PART 1

The Company as of Today

Chapter 1

The Industrial Company: its Purpose, History, Context, and its Tomorrow?

The industrial company, as we know it, dates back almost 100 years. However, the understanding of technical issues, the customer–supplier relationship, and the place of the individual within the company have changed dramatically. At the beginning of this century, the consideration of sustainable development, depletion of fossil materials, and climate change require new approaches where innovation plays a decisive role.

Existing enterprises in liberal countries, or even countries that claim to represent socialist systems such as China, have very common characteristics due to their structure, mode of organization, and operation; these enterprises are based on capitalism that can be defined as a system "based on individual investments to produce marketable goods" [APP 10].

This is the type of company that we will be discussing.

The 18th Century witnessed the birth of the entrepreneur who risked his capital in the hope of achieving profit.

One cannot separate the company from its historical, social, economic, and environmental contexts. It is necessary to go back several centuries to understand the company today; its beginning was slow when compared to the rapid changes that have affected us relentlessly since the beginning of this century.

A *flashback* to the past will help us to throw light on the future.

Chapter written by Jean-Pierre DAL PONT.

1.1. Purpose, structure, typology

The purpose of the industrial company is to satisfy customers by selling them products coming from manufacturing tools, sometimes with services required for their use: after-sale customer service, technical support, possible reclamation after the use of by-products generated by the process if they are chemical products.

In the manufacturing (automotive, electrical equipment, audio visual, etc.) industry, the recycling of all or a part of equipment takes the form of a genuine *fully fledged industry*, due to the depletion of certain raw materials such as copper, rare earth elements and due to their cost, which keeps on increasing.

It is the existence of manufacturing means that distinguishes the industrial company from service corporations, such as banks, insurance companies, food service companies, and so on. The borderline between these two concepts is not clear cut. The kitchens of a food service company make up an industrial tool, thereby requiring maintenance and energy; this tool can be the source of environmental damage (smells, smoke, waste) which must be controlled using chemical processes.

The industrial company makes increasing use of subcontracting for executing non-strategic tasks, that is tasks which are not a part of the enterprise's business. If security, cleaning, catering, and so on, can be rightly classified under this category, it is questionable whether the outsourcing of maintenance, instrumentation, inspection, utility production and sometimes, the complete manufacturing of the finished product is safe. There could be loss of control of know-how and project management.

The products marketed by the company originate from its research and development services and engineering and design departments or have been acquired from third-parties via patent or license purchases. The know-how and knowledge accumulated over the years are thus one of the essential characteristics in this type of organization.

At the initial stage of the company, there are generally one or more individuals who are willing to start out – the entrepreneur(s) – with reasons as diverse as the desire to buy their independence, sometimes by alienating themselves, to earn money and notoriety, to develop themselves, and so on.

The company is a *human venture*.

Industrial enterprises are vastly diverse. Can we compare General Motors, a skilled tradesman working alone or with a partner, an IT multinational, a pharmaceutical company or a building firm with 20 employees? What these enterprises have in common is the act of implementing financial, human, and intellectual means. The intellectual means recovered by the implemented technologies differentiate them from the original input.

1.1.1. *The four pillars of the company*

Any company is supported by four pillars: economic, financial, human, and legal.

1.1.1.1. *The economic pillar: the product/market relationship*

The concept of product/market relationship is currently the very basis of the economic concept.

The product is what the company offers on determined markets (automotive, electrical goods, audiovisual, construction, etc.) where it will face competition.

What the customer wants (Figure 1.1) is a product that meets his requirements, this is its *functionality*.

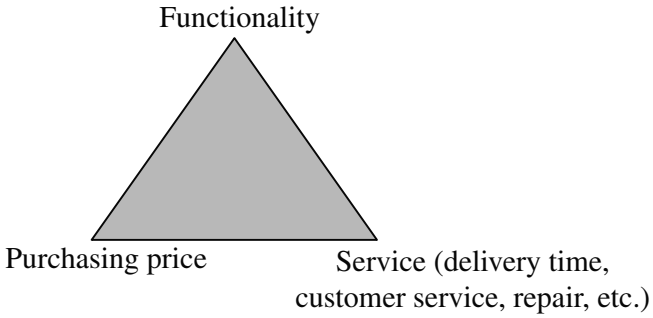


Figure 1.1. *The product seen by the customer*

The primary function of an automobile is, but not limited to, transportation. The customer also wants to spend as little as possible while being served quickly and assured of support from the supplier (after-sale customer service, repair, etc.).

Success at the company level (Figure 1.2) is based on another tripod:

– marketing that aims to analyze the markets in order to identify the customer's requirements;

– research and development (R&D) in charge of designing the product and the engineering (engineering and design department), which must define the industrial tool and have it built;

– production and logistics, whose mission is the creation of the product and making it available to the customer, in other words, the distribution.

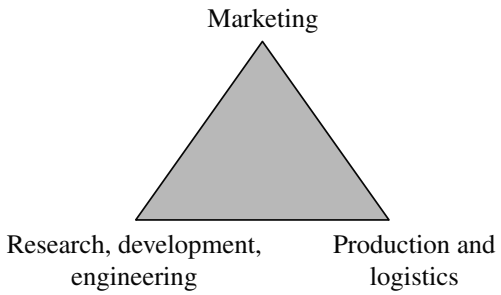


Figure 1.2. *The product seen by the company*

A wobbly *tripod* is a source of failures and disappointments. A product may be excellent, perfectly respond to demand, but if the plant that manufactures it is unreliable (breakdowns, repeated strikes, etc.), then the customer is tempted to look for another source of supply.

1.1.1.2. *The financial pillar*

Right from its creation, the company has required stable resources. This cash requirement is covered by the capital, which is provided by the entrepreneur and his associates, if any, and by loans taken mostly from the banks. This is the liability of the company.

The entrepreneur takes a risk that he shares with his shareholders.

He, therefore, has a *duty to achieve a given result (profit)* to pay for the capital loaned.

The company is the permanent seat of exchanges:

– *expenses*, caused by the production and distribution; and

– *revenues* generated by sales. The company must have money at all times: this is the treasury. The initial economic difficulties faced by an company are always at the treasury level. The inability to pay implies the suspension of payment.

1.1.1.3. *The human pillar*

Employees are considered the first asset of the company. They are the individuals who run the company and make it evolve; they dedicate the largest part of their everyday life to it, often carrying with them a sense of pride.

The company provides a social status: it is a source of development, satisfaction but sometimes also of imbalance, frustration, alienation, and even illness. Work

forms an integral part of life; to assert this, all we have to do is listen to what the unemployed have to say. All enterprises state that their greatest capital is human capital, but how many of them practise what they preach? Stress, various occupational illnesses, suicides, and acts of violence are dreadful indicators of deep problems.

1.1.1.4. *The legal pillar*

The legal form of the company defines the hierarchy within the company and the relationships with third-parties.

The company has the obligation to accept the laws of the countries where it operates, be it only for the quality of the products that it sells there, which must respect some rules and adhere to certain codes. In capitalist economy countries, there are several types of companies: partnerships, joint stock companies, cooperative enterprises, and so on.

Most companies are *corporations*, whereas the individual is a *physical person*. Owing to this corporation status, the company has the right to have capital, to sign contracts, buy, sell, use, and so on.

1.1.2. *Typology of enterprises*

Enterprises can be classified according to several criteria. Besides the legal form that we have just described, enterprises are most often characterized by their size and the nature of their job stream.

1.1.2.1. *The size of the company*

This is the most important and most accessible criterion. It gives the company its power, its local, national, and international impact, and its ability to influence its field of activity.

The size of the company can be measured by the amount of capital, turnover, and by the number of employees.

French regulation distinguishes 4 categories of enterprises based on their size:

– small office/home office (SOHO) with less than 10 employees;

– small and medium-sized enterprises (SME) with 10–249 employees;

– mid-sized enterprises with 250–4,999 employees;

– large enterprises, which employ more than 5,000 employees.

1.1.2.2. *The enterprise's business*

Enterprises, excluding non-financial or insurance companies can be industrial, commercial, agricultural, or service providers.

The company can belong either to the private sector or to the public sector (as with national energy or transport suppliers such as the Private – DOW Chemicals and the Public – NASA). The major technological breakthrough in information technology, especially with the Internet, and the significant interest in genetics have led to the creation of start-up companies. This is the domain of "venture" capital: the shareholder expects significant returns, given the nature of innovative products ... which need to be invented.

1.2. A centennial history

One cannot separate the history of today's company from the historical context of the last 6 centuries. The extraordinary exploration of the planet by men goes hand in hand, over time, with increasing technological discoveries.

The resulting innovations impacted on companies on a permanent basis.

The Age of Enlightenment brought about a revolution of ideas and the reconsideration of age old social systems.

The discovery of unprecedented mineral wealth (gold, silver), the use of unknown crops in Europe (sugarcane, cotton), not to mention silk, spices and furs, transformed companies. This influenced events by endowing some of the nations with powers that were not possessed by conquered countries; supremacy of transportation, where sea transport was practically the only viable mode of travel till the mid-19th Century, supremacy of weapons (rifle against bow, rapid-fire gun against primitive gun).

We must also take into consideration the importance of the quality of administrative and organizational systems and of the management that enables the efficient use of technical and human resources. It remains perplexing that England (excluding Scotland and Wales), populated by only 5–6 million people in the 18th Century, was able to conquer a country like India with 40 times as many people.

1.2.1. *The Europeanization of the planet*

Man, since time immemorial, has continued to migrate, to go further, driven by a desire for material and the quest for knowledge, or pushed by the need to move to escape famines, enemies, and disasters. Every human group has always tried to enslave its neighbors, to enforce its laws or its ideology on them: the missionaries have always accompanied the warriors.

Globalization as we observe it today has transformed the world into a single stage. In fact, globalization commenced in the late 15th Century with the discovery of America by Christopher Columbus, who landed in the Caribbean in 1492. Subsequently, the Portuguese, Spanish, French, English, and Dutch competed for vast territories.

The conquerors of these countries were able to control the Americas, Africa, and Australia; they imposed the culture and language of their native country, for better or worse; they exchanged goods, precious metals, techniques, animals, plants, and so on, as well as diseases with devastating effects. From the Pre-Columbian populations estimated at 90–110 million inhabitants, only 10% would survive the invaders [APP 10].

It is interesting to note that massive wealth acquired far away had very little impact on the lifestyle of some of the colonizing countries. The Spanish hidalgos despised trade, while a French nobleman derogated himself by being involved in trade.

Japan and China remain as special cases; we will analyze them later.

It is from the mid-18th Century that the great discovered territories experienced unprecedented growth, along with expansion of Europeanization. This standardization of the planet proceeded hand-in-hand with the Industrial Revolution and population growth.

Thirty million Europeans emigrated between 1880 and 1914, mainly to the United States, which accommodated the underprivileged and persecuted looking for a world of freedom and opportunity. The colonies provided opportunities to those who were not put off by exile and remoteness.

The need for manpower resulted in slavery. Brazil imported 4 million Africans over 3 centuries to cultivate sugar cane [APP 10]. The Caribbean soon followed suit.

The invention of the *Cotton gin* (*gin*, diminutive for *engine*) in 1793 by Ely Whitney [DOD 84] facilitated the separation of seeds from the staple fibers of American cotton. This simple invention allowed intensive production of cotton in the southern colonies. This resulted in the prosperity of plantation owners and the development of slavery, in turn leading to the American Civil War from 1861 to 1865.

The two world wars, a sad appanage of the first half of the 20th Century, saw a significant disruption of the global order. The beginning of the 21st Century sees globalization in full swing. Blue jeans, Coca-Cola® and other soft drinks have taken hold of the planet. The suit and tie is worn by businessmen from Tokyo to New York. There are no more borders to information and exchange of goods. The American model of consumption imposes itself universally, but for how long?

1.2.2. *Evolution of the company over time*

In Table 1.1, we have tried to represent the evolution of the Western company from the 19th Century to the present day. They are of course the "state-of-the-art" enterprises of their time. We can note that, even in countries just as developed as France, we find Taylorist enterprises. What about developing countries?

We can define 4 periods which lie between the 19th Century and the end of the 20th Century. Each period corresponds to a vision of the company, which is sometimes strongly influenced by political–economic theories such as capitalism or the various forms of communism, and the weight of great historical events.

The employee is managed very differently in terms of hiring, training, salary, job security, safety, working conditions, and also in terms of hierarchy. He will maintain highly variable relationships with his superiors depending on the time and the type of company where he works.

Breakthroughs in technology (cars, plastics, aviation, information technology, nuclear industry, etc.) will create new industries, new professions, influence the lifestyle of the citizen, and completely change his behavior and way of thinking. The old technologies will disappear; this forms the basis of Schumpeterism (see Box 1.5).

The Industrial Revolution of the 19th Century has rationalized the concentration of men, machines, and capital and given rise to the entrepreneur and the "captain of industry". The foreman is the keeper of knowledge; and has total control over the worker. There are no engineers as yet.

1.2.3. *The Industrial Revolution in England*

The term "The Industrial Revolution in England" refers to the transformation of the essentially agricultural and artisan society of the 19th Century into a society that drew most of its wealth from industry based on mining, river, sea and land transport, and of course, on trade. The development of railway transport represented a revolution in itself.

Everyone agrees to the fact that this revolution based on the steam engine was born in England and that it gradually spread to France and Germany. The United States, by virtue of its size, its extreme wealth, the quality of its manpower provided to entrepreneurs through immigration and its liberal system, overtook Europe in the late 19th Century. The 20th Century was undoubtedly "American", but what will the 21st Century be?

Chinese, perhaps?

Period	Highlights	The company as an organization	The individual in the company	Socio-political environment	Breakthroughs New management methods
19th Century	Industrial Revolution Colonization	Manufacturing: emergence of the company replacing craftmanship Huge concentration of capital, machinery, men The factory	Foremen and laborers Birth of the engineer	Capitalism American Civil War–1st Industrial War (1861–1865) Marxism	Steam engine Mines, steel industry Cotton in the U.S. Chemical industry (dyes, explosives) Electricity
Late 19th Century early 20th Century (1937)	Productivity revolution	The company is a closed system Profit maximization F. W. Taylor (*Scientific Management*, 1909). Taylorism: study of tasks H. Fayol (Industrial and General administration, 1916)	Strong hierarchy, unity of command Work broken down into specialized tasks Scientific management Control, centralization, organization by departments	World War I (1914–1918) The Popular Front (France) (1936) Fascism The New Deal (USA) Marxism-Leninism	Assembly line (Ford) Petroleum Applied Research (Thomas Edison) Volkswagen Socio-technological giants (TVA project in Tennessee)

Table 1.1. *Brief overview on the evolution of the company and its environment (the Western world and Japan)*

Period	Highlights	The company as an organization	The individual in the company	Socio-political environment	Breakthroughs New management methods
		Fayolism: definition of functions H. Ford, Fordism: assembly lines (1913) (assembly-line work)	Motivation by money		
1937–1960	Study of the psychology and behaviour of employees (Hawthorne Plant) Behaviorism	The company is considered to be an open system Beginning of decentralization Objective-based management	Man is no longer considered to be 100% rational Money is no longer the only motivation Birth of communication	World War II (1939–1945) Production economy The Glorious 30 years in France: 1945–1973	Sulfamids, penicillin Nylon Nuclear energy (Hiroshima, 1945) Computers United States: – Value Analysis (1942); – project-based management (1960); – strategic management (1960).

Table 1.1. *(continued) Brief overview on the evolution of the company and its environment (the Western world and Japan)*

1960–2000	IT Revolution Consultants (management breakthroughs)	Matrix management Supply Chain (customer-supplier reconciliation) Computers invade the company Internationalization Computer engineering Telecommuting Product/market relationship Product Life Cycle Re-engineering	*Beginning of period* The individual is considered to be preponderant, it is mollycoddled Continuing education Expatriation Need for adaptation and flexibility *End of period* Unsecured job (employability) Loss of references	R. Carson, *Silent Spring* (1962) Market economy Globalization Free trade against protectionism Global competition Rich countries against poor countries 1973: first oil crisis Industrial disasters: Seveso-Bhopal ... 1989: fall of communism Management by finance Customer is king	Tarnishing the image of chemistry Genetic engineering Space Exploration Electronics, Internet Quality (TQM) Process Analysis Pension funds lead the world Company concentration (by sectors)

Table 1.1. *(continued) Brief overview on the evolution of the company and its environment (the Western world and Japan)*

Period	Highlights	The company as an organization	The individual in the company	Socio-political environment	Breakthroughs New management methods
21st Century	Knowledge management New production concepts Companies based on knowledge	Matrix management Customer-supplier partnership Subcontracting, distribution Company-society relationship: – corporate citizen – redefinition of work – Consideration of the concept of sustainable development	Need for reconsideration (adaptation) Loss of reference (loss of fidelity to the company) The company turned over to financial power Participation in the company (stock options)	Unpredictable world Technological revolutions every 10 years Sustainable development Product safety Emerging countries: China Poor countries against rich countries The employee capitalizes Media hype	Genetics (hopes and concerns) GMO Digital Revolution Continues

Table 1.1. *(continued) Brief overview on the evolution of the company and its environment (the Western world and Japan)*

Japan entered the scene in the late 19th Century and cornered a vast empire in Asia; at the height of its ambitions defeating the Russian fleet at the Battle of Tsushima in 1905 and conquering what is now Taiwan, Korea, and a part of China. Having been defeated in 1945, Japan, reduced to its historic space, launched itself in to the commercial conquest of the world, which we will come back to later.

The origins of the Industrial Revolution are complicated. Joyce Appleby: [APP 10] questions the fact that this revolution started in England whereas it could have started in France, Germany, or China. These three countries in fact had intelligentsia of the highest order and a certain political stability, along with coal and iron in abundance.

It was actually the combination of a number of elements that enabled England to lead an unprecedented transformation during the first half of the 19th Century; this transformation began with the 18th Century and continued for two centuries. It should be noted that only at the end of the period, that is at the end of the 19th Century, could the British people ... finally enjoy the benefits of the machine age. The factors that enabled England to make a mark for itself include, but are not limited to:

– *innovations*, in large numbers, which entrepreneurs industrialized and perfected for decades to conduct "business" as we would say today: it is impossible to list all of them!

As early as 1712, the Newcomen pump enabled us to extract the water that flooded mines (Figure 1.3).

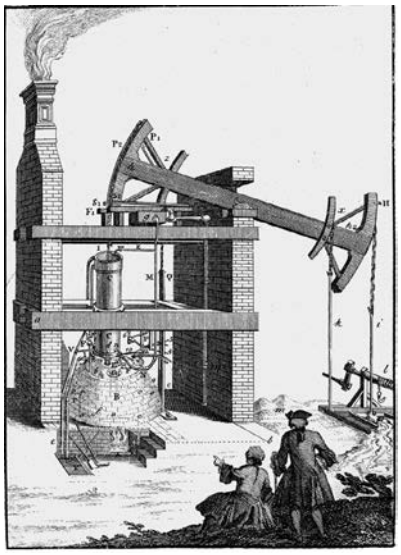


Figure 1.3. *Newcomen pump*

Thomas Newcomen (1663–1729), a blacksmith by profession, is considered to be "the Father of the Industrial Revolution". The pump that bears his name was the first "steam engine" to use steam power economically. Steam is injected into the cylinder where the steam lifts a piston. Cold water which is injected into the cylinder condenses the steam, thus creating a vacuum. Under the effect of atmospheric pressure, the piston goes down. The movement of the piston is transmitted to a reciprocating pump by means of a balancing beam. Many coal mines rendered unusable due to flooding were saved from bankruptcy. The first pump was installed in 1712. When Newcomen died, 100 pumps were in use. This technology prevailed for 50 years and was then modernized by James Watt (1736–1819). In 1763, he created a real steam engine by installing, amongst other things, a condenser that was separated from the piston (patent of 1769). The success of his partnership with Matthew Boulton (1728–1809) for the sales of machines, resulting from his inventive talent, is legendary. Boulton, who had a keen marketing sense, enabled Watt to devote himself to his works by freeing him of trade and financial concerns [BIL 96].

The Stephensons invented steam traction and railways. The textile industry was the first industry in the 19th Century: the steam engine enabled the mechanization of this industry.

1.2.3.1. *Intellectual openness, entrepreneurship and protection of discoveries*

Thinkers reflect on the governance of society, on human nature, on the production of wealth, and on the value of work. Among them, Adam Smith (1723–1790) is considered to be the founder of modern economics. His book in 1776, *Inquiry into the Nature and Causes of the Wealth of Nations*, established theories in relation to work, wages, prices, and taxes. He advocated free trade and non-interventionism of the state in economic affairs; he was opposed to corporations.

More than a century before Taylor, he advocated work specialization in order to increase productivity; his hairpin example is well known.

Inventions have been protected by patents since 1624 [APP 10], thus paying back the efforts and investments of the inventors.

1.2.3.2. *An efficient banking system*

The Bank of England, founded in 1694 [APP 10], emerged as the most important institution in Europe in the 18th Century. We can recollect that the first modern bank was founded in 1609 by the Dutch and that Bonaparte founded the Banque de France in 1800.

The effectiveness of the English system prompted Napoleon to call England a nation of shopkeepers!

1.2.3.3. *The development of agriculture, political stability, population growth*

At the beginning of the 17th Century [APP 10], 80% of the population worked on the land. England had 5–6 million people and 1 million horses. Advances in agriculture were very significant and the specter of famine disappeared. The population of England doubled between 1780 and 1830.

In the mid-19th Century, only 40% of the population was working on the land. This percentage is at 3% today. The end of the Napoleonic Wars brought about stability in the country and an unprecedented development of the colonial empire, a natural outlet for manufactured goods, and an important source of raw materials.

1.2.4. *Taylorism, Fordism, Fayolism*

In the late 19th and early 20th Century, Frederick Taylor and Henri Fayol (see Boxes 1.1 and 1.2) provided the traditional company with the form that we know today.

Taylorism [POU 98], still unduly criticized a century after its birth, probably due to the lack of knowledge of the industrial life of its detractors, has revolutionized the life of the factory.

Taylor invented the analysis of the actions needed to accomplish a task: this forms the basis of scientific management.

Translated into modern language, Taylor wanted to:

– *improve plant productivity* by asking the worker for an "honest day's work". But the timing, the visible tip of the iceberg, was unwelcome. The worker felt like a robot;

– *improve the manufacturing processes* (Taylor was the world's leading specialist in machining), know the costs (Taylor was an accountant) by the introduction of what was to become analytical accounting;

– *reconcile workers and employers* by efficiently distributing the profit generated by better management, but the worker is paid for piece work;

– *select and train workers* (*best man to fit a job*);

– divide labor between those who design it and those who perform it: drive out empiricism; birth of the modern engineer, engineering and design departments, planning department, and scheduling.

The foreman is restricted to the supervision of laborers.

Henry Ford [LAC 87] adopted Taylorism to the letter (see below). He invented the assembly line in 1913 for the assembly of magnetos which reduced the time required for their production from 15 to 5 minutes.

Detroit emerged as the kingdom of timing, division of labor, cutting waste, and the continuous study of the manufacturing process. Previously, each car was handmade by skilled workers. The division into basic assembly line tasks, which are simple to perform, makes manufacturing by unskilled workers possible. We can recollect Charlie Chaplin's *Modern Times*.

The production increased from 160,000 to 320,000 cars from 1912 to 1914 with the same strength of 14,000 workers.

However, Henry Ford, by reducing the manufacturing costs and hence the selling price, enabled the average American to buy a car; he even received congratulatory letters from "public enemies no. 1" (Dillinger, Bonnie and Clyde) for whom the car was an essential "work tool". Ford's technology revolutionized the *American way of life* for the better and perhaps for the worse.

Fifteen million Model Ts were produced between 1908 (the year of launch) and 1927, when the Model "A" replaced the Model "T". In 1919, half of the cars in American were Model Ts.

Ford also invented vertical integration; he produced steel for manufacturing his automobiles and had his own distribution network. In 1917, the "Rouge" plant was the largest factory in the world: 1,600 m long and 2,500 m wide.

Louis Renault met Taylor and Ford during a trip to the United States in 1911. He wanted to introduce their methods in France.

However, the ill-prepared application of the "Taylor system" resulted in major strikes, including the 44 day strike in 1913. Renault generalized timing after dismissing the union leaders.

Fayolism refers to the management of the company, whereas Taylorism refers to the factory.

Fayolism classifies the set of operations in the company into six main functions: technical, commercial, financial, accounting, administrative, and safety.

H. Fayol defined 14 principles of management from which we will quote:

– the division of labor into specialized tasks;

– the unity of command: the employee has only one manager;

– promotion of the best employees.

Fayol can be considered as the founder of modern management. Administration means anticipating, organizing, and controlling.

F.W. Taylor was born near Philadelphia, to a very wealthy Quaker family. He passed the entrance test at Harvard, gave up his studies and became a simple worker in a small pump plant and then joined a steel plant, the Midvale Steel Co., where he worked for 12 years. He became a foreman and then a mechanical engineer by taking correspondence courses. He also held the post of accountant before finishing as chief engineer. Taylor became a specialist in metal working, with many patents, which made him rich and famous. He established himself as a consulting engineer in 1893.

Taylor invented the job analysis technique, whose most obvious manifestation is the timing of tasks. His book, *The Principles of Scientific Management* (1911), applies Taylorism and forms the basis of scientific management.

He had many supporters: Henry Ford, Louis Renault, Lenin, and so on.

Box 1.1. *Frederick Winslow Taylor (1856–1915)*

1.2.5. *The advent of research*

The scientific discoveries of the late 19th and early 20th Centuries had a significant impact on enterprises.

The entrepreneur carried out research to create business. In modern-day terms, he wanted to innovate. Innovation means creating new products, new applications, whereas invention is limited to the acquisition of new knowledge.

H. Fayol, a French Engineer, graduated from the School of Mines of Saint-Etienne (France). He was the director of the Commentry mine for 30 years. He became the CEO of the Company "Société de Commentry, Fourchambault, Decazeville", a post from which he retired at the age of 77. Fayol laid the foundations of "administrative theory". His major work, *Administration industrielle et générale*, was published in 1916. He is considered to be one of the pioneers of management.

Box 1.2. *Henri Fayol (1841–1925)*

Non other than T.A. Edison better symbolizes the integration of research into the company. *Start-ups*, already mentioned, can be considered as a system pushed to the extreme: one that speculates on innovations ... potential innovations.

No company today can do without research.

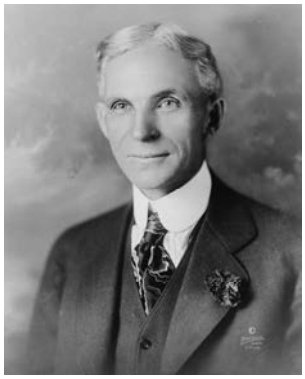
1.2.6. *The individual in the company*

Everything we have just discussed primarily relates to two periods ending around 1937. Until then, the company was a closed system, where man was considered to be completely rational. The salary must be sufficient to meet his needs. "Work and keep quiet" one might say.

Starting from the 1930s, the rise in the level of education, standard of living, access to more information, the growing maturity of the working masses (to use Marxist-Leninist terms) changed this Taylorian perception of the labor world.

A significant number of schools try to understand the behavior of the individual in the company. Elton Mayo (1880–1949) is regarded as the founder of the Human

Relations movement and work sociology. The Ecole de Mayo, whose influence was significant around 1940, gave rise to *behaviorism*.



H. Ford, the son of a farmer, was the pioneer of the American automotive industry. An eccentric and visionary, he invented the standardization of major parts and assembly line work in his plants at Detroit. He fervently adopted Taylorism: everything was timed. Assembly line work was used for the first time in 1913 to manufacture magnetos. Applied to the manufacture of the famous Model "T", it reduced the assembly time from 13 hours to one and a half hours. The Model "T" was the first car available to the average American.

Box 1.3. *Henry Ford (1863–1947) [LAC 87]*

Frederick Herzberg, a Professor of psychology, studied the motivations of men at work. Douglas McGregor proposed theories X and Y. According to theory X, man is lazy by nature, whereas theory Y states that he can be motivated if appropriate motivating elements can be found. Psychologists and social psychologists entered the company after the war.

Labor laws became increasingly concerned about protecting the employee. Advances in medicine, reduction of working hours, respect for rest periods, consideration of occupational hazards, the study of risk related to products, and ergonomic studies were some of the many benefits offered to workers in developed countries.

No other country in the world is more "consuming" than the United States, which was considered to be the "master of the world" after World War II. The end of hostilities halted the military–industrial system resulting from the unprecedented

transformation of the industry in peacetime, especially in the automotive industry, to manufacture airplanes, tanks, and the most diverse means of transportation. The number of men and women in the armed forces would reduce from 12 million to no more than 1 and a half million in peacetime. Consumption broke all records: cars, refrigerators, televisions, and single-family houses were offered on credit to a population looking for comfort.

T.A. Edison, a news vendor (train boy) at the age of 12, deaf and self-taught, Edison was the author of 1,093 patents. An inventor of the phonograph and the incandescent lamp, among other things, he established companies for manufacturing and distributing electricity. His inventions helped America to transform from an agricultural country in to an industrial country. Visitors can visit his house and laboratory in West Orange, New Jersey. His friend Henry Ford relocated his first laboratory from Menlo Park (New Jersey), where he invented the incandescent lamp, to Greenfield Village, the first American theme park opened in 1929 near Detroit.

Box 1.4. *Thomas Alva Edison (1847–1931) [PRE 89, ISR 98, JOS 92]*

After World War II, France experienced exceptional growth: France copied the United States.

This is the period of *The Glorious Thirty*, the 30 years that ended with the first oil crisis in 1973.

There was a gradual change from a manufacturing economy to a free market economy. The customer found everything he desired; the situation was thus far from shortage.

J. Schumpeter, Austrian Finance Minister in 1919, did not prove himself to be a very shrewd banker. He left for the United States in 1935 where he taught at Harvard.

The book *Capitalism, Socialism, and Democracy*, published in 1942, is one of his most remarkable works. He invented the term *creative destruction,* a process by which new technologies, new products, and new manufacturing and distribution methods throw out the old and force companies to adapt themselves if they want to survive.

Innovation is not only a source of progress but also a crisis factor responsible for economic cycles; an expansion phase is followed by a recession phase.

Like Karl Marx, Schumpeter believed in the fall of capitalism in evolved societies. However, he thought that this would be the best economic system, provided it was implemented by entrepreneurs who took risks.

Box 1.5. *Joseph A. Schumpeter (1883–1950) [SCH 75]*

Advertising incited him to consume. Globalization amplified the phenomenon of competition. A job is no longer guaranteed. The loyalty that bound the employee to his company vanishes slowly. The best people sell themselves to the highest bidder. The company tries to retain them by employee stock ownership plans and partnerships. The company has become an open system.

During this period, the pace of innovation quickened. The last decades of the 20th Century were marked by the IT revolution of which the Internet is a part. This revolution is similar to that of the printing revolution in the 15th Century, which still continues today: its effects have not yet been assessed. *The period of certainties is over*.

The conquest of space had an unexpected consequence. The photograph of the Earth taken from space showed us that our living space is finite. The concept of company and notion of work are being challenged; resources, including petroleum, are limited. The purpose of the company and work are being challenged.

The energy problem began to increase sharply. Use of nuclear energy for peaceful purposes appeared to be an interesting solution in addition to renewable energy sources (hydropower, wind, solar, biomass, tidal, etc.).

1.3. New challenges imposed by globalization and sustainable development

The dawn of the 21st Century brings with it challenges that are unprecedented in the history of mankind. Population growth, the inevitable exhaustion of fossil resources (petroleum, copper, lithium), climatic disturbances, climate change, and disparities in living standards generate fear and questions.

The rich industrialized countries have mostly adopted the same capitalist system, born with the industrial revolution.

1.3.1. *Globalization*

The company is now faced with the globalization of economies and competition which keeps on growing. There are practically no barriers to trade and communication. In this context, enterprises are forced to define their strategies at a global level. The various financial crises that punctuated the global economy over the last 10 years continue to threaten the global stock markets.

The Asian countries, which represent half of all humanity, market quality products, although they have not completely monopolized entire markets such as the audiovisual or the motorcycle industry. Next to an aging but still powerful Japan, the *four dragons* (South Korea, Singapore, Taiwan, and in China) have risen to an international level. China with over 1.3 billion people "has woken up from a slumber" and transformed completely.

"*Globalization of the economy implies the globalization of responsibility*" (Kofi Annan, former Secretary General of the UN).

The concept of sustainable development changes the enterprise's mission: it places man at the center of the system; this is a new vision. The industrial company or the service company, whether private or public, is thus obliged to implement a governance to cope with the abovementioned notions.

The UNDP (United Nations Development Programme) simply defines governance as – the exercise of economic, political, and administrative authority. It requires: "participation, transparency, and accountability". To further simplify this, we can say that governance is the organization of decision-making processes, either at the government level or at the company level. There can be no governance without a value system!

1.3.1.1. *Communication*

Extraordinary improvement of communication and its deployment are undoubtedly the key factor of a system of belonging to the same planet. The Internet, mobile phone, and fax enable individuals who have never seen each other and, in most cases, have little chance of meeting each other, to connect almost instantaneously.

Television brings the world within reach of the poorest; it shows him landscapes that he has never seen and undoubtedly will never see, and gives him the impression of a global village. CNN, Cable News Network, right from its foundation in 1980, has given live reports of events around the world.

1.3.1.2. *Transportation, space exploration*

The development of aviation, which is just a century old, gave birth to mass tourism. One "does China" after visiting Machu Pichu in Peru. Tourism, which is manna from heaven for poor countries, "desecrates" the sites that were the very soul of the visited country; it leaves behind waste and exacerbates the desires of the underprivileged. The vision of the Earth by satellite gives a sense of finiteness and containment to "Earthlings". Nothing escapes the space objects and "terrestrial" cameras which constantly monitor us.

1.3.1.3. *The internationalization of goods and cash flows*

Globalization leads to the commoditization of consumer goods; we buy the latest Japanese or Korean audiovisual product in New York. China has emerged as the global workshop; it knows how to exploit its manpower that costs about one-tenth of what it costs in developed countries to launch industries demanding personnel, such as the textile, electronics and plastics industries, and manufacturing industries in general.

The globalization of trade leads to economic globalization.

1.3.1.4. *The new geopolitical order*

The planet has almost nothing left to be discovered: there is practically no virgin land. Now, under the surveillance of satellites, it is "watched" constantly by the superpowers and nothing can obstruct the Internet.

There is practically no conquest of one country by another; the conquest of Kuwait by Iraq in 2001 was cut short. Countries are no longer colonized by other countries ... at least openly. The colonial wars are over! Other subtler forms of war including terrorism and religious intolerance have replaced them.

1.3.1.5. *The conquest of today is the conquest of markets*

One billion people consume 80% of the planet's resources; 1 billion of the "damned" endanger its future through deforestation, land overuse, water pollution, and generation of greenhouse gases, especially CO_2 by burning carbon fuels. Do we need to emphasize that these poor people are at the origin of a population explosion that puts their future at risk and drives them to a wild emigration that is feared and rejected by most of the developed countries?

Another division is economic by nature: North America, Europe, and Asia-Pacific, mainly China, represent the existing forces and the forces in the making. Scientific progress and technological revolutions are changing our way of life more and more quickly each day and widening the gap that separates the developed countries from the rest of the world, and why not say it openly, the United States from the rest of the world! What we have just mentioned is the cause of fears that are becoming more and more intense.

1.3.1.6. *Fears*

1.3.1.6.1. Fear ahead of progress

It seems to be clear that, since the 1970s, technological progress has led to changes that society cannot take in and understand. This holds true for GMOs (genetically modified organisms), genetic engineering, and nanotechnologies. Some would want to stop every progress, even though progress has always existed undoubtedly, we would be surprised to meet our grandmother *Lucy* (Australopithecus afarensis) at a street corner.

1.3.1.6.2. Fear of the nuclear industry

In 1945, the United States alone had the knowledge and means to manufacture the atomic bomb. Currently, the atomic bomb is within reach of any country that wants to develop it. The fear of the bomb is coupled with the fear of nuclear power plants; the Chernobyl disaster 20 years ago is in everyone's memory and what about Japan's cataclysm in March 2011? The fear of contamination by radioactive materials and terrorist attacks using "dirty" bombs is also prevalent. The collapse of Russia and the waste that has resulted from it, leaves us to weigh suspicions that the accidents involving nuclear submarines will not disappear.

1.3.1.6.3. Fear related to the internationalization of enterprises, technological transfers

From 1970, large enterprises have tried to become global and leave their native country. China is a major target. They have sometimes relocated their production to countries with cheap labor. The developed countries are flooded with Asian products at prices that defy competition.

1.3.1.6.4. Fear of job loss

The feeling that setting up enterprises abroad helped in the drain of technology and created many competitors for the future has not yet disappeared.

1.3.1.6.5. Fear related to energy problems

The Industrial Revolution led to the exploitation of natural resources. This exploitation keeps on increasing rapidly. Developed countries are dependent on distant countries for their energy supply (oil and gas). Pipelines and gas pipes pass through countries which are sometimes unstable.

1.3.1.6.6. Fear related to pollution

There are no boundaries to pollution! The atmosphere and oceans are the finite receptacles. Water pollution, especially of water tables, is a major concern for the French.

1.3.1.6.7. Fear related to armed conflicts due to ideological conflicts

If the specter of a third world war seems to be far away (the Cuban missile crisis of 1962 is not so distant), the possession of weapons of mass destruction, whether nuclear or biological, by “high-risk” countries poses the question of their control. Poverty and underdevelopment are undoubtedly the breeding ground for fanaticism. But so far, the rise of fanaticism and terrorism that ensues from it appears to be the greatest danger.

1.3.1.7. *The benefits of globalization: towards global governance, reasons for hope*

However, it’s not all doom and gloom! Communication at a global level can help us to know what is going on! Poor countries know that they are poor ... and declare it. Surveillance of the Earth helps to track the state of pollution, the ravages of deforestation, fire detection, construction of plants whose purpose may be risky and, in short, to monitor the state of the planet in real-time.

Scientific progress provided developed countries with a well-being which was unknown till now. Famines, although not completely eradicated, have declined significantly. China and India have become self-sufficient in food.

There is a global solidarity for the good reason that every country depends on others. Governance is gradually establishing itself at a global level. Many summits resound around the planet, aided by global conferences. Child labor, the situation of women and issues related to water and pollution are examined.

The big international companies are the holders of wealth: capital wealth and intellectual wealth. It is estimated that the top 300 companies of the world produce a quarter of the global production!

The UN tries to be the world's policeman: its blue beret peacekeepers are present in conflict zones, but its soldiers practically have no right to use their weapons. The IAEA (International Atomic Energy Agency), based in Vienna, strives to inspect nuclear power plants.

Governance will either be global or will not exist.

1.3.2. *Sustainable development*

Every week, we receive an announcement of a conference or a forum on sustainable development. Industrial companies or service firms announce their engagement on this subject. All of this is hinted at in the media. Sustainable development has become an essential concept!

1.3.2.1. *Birth of a concept*

The following chronology highlights the essential steps that led to the concept of sustainable development; environmentalism can be considered to be its starting point.

Some of the milestones:

– 1850: David Thoreau: transcendentalism;

– 1962: Rachel Carson, *Silent Spring*;

– by 1970: the multinationals in question;

– 1971: first Ministry of the Environment in France;

– 1973: first oil crisis;

– by 1975: technological development faster than social transformation;

– 1987: Brundtland Commission: concept of sustainable development;

– 1960–1990: Internet;

– globalization, media coverage (mediacracy), space exploration (monitoring the Earth), disasters: Seveso (1976), Bhopal (1984), AZF-Toulouse explosion (2001), Aral Sea;

– 1992: Rio Summit: "First Earth Summit";

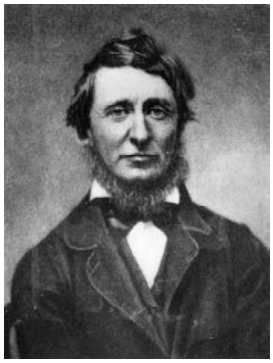
– 1997: Kyoto protocol (global warming);

– 2002: Johannesburg Summit (Rio + 10): reducing the number of people without drinking water by 50% by 2015;

– 2005: enforcement of the Kyoto Protocol on reducing greenhouse gas (GHG) emissions in the European Union. Integration of the precautionary principle in the French constitution;

– 2009: Copenhagen Summit on climate change.

Two American figures, a century apart, have strongly influenced their age.



Was he the first *ecologist*?

At the age of 28, H.D. Thoreau lived in a small *cabin* in the woods, near a beautiful pond in the vicinity of Boston. He refused to pay his taxes, which led him into trouble. A little recognized author of his time, he was the inventor of civil disobedience and passive resistance: he inspired Gandhi and Martin Luther King Jr.

Box 1.6. *Henry David Thoreau (1817–1862)*

"*Sustainable development will be planetary or will not exist*!"

Humanity has to face new challenges. The list is long. We will only point out a few:

– the problems related to the depletion of energy reserves;

– the critical issue of water and population growth;

– the widening of the gap between rich and poor countries;

– imbalances caused by the rise of power in China, India, Brazil, and Russia (BRIC countries);

– commoditization of nuclear weapons, terrorism, and so on.

But what is meant by *sustainable development* today?

The following definition seems to be most appropriate:

Sustainable development can be described as development that is socially desirable, *ecologically sustainable*, *and most importantly economically viable*.

A graphical representation helps us to better understand this concept.

The 3Ps (*People*, *Profit*, *Planet*) illustrate the definition of a socially desirable, environmentally sustainable, and economically viable development.

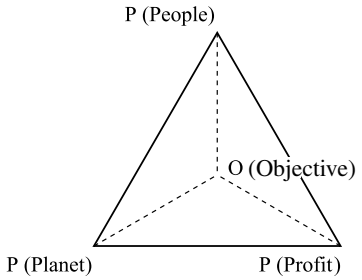


Figure 1.4. *Sustainable development*

The following example shows the difficulty of the problem: locusts devastate crops in some of the countries of the Sahel. Is it necessary to use insecticides knowing that, if misused, they will pollute the soil and rivers and that the starving people will eat contaminated locusts? Should financial aid be given to the governments of these countries? Where will this money go? If global organizations take control of the problem, will they not be accused of interference?

This is an urgent problem: if insecticides are not dealt with, there will be deaths, can we expect that people have been educated, that a semblance of governance has been set up ... What should we do? The point O (O for objective) represents a desirable balance: its position in the triangle will vary from country to country; the United States does not have the same needs as a country of the Sahel.

Sustainable development means knowledge of our habitat: the planet Earth.

R. Carson was undoubtedly the inspiration for *sustainability*. A marine biologist, Rachel was among the first to understand that different species should be given time to reproduce so that fishing remains *sustainable*.

She was born into a poor family in Pennsylvania. Being a very talented student, she studied biology, especially marine biology. After graduating from *John Hopkins University*, she joined the *US Bureau of Fisheries*, when depression was at its peak, and at a time when women scientists were rarely considered and little regarded.

To survive, she began to write articles for the press.

In 1951, at the age of 44, her book *The Sea Around Us* [CAR 51] brought her fame and affluence. Americans became aware of the importance of oceans and seas. In 1952, she resigned her government job to live by her writing.

In 1945, the cessation of hostilities left large amounts of DDT, which was regarded as a miracle product because it had helped to avoid pandemics. DDT was sprayed into the air, without due care, even on residential houses. Rachel Carson realized that the uncontrolled use of insecticides can kill birds and gets accumulated in animals. She condemned their misuse in a book entitled *Silent Spring* [CAR 51], published in 1962. This book received an unexpected reception.

During the Cold War and at the time of nuclear tests, Rachel Carson increased public awareness about the dangers of uncontrolled use of toxic products, especially those with residual effects which concentrate on the food chain. As an ecologist ahead of her time, she drew attention toward the fragile balances that govern life in ecosystems. She was at the height of her fame when she lost her battle with cancer.

Box 1.7. *Rachel Carson (1907–1964)*

1.4. Our planet

1.4.1. *Balances and biogeochemical cycles*

Life on Earth, such that we know of, results from an infinite number of balances which are sometimes precarious. Thus, eutrophication of an aquatic ecosystem is caused by an excess of nitrogen and phosphorus contributed to by houses, agriculture, and industry. Excessive consumption of oxygen resulting from it deprives the system of this essential element and leads to the death of living organisms. Phosphate detergents were the major agents in the eutrophication of lakes infested with algae.

Anthropogenic CO_2 keeps on increasing along with industrial development; it seems to be certain that it cannot be reduced naturally. It enriches the atmosphere and contributes to the greenhouse effect.

1.4.2. *Global warming – greenhouse effect*

Global warming is, at present, the subject of debate. Scientists and politicians share the center stage. It is now accepted that the temperature of the globe has increased by at least 0.5°C in a century. Europeans are dismayed at the gradual disappearance of their glaciers; Dr. Etienne, with many others, observed the sharp disappearance of the ice packs in the Arctic Sea. The sea level rises by about 1 mm every year.

The carbon cycle is extraordinarily complex. At present, it is considered that greenhouse gases are responsible for global warming. Human activities are responsible for the production of 7.9 Gt (gigatons: billion tons) of CO_2 per year, which largely exceeds the absorptive capacity of oceans and the biosphere.

The rise in sea temperature would lead to the desorption of dissolved CO_2: this would cause an increase in CO_2 content in the atmosphere, as well as the partial pressure of water vapor, which is also a greenhouse gas. The increase in cloudiness would reflect a major portion of solar energy toward space. This would have the effect of cooling the Earth. The problem is extremely complicated!

Of late, researchers have been concerned about the disturbances in the Gulf Stream: its branch that carries the warm waters of the Gulf of Mexico toward the North Atlantic would lose 30% of its intensity in 50 years; this would be due to the decrease in salinity of the North Atlantic. Will Brittany and France be covered by glaciers in the next century?

It is estimated that the water level of oceans could rise by 30 cm to 1 m by the end of the century if nothing is done to combat global warming. The archipelago of

the Maldives would be submerged first, followed by parts of Bangladesh, the Netherlands, and some of the coastal African countries. The consequences for these populations would be dramatic.

The ozone layer protects us from harmful Ultra violet (UV) rays: the deterioration of the ozone layer (ozone hole) by chlorofluorocarbons (CFCs) has led to the control of their commercialization, at least in industrialized countries; their production should be completely banned by 2030. The greenhouse gases contribute to maintaining an average temperature of 10–20°C throughout the globe: without them, the temperature would be −18°C.

Life on Earth would not exist without the energy provided by the Sun. This energy is essential for the process of manufacturing organic matter from absorbed CO_2 and atmospheric water, through photosynthesis, which creates biomass and releases oxygen:

$$CO_2 + H_2O + \text{energy} \rightarrow O_2 + \text{“Biomass”}$$

The reverse reaction is respiration and it releases CO_2 by absorbing oxygen.

“Energy flows and material flows on Earth are closely linked”.

Photosynthesis is one “biogeochemical cycle” among others. The water cycle is of utmost importance. The Sun, which is a gigantic heat engine, evaporates ocean water. This water rises into the atmosphere and condenses in the form of rain and snow. The evapotranspiration of plants largely contributes to rainfall. Nitrogen, phosphorus, metals, and metalloids are also the source of biogeochemical cycles, which are essential for life.

The Sun also sets in motion vast amounts of air (wind). Along with the moon, it causes huge movements of water: these are tides and vortices, with a width of a few dozen to several hundred kilometers. These movements were discovered recently with the help of satellites. These fluid movements are of enormous importance; for illustrative purposes, let us cite only the *El Niño* and *La Niña* which had devastating effects on South America.

1.4.3. *Ecology and ecosystems*

Ecology is considered to be of crucial importance today. The term “ecology” was introduced by Haeckel in 1866, and is derived from the Greek words *oikos*, meaning home or habitat, and *logos*, meaning science. Ecology and economics are now inseparable disciplines. Haeckel defined ecology as the study of the adaptation of

living things to their environment. The images of the Earth taken by astronauts in the years 1968–1970 have placed ecology at the forefront. Since then humanity has been aware that our planet was a finite and complex system.

By ecology, we now refer to the study of interactions of living organisms with each other and in relation to their non-living environment (biotope), which is composed of matter and energy. Ecology is no longer considered to be a sub-discipline of biology, but a discipline in itself involving all the sciences: chemistry, physics, biology, sociology, geography, astronomy, mechanics, and so on, to name but a few.

Systems theory introduced by L. Von Bertalanffy in 1968 was used to produce a systemic vision of the planet. The concept of the ecosystem introduced by A. Tansley in 1935 is particularly enriching [FRO 99]:

"ecosystem = biocenosis + biotope"

Biocenosis includes all living beings of the same habitat. A pond can be home to frogs, fish, crayfish, an infinite number of bacteria, water lilies, and other plants.

A pond can be a part of forest; it may be surrounded by meadows located in the same valley traversed by a river that is in turn part of a region.

The construction of a dam (anthropogenic action) on the river can radically change life in the pond. Biocenosis constantly changes the biotope: the cows that graze a meadow change it; the meadow will change over the year according to the seasons. We must not forget that the Earth is constantly changing: volcanic eruptions and tsunamis due to the interpenetration of tectonic plates are there to remind us of that.

The living environment can be considered as a set of structured systems that "fit" hierarchically in the space-time continuously. By population, we mean that the set of individuals belonging to the same species live together in the same habitat (e.g. frogs in a pond).

Interactions in an ecosystem are manifold. At first, there is competition for food; the food chain is one of the major characteristics of a living organism. The examination of a sea bed is significant: each population competes for food in order to survive. Parasitism, mimicry, camouflage, and coexistence are the most incredible forms for the delight of those who know how to observe: each population has its strategy to survive. Evolution is often mandatory.

To adapt itself, any ecosystem is a source of feedback that serves as a regulator. As such, the prey/predator concept is significant. The ecosystem that is home to a population of rabbits and a population of foxes is balanced by itself, too many foxes

lead to the disappearance of rabbits, which in turn leads to the decrease in the fox population, following a lack of food.

The biosphere, which is the set of living things on Earth, is divided into the following ecosystems: lithosphere, hydrosphere (oceans, glaciers, rivers, lakes, groundwater), and atmosphere. The inertia of these systems varies considerably: the effects of air pollution are much quicker than that of an ocean.

To conclude this section, we can provide an overview of ecology and consider the interaction of two key ecosystems: the urban ecosystem and the rural ecosystem. The first ecosystem, with a very high concentration of human population, produces no or very little biomass. It seems to be clear that the biomass of Central Park is of little consequence for New York. The importance of this biomass is clearly of a completely different order!

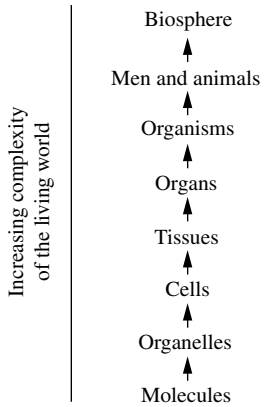


Figure 1.5. *Systemic analysis of the living organism [DUR 98]*

1.4.4. *Oceans*

The oceans and seas cover 70.9% of the Earth's surface, or 510 million sq km (a thousand times the size of France) [MIN 09]. The Pacific Ocean represents half of the total surface of all oceans. The study of this system that is typical of our planet and essential for life began only in mid-19th Century. The fact is that the lands are largely located in the Northern hemisphere, whereas the Southern hemisphere accounts for 81% of marine areas, which strongly influences the ocean circulation.

Ever since the 1970s, the study of oceans (currents, salinity, temperature, dissolved gases, seismic activity) and their monitoring have been greatly facilitated by improved analytical methods (probes) and by the use of satellites. The whole

globe is now seen to be almost continuous. Altimetry satellites measure the sea level with an accuracy of 1 cm, whereas, contrary to what one might think, the sea is not "flat". Differences have been detected in the level of the sea of 10 m!

The use of isotopes (tritium, carbon-14) has revealed the underwater currents. Oceanography involves physics, chemistry, biology, geology, climatology: it is a science in itself.

The food chain goes from the smallest organisms (plankton) to the largest animals (whales, octopus) and includes the largest living system (the Great Barrier Reef, off Australia). The wind gives rise to marine surface currents which are subjected to Coriolis forces (circulation in a clockwise direction in the northern hemisphere, whereas they are subjected in an anti-clockwise direction in the southern hemisphere). The trade winds carry water from east to west in the northern hemisphere. The Gulf Stream carries warm waters from the Gulf of Mexico to Europe; Britain benefits from this.

Surface currents generate the thermohaline circulation, or in depth-related circulation to density changes, caused by changes in temperature and salinity. *Upwelling* means the ride-up of cold water to the surface. This is one of the causes of the *El Niño* effect. This upwelling creates an intense nutrient-rich marine life. Conversely, it has been proven that in some parts of the world, surface waters plunge deeply: *downwelling*. This occurs in the North Atlantic where the water cools, its density increases, it will then dive to the bottom of the ocean heading for the Antarctic and resurface in the Pacific and Indian Oceans. Global ocean circulation has been compared to a rotating treadmill that has been measured, it takes 1,000 years to make a full turn.

The ocean and atmosphere are intertwined. They continuously exchange energy and matter. Solar radiation is the major source of ocean energy. The ocean absorbs sunlight and re-emits infrared radiation. It absorbs it at the equator and re-emits it at high latitudes. The ocean is a heat engine which redistributes heat from warm equatorial regions to cold polar regions through ocean currents. The ocean is a huge reservoir of energy and plays a stabilizing role by its inertia.

The ocean is a huge carbon reservoir (40,000 Gt). The solubility of CO_2 in water depends on the partial pressure of CO_2 in the atmosphere and the water temperature. The lower the temperature, the more CO_2 water can store. Areas of high latitude are CO_2 storage areas, where storage is amplified by *downwelling*. Warm and *upwelling* areas are the *areas of release* of CO_2.

Around 1960, the movements of the Earth's crust and plate tectonics responsible for tsunamis were understood.

1.4.5. *Demography*

Demography is the science that deals with the study of human populations in terms of quantity, concerning their size, structure, and evolution. It is based on what is most fundamental for man, life and death.

There is an exponential increase in the world's population. It took about a century to grow from 1 billion in 1830 to 2 billion by 1930. Approximately 70 years were enough to shift from 2–7 billion today (Figure 1.6).

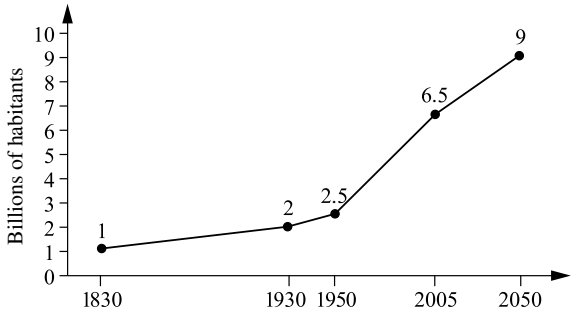


Figure 1.6. *The world's population (historical and projected)*

The fertility rate required for acquiring a stable population is 2.1 for developed countries and 2.5 for developing countries. Today, the world has seen its population increasing by 79 million inhabitants per year.

The UN projections for 2050 ranges from 9–12 billion individuals according to different hypotheses essentially related to the fertility rates.

The evolution of the population by geographic area (Table 1.2) shows the decrease of the European population by 2050.

Europe was the source of heavy emigration in the 19th Century and is today the leading continent for immigration.

1.4.5.1. *Urbanization and megalopolises*

Every day 160,000 people migrate from the countryside to the cities due to lack of land and labor, and due to conflicts.

The world's population is experiencing a massive urbanization with the incredible growth of megalopolises (Chongqing, Mexico city, Shanghai, São Paulo). There are now 19 megacities with more than 10 million inhabitants.

Area/Year	1950	2005	2050*
Developed countries	813	1,210	1,236
of which Europe is a part	547	728	653
Developing countries	1,706	5,254	7,840
Africa	224	906	1,937
Latin America	167	561	783
Asia	1,315	3,787	5,120
Globally	2,519	6,464	9,076

**Average variant of four scenarios*
Source: World Population Prospects: The 2004 Revision Highlights. New York Nations Unies 2005

Table 1.2. *Evolution of the population by region/geographic zones (million)*

The UN estimates that 63% of the world's population will live in urban areas in 2050.

The contrast between the north and south of the Mediterranean (democracies and aging population in the north and authoritarian regimes and exponential increase in population in the south) will undoubtedly lead to disruption in the lives of citizens of neighboring countries such as France.

Table 1.3 helps us to visualize the town/country interactions and to have a systemic view.

Incoming	City	Outgoing
People Energy Food Water Raw materials Chemicals Manufactured goods Money Information Homes	Systems: hospital, education, banking, transport, roads, energy, etc. Safety: police, fire fighters, etc. Recreation: parks, gardens, plays, theaters, tourist attractions, etc. Storage: cars, food, water, household products	People Residues, garbage, chemicals Pollution: air, noise, polluted water, GHG (greenhouse gases) Manufactured products Culture Diverse riches

Table 1.3. *Simplified systematic analysis of an urban area*

A city is a complex system, and a source of all kinds of imbalance that increase with size. A city can live only if it receives resources from non-urbanized areas. It was estimated that a city like London is in need of 60 times its area to live.

The population cluster of cities creates incredible megapolises. Boston will soon be connected to Washington via New York, Philadelphia, and Baltimore. This *strip* of 800 km will house 60 million people, that is twice the population of Canada. By 2015, Mexico city will reach 19 million inhabitants, Shanghai 15 million, Karachi 20 million, Dhaka 19 million, Beijing 20 million, São Paulo 19 million, and Tokyo 29 million. Chongqing is now regarded as the largest city in the world with 30 million people.

18 million Mexicans live in Mexico City (one Mexican in six), where the pollution, noise and crime rate has reached appalling levels. 6 million people live in slums (*barrios*) without water supply or electricity. How can these urban monsters be "sustained"?

1.4.5.2. *The demographic transition*

The demographic transition is an interesting phenomenon which allows us to show the evolution of a population with the pyramid of ages. This phenomenon shows the transition from a nearly balanced mortality system and high fertility to a system in which the fertility far exceeds the mortality to reach a steady state of low fertility and mortality.

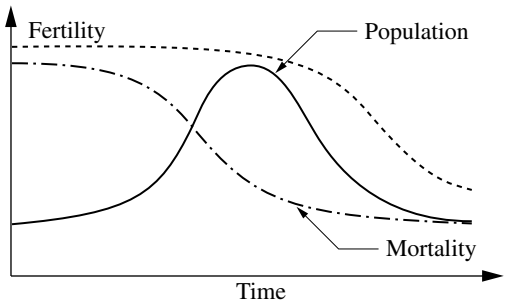


Figure 1.7. *The demographic transition*

This is the process experienced by all countries as they move from a traditional agrarian economy to an industrial economy. The duration of this process can take 50 years to over a century.

Earlier in this cycle, the decline in mortality is caused by medical advances, healthy eating, social progress, whereas the birth rate remains at a higher level. The

fertility decline has resulted in a decrease in population and an aging population. The age pyramid is inverted.

The population is growing strongly in mid-cycle.

Sub-saharan Africa is an example of the beginning of the cycle where the old continent is at the end of the cycle. Immigration barely compensates for the low birth rate. China, with a coercive birth control system, has virtually reached a level. Japan is in an unprecedented aging process. Its population of 117 million people is expected to fall to 80 million by 2050.

1.4.5.3. *Some laws and concepts: the case of France*[1]

– *Median age*: age that divides the population into two classes of equal size. In France, it is 38.5 years, where 30 millions of French people are less than 38.5 years, and 30 million are over 38.5 years.

– *Longevity*: maximum duration of human life. This has not changed over the ages and is about 115–120 years. The case of Jeanne Calment, who died at the age of 122 years, is an exception.

– *Death rate (birth rate)*: number of deaths (births) with respect to the population of that year.

– *Life expectancy*: number of years left to live on average *to a fixed age*. A Russian man has a life expectancy at birth of 60 years. Compare this with 77 years for the French. Smoking and alcohol are the main cause of mortality in Russia.

– *Infant mortality rate*: number of deaths of children under 1 year with respect to the observed number of live births that year.

In France, during the late 18th Century, the population was about 30 million. France was the most populous country in Europe. Life expectancy was 25 years, 30% of children died before the age of 1. Only one out of five lived till the age of 80.

In 2000, life expectancy at birth was 77 years for men and 84 years for women. Immunization, sanitation, water supply, the virtual disappearance of hard labor, raising the level of culture, improved nutrition, and medical care are responsible for the decline in mortality.

In 2002, there were 763,000 births, representing a birth rate of 12‰. In the same year, the number of deaths was about 540,000, and the death rate was 9‰. The infant mortality rate was 4.3‰ in 2003, in which France ranked 8th in the world. It

1 Definitions and figures from the INSEE.

was 15 times higher in 1945. The risk of death decreased from birth till the age of 8–10 years. It then increased. France is the first country that saw a decline in fertility from the late 18th Century.

1.4.5.4. *Demography and sustainability*

Undoubtedly, population issues are the key factor for sustainability taken in its broadest sense and social stability. Some believe that the world is not overpopulated and that overpopulation is not a problem, whereas others oppose this belief. "Sustainable" population is between 20 and 2 billion according to the experts: 8 billion represent an average opinion which seems to be reasonable.

It seems that the impact of AIDS in some countries, especially African countries, is not yet measured at a fair value; some of the countries are beginning to run out of labor!

1.4.5.5. *The age pyramid*

The age pyramid reflects the situation of a country during the demographic transition process.

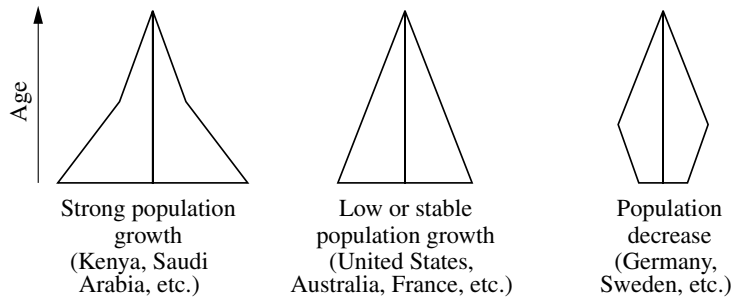


Figure 1.8. *Typical age pyramids*

1.4.6. *Energy*

For millennia, man has used fire for his domestic needs, and to make metals and glass. He was able to harness the wind and water, using his own strength and that of the animals to move, eat ... and to make war.

The concept of energy only emerged in the late 18th Century and it is due to Denis Papin, with Carnot, Watt, Thomson, and others that we came to know about the "fire-engines".

It took several decades to effectively transform heat energy with the advent of the steam engine, and several decades for thermodynamics to become a science,

a tough science which is not the most popular among students. The Industrial Revolution and all the technological advances it brought with it were based primarily on mastering energy, energy from the "king" of energies, coal, and then oil/petroleum and gas in the 20th Century, which are energies that are easier to extract, transform, and transport.

Hence industry has used non-renewable fossil fuels. Coal is derived from the transformation of plants which have been there for hundreds of millions of years, while oil/petroleum is formed from plankton.

The welfare of rich countries has led to the consumption of energy without precedent. The inhabitants of these countries now have light at the flick of a switch, cook their food on a stove, and fill the fuel tank of their car. Apparently, this situation will continue, and fossil fuels will run out, since the emerging giants – China and India – have enormous energy requirements.

Energy consumption is one of the major disparities between rich and poor countries. Sustainable development is inconceivable without equitable access to energy. Energy, along with water, is the great problem, the biggest challenge that humanity is facing in the 21st Century: this challenge is about providing reliable energy at a cost compatible with the development of the whole world, thereby protecting the environment, particularly by maintaining the level of CO_2 in the atmosphere at a reasonable level to avoid global warming.

1.4.6.1. *Some figures on energy*

The world now consumes about 9 Gtep (gigatep), say 9 billion teo/p (tonnes of equivalent oil/petroleum). The distribution is approximately as follows: 37% of energy from oil/petroleum, 22% from natural gas, 24% from coal, 7% from nuclear, and less than 3% from hydropower.

The global average consumption is about 1.5 teo per capita. The disparities are huge: an American has 7.9 teo/year against 3.7 for a European, and 0.2 for the inhabitants of Bangladesh. It is to be noted that 1.6 billion people do not have access to electricity.

The so-called renewable energies relate to hydropower, biomass, wind, solar, geothermal, and use of ocean currents; these energies represent only 10% of energy worldwide (7% in France).

The global oil/petroleum consumption is now about 80 million barrels per day. A barrel is 159 liters. So, it is about 12 million tonnes of oil/petroleum that the planet "burns" each day, 4.4 billion tonnes per year. The United States consumes a quarter of that production and can meet only 50% of their needs. Former US President George W. Bush said that it was intolerable that the first country in the world

depends on Saudi Arabia for its future, and has begun explorations in Alaska. One cannot ignore that the U.S. dependence on energy influences its foreign policy.

1.4.6.2. *What will be the case of energy in future? What will we do about it in the future?*

According to the experts, the years 2040–2050 will face the *Peak Oil crisis*, that is to say, the period when oil production will become lower than demand. Optimists, who, based on a similar situation which happened during the oil shocks of 1973 and 1980 claim that unexplored reserves exist. It is true that we are extracting an average of only 30% of what is in the reservoirs.

Processes for enhanced oil recovery (EOR) have been developed, but they will be used only when the cost of oil exceeds $100. Oil shale and tar sands, from heavy oils (Canada, Venezuela), represent considerable reserves, but are difficult to use: again, it's all about the price and process.

Gas should "survive" oil for two to three decades. The use of shale gas was made possible by the use of horizontal drilling which seems to double the reserves of natural gas; Will we still able to afford it! *It is henceforth accepted that the era of cheap oil is over*. *What will the fuel rates of our cars be?*

The energy risk is perhaps the biggest threat for industrialized countries which depend on developing countries for their supply. Two-thirds of proven oil reserves are in the Middle East. Moreover, the Middle East, Central Asia, and Russia own 80% of natural gas reserves.

The fact that the world and especially the United States are no longer investing in refineries poses a huge risk to the economy, just as Hurricane Katrina ravaged New Orleans in August 2005 which left the United States in a situation of instability causing serious economic consequences.

Coal has reserves for centuries and can be "reborn" if SO_2 is eliminated and CO_2 is sequestrated. Techniques exist and continue to be improved.

Nuclear power has produced many fears after several disasters of which the one at Chernobyl in April 1986 remains the target of environmentalists because of the risk inherent in the plants and storing of radioactive waste. Uranium reserves will exist for about 2–3 centuries. France, which has 59 power plants set up for a nominal capacity of 63 GWe (gigawatts of electricity) has proved the reliability that could be achieved in this type of procurement. France now plays a major leading role with the ITER program (fusion reactor). Fourth-generation plants, with improved yields, are being studied.

Renewable energy, whose interest is growing in view of concerns over greenhouse gases, can contribute to a certain independence with respect to oil.

France, the second largest agricultural country in the world, is focusing on the use of biomass (biofuel program or diester). However, it would take a quarter of France's industrial crops to meet about 10% of their energy needs. Wind power, the darling of environmentalists, is likely to remain marginal, but in times of shortage everything counts. There would have to be 25,000 wind turbines of 1 MW to meet 20% of the present needs of France.

There is no doubt, at least in developed countries, that energy savings must be revived, especially in terms of housing and transport. Many programs were created in 1973 and significant progress has been made, but the fear had vanished, and the effort has slowed.

The energy issue will remain for a long long time! Efforts should continue on research.

1.4.7. *Water*

Water is life. Without water, no economic development is possible! And yet ... a billion people (one in six people) lack drinking water, 2.4 billion people lack water to meet their basic hygiene needs. The fourth World Water Forum held in Mexico in March 2006, re-emphasized this. It is estimated that water-borne diseases killed about 8 million people in 2004!

The basin concept has emerged recently and highlighted the political problems associated with it. The water of the Jordan is without doubt one of the causes of conflict between Palestinians and Israelis.

Turkey is the water tower of the Middle East. It began the enormous construction project of 22 dams and 19 hydroelectric plants to irrigate 1 million hectares in Kurdistan. Turkey can control the Tigris and the Euphrates, thus Iraq and Syria. The Nile and the rivers that are attributed to it give life to 100 million people belonging to 10 countries. The expected increase in world population will be faced with a water problem/scarcity: conflicts are not far off!

1.4.8. *What will be the future for French agriculture?*

Agriculture has shaped the French landscape. French agriculture, the second largest agricultural society in the world, leading the way for wheat, wine, and sugar beet, is in a transition phase. Yields of more than 100 q/ha (quintals per hectare) for wheat were obtained by seed selection, with new tilling methods and ... by the use of pesticides and fertilizers.

But the number of farms is decreasing; the forest grows by 170,000 acres each year. Some areas are becoming deserts. The countryside is no longer only seen as a food producer, but is also considered as a recreational area for the urbanites and especially as an actor in the protection of the environment. French agriculture and forestry are now considered under the aspect of the validation of their biomass.

Beet, producing sugar, grain and starch, may lead to ethanol through fermentation. The esterification of rapeseed oil and sunflower oil result in diesters, called biofuels, alternatives, like ethanol, to petroleum products. Usage of waste (straw, etc.) and timber generates energy. The forest is a storage for CO_2 and wood energy, as has been the case for thousands of years.

The race for the increase of yields of agricultural production is the root cause of much of the pollution of groundwater and coastal waters by pesticides. The cultivation of GMOs raises hitherto unknown fears. It is therefore a question of controlling agriculture and forests today, which should take into account the economic, environmental, social aspects respecting the specificity of each region. The debate is just beginning! We bet that it will last a long time.

1.5. The company of tomorrow. Some thoughts

Companies in developed countries are companies based on science and technology.

These companies have taken advantage year after year of technological knowledge with an incredible speed, sometimes by despoiling the least developed countries and thus widening a gap growing between them and the rest of the world.

It is the *industrial tool*, taken in the broadest sense, which is at the root of these changes. It is that which transforms fossil and plant resources into chemicals, transportation means, power generators and to provide society with a growing number of goods and services.

The question on the future of the planet, which increasingly appears as an finite system", which a few decades ago, to the general public seemed to be a system without limits, is the question of *what is to be produced*, *how and where we want to produce?*

The company must keep the best of its traditional operation but must take into account the new requirements that the term "sustainable development" has highlighted.

The company now faces an unpredictable world where hype (some speak of mediacracy) amplifies phenomena beyond reason. Terrorism and financial scandals across the world bring a new unbearable dimension to the world.

The bankruptcy of Lehman Brothers in September 2008 took the world by surprise and has caused an unprecedented crisis, whose effects are ongoing at the time of writing. Countries are on the brink, the debt of some of these companies, like that of France, is stunning. The *subprime* crisis in the United States raises the question of the merits of capitalism: do we have the right to speculate on what does not exist? Where did the money go?

The "virtuous" skilled engineer, from whom greater clarity is requested in his work, can he remain in a world ruled by finance or cash flows which are opaque or to say the least destructive of value?

One of the major projects in the world, the most discreet, perhaps, is that of IFRS (*International Financial Reporting Standards*), financial tools whose role is to ensure, among other things, the accounting transparency of enterprises, the correct validation of assets and liabilities to restore the confidence of citizens who are asked to invest their savings [LEM 10]!

1.5.1. *Emerging countries*

Emerging countries of BRIC (Brazil, Russia, India, and China) and probably soon, South Africa, not to mention the four dragons, will weigh heavily on the global economy with their economic weight, strong growth, demography, and desire to progress.

The West cannot impose its politics and undoubtedly its vision on the rest of the world! What will be the result of this inevitable clash?

The case of China is significant in this regard: at the risk of repeating ourselves, we may wonder if the 21st Century will not be Chinese!

1.5.1.1. *China yesterday, today, and tomorrow*

Until the early 16th Century, China was a closed world. It did not communicate, and carried out business with the outside world only through the small enclave of Macau given to the Portuguese in 1577; this would be the starting point of the Italian Jesuit Matteo Ricci who waited for 20 years to reach Beijing during the Ming dynasty [CRO 57]. Ricci, the first Sinologist, reached China to become a respected scholar.

China is a "Still" world as Alain Peyrefitte wrote [SAL 97] but a world perfectly organized and well administered. The English opened up this world through the ignominious Opium War which ended with the Treaty of Nanking in 1842 (unequal treaties as the Chinese call it).

China was partially occupied by the West and Japan from 1842 until the foundation of the People's Republic of China (PRC) in 1949 by "Chairman Mao".

Mao's "reign" ended with the Cultural Revolution from 1966 to 1976 and his death in 1976.

President Deng Xiaoping (1904–1997) brought about an Enlightened Socialism in his country, and propelled it in a few decades to the pinnacle of the big players. This was the result of the work of a population of 1.3 billion industrious people, used to living with few means while working tremendously hard.

China, the world's workshop and, especially for the United States, has an enormous wealth of coal, metals, rare earth to its name. Tibet is the water tower of Asia.

China has enormous challenges ahead for the Chinese interior to improve their standard of living rather than focusing on the coastal strip from Canton to Shanghai via Tianjin and Qingdao, thus holding out the prospect of improving China's living standards.

It is already apparent that China will not have the fleet of cars equal to that of the European Union (540 cars/1,000 inhabitants) or to that of the United States (800 cars/1,000 inhabitants) as against 40 approximately for China.

China will therefore be confronted very quickly with changes in society like the developed countries.

1.5.2. *What are the values for tomorrow?*

It would take about three Earths to meet the needs of humans if they all had the same standard of living as that of France, five planets to have that of the United States.

The nations will be forced to find ways to deal with an impossible situation.

New values need to be found!

The engineer and especially the process engineer will be required to contribute to the evolution of the world.

An irony, which history does not lack, while "Communist" regimes disappear or give way to socialist regimes or even right-wing regimes, Karl Marx (1818–1883), author of *Das Kapital* [MAR 83], returns to center stage with this question: "what value should be given to work?".

1.5.3. *A new company for a new society*

Globalization intensifies competition, but it creates opportunities.

The concept of sustainable development is not the latest media term/concept in fashion: it will persist. Humanity is realizing that its living space is finite, and that our behavior today will affect the lives of generations to come, especially if the world's population increases by 50% within 40 or 50 years. This is true for energy, the environment, and the use of our resources.

The information revolution is not over. Technological advances are occurring at a high frequency, making obsolete the transformation processes and organizations. Along with a company that is based on IT, a new forward-looking concept can be added: a knowledge-based society.

Knowledge management is necessary because of the fragmentation of knowledge generated by the increasing complexity and the proliferation of technology and by the mobility of required or subjected individuals.

The company will have to manage its intellectual capital. New technologies of information and communication technologies (ICTs) play a role in making individuals work together and therefore facilitate the sharing of knowledge, especially tacit knowledge, knowledge specific to the individual which cannot be written and conceptualized, in contrast to explicit knowledge, which exists in reports and memos. The reconciliation of the company, the customer and its suppliers will continue. The company will also catch up with the society, the communities where it operates. The transparent company, and corporate citizenship are not just words. The company will always be judged on its profit, but this is not the only criterion.

The employee, in response to this changing world, will be forced to train throughout his life. Immediate access to information will result in lower hierarchical levels, the individual will become more and more specialized, but will learn to position himself between the provision of upstream information and the downstream information that awaits him. The concept of added value, that is to say the amount of the contribution of the individual to society, will take a higher value.

The employee, riveted to the screen of his computer, corresponds more practically with the world but is, in fact, increasingly isolated: a strange paradox. Globalization will need to adapt to multiculturalism.

What about the concepts that we have tried to develop in this book, organizations from which he is inspired? They will continue, but become more and more fluid so that the company gains in responsiveness, in adaptability in a changing and unpredictable environment.

The major functions of the company still have good years ahead of them, because man needs more and more references since everything will be complicated in the long run. But all these functions will be forced to evolve.

The entrepreneurs of tomorrow are those who will be able to explain this.

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