface becomes darker and less reflective because particles of soot previously trapped in the snow and ice become exposed. This darkened surface absorbs an increased amount of solar radiation, and the result is accelerated melting.

The methane hydrate feedback loop

If we look at the distant future, by far the most dangerous feedback loop involves methane hydrates or methane clathrates. When organic matter is carried into the oceans by rivers, it decays to form methane. The methane then combines with water to form hydrate crystals, which are stable at the temperatures and pressures which currently exist on ocean floors. However, if the temperature rises, the crystals become unstable, and methane gas bubbles up to the surface. Methane is a greenhouse gas which is 70 times as potent as CO_2.

The worrying thing about the methane hydrate deposits on ocean floors is the enormous amount of carbon involved: roughly 10,000 gigatons. To put this huge amount into perspective, we can remember that the total amount of carbon in world CO2 emissions since 1751 has only been 337 gigatons.

A runaway, exponentially increasing, feedback loop involving methane hydrates could lead to one of the great geological extinction events that have periodically wiped out most of the animals and plants then living. This must be avoided at all costs.

A feedback loop from warming of soils

On October 6, 2017, the journal *Science* published an article entitled *Long-term pattern and magnitude of soil carbon feedback to the climate system in a warming world*[10]. The lead author, Jerry Melillo, is an ecologist working at the Marine Biological Laboratory, Woods Hole Massachusetts. In an interview with *Newsweek*, he said: "This self-reinforcing feedback is potentially a global phenomenon with soils, and once it starts it may be very difficult to turn off. It's that part of the problem that I think is sobering... We think that one of the things that may be happening is both a reorganization of the microbial community structure and its functional capacity,"

The study reported on three decades of observations of heated sections of a forest owned by Harvard University. The heated sections were 5^{o}C warmer than control sections.

Drying of forests and forest fires

According to a recent article in *Nature*[11],"Across the American west, the area burned each year has increased significantly over the past several decades, a trend that scientists attribute both to warming and drying and to a century of wildfire suppression and other human activities. Allen suggests that the intertwined forces of fire and climate change will take ecosystems into new territory, not only in the American west but also elsewhere around the world. In the Jemez, for example, it could transform much of the ponderosa pine (Pinus ponderosa) forest into shrub land. 'We're losing forests as we've known them for a very long time,' says Allen. 'We're on a different trajectory, and we're not yet sure where we're going.'

"All around the American west, scientists are seeing signs that fire and climate change are combining to create a 'new normal'. Ten years after Colorado's largest recorded fire burned 56,000 hectares southwest of Denver, the forest still has not rebounded in a 20,000-hectare patch in the middle, which was devastated by an intense crown fire. Only a few thousand hectares, which

[10] J.M. Melillo et al., *Long-term pattern and magnitude of soil carbon feedback to the climate system in a warming world*, Science, Vol. 358, pp. 101-105, (2017).

[11] http://www.nature.com/news/forest-fires-burn-out-1.11424

the US Forest Service replanted, look anything like the ponderosa-pine stands that previously dominated the landscape."

Tipping points and feedback loops

A tipping point is usually defined as the threshold for an abrupt and irreversible change[12]. To illustrate this idea, we can think of a book lying on a table. If we gradually push the book towards the edge of the table, we will finally reach a point after which more than half of the weight of the book will not be not supported by the table. When this "tipping point" is passed the situation will suddenly become unstable, and the book will fall to the floor. Analogously, as the earth's climate gradually changes, we may reach tipping points. If we pass these points, sudden instabilities and abrupt climatic changes will occur.

Greenland ice cores supply a record of temperatures in the past, and through geological evidence we have evidence of sea levels in past epochs. These historical records show that abrupt climatic changes have occurred in the past.

Timothy Michael Lenton, FRS, Professor of Climate Change and Earth System Science at he University of Exeter, lists the following examples of climatic tipping points:

- Boreal forest dieback
- Amazon rainforest dieback
- Loss of Arctic and Antarctic sea ice (Polar ice packs) and melting of Greenland and Antarctic ice sheets
- Disruption to Indian and West African monsoon
- Formation of Atlantic deep water near the Arctic ocean, which is a component process of the thermohaline circulation.
- Loss of permafrost, leading to potential Arctic methane release and clathrate gun effect

It can be seen from this list that climate tipping points are associated with feedback loops. For example, the boreal forest dieback and the Amazon rainforest dieback tipping points are associated with the feedback loop involving the drying of forests and forest fires, while the tipping point involving loss of

[12]Other definitions of tipping points are possible. A few authors define these as points beyond which change is inevitable, emphasizing that while inevitable, the change may be slow.

Figure 10.9: **Indigenous people marching in defense of Mother Earth.**

Arctic and Antarctic sea ice is associated with the Albedo effect feedback loop. The tipping point involving loss of permafrost is associated with the methane hydrate feedback loop.

Once a positive feedback loop starts to operate in earnest, change may be abrupt.

The UN Climate Change Summit, September, 2014

Delegates at the United Nations Climate Summit were shown images of the inspiring and heartfelt People's Climate March, which took place on Sunday, September 21st. The organizers of the march had expected 100,000 participants. In fact, more than 400,000 people came, and the march was unique in its artistic brilliance and its ethnic diversity. It was one of 2,600 events in 170 nations. The slogan of the march in New York was "To change everything, we need everyone", and in fact everyone came!

More than 400,000 people participated in New York's People's Climate March, and the march was unique in its artistic brilliance and its ethnic diversity. It was one of 2,600 events in 170 nations.

Figure 10.10: **Marchers in New York advocation action to prevent catastrophic climate change, September 21, 2014. The march supported the United Nations Climate Change Summit. Worldwide, 600,000 people marched, making this event the largest public climate change action in history.**

The Paris Climate Conference, 2015

WE NEED SYSTEM CHANGE, NOT CLIMATE CHANGE! Civil society, excluded from the COP21 conference by the French government, carried banners with this slogan on the streets of Paris. They did so in defiance of tear-gas-using black-clad police. System change has been the motto for climate marches throughout the world. Our entire system is leading us towards disaster, and this includes both economic and governmental establishments. To save human civilization, the biosphere and the future, the people of the world must take matters into their own hands and change the system.[13]

Our present situation is this: The future looks extremely dark because of human folly, especially the long-term future. The greatest threats are catastrophic climate change and thermonuclear war, but a large-scale global famine also has to be considered. All these threats are linked.

Inaction is not an option. We have to act with courage and dedication, even if the odds are against success, because the stakes are so high. The mass media could mobilize us to action, but they have failed in their duty. Our educational system could also wake us up and make us act, but it too has failed us. The battle to save the earth from human greed and folly has to be fought through non-violent action on the streets and in the alternative media.

We need a new economic system, a new society, a new social contract, a new way of life. Here are the great tasks that history has given to our generation: We must achieve a steady-state economic system. We must restore democracy. We must decrease economic inequality. We must break the power of corporate greed. We must leave fossil fuels in the ground. We must stabilize and ultimately reduce the global population. We must eliminate the institution of war. And finally, we must develop a more mature ethical system to match our new technology.[14]

What are the links between the problems facing us? There is a link between climate change and war. We need to leave fossil fuels in the ground if we are to avoid catastrophic climate change. But nevertheless, the stuggle for the world's last remaining oil and gas resources motivated the invasion of Iraq,

[13]http://www.commondreams.org/views/2015/12/11/we-are-out-time-we-need-leap
http://www.thenation.com/article/naomi-klein-sane-climate-policies-are-being-undermined-by-corporate-friendly-trade-deals/
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http://www.countercurrents.org/avery280914.htm

[14]http://www.fredsakademiet.dk/library/need.pdf

and it now motivates the war in Syria. Both of these brutal wars have caused an almost indescribable amount of suffering.

ISIS runs on oil, and the unconditional support of Saudi Arabia by the West is due to greed for oil. Furthermore, military establishments are among the largest users of oil, and the largest greenhouse gas emitters. Finally, the nearly 2 trillion dollars that the world now spends on armaments and war could be used instead to speed the urgently needed transition to 100% renewable energy, and to help less-developed countries to face the consequences of climate change.

There are reasons for hope. Both solar energy and wind energy are growing at a phenomenal rate, and the transition to 100% renewable energy could be achieved within a very few decades if this growth is maintained. But a level playing field is needed. At present fossil fuel corporations receive half a trillion dollars each year in subsidies. Nuclear power generation is also highly subsidized (and also closely linked to the danger of nuclear war). If these subsidies were abolished, or better yet, used to encourage renewable energy development, the renewables could win simply by being cheaper.[15]

We can also take inspiration from Pope Francis, whose humanitarian vision links the various problems facing us. Pope Francis also shows us what we can do to save the future, and to give both economics and government a social and ecological conscience.

None of us asked to be born in a time of crisis, but history has given great tasks to our generation. We must rise to meet the crisis. We must not fail in our duty to save the gifts of life and civilization that past generations have bequeathed to us.We must not fail in our duty future generations.

[15]http://eruditio.worldacademy.org/issue-5/article/urgent-need-renewable-energy
https://www.youtube.com/watch?v=MVwmi7HCmSI
https://www.youtube.com/watch?v=AjZaFjXfLec
https://www.youtube.com/watch?v=m6pFDu7lLV4
https://www.youtube.com/watch?v=MVwmi7HCmSI
http://therightsofnature.org/universal-declaration/

Figure 10.11: **An indigenous girl from South America advocating action to prevent environmental destruction and climate change.**

Figure 10.12: **Native peoples defending nature.**

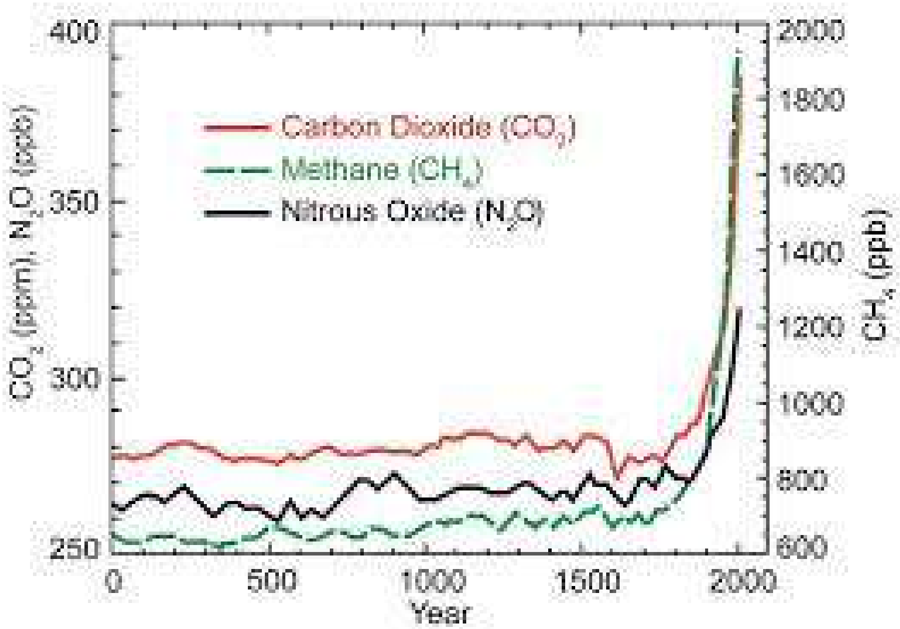

Figure 10.13: **Concentrations of the most important greenhouse gasses ploted as functions of time.**

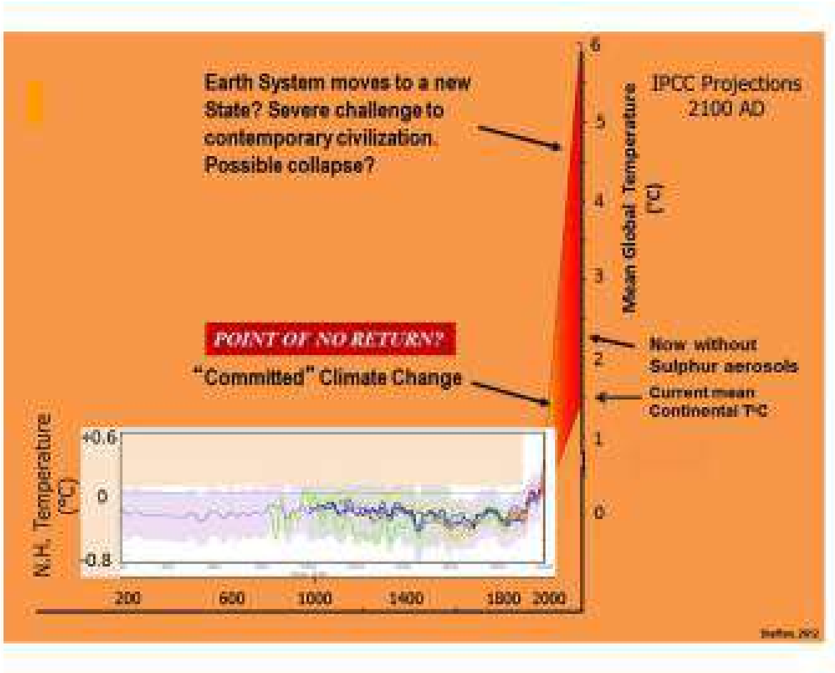

Figure 10.14: **Historical and predicted global temperatures.**

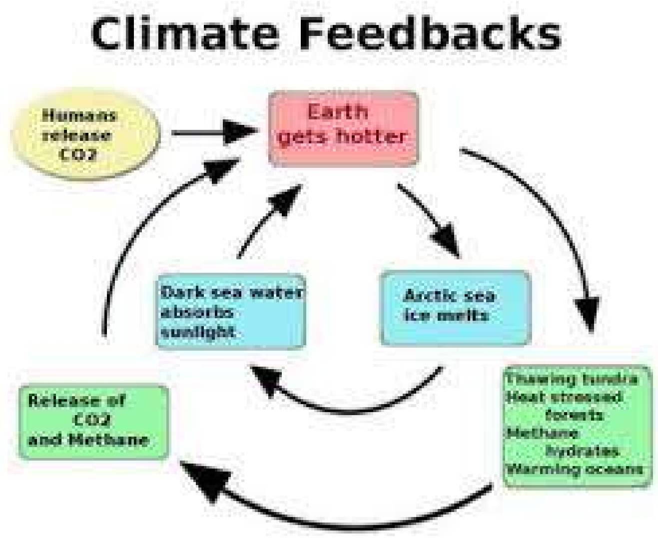

Figure 10.15: **Some of the feedback loops involved in climate change.**

Figure 10.16: **Climate change will produce severe droughts in regions that today produce much of the world's food.**

Figure 10.17: **Rising sea levels are already affecting vulnerable parts of the world.**

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Chapter 11

ETHICS FOR THE FUTURE

Science investigates, religion interprets. Science gives man knowledge, which is power; religion gives man wisdom, which is control. Science deals mainly with facts; religion deals mainly with values. The two are not rivals. Martin Luther King Jr.

11.1 Some goals for the future

History has given all of us living today an enormous responsibility, and several daunting tasks: If civilization is to survive, we must not only stabilize the global population and avoid catastrophic climate, but also, even more importantly, we must eliminate the institution of war.

We face these difficult tasks with an inherited emotional nature that has not changed much during the last 40,000 years. Furthermore, we face the challenges of the 21st century with an international political system based on the anachronistic concept of the absolutely sovereign nation-state. However, the human brain has shown itself to be capable of solving even the most profound and complex problems. The mind that has seen into the heart of the atom must not fail when confronted with paradoxes of the human heart.

We must replace the old world of international anarchy, chronic war and institutionalized injustice, by a new world of law. The United Nations Charter, the Universal Declaration of Human Rights and the International Criminal Court are steps in the right direction, but these institutions need to be greatly strengthened and reformed.

We also need a new global ethic, where loyalty to one's family and nation will be supplemented by a higher loyalty to humanity as a whole.

In the words of the great Hungarian-American biochemist Albert Szent-Györgyi, "Man lives in a new cosmic world for which he was not made. His survival depends on how well and how fast he can adapt himself to it, rebuilding all his ideas, all his social and political institutions. ...Modern science has abolished time and distance as factors separating nations. On our shrunken globe today, there is room for one group only - the family of man."

The Russell-Einstein Manifesto of 1955, which led to the founding of Pugwash Conferences on Science and World Affairs, contains the following words: "There lies before us, if we choose, continual progress in happiness, knowledge, and wisdom. Shall we, instead, choose death, because we cannot forget our quarrels? We appeal as human beings to human beings: Remember your humanity, and forget the rest."

Strengthening the United Nations

The problem of building a stable, just, and war-free world is difficult, but it is not impossible. The large regions of our present-day world within which war has been eliminated can serve as models. There are a number of large countries with heterogeneous populations within which it has been possible to achieve internal peace and social cohesion, and if this is possible within such extremely large regions, it must also be possible globally.

When we ask how very large and heterogeneous states achieve internal peace and security, we find that they do so by means of laws that act directly on individual citizens. Thus, the International Criminal Court is an extremely important first step towards the globalization of the methods of governance used by large states. The power to make and enforce laws which act directly on individuals is one of the key powers of successful federations.

An extremely important first step towards strengthening the United Nations would be to give the U.N. a greatly enlarged and reliable source of income. The amount of money available to the U.N., and its member organizations such as UNESCO, WHO and FAO, should be increased by a factor of at least 50. The beneficial services rendered by expanded agencies such as WHO would give the U.N. *de facto* power and prestige that could be used in situations where conflict resolution is needed.

Various sources of increased income have been proposed:

- Dues paid to the U.N. by member states. These should be compulsory in the sense that member states would lose their voting rights if they did not pay their dues.

- Revenues from resources belonging to the international community, for example sea-bed resources.

- A tax on multinational corporations for the service of regulating international agreements.

- The Tobin tax, i.e. a tax of between 0.1% and 1% on international currency transactions.

12 European countries favor the Tobin tax. These include France and Germany, although not the U.K.

Tobin taxes are in place in some of the world's fastest-growing financial centers - Hong Kong, Mumbai, Seoul, Johannesburg and Taipei - where they are said to collectively raise 12 billion U.K. pounds a year.

The volume of international currency transactions is so enormous that a universally imposed Tobin tax of only 0.5% would raise between $100 billion and $300 billion per year. In 2015 the total UN budget was only $5.6 billion, an absurdly small sum, considering the enormous importance of global governance, or the fact that the world spends $1.7 trillion each year on armaments..

11.2 The ethics of Mahatma Gandhi

If humans are ever to achieve a stable global society in the future, they will have to become much more modest in their economic behavior and much more peaceful in their politics. For both modesty and peace, Gandhi is a useful source of ideas. The problems with which he struggled during his lifetime are extremely relevant to us in the 21st Century, when both nuclear and ecological catastrophes threaten the world.

Avoiding escalation of conflicts

Today we read almost every day of killings that are part of escalating cycles of revenge and counter-revenge, for example in the Middle East. Gandhi's experiences both in South Africa and in India convinced him that such cycles could only be ended by unilateral acts of kindness and understanding from one of the parties in a conflict. He said, "An eye for an eye makes the whole world blind".

To the insidious argument that "the end justifies the means", Gandhi answered firmly: "They say that 'means are after all means'. I would say that 'means are after all everything'. As the means, so the end. Indeed, the Creator has given us limited power over means, none over end... The means may be likened to a seed, and the end to a tree; and there is the same inviolable connection between the means and the end as there is between the seed and the tree. Means and end are convertible terms in my philosophy of life."

Gandhi's advocacy of non-violence is closely connected to his attitude towards ends and means. He believed that violent methods for achieving a desired social result would inevitably result in an escalation of violence. The end achieved would always be contaminated by the methods used. He was influenced by Leo Tolstoy with whom he exchanged many letters, and he in turn influenced Martin Luther King and Nelson Mandela.

The power of truth

Gandhi was trained as a lawyer, and when he began to practice in South Africa, in his first case, he was able to solve a conflict by proposing a compromise that satisfied both parties. Of this result he said, "My joy was boundless. I had learnt the true practice of law. I had learnt to find out the better side of human nature and to enter men's hearts. I realized that the true function of a lawyer was to unite parties riven asunder." When Gandhi became involved with the struggle for civil rights of the Indian minority in South Africa, his background as a lawyer once more helped him. This time his jury was public opinion in England. When Gandhi lead the struggle for reform, he insisted that the means of protest used by his followers should be non-violent, even though violence was frequently used against them. In this way they won their case in the court of public opinion. Gandhi called this method of protest "satyagraha", a Sanskrit word meaning "the power of truth". In today's struggles for justice and peace, the moral force of truth and nonviolence can win victories in the court of world public opinion.

Harmony between religious groups

Gandhi believed that at their core, all religions are based on the concepts of truth, love, compassion, nonviolence and the Golden Rule. When asked whether he was a Hindu, Gandhi answered, "Yes I am. I am also a Christian, a Muslim, a Buddhist and a Jew." When praying at his ashram, Gandhi made a point of including prayers from many religions. One of the most serious problems that he had to face in his efforts to free India from British rule was disunity and distrust, even hate, between the Hindu and Muslim communities. Each community felt that with the British gone, they might face violence and repression from the other. Gandhi made every effort to bridge the differences and to create unity and harmony. His struggles with this problem are highly relevant to us today, when the world is split by religious and ethnic differences.

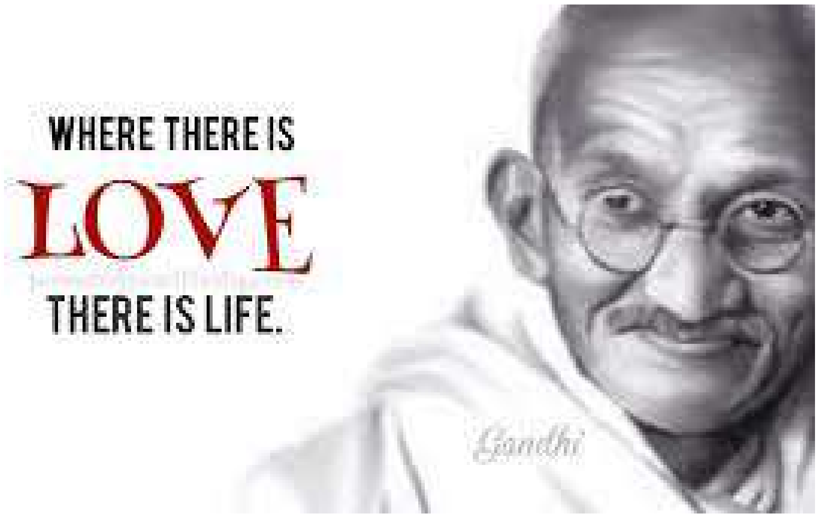

Figure 11.1: **Mahatma Gandhi firmly rejected the insidious doctrine that "the end justifies the means".**

Solidarity with the poor

Today's world is characterized by intolerable economic inequalities, both between nations and within nations. 8 million children die each year from poverty-related causes. 1.3 billion people live on less than 1.25 dollars a day. Gandhi's concern for the poor can serve as an example to us today, as we work to achieve a more equal world. He said, "There is enough for every man's need, but not for every man's greed."

Voluntary reduction of consumption

After Gandhi's death, someone took a photograph of all his worldly possessions. It was a tiny heap, consisting of his glasses, a pair of sandals, a homespun cloth (his only garment) and a watch. That was all. By reducing his own needs and possessions to an absolute minimum, Gandhi had tried to demonstrate that the commonly assumed connection between wealth and merit is false. This is relevant today, in a world where we face a crisis of diminishing resources. Not only fossil fuels, but also metals and arable land per capita will become scarce in the future. This will force a change in lifestyle, particularly in the industrialized countries, away from consumerism and towards simplicity. Gandhi's example can teach us that we must cease to use wealth and "conspicuous consumption" as a measure of merit.

Gandhian economics

In his autobiography, Mahatma Gandhi says: "Three moderns have left a deep impression on my life and captivated me: Raychandbhai (the Indian philosopher and poet) by his living contact; Tolstoy by his book 'The Kingdom of God is Within You'; and Ruskin by his book 'Unto This Last'." Ruskin's book, "Unto This Last", which Gandhi read in 1904, is a criticism of modern industrial society. Ruskin believed that friendships and warm interpersonal relationships are a form of wealth that economists have failed to consider. He felt that warm human contacts are most easily achieved in small agricultural communities, and that therefore the modern tendency towards centralization and industrialization may be a step backward in terms of human happiness. While still in South Africa, Gandhi founded two religious Utopian communities based on the ideas of Tolstoy and Ruskin, Phoenix Farm (1904) and Tolstoy Farm (1910).

Because of his growing fame as the leader of the Indian civil rights movement in South Africa, Gandhi was persuaded to return to India in 1914 and to take up the cause of Indian home rule. In order to reacquaint himself with conditions in India, he travelled tirelessly, now always going third class as a matter of principle.

During the next few years, Gandhi worked to reshape the Congress Party into an organization which represented not only India's Anglicized upper middle class but also the millions of uneducated villagers who were suffering under an almost intolerable burden of poverty and disease. In order to identify himself with the poorest of India's people, Gandhi began to wear only a white loincloth made of rough homespun cotton. He traveled to the remotest villages, recruiting new members for the Congress Party, preaching non-violence and "firmness in the truth", and becoming known for his voluntary poverty and humility. The villagers who flocked to see him began to call him "Mahatma" (Great Soul).

Disturbed by the spectacle of unemployment and poverty in the villages, Gandhi urged the people of India to stop buying imported goods, especially cloth, and to make their own. He advocated the reintroduction of the spinning wheel into village life, and he often spent some hours spinning himself. The spinning wheel became a symbol of the Indian independence movement, and was later incorporated into the Indian flag.

The movement for boycotting British goods was called the "Swadeshi movement". The word Swadeshi derives from two Sanskrit roots: Swa, meaning self, and Desh, meaning country. Gandhi described Swadeshi as "a call to the consumer to be aware of the violence he is causing by supporting those industries that result in poverty, harm to the workers and to humans or other creatures."

Gandhi tried to reconstruct the crafts and self-reliance of village life that he felt had been destroyed by the colonial system. "I would say that if the village perishes, India will perish too", he wrote, "India will be no more India. Her own mission in the world will get lost. The revival of the village is only possible when it is no more exploited. Industrialization on a mass scale will necessarily lead to passive or active exploitation of the villagers as problems of competition and marketing come in. Therefore we have to concentrate on the village being self-contained, manufacturing mainly for use. Provided this character of the village industry is maintained, there would be no objection to villagers using even the modern machines that they can make and can afford to use. Only they should not be used as a means of exploitation by others."

"You cannot build nonviolence on a factory civilization, but it can be built on self-contained villages... Rural economy as I have conceived it, eschews exploitation altogether, and exploitation is the essence of violence... We have to make a choice between India of the villages that are as ancient as herself and India of the cities which are a creation of foreign domination..."

"Machinery has its place; it has come to stay. But it must not be allowed to displace necessary human labour. An improved plow is a good thing. But if by some chances, one man could plow up, by some mechanical invention of his, the whole of the land of India, and control all the agricultural produce, and if the millions had no other occupation, they would starve, and being idle, they would become dunces, as many have already become. There is hourly danger of many being reduced to that unenviable state."

In these passages we see Gandhi not merely as a pioneer of nonviolence; we see him also as an economist. Faced with misery and unemployment produced by machines, Gandhi tells us that social goals must take precedence over blind market mechanisms. If machines are causing unemployment, we can, if we wish, and use labor-intensive methods instead. With Gandhi, the free market is not sacred; we can do as we wish, and maximize human happiness, rather than maximizing production and profits.

Mahatma Gandhi was assassinated by a Hindu extremist on January 30, 1948. After his death, someone collected and photographed all his worldly goods. These consisted of a pair of glasses, a pair of sandals, a pocket watch and a white homespun loincloth. Here, as in the Swadeshi movement, we see Gandhi as a pioneer of economics. He deliberately reduced his possessions to an absolute minimum in order to demonstrate that there is no connection between personal merit and material goods. Like Veblen, Mahatma Gandhi told us that we must stop using material goods as a means of social competition. We must start to judge people not by what they have, but by what they are.

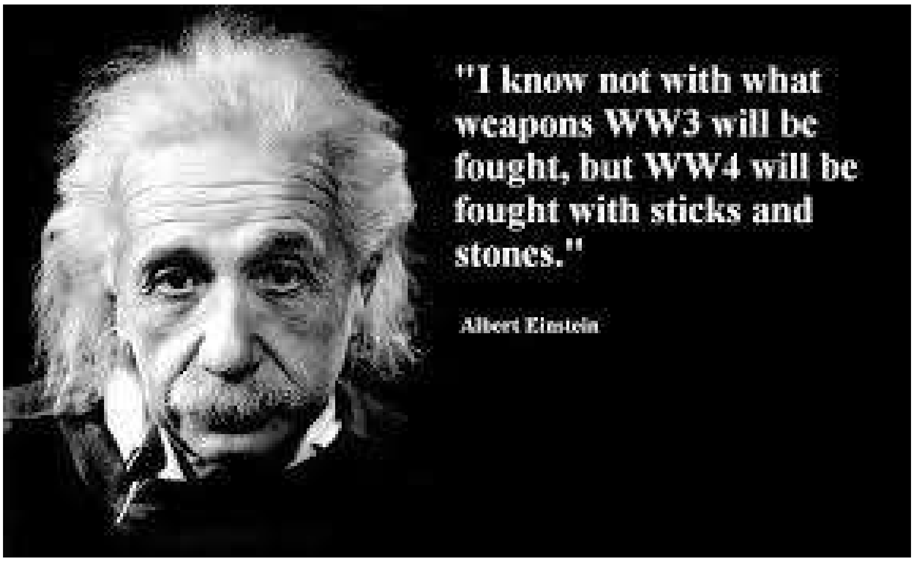

Figure 11.2:

11.3 The ethics of Albert Einstein

Besides being one of the greatest physicists of all time, Albert Einstein was a lifelong pacifist, and his thoughts on peace can speak eloquently to us today. We need his wisdom today, when the search for peace has become vital to our survival as a species.

Einstein's letter to Freud: Why war?

Because of his fame, Einstein was asked to make several speeches at the Reichstag. and in all these speeches he condemned violence and nationalism, urging that these be replaced by and international cooperation and law under an effective international authority. He also wrote many letters and articles pleading for peace and for the renunciation of militarism and violence.

Einstein believed that the production of armaments is damaging, not only economically, but also spiritually. In 1930 he signed a manifesto for world disarmament sponsored by the Womens International League for Peace and Freedom. In December of the same year, he made his famous statement in New York that if two percent of those called for military service were to refuse to fight, governments would become powerless, since they could not imprison that many people. He also argued strongly against compulsory military service and urged that conscientious objectors should be protected by the international community. He argued that peace, freedom of individuals, and security of societies could only be achieved through disarmament, the alternative being "slavery of the individual and annihilation of civilization".

In letters, and articles, Einstein wrote that the welfare of humanity as a whole must take precedence over the goals of individual nations, and that we cannot wait until leaders give up their preparations for war. Civil society, and especially public figures, must take the lead. He asked how decent and self-respecting people can wage war, knowing how many innocent people will be killed.

In 1931, the International Institute for Intellectual Cooperation invited Albert Einstein to enter correspondence with a prominent person of his own choosing on a subject of importance to society. The Institute planned to publish a collection of such dialogues. Einstein accepted at once, and decided to write to Sigmund Freud to ask his opinion about how humanity could free itself from the curse of war. A translation from German of part of the long letter that he wrote to Freud is as follows:

"Dear Professor Freud, The proposal of the League of Nations and its International Institute of Intellectual Cooperation at Paris that I should invite a person to be chosen by myself to a frank exchange of views on any problem that I might select affords me a very welcome opportunity of conferring with you upon a question which, as things are now, seems the most important and insistent of all problems civilization has to face. This is the problem: Is there any way of delivering mankind from the menace of war? It is common knowledge that, with the advance of modern science, this issue has come to mean a matter of life or death to civilization as we know it; nevertheless, for all the zeal displayed, every attempt at its solution has ended in a lamentable breakdown."

"I believe, moreover, that those whose duty it is to tackle the problem professionally and practically are growing only too aware of their impotence to deal with it, and have now a very lively desire to learn the views of men who, absorbed in the pursuit of science, can see world-problems in the perspective distance lends. As for me, the normal objective of my thoughts affords no insight into the dark places of human will and feeling. Thus in the enquiry now proposed, I can do little more than seek to clarify the question at issue and, clearing the ground of the more obvious solutions, enable you to bring the light of your far-reaching knowledge of man's instinctive life upon the problem.."

"As one immune from nationalist bias, I personally see a simple way of dealing with the superficial (i.e. administrative) aspect of the problem: the setting up, by international consent, of a legislative and judicial body to settle every conflict arising between nations... But here, at the outset, I come up against a difficulty; a tribunal is a human institution which, in proportion as the power at its disposal is... prone to suffer these to be deflected by extrajudicial pressure..."

Freud replied with a long and thoughtful letter in which he said that a tendency towards conflict is an intrinsic part of human emotional nature, but that emotions can be overridden by rationality, and that rational behavior is the only hope for humankind.

The fateful letter to Roosevelt

Albert Einstein's famous relativistic formula, relating energy to mass, soon yielded an understanding of the enormous amounts of energy released in radioactive decay. Marie and Pierre Curie had noticed that radium maintains itself at a temperature higher than its surroundings. Their measurements and calculations showed that a gram of radium produces roughly 100 gram-calories of heat per hour. This did not seem like much energy until Rutherford found that radium has a half-life of about 1,000 years. In other words, after a thousand years, a gram of radium will still be producing heat, its radioactivity only reduced to one-half its original value. During a thousand years, a gram of radium produces about a million kilocalories, an enormous amount of energy in relation to the tiny size of its source! Where did this huge amount of energy come from? Conservation of energy was one of the most basic principles of physics. Would it have to be abandoned?

The source of the almost-unbelievable amounts of energy released in radioactive decay could be understood through Einstein's formula equating the energy of a system to its mass multiplied by the square of the velocity of light, and through accurate measurements of atomic weights. Einstein's formula asserted that mass and energy are equivalent. It was realized that in radioactive decay, neither mass nor energy is conserved, but only a quantity more general than both, of which mass and energy are particular forms. Scientists in several parts of the world realized that Einstein's discovery of the relationship between mass and energy, together with the discovery of fission of the heavy element uranium meant that it might be possible to construct a uranium-fission bomb of immense power.

Meanwhile night was falling on Europe. In 1929, an economic depression had begun in the United States and had spread to Europe. Without the influx of American capital, the postwar reconstruction of the German economy collapsed. The German middle class, which had been dealt a severe blow by the great inflation of 1923, now received a second heavy blow. The desperate economic chaos drove German voters into the hands of political extremists.

On January 30, 1933, Adolf Hitler was appointed Chancellor and leader of a coalition cabinet by President Hindenburg. Although Hitler was appointed legally to this post, he quickly consolidated his power by unconstitutional means: On May 2, Hitler's police seized the headquarters of all trade unions, and arrested labor leaders. The Communist and Socialist parties were also banned, their assets seized and their leaders arrested. Other political parties were also smashed. Acts were passed eliminating Jews from public service; and innocent Jewish citizens were boycotted, beaten and arrested. On March 11, 1938, Nazi troops entered Austria.

On March 16, 1939, the Italian physicist Enrico Fermi (who by then was a refugee in America) went to Washington to inform the Office of Naval Operations that it might be possible to construct an atomic bomb; and on the same day, German troops poured into Czechoslovakia.

A few days later, a meeting of six German atomic physicists was held in Berlin to discuss the applications of uranium fission. Otto Hahn, the discoverer of fission, was not present, since it was known that he was opposed to the Nazi regime. He was even said to have exclaimed: "I only hope that you physicists will never construct a uranium bomb! If Hitler ever gets a weapon like that, I'll commit suicide."

The meeting of German atomic physicists was supposed to be secret; but one of the participants reported what had been said to Dr. S. Flügge, who wrote an article about uranium fission and about the possibility of a chain reaction. Flügge's article appeared in the July issue of Naturwissenschaften, and a popular version in the Deutsche Allgemeine Zeitung. These articles greatly increased the alarm of American atomic scientists, who reasoned that if the Nazis permitted so much to be printed, they must be far advanced on the road to building an atomic bomb.

In the summer of 1939, while Hitler was preparing to invade Poland, alarming news reached the physicists in the United States: A second meeting of German atomic scientists had been held in Berlin, this time under the auspices of the Research Division of the German Army Weapons Department. Furthermore, Germany had stopped the sale of uranium from mines in Czechoslovakia.

The world's most abundant supply of uranium, however, was not in Czechoslovakia, but in Belgian Congo. Leo Szilard, a refugee Hungarian physicist who had worked with Fermi to measure the number of neutrons produced in uranium fission, was deeply worried that the Nazis were about to construct atomic bombs; and it occurred to him that uranium from Belgian Congo should not be allowed to fall into their hands.

Szilard knew that his former teacher, Albert Einstein, was a personal friend of Elizabeth, the Belgian Queen Mother. Einstein had met Queen Elizabeth and King Albert of Belgium at the Solvay Conferences, and mutual love of music had cemented a friendship between them. When Hitler came to power in 1933, Einstein had moved to the Institute of Advanced Studies at Princeton; and Szilard decided to visit him there. Szilard reasoned that because of Einstein's great prestige, and because of his long-standing friendship with the

Belgian Royal Family, he would be the proper person to warn the Belgians not to let their uranium fall into the hands of the Nazis. Einstein agreed to write to the Belgian king and queen.

On August 2, 1939, Szilard again visited Einstein, accompanied by Edward Teller and Eugene Wigner, who (like Szilard) were refugee Hungarian physicists. By this time, Szilard's plans had grown more ambitious; and he carried with him the draft of another letter, this time to the American President, Franklin D. Roosevelt. Einstein made a few corrections, and then signed the fateful letter, which reads (in part) as follows:

"Some recent work of E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into an important source of energy in the immediate future. Certain aspects of the situation seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe, therefore, that it is my duty to bring to your attention the following.."

"It is conceivable that extremely powerful bombs of a new type may be constructed. A single bomb of this type, carried by boat and exploded a port, might very well destroy the whole port, together with some of the surrounding territory.."

The letter also called Roosevelt's attention to the fact that Germany had already stopped the export of uranium from the Czech mines under German control. After making a few corrections, Einstein signed it. On October 11, 1939, three weeks after the defeat of Poland, Roosevelt's economic adviser, Alexander Sachs, personally delivered the letter to the President. After discussing it with Sachs, the President commented,"This calls for action." Later, when atomic bombs were dropped on civilian populations in an already virtually-defeated Japan, Einstein bitterly regretted having signed Szilard's letter to Roosevelt. He said repeatedly that signing the letter was the greatest mistake of his life, and his remorse was extreme.

Throughout the remainder of his life, in addition to his scientific work, Einstein worked tirelessly for peace, international understanding and nuclear disarmament. His last public act, only a few days before his death in 1955, was to sign the Russell-Einstein Manifesto, warning humankind of the catastrophic consequences that would follow from a war with nuclear weapons.

A few more things that Einstein said about peace:

We cannot solve our problems with the same thinking that we used when we created them.

It has become appallingly obvious that our technology has exceeded our human-

ity.

Peace cannot be kept by force; it can only be achieved by understanding.

The world is a dangerous place to live; not because of the people who are evil, but because of the people who don't do anything about it.

Insanity: doing the same thing over and over again and expecting to get different results.

Nothing will end war unless the people themselves refuse to go to war.

Past thinking and methods did not prevent world wars. Future thinking must prevent war.

You cannot simultaneously prevent and prepare for war.

Never do anything against conscience, even if the state demands it.

Taken as a whole, I would believe that Gandhi's views were the most enlightened of all political men of our time.

Without ethical culture, there is no salvation for humanity.

War seems to me to be a mean, contemptible thing: I would rather be hacked in pieces than take part in such an abominable business. And yet so high, in spite of everything, is my opinion of the human race that I believe this bogey would have disappeared long ago, had the sound sense of the nations not been systematically corrupted by commercial and political interests acting through the schools and the Press.

11.4 The ethics of Saint Francis

The life of Saint Francis

Saint Francis of Assisi was born in 1181 in the Italian hilltop town of Assisi. His father, Pietro di Bernardone, was a prosperous silk merchant, and his mother Pica de Bourlemont, was a noblewoman from Provence. Saint Francis was originally called Giovanni, but his father later renamed him Francesco because

Figure 11.3: **Saint Francis**

of his successful business dealings in France and his admiration for all things French.

After leading the ordinary (somewhat dissolute) life of a wealthy young man of that period, Saint Francis underwent a religious conversion, following which he renounced his inheritance and embraced a life of poverty. Although not ordained as a priest, he began teaching what he believed to be the true Christian message. He soon acquired a small group of followers, and he traveled with them to Rome to ask Pope Innocent III for permission to found a new religious order. During his life, Saint Francis founded three religious orders.

Saint Francis continued to preach, and is even said to have preached to birds and animals, whom he regarded as his sisters and brothers. His attitude towards nature can be seen in his "Canticle of the Sun":

Canticle of the Sun

Most High, all powerful, good Lord,
Yours are the praises, the glory, the honor,

and all blessing.

To You alone, Most High, do they belong,
and no man is worthy to mention Your name.

Be praised, my Lord, through all your creatures,
especially through my lord Brother Sun,
who brings the day; and you give light through him.
And he is beautiful and radiant in all his splendor!
Of you, Most High, he bears the likeness.

Praise be You, my Lord, through Sister Moon
and the stars, in heaven you formed them
clear and precious and beautiful.

Praised be You, my Lord, through Brother Wind,
and through the air, cloudy and serene,
and every kind of weather through which
You give sustenance to Your creatures.

Praised be You, my Lord, through Sister Water,
which is very useful and humble and precious and chaste.

Praised be You, my Lord, through Brother Fire,
through whom you light the night and he is beautiful
and playful and robust and strong.

Praised be You, my Lord, through Sister Mother Earth,
who sustains us and governs us and who produces
varied fruits with colored flowers and herbs.

Praised be You, my Lord,
through those who give pardon for Your love,
and bear infirmity and tribulation.

Blessed are those who endure in peace
for by You, Most High, they shall be crowned.

Praised be You, my Lord,
through our Sister Bodily Death,
from whom no living man can escape.

Woe to those who die in mortal sin.
Blessed are those whom death will
find in Your most holy will,
for the second death shall do them no harm.

Praise and bless my Lord,
and give Him thanks
and serve Him with great humility.

Canonization

Pope Gregory IX canonized Francis on 16 July 1228. Along with Saint Catherine of Sienna, he was designated Patron Saint of Italy. He later became associated with patronage of animals and the natural environment, and it became customary for Catholic and Anglican churches to hold ceremonies blessing animals on his feast day of 4 October.

A prayer of Saint Francis

Blessed is he who loves and does not therefore desire to be loved;
Blessed is he who fears and does not therefore desire to be feared;
Blessed is he who serves and does not therefore desire to be served;
Blessed is he who behaves well toward others and does not desire that others behave well toward him;

11.5 The ethics of Pope Francis

Despite the worrying nature of the threats that we are facing, there are reasons for hope. One of the greatest of these is the beautiful, profound and powerful encyclical that has just been released by Pope Francis.

When he accepted the responsibility for leading the world's 1.2-billion-strong Catholic Church, Cardinal Bergoglio of Argentina adopted the name Francis, after the universally loved Saint Francis of Assisi, whose life of simplicity, love for the poor, and love of nature he chose as the model for his Papacy. The Pope's inspiring encyclical letter "Laudato Si' " takes its name from a canticle of Saint Francis, that begins with the words "Praise be to you, my Lord, through our sister, mother Earth, who sustains and governs us..."

We can remember that Saint Francis regarded birds and animals as his brothers and sisters. He even thought of the sun, moon, clouds, rain and water as

Figure 11.4: **Pope Francis reminds us that Christian ethics require both respect and care for the earth and elimination of the institution of war.**

brothers and sisters. Like his chosen namesake, Pope Francis stresses the unity of all of nature, and our kinship with all of creation. Francis appeals to love. We can be saved through love.

His encyclical is addressed not only to Catholics, but also to all men and women of good will, and almost all of its 102 pages appeal to moral sensibilities and rational arguments that can be shared by all of us. Pope Francis stresses that the natural world that sustains us is in grave danger from our ruthless exploitation and greed-driven destruction of all the beauty and life that it contains: animals, forests, soil, and air.

Pope Francis tells us that the dictates of today's economists are not sacred: In the future, if we are to survive, economics must be given both a social conscience and an ecological conscience. Nor are private property and profits sacred. They must be subordinated to the common good, and the preservation of our global commons.

Less focus on material goods need not make us less happy. The quality of our lives can be increased, not decreased, if we give up our restless chase after power and wealth, and derive more of our pleasures from art, music and literature, and from conversations with our families and friends, Please read this great encyclical in its entirety. It can give us hope and courage as we strive to make the changes that are needed to avert an ecological mega-catastrophe.

Don Joao Mamede Filho is the Bishop of the Diocesis of Umuarama, commented: " 'Laudato Si', considered by environmentalists all around the world as the Green Encyclical, has become a work read by Christians and non-Christians alike in all corners of the world. In it, Pope Francis calls on us all to take care of our 'Common Home' and all that exists in it.

"In his call, the Pope reaffirms that the planet is a common good that must be preserved and guarded. Therefore, it is our duty to refrain from any human activity that may degrade, pollute or pose any kind of threat or risk to our planet and those who inhabit it.

"'Laudato Si' also presents a strong and persisting plea for a shift towards a new energy and development model, leaving fossil fuels behind. Since these energy sources are responsible for the highest emissions of greenhouse gases, they pollute, render climate changes more intense, bring on diseases, and kill.

"It is important to remember that, at the beginning of Creation, an organic relationship between all living beings was established. All that exists is connected and coexists in a sustainable and wholesome manner. However, by choosing dirty energy sources such as fossil fuels, which leave trails of destruction behind them, we disconnect ourselves from our surroundings and ignore the harm they may cause us and to our fellow creatures."

11.6 All humans are brothers and sisters!

Besides a humane, democratic and just framework of international law and governance, we urgently need a new global ethic, - an ethic where loyalty to family, community and nation will be supplemented by a strong sense of the brotherhood of all humans, regardless of race, religion or nationality. Schiller expressed this feeling in his "Ode to Joy", a part of which is the text of Beethoven's Ninth Symphony. Hearing Beethoven's music and Schiller's words, most of us experience an emotion of resonance and unity with the message: All humans are brothers and sisters - not just some - all! It is almost a national anthem of humanity. The feelings that the music and words provoke are similar to patriotism, but broader. It is this sense of a universal human family that we need to cultivate in education, in the mass media, and in religion. We already appreciate music, art and literature from the entire world, and scientific achievements are shared by all, regardless of their country of origin. We need to develop this principle of universal humanism so that it will become the cornerstone of a new ethic.

Figure 11.5: **The message of Beethoven's Choral 9th: All humans are brothers and sisters! Not just some - All!**

11.7 The ethics of Henry David Thoreau

In the distant future (and perhaps even in the not-so-distant future) industrial civilization will need to abandon its relentless pursuit of unnecessary material goods and economic growth. Modern society will need to re-establish a balanced and harmonious relationship with nature. In preindustrial societies harmony with nature is usually a part of the cultural tradition. In our own time, the same principle has become central to the ecological counter-culture while the main-stream culture thunders blindly ahead, addicted to wealth, power and growth.

In the 19th century the American writer, Henry David Thoreau (1817-1862), pioneered the concept of a simple life, in harmony with nature. Today, his classic book, *Walden*, has become a symbol for the principles of ecology, simplicity, and respect for nature.

Thoreau was born in Concord Massachusetts, and he attended Harvard from 1833 to 1837. After graduation, he returned home, worked in his family's pencil factory, did odd jobs, and for three years taught in a progressive school founded by himself and his older brother, John. When John died of lockjaw in 1842, Henry David was so saddened that he felt unable to continue the school alone.

Nonviolent civil disobedience

Thoreau refused to pay his poll tax because of his opposition to the Mexican War and to the institution of slavery. Because of his refusal to pay the tax (which was in fact a very small amount) he spent a night in prison. To Thoreau's irritation, his family paid the poll tax for him and he was released. He then wrote down his ideas on the subject in an essay entitled *The Duty of Civil Disobedience*, where he maintains that each person has a duty to follow his own individual conscience even when it conflicts with the orders of his government.

In his essay, Thoreau said: "A common and natural result of an undue respect for law is that you may see a file of soldiers, colonel, captain, corporal, privates, powder-monkeys, and all marching in admirable order over hill and dale to the wars, against their wills, ay, against their common sense and consciences, which makes it very steep marching indeed, and produces a palpitation of the heart. They have no doubt that it is a damnable business in which they are concerned; they are all peaceably inclined. Now, what are they? Men at all? or small movable forts and magazines, at the service of some unscrupulous man in power?"

"Under a government that which imprisons any unjustly", Thoreau wrote, "the true place for a just man is in prison." Civil Disobedience influenced Tolstoy, Gandhi and Martin Luther King, and it anticipated the Nuremberg Principles.

Harmony with nature

Thoreau became the friend and companion of the transcendentalist writer Ralph Waldo Emerson (1803 1882), who introduced him to a circle of New England writers and thinkers that included Ellery Channing, Margaret Fuller and Nathaniel Hawthorne.

Nathaniel Hawthorne described Thoreau in the following words: "Mr. Thorow [sic] is a keen and delicate observer of nature, a genuine observer, which, I suspect, is almost as rare a character as even an original poet; and Nature, in return for his love, seems to adopt him as her especial child, and shows him secrets which few others are allowed to witness. He is familiar with beast, fish, fowl, and reptile, and has strange stories to tell of adventures, and friendly passages with these lower brethren of mortality. Herb and flower, likewise, wherever they grow, whether in garden, or wild wood, are his familiar friends. He is also on intimate terms with the clouds and can tell the portents of storms. It is a characteristic trait, that he has a great regard for the memory of the Indian tribes, whose wild life would have suited him so well; and strange to

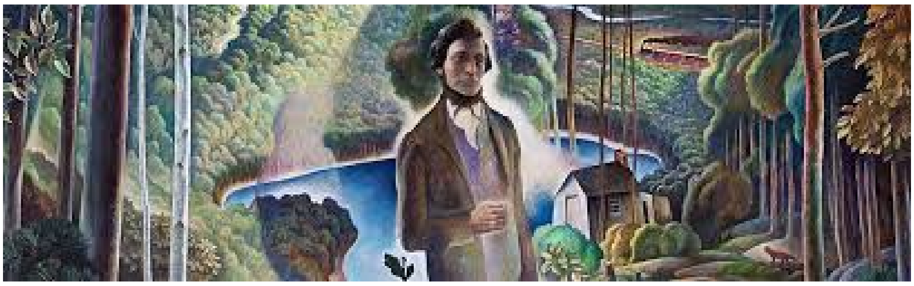

Figure 11.6: **Thoreau, with his cabin at Walden Pond in the background.**

say, he seldom walks over a plowed field without picking up an arrow-point, a spear-head, or other relic of the red men, as if their spirits willed him to be the inheritor of their simple wealth."

Walden, an experiment in simple living

At Emerson's suggestion, Thoreau opened a journal, in which he recorded his observations concerning nature and his other thoughts. Ultimately the journal contained more than 2 million words. Thoreau drew on his journal when writing his books and essays, and in recent years, many previously unpublished parts of his journal have been printed.

From 1845 until 1847, Thoreau lived in a tiny cabin that he built with his own hands. The cabin was in a second-growth forest beside Walden Pond in Concord, on land that belonged to Emerson. Thoreau regarded his life there as an experiment in simple living. He described his life in the forest and his reasons for being there in his book *Walden*,

"Most of the luxuries", Thoreau wrote, "and many of the so-called comforts of life, are not only not indispensable, but positive hindrances to the elevation of mankind. With respect to luxuries, the wisest have ever lived a more simple and meager life than the poor. The ancient philosophers, Chinese, Hindoo, Persian, and Greek, were a class than which none has been poorer in outward riches, none so rich in inward."

Elsewhere in "Walden", Thoreau remarks, "It is never too late to give up your prejudices", and he also says, "Why should we be in such desperate haste to succeed, and in such desperate enterprises? If a man does not keep pace with his companions, perhaps it is because he hears a different drummer." Other favorite quotations from Thoreau include "Rather than love, than money, than fame, give me truth", "Beware of all enterprises that require new clothes", "Most men lead lives of quiet desperation" and "Men have become tools of their tools."

Thoreau's closeness to nature can be seen from the following passage, written by his friend Frederick Willis, who visited him at Walden Pond in 1847, together with the Alcott family: "He was talking to Mr. Alcott of the wild flowers in Walden woods when, suddenly stopping, he said: 'Keep very still and I will show you my family.' Stepping quickly outside the cabin door, he gave a low and curious whistle; immediately a woodchuck came running towards him from a nearby burrow. With varying note, yet still low and strange, a pair of gray squirrels were summoned and approached him fearlessly. With still another note several birds, including two crows flew towards him, one of the crows nestling upon his shoulder. I remember that it was the crow resting close to his head that made the most vivid impression on me, knowing how fearful of man this bird is. He fed them all from his hand, taking food from his pocket, and petted them gently before our delighted gaze; and then dismissed them by different whistling, always strange and low and short, each wild thing departing instantly at hearing his special signal."

Thoreau's views on religion

Towards the end of his life, when he was very ill, someone asked Thoreau whether he had made his peace with God. "We never quarreled", he answered.

In an essay published by the Atlantic Monthly in 1853, Thoreau described a pine tree in Maine with the words: "It is as immortal as I am, and perchance will go to as high a heaven, there to tower above me still." However, the editor (James Russell Lowell) considered the sentence to be blasphemous, and removed it from Thoreau's essay.

In one of his essays, Thoreau wrote: "If a man walk in the woods for love of them half of each day, he is in danger of being regarded as a loafer; but if he spends his whole day as a speculator, shearing off those woods and making the earth bald before her time, he is esteemed an industrious and enterprising citizen."

A few more things that Thoreau said

It is the beauty within us that makes it possible for us to recognize the beauty around us. The question is not what you look at, but what you see.

Simplify your life. Don't waste the years struggling for things that are unimportant. Don't burden yourself with possessions. Keep your needs and wants simple and enjoy what you have. Don't destroy your peace of mind by looking *back, worrying about the past. Live in the present. Simplify!*

Go confidently in the direction of your dreams. Live the life you've imagined.

Happiness is like a butterfly; the more you chase it, the more it will elude you, but if you turn your attention to other things, it will come and sit softly on your shoulder.

Rather than love, than money, than fame, give me truth.

The mass of men lead lives of quiet desperation.

You must live in the present, launch yourself on every wave, find your eternity in each moment. Fools stand on their island of opportunities and look toward another land. There is no other land; there is no other life but this

Be not simply good, be good for something,

Books are the treasured wealth of the world and the fit inheritance of generations and nations.

If you have built castles in the air, your work need not be lost; that is where they should be. Now put the foundations under them.

If a man does not keep pace with his companions, perhaps it is because he hears a different drummer. Let him step to the music he hears, however measured or far away.

The greatest compliment that was ever paid me was when one asked me what I thought, and attended to my answer.

We need the tonic of wildness...At the same time that we are earnest to explore and learn all things, we require that all things be mysterious and unexplorable, that land and sea be indefinitely wild, unsurveyed and unfathomed by us because unfathomable. We can never have enough of nature.

11.8 The message of Bertha von Suttner

Early life and marriage

Baroness Bertha von Suttner (1843-1914) was born in Prague as Countess Kinsky. She was the posthumous daughter of a Field Marshall, and during the first part of her life, she accepted the military traditions of her family. Later she vigorously opposed militarism, and she became a leader of the peace movement. It was her arguments that persuaded Alfred Nobel to establish the Nobel Peace Prize, and in 1905 she became the first woman to receive the prize.

After serving as Alfred Nobel's secretary (and close friend) in Paris (1876), Bertha married Baron Arthur von Suttner. However, the von Suttner family was strongly opposed to the marriage, and the young couple left for the Caucasus where for nine years they earned a living by giving lessons in languages and music. During this period, Bertha von Suttner became a highly successful writer.

In 1885 the von Suttner family relented, and welcomed the couple back to Austria. Here Bertha von Suttner wrote most of her books, including her many novels. The couple's life was oriented almost solely toward the literary until, through a friend, they learned about the International Arbitration and Peace Association1 in London and about similar groups on the Continent, organizations that had as an actual working objective what they had now both accepted as an ideal: arbitration and peace in place of armed force.

Bertha von Suttner immediately added material on this to her second serious book, *Das Maschinenzeitalter (The Machine Age)* which, when published early in 1889. Her book was much discussed and reviewed. It criticizing many aspects of the times, and it was among the first to foretell the results of exaggerated nationalism and armaments. Her novel *Lay Down Your Arms*, published in the same year, had a huge impact.

The 1905 Nobel Peace Prize

Here are some excerpts from Bertha von Suttner's acceptance speech:

One of the eternal truths is that happiness is created and developed in peace, and one of the eternal rights is the individual's right to live. The strongest of all instincts, that of self-preservation, is an assertion of this right, affirmed and sanctified by the ancient commandment "Thou shalt not kill."

It is unnecessary for me to point out how little this right and this commandment are respected in the present state of civilization. Up to the present time, the military organization of our society has been founded upon a denial of the

Figure 11.7: **Bertha von Suttner**

possibility of peace, a contempt for the value of human life, and an acceptance of the urge to kill...

It is erroneous to believe that the future will of necessity continue the trends of the past and the present. The past and present move away from us in the stream of time like the passing landscape of the riverbanks, as the vessel carrying mankind is borne inexorably by the current toward new shores...

"If you keep me in touch with developments, and if I hear that the Peace Movement is moving along the road of practical activity, then I will help it on with money." These words were spoken by that eminent Scandinavian to whom I owe this opportunity of appearing before you today, Ladies and Gentlemen. Alfred Nobel said them when my husband and I visited with him in 1892 in Bern, where a peace congress was in progress...

..although the supporters of the existing structure of society, which accepts war, come to a peace conference prepared to modify the nature of war, they are basically trying to keep the present system intact. The advocates of pacifism, inside and outside the Conference, will, however, defend their objectives and press forward... to "bring nearer the time when the sword shall not be the arbiter among nations".

A few more things the Bertha von Suttner said about peace

Strange how blind people are! They are horrified by the torture chambers of the Middle Ages, but their arsenals fill them with pride!

After the verb 'to Love', 'to Help' is the most beautiful verb in the world.

11.9 Helen Keller's message

Childhood

Helen was a normal child until the age of 19 months, when she contracted an illness which may have been scarlet fever or meningitis. It left her both deaf and blind. When Helen was 6 years old, her parents followed the advice of Alexander Graham Bell and contacted the Perkins Institute for the Blind. The Perkins Institute recommended their recent graduate Annie Sullivan, who became Helen's teacher.

Annie Sullivan, who was 20 years old at that time and also blind, began to work with Helen, spelling out words on the palm of Helen's hand. This method

Figure 11.8: **Helen Keller: Although blind, she could see injustice. Although deaf, she could hear the cries of the oppressed, and the voices of victims of war.**

was unsuccessful at first, but one day, when Annie Sullivan was spelling out "water" on one of Helen's hands while water was running over the other, Helen suddenly realized that the letters were a symbol for water. For the next many days, the child almost wore her teacher out by demanding the spelling of hundreds of other things within her experience. Annie Sullivan later became Helen's lifelong friend and companion.

Victory over a triple handicap

Starting in 1888, Helen Keller began her formal education, at first at the Perkins Institute, then at a succession of other schools. Finally, at the age of 24, with financial help from a wealthy friend of Mark Twain. Helen graduated from Radcliffe College. She was the first blind and deaf person to obtain a BA degree. On the way to this triumph, Helen had taught herself to speak normally, and she could understand what other people were saying by placing her hand on their lips.

Helen Keller quickly developed into a popular lecturer and author. She spoke and wrote to advocate many social reforms, including woman's suffrage, labour rights, socialism and antimilitarism.

The story of Helen Keller and Annie Sullivan, as told in Helen's *Autobiography*, became known to a very wide public through the drama *The Miracle Worker*, which was first produced as a radio broadcast, then as a television drams, then as a Broadway play and finally as a succession of films.

Here is a newspaper account of one of Helen Keller's lectures:

"The wonderful girl who has so brilliantly triumphed over the triple afflictions of blindness, dumbness and deafness, gave a talk with her own lips on 'Happiness,' and it will be remembered always as a piece of inspired teaching by those who heard it.

"According to those who attended, Helen Keller spoke of the joy that life gave her. She was thankful for the faculties and abilities that she did possess and stated that the most productive pleasures she had were curiosity and imagination. Keller also spoke of the joy of service and the happiness that came from doing things for others ... Keller imparted that 'helping your fellow men is one's only excuse for being in this world and in the doing of things to help one's fellows lay the secret of lasting happiness.' She also told of the joys of loving work and accomplishment and the happiness of achievement. Although the entire lecture lasted only a little over an hour, the lecture had a profound impact on the audience."

A few things that Helen Keller said

Strike against war, for without you no battles can be fought! Strike against manufacturing shrapnel and gas bombs and all other tools of murder! Strike against preparedness that means death and misery to millions of human beings! Be not dumb, obedient slaves in an army of destruction! Be heroes in an army of construction.

The best and most beautiful things in the world cannot be seen or even touched - they must be felt with the heart.

Believe. No pessimist ever discovered the secrets of the stars or sailed to an uncharted land or opened a new heaven to the human spirit

Alone we can do so little. Together we can do so much!

It is for us to pray not for tasks equal to our powers, but for powers equal to our tasks, to go forward with a great desire forever beating at the door of our hearts as we travel toward our distant goal

When one door of happiness closes, another opens; but often we look so long at the closed door that we do not see the one which has been opened for us.

To keep our faces toward change, and behave like free spirits in the presence of fate, is strength undefeatable.

Self-pity is our worst enemy and if we yield to it, we can never do anything wise in the world.

Security is mostly a superstition. It does not exist in nature, nor do the children of men as a whole experience it. Avoiding danger is no safer in the long run than outright exposure. Life is either a daring adventure or nothing

I do not want the peace that passeth understanding. I want the understanding which bringeth peace.

11.10 The Universal Declaration of Human Rights

On December 10, 1948, the General Assembly of the United Nations adopted a Universal Declaration of Human Rights. 48 nations voted for adoption, while 8 nations abstained from voting. Not a single state voted against the Declaration. In addition, the General Assembly decided to continue work on the problem of implementing human rights. The preamble of the Declaration stated the it was intended "as a common standard of achievement for all peoples and nations, to the end that every individual and every organ of society, keeping this Declaration constantly in mind, shall strive by teaching and education to promote respect for these rights and freedoms."

Articles 1 and 2 of the Declaration state that "all human beings are born free and equal in dignity and in rights", and that everyone is entitled to the rights and freedoms mentioned in the Declaration without distinctions of any kind. Neither race color, sex, language, religion, political or other opinion, national or social origin, property or social origin must make a difference.

The Declaration states that everyone has a right to life, liberty and security of person and property. Slavery and the slave trade are prohibited, as well as torture and cruel, inhuman or degrading punishments. All people must be equal before the law, and no person must be subject to arbitrary arrest, detention or exile. In criminal proceedings an accused person must be presumed innocent until proven guilty by an impartial public hearing where all necessary provisions have been made for the defense of the accused.

No one shall be subjected to interference with his privacy, family, home or correspondence. Attacks on an individual's honor are also forbidden. Everyone has the right of freedom of movement and residence within the borders of a state, the right to leave any country, including his own, as well as the right to return to his own country. Every person has the right to a nationality and cannot be arbitrarily deprived of his or her nationality.

All people of full age have a right to marry and to establish a family. Men and women have equal rights within a marriage and at its dissolution, if this takes place. Marriage must require the full consent of both parties.

The Declaration also guarantees freedom of religion, of conscience, and of opinion and expression, as well as freedom of peaceful assembly and association. Everyone is entitled to participate in his or her own government, either directly or through democratically chosen representatives. Governments must be based on the will of the people, expressed in periodic and genuine elections with universal and equal suffrage. Voting must be secret.

Everyone has the right to the economic, social and cultural conditions needed for dignity and free development of personality. The right to work is affirmed. The job shall be of a person's own choosing, with favorable conditions of work, and remuneration consistent with human dignity, supplemented if necessary with social support. All workers have the right to form and to join trade unions.

Article 25 of the Declaration states that everyone has the right to an adequate standard of living, including food, clothing, housing and medical care, together with social services. All people have the right to security in the event of unemployment, sickness, disability, widowhood or old age. Expectant mothers are promised special care and assistance, and children, whether born in or out of wedlock, shall enjoy the same social protection. Everyone has the right to education, which shall be free in the elementary stages. Higher education shall be accessible to all on the basis of merit. Education must be directed towards the full development of the human personality and to strengthening respect for human rights and fundamental freedoms. Education must promote understanding, tolerance, and friendship among all nations, racial and religious groups, and it must further the activities of the United Nations for the maintenance of peace.

A supplementary document, the Convention on the Rights of the Child, was adopted by the United Nations General Assembly on the 12th of December, 1989. Furthermore, in July 2010, the General Assembly passed a resolution affirming that everyone has the right to clean drinking water and proper sanitation.

Many provisions of the Universal Declaration of Human Rights, for example Article 25, might be accused of being wishful thinking. In fact, Jean Kirkpatrick, former US Ambassador to the UN, called the Declaration "a letter to Santa Claus". Nevertheless, like the Millennium Development Goals, the

Universal Declaration of Human Rights has great value in defining the norms towards which the world ought to be striving.

It is easy to find many examples of gross violations of basic human rights that have taken place in recent years. Apart from human rights violations connected with interventions of powerful industrial states in the internal affairs of third world countries, there are many cases where governmental forces in the less developed countries have violated the human rights of their own citizens. Often minority groups have been killed or driven off their land by those who coveted the land, as was the case in Guatemala in 1979, when 1.5 million poor Indian farmers were forced to abandon their villages and farms and to flee to the mountains of Mexico in order to escape murderous attacks by government soldiers. The blockade of Gaza and the use of drones to kill individuals illegally must also be regarded as gross human rights violations, and there are many recent examples of genocide.

Wars in general, and in particular, the use of nuclear weapons, must be regarded as gross violations of human rights. The most basic human right is the right to life; but this is right routinely violated in wars. Most of the victims of recent wars have been civilians, very often children and women. The use of nuclear weapons must be regarded as a form of genocide, since they kill people indiscriminately, babies, children, young adults in their prime, and old people, without any regard for guilt or innocence.

Furthermore, recent research shows that a war fought with nuclear weapons would be an ecological disaster. Smoke from burning cities would rise to the stratosphere, where it would spread globally and remain for a period of 10 years, blocking sunlight, destroying the the ozone layer, and blocking the hydrological cycle. An all-out war with thermonuclear weapons would essentially destroy all agriculture for such a long period that most humans would die from starvation. The damage to the biosphere would also be enormous. We may ask: by what right do the nuclear nations threaten the world with a disaster of these proportions? Would not a war fought with nuclear weapons be the greatest imaginable violation of human rights? We should remember that both war in general and the use of nuclear weapons in particular violate democratic principles: The vast majority of ordinary citizens prefer peace to war, and the vast majority also long for a world without nuclear weapons.

It is plain that if the almost unbelievable sums now wasted on armaments were used constructively, most of the pressing problems facing the world today could be solved; but today the world spends more that 20 times as much on armaments as it does on development.

Today's world is one in which roughly 10 million children die every year from diseases related to poverty. Besides this enormous waste of young lives through malnutrition and preventable disease, there is a huge waste of opportunities through inadequate education. The rate of illiteracy in the 25 least developed countries is 80 percent, and the total number of illiterates in the world is estimated to be 800 million. Meanwhile every 60 seconds the world spends roughly 3 million dollars on armaments. The millions who are starving have a right to food. The millions of illiterates have a right to education. By preferring armaments to development, we deny them these rights.

It is time for civil society to make its voice heard. Politicians are easily influenced by lobbies and by money, but in the last analysis they have to listen to the voice of the people. We have seen this recently in Tunisia, Egypt, Libya, Bahrain and Yemen. We should try to learn from the courage of the people of these countries who have defied guns and tanks to demand their human rights. No single person can achieve the changes that we need, but together we can do it: together we can build the world that we choose.

No one living today asked to be born in a time of crisis, but the global crisis of the 21st century has given each of us an enormous responsibility: We cannot merely leave things up to the politicians, as we have been doing. The future is in our own hands: the hands of the people, the hands of civil society. This is not a time for building private utopias or cultivating our own gardens. Today everyone has two jobs: Of course we have to earn a living, but in addition, all of us have the duty to work actively, to the best of our abilities, to save humanity's future and the biosphere.

Figure 11.9: **Eleanor Roosevelt and the Universal Declaration of Human Rights, which she helped to draft.**

11.11 The voice of Martin Luther King, Jr.

The son of a southern Baptist minister, Martin Luther King, Jr received his Ph.D. in theology from Boston University in 1955. During his studies, he had admired Thoreau's essay "On the Duty of Civil Disobedience," and he had also been greatly moved by the life and teachings of Mahatma Gandhi.

Martin Luther King Jr. had been pastor of the Dexter Avenue Baptist Church in Montgomery Alabama for only a year when he was chosen to lead a boycott protesting segregation in the Montgomery buses. Suddenly thrust into this situation of intense conflict, he remembered both the Christian principle of loving one's enemies and Gandhi's methods of non-violent protest. In his first speech as President of the Montgomery Improvement Association (a speech which the rapid pace of events had forced him to prepare in only twenty minutes, five of which he spent in prayer), he said:

"Our method will be that of persuasion, not coercion. We will only say to people, 'Let your conscience be your guide'. Our actions must be guided by the deepest principles of our Christian faith. Love must be our regulating ideal. Once again we must hear the words of Jesus echoing across the centuries: 'Love your enemies, bless them that curse you, and pray for them that despitefully use you.' If we fail to do this, our protest will end up as a meaningless drama on the stage of history, and its memory will be shrouded by the ugly garments of shame. In spite of the mistreatment that we have confronted, we must not become bitter and end up by hating our white brothers. As Booker T. Washington said, 'Let no man pull you down so low as to make you hate him.'"

"If you will protest courageously, and yet with dignity and Christian love, when the history books are written in future generations, the historians will have to pause and say, 'There lived a great people, a black people, who injected new meaning and dignity into the veins of civilization.' This is our challenge and our overwhelming responsibility."

Victory in the court of public opinion

This speech, which Dr. King made in December 1955, set the tone of the black civil rights movement. Although the protesters against racism were often faced with brutality and violence; although many of them, including Dr. King were unjustly jailed; although the homes of the leaders were bombed; although they constantly received telephone calls threatening their lives; although many civil rights workers were severely beaten, and several of them killed, they never resorted to violence in their protests against racial discrimination. Because of this adherence to Christian ethics, public opinion shifted to the side of the civil rights movement, and the United States Supreme Court ruled bus segregation to be unconstitutional.

Welcomed to India by Nehru

In 1959, while recovering from an almost-fatal stabbing, Martin Luther King Jr. visited India at the invitation of Prime Minister Jawaharlal Nehru. Dr. King and his wife Coretta were warmly welcomed by Nehru, who changed his schedule in order to meet them. They had an opportunity to visit a religious community or "ashram" that Gandhi had founded, and they discussed non-violence with many of Gandhi's disciples.

King is awarded the Nobel Peace Prize

In 1964, the change in public opinion produced by the non-violent black civil rights movement resulted in the passage of the civil rights act. In the same year, Dr. King was awarded the Nobel Peace Prize. He accepted it, not as an individual, but on behalf of all civil rights workers; and he immediately gave all the prize money to the movement.

Opposition to the Viet Nam War

In 1967, a year before his assassination, Dr. King forcefully condemned the Viet Nam war in an address at a massive peace rally in New York City. He felt that opposition to war followed naturally from his advocacy of non-violence. Speaking against the Viet Nam War, Dr. King said: "We have corrupted their women and children and killed their men. They move sadly and apathetically as we herd them off the land of their fathers into concentration camps where minimal social needs are rarely met. They know they must move on or be destroyed by our bombs ... primarily women and children and the aged watch as we poison their water, as we kill a million acres of their crops. They must weep as the bulldozers roar through their areas preparing to destroy the precious trees. They wander into the hospitals. So far we may have killed a million of them, [in Vietnam by 1967] mostly children. They wander into the towns and see thousands of the children, homeless, without clothes, running in packs on the streets like animals. They see the children degraded by our soldiers as they beg for food. They see the children selling their sisters to our soldiers, soliciting for their mothers."

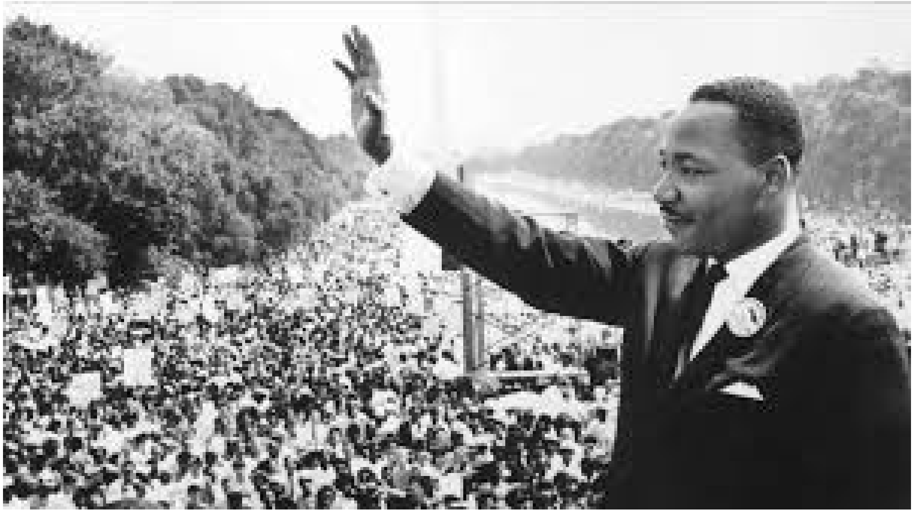

Figure 11.10: **Dr. Martin Luther King Jr. speakes in Washington: "I have a dream!"**

Opposition to nuclear weapons

In his book, "Strength to Love", Dr. King wrote,"Wisdom born of experience should tell us that war is obsolete. There may have been a time when war served a negative good by preventing the spread of an evil force, but the power of modern weapons eliminates even the possibility that war may serve as a negative good. If we assume that life is worth living, and that man has a right to survival, then we must find an alternative to war ... I am convinced that the Church cannot be silent while mankind faces the threat of nuclear annihilation. If the church is true to her mission, she must call for an end to the nuclear arms race."

Assassination

On April 4, 1968, Dr. King was shot and killed. A number of people, including members of his own family, believe that he was killed because of his opposition to the Viet Nam War. This conclusion is supported by the result of a 1999 trial initiated by members of the King family. Summing up the arguments to the jury, the family's lawyer said "We are dealing in conspiracy with agents of the City of Memphis and the governments of the State of Tennessee and the United States of America. We ask that you find that a conspiracy existed." After two and a half hour's deliberation, the jury found that Lloyd Jowers and "others, including governmental agencies, were parties to this conspiracy". The verdict of the jury remains judicially valid today, and it has never been overturned in a court of law, although massive efforts have been made to discredit it.

Redemptive love

Concerning the Christian principle of loving one's enemies, Dr. King wrote: "Why should we love our enemies? Returning hate for hate multiplies hate, adding deeper darkness to a night already devoid of stars. Darkness cannot drive out darkness; only light can do that. Hate cannot drive out hate. Only love can do that ... Love is the only force capable of transforming an enemy into a friend. We never get rid of an enemy by meeting hate with hate; we get rid of an enemy by getting rid of enmity... It is this attitude that made it possible for Lincoln to speak a kind word about the South during the Civil War, when feeling was most bitter. Asked by a shocked bystander how he could do this, Lincoln said, 'Madam, do I not destroy my enemies when I make them my friends?' This is the power of redemptive love."

To a large extent, the black civil rights movement of the '50's and '60's succeeded in ending legalized racial discrimination in America. If the methods used had been violent, the movement could easily have degenerated into a nightmare of interracial hatred; but by remembering the Christian message, "Love your enemy; do good to them that despitefully use you", Martin Luther King Jr. raised the ethical level of the civil rights movement; and the final result was harmony and understanding between the black and white communities. Later the nonviolent methods of Gandhi and King were successfully applied to the South African struggle against Apartheid by Nelson Mandela and his followers.

Here are a few more things that Martin Luther King said

I have decided to stick to love...Hate is too great a burden to bear

Faith is taking the first step even when you can't see the whole staircase.

Our lives begin to end the day we become silent about things that matter.

In the end, we will remember not the words of our enemies, but the silence of our friends.

If you can't fly then run, if you can't run then walk, if you can't walk then crawl, but whatever you do you have to keep moving forward.

Only in the darkness can you see the stars.

There comes a time when a person must take a position that is neither safe, nor politic, nor popular, but he must take it because conscience tells him it is right.

Everybody can be great...because anybody can serve. You don't have to have a college degree to serve. You don't have to make your subject and verb agree to serve. You only need a heart full of grace. A soul generated by love.

Forgiveness is not an occasional act, it is a constant attitude.

We must accept finite disappointment, but never lose infinite hope.

There is some good in the worst of us and some evil in the best of us. When we discover this, we are less prone to hate our enemies.

We must live together as brothers or perish together as fools.

Intelligence plus character - that is the goal of true education

True peace is not merely the absence of tension; it is the presence of justice.

Science investigates; religion interprets. Science gives man knowledge, which is power; religion gives man wisdom, which is control. Science deals mainly with facts; religion deals mainly with values. The two are not rivals.

The ultimate measure of a man is not where he stands in moments of comfort and convenience, but where he stands at times of challenge and controversy.

We know through painful experience that freedom is never voluntarily given by the oppressor, it must be demanded by the oppressed.

Injustice anywhere is a threat to justice everywhere. We are caught in an inescapable network of mutuality, tied in a single garment of destiny. Whatever affects one directly, affects all indirectly.

We have also come to this hallowed spot to remind America of the fierce urgency of Now. This is no time to engage in the luxury of cooling off or to take the tranquilizing drug of gradualism. Now is the time to make real the promises of democracy.

The time is always right to do what is right.

For when people get caught up with that which is right and they are willing to sacrifice for it, there is no stopping point short of victory.

All we say to America is, 'Be true to what you said on paper.' If I lived in... any totalitarian country, maybe I could understand the denial of certain basic First Amendment privileges, because they hadn't committed themselves to that over there. But somewhere I read of the freedom of assembly. Somewhere I read of the freedom of speech. Somewhere I read of the freedom of the press. Somewhere I read that the greatness of America is the right to protest for right.

We've got some difficult days ahead. But it really doesn't matter with me now because I've been to the mountaintop . . .I've looked over and I've seen the promised land. I may not get there with you. But I want you to know tonight that we as a people will get to the promised land.

11.12 ICAN wins the 2017 Nobel Peace Prize

What is ICAN?

The International Campaign to Abolish Nuclear Weapons, abbreviated ICAN, is a coalition of 468 NGO's in 101 countries. The purpose of ICAN is to change the focus in the disarmament debate to "the the humanitarian threat posed by nuclear weapons, drawing attention to their unique destructive capacity, their catastrophic health and environmental consequences, their indiscriminate targeting, the debilitating impact of a detonation on medical infrastructure and relief measures, and the long-lasting effects of radiation on the surrounding area."

ICAN was founded in 2007 by the International Physicians for the Prevention of Nuclear War, an organization which itself received a Nobel Peace Prize in 1985. IPPNW was inspired by the success of the campaign that achieved the Ottawa Treaty in 1997, a treaty which banned antipersonnel land-mines against bitter opposition from the worst offenders. Thus, from the start. ICAN envisioned a treaty passed and without the participation or signatures of the nuclear weapons states. ICAN believed that such a treaty would have the great value of unambiguously underlining the illegality, immorality and omnicidal nature of nuclear weapons. Nuclear weapons states would eventually be forced

Figure 11.11: **From left to right: Berit Reiss-Andersen, Chairman of the Norwegian Nobel Committee, Setsuko Thurlow, an 85-year-old survivor of the 1945 atomic bombing of Hiroshima, and ICAN Executive Director Beatrice Fihn.**

to yield to the will of the vast majority of humankind.

On July 7, 2017, the Treaty on the Prohibition of Nuclear Weapons was adopted by an overwhelming majority, 122 to 1, by the United Nations General Assembly. The adoption of the treaty, a milestone in humanity's efforts to rid itself of nuclear insanity, was to a large extent due to the efforts of ICAN's participating organizations.

On December 10, 2017 ICAN's efforts were recognized by the award of the Nobel Peace Prize. Part of the motivation for the award was the fact that the threat of a thermonuclear global catastrophe is higher today than it has been at any time since the Cuban Missile Crisis. Because of the belligerent attitudes and mental instability of Donald Trump and Kim Jong-un, the end of human civilization and much of the biosphere is, in the words of Beatrice Fihn, "only a tantrum away".

11.13 Compassion versus greed

Humans are capable of great compassion and unselfishness. Mothers and fathers make many sacrifices for the sake of their families. Kind teachers help us through childhood, and show us the right path. Doctors and nurses devote themselves to the welfare of their patients.

Sadly there is another, side to human nature, a darker side. Human history is stained with the blood of wars and genocides. Today, this dark, aggressive side of human nature threatens to plunge our civilization into an all-destroying thermonuclear war.

Humans often exhibit kindness to those who are closest to themselves, to their families and friends, to their own social group or nation. By contrast, the terrible aggression seen in wars and genocides is directed towards outsiders. Human nature seems to exhibit what might be called "tribalism": altruism towards one's own group; aggression towards outsiders. Today this tendency towards tribalism threatens both human civilization and the biosphere.

Greed, in particular the greed of corporations and billionaire oligarchs, is driving human civilization and the biosphere towards disaster.

The greed of giant fossil fuel corporations is driving us towards a tipping point after which human efforts to control climate change will be futile because feedback loops will have taken over. The greed of the military industrial complex is driving us towards a Third World War that might develop into a catastrophic thermonuclear war. The greed of our financial institutions is also driving us towards economic collapse, as we see in the case of Greece.

Until the start of the Industrial Revolution in the 18th and 19th centuries, human society maintained a more or less sustainable relationship with nature. However, with the beginning of the industrial era, traditional ways of life, containing elements of both social and environmental ethics, were replaced by the money-centered, growth-oriented life of today, from which these vital elements are missing.

According to the followers of Adam Smith (1723-1790), self-interest (even greed) is a sufficient guide to human economic actions. The passage of time has shown that Smith was right in many respects. The free market, which he advocated, has turned out to be the optimum prescription for economic growth. However, history has also shown that there is something horribly wrong or incomplete about the idea that self-interest alone, uninfluenced by ethical and ecological considerations, and totally free from governmental intervention, can be the main motivating force of a happy and just society. There has also proved to be something terribly wrong with the concept of unlimited economic growth.

The Industrial Revolution marked the start of massive human use of fossil fuels. The stored energy from several hundred million years of plant growth began to be used at roughly a million times the rate at which it had been formed. The effect on human society was like that of a narcotic. There was a euphoric (and totally unsustainable) surge of growth of both population and industrial production. Meanwhile, the carbon released into the atmosphere from the burning of fossil fuels began to duplicate the conditions which led to the 5 geologically-observed mass extinctions, during each of which more than half of all living species disappeared forever.

The Stern Review Discussion Paper of 2006 stated that "Melting of permafrost in the Arctic could lead to the release of huge quantities of methane. Dieback of the Amazon forest could mean that the region starts to emit rather than to absorb greenhouse gases. These feedbacks could lead to warming that is at least twice as fast as current high-emission projections, leading to temperatures higher than seen in the last 50 million years."

The greed of giant fossil fuel corporations has recently led them to conduct large-scale advertising campaigns to convince the public that anthropogenic climate change is not real. These corporations own vast oil, coal and gas reserves that must be kept in the ground if we are to avoid catastrophic global warming. It does not seem to bother the fossil fuel giants that if the earth is made uninhabitable, future generations of both humans and animals will perish.

When the United Nations was established in 1945, the purpose of the organization was to abolish the institution of war. This goal was built into many of the articles of the UN Charter. Accordingly, throughout the world, many War Departments were renamed and became Departments of Defense. But the very name is a lie. In an age of nuclear threats and counter-threats, populations are by no means protected. Ordinary citizens are just hostages in a game for power and money. It is all about greed.

Why is war continually threatened? Why is Russia threatened? Why is war with Iran threatened? Why fan the flames of conflict with China? Is it to "protect" civilians? Absolutely not! In a thermonuclear war, hundreds of millions of civilians would die horribly everywhere in the world, also in neutral countries. What is really being protected are the profits of arms manufacturers. As long as there are tensions; as long as there is a threat of war, military budgets are safe; and the profits of arms makers are safe. The people in several "democracies", for example the United States, do not rule at the moment. Greed rules.

Greed and lack of ethics are built into the structure of corporations. By law, the Chief Executive Officer of a corporation must be entirely motivated by the collective greed of the stockholders. He must maximize profits. Nothing must count except the bottom line. If the CEO abandons this single-minded chase after corporate profits for ethical reasons, or for the sake of humanity or the biosphere or the future, he (or she) must, by law, be fired and replaced.

Occasionally, for the sake of their public image, corporations seem to do something for other motives than their own bottom line, but it is usually window dressing. For example, Shell claims to be supporting research on renewable energy. Perhaps there is indeed a small renewable energy laboratory somewhere in that vast corporation; but the real interest of the organization is somewhere else. Shell is sending equipment on a large scale to drill for more and more environment-destroying oil in the Arctic.

What does Christianity say about greed? Wikipedia states that "The seven deadly sins, also known as capital vices or cardinal sins, is a classification of vices (part of Christian ethics) that has been used since early Christian times to educate and instruct Christians concerning fallen humanity's tendency to sin. In the currently recognized version, the sins are usually given as wrath, greed, sloth, pride, lust, envy and gluttony. Each is a form of Idolatry-of-Self wherein the subjective reigns over the objective."

Saint Thomas Aquinas wrote: "Greed is a sin against God, just as all mortal sins, in as much as man condemns things eternal for the sake of temporal things".

In the New Testament, we can find many passages condemning greed, for example:

"For the love of money is the root of all evil: which while some coveted after, they have erred from the faith, and pierced themselves through with many sorrows." Timothy 6:10

"Lay not up for yourselves treasures upon earth, where moth and rust doth corrupt, and where thieves break through and steal." Mathew 6:19

In his encyclical Laudato Si', and on his recent visit to South America, Pope Francis has spoken strongly against economic activity that lacks both social and environmental ethics.

Much depends on whether we are able to break the power that corporations and extremely rich oligarchs now hold over our governments and our mass media. Pope Francis has shown by example what a world leader of courage and honesty can do. Most of us are not in such a position, but each person can do his or her best to restore democracy where it has been lost to corporate money and greed. If the mass media have sold themselves to the highest bidder, we can make our own media. If most politicians are corrupt, we can make our own political movements. As Shelly said, "We are many, they are few".

We need your voice today

Saint Francis said:
Blessed is he who loves and does not therefore desire to be loved;
Blessed is he who fears and does not therefore desire to be feared;
Blessed is he who serves and does not therefore desire to be served;
Blessed is he who behaves well toward others and does not desire that others behave well toward him.

William Blake said:
Every Night & every Morn
Some to Misery are Born
Every Morn and every Night
Some are Born to sweet delight
Some are Born to sweet delight
Some are Born to Endless Night.

Thomas Paine said:
It is a perversion of terms to say that a charter gives rights. It operates by a contrary effect: that of taking rights away. Rights are inherently in all the inhabitants; but charters, by annulling those rights, in the majority, leave the right, by exclusion, in the hands of a few... They... consequently are instruments of injustice ... The fact, therefore, must be that the individuals, themselves, each, in his own personal and sovereign right, entered into a contract with each other to produce a government: and this is the only mode in which governments have a right to arise, and the only principle on which they have a right to exist.

Thomas Jefferson said:
I know of no safe depository of the ultimate powers of the society but the people themselves; and if we think them not enlightened enough to exercise their control with a wholesome discretion, the remedy is not to take it from them but to inform their discretion.

Mary Wollstonecraft said:
I entreat (men) to assist to emancipate their companion, to make her a help meet for them! Would men but generously snap our chains, and be content with rational fellowship instead of slavish obedience, they would find us more observant daughters, more affectionate sisters, more faithful wives, more reasonable mothers: in a word, better citizens.

William Godwin said:
To whom does any article, suppose a loaf of bread, justly belong? I have an hundred loaves in my possession, and in the next street there is a poor man expiring with hunger, to whom one of these loaves would be a means of preserving his life. If I withhold this loaf from him, am I not unjust? If I impart it, am I not complying with what justice demands?

The Marquis de Condorcet said:
Any person who has contributed to the progress of mankind to the best of his ability becomes immune to personal disaster and suffering. He knows that human progress is inevitable and can take comfort and courage from his inner picture of the epic march of mankind, through history, towards a better future.

Thomas Robert Malthus said:
That population cannot increase without the means of subsistence is a proposition so evident that it needs no illustration. That population does invariably increase, where there are means of subsistence, the history of every people who have ever existed will abundantly prove. And that the superior power cannot be checked without producing misery and vice, the ample portion of these two bitter ingredients in the cup of human life, and the continuance of the physical causes that seem to have produced them, bear too convincing a testimony. (He later modified this opinion and made it less pessimistic by allowing for the effect of preventive checks such as late marriage. Malthus considered birth control to be a form of vice, but today it is accepted as the most humane method of avoiding the grim Malthusian forces, famine, disease and war.)

Percy Bysshe Shelley said:
Rise, like lions after slumber
In unvanquishable number!
Shake your chains to earth like dew
Which in sleep had fallen on you:
Ye are many, they are few!

Robert Owen said:
I know that society may be formed so as to exist without crime, without poverty, with health greatly improved, with little, if any, misery. and with intelligence and happiness increased a hundredfold; and no obstacle whatsoever intervenes at this moment except ignorance to prevent such a state of society from becoming universal.

John Stuart Mill said:

The only purpose for which power can be rightfully exercised over any member of a civilized community, against his will, is to prevent harm to others.

Henry David Thoreau said:
Simplify your life. Don't waste the years struggling for things that are unimportant. Don't burden yourself with possessions. Keep your needs and wants simple and enjoy what you have. Don't destroy your peace of mind by looking back, worrying about the past. Live in the present. Simplify!

Count Leo Tolstoy said:
The sharpest of all contradictions can be seen between the government's professed faith in the Christian law of the brotherhood of all humankind, and the military laws of the state, which force each young man to prepare himself for enmity and murder.

Mahatma Gandhi said:
They say that 'means are after all means'. I would say that 'means are after all everything'. As the means, so the end. Indeed, the Creator has given us limited power over means, none over end... The means may be likened to a seed, and the end to a tree; and there is the same inviolable connection between the means and the end as there is between the seed and the tree. Means and end are convertible terms in my philosophy of life.

Martin Luther King said:
Wisdom born of experience should tell us that war is obsolete. There may have been a time when war served a negative good by preventing the spread of an evil force, but the power of modern weapons eliminates even the possibility that war may serve as a negative good. If we assume that life is worth living, and that man has a right to survival, then we must find an alternative to war ... I am convinced that the Church cannot be silent while mankind faces the threat of nuclear annihilation. If the church is true to her mission, she must call for an end to the nuclear arms race.

Wilfred Owen said:
If in some smothering dream, you too could pace
Behind the wagon that we flung him in,
And watch the white eyes writhing in his face,
His hanging face, like a devil's sick of sin,
If you could hear, at every jolt, the blood
Come gargling from the froth-corrupted lungs
Obscene as cancer, bitter as the cud

Of vile, incurable sores on innocent tongues,
My friend, you would not tell with such high zest
To children ardent for some desperate glory,
The old Lie: Dulce et decorum est
Pro patria mori.

Albert Einstein said:
The unleashed power of the atom has changed everything except our ways of thinking, and thus we drift towards unparalleled catastrophes.

Edna St. Vincent Millay said:
Man, doughty Man, what power has brought you low,
That heaven itself in arms could not persuade
To lay aside the lever and the spade
And be as dust among the dusts that blow?
Whence, whence the broadside? Whose the heavy blade?...
Strive not to speak, poor scattered mouth; I know.

Bertha von Suttner said:
Strange how blind people are! They are horrified by the torture chambers of the Middle Ages, but their arsenals fill them with pride!

George Orwell said:
In a time of deceit telling the truth is a revolutionary act

Helen Keller said:
Strike against war, for without you no battles can be fought! Strike against manufacturing shrapnel and gas bombs and all other tools of murder! Strike against preparedness that means death and misery to millions of human beings! Be not dumb, obedient slaves in an army of destruction! Be heroes in an army of construction.

Today, human civilization and the biosphere are facing a crisis. Here are the tasks which history has given to our generation:

- We must abolish the institution of war before modern weapons destroy us.

- We must replace institutionalized violence by a just, democratic and enforcible system of global governance and international law.

- We must stabilize and ultimately reduce global population to a level that can be supported by sustainable agriculture.
- We must leave fossil fuels in the ground.
- We must avoid the large-scale global famine which threatens us because of the combined effects of climate change, population growth and the end of the fossil fuel era.
- We must achieve a steady-state economic system. Limitless growth on a finite planet is a logical absurdity.
- We must decrease economic inequality, both between nations and within nations,
- We must strive for governments that are true democracies rather than oligarchies.
- And finally, we must develop a mature ethical system to match our new technology.

These are difficult tasks, but together we can overcome the difficulties. As Helen Keller said, *Alone we can do so little! Together we can do so much!*

At a time of crisis, with the future at stake, please don't be silent. We urgently need your voice today!

11.14 The fragility of our complex civilization

The rapid growth of knowledge

Cultural evolution depends on the non-genetic storage, transmission, diffusion and utilization of information. The development of human speech, the invention of writing, the development of paper and printing, and finally, in modern times, mass media, computers and the Internet: all these have been crucial steps in society's explosive accumulation of information and knowledge. Human cultural evolution proceeds at a constantly-accelerating speed, so great in fact that it threatens to shake society to pieces.

In many respects, our cultural evolution can be regarded as an enormous success. However, at the start of the 21st century, most thoughtful observers agree that civilization is entering a period of crisis. As all curves move exponentially upward, population, production, consumption, rates of scientific discovery, and so on, one can observe signs of increasing environmental stress, while the continued existence and spread of nuclear weapons threaten civilization with destruction. Thus, while the explosive growth of knowledge has brought many benefits, the problem of achieving a stable, peaceful and sustainable world remains serious, challenging and unsolved.

Our modern civilization has been built up by means of a worldwide exchange of ideas and inventions. It is built on the achievements of many ancient cultures. China, Japan, India, Mesopotamia, Egypt, Greece, the Islamic world, Christian Europe, and the Jewish intellectual traditions, all have contributed. Potatoes, corn, squash, vanilla, chocolate, chili peppers, and quinine are gifts from the American Indians.

The sharing of scientific and technological knowledge is essential to modern civilization. The great power of science is derived from an enormous concentration of attention and resources on the understanding of a tiny fragment of nature. It would make no sense to proceed in this way if knowledge were not permanent, and if it were not shared by the entire world.

Science is not competitive. It is cooperative. It is a great monument built by many thousands of hands, each adding a stone to the cairn. This is true not only of scientific knowledge but also of every aspect of our culture, history, art and literature, as well as the skills that produce everyday objects upon which our lives depend. Civilization is cooperative. It is not competitive.

Our cultural heritage is not only immensely valuable; it is also so great that no individual comprehends all of it. We are all specialists, who understand only a tiny fragment of the enormous edifice. No scientist understands all of science. Perhaps Leonardo da Vinci could come close in his day, but today it is impossible. Nor do the vast majority people who use cell phones, personal computers and television sets every day understand in detail how they work. Our health is preserved by medicines, which are made by processes that most of us do not understand, and we travel to work in automobiles and buses that we would be completely unable to construct.

The fragility of modern society

As our civilization has become more and more complex, it has become increasingly vulnerable to disasters. We see this whenever there are power cuts or transportation failures due to severe storms. If electricity should fail for a very long period of time, our complex society would cease to function. The population of the world is now so large that it is completely dependent on the high efficiency of modern agriculture. We are also very dependent on the stability of our economic system.

The fragility of modern society is particularly worrying, because, with a little thought, we can predict several future threats which will stress our civilization very severely. We will need much wisdom and solidarity to get safely through the difficulties that now loom ahead of us.

We can already see the the problem of famine in vulnerable parts of the world. Climate change will make this problem more severe by bringing aridity to parts of the world that are now large producers of grain, for example the Middle West of the United States. Climate change has caused the melting of glaciers in the Himalayas and the Andes. When these glaciers are completely melted, China, India and several countries in South America will be deprived of their summer water supply. Water for irrigation will also become increasingly problematic because of falling water tables. Rising sea levels will drown many rice-growing areas in South-East Asia. Finally, modern agriculture is very dependent on fossil fuels for the production of fertilizer and for driving farm machinery. In the future, high-yield agriculture will be dealt a severe blow by the rising price of fossil fuels.

Economic collapse is another threat that we will have to face in the future. Our present fractional reserve banking system is dependent on economic growth. But perpetual growth of industry on a finite planet is a logical impossibility. Thus we are faced with a period of stress, where reform of our growth-based economic system and great changes of lifestyle will both become necessary.

How will we get through the difficult period ahead? I believe that solutions to the difficult problems of the future are possible, but only if we face the problems honestly and make the adjustments which they demand. Above all, we must maintain our human solidarity.

Figure 11.12: **The earth at night, seen from space: The thin layer of atmosphere covering the earth is vulnerable to the greenhouse gases that can cause catastrophic climate change. At night we can see the massive energy use that produces these greenhouse gases.**

11.15 Looking towards the future

Tensions created by the rapidity of technological change

In human cultural evolution, information transfer and storage through the language of molecular complementarity is supplemented by new forms of biological information flow and conservation - spoken language, writing, printing, and more recently electronic communication. The result has been a shift into a much higher evolutionary gear.

Because of new, self-reinforcing mechanisms of information flow and accumulation, the rate of evolutionary change has increased enormously: It took 3 billion years for the first autocatalytic systems to develop into multicellular organisms. Five hundred million years were required for multicellular organisms to rise from the level of sponges and slime molds to the degree of complexity and organization that characterizes primates and other mammals; but when a branch of the primate family developed a tool-using culture, spoken language, and an enlarged brain, only 40,000 years were required for our ancestors to change from animal-like hunter-gatherers into engineers, poets and astronomers.

During the initial stages of human cultural evolution, the rate of change was slow enough for genetic adaptation to keep pace. The co-evolution of speech, tool use, and an enlarged brain in hominids took place over a period of several million years, and there was ample time for genetic adaptation. The prolonged childhood which characterizes our species, and the behavior patterns of familial and tribal solidarity, were built into the genomes of our ancestors during the era of slow change, when cultural and genetic evolution moved together in equilibrium. However, as the pace of cultural information accumulation quickened, genetic change could no longer keep up.

Genetically we are almost identical with our neolithic ancestors; but their world has been replaced by a world of quantum theory, relativity, supercomputers, antibiotics, genetic engineering and space telescopes - unfortunately also a world of nuclear weapons and nerve gas. Because of the slowness of genetic evolution in comparison to the rapid and constantly-accelerating rate of cultural change, our bodies and minds are not perfectly adapted to our new way of life. They reflect more accurately the way of life of our hunter-gatherer ancestors.

In addition to the contrast between the slow pace of genetic evolution when compared with the rapid and constantly-accelerating rate of cultural evolution, we can also notice a contrast between rapidly- and slowly-moving aspects of cultural change: Social institutions and structures seem to change slowly when compared with the lightning-like pace of scientific and technological innovation. Thus, tensions and instability characterize information-driven society, not only because science and technology change so much more rapidly than institutions, laws, and attitudes, but also because human nature is not completely appropriate to our present way of life. In particular, human nature seems to contain an element of what might be called "tribalism", because our emotions evolved during an era when our ancestors lived in small, mutually hostile tribes, competing with one an- other for territory on the grasslands of Africa.

Looking towards the future, what can we predict? Detailed predictions are very difficult, but it seems likely that information technology and biotechnology will for some time continue to be the most rapidly-developing branches of science, and that these two fields will merge. We can guess with reasonable certainty that much progress will be made in understanding the mechanism of the brain, and in duplicating its functions artificially. Scientists of the future will undoubtedly achieve greatly increased control over the process of evolution. Thus it seems probable that the rapidity of scientific and technological change will produce ethical dilemmas and social tensions even more acute than those which we experience today. It is likely that the fate of our species (and the fate of the biosphere) will be made precarious by the astonishing speed of scientific and technological change unless this progress is matched by the achievement of far greater ethical and political maturity than we have yet attained.

Science has proved to be double-edged - capable of great good, but also of great harm. Information-driven human cultural evolution is a spectacular success - but can it become stable? Terrestrial life can look back on almost four billion years of unbroken evolutionary progress. Can we say with confidence that an equal period stretches ahead of us?

Can information-driven society achieve stability?

"We are living in a very special time", Murray Gell-Mann[1] remarked in a recent interview, "Historians hate to hear this, because they have heard it so many times before, but we *are* living in a very special time. One symptom of this is the fact that human population has for a long time been increasing according to a hyperbolic curve - a constant divided by 2020 minus the year."

The hyperbola has the form P = C/(2020 – y), P being the population, y, the year, and C a constant. This form is at first surprising. One might have expected it to be an exponential, if the rate of increase were proportional to the population already present. The fact that the curve is instead a hyperbola can be understood in terms of the accumulation of cultural information. New techniques (for example the initial invention of agriculture, the importation of potatoes to Europe, or the introduction of high-yield wheat and rice varieties) make population growth possible. In the absence of new techniques, population is usually held in check by the painful Malthusian forces - famine, disease, and war.

Gell Mann's curve shows an explosive growth of human population, driven by an equally explosive growth of stored cultural information - especially agricultural and medical information, and the information needed for opening new land to agriculture. As Gell-Mann remarks, population cannot continue to increase in this way, because we are rapidly approaching the limits of the earth's carrying capacity. Will human numbers overshoot these limits and afterwards crash disastrously? There is certainly a danger that this will happen.

Besides the challenge of stabilizing global population, the information-driven human society of the future will face another daunting task: Because of the enormously destructive weapons that have already been produced through the misuse of science, and because of the even worse weapons that may be invented in the future, the long-term survival of civilization can only be insured if society is able to eliminate the institution of war. This task will be made more difficult by the fact that human nature seems to contain an element of tribalism.

Humans tend to show great kindness towards close relatives and members of their own group, and are even willing to sacrifice their lives in battle in defense of their own family, tribe or nation. This tribal altruism is often accompanied

[1] Gell-Mann is an American physicist who was awarded a Nobel Prize in 1969 for his contributions to the theory of elementary particles.

by inter-tribal aggression - great cruelty towards the "enemy", i.e. towards members of a foreign group which is perceived to be threatening ones own. The fact that human nature seems to contain a genetically-programmed tendency towards tribalism is the reason why we find football matches entertaining, and the reason why Arthur Koestler once remarked: "We can control the movements of a space-craft orbiting about a distant planet, but we cannot control the situation in Northern Ireland."

How could evolutionary forces have acted to make the pattern of tribal altruism and inter-tribal aggression a part of human nature? To put the same question differently, how could our ancestors have increased the chances for survival of their own genes by dying in battle? The statistician R.A. Fisher and the evolutionary biologist J.B.S. Haldane considered this question in the 1920's.[2] Their solution was the concept of population genetics, in which the genetically homogeneous group as a whole - now sometimes called the "deme" - is taken to be the unit upon which evolutionary forces act.

Haldane and Fisher postulated that the small tribes in which our ancestors lived were genetically homogeneous, since marriage within the tribe was more probable than marriage outside it. This being the case, a patriotic individual who died for the tribe, killing many members of a competing tribe in the process, increased the chance of survival for his or her own genes, which were carried into the future by the surviving members of the hero's group. The tribe as a whole either lived or died; and those with the best "team spirit" survived most frequently.

Because of the extraordinarily bitter and cruel conflicts between ethnic groups which can be found in both ancient and modern history, it is necessary to take the ideas of Haldane and Fischer seriously. This does not mean that the elimination of the institution of war is impossible, but it means that the task will require the full resources and full cooperation of the world's educational systems, religions, and mass media. It will be necessary to educate children throughout the world in such a way that they will think of humanity as a single group - a large family to which all humans belong, and to which they owe their ultimate loyalty.

In addition to educational reform, and reform of the images presented by the mass media, the elimination of war will require the construction of a democratic, just, and humane system of international governance, whose laws will act on individuals rather than on states. The problems involved are very difficult, but they must be solved if the information-driven society of the future is to achieve stability.

[2] More recently the evolution of tribal altruism and inter-tribal aggression has also been discussed by W.D. Hamilton and Richard Dawkins.

Respect for natural evolution

The avalanche of new techniques in biotechnology and information technology will soon give scientists so much power over evolution that evolutionary ethical problems will become much more acute than they are today. It is already possible to produce chimeras, i.e. transgenic animals and plants incorporating genetic information from two or more species. Will we soon produce hybrids which are partly machines and partly living organisms? What about artificial life? Will humans make themselves obsolete by allowing far more intelligent beings to evolve in cyberspace, as Thomas Ray proposes? What about modification and improvement of our own species? Is there a limit beyond which we ought not to go in constructing new organisms to suit human purposes?

Perhaps one answer to these questions can be found by thinking of the way in which evolution has operated to produce the biosphere. Driven by the flood of Gibbs free energy which the earth receives from the sun, living organisms are generated and tested by life. New generations are randomly modified by the genetic lottery, sometimes for the worse, and sometimes for the better; and the instances of improvement are kept. It would be hard to overestimate the value of this mechanism of design by random modification and empirical testing, with the preservation of what works. The organisms which are living today are all champions! They are distillations of vast quantities of experience, end products of four billion years of solar energy income.

The beautiful and complex living organisms of our planet are exquisitely adapted to survive, to live with each other, and to form harmonious ecological systems. Whatever we do in biotechnology ought to be guided by caution and by profound respect for what evolution has already achieved. We need a sense of evolutionary responsibility, and a non-anthropocentric component in our system of ethics.

Construction versus destruction

It is often said that ethical principles cannot be derived from science - that they must come from somewhere else. Nevertheless, when nature is viewed through the eyes of modern science, we obtain some insights which seem almost ethical in character. Biology at the molecular level has shown us the complexity and beauty of even the most humble living organisms, and the interrelatedness of all life on earth. Looking through the eyes of contemporary biochemistry, we can see that even the single cell of an amoeba is a structure of miraculous complexity and precision, worthy of our respect and wonder.

Knowledge of the second law of thermodynamics - the statistical law favoring disorder over order - reminds us that life is always balanced like a tight-rope walker over an abyss of chaos and destruction. Living organisms distill their order and complexity from the flood of thermodynamic information which reaches the earth from the sun. In this way, they create local order; but life remains a fugitive from the second law of thermodynamics. Disorder, chaos, and destruction remain statistically favored over order, construction, and complexity.

It is easier to burn down a house than to build one, easier to kill a human than to raise and educate one, easier to force a species into extinction than to replace it once it is gone, easier to burn the Great Library of Alexandria than to accumulate the knowledge that once filled it, and easier to destroy a civilization in a thermonuclear war than to rebuild it from the radioactive ashes. Knowing this, scientists can form an almost ethical insight: To be on the side of order, construction, and complexity, is to be on the side of life. To be on the side of destruction, disorder, chaos and war is to be against life, a traitor to life, an ally of death. Knowing the precariousness of life - knowing the statistical laws that favor disorder and chaos, we should resolve to be loyal to the principle of long continued construction upon which life depends.

What kind of future world do we want?

Our political and educational systems must reflect the kind of world that we want for the future - and what kind of world do we want? We want a world where war is abolished as an institution, and where the enormous resources now wasted on war are used constructively. We want a world where a stable population of moderate size lives in comfort and security, free from fear of hunger or unemployment. We want a world where peoples of all countries have equal access to resources, and an equal quality of life. We want a world with a new economic system, not designed to produce unlimited growth, but aiming instead at meeting the real needs of the human community in equilibrium with the global environment. We want a world of changed values, where extravagance and waste are regarded as morally wrong; where kindness, wisdom and beauty are admired; and where the survival of other species than our own is regarded as an end in itself, not just a means to our own ends.

In our reverence for the intricate beauty and majesty of nature, and our respect for the dignity and rights of other humans, we can feel united with the great religious and philosophical traditions of mankind, and with the traditional wisdom of our ancestors.

Pictures sent back by the astronauts show the earth as it really is - a small, fragile, beautiful planet, drifting on through the dark immensity of space - our home, where we must learn to live in harmony with nature and with each other.

11.16 Chaplin's speech: Hope

At the end of his 1940 film, **The Great Dictator**, Charlie Chaplin suddenly abandons satire and speaks to us directly with his own voice, his own idealism. In the film, the speech is given by a small Jewish barber, who looks very much like the dictator, Adenoid Henkel (Adolf Hitler). Mistaken for Henkel, the barber must address a huge expectant crowd. Here is the speech:

Hynkel: I'm sorry, but I don't want to be an Emperor - that's not my business. I don't want to rule or conquer anyone. I should like to help everyone, if possible - Jew, gentile, black man, white. We all want to help one another; human beings are like that. We want to live by each other's happiness, not by each other's misery. We don't want to hate and despise one another. In this world there's room for everyone and the good earth is rich and can provide for everyone.

The way of life can be free and beautiful.

But we have lost the way.

Greed has poisoned men's souls, has barricaded the world with hate, has goose-stepped us into misery and bloodshed. We have developed speed but we have shut ourselves in. Machinery that gives abundance has left us in want. Our knowledge has made us cynical, our cleverness hard and unkind. We think too much and feel too little. More than machinery, we need humanity. More than cleverness, we need kindness and gentleness. Without these qualities, life will be violent and all will be lost.

The aeroplane and the radio have brought us closer together. The very nature of these inventions cries out for the goodness in men, cries out for universal brotherhood for the unity of us all. Even now my voice is reaching millions throughout the world, millions of despairing men, women, and little children, victims of a system that makes men torture and imprison innocent people.

To those who can hear me I say, "Do not despair." The misery that is now upon us is but the passing of greed, the bitterness of men who fear the way of human progress. The hate of men will pass and dictators die; and the power they took from the people will return to the people and so long as men die, liberty will never perish.

Soldiers: Don't give yourselves to brutes, men who despise you, enslave you, who regiment your lives, tell you what to do, what to think and what to feel; who drill you, diet you, treat you like cattle, use you as cannon fodder. Don't give yourselves to these unnatural men, machine men, with machine minds and machine hearts! You are not machines! You are not cattle! You are men! You have the love of humanity in your hearts. You don't hate; only the unloved hate, the unloved and the unnatural.

Figure 11.13: **Look up, Hannah!**

Soldiers: Don't fight for slavery! Fight for liberty! In the seventeenth chapter of Saint Luke it is written, "the kingdom of God is within man" - not one man, nor a group of men, but in all men, in you, you the people have the power, the power to create machines, the power to create happiness. You the people have the power to make this life free and beautiful, to make this life a wonderful adventure.

Then, in the name of democracy, let us use that power! Let us all unite!! Let us fight for a new world, a decent world that will give men a chance to work, that will give you the future and old age a security. By the promise of these things, brutes have risen to power, but they lie! They do not fulfill their promise; they never will. Dictators free themselves, but they enslave the people!! Now, let us fight to fulfill that promise!! Let us fight to free the world, to do away with national barriers, to do away with greed, with hate and intolerance. Let us fight for a world of reason, a world where science and progress will lead to all men's happiness.

Soldiers: In the name of democracy, let us all unite!!!

In Chaplin's film, Hannah is the sweetheart of the Jewish barber, and she is listening (as he hopes) to a radio broadcast of the speech. He continues his speech, talking to her:

Hannah, can you hear me? Wherever you are, look up, Hannah. The clouds are lifting. The sun is breaking through. We are coming out of the darkness into the light. We are coming into a new world, a kindlier world, where men will rise above their hate, their greed and brutality.

Look up, Hannah. The soul of man has been given wings, and at last he is beginning to fly. He is flying into the rainbow – into the light of hope, into the future, the glorious future that belongs to you, to me, and to all of us.

Look up, Hannah. Look up!

Figure 11.14: **Alone we can do so little; together, we can do so much!**

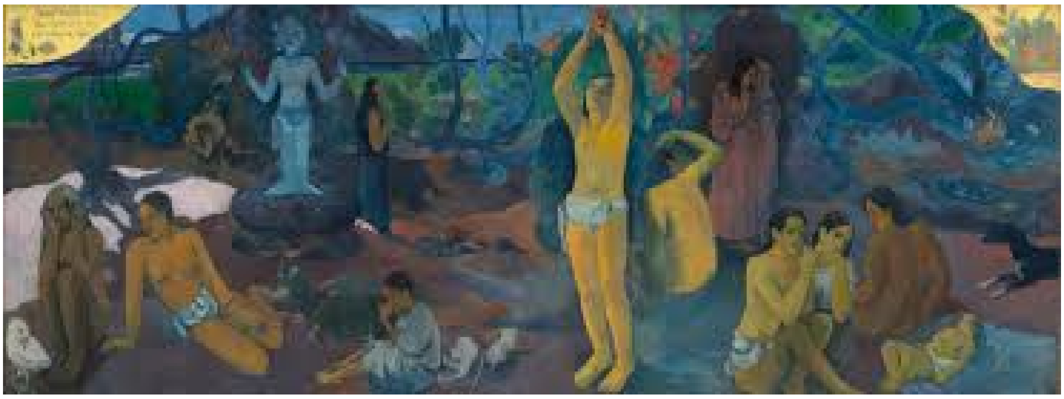

Figure 11.15: **Where do we come from? What are we? Where are we going?**

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