SCIENCE, TECHNOLOGY, AND SOCIETY

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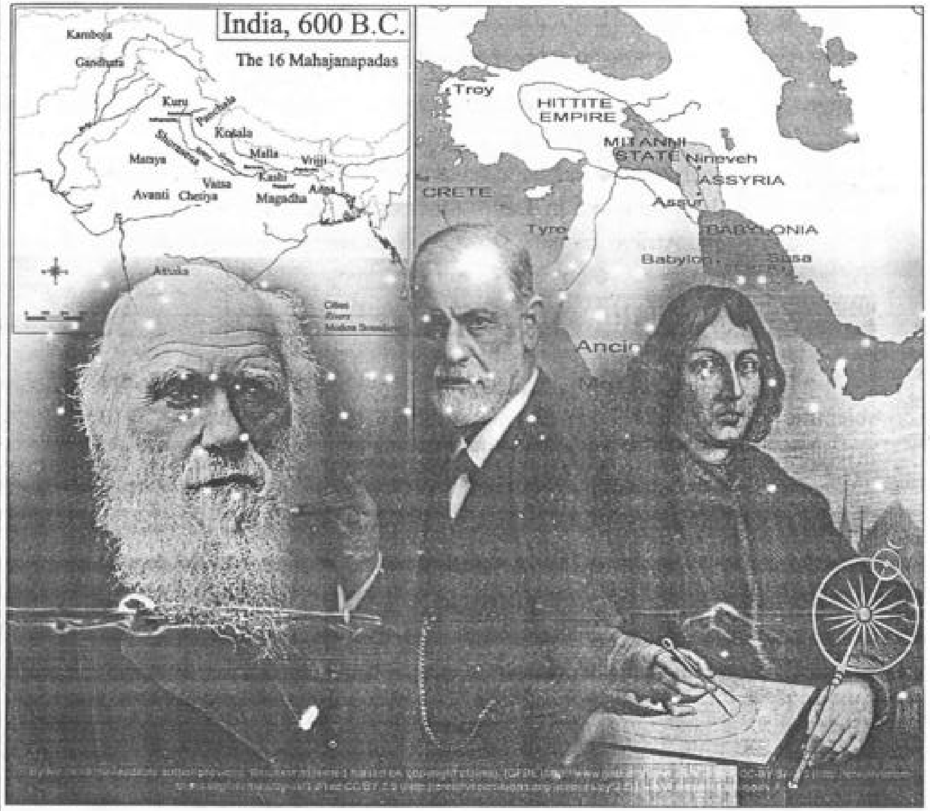
CHAPTER I General Concepts and Historical Events in Science, Technology, and Society



LESSON

1 INTELLECTUAL REVOLUTIONS THAT DEFINED SOCIETY

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- discuss how the ideas postulated by Copernicus, Darwin, and Freud contributed to the spark of scientific revolution; and
- analyze how scientific revolution is done in various parts of the world like in Latin America, East Asia, Middle East, and Africa.

INTRODUCTION

This lesson will give light to the development of science and scientific ideas in the heart of the society. It is the goal of this lesson to articulate ways by which society is transformed by science and technology.

Scientific Revolution

Science is as old as the world itself. There is no individual that can exactly identify when and where science began. From the genesis of time, science has existed. It is always interwoven with the society. So, how can science be defined?

1. **Science as an idea.** It includes ideas, theories, and all available systematic explanations and observations about the natural and physical world.

2. **Science as an intellectual activity.** It encompasses a systematic and practical study of the natural and physical world. This process of study involves systematic observation and experimentation.

3. **Science as a body of knowledge.** It is a subject or a discipline, a field of study, or a body of knowledge that deals with the process of learning about the natural and physical world. This is what we refer to as school science.

4. **Science as a personal and social activity.** This explains that science is both knowledge and activities done by human beings to develop better understanding of the world around them. It is a means to improve life and to survive in life. It is interwoven with people's lives.

Human beings have embarked in scientific activities in order to know and understand everything around them. They have persistently observed and studied the natural and the physical world in order to find meanings and seek answers to many questions. They have developed noble ideas, later known as philosophy, to provide alternative or possible explanations to certain phenomena. Humans also used religion to rationalize the origins of life and all lifeless forms.

The idea of scientific revolution is claimed to have started in the early 16th century up to the 18th century in Europe. Why in Europe? The probable answer is the invention of the printing machine and the blooming intellectual activities done in various places of learning, and the growing number of scholars in various fields of human interests. This does not mean, however, that science is a foreign idea transported from other areas of the globe. Anyone who can examine the history of science, technology, medicine, and mathematics is aware that all great civilizations of the ancient world had their own sophisticated traditions and activities related to these disciplines.

Scientific revolution was the period of enlightenment when the developments in the fields of mathematics, physics, astronomy, biology, and chemistry transformed the views of society about nature. It explained the emergence or birth of modern science as a result of these developments from the disciplines mentioned. The ideas generated during this period enabled the people to reflect, rethink, and reexamine their beliefs and their way of life. There is no doubt that it ignited vast human interests to rethink how they do science and view scientific processes.

Scientific revolution was the golden age for people committed to scholarly life in science but it was also a deeply trying moment to some scientific individuals that led to their painful death or condemnation from the religious institutions who tried to preserve their faith, religion, and theological views. Some rulers and religious leaders did not accept many of the early works of scientists. But these did not stop people especially scientists to satisfy their curiosity of the natural and physical world.

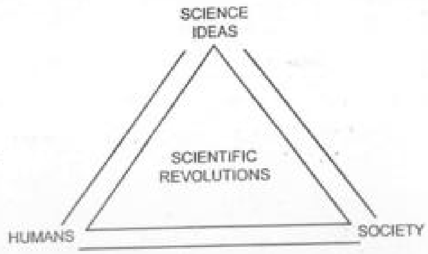


Figure 1. Influences to Scientific Revolution

Scientific revolution is very significant in the development of human beings, transformation of the society, and in the formulation of scientific ideas. It significantly improved the conduct of scientific investigations, experiments, and observations. The scientific revolution also led to the creation of new research fields in science and prompted the establishment of a strong foundation for modern science. In many ways, scientific revolution transformed the natural world and the world of ideas.

Some Intellectuals and their Revolutionary Ideas

To further understand what exactly happened during the scientific revolution, it is important to examine the different individuals whose ideas have shaken and contested the dominant theories and ideas during this period—the truths of their time. Scientists in all periods of time are driven

by their curiosity, critical thinking, and creativity to explore the physical and natural world. Their love for science is driven by their deep passion *to know* and *to discover*.

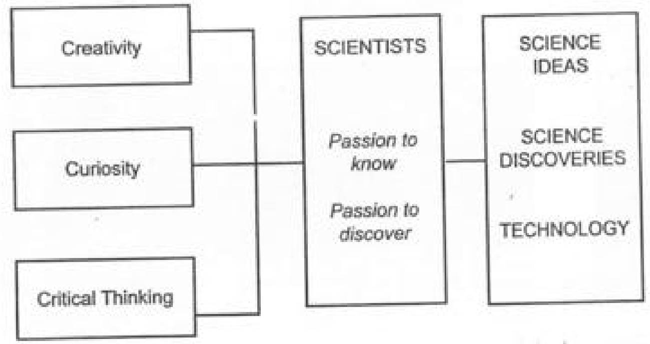


Figure 2. Variables that Influence the Development of Science Ideas, Science Discoveries, and Technology

Scientists are not driven by clamor for honor and publicity. They are ordinary people doing extraordinary things. Some scientists were never appreciated during their times, some were sentenced to death, while others were condemned by the Church during their time. In spite of all the predicaments and challenges they experienced, they never stopped experimenting, theorizing, and discovering new knowledge and ideas.

In this part of the lesson, three notable scientists are discussed. For sure, there were many scientists who worked before and after these individuals. However, it is important to note that these men, particularly through their ideas, had shaken the world.

Nicolaus Copernicus

One of the Renaissance men, particularly in the field of science, is Nicolaus Copernicus. Knowledge about the nature of the universe had been essentially unchanged since the great days of Ancient Greece, some 1,500 years before Copernicus came on the scene (Gribbin, 2003). This continued up to the Renaissance period. In one important way, Copernicus resembled the Greek ancient philosophers or thinkers—he did not do anything extensive such as observing heavenly bodies or inviting people to test his ideas. His ideas were an example of what is presently called as a *thought experiment*. By the time he finished his doctorate degree, Copernicus had been appointed as canon at Frombork Cathedral in Poland. Despite his duty as a canon, he had plenty of time to sustain his interest in astronomy. Copernicus was strongly influenced by a book entitled *Epitome* published in 1496 by a German author, Johannes Müeller. This book contains Müeller's observations of the heavens and some commentary on earlier works especially that of Ptolemy.

Copernicus's idea and model of the universe was essentially complete in 1510. Not long after that, he circulated a summary of his ideas to his few close friends in a manuscript called *Commentariolus* (*Little Commentary*). There was no proof that Copernicus was concerned about the risk of persecution by the Church if he published his ideas formally.

Copernicus was a busy man. His duty as a canon and as a doctor affected his time to formally publish his work and advance his career in astronomy. The publication of his book *De revolutionibus orbium coelestium* (*On the Revolutions of the Heavenly Spheres*) in 1543 is often cited as the start of the scientific revolution.

In his book, he wanted a model of the universe in which everything moved around a single center at unvarying rates (Griboin, 2003). Copernicus placed the Sun to be the centerpiece of the universe. The Earth and all the planets are surrounding or orbiting the Sun each year. The Moon, however, would still be seen orbiting the Earth. Copernicus's model of the Earth orbiting around the Sun automatically positioned the planets into a logical sequence. In his model, Copernicus outlined two kinds of planetary motion: (1) the orbits of Venus and Mercury lay inside the orbit of the Earth, thus, closer to the Sun; and (2) the orbits of Mars, Saturn, and Jupiter lay outside the Earth's orbit, thus, farther from the Sun. From this model, he would work on the length of time it will take for each planet to orbit once around the Sun. The result would form a sequence from Mercury, with a shortest year, through Venus, Earth, Mars, Jupiter, and Saturn with the longest year. He placed the planets in order of increasing distance from the Sun. One of the great problems in

the Copernicus model, however, was the position of the stars. The stars cannot be placed in a fixed position like crystals in a distance sphere.

Copernicus is also a courageous man. Although the Copernican model makes sense now, during those times, it was judged to be heretic and therefore it was an unacceptable idea to be taught to Catholics. The Catholic Church banned the Copernican model and was ignored by Rome for the rest of the 16th century.

THINK ABOUT THESE QUESTIONS

1. What is the contribution of Copernicus in the philosophy of science?
2. Do you think thought experiment is still useful in science in the present time?
3. Do you think the Church should intervene in scientific activities?

Charles Darwin

Charles Darwin is famous for his theory of evolution. He changed our concept of the world's creation and its evolution. Johnson (2012) described Darwin as a genius who came from a line of intellectually gifted and wealthy family. He developed his interest in natural history during his time as a student at Shrewsbury School. He would also spend time taking long walks to observe his surroundings while collecting specimens and he pored over books in his father's library (Gribbin, 2003). According to Johnson, Darwin went to the best schools but was observed to be a mediocre student. He struggled in his study in medicine and ministry, which his father has imposed to him. Darwin's life soon changed when one of his professors recommended him to join a five-year voyage through the *HMS Beagle* on the Islands of Galapagos.

Darwin published his book *The Origin of Species* in 1589. This book is considered to be one of the most important works in scientific literature. Darwin collected many significant materials in order to present his theory with overwhelming evidence. His book presented evidence on how species evolved over time and presented traits and adaptation that differentiate species. Like many other scholars, Darwin accumulated many pertinent materials and data that he could ever possibly need to substantiate his theory.

Darwin's observational skills as a scientist were extraordinary that moved beyond the realms of plants and animals into the realms of humans. His book *The Descent of Man* was so impressive yet very controversial. He introduced the idea of all organic life, including human beings, under the realm of evolutionary thinking. This replaced the dominant views of a religious or biblical design that places human beings in a privileged position of having been created by God. Darwin's theory of evolution scientifically questioned this view.

Darwin's accomplishments were so diverse that it is useful to distinguish two fields to which he made major contributions: evolutionary biology and philosophy of science. More than these works, what made Darwin truly remarkable was his courage to challenge religious and unscientific ideas that are deemed to be prominent during those days. His unorthodox way of pursuing science gave more value to evidence-based science. Darwin provided a different framework for doing scientific activities. It is a science marked by observation and experiment.

THINK ABOUT THESE QUESTIONS

1. What is Darwin's contribution to modern science?
2. How can Darwin's evolutionary theory influence the following fields in modern times:
   - Economy
   - Agriculture
   - Political Science
   - Religion

Sigmund Freud

Freud is a famous figure in the field of psychology. Rosenfels (1980) also described him as a towering literary figure and a very talented communicator who did his share to raise the consciousness of the civilized world in psychological matters.

However, apart from these, Freud also made a significant contribution in the scientific world through the development of an important observational method to gather reliable data to study human's inner life. This method is popularly known as the method of psychoanalysis. The scientific hypothesis he formulated formed the essential fundamental version of this method. For Freud, this method of psychoanalysis is a scientific way to study the human mind and neurotic illness. It is no doubt that amidst all questions on his works that led to some sort of academic controversy, his method of psychoanalysis had great impact on the scientific way of understanding human nature.

Freud is not a traditional thinker. According to Weiner (2016), his method of psychoanalysis was proven to be effective in understanding some neurological conditions that were not understood by medicine at that time. His method was unorthodox—focusing on human sexuality and the evil nature of man. This posed immense challenges to scholars and ordinary citizens of his time. To some, they found his ideas not easy especially in his explanations of human sexuality.

Freud was born in a much later period from the scientific revolution but his contribution to knowledge can be seen in many aspects of the human scene, including art, literature, philosophy, politics, and psychotherapy. Whether he is more of a psychologist or a scientist is for people to decide. The fact remains that Freudian ideas and theories are still considered nowadays as a great inspiration to examine human mind and behavior in a more scientifically accepted way.

THINK ABOUT THESE QUESTIONS

1. By looking for other sources and literatures, what are the controversies or questions on Freud's ideas?
2. How can you describe Freudian ideas as a scientist?
3. If Freud is still alive, what do you think are the major changes he would make to his theory?

Cradles of Early Science

Development of Science in Mesoamerica

Mesoamerica includes the entire area of Central America from Southern Mexico up to the border of South America. There is no doubt that the Mesoamerican region is rich in culture and knowledge prior to the arrival of its European colonizers.

The *Maya civilization* is one of the famous civilizations that lasted for approximately 2,000 years. These people are known for their works in astronomy. They incorporated their advanced understanding of astronomy into their temples and other religious structures. This allows them to use their temples for astronomical observation. For example, the pyramid at Chichén Itzá in Mexico is situated at the location of the Sun during the spring and fall equinoxes.

Mayan knowledge and understanding about celestial bodies was advanced for their time, as evidenced by their knowledge of predicting eclipse and using astrological cycles in planting and harvesting. The Mayans are also known for measuring time using two complicated calendar systems. These calendars were very useful for their life especially in planning their activities and in observing their religious rituals and cultural celebrations.

The Mayans also developed the technology for growing different crops and building elaborate cities using ordinary machineries and tools. They built hydraulics system with sophisticated waterways to supply water to different communities.

Furthermore, they used various tools and adapt themselves to innovations especially in the field of arts. The Mayans built looms for weaving cloth and devised a rainbow of glittery paints made from a mineral called *mica*. They are also believed to be one of the first people to produce rubber products 3,000 years before Goodyear received its patent in 1844.

The Mayans are considered one of the most scientifically advanced societies in Mesoamerica. They are also famous as one of the world's first civilizations to use a writing system known as the Mayan hieroglyphics. They were also skilled in mathematics and created a number system based on the numeral 20. Moreover, they independently developed the concept of zero and positional value, even before the Romans did.

The *Inca civilization* is also famous in Mesoamerica. The Incas made advanced scientific ideas considering their limitations as an old civilization. The following were scientific ideas and tools that they developed to help them in everyday life:

1. roads paved with stones;
2. stone buildings that surmounted earthquakes and other disasters;
3. irrigation system and technique for storing water for their crops to grow in all types of land;
4. calendar with 12 months to mark their religious festivals and prepare them for planting season;
5. the first suspension bridge;
6. *quipu*, a system of knotted ropes to keep records that only experts can interpret; and
7. Inca textiles since cloth was one of the specially prized artistic achievements.

Following the Inca, the *Aztec civilization* has also made substantial contributions to science and technology and to the society as a whole. Some of their contributions are the following:

1. **Mandatory education.** The Aztec puts value on education; that is why their children are mandated to get education regardless

of their social class, gender, or age. It is an early form of universal or inclusive education.

2. **Chocolates.** The Aztec in Mexico developed chocolate during their time. In the Mayan culture, they used it as currency. The Aztec valued the cacao beans highly and made it as part of their tribute to their gods.
3. **Antispasmodic medication.** They used a type of antispasmodic medication that could prevent muscle spasms and relax muscles, which could help during surgery.
4. **Chinampa.** It is a form of Aztec technology for agricultural farming in which the land was divided into rectangular areas and surrounded by canals.
5. **Aztec calendar.** This enabled them to plan their activities, rituals, and planting season.
6. **Invention of the canoe.** A light narrow boat used for traveling in water systems.

Development of Science in Asia

Asia is the biggest continent in the world and the home of many ancient civilizations. It is a host to many cultural, economic, scientific, and political activities of all ages. In the field of science, technology, and mathematics, great civilizations have stood out: India, China, and the Middle East civilizations. These civilizations were incomparable in terms of their contributions to the development of knowledge during their time.

India

India is a huge peninsula surrounded by vast bodies of water and fortified by huge mountains in its northern boarders. The Indians creatively developed various ideas and technologies useful in their everyday lives. They are known for manufacturing iron and in metallurgical works. Their iron steel is considered to be the best and held with high regard in the whole of Roman Empire.

India is also famous in medicine. For example, Ayurveda, a system of traditional medicine that originated in ancient India before 2500 BC, is still practiced as a form of alternative medicine. They discovered some medicinal properties of plants that led them to develop medicines to cure various illnesses. Some ancient texts, like the *Susruta Samhita*, describes different surgical and other medical procedures famous in Ancient India.

Ancient India is also notable in the field of astronomy. They developed theories on the configuration of the universe, the spherical self-supporting Earth, and the year of 360 days with 12 equal parts of 30 days each. Sama (2008) noted that their interest in astronomy was also evident in the first 12 chapters of the *Siddhanta Shiromani*, written in the 12th century. According to Sama (2008), this ancient text covered topics such as: mean longitudes of the planets; true longitudes of the planets; the three problems of diurnal rotation; syzygies; lunar eclipses; solar eclipses; latitudes of the planets; risings and settings; the moon's crescent; conjunctions of the planets with each other; conjunctions of the planets with the fixed stars; and the paths of the Sun and Moon.

Ancient India is also known for their mathematics. Bisht (1982) noted that the earliest traces of mathematical knowledge in the Indian subcontinent appeared in the Indus Valley Civilization. The people of this civilization, according to Bisht (1982), tried to standardize measurement of length to a high degree of accuracy and designed a ruler, the Mohenjo-daro ruler.

Clifford (2008) and Bose (1998) pointed out that Indian astronomer and mathematician Aryabhata (476–550), in his *Aryabhatiya*, introduced a number of trigonometric functions, tables, and techniques, as well as algorithms of algebra. In 628 AD, another Indian, Brahmagupta, also suggested that gravity was a force of attraction, and lucidly explained the use of zero as both a placeholder and a decimal digit, along with the Hindu-Arabic numeral system now used universally throughout the world (Clifford, 2008; Bose, 1998). Another Indian named Madhava of Sangamagrama is also considered as the founder of mathematical analysis (Joseph, 1991).

China

China is one of the ancient civilizations with substantial contributions in many areas of life like medicine, astronomy, science, mathematics, arts, philosophy, and music, among others. Chinese civilizations have greatly influenced many of its neighbor countries like Korea, Japan, Philippines, Vietnam, Thailand, Cambodia, Myanmar, and other countries that belong to the old Silk Road.

The Chinese are known for traditional medicines, a product of centuries of experiences and discovery of the Chinese people. They discovered various medical properties and uses of different plants and animals to cure human illness. An example is the practice of acupuncture.

In terms of technology, the Chinese are known to develop many tools. Among the famous discoveries and inventions of the Chinese civilizations were compass, papermaking, gunpowder, and printing tools that became known in the West only by the end of the Middle Ages (Davies, 1995). They also invented other tools like iron plough, wheelbarrow, and propeller, among others. They developed a design of different models of bridges (Zhongguo ke xue yuan, 1983), invented the first seismological detector, and developed a dry dock facility (Needham et al., 1971).

In the field of astronomy, the Chinese also made significant records on supernovas, lunar and solar eclipses, and comets, which were carefully recorded and preserved to understand better the heavenly bodies and their effects to our world (Mayall, 1939). They observed the heavenly bodies to understand weather changes and seasons that may affect their daily activities. They used lunar calendars, too. The Chinese are also known in seismology. This made them more prepared in times of natural calamities.

China made substantial contributions in various fields. The list of their discoveries and inventions is overwhelming. These contributions were made along with mathematics, logic, philosophy, and medicine. However, cultural factors prevented these Chinese achievements from developing into modern science. According to Needham (1986), it may have been the religious and philosophical framework of Chinese intellectuals that made them unable to accept the ideas of laws of nature.

Middle East Countries

The Middle East countries are dominantly occupied by Muslims. With the spread of Islam in the 7th and 8th centuries, a period of Muslim scholarship, or what is called the Golden Age of Islam lasted until the 13th century. The common language of Arabic, access to Greek texts from the Byzantine Empire, and their proximity to India were contributory to the intellectualization of the Muslims and provided their scholars knowledge to create innovations and develop new ideas. But contrary to the Greeks, Muslim scientists placed greater value on science experiments rather than plain-thought experiments. This led to the development of the scientific method in the Muslim world, and made significant improvements by using experiments to distinguish between competing scientific theories set within a generally empirical orientation. A Muslim scientist named Ibn al-Haytham is also regarded as the Father of Optics, especially for his empirical proof of the intromission theory of light.

In mathematics, the mathematician Muhammad ibn Musa al-Khwarizmi gave his name to the concept of the algorithm while the term algebra is derived from *al-jabr*, the beginning of the title of one of his publications. What is now known as the Arabic Numeral System originally came from India, but Muslim mathematicians did make several refinements to the number system, such as the introduction of decimal point notation.

Muslim chemists and alchemists also played an important role in the foundation of modern chemistry (Durant, 1980). In particular, some scholars considered Jābir ibn Hayyān to be the "Father of Chemistry" (Derewenda, 2007; Warren, 2005).

In the field of medicine, Ibn Sina pioneered the science of experimental medicine and was the first physician to conduct clinical trials (Jacquart, 2008). His two most notable works in medicine, the *Book of Healing* and *The Canon of Medicine*, were used as standard medicinal texts in both the Muslim world and in Europe during the 17th century. Among his many contributions are the discovery of the contagious nature of infectious diseases and the introduction of clinical pharmacology (Craig & Walter, 2000).

There are numerous Muslim scholars who made significant contributions in the field of science, mathematics, astronomy, philosophy, and even in the field of social sciences. The decline of this golden age of Islam started in the 11th to 13th century due to the conquest of the Mongols whereby libraries, observatories, and other learning institutions were destroyed.

Development of Science in Africa

Africa is blessed with natural and mineral resources. Science also emerged in this part of the planet long before the Europeans colonized it. The history of science and mathematics show that similar to other ancient civilizations, the early civilizations in Africa are knowledge producers, too.

The ancient Egyptian civilization has contributed immensely and made significant advances in the fields of astronomy, mathematics, and medicine. For example, the development of geometry was a product of necessity to preserve the layout and ownership of farmlands of the Egyptians living along the Nile River. The rules of geometry were developed and used to build rectilinear structures, the post of lintel architecture of Egypt. These early science activities in Egypt were developed to improve the quality of life of the Egyptians especially in building their early homes and cities. The great structures of the Egyptian pyramids and the early dams built to divert water from the Nile River are some proofs of their advanced civilization.

Egypt was known to be a center of alchemy, which is known as the medieval forerunner of chemistry. They tried to study human anatomy and pharmacology, and applied important components such as examination, diagnosis, treatment, and prognosis for the treatment of diseases. These components displayed strong parallels to the basic empirical method of studying science.

Astronomy was also famous in the African region. For instance, documents show that Africans used three types of calendars: lunar, solar, and stellar, or a combination of the three.

Metallurgy was also known in the African regions during the ancient times. North Africa and the Nile Valley imported iron technology from the Near East region that enabled them to benefit from the developments during the Bronze Age until the Iron Age. They invented metal tools used in their homes, in agriculture, and in building their magnificent architectures.

Mathematics was also known to be prominent in the life of early people in the African continent. The Lebombo Bone from the mountains between Swaziland and South Africa, which may have been a tool for multiplication, division, and simple mathematical calculation or a six-month lunar calendar, is considered to be the oldest known mathematical artifact dated from 35,000 BCE. Ancient Egyptians are good in the four fundamental mathematical operations and other mathematical skills. They have knowledge of the basic concepts of algebra and geometry. The Islamic regions in Africa during the medieval period was also benefiting from mathematical learning, which is considered advanced during those times, such as algebra, geometry, and trigonometry.

SUMMARY

Scientific revolution is a golden age in the history of science. It marked the birth of science as a discipline and as a field of inquiry and gave birth to the development of the scientific method. It was a time in the history of science where many scientific ideas and discoveries, which were considered innovative and useful, were developed. Some of these ideas were also controversial in the scientific community and in the political arena. The scientific revolution significantly changed how people study science and do scientific activities. It inspired human creativity and critical thinking, moving away from thought experiments to data-driven and experiment-based ideas.

There were many intellectuals who made essential contributions in science during the period of scientific revolution. Nicolaus Copernicus developed a model of the universe in which everything moved around a single center at unvarying rates. He placed the Sun in the center of the universe and all the planets were surrounding or orbiting it. Copernicus's model of planets orbiting around the Sun automatically positioned the planets into a logical sequence. Charles Darwin made significant contribution in the field of evolutionary biology and philosophy of science. His theory of evolution by natural selection is very useful in many fields until now. Sigmund Freud developed the idea of psychoanalysis that helped in understanding human behavior especially neurological conditions.

Science also developed in different parts of the world: in Asia, Europe, Mesoamerica, and Africa. People in these continents invented tools to help them in everyday life, discovered medicines to cure diseases, observed heavenly bodies, built structures, discovered many things, and invented mathematics as a tool and as a discipline. Science provided different ancient civilizations the means to survive and understand the natural and physical world. It also enabled human beings to develop various technologies that helped them in their everyday tasks.

THINK ABOUT THESE QUESTIONS

1. How did society shape science and how did science shape society?
2. How do social and human issues influence science?
3. How do the political and cultural landscapes of the society affect the development of scientific culture, science activities, and science literacy?
4. Considering the current state of our society, do you think science literacy among people has contributed to the growth of our economy?
5. How can science influence government policies?

ACTIVITY

1. Form a small group.
2. Review the history of science and make a timeline highlighting the major discoveries and developments in science.

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LESSON

2 SCIENCE, TECHNOLOGY, AND NATION-BUILDING

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- discuss the role of science and technology in Philippine nation-building;
- evaluate government policies pertaining to science and technology in terms of their contributions to nation-building; and
- identify actual science and technology policies of the government and appraise their impact on the development of the Filipino nation.

INTRODUCTION

This lesson will discuss the influence of science and technology in the development of the Philippine society. It identifies government programs, projects, and policies geared toward boasting the science and technological capacity of the country. This lesson will also include discussions on Philippine indigenous science and technology.

Brief Historical Background of Science and Technology in the Philippines

The history of science and technology in the Philippines started way back before the country gained its independence from the American colonizers. Before the coming of the Spanish colonizers, the early inhabitants of the archipelago had their own culture and traditions. They had their own belief system and indigenous knowledge system that keeps them organized and sustained their lives and communities for many years.

Science, in pre-Spanish Philippines, is embedded in the way of life of the people. Scientific knowledge is observed in the way they plant their crops that provide them food, in taking care of animals to help them in their daily tasks, and for food production. Science is observed in the way they interpret the movements of heavenly bodies to predict seasons and climates, and in organizing days into months and years. They use science in preparing the soil for agricultural purposes and like any other ancient cultures, they discovered the medicinal uses of plants.

Technology is used by people in building houses, irrigations, and in developing tools that they can use in everyday life. They developed tools for planting, hunting, cooking, and fishing; for fighting their enemies during war or tribal conflicts; and for transportation, both on land and on waterways. They also developed technologies in creating musical instruments.

The different archeological artifacts discovered in different parts of the country also prove that the Metal Age also had a significant influence on the lives of early Filipinos. The sophisticated designs of gold and silver jewelry, ceramics, and metal tools proved that their technological ideas helped in the development of different tools. Also, trading with China, Indonesia, Japan, and other nearby countries have influenced their lives by providing different opportunities for cultural and technological exchange.

All these ancient practices in science and technology are considered now as indigenous science or folk science.

When the Spaniards colonized the country, they brought with them their own culture and practices. They established schools for boys and girls and introduced the concept of subjects and disciplines. It was the beginning of formal science and technology in the country, known now as school of science and technology.

Learning of science in school focuses on understanding different concepts related to the human body, plants, animals, and heavenly bodies. Technology focuses on using and developing house tools used in everyday life.

Life during the Spanish era slowly became modernized, adapting some Western technology and their ways of life. The Filipinos developed ways to replicate the technology brought by the Spaniards using indigenous materials. Medicine and advanced science were introduced in formal colleges and universities established by the Catholic orders.

The galleon trade has brought additional technology and development in the Philippines. Although it is only beneficial for the Spaniards, these trades allowed other ideas, crops, tools, cultural practices, technology, and Western practices to reach the country. Some Filipino students who were able to study in Europe also contributed to the advancement of medicine, engineering, arts, music, and literature in the country.

The Philippines, being one of the centers of global trade in Southeast Asia during that time, was considered to be one of the most developed places in the region. Although the country is blessed with these developments, the superstitious beliefs of the people and the Catholic doctrines and practices during the Spanish era halted the growth of science in the country.

The Americans have more influence in the development of science and technology in the Philippines compared to the Spaniards. They established the public education system, improved the engineering works and the health conditions of the people. They established a modern research university, the University of the Philippines, and created more public hospitals than the former colonial master. The mineral resources of the country were also explored and exploited during the American times. Transportation and communication systems were improved, though not accessible throughout the country.

The Americans did everything to "Americanize" the Philippines. They reorganized the learning of science and introduced it in public and private schools. In basic education, science education focuses on nature studies and science and sanitation, until it became a subject formally known as "Science." The teaching of science in higher education has also greatly improved and modernized. Researches were done to control malaria, cholera, and tuberculosis and other tropical diseases.

The desire of the Americans to develop the human resources of the Philippines to serve their own interests is, somehow, beneficial in the country. These allowed American scholars to introduce new knowledge and technology in the country. The Protestant church missions in different places in the country also brought hospitals and schools to far-flung areas. Little by little, these efforts built a stronger foundation for science and technology in the country.

However, World War II has destabilized the development of the country in many ways. Institutions and public facilities were turned into ashes, houses were burned, and many lives were destroyed. The country had a difficult time to rebuild itself from the ruins of the war. The human spirit to survive and to rebuild the country may be strong but the capacity of the country to bring back what was destroyed was limited. The reparation funds focused on building some institutions and public facilities like schools, hospitals, and transportation systems. The reparation money from Japan was also concentrated on building highways and in providing technological training and human resource development in the country.

Since the establishment of the new republic, the whole nation has been focusing on using its limited resources in improving its science and technological capability. It has explored the use of ODA or Overseas Development Allocations from different countries to help the country improve its scientific productivity and technological capability. Human resource development is at the heart of these efforts focusing on producing more engineers, scientists, technology experts, doctors, and other professionals in the country.

The development of science and technology in the Philippines, based on its brief history, is shaped by several factors and influences. Like in the history of science in other countries, it is always shaped by human and social activities, both internal and external.

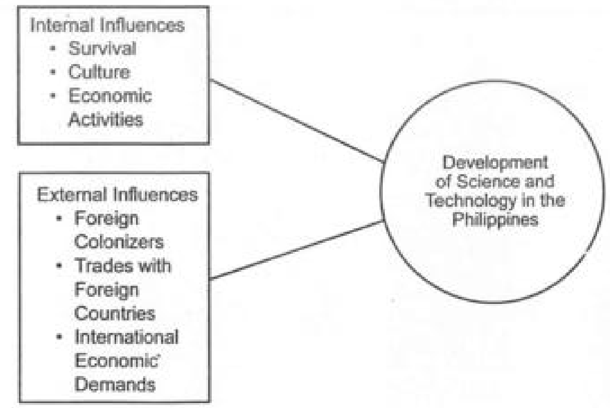

Figure 3. Influences in the Development of Science and Technology in the Philippines

Science and technology may have significant impact on the lives of the people and in the development of the Philippine society. However, improving the quality of science education still remains as a big challenge in the country. School science from basic education to graduate education is improving slowly, and there are only few students enrolling in science and technology courses.

THINK ABOUT THESE QUESTIONS

1. What are the significant contributions of the Spaniards and Americans to the development of science and technology in the Philippines?
2. What can you say about the state of science and technology during the Spanish and American period?
3. How does school science shape science and technology in the country?

Government Policies on Science and Technology

The Philippine government introduced and implemented several programs, projects, and policies to boost the area of science and technology. The goal is to prepare the whole country and its people to meet the demands of a technologically driven world and capacitate the people to live in a world driven by science.

Padilla-Concepcion (2015) reported that in 2015, in response to the ASEAN 2015 Agenda, the government, particularly the Department of Science and Technology (DOST), has sought the expertise of the National Science and Technology (DOST), has sought the expertise of the National Research Council of the Philippines (NCRP) to consult various sectors in the society to study how the Philippines can prepare itself in meeting the ASEAN 2015 Goals. As a result of the consultation, the NCRP is expected to recommend policies and programs that will improve the competitiveness of the Philippines in the ASEAN Region.

The NCRP clustered these policies into four, namely:

1. Social Sciences, Humanities, Education, International Policies and Governance
   - Integrating ASEAN awareness in basic education without adding to the curriculum
   - Emphasizing teaching in the mother tongue
   - Developing school infrastructure and providing for ICT broadband
   - Local food security
2. Physics, Engineering and Industrial Research, Earth and Space Sciences, and Mathematics
   - Emphasizing degrees, licenses, and employment opportunities
   - Outright grants for peer monitoring
   - Review of R.A. 9184
   - Harnessing science and technology as an independent mover of development

3. Medical, Chemical, and Pharmaceutical Sciences
   - Ensuring compliance of drug-manufacturing firms with ASEAN-harmonized standards by full implementation of the Food and Drug Administration
   - Creating an education council dedicated to standardization of pharmaceutical services and care
   - Empowering food and drug agencies to conduct evidence-based research as pool of information
   - Allocating two percent of the GDP to research
   - Legislating a law supporting human genome projects
4. Biological Sciences, Agriculture, and Forestry
   - Protecting and conserving biodiversity by full implementation of existing laws
   - Use of biosafety and standard model by ASEAN countries
   - Promoting indigenous knowledge systems and indigenous people's conservation
   - Formulation of common food and safety standards

There are also other existing programs supported by the Philippine government through the DOST. Some of these projects are the following:

- Providing funds for basic research and patents related to science and technology. The government funds basic and applied researches. Funding of these research and projects are also from the Overseas Development Aid (ODA) from different countries.
- Providing scholarships for undergraduate and graduate studies of students in the field of science and technology. Saloma (2015) pointed out that the country needs to produce more doctoral graduates in the field of science and technology, and produce more research in these fields, including engineering.

- Establishing more branches of the Philippine Science High School System for training young Filipinos in the field of science and technology.
- Creating science and technology parks to encourage academe and industry partnerships.
- Balik Scientist Program to encourage Filipino scientists abroad to come home and work in the Philippines or conduct research and projects in collaboration with Philippine-based scientists.
- Developing science and technology parks in academic campuses to encourage academe and industry partnerships.
- The establishment of the National Science Complex and National Engineering Complex within the University of the Philippines campus in Diliman. These aimed to develop more science and technology and engineering manpower resources needed by the country. They also aimed to produce more researches in these fields.

The Philippine-American Academy of Science and Engineering (PAASE, 2008) identified several capacity-building programs such as:

- Establishment of national centers of excellence
- Manpower and institutional development programs, such as the Engineering and Science Education Program (ESEP) to produce more PhD graduates in science and engineering
- Establishment of regional centers to support specific industries that will lead the country in different research and development areas
- Establishment of science and technology business centers to assist, advice, and incubate technopreneurship ventures
- Strengthen science education at an early stage through the Philippine Science High School system

In the field of education, several science-related programs and projects were created to develop the scientific literacy of the country.

Special science classes were organized and special science elementary schools were established in different regions. Aside from these, science and mathematics in basic education were continuously improved. The current K to 12 education program included Science, Technology, Engineering, and Mathematics (STEM) as one of its major tracks in the senior high school program to encourage more students to enroll in science-related fields in college.

Lately, the Commission on Higher Education launched its Philippine-California Advanced Research Institutes (PICARI) Project to allow several higher education institutions in the Philippines and some US-based laboratories, research institutes, and universities to work on research and projects related to science, agriculture, engineering, health, and technology. This project is hoped to strengthen the STEM competitiveness of the country.

There are many other areas and fields that the country is looking forward to embark various research and projects. The following are some of them:

1. Use of alternative and safe energy
2. Harnessing mineral resources
3. Finding cure for various diseases and illness
4. Climate change and global warming
5. Increasing food production
6. Preservation of natural resources
7. Coping with natural disasters and calamities
8. Infrastructure development

The Philippine Congress has also created various laws related to science and technology. These laws serve as a legal framework for science and technology in the country. These laws vary according to different themes such as: conservation, health-related, technology-building, and supporting basic research, among others. Some laws and policies are in line with international treaties such as the United Nations (UN), United Nations Educational, Scientific and Cultural Organization (UNESCO), Association of Southeast Asian Nations (ASEAN) and other international agencies.

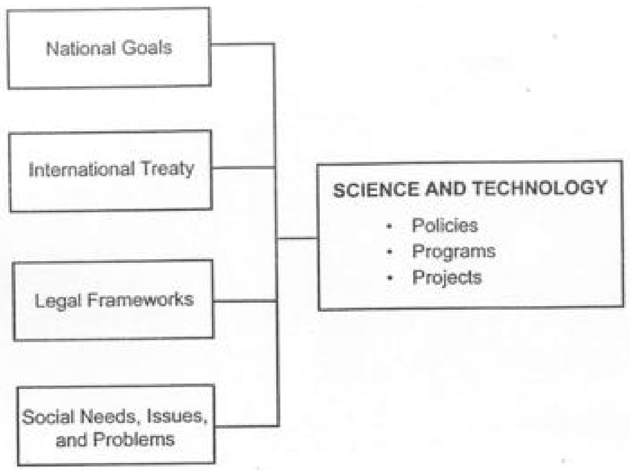

Figure 4. Development of Science and Technology Policies in the Philippines

As shown in the diagram, the development of policies in science and technology is shaped or influenced by several variables: policies need to be aligned to national goals, consider international commitments based on legal frameworks, and respond to various social needs, issues, and problems. Science and technology policies ensure that the whole country and all people will experience the progress that science can bring. Policies are guides to direct all efforts to a goal of developing a scientifically advanced country.

Famous Filipinos in the Field of Science

School science is filled with names of foreign scientists: Einstein, Galileo Galilei, Newton, Faraday, Darwin, and many other Western scientists. We rarely hear of Filipino scientists being discussed in science classes. Lee-Chua (2000) identified 10 outstanding Filipino scientists who have made significant contributions in Philippine science. These scientists are also famous abroad especially in different science disciplines: agriculture, mathematics, physics, medicine, marine science, chemistry, engineering, and biology.

These Filipino scientists are:

1. Ramon Cabanos Barba – for his outstanding research on tissue culture in Philippine mangoes
2. Josefino Cacas Comiso – for his works on observing the characteristics of Antarctica by using satellite images
3. Jose Bejar Cruz Jr. – known internationally in the field of electrical engineering; was elected as officer of the famous Institute of Electrical and Electronic Engineering
4. Lourdes Jansuy Cruz – notable for her research on sea snail venom
5. Fabian Millar Dayrit – for his research on herbal medicine
6. Rafael Dineros Guerrero III – for his research on *tilapia* culture
7. Enrique Mapua Ostrea Jr. – for inventing the meconium drugs testing
8. Lilian Formalejo Patena – for doing research on plant biotechnology
9. Mari-Jo Panganiban Ruiz – for being an outstanding educator and graph theorist
10. Gregory Ligot Tangonan – for his research in the field of communications technology

There are other outstanding Filipino scientists who are recognized here and abroad for their outstanding contributions in science:

- Caesar A. Saloma – an internationally renowned physicist
- Edgardo Gomez – famous scientist in marine science
- William Padolina – chemistry and president of National Academy of Science and Technology (NAST)–Philippines
- Angel Alcala – marine science

There are other scientists in the Philippines who were not identified in the list. Yet, the Philippines still need more scientists and engineers, and there is a need to support scientific research in the country. The University of the Philippines–Los Baños is a science paradise for agriculture, forestry, plant and animal science, and veterinary science. It has produced numerous scientists and various research in the fields mentioned. The University of the

Philippines–Visayas is also a national center for marine science, fisheries, and other related sciences. The University of the Philippines–Manila is a center of excellence and has produced many researchers, doctors, health professionals, and scientists in the area of medical and public health. The University of the Philippines–Diliman also has established a national science and engineering complex to develop more research and produce more scientists and engineers in the country. The government must find ways to establish more research laboratories and research institutes. There is also a need to find ways on how their researches are disseminated to the public.

Many of these Filipino scientists are products of good school science. It means they were taught and inspired by great teachers. Their interests in science started to manifest during their childhood years. Their natural environment ignited their curiosity to learn more about the natural and physical environment. Schools and the laboratories where they studied and worked nurtured this.

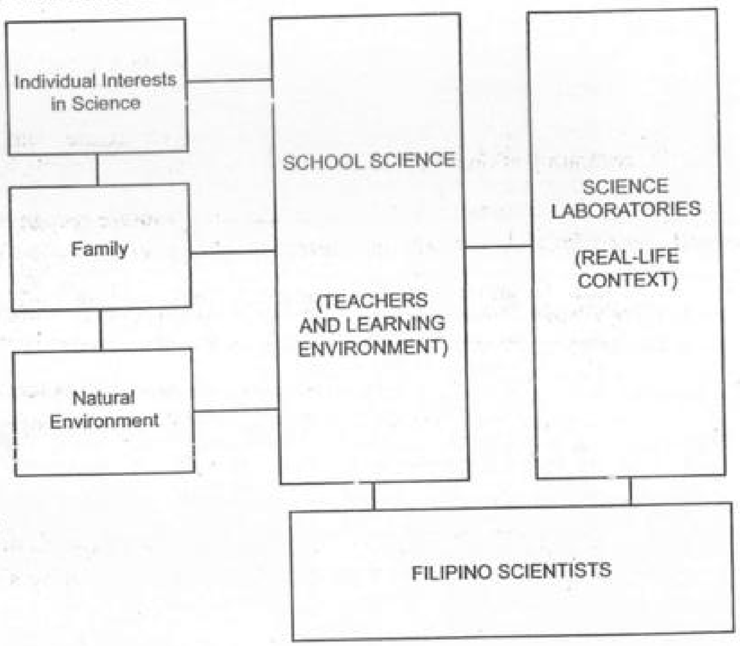

Figure 5. Factors that Influence the Development of Filipino Scientists

Many Filipino scientists, whether they are in the country or abroad, always excel in their job. The Filipino spirit in their souls has never faded. They continue to bring honor to the country. They make ordinary things in an extraordinary way. They are always at par with other scientists in spite of the limited facilities we have here in the country.

SUMMARY

This lesson discussed the influence of science and technology in the development of the Philippines as a country. Even before the time of Spanish colonization in the Philippines, various people and communities already practiced science. They invented tools and built structures, studied the medicinal uses of plants, observed heavenly bodies to predict seasons and weather, and used indigenous science in agriculture. These are considered indigenous science, which is one of the foundations of modern science.

The growth of science and its development as a field in the country is a hybrid of indigenous and foreign ideas. Spain and the United States, being the former colonial masters of the country, played an important role in building the foundation of science in the Philippines. To further strengthen the science program in the Philippines, the government establishes various science programs, policies, and projects.

Through the years, many Filipinos were able to establish themselves as scientists and science educators in various scientific areas and fields. Invention and innovations were done by these Filipino scientists. Finally, the demands of globalization, especially the ASEAN economic agenda, prompted the Philippines to invest in science and technology programs and projects.

THINK ABOUT THESE QUESTIONS

1. Identify several issues in the Philippines. What science- and technology-related policies could be developed and implemented to solve these issues?
2. What can you say about the implementation of some science and technology policies and projects in the country?
3. What are the laws related to science and technology in the Philippines from the year 2000?
4. How are these laws implemented?

ACTIVITY

1. Identify several Filipino scientists.
2. Research on their contributions in the field of science
3. Examine what made them pursue a career in science.
4. Present the result of your work in class.

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LESSON 3

SCIENCE EDUCATION IN THE PHILIPPINES

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- discuss the concept of science education; and
- identify science schools established to promote science education in the Philippines.

INTRODUCTION

The Philippines is trying its best to improve the state of science education in the country. This lesson will discuss the concept of science education and will identify some strategies to promote science education in the country. One of the strategies is to establish science schools that will encourage students to pursue their career in science and technology and to nurture their gifted potentials in science.

The Concept of Science Education

Science education focuses on teaching, learning, and understanding science. Teaching science involves developing ways on how to effectively teach science. This means exploring pedagogical theories and models in helping teachers teach scientific concepts and processes effectively. Learning science, on the other hand, includes both pedagogy and the most interesting aspect, which is helping students understand and love science.

Understanding science implies developing and applying science-process skills and using science literacy in understanding the natural world and activities in everyday life.

Getting deeper into the discourse of science education, John Dewey (2001) stressed the importance of utilizing the natural environment to teach students. Accordingly, nature must indeed furnish its physical stimuli to provide wealth of meaning through social activities and thinking. It is not surprising therefore that science education is important. In fact, Marx (1994) opines that science is going to be one of the most important school subjects in the future.

Science education is justified by the vast amount of scientific knowledge developed in this area that prepares citizens in a scientifically and technologically driven world. Science education provides skills and knowledge that are necessary for a person to live in what Knight (1986) describes as the age of science and to develop a citizenry that will meet the goals of science in the society (Tilghman, 2005). Developing a science culture is therefore an immense responsibility for schools.

Science Education in Basic and Tertiary Education

In basic education, science education helps students learn important concepts and facts that are related to everyday life (Carale & Campo, 2003; Meador, 2005; Worth & Grollman, 2003) including important skills such as process skills, critical thinking skills, and life skills that are needed in coping up with daily life activities (Chaille & Britain, 2002). Science education also develops positive attitude such as: the love for knowledge, passion for innovative things, curiosity to study about nature, and creativity (Lind, 1997). Science education will develop a strong foundation for studying science and for considering science-related careers in the future. This is an investment for the country to develop a scientifically cultured and literate citizenry.

In tertiary education, science education deals with developing students' understanding and appreciation of science ideas and scientific

works. This is done through offering basic science courses in the General Education curriculum. Science education in the tertiary level also focuses on the preparation of science teachers, scientists, engineers, and other professionals in various science-related fields such as engineering, agriculture, medicine, and health sciences. The state provides scholarships to encourage more students to pursue science courses.

Science Schools in the Philippines

One outstanding program for science education supported by the government is the establishment of science schools in various parts of the country. There are also several government programs implemented by the Department of Education and few private schools for science education.

Philippine Science High School System (PSHSS)

This is a government program for gifted students in the Philippines. It is a service institute of the Department of Science and Technology (DOST) whose mandate is to offer free scholarship basis for secondary course with special emphasis on subjects pertaining to the sciences, with the end-view of preparing its students for a science career (Republic Act No. 3661). The school maintains a dormitory for all its students.

Since its inception, the PSHSS continues to pursue its vision to develop Filipino science scholars with scientific minds and passion for excellence. PSHSS students have proven to be a beacon of excellence, courage, and hope for the country. They have brought honor to the Philippines through their exemplary achievements in various international competitions and research circles. When the students graduate from the school, they are expected to pursue degrees in science and technology at various colleges and universities locally or abroad.

Special Science Elementary Schools (SSES) Project

The Special Science Elementary Schools (SSES) Project is in pursuance to DepEd Order No. 73 s. 2008, and DepEd Order No. 51 s. 2010. This project started in June 2007 with 57 identified elementary schools that participated or were identified as science elementary schools in the country. Since its inception, the number have grown to more than 60 schools nationwide and this is now its sixth year of implementation.

The SSES Project aims to develop Filipino children equipped with scientific and technological knowledge, skills, and values. Its mission is to:

- provide a learning environment to science-inclined children through a special curriculum that recognizes the multiple intelligences of the learners;
- promote the development of lifelong learning skills; and
- foster the holistic development of the learners.

The subject Science and Health is taught in Grade I with a longer time compared to other subjects: 70 minutes for Grades I to III and 80 minutes for Grades IV to VI. The curriculum also utilizes different instructional approaches that address the learning styles and needs of the learners like the use of investigatory projects.

Quezon City Regional Science High School

The school was established on September 17, 1967. Originally, it was named Quezon City Science High School. It was turned into a regional science high school for the National Capital Region in 1999. The school was a product of a dream to establish a special science school for talented students in science and mathematics. The focus of the curriculum is on science and technology. The school still teaches the basic education courses prescribed by the Department of Education (DepEd) for secondary education. However, there are additional subjects in sciences and technology that students should take. The school envisions to serve as a venue in providing maximum opportunities for science-gifted students to develop spirit of inquiry and creativity. The school is well-supported by the local government unit and by the Parents and Teachers Association (PTA). The school is under the Department of Education.

Manila Science High School

The school was established on October 1, 1963 as the Manila Science High School (MSHS). It is the first science high school in the Philippines. The organization and curriculum of the school puts more emphasis on science and mathematics. MSHS aims to produce scientists with souls. In order to do this, humanities courses and other electives are included in their curriculum. Students are also encouraged to participate in various extracurricular activities. The school administers an entrance exam, the Manila Science High School Admission Test (MSAT), for students who wish to enroll. The MSAT has five parts: aptitude in science, aptitude test in mathematics, problem-solving test in science, problem-solving test in mathematics, and proficiency in English. The school prides itself from producing outstanding alumni and for winning various national competitions.

Central Visayan Institute Foundation

It is the home and pioneer of the prominent school-based innovation known as the Dynamic Learning Program (DLP). The DLP is a synthesis of classical and modern pedagogical theories adapted to foster the highest level of learning, creativity, and productivity.

The school takes pride in its Research Center for Theoretical Physics (RCTP) established in 1992, which organizes small international workshops to foster the informal but intense exchange of ideas and perspectives on outstanding problems in physics and mathematics.

SUMMARY

Science education deals with the teaching and learning of science and in helping the public develop science literacy. This is important in the promotion and development of science and technology in the country. Science education deals with the development of people in science, which is the heart of science, technology, and society.

This lesson focused on discussing the concept of science education and introduced science education in the Philippines from basic education to tertiary education. To promote science education, science schools were established to develop gifted students in science and mathematics, such as the Philippine Science High School System (PSHSS), Manila Science High School, Quezon City Regional Science High School, and the Special Science Elementary Schools Project. Science programs and projects were organized and developed to nurture innovation in science in the country, and to encourage individuals to pursue careers and research in science and technology.

THINK ABOUT THESE QUESTIONS

1. What other government projects and programs are available for science education in the Philippines?
2. Are there private schools with outstanding science education programs? Identify and compare their science education programs with public science schools.

ACTIVITY

1. Discuss science-related issues and problems in the country.
2. Identify science and technology policies that could be adapted or implemented in the Philippines.

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LESSON

4 INDIGENOUS SCIENCE AND TECHNOLOGY IN THE PHILIPPINES

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- discuss the concept of indigenous science; and
- discuss the contribution of indigenous science in the development of science and technology in the Philippines.

INTRODUCTION

This lesson focuses on indigenous science and technology in the Philippines. Filipinos, especially during the early times, tried to invent tools that will help them in everyday life. They also developed alternative ideas in explaining various phenomena and in explaining the world around them. This system of knowledge is called indigenous knowledge, which is the foundation of indigenous science.

Indigenous Knowledge System

Indigenous knowledge is embedded in the daily life experiences of young children as they grow up. They live and grow in a society where the members of the community prominently practice indigenous knowledge. Their parents and other older folks served as their first teachers and their methods of teaching are very effective in transmitting cultural knowledge in their minds. The lessons they learned are intimately interwoven with their culture and the environment. These lessons comprised of good values

and life stories of people on their daily life struggles. Their views about nature and their reflections on their experiences in daily life are evident in their stories, poems, and songs.

Some examples of indigenous knowledge that are taught and practiced by the indigenous people are:

- predicting weather conditions and seasons using knowledge in observing animals' behavior and celestial bodies;
- using herbal medicine;
- preserving foods;
- classifying plants and animals into families and groups based on cultural properties;
- preserving and selecting good seeds for planting;
- using indigenous technology in daily lives;
- building local irrigation systems;
- classifying different types of soil for planting based on cultural properties;
- producing wines and juices from tropical fruits; and
- keeping the custom of growing plants and vegetables in the yard.

Indigenous Science

Indigenous science is part of the indigenous knowledge system practiced by different groups of people and early civilizations (Gribbin, 2001; Mkapa, 2004; Sibisi, 2004). It includes complex arrays of knowledge, expertise, practices, and representations that guide human societies in their enumerable interactions with the natural milieu: agriculture, medicine, naming and explaining natural phenomena, and strategies for coping with changing environments (Pawilen, 2005). Ogawa (1995) claimed that it is collectively lived in and experienced by the people of a given culture.

According to Cajete (2004), indigenous science includes everything, from metaphysics to philosophy and various practical technologies practiced by indigenous peoples both past and present. Iaccarino (2003) elaborated this idea by explaining that science is a part of culture, and how science is done largely depends on the cultural practices of the people.

Indigenous beliefs also develop desirable values that are relevant or consistent to scientific attitudes as identified by Johnston (2000), namely: (1) motivating attitudes; (2) cooperating attitudes; (3) practical attitudes; and (4) reflective attitudes. These cultural beliefs therefore can be good foundation for developing positive values toward learning and doing science and in bringing science in a personal level.

Pawilen (2005) explained that indigenous science knowledge has developed diverse structures and contents through the interplay between the society and the environment. According to Kuhn (1962), developmental stages of most sciences are characterized by continual competition between a number of distinct views of nature, each partially derived from, and all roughly compatible with the dictates of scientific observation and method. Sibisi (2004) also pointed out that indigenous science provides the basics of astronomy, pharmacology, food technology, or metallurgy, which were derived from traditional knowledge and practices.

THINK ABOUT THESE QUESTIONS

1. What is your understanding of indigenous science?
2. What are examples of indigenous science practices?
3. Why do some people believe in indigenous science?
4. Do you think indigenous science should be considered science?
5. What is the role of indigenous science in the development of science and technology?

Pawilen (2006) developed a simple framework for understanding indigenous science. Accordingly, indigenous science is composed of traditional knowledge that uses science process skills and guided by community values and culture.

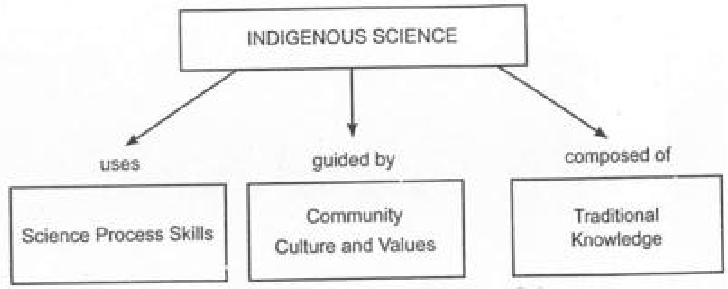

Figure 6. The Concept of Indigenous Science

1. Indigenous science uses science process skills such as observing, comparing, classifying, measuring, problem solving, inferring, communicating, and predicting.
2. Indigenous science is guided by culture and community values such as the following:
   - The land is a source of life. It is a precious gift from the creator.
   - The Earth is revered as "Mother Earth." It is the origin of their identity as people.
   - All living and nonliving things are interconnected and interdependent with each other.
   - Human beings are stewards or trustee of the land and other natural resources. They have a responsibility to preserve it.
   - Nature is a friend to human beings—it needs respect and proper care.
3. Indigenous science is composed of traditional knowledge practiced and valued by people and communities such as ethno-biology, ethno-medicine, indigenous farming methods, and folk astronomy.

Indigenous science is important in the development of science and technology in the Philippines. Like the ancient civilizations, indigenous science gave birth to the development of science and technology as a field and as a discipline. Indigenous science helped the people in understanding the natural environment and in coping with everyday life. UNESCO's Declaration on Science and the Use of Scientific Knowledge (1999) recognized indigenous science as a historical and valuable contribution to science and technology.

SUMMARY

This lesson discussed the concept of indigenous knowledge and its influence to the development of indigenous science. The communities in the Philippines have maintained vast amounts of indigenous knowledge, cultural practices, traditions, and beliefs. These include beliefs and practices ranging from different areas such as health, environment, peace and order, agriculture, food production, astronomy, music, and literature. The indigenous knowledge system of the people served as the foundation for the development of indigenous science.

Even before the time of the Spanish colonization in the Philippines, various people and communities already practiced science. They invented tools and built structures, studied the medicinal uses of plants, observed heavenly bodies to predict seasons and weather, and used indigenous science in agriculture. These are considered indigenous science, which is one of the foundations of modern science.

THINK ABOUT THESE QUESTIONS

1. What is the role of indigenous knowledge in the development of indigenous science?
2. What is the role of indigenous science in the development of science and technology in the Philippines?
3. How do society and culture influence the development of science and technology?

ACTIVITY

1. Identify Filipino indigenous knowledge.
2. Research on the connection of indigenous knowledge to science and technology.
3. Present the result of your work to the class.

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CHAPTER II Science, Technology, and Society and the Human Condition

LESSON

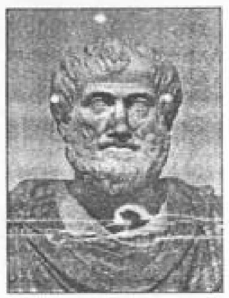
1 HUMAN FLOURISHING

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- identify different conceptions of human flourishing;
- determine the development of the scientific method and validity of science; and
- critic human flourishing vis-a-vis progress of science and technology to be able to define for themselves the meaning of a good life.

INTRODUCTION



Eudaimonia, literally "good spirited," is a term coined by renowned Greek philosopher Aristotle (385–323 BC) to describe the pinnacle of happiness that is attainable by humans. This has often been translated into "human flourishing" in literature, arguably likening humans to flowers achieving their full bloom. As discussed in the *Nicomachean Ethics*, Aristotle's human flourishing arises as a result of different components such as *phronesis*, friendship, wealth, and power. In the Ancient Greek society, they believe that acquiring these qualities will surely bring the seekers happiness, which in effect allows them to partake in the greater notion of what we call the *Good*.

As times change, elements that comprise human flourishing changed, which are subject to the dynamic social history as written by humans. People found means to live more comfortably, explore more places, develop more products, and make more money, and then repeating the process in full circle. In the beginning, early people relied on simple machines to make hunting and gathering easier. This development allowed them to make grander and more sophisticated machines to aid them in their endeavors that eventually led to space explorations, medicine innovations, and ventures of life after death. Our concept of human flourishing today proves to be different from what Aristotle originally perceived then—humans of today are expected to become a "man of the world." He is supposed to situate himself in a global neighborhood, working side by side among institutions and the government to be able to reach a common goal. Competition as a means of survival has become passé; coordination is the new trend.

Interestingly, there exists a discrepancy between eastern and western conception regarding society and human flourishing. It has been observed that western civilization tends to be more focused on the individual, while those from the east are more community-centric. Human flourishing as an end then is primarily more of a concern for western civilizations over eastern ones. This is not to discredit our kinsfolk from the east; perhaps in their view, community takes the highest regard that the individual should sacrifice himself for the sake of the society. This is apparent in the Chinese Confucian system or the Japanese Bushido, both of which view the whole as greater than their components. The Chinese and the Japanese encourage studies of literature, sciences, and art, not entirely for oneself but in service of a greater cause. The Greek Aristotelian view, on the other hand, aims for *eudaimonia* as the ultimate good; there is no indication whatsoever that Aristotle entailed it instrumental to achieve some other goals. Perhaps, a person who has achieved such state would want to serve the community, but that is brought upon through deliberation based on his values rather than his belief that the state is greater than him, and thus is only appropriate that he should recognize it as a higher entity worthy of service.

Nevertheless, such stereotypes cannot be said to be true given the current stance of globalization. Flourishing borders allowed people full access to cultures that as a result, very few are able to maintain their original philosophies. It is in this regard that we would tackle human flourishing—in a global perspective and as a man of the world.

Science, Technology, and Human Flourishing

In the previous chapters, contributions of science and technology have been laid down thoroughly. Every discovery, innovation, and success contributes to our pool of human knowledge. Perhaps, one of the most prevalent themes is human's perpetual need to locate himself in the world by finding proofs to trace evolution. The business of uncovering the secrets of the universe answers the question of our existence and provides us something to look forward to. Having a particular role, which is uniquely ours, elicits our idea of self-importance. It is in this regard that human flourishing is deeply intertwined with goal setting relevant to science and technology. In this case, the latter is relevant as a tool in achieving the former or echoing Heidegger's statement, technology is a human activity that we excel in as a result of achieving science. Suffice to say that the end goals of both science and technology and human flourishing are related, in that the *good* is inherently related to the *truth*. The following are two concepts about science which ventures its claim on truth.

Science as Method and Results

For the most part, science's reputation stems from the objectivity brought upon by an arbitrary, rigid methodology whose very character absolves it from any accusation of prejudice. Such infamy effectively raised science in a pedestal untouchable by other institutions—its sole claim to reason and empiricism—garnering supporters who want to defend it and its ways.

In school, the scientific method is introduced in the earlier part of discussions. Even though the number of steps varies, it presents a general idea of how to do science:

1. **Observe** and determine if there are unexplained occurrences unfolding.
2. **Determine the problem** and identify factors involved.
3. Through past knowledge of similar instance, **formulate hypothesis** that could explain the said phenomenon. Ideally, the goal is to **reject the null hypothesis** and accept the alternative hypothesis for the study "to count as significant" (can also be separated into additional steps such as "to generate prediction" or "to infer from past experiments").
4. **Conduct experiment** by setting up dependent and independent variables, and trying to see how independent ones affect dependent ones.
5. **Gather and analyze** results throughout and upon culmination of the experiment. Examine if the data gathered are significant enough to conclude results.
6. **Formulate conclusion and provide recommendation** in case others would want to broaden the study.

At least in the students' formative years, the above routine is basic methodology when introducing them to experimentation and empiricism—two distinct features that give science edge over other schools of thought. Throughout the course of history, however, there exists heavy objections on the scientific procedure; the line separating science and the so-called pseudoscience becomes more muddled.

Verification Theory

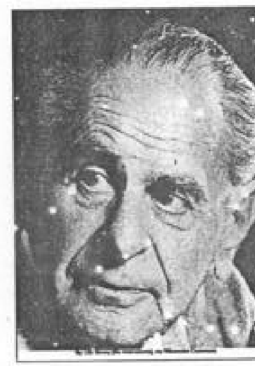
The earliest criterion that distinguishes philosophy and science is verification theory. The idea proposes that a discipline is science if it can be confirmed or interpreted in the event of an alternative hypothesis being accepted. In that regard, said theory gives premium to empiricism and only takes into account those results which are measurable and experiments which are repeatable. This was espoused by a movement in the early twentieth century called the *Vienna Circle*, a group of scholars who believed that only those which can be observed should be regarded as meaningful and reject those which cannot be directly accessed as meaningless. Initially, this proved to be attractive due to general consensus from people, which happened to see for themselves how the experiment occurred, solidifying its validity and garnering supporters from esteemed figures. Its shortcomings, however, proved to be a somewhat too risky—several budding theories that lack empirical results might be shot down prematurely, causing slower innovation and punishing ingenuity of newer, novel thoughts. Celebrated discoveries in physics, for instance, are initially theorized without proper acknowledgment of their being. Einstein's theory on the existence of gravitational waves would, following this thought, be dismissed due to lack of evidence almost a hundred years ago. Quantum mechanics would not have prospered if the scientific society during the time of Edwin Schrödinger did not entertain his outrageous thought that the cat in the box is both dead and alive, which can only be determined once you look in the box yourself.

Aside from above critique, this theory completely fails to weed out bogus arguments that explain things coincidentally. A classic example is astrology, whose followers are able to employ the verification method in ascertaining its reliability. The idea is that since one already has some sort of expectations on what to find, they will interpret events in line with said expectations. American philosopher Thomas Kuhn warned us against bridging the gap between evidence and theory by attempting to interpret the former according to our own biases, that is, whether or not we subscribe to the theory. Below is a short story illustrating this point:

> Suppose, for instance, this girl, Lea has a (not-so-scientific) theory that her classmate Ian likes her. *Good*, she thought, *I like him too. But how do I know that he likes me?*
>
> She began by observing him and his interactions with her. Several gestures she noted include his always exchanging pleasantries with her whenever they bump into each other, his big smile when he sees her, and him going out of his way to greet her even when riding a jeepney. Through these observations, she was then able to conclude that Ian does like her because, she thought, *why would anyone do something like that for a person he does not like?*
>
> As it turns out, however, Ian is just generally happy to meet people he knew. He had known Lea since they were in first year and regards her as a generally okay person. It is no surprise then that upon learning that Ian basically does this to everyone, Lea was crushed. She vowed to herself that she would never assume again.

Based from above story, is it justified for Lea to think that Ian does not like her? Not quite. The next criterion also warns us about the danger of this view.

Falsification Theory



Perhaps the current prevalent methodology in science, falsification theory asserts that as long as an ideology is not proven to be false and can best explain a phenomenon over alternative theories, we should accept the said ideology. Due to its hospitable character, the shift to this theory allowed emergence of theories otherwise rejected by verification theory. It does not promote ultimate adoption of one theory but instead encourages research in order to determine which among the theories can stand the test of falsification. The strongest one is that which is able to remain upheld amidst various tests, while being able to make particularly risky predictions about the world. Karl Popper is the known proponent of this view. He was notorious for stating that up-and-coming theories of the time, such as Marx's Theory of Social History and Sigmund Freud's Psychoanalysis, are not testable and thus not falsifiable, and subsequently questioning their status as scientific. Albeit majority of scientists nowadays are more inclined to be Popperian in their beliefs, this theory, similar to the theory above, presents certain dangers by interpreting an otherwise independent evidence in light of their pet theory.

To illustrate, previous story is restated:

Ian is generally everybody's friend. He likes to be around people and generally aspires to become everybody's friend. However, there is this one girl, Lea, who seemed to not like him when he is around. Every time he waves at her, she turns away, and when they are in the same room, she avoids his glances. Through this, he concluded that Lea does not like him and does his best to show her that he is not a threat. He began greeting her whenever they pass by each other at the corridor, even going so far as calling her attention when he was in the jeepney and saw her walking past. When they are able to talk to each other, he found out that Lea is just really shy and is not accustomed to people greeting her. He then was able to conclude that his initial impression of her not liking him (as a person) is wrong and thus said proposition is rejected.

Although there is no happy ending yet for Lea and Ian, we can thus see how in this case, falsification method is prone to the same generalizations committed by the verification method. There is no known rule as to the number of instance that a theory is rejected or falsified in order for it to be set aside. Similarly, there is no assurance that observable event or "evidences" are indeed manifestations of a certain concept or "theories." Thus, even though, theoretically, falsification method is more accepted, scientists are still not convinced that it should be regarded as what makes a discipline scientific.

Science as a Social Endeavor

Due to inconclusiveness of the methodologies previously cited, a new school of thought on the proper demarcation criterion of science emerged. Several philosophers such as Paul Thagard, Imre Lakatos, Helen Longino, David Bloor, and Richard Rorty, among others, presented an alternative demarcation that explores the social dimension of science and effectively, technology. Sciences cease to belong solely to gown-wearing, bespectacled scientists at laboratories. The new view perpetuates a dimension which generally benefits the society. For instance, far-off

places in South America where many of the tribes remain uncontacted, do not regard western science as their science. Whatever their science is, it can be ascertained that it is in no way inferior to that of globalized peoples' science. Thus, it presents an alternative notion that goes beyond the boundaries of cold, hard facts of science and instead projects it in a different light, such as a manifestation of shared experience forging solidarity over communities.

Science and Results

For the most part, people who do not understand science are won over when the discipline is able to produce results. Similar to when Jesus performed miracles and garnered followers, people are sold over the capacity of science to do stuff they cannot fully comprehend. In this particular argument, however, science is not the only discipline which is able to produce results—religion, luck, and human randomness are some of its contemporaries in the field. For some communities without access to science, they can turn to divination and superstition and still get the same results. Science is not entirely foolproof, such that it is correct 100% of the time. Weather reports, for one, illustrate fallibility and limitations of their scope, as well as their inability to predict disasters. The best that can be done during an upcoming disaster is to reinforce materials to be more calamity proof and restore the area upon impact. It can be then concluded that science does not monopolize the claim for definite results.

Science as Education

Aforementioned discussion notes that there is no such thing as a singular scientific method, offering instead a variety of procedures that scientists can experiment with to get results and call them science. Discoveries in physics, specifically in quantum mechanics, appeared to have debunked the idea of objectivity in reality, subscribing instead to alternative idea called intersubjectivity. With objectivity gone, it has lost its number one credence. Nevertheless, there still exists a repressing concept that comes about as a result of unjustified irreverence of science—our preference of science-inclined students over those which are less adept.

There are distinct portions in entrance exams in the secondary and tertiary levels that are dedicated to science and mathematics. In the Philippines, a large distribution of science high schools can be found all over the country, forging competition for aspiring students to secure a slot and undergo rigorous science and mathematics training based on specialized curricula. Although arguable as these schools also take great consideration in providing holistic education by assuring that other non-science courses are covered, adeptness in science and mathematics are the primary condition to be admitted. This preference is also reflected on the amount of STEM (Science, Technology, Engineering, Mathematics)-offering schools accommodating Grades 11 and 12. Among all the clusters being offered, STEM trumps the remaining clusters in terms of popularity and distribution, with Accounting and Business coming in as a close second. One might infer that there are more demand in this field as students are preconditioned that the field would latter land them high-paying jobs and a lucrative career after graduation.

How is science perceived by those who graduated from this field? A couple of years ago, a student entered a class all curious and excited. When he was made to report on Paul Feyerabend's work *How to Defend Society Against Science* one day, he looked dissident, staunchly refusing to consider the author's ideas on science and critiquing him instead. When asked why, he reasoned out that he had come from a science high school and was trained to regard science in a distinct accord. As isolated a case as it may seem, it somewhat suggests that the aforementioned kind of academic environment has made students unwelcoming of objections against science. Reminiscent of Paul Feyerabend's sentiment above, he muses how the educational system can hone and preserve students' capacity to entertain other options and decide for themselves the best among all presented. It will thus reinforce their imagination and allow some level of unorthodoxy, bringing forth novel discoveries that otherwise would not be considered had they stuck to the default methodology. Innovations are brought forth by the visionaries, not the prude legalists, and several notable figures in science even consider themselves as outsiders.

If one is really in pursuit of human flourishing, it would make sense for them to pursue it holistically. Simply mastering science and technology would be inadequate if we are to, say, socialize with people or ruminate on our inner self. Aristotle's *eudaimonic* person is required to be knowledgeable about science, among other things of equal importance. They are supposed to possess intellectual virtues that will enable them to determine truth from falsehood or good reasoning from poor reasoning. A true *eudaimon* recognizes that flourishing requires one to excel in various dimensions, such as linguistic, kinetic, artistic, and socio-civic. Thus, he understands that he should not focus on one aspect alone.

How Much Is Too Much?

In 2000, world leaders signed the Millennium Development Goals (MDG) that targets eight concerns, one of which states that they should be able to forge a global partnership for development. Inasmuch as the institutes imposing them do so in good faith, the primary goal to achieve growth for all might prove to be fatal in the long run.

Economists believe that growth is the primary indicator of development, as both go hand in hand, and has put forth their resources in trying to achieve such. Technology has been a primary instrument in enabling them to pursue said goal, utilizing resources, machineries, and labor. What is missing in this equation is that growth presents an illusory notion of sustainability—the world's resources can only provide so much, it cannot be expected to stretch out for everybody's consumption over a long period of time. Moreover, growth is not infinite—there is no preordained ceiling once the ball starts rolling. If the MDG convention's intent was to get everyone in the growth ship, that ship will surely sink before leaving the port. The same analogy applies to the capacity of nature to accommodate us, which Joseph Hickel contemplated on, suggesting that developed countries should not push forth more growth but instead adopt "de-development" policies or else, everybody loses. The rapid pace of technological growth allows no room for nature to recuperate, resulting in exploitation and irreversible damages to nature. Right now, we are experiencing repercussions of said exploits in the hands of man-made climate change, which would snowball and affect majority of flora and fauna, driving half of the latter extinct in less than a hundred year from now. If this continues in its currently alarming rate, we might bring about our own extinction.

SUMMARY

Human flourishing is defined as being "good spirited" in the classical Aristotelian notion. Humans generally have a notion on what it means tc flourish; albeit in the advent of science and technology, they chose to hinge their ends alongside the latter's results. While it is true that science equips its knowers some details about the world, its main claim to objectivity and systematic methodology is at the very least flawed. However, that does not stop institutions to favor those who excel in said discipline. Finally, the economic perception of enrichment, otherwise known as growth, is heavily fueled by technology and should be impeded. We have to rethink of our perception of a good life apart from one presented in this regard.

THINK ABOUT THESE QUESTIONS

1. Is our reverence of science justified? Explain.
2. Were we successful so far in trying to tie down technology with what we conceive as human flourishing?
3. What do you think constitutes human flourishing?

ACTIVITIES

1. **Group Presentation.** For each group, state a brief history on discovery that brought about the invention or discovery of the things stated below. State their contributions in our scientific development.
   a. Gravity
   b. Telescope
   c. Processed Food

   d. Microscope
   e. Radio
   f. Benzene Ring
   g. Large Hadron Collider
   h. Guns
   i. Internet
   j. Cell phones
2. **Brainstorming.** By group, try to determine the possible alternatives to growth and development. List down several ways to promote sustainable living and start a mini-campaign advocating the method of your choice.

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LESSON 2 TECHNOLOGY AS A WAY OF REVEALING

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- explain the concept of human condition before science technology;
- identify the change that happened in human condition after science and technology; and
- name ways on how technology aided in revealing the truth about the human being.

INTRODUCTION

Comparing the lives of the people before and now will make anyone realize the changes that happened in society not just in terms of culture, language, or rights but more importantly, changes in people's way of life due to the existence of science and technology.

The term "generation gap" is attributed mainly to the changes brought about by technology. Although the original idea is for technology to help everyone, it cannot be denied that until today, not everyone is comfortable in using the different kinds of technologies. Mostly those who belong to the older generation think that these technologies are too complicated to operate. They have been used to the simple living in the past and these available technological devices, though very appealing, are a difficult puzzle to them.

proud to show off their hunt and how good of a hunter they were? Were they concerned with social standing and stratification? How about the meaning of life? Were they also curious on finding explanations to certain phenomena?

At least for the last question, it seems that they have found their answer in the person of religion. Excavations on the latter half of the Stone Age include several figures thought to be ceremonial, meaning, that perhaps people of the time had also painstakingly wrought and hewed said figures in honor of some deity. This notion, as it was then and as it is now, is often people's resort to make sense of events happening outside their control. The initial roster of primitive gods includes objects they encounter through their day-to-day lives, so it is not surprising that different tribes may have different gods. Those who might have lived alongside majestic creatures, such as elephants and mammoths, might have been awed by their size and worshiped them as the owner of the land, asking for blessings in their hunting ground. On the contrary, they might have hunted the mammoths for their woolly coat and meat, taking down the animal for the entire community to eat. In windy places near mountains, they might have had a mountain god to explain wind currents and ask for provisions. On the other hand, those who were near coastal areas or bodies of water might have had water gods they referred to when asking for a good catch. However, it might be also the case that people of prior civilizations shared several generic gods, such as the sun.

Nevertheless, it can be positively inferred that like the people of today, our ancestors also found the need to explain things in a way that makes sense to them. They quickly realized that there are events outside of their control and attempted to justify things as being a work of a supernatural being. Throughout the course of history, religion remains to be the strongest contender to science arguably due to its being the most easily grasped. Admittedly, once people stop connecting the dots between cause and effect, they turn to something that could possibly explain their inadequacies in making sense of the world. The people of yesterday appeared to have acknowledged early on that they could only do and understand as much, that perhaps other powers at play also existed alongside them. This notion effectively humbled and perhaps grounded

them, with their constant befuddlement serving as an early reminder that they were way behind several larger, more powerful forces in nature in terms of order of things.

The Human Condition in the Common Era

For a long time, humans were content with their relationship with nature. Earliest case of man-made extinction occurred over 12,000 years ago, possibly brought upon by hunting and territorial disputes. The Holocene extinction, also called the sixth extinction or more aptly Anthropocene extinction, occurred from as early as between 100,000 to 200,000 years up to the present. It pertains to the ongoing extinction of several species—both flora and fauna—due to human activity. Driven by their primal need to survive and gaining the upper hand in terms of development and adaptability, humans were quick to find ways to drive off other megafaunas threatening a prospective hunting spot and eventually, settling grounds. Growing population also necessitated finding additional resources, leading to overhunting and overfishing common prey, some of which were endemic to the area. Hunting, coupled with a changing terrain that the humans began cultivating when agriculture emerged some 9,000 years ago, caused several species to lose competition in territory and food resources. Formation of communities caused humans to expand more in territory and more people to feed; large, separate communities hailing from the same ancestors and residing in the same large community paved way for civilizations. Even as a community, the people realized that though they were at most self-sufficient, they were in constant need of resources. Albeit waging wars with other tribes seemed to be the early solution, they were able to find out some 5,000 years ago that engaging in a peaceful negotiation was also a possible and less bloody method. They realized that they could get hold of things not present in their towns by offering something of same value present in theirs. It is in this process that trade emerged, leading to cross-town and eventually cross-cultural interaction as more products were exchanged and the initial needs extended to wants.

People then had a new objective—gather as much products as possible. They have turned to wealth as one of their goals as humans and ultimately as civilizations, for they perceived that those who have many, live comfortably and thus are generally happier than those who do not have sufficient wealth. Thus, they began to hunt, farm, and produce things with prospect of profit. A nuclear community which is initially self-sufficient has to accommodate their growing population with depleting resources, leading them to be reliant to other communities' produce which keeps them surviving. In return, these communities have to make use of their current resources twice as much to provide for other communities' needs. Products of every kind were exchanged, ranging from necessary ones such as crops, cattle, poultry, others of kind, and clothing materials, up to metals, accessories, weapons, spices, literature, and entertainment. They were able to find and create niches for interests. When they could not sell products, they used their skills and got compensated for it—bringing forth a specialized group of artisans. Humanity became more complex. The primary goal was not merely to survive, but to live the good life.

Technology has been instrumental in all of these because in searching for the good life, people were able to come up with creations that would make life easier, more comfortable, and more enriching. Although the good life envisioned before might be pale in comparison to the multifariousness of today, it offered us the initial intricacies of how today came to be. Such intricacies are also evident in the machines created and causes endeavored by the people of long ago. They perceive death as, at the very least, unpleasant and concocted potions to ward evil off from their kinsmen, often appealing to their gods for blessings. Medicine was thus born, although it would take a considerably long time before it part ways with potion. They became fixated with gold and were adamant in procuring more, trying to use incantations with mixtures of substances to turn lead into one. This ultimately paved way for the emergence of chemistry in its primitive form, not quite distinct from alchemy. Due to differing races, belief, or abundance of resources and/or territory, wars were always being waged, leading communities to allocate resources to the militia. Initially, the early leaders were those who portrayed exceptional strength among their group—this condition carried on for generations. Physical strength was valued at most, although there appeared to be as many intellectually gifted figures just the same. These innovators were primarily the ones behind discoveries and triumphs of these civilizations.

Position-wise, the humans of today are much better off compared to humans several centuries ago. Advancements in medicine, technology, health, and education ushered in humanity's best yet, and show no sign of stopping. Below are some of the notable comparisons then and now:

1. **Mortality Rate.** Due to technology, lesser women and children die during birth, assuring robust population and strong workforce. Medical care for premature infants allows them to survive and develop normally, while proper maternal care ensures that mothers can fully recover and remain empowered.

2. **Average Lifespan.** Aside from the reason that people engage less in combat and are less likely to die in treatable diseases now as opposed to then, science is able to prolong lives by enhancing living status and discovering different remedies to most diseases. Distribution of medicines is also made easier and faster.

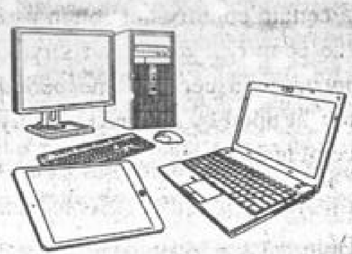
3. **Literacy Rate.** Access to education provided to more individuals generally creates a more informed public that could determine a more just society.

4. **Gross Domestic Product (GDP).** Although not an indicator of an average person's lifestyle in a certain country, it is often used to determine the value of the country's goods and services produced within the territory given a certain time period. Higher country income is brought upon by high productivity, often an indicator of presence of technology.

The Essence of Technology

Humanity has indeed come a long way from our primitive ways, and as a general rule, it is said that we are more "developed" than we were before. Above data are few indicators of the route that we have come to take as species, and there are no signs of stopping. Modern humans are reliant on technology in their search for the good life. We see ways and means from nature to utilize and achieve growth—a goal that we believe would bring forth betterment.

In retrospect, this view of technology proves to be goal-oriented. It assumes that it is instrumental in achieving a goal in mind, that it is a purposeful, deliberate craft humans steer in order to reach some greater good. In the advent of postmodernism, however, the deterministic view appended to technology crumbled as people began to question if anything is deterministic at all. Apart from its purpose, what is technology? Was the history of technology brought purposeful choices for man in his search for the ultimate good? Some tried to redefine technology away from its purpose. One philosopher by the name of Martin Heidegger argued that its essence, or purpose, and being are different from each other. He was able to expound on this point upon identifying that technology can either be perceived as first, a means to achieve man's end and second, that which constitutes human activity. The second perspective paints technology in such a way that each period reveals a particular character regarding man's being. A characteristic design, or flaw, unfolds based on the repercussions brought upon by immersing ourselves with a piece of new technology. In effect, through technology, a myriad of new questions begins to mount. Rather than thinking that humans have a clear idea of what to expect in a good life, it can be stated that technology allows humans to confront the unknown and see how they would react.



This is not a good thing altogether though, for technological revelation is but one of the many ways to perceive the world. However, as long as humans are invested in growth and development, we cannot distance ourselves from this perspective. In the name of growth, we view the world as a field of resources, went on attributing monetary value on seemingly priceless entities. We begin to categorize nature as renewable and nonrenewable instead of seeing it as it is. Humans are reduced into the amount of productivity they are able to render during their lifetime, and our current mindset is geared toward which would utilize our own skills. A good life is one which is practical in essence; a life which makes use of our labor and which we get compensated fairly upon. It is no wonder that the sciences are one of the most sought after courses, for the opportunities are plenty and the

resources are bountiful. Since humans appear not to really know what they are seeking for, the search continues. It is a looming fear, however, that the path we are treading will not take us to the right direction, leading us in endless circles instead in our pursuit of the good life.

This is the danger presented by too much reliance on technology. Humans lose track of things that matter, reducing their surroundings to their economic value. As this presents strong backing by the sciences whose reverence is also brought upon by our deluded enchantment with technology, it will prove to be a herculean task to distance ourselves from this perspective and consider alternatives. After all, it was science and technology that gave us explanations, which worked for us and benefited us. Rejecting a working, tried-and-tested process seems foolish, more so, knowing that there are no options of equal value. It will be absurd to venture the dark and the unknown, but it should be done in order for us to retrace our steps to be able to achieve the *Good*.

Backtracking the Human Condition

Technology's initial promises proved to be true, regardless of its ramifications. All in all the human condition improved, only if by improving we measure the level of comfort, various scientific breakthroughs, and improved lifestyles of those who had the luxury to afford to do so. Different machineries aid in prolonging lives—assisting those with disabilities, honing efficiency in industrial workplaces, and even exploring the universe for places we can thrive once all the Earth's resources are depleted. As to the initial aims, it appears that things really did not much differ. Some places in the world are still battling for their daily survival—diseases, tribe wars, lack of habitable territories, and competitions on resources are several factors contributing to such. People still wage wars on the basis of races, belief, and abundance of resources and/or territory; except that now, they are able to inflict such in a global scale. A lot of people still subscribe to religion in explaining things that they do not know. For those who have ceased to do so, they have turned their worships to reverence of science. Whether science or religion, these people are still bent on trying to make sense of the events happening in the world on the basis of either of these two paradigms. They are still trying to discover and rediscover things that would give meaning to their lives—whether it be honor, strength, or merit. People are still trying to make sense of their existence in the world, and technology does little to aid them in their pursuit of life's meaning.

It seems that the human condition, although more sophisticated, is nothing but a rehashed version of its former self. Nothing much has changed since then, and it appears that nothing will change in the times to come if we fail to shift our view elsewhere. While it is true that technology offered us one compelling notion of the truth and the good, we should be staunch in our resolve if we want to know the real one. For starters, we might begin with considering other concepts, which corresponds to the *Good*, such as Aristotle's conception of human flourishing. His notion entertains the idea of holistic enrichment of a person situated in his society. A notable distinction on Aristotle's idea is his subscription on evaluative concepts called virtues and their role in achieving the good life. Technological advancements are seemingly occurring in a rapid pace that our morality cannot quite keep up; no such consideration was given in this approach in achieving the good life. This will further be discussed in the following chapters.

SUMMARY

Science and technology has been part of human activity since the beginning of our species. It has aided us in survival and helped us outsmart our adversaries, provided us comfortable living, allowed us to explore the world, and assisted us in discovering more about ourselves and the truth. However, it also leads us to a paradox in which we are only able to see the world in the lenses of technological innovations. In our pursuit of growth, we had conveniently forgotten that technology only presents one approach in viewing the world. This forgetfulness leads us to evaluate objects as consumable or not—transcending to other human beings, determining their capacity to be productive. Our valuation of things became one-dimensional, geared toward production of goods for more consumption, which we believe would lead us to the good life. This is only one conception of technology, as Heidegger also proposed that technology is what humans do. Advancements in the field expose us to previously unknown predicaments, effectively helping us to reveal our own natures and enforcing one perspective in finding the truth. Now that it is acknowledged, we can try and divert our search to other approaches.

THINK ABOUT THESE QUESTIONS

1. What would have happened to humankind if technology did not exist?
2. Do you agree with Martin Heidegger in his idea that technology should only be seen as one of the approaches in perceiving truth? What are other possible approaches we should consider?

ACTIVITIES

1. **Role-playing.** Try to imagine the world without technology. How do you think your day-to-day life would be like? Do this by illustrating a scenario where a certain technological innovation does not exist. Below are examples you could use:
   a. Watch
   b. Phone
   c. Light bulbs
   d. Cars
   e. Printing Press
   f. Electricity
2. **Philosophical Debate.** Discuss whether technology is a means to an end or an end in itself. The class will be divided into two groups. The first group supports the notion that technology is an instrument to achieve human goals, and the second group supports the notion that technology is what humanity does. List down pertinent points and construct an individual position paper regarding your stance.

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LESSON
3 THE GOOD LIFE

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- examine what is meant by a good life;
- identify how humans attempt to attain what is deemed to be a good life; and
- recognize possibilities available to human being to attain the good life.

INTRODUCTION

In Ancient Greece, long before the word "science" has been coined, the need to understand the world and reality was bound with the need to understand the self and the good life. For Plato, the task of understanding the things in the world runs parallel with the job of truly getting into what will make the soul flourish. In an attempt to understand reality and the external world, man must seek to understand himself, too. It was Aristotle who gave a definitive distinction between the theoretical and practical sciences. Among the theoretical disciplines, Aristotle included logic, biology, physics, and metaphysics, among others. Among the practical ones, Aristotle counted ethics and politics. Whereas "truth" is the aim of the theoretical sciences, the "good" is the end goal of the practical ones. Every attempt to know is connected in some way in an attempt to find the "good" or as said in the previous lesson, the attainment of human flourishing. Rightly so, one must find the truth about what the good is before one can even try to locate that which is good.

In the previous lesson, we have seen how a misplaced or an erroneous idea of human flourishing can turn tables for all of us, make the sciences work *against* us rather than *for* us, and draw a chasm between the search for truth and for the good. In this lesson, we endeavor to go back a little and answer these questions: What does it really mean to live a good life? What qualifies as a good existence? Granting this understanding, we are assumed to be in a better position to reconcile our deepest existential needs as human beings and science as tool to maneuver around the world.

Aristotle and How We All Aspire for a Good Life

It is interesting to note that the first philosopher who approached the problem of reality from a "scientific" lens as we know now, is also the first thinker who dabbled into the complex problematization of the end goal of life: *happiness*. This man is none other than Aristotle.

Compared to his teacher and predecessor, Plato, Aristotle embarked on a different approach in figuring out reality. In contrast to Plato who thought that things in this world are not real and are only copies of the real in the *world of forms*, Aristotle puts everything back to the ground in claiming that this world is all there is to it and that this world is the only reality we can all access. For Plato, change is so perplexing that it can only make sense if there are two realities: the *world of forms* and the *world of matter*. Consider the human person. When you try to see yourself in front of the mirror, you normally say and think that you are looking at yourself—that is, you are the person who slept last night and you are the same person looking at yourself now, despite the occasional changes like a new pimple that grows on your nose. The same is true for a seed that you threw out of the garden last month. When you peek into the same patch of land where the seed ingrained itself into, you may be surprised to see a little plant showing itself to you and to the sun. Plato recognized change as a process and as a phenomenon that happens in the world, that in fact, it is constant. However, Plato also claims that despite the reality of change, things remain and they retain their ultimate "whatness"; that you remain to be you despite the pimple that now sits atop your nose. Plato was convinced that reality is full of these seemingly contrasting

manifestations of change and permanence. For Plato, this can only be explained by postulating two aspects of reality, two worlds if you wish: the *world of forms* and the *world of matter*. In the *world of matter*, things are changing and impermanent. In the *world of forms*, the entities are only copies of the ideal and the models, and the *forms* are the only real entities. Things are red in this world because they participate in what it means to be red in the *world of forms*.

Aristotle, for his part, disagreed with his teacher's position and forwarded the idea that there is no reality over and above what the senses can perceive. As such, it is only by observation of the external world that one can truly understand what reality is all about. Change is a process that is inherent in things. We, along with all other entities in the world, start as potentialities and move toward actualities. The movement, of course, entails change. Consider a seed that eventually germinates and grows into a plant. The seed that turned to become the plant underwent change—from the potential plant that is the seed to its full actuality, the plant.

Aristotle extends this analysis from the external world into the province of the human person and declares that even human beings are potentialities who aspire for their actuality. Every human being moves according to some end. Every action that emanates from a human person is a function of the purpose (*telos*) that the person has. When a boy asks for a burger from a Filipino burger joint, the action that he takes is motivated primarily by the purpose that he has, inferably to get full or to taste the burger that he only sees on TV. When a girl tries to finish her degree in the university, despite the initial failures she may have had, she definitely is being propelled by a higner purpose than to just graduate. She wants something more, maybe to have a license and land a promising job in the future. Every human person, according to Aristotle, aspires for an end. This end, we have learned from the previous chapters, is happiness or human flourishing.

No individual—young or old, fat or skinny, male or female—resists happiness. We all want to be happy. Aristotle claims that happiness is the be all and end all of everything that we do. We may not realize it but the end goal of everything that we do is happiness. If you ask one person why he is doing what he is doing, he may not readily say that it is happiness that motivates him. Hard-pressed to explain why he is motivated by what motivates him will reveal that happiness is the grand, motivating force in everything that he does. When Aristotle claims that we want to be happy, he does not necessarily mean the everyday happiness that we obtain when we win a competition or we eat our favorite dish in a restaurant. What Aristotle actually means is human flourishing, a kind of contentment in knowing that one is getting the best out of life. A kind of feeling that one has maxed out his potentials in the world, that he has attained the crux of his humanity.

Happiness as the Goal of a Good Life

In the eighteenth century, John Stuart Mill declared the Greatest Happiness Principle by saying that an action is right as far as it maximizes the attainment of happiness for the greatest number of people. At a time when people were skeptical about claims on the metaphysical, people could not make sense of the human flourishing that Aristotle talked about in the days of old. Mill said that individual happiness of each individual should be prioritized and collectively dictates the kind of action that should be endorsed. Consider the pronouncements against mining. When an action benefits the greatest number of people, said action is deemed ethical. Does mining benefit rather than hurt the majority? Does it offer more benefits rather than disadvantages? Does mining result in more people getting happy rather than sad? If the answers to the said questions are in the affirmative, then the said action, mining, is deemed ethical.

The ethical is, of course, meant to lead us to the good and happy life. Through the ages, as has been expounded in the previous chapters, man has constantly struggled with the external world in order to reach human flourishing. History has given birth to different schools of thought, all of which aim for the good and happy life.

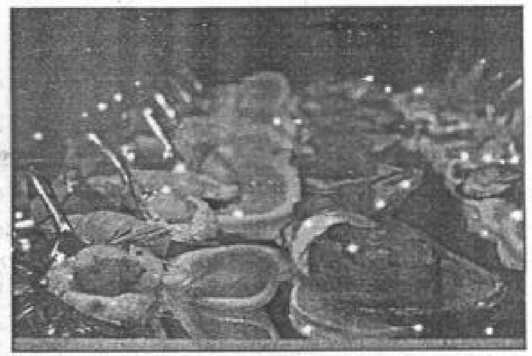
Materialism

The first materialists were the atomists in Ancient Greece. Democritus and Leucippus led a school whose primary belief is that the world is made up of and is controlled by the tiny indivisible units in the

world called *atomos* or seeds. For Democritus and his disciples, the world, including human beings, is made up of matter. There is no need to posit immaterial entities as sources of purpose. *Atomos* simply comes together randomly to form the things in the world. As such, only material entities matter. In terms of human flourishing, matter is what makes us attain happiness. We see this at work with most people who are clinging on to material wealth as the primary source of the meaning of their existence.

Hedonism

The hedonists, for their part, see the end goal of life in acquiring pleasure. Pleasure has always been the priority of hedonists. For them, life is about obtaining and indulging in pleasure because life is limited. The mantra of this school of thought is the famous, "Eat, drink, and be merry for tomorrow we die." Led by Epicurus, this school of thought also does not buy any notion of afterlife just like the materialists.



Stoicism

Another school of thought led by Epicurus, the stoics espoused the idea that to generate happiness, one must learn to distance oneself and be apathetic. The original term, *apatheia*, precisely means to be indifferent. For the stoics, happiness can only be attained by a careful practice of apathy. We should, in this worldview, adopt the fact that some things are not within our control. The sooner we realize this, the happier we can become.

Theism

Most people find the meaning of their lives using God as a fulcrum of their existence. The Philippines, as a predominantly Catholic country, is witness to how people base their life goals on beliefs that hinged on some form of supernatural reality called heaven. The ultimate basis of happiness for theists is the communion with God. The world where we are in is only just a temporary reality where we have to maneuver around while waiting for the ultimate return to the hands of God.

Humanism

Humanism as another school of thought espouses the freedom of man to carve his own destiny and to legislate his own laws, free from the shackles of a God that monitors and controls. For humanists, man is literally the captain of his own ship. Inspired by the enlightenment in seventeenth century, humanists see themselves not merely as stewards of the creation but as individuals who are in control of themselves and the world outside them. This is the spirit of most scientists who thought that the world is a place and space for freely unearthing the world in seeking for ways on how to improve the lives of its inhabitants.

As a result of the motivation of the humanist current, scientists eventually turned to technology in order to ease the difficulty of life as illustrated in the previous lessons. Scientists of today meanwhile are ready to confront more sophisticated attempts at altering the world for the benefit of humanity. Some people now are willing to tamper with time and space in the name of technology. Social media, as an example, has been so far a very effective way of employing technology in purging time and space. Not very long ago, communication between two people from two continents in the planet will involve months of waiting for a

mail to arrive. Seeing each other real time while talking was virtually impossible. Now, communication between two people wherever they are, is not just possible but easy. The Internet and smart phones made real-time communication possible not just between two people, but even with multiple people simultaneously.

Technology allowed us to tinker with our sexuality. Biologically male individuals can now undergo medical operation if they so wish for sexual reassignment. Breast implants are now available and can be done with relative convenience if anyone wishes to have one. Hormones may also be injected in order to alter the sexual chemicals in the body.

Whether or not we agree with these technological advancements, these are all undertaken in the hopes of attaining the good life. The balance, however, between the good life, ethics, and technology has to be attained.

SUMMARY

Man is constantly in pursuit of the good life. Every person has his perspective when it comes to what comprises the good life. Throughout history, man has worked hard in pointing out what amounts to a good, happy life. Some people like the classical theorists thought that happiness has to do with the insides of the human person. The soul, as the seat of our humanity, has been the focus of attention of this end goal. The soul has to attain a certain balance in order to have a good life, a life of flourishing. It was only until the seventeenth century that happiness became a centerpiece in the lives of people, even becoming a full-blown ethical foundation in John Stuart Mill's utilitarianism. At present, we see multitudes of schools of thought that all promise their own key to finding happiness. Science and technology has been, for the most part, at the forefront of man's attempts at finding this happiness. The only question at the end of the day is whether science is taking the right path toward attaining what it really means to live a good life.

THINK ABOUT THESE QUESTIONS

1. What is the good life?
2. What is the relationship between the good life and science?
3. Does technology always lead us to the good life? How and why?

ACTIVITIES

1. **Good Life Collage.** Cut out pictures in magazines or newspapers that demonstrate how technology has made the man's desire for a happy life more realizable. You may also opt to print out pictures from websites and other sources. Explain how these technological advancements have made the campaign for the attainment of good life easier or otherwise. Present it in class.
2. **Compare and Contrast.** Identify two modes of doing the same thing where one involves a more technologically advanced method. Example would be snail mail vs. e-mail. List down as many examples. Brainstorm with a partner if a less technologically sophisticated mechanism can actually turn out to be better in terms of reaching for the good life. Is the more technologically advanced always better?

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LESSON

4 WHEN TECHNOLOGY AND HUMANITY CROSS

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- know the different technological advancements in society;
- discuss the development of science and technology in the Philippines;
- discuss the effects of the interplay between technology and humanity through the dilemma(s) they face.

INTRODUCTION

The ever-growing society has made people see technology as some form of necessity. Tracing back its origins, the word "technology" came from the Greek words *technē* and *logos* which mean art and word, respectively. Taking the two words together, technology means a discourse on arts (Buchanan, 2010). It first appeared in the seventeenth century where the concept was only used to talk about the arts, specifically applied arts. However, as technology progressed, the concept also started to have a wider range of meaning where art is no longer the only topic included. Concepts like machine and tools were also attached to the word "technology" which is the more popular sense of the concept nowadays.

The roles played by technology these days are very crucial not only to a few but also to everyone. In one way or another, each person in the society is directly or indirectly affected by technology whether he wills it or not. In fact, most people survive their everyday lives with great

reliance to the different technological advancements already available to the masses. While there may be some who would claim that their lives are not greatly affected by technology, the fact cannot be denied that technology is already an inevitable part of the society.

It is with great effort that people were able to achieve such great inventions. It makes life so much easier and more convenient than ever before. It can clearly be seen from the simplest task at home to the most complicated ones inside the office or laboratory. Technology these days enjoys such fame and glory because of the many different benefits it brings to mankind. Some would even say that it does not only bring convenience but also pleasure and happiness to people. This is because of the different leisure activities that technology can offer to people. For example, it allows people to listen to good music wherever they are. Another is, it allows them to communicate with their loved ones anywhere in the world; but most of all, it allows them to surf and play games anytime, anywhere.

The act of pinpointing a single activity that does not in any way require the use of technology has become very hard because almost all activities that humans perform already require the assistance of some kind of technological advancement. But this is not all, for there are people who would even argue that technology has become a necessity and no longer a want. At present, people work very hard in order to save money to buy these "necessities" while in the past, people only used their money for the things that would help them survive like food, housing, and clothing. In effect, anything outside these categories was considered a luxury. However, that is no longer the case at present.

In general, technology keeps on progressing due to not only the changing times and environment but also to the ever-progressing mind of mankind. It would not be possible for all these technological advancements to exist if it were not for the brilliance, creativeness, and power of the mind. However, it is also important to note that anything too much is bad. The same problem is faced by technology. Although it has been very helpful to people, it is still not immune to criticisms and backlash. Various ethical dilemmas have been identified throughout time involving the use of different technological devices and its effects to humanity. Usually, different problems arise when either the technological device available is misused or if in the first place, it was invented to produce bad results. People who are aware of the possible dangers of the use or misuse of technology are not keeping still. They lay these dilemmas for the public to see and realize what they are in for.

In this lesson, several technological devices will be properly introduced, the roles they play in society and their effects, particularly to the lives of the people will be identified, and the problems they face will also be examined thoroughly.

Television Sets, Mobile Phones, Computers, and Humanity

A number of technological devices can be easily found inside the home, the most accessible place to anyone. Having said that, it can also be easily inferred that these technological devices are some of the most popular and most commonly used types of devices across all age groups. Almost all households, if not all, own these types of devices. To be more specific, these "celebrities" in the field of technology are television sets, mobile phones, and computers. People all over the world use these technologies every day to accomplish different purposes.

First, according to Kantar Media, one of the most trusted television audience measurement providers, in the Philippines, 92 percent of urban homes and 70 percent of rural homes own at least one television set. It is for this reason why television remains to be the ultimate medium for advertisement placements (*The Manila Times*, 2014). This survey simply shows that almost all Filipinos use this particular type of device. In fact, Filipinos are believed to have this big fascination for television. Most of the time, they watch television during their free time or any time of the day when they have nothing important to do. In addition to this, Kantar Media also reported that in the Philippines, the current count of

households with television set already reached 15.135 million (Noda, 2012). This number signifies something, that is, television plays a great role in the lives of the people or in this case, the Filipinos.

Television was a product of different experiments by various people. Paul Gottlieb Nipkow, a German student, in the late 1800s was successful in his attempt to send images through wires with the aid of a rotating metal disk. This invention was then called the "electric telescope" that had 18 lines of resolution. After some time, in 1907, two inventors, Alan Archibald Campbell-Swinton who was an English scientist and Boris Rosing who was a Russian scientist, created a new system of television by using the cathode ray tube in addition to the mechanical scanner system. This success story gave rise to two types of television systems, namely, mechanical and electronic television (Jezek, n.d.). These experiments inspired other scientists to improve the previous inventions, which led to the modern television people now have. However, it is important to remember that several scientists and several experiments were performed first before finally achieving the modern television at present.

Second, Filipinos love to use their mobile phones anywhere, anytime. They use it for different purposes other than for communication. More than half of the Filipino population own at least one mobile phone regardless of type. In 2010, global research agency Synovate conducted a survey and declared 67 percent product ownership in the country. In fact, it was also claimed that mobile phones are considered a must-have among young Filipinos (*ABS-CBN News*, 2010). To prove that Filipinos really love to use their mobile phones, the Ipsos Media Atlas Philippines Nationwide Urban 2011–2012 survey results showed that one in every three Filipinos cannot live without a mobile phone. In other words, 30 percent of the Philippine urban population nationwide said that mobile phones are necessities in life (Roa, 2012). Philippine streets are full of people using their mobile phones. Not only this, there are some Filipinos who even own more than one mobile phone.

Mobile phones have a very interesting background story. On April 3, 1973, Martin Cooper, a senior engineer at Motorola, made the world's first mobile phone call. He called their rival telecommunications company and properly informed them that he was making the call from a mobile phone. The mobile phone used by Cooper weighed 1.1 kilograms and measured 228.6 x 127 x 44.4 mm. This kind of device was capable of a 30-minute talk time. However, it took 10 hours to charge. In 1983, Motorola made their first commercial mobile phone available to the public. It was known as the Motorola DynaTAC 8000X (Goodwin, 2016).

Lastly, computers and laptops have also become part of many of the Filipino households. There are some Filipino families who own more than one computer or laptop while some own at least one computer or laptop. However, the number of computers or laptops sold per year may not be as high as the number of mobile phones and television sets. This is because of the relatively higher cost of computers and laptops. While it is true that almost all Filipino families own at least one television set and a mobile phone, it is not possible for all Filipino families to own at least one computer or laptop. In fact, most of the profits gained by computer and laptop manufacturers come from offices, businesses, or schools where such devices have become part of their necessities.

In 2010, 3.6 trillion was the estimated total value output of all manufacturing establishments. Semi-conductor devices and other electronic components took more than half of the total value output of all manufacturing establishments. To be more specific, 5.4 percent of the total value output came from computers and peripheral equipment and accessories (PSA, 2013). In line with the growing number of computer and laptop sales, there has also been a growing number of Internet users in the Philippines. Although there have been problems regarding the Internet providers, this never hindered Filipinos from continuously using the Internet.

Just like television sets and mobile phones, computers and laptops also have a long background history of trial and error. It was Charles Babbage, a nineteenth-century English Mathematics professor, who designed the Analytical Engine which was used as the basic framework of the computers even until the present time. In general, computers can be classified into three generations. Each generation of the computer was used for a certain period of time and each gave people a new and improved version of the previous one (Steitz, n.d.).

Laptops have been available to the public for even less time than personal computers. Before, the first design of computer was so big that it could occupy whole floors of buildings. It was not long before people started dreaming that they could bring their devices to any place they wished. They hoped that someday it would be possible for these devices to be portable. It was believed that the transition from a personal computer to a laptop was only a matter of design, an improvement and a little deviation from the standard design of a personal computer. The first true portable computer was released in April 1981. It was called the Osborne 1 (Orfano, 2011). From that moment on, the evolution of laptops continued until the present time where various designs and models are already available.

A typical household owns at least four of the following devices: a mobile phone (89%), smartphone (53%), tablet (14%), desktop (39%), laptop or netbooks (37%), and smart TV (4%) (Philstar, 2013). These data prove the deep-seated fascination of Filipinos to different technological devices.

Here are some facts about Filipinos and their use of gadgets and the Internet (Rappler, n.d.):

- Mobile phone subscription is at 119 million.
- Filipinos spend approximately 3.2 hours on mobile and 5.2 hours on desktop daily.
- Currently, the Philippines has one of the highest digital populations in the world.
- There are now 47 million active Facebook accounts in the Philippines.
- The Philippines is the fastest-growing application market in Southeast Asia.

Roles Played by These Technological Advancements

Television sets, mobile phones, and computers or laptops all have different functions and roles played in the lives of the people, although some may be a little similar. These roles have become so essential that people, more specifically Filipinos, developed a strong inclination toward technology and its products.

For instance, television is mainly used as a platform for advertisements and information dissemination. In fact, television remains to be the most used avenue by different advertising companies not only in the Philippines but also all over the world. Various advertising companies trust that television is still one of the most used technological devices up until today. However, it is important to note that these are just some of the roles played by television. Aside from the ones mentioned above, it also serves as a recreational activity and good stress reliever to most families, specifically to Filipino families. Television also is a good platform for different propagandas and advocacies. Lastly, it can also be a good way to bond with one's family members.

Mobile phones, on the other hand, also have their own roles in the lives of the people. They are primarily used for communication. Mobile phones offer services like texting and calling. In the past, these were the only functions of the mobile phone but as technology progressed, there have been many additional features included on mobile phones. For example, in the present, people use their mobile phones to surf the Internet and to take pictures more than to text or to call people. This is the reason why more and more people all over the world prefer to buy smartphones over the old models where such features are not available. Other applications include music player, calendar, radio, television, and photo editor, among others. These are just some of the additional features of mobiles phones in the present. These make this particular technological device very appealing to the masses. It is like an all-in-one device. In addition, it is very portable and convenient because it can fit into any space, may it be inside the pocket or bag.

Personal computers and laptops also have useful set of functions and roles. Although most of the functions found in these technological devices are now also available in mobile phones, they still offer their own unique features that make them attractive. For example, personal computers and laptops can be used to surf the Internet and communicate. Just like the mobile phones, these devices also have features like calendar, calculator, music player, movie player, camera, and many more. However, for a lot of people, they prefer to do their job using either a personal computer or

a laptop than a mobile phone. One reason is that a personal computer or a laptop has wide keyboard than using a mobile phone, especially when the mobile phone has a small screen. Contrary to mobile phones, personal computers and laptops have wide screens and separate keyboards, although some mobile phones can now be connected to a keyboard. Another reason is that the availability of a mouse or a touchpad made these two technological devices easier to maneuver than mobile phones. Lastly, for the youth and those who love to play different computer games, personal computers or laptops are really the better choice because these allow them to play with comfort and convenience. However, it cannot be denied that some would even prefer laptops over personal computers for the simple reason that personal computers are not portable and there are times when they need to bring such devices to different places.

Ethical Dilemma Faced by These Technological Advancements

While it is true that these technological devices are useful and beneficial, the fact remains that there are several dilemmas faced by these "necessities." First, most parents would argue that these devices make their children lazy and unhealthy. This is because of the fact that people who are fixated on these technological advancements start and end their day by using such devices. They have a great tendency to sit and chill all day long without doing anything productive in their homes, thus making them unhealthy because they do not just skip meals sometimes but also lack exercise or any bodily movements. Here, it can be inferred that these types of people are already overly dependent on these technological devices. For example, those who love to watch television shows stay in front of the television for more than six hours a day while those who love to surf the Internet or play computer games stay on their laptops, computers, or mobile phones for more than half a day. These people have the tendency to be unaware of the time because they are so engrossed with the use of technological device. In fact, if they get disturbed, there is a great chance that they will get mad or annoyed. Moreover, these are the same people who are more likely to experience alienation because they no longer take time to get out of their houses and mingle with other people.

Another dilemma faced by these technological devices is the moral dilemma. People, especially the children who are not capable yet of rationally deciding for themselves what is right or wrong, are freely exposed to different things on television, mobiles phones, laptops, or computers. Because of the availability and easy access to the Internet, they can just easily search the web and go to different websites without restrictions. This allows them to see, read, or hear things which are not suitable for their very young age. This makes them very vulnerable to character change and can greatly affect the way they view the world and the things around them.

On the first dilemma, it is really concerning to know that there are people who develop different kinds of sickness because of too much use of technological devices. Not only this, it also causes them to become reclusive, alienating themselves from other people. Although some would argue that technology brings people together, it can also be argued that this is not always the case in the real world because it may bring them virtually closer but not physically or personally. In fact, there are people who are friends, for example, only on social media but not in real life. This just shows that there are things that technology claims to do but in reality, does not. It is for these reasons why there are people who call for the establishment of ethics of technology. This subcategory of ethics will in one way or another guide people on how technology ought to be used in order to prevent abuse and other unfortunate results.

Digging deeper, it can be said that these reasons make such devices somewhat unethical because they bring undesirable consequences to people. However, it can also be argued that it is not the fault of the technological devices but the agents using them or the ones making them. The classic deontological and teleological approaches to ethics are already too old to be applied in such cases. This is because technology has become very complicated and dynamic over time. Having said this, it is true that there are problems that can no longer be addressed by using these theories only. This is why the ethics of responsibility is an appropriate theory that can be used in these dilemmas.

The word "responsibility" in the sense of being accountable for and accountable to is very appropriate to the ethics of technology because it makes each and every person in the scientific-technological development

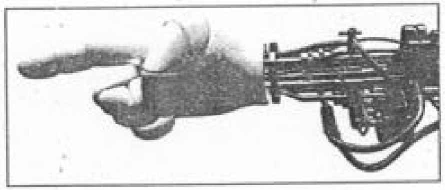
a proxy with reference to one another. In other words, each person must indicate the priorities, values, norms, and principles that constitute the grounds for one's actions and define one's contribution to the scientific-technological event. The ethics of responsibility focuses on the positive rather than the negative. Instead of asking "What ought not to be allowed?" ask "What ought to be allowed?" To put it in another way, people who are part of the scientific development ought to let the public know the good in their respective technological contribution/s. In this way, the people will have an idea how the devices ought to be used in order to maximize their positive results.

However, it is also important for the people in the scientific world to inform the masses of the dangers of their contribution/s to the world of technology. In this way, the people will be sufficiently aware of what to do and what not to do. In addition to this, the agents using the devices should also be accountable to and accountable for their use of their gadgets.

Going back to the first dilemma, it can be said that the agents using the devices are the ones to be blamed for the undesirable consequences, namely, laziness and unhealthiness. However, it is the assumption that the people in the scientific-technological world have properly informed the public of the positive tenor of their action in technology and the possible dangers of the misuse of their technological contribution. Thus, the undesirable consequences are brought about by the misuse of the agent. Now, talking about alienation, it can be concluded that the people in the scientific-technological world are blameworthy because they tell the people something that seems positive but when examined closely, brings more bad than good.

On the second dilemma, the people in the scientific world nor the children are blameworthy because first, the children are not yet capable of rationally deciding for themselves what is good and what is bad. Second, even if creators of these technologies went out of their way to inform children of the pros and cons of these technological contributions, it would still be useless because the children have no capacity to understand them yet. So in this dilemma, the ones to be blamed are the adults who allowed the children to have access to such devices in the first place without any supervision. It is the recklessness and overconfidence of the adults that cause the character change in children.

Robotics and Humanity



Another great product of the innovative minds of the people is the robot. Robots are now widely used. For example, there are the so-called service robots. These particular robots do specific tasks but focus mainly in assisting their masters in their everyday tasks. The International Federation of Robotics (IFR) and United Nations Economic Commission for Europe (UNECE) made it their task to formulate a working definition for service robots. A preliminary extract of the relevant definition is (IFR, 2012):

- A robot is an actuated mechanism programmable in two or more axes with a degree of autonomy, moving within its environment, to perform intended tasks. Autonomy in this context means the ability to perform intended tasks based on current state and sensing without human intervention.
- A *service robot* is a robot that performs useful tasks for humans or equipment excluding industrial automation application. Note: A robot may be classified according to its intended application as an industrial robot or a service robot.
- A *personal service robot* or a *service robot for personal use* is a service robot used for a noncommercial task, usually by laypersons. Examples are domestic servant robot, automated wheelchair, personal mobility assist robot, and pet exercising robot.
- A *professional service robot* or a *service robot for professional use* is a service robot used for a commercial task, usually operated by a properly trained operator. Examples are cleaning robot for public places, delivery robot in offices or hospitals, fire-fighting robot, rehabilitation robot, and surgery robot in hospitals. In this context, an operator is a person designated to start, monitor, and stop the intended operation of a robot or a robot system.

Germany was one of the first countries to develop service robots. As part of the German Federal Ministry of Education and Research's "Service Robotics Innovation Lead Initiative," it sponsored a collaborative project called DESIRE (Deutsche Servicerobotik Initiative–Germany Service Robotics Initiative) which was launched on October 1, 2005. DESIRE has the following individual objectives (DESIRE, 2009):

- To achieve a technological edge toward attaining key functions and components that are suited for everyday use
- To create a reference architecture for mobile manipulation
- To promote the convergence of technologies through integration into a common technology platform
- To conduct pre-competition research and development activities for new products and technology transfer in start-up enterprises in the field of service robotics

Some of the expected work to be performed by DESIRE are the following: (1) "Clear up the kitchen table" – all objects on top of the kitchen table will be moved to where they belong; (2) "Fill the dishwasher" – the dirty dishes will be sorted correctly into the dishwasher; and (3) "Clear up this room" – all objects that are not in their proper places will be moved to where they belong (Mock, n.d.).

The earliest conception of robots can be traced around 3000 B.C. from the Egyptians. Their water clocks used human figurines to strike the hour bells. This mechanical device was built to carry out a specific physical task regularly. From that time on, different machines were already built that displayed the same mechanism and characteristics as the robots in the present. For example, there was a wooden pigeon that could fly, a talking doll, steam-powered robots, and hydraulically-operated statues that could speak and gesture. However, the earliest robots as people know them were created in the early 1950s by George Devol. "Unimate" was his first invention from the words "Universal Automation." Unfortunately, his attempt to sell his product to the industry did not succeed. After Unimate, several robots were also invented which were better versions of the previous ones (Stanford, n.d.). Ever since, people never stopped their quest in the field of robotics.

Roles Played by Robotics

Robots play different roles not only in the lives of the people but also in the society as a whole. They are primarily used to ease the workload of mankind. They were invented to make life more efficient and less stressful. On one hand, they perform complicated activities which human beings are incapable of doing. On the other hand, they perform the simplest tasks at home so that their masters can perform the complex ones without stressing themselves over the simple tasks. There are also robots which are made for pleasure. To be more specific, these types of robots perform activities to entertain people. They can usually be found in amusement parks or exhibits. In addition, there are also some robots which were made to serve as toys. They also perform different activities but they are usually child-friendly. Other examples of robots are those which can be seen in movies. One of the reasons why robots are very famous is because of movies. A number of local and national movies were inspired by robots. This goes to show that people have developed a distinct fascination over robots.

Just like people living in the society, robots also have their own set of rules and characteristics that define what a good robot is. These laws were formulated by Isaac Asimov back in the 1940s, when he was thinking of the ethical consequences of robots. These are the following (Stanford, n.d.):

Law One:

A robot may not injure a human being or, through inaction, allow a human being to come to harm.

Law Two:

A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.

Law Three:

A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Ethical Dilemma/s Faced by Robotics

Just like any other technological advancements, robotics also faces different problems and dilemmas. Although the idea is to help people and make their lives a lot easier than before, it is still not immune to different ethical dilemmas and possible undesirable outcomes. One of the dilemmas faced by robots is safety. Who should be held accountable if someone's safety is compromised by a robot? Who should be blamed, the robot, the agent using the robot, or the maker/inventor of the robot? It is important to know who should be blamed and who should be held responsible if such thing happens.

Another ethical dilemma faced by robots is the emotional component. This may seem a little absurd as of the moment, but looking at how fast technology progresses nowadays, it is not completely impossible for robots to develop emotions (Evans, 2007).

So here, the questions become, "What if robots become sentient? Should they be granted robot rights? Should they have their own set of rights to be upheld, respected, and protected by humans?" It is interesting to know how people would react if the time comes when robots can already feel pain and pleasure. Would they act differently or not at all?

In the field of robotics, there are the so-called partial autonomy and full autonomy. *Partial autonomy* includes active human-robot interaction while *full autonomy* excludes active human-robot interaction. In other words, a robot with full autonomy can perform actions or activities even without a master telling it what should be done or what should be performed next (IFR, 2012).

Using Asimov's laws for robots, it can be concluded that robots are ethical but only if they strictly follow the laws specified. They are ethical mostly because the laws formulated by Asimov ensure the safety of not only the users of the technology but also the people around him. Remember that these service robots are already available to the public; thus, they can already be found inside the homes. Having said that, the safety of not only the owner of the technology but also all the people inside the house should be the priority more than anything else. In other words, the service robots only follow what their masters tell them to do with great consideration to the laws formulated by Asimov. However, if the agent using the technology misuses the robot to achieve personal agendas, then without a doubt, the agent should be held accountable for any consequences it may bring. It is important to note that this is under the assumption that the robot strictly followed the laws specified without any form of deviation.

If the problems arise when the robot deviates from the laws specified, then the maker or the inventor of the machine should be blameworthy. It just means that the robot was not programmed very well because it violated the laws. Other problems may arise when the machine develops the ability to think for itself. In this case, the one that should be blame can both be the maker or inventor and the robot itself. This is because, in the first place, the maker gave the robot the capacity to think for itself so he should be very much aware of its possible consequences. To put it in another way, the maker programmed the robot in such a way that it can already think for itself even without an active participation from a human being. In addition, since the robot thinks for itself, whatever decision it makes and whatever consequence it may bring, the robot itself should be held responsible.

For the second dilemma, it is just right for the robots to be given their own set of rights should they develop the ability to feel different kinds of emotion. It can be argued that the same thing happened with animals. Before, animals did not have their own set of rights because people believed that they were not capable of having emotions. However, after years of testing and experimenting, it was concluded that animals are indeed capable of emotions. It is for this reason that people decided

to give them rights that are due to them. The same should be done to robots without any reservations. Should that time come, they ought to be treated differently and they ought to have new laws to follow in order to accommodate the new characteristic they have developed.

SUMMARY

In modern times, there are different technological advancements in all forms and sizes may it be inside the home, the workplace, the learning place, or simply on the streets. It is now very accessible to almost anyone in the world. It is not completely impossible to say that each person in the world owns at least one technological device. Besides, technology is not enclosed to expensive and high-end devices. Simple types of machines that can perform simple task regularly can already be considered a form of technology. However, despite its usefulness and beneficial characteristics, there are still some problems faced by the different technological advancements. To be more specific, these problems are ethical in nature that involve not only the machine but also mankind. It is now impossible for technology and humanity not to cross paths because as some would argue, technology has become a necessity for people. At the end of the day, ethics should still be enforced in the field of technology so as to ensure the safety and morality of these devices to people.

THINK ABOUT THESE QUESTIONS

1. Do people really need technology in their lives? Is it really a necessity?
2. How do you reconcile the 'need' for technology and the dilemma/s it faces?
3. Should there be an ethics of technology?

ACTIVITIES

1. **Philosophical Discussion.** Discuss the different ethical dilemmas faced by technological advancements in the society through a philosophical discussion. Do this by forming three groups. The first group will serve as the facilitators of the discussion. The second group will be the supporting side and the third group will be the opposing side. A topic shall be chosen before the planned date of discussion. The facilitators should present a paper detailing the topic without choosing any side. The discussion will start after the reading of the paper presented by the facilitators. Each side will lay their arguments and questions, and then in an orderly manner, each group will take turns answering the questions or rebutting the other side's arguments. The facilitators will make sure that the arguments and questions remain true to the topic.

   Suggested topics:

   a. Do technological devices bring more good than bad to people?
   b. Should there be more budget for technological researches despite the dilemmas they are currently facing?
   c. Should there be a limit to technological advancements?

2. **Group Skit.** Form groups with equal number of members depending on the class size. Each group should choose a unique topic and its perceived effects and the dilemma it entails. Show your stand on a technological dilemma through a skit. Do not forget to show the role or roles played by the technological advancement in the lives of the people.

   Suggested topics:

   a. Robots that are capable of having emotions
   b. Google and stupidity
   c. Filipinos' addiction to different technologies
   d. Waze application

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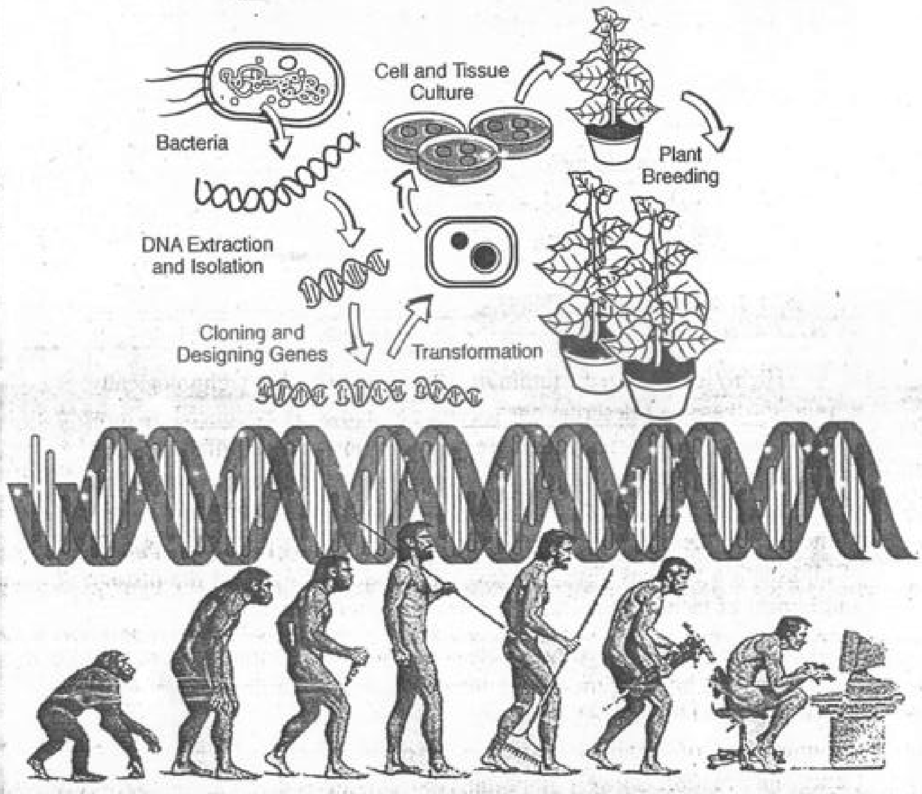
CHAPTER III Specific Issues in Science, Technology, and Society



LESSON

1 THE INFORMATION AGE

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- define Information Age;
- discuss the history of Information Age; and
- understand the factors that need to be considered in checking website sources.

INTRODUCTION

Highly modernized, automated, data-driven, and technologically advanced—these best describe our society nowadays, as evidenced by how information could be transferred or shared quickly. The different areas of society have been influenced tremendously such as communication, economics, industry, health, and the environment. Despite our gains due to the growing development of information technology, the rapid upgrade of information also has disadvantages. This lesson will discuss the history and impact of technological advancements to society.

Life is accompanied by endless transmission of information that takes place within and outside the human body. According to Webster's Encyclopedic Unabridged Dictionary, information is "knowledge communicated or obtained concerning a specific fact or circumstance." Hence, information is a very important tool for survival.

The Information Age is defined as a "period starting in the last quarter of the 20th century when information became effortlessly accessible through publications and through the management of information by

computers and computer networks" (Vocabulary.com, n.d.). The means of conveying symbolic information (e.g., writing, math, other codes) among humans has evolved with increasing speed. The Information Age is also called the Digital Age and the New Media Age because it was associated with the development of computers.

According to James R. Messenger who proposed the Theory of Information Age in 1982, "the Information Age is a true new age based upon the interconnection of computers via telecommunications, with these information systems operating on both a real-time and as-needed basis. Furthermore, the primary factors driving this new age forward are convenience and user-friendliness which, in turn, will create user dependence."

History

The table below traces the history and emergence of the Information Age (United States American History, n.d.).

Table 1. Timeline of the Information Age

Year	Event
3000 BC	Sumerian writing system used pictographs to represent words
2900 BC	Beginnings of Egyptian hieroglyphic writing
1300 BC	Tortoise shell and oracle bone writing were used
500 BC	Papyrus roll was used
220 BC	Chinese small seal writing was developed
100 AD	Book (parchment codex)
105 AD	Woodblock printing and paper was invented by the Chinese
1455	Johannes Gutenberg invented the printing press using movable metal type
1755	Samuel Johnson's dictionary standardized English spelling

1802	• The Library of Congress was established • Invention of the carbon arc lamp
1824	Research on persistence of vision published
1830s	• First viable design for a digital computer • Augusta Lady Byron writes the world's first computer program
1837	Invention of the telegraph in Great Britain and the United States
1861	Motion pictures were projected onto a screen
1876	Dewey Decimal system was introduced
1877	Eadweard Muybridge demonstrated high-speed photography
1899	First magnetic recordings were released
1902	Motion picture special effects were used
1906	Lee DeForest invented the electronic amplifying tube (triode)
1923	Television camera tube was invented by Zvorkyn
1926	First practical sound movie
1939	Regularly scheduled television broadcasting began in the US
1940s	Beginnings of information science as a discipline
1945	Vannevar Bush foresaw the invention of hypertext
1946	ENIAC computer was developed
1948	Birth of field-of-information theory proposed by Claude E. Shannon
1957	Planar transistor was developed by Jean Hoerni
1958	First integrated circuit
1960s	Library of Congress developed LC MARC (machine-readable code)
1969	UNIX operating system was developed, which could handle multitasking
1971	Intel introduced the first microprocessor chip
1972	Optical laserdisc was developed by Philips and MCA
1974	MCA and Philips agreed on a standard videodisc encoding format

1975	Altair Microcomputer Kit was released: first personal computer for the public
1977	RadioShack introduced the first complete personal computer
1984	Apple Macintosh computer was introduced
Mid 1980s	Artificial intelligence was separated from information science
1987	Hypercard was developed by Bill Atkinson recipe box metaphor
1991	Four hundred fifty complete works of literature on one CD-ROM was released
January 1997	RSA (encryption and network security software) Internet security code cracked for a 48-bit number

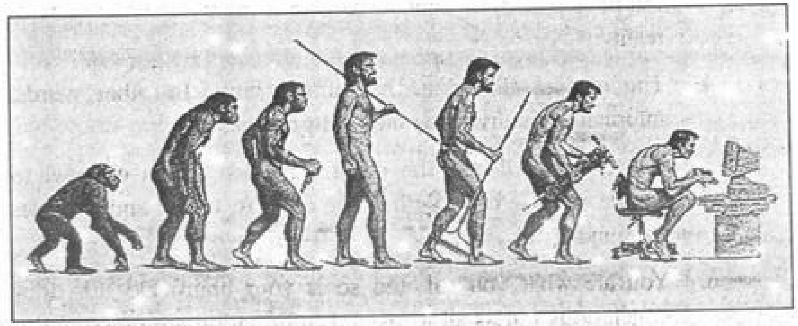


Figure 7. Evolution of Man and Information

As man evolved, information and its dissemination has also evolved in many ways. Eventually, we no longer kept them to ourselves; instead, we share them and manage them in different means. Information got ahead of us. It started to grow at a rate we were unprepared to handle. Because of the abundance of information, it was difficult to collect and manage them starting in the 1960s and 1970s. During the 1980s, real angst set in. Richard Wurman called it "Information Anxiety." In the 1990s, information became the currency in the business world. Information was the preferred medium of exchange and the information managers served as information officers. In the present generation, there is no doubt that information has turned out to be a commodity, an overdeveloped product, mass-produced, and unspecialized. Soon, we become overloaded with it.

2. Desktop Computer

It is described as a PC that is not designed for portability. The assumption with a desktop is that it will be set up in a permanent spot. A workstation is simply a desktop computer that has a more powerful processor, additional memory, and enhanced capabilities for performing special group of tasks, such as 3D graphics or game development. Most desktops offer more storage, power, and versatility than their portable versions (UShistory.org, 2017).

3. Laptops

These are portable computers that integrate the essentials of a desktop computer in a battery-powered package, which are somewhat larger than a typical hardcover book. They are commonly called notebooks.

4. Personal Digital Assistants (PDAs)

These are tightly integrated computers that usually have no keyboards but rely on a touch screen for user input. PDAs are typically smaller than a paperback, lightweight, and battery-powered (UShistory.org, 2017).

5. Server

It refers to a computer that has been improved to provide network services to other computers. Servers usually boast powerful processors, tons of memory, and large hard drives (UShistory.org, 2017).

6. Mainframes

These are huge computer systems that can fill an entire room. They are used especially by large firms to describe the large, expensive machines that process millions of transactions every day. The term "mainframe" has been replaced by enterprise server. Although some supercomputers are single computer systems, most comprise multiple, high-performance, parallel computers working as a single system (UShistory.org, 2017).

7. Wearable Computers

They involve materials that are usually integrated into cell phones, watches, and other small objects or places. They perform common computer applications such as databases, email, multimedia, and schedulers (UShistory.org, 2017).

The World Wide Web (Internet)

Several historians trace the origin of the Internet to Claude E. Shannon, an American Mathematician who was considered as the "Father of Information Theory." He worked at Bell Laboratories and at age 32, he published a paper proposing that information can be quantitatively encoded as a sequence of ones and zeroes.

The Internet is a worldwide system of interconnected networks that facilitate data transmission among innumerable computers. It was developed during the 1970s by the Department of Defense. In case of an attack, military advisers suggested the advantage of being able to operate on one computer from another terminal. In the early days, the Internet was used mainly by scientists to communicate with other scientists. The Internet remained under government control until 1984 (Rouse, 2014).

One early problem faced by Internet users was speed. Phone lines could only transmit information at a limited rate. The development of fiber-optic cables allowed for billions of bits of information to be received every minute. Companies like Intel developed faster microprocessors so personal computers could process the incoming signals at a more rapid rate (UShistory.org, 2017).

Sergey Brin and Larry Page, directors of a Stanford research project, built a search engine that listed results to reflect page popularity when they determined that the most popular result would frequently be the most usable. After talking with family, friends, and other investors into contributing $1 million, the researchers launched their company in 1998. Google is now the world's most popular search engine, accepting more than 200 million queries daily.

Back then, new forms of communication were also introduced. Electronic mail, or email, was a suitable way to send a message to fellow workers, business partners, or friends. Messages could be sent and received at the convenience of the individual. A letter that took several days to arrive could be read in minutes. Internet service providers like America Online and CompuServe set up electronic chat rooms. These were open areas of cyberspace where interested parties could join in a conversation with perfect strangers. "Surfing the net" became a pastime in and of itself (UShistory.org, 2017).

Consequently, companies whose businesses are built on digitized information have become valuable and powerful in a relatively short period of time; the current Information Age has spawned its own breed of wealthy influential brokers, from Microsoft's Bill Gates to Apple's Steve Jobs to Facebook's Mark Zuckerberg.

Critics charged that the Internet created a technological divide that increased the gap between the members of the higher class and lower class of society. Those who could not afford a computer or a monthly access fee were denied these possibilities. Many decried the impersonal nature of electronic communication compared to a telephone call or a handwritten letter.

On one hand, the unregulated and loose nature of the Internet allowed pornography to be broadcast to millions of homes. Protecting children from these influences or even from meeting violent predators would prove to be difficult. Nowadays, crimes in various forms are rampant because of the use of social media. Cyberbullying is an issue that poses alarm worldwide. Consequently, we need to be aware of the possible harm and damage due to abuse of these advances in the Information Age.

Applications of Computers in Science and Research

One of the significant applications of computers for science and research is evident in the field of bioinformatics. Bioinformatics is the application of information technology to store, organize, and analyze vast amount of biological data which is available in the form of sequences and structures of proteins–the building blocks of organisms and nucleic acids–the information carrier (Madan, n.d.).

Early interest in bioinformatics was established because of a need to create databases of biological sequences. The human brain cannot store all the genetic sequences of organisms and this huge amount of data can only be stored, analyzed, and be used efficiently with the use of computers.

While the initial databases of protein sequences were maintained at individual laboratories, the development of a consolidated formal database, known as SWISS-PROT protein sequence database, was initiated in 1986. It now has about 70,000 protein sequences from more than 5,000 model organisms, a small fraction of all known organisms. The enormous variety of divergent data resources is now available for study and research by both academic institutions and industries. These are made available as public domain information in the larger interest of research community through the Internet (www.ncbi.nlm.nih.gov) and CD-ROMs (on request from www.rcsb.org). These databases are constantly updated with additional entries (Madan, n.d.).

Computers and software tools are widely used for generating these databases and to identify the function of proteins, model the structure of proteins, determine the coding (useful) regions of nucleic acid sequences, find suitable drug compounds from a large pool, and optimize the drug development process by predicting possible targets. Some of the software tools which are handy in the analysis include: BLAST (used for comparing sequences); Annotator (an interactive genome analysis tool); and GeneFinder (tool to identify coding regions and splice sites) (Madan, n.d.).

The sequence information generated by the human genome research, initiated in 1988, has now been stored as a primary information source for future applications in medicine. The available data is so huge that if compiled in books, the data would run into 200 volumes of 1,000 pages each and reading alone (ignoring understanding factor) would require 26 years working around the clock. For a population of about five billion human beings with two individuals differing in three million bases, the genomic sequence difference database would have about 15,000,000 billion entries. The present challenge to handle such huge volume of data is to improve database design, develop software for database access, and manipulation and device data-entry procedures to compensate for the varied computer procedures and systems used in different laboratories. The much-celebrated complete human genome sequence which was formally announced on the 26th of June 2000 involved more than 500 x 1018 (500 million trillion) calculations during the process of assembling the sequences alone. This can be considered as the biggest exercise in the history of computational biology (Madan, n.d.).

Moreover, from the pharmaceutical industry's point of view, bioinformatics is the key to rational drug discovery. It reduces the number of trials in the screening of drug compounds and in identifying potential drug targets for a particular disease using high-power computing workstations and software like Insight. This profound application of bioinformatics in genome sequence has led to a new area in pharmacology--Pharmacogenomics, where potential targets for drug development are hypothesized from the genome sequences. Molecular modeling, which requires a lot of calculations, has become faster due to the advances in computer processors and its architecture (Madan, n.d.).

In plant biotechnology, bioinformatics is found to be useful in the areas of identifying diseases resistance genes and designing plants with high nutrition value (Madan, n.d.).

How to Check the Reliability of Web Sources

The Internet contains a vast collection of highly valuable information but it may also contain unreliable, biased information that mislead people. The following guidelines can help us check the reliability of web sources that we gather. It is noteworthy to consider and apply the following guidelines to avoid misinformation. (Lee College Library, n.d.)

1. Who is the author of the article/site?
   - How to find out?

     Look for an "About" or "More About the Author" link at the top, bottom, or sidebar of the webpage. Some pages will have a corporate author rather than a single person as an author. If no information about the author(s) of the page is provided, be suspicious.

     ✓ Does the author provide his or her credentials?

     ✓ What type of expertise does he or she have on the subject he or she is writing about? Does he or she indicate what his or her education is?

     ✓ What type of experience does he or she have? Should you trust his or her knowledge of the subject?

     Try searching on the Internet for information about the author.

     ✓ What kinds of websites are associated with the author's name? Is he or she affiliated with any educational institution?

     ✓ Do commercial sites come up? Do the websites associated with the author give you any clues to particular biases the author might have?

2. Who published the site?
   - How to find out?

     ✓ Look at the domain name of the website that will tell you who is hosting the site. For instance, the Lee College Library website is: http://www.lee.edu/library. The domain name is "lee.edu." This tells you that the library website is hosted by Lee College.

     ✓ Search the domain name at http://www.whois.sc/. The site provides information about the owners of registered domain names. What is the organization's main purpose? Check the organization's main website, if it has one. Is it educational? Commercial? Is it a reputable organization?

     ✓ Do not ignore the suffix on the domain name (the three-letter part that comes after the "."). The suffix is usually (but not always) descriptive of what type of entity hosts the website. Keep in mind that it is possible for sites to obtain suffixes that are misleading. Here are some examples:

     .edu = educational

     .com = commercial

.mil = military

.gov = government

.org = nonprofit

3. What is the main purpose of the site? Why did the author write it and why did the publisher post it?
   - To sell a product?
   - As a personai hobby?
   - As public service?
   - To further scholarship on a topic?
   - To provide general information on a topic?
   - To persuade you of a particular point of view?

4. Who is the intended audience?
   - Scholars or the general public?
   - Which age group is it written for?
   - Is it aimed at people from a particular geographic area?
   - Is it aimed at members of a particular profession or with specific training?

5. What is the quality of information provided on the website?
   - Timeliness: When was the website first published? Is it regularly updated? Check for dates at the bottom of each page on the site.
   - Does the author cite sources? Just as in print sources, web sources that cite their sources are considered more reliable.
   - What type of other sites does the website link to? Are they reputable sites?
   - What types of sites link to the website you are evaluating? Is the website being cited by others?

Examples of Useful and Reliable Web Sources

1. AFA e-Newsletter (Alzheimer's Foundation of America newsletter)
2. American Memory – the Library of Congress historical digital collection.
3. Bartleby.com Great Books Online – a collection of free e-books including fictions, nonfictions, references, and verses.
4. Chronicling America – search and view pages from American newspapers from 1880–1922.
5. Cyber Bullying – a free collection of e-books from ebrary plus additional reports and documents to help better understand, prevent and take action against this growing concern.
6. Drug information websites:
   - National Library of Medicine's MedlinePlus
   - Drugs.com
   - PDRhealth
7. Global Gateway: World Culture & Resources (from the Library of Congress)
8. Google Books
9. Googlescholar.com
10. History sites with primary documents:
    - AMDOCS: Documents for the study of American history
    - Avalon Project: Documents in Law, History and Diplomacy (Yale Law School)
    - Internet Modern History Sourcebook: Colonial Latin America
    - Teacher Oz's Kingdom of History

11. Illinois Digital Archives – the Illinois State Library working with libraries, museums, and historical societies in Illinois provides this collection of materials related to Illinois history.

12. Internet Archive – a digital library of Internet sites and other cultural artifacts in digital form.

13. Internet Archive for CARLI digitized resources

14. Internet Public Library

15. ipl2 – a merger of Librarians' Internet Index and Internet Public Library. Special interest may include the "Literary Criticisms" page which can be found after clicking on the "Special Collections" link.

16. Librarians' Internet Index

17. Making of America – a digital library of primary sources in American social history.

18. Maps – from the University of Texas at Austin collection. Includes historical and thematic maps.

19. NationMaster – a massive central data source and a handy way to graphically compare nations. It is a vast compilation of data from such sources as the CIA World Factbook, UN, and OECD.

20. Nursing sites:
    - AHRQ (www.ahrq.gov)
    - National Guidelines Clearinghouse (www.guideline.gov)
    - PubMed (www.nlm.nih.gov)

21. Project Gutenberg – the first and largest single collection of free electronic books with currently over 20,000 e-books available.

22. Shmoop – literature, US history, and poetry information written primarily by PhD and masters students from top universities like Stanford, Berkeley, Harvard, and Yale.

23. StateMaster – a unique statistical database which allows you to research and compare a multitude of different data on US states using various primary sources such as the US Census Bureau, the FBI, and the National Center for Educational Statistics. It uses visualization technology like pie charts, maps, graphs, and scatter plots to provide data.

24. Virtual Reference – selected web resources compiled by the Library of Congress.

One can also visit the university library and seek help from librarians as they are knowledgeable and the library has a rich collection of online library resources that are very useful for academic and research purposes.

SUMMARY

Nowadays, information could be shared or transferred quickly. People are becoming more interested in sharing information about themselves. Various aspects of our society are also being influenced by the Information Age especially communication, economics, industry, health, and the environment. The rapid upgrade of information poses both positive and negative impacts to our society. Therefore, we need to carefully check our motives before disseminating information and we also need to verify information before believing them and using and sharing them. We should share information that could help improve our lives and others.

THINK ABOUT THESE QUESTIONS

1. Who are the contributors of the technological advances of the Information Age?
2. Aside from communication, what other aspects of society is/are being influenced in the Information Age?
3. What other technological advancements can possibly be developed in the future?

ACTIVITIES

1. **Video presentation.** Form groups consisting of three to five members each and prepare a video presentation that focuses on the evolution of transmission of information in various time periods and areas of the world. Refer to Table 1 presented in the discussion. The members may act in the video presentation and they can use props or materials to improve the presentation. Limit the video presentation in three to five minutes.

2. **Creative work.** Think of a device with special features that you can develop to help improve lives of people in our society. It could be something that you can develop to help in communication, transportation, health, and the like. Illustrate your device in a short bond paper. Show your output in class and explain.

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LESSON

2 BIODIVERSITY AND THE HEALTHY SOCIETY

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- determine the interrelatedness of society, environment, and health;
- create a diagram that would show the relatedness of species in forming up a diverse and healthy society without compromising one another; and
- identify everyday tasks and evaluate whether they contribute to the wellness and health of biodiversity and society or not.

INTRODUCTION

Decrease in biodiversity is eminent worldwide. Vertebrates fell to 60% from the 1970s due to human causes. It is projected that by 2020, wildlife decline will be 67% of the present number. The World Wide Fund for Nature and Zoological Society of London reported an annual decrease in wildlife by 2%. A major cause is human population which has doubled in number since 1960 to 7.4 billion. Humans have industrialized the natural habitat of wildlife as well as marine life. Leaving these creatures with no place to live would eventually cause their deaths. Marco Lambertini, the General Director of WWF International, described that the disappearance of wildlife is at an unprecedented rate. Earth might enter the sixth mass extinction event according to experts. Mass extinction is described as the disappearance of species at a rate of 1,000 faster than usual. Moreover, the disappearance of species in a certain environment causes an imbalance in the ecosystem, producing more chaotic changes that harm the entire ecosystem (Inquirer.net, 2016).

This is but a pressing statement for people to know more about the importance of our diverse environment, and how human activities can either contribute to its growth or destruction. There is a growing importance of studying how society, environment, and health is interrelated to each other, that if human beings fail to recognize the needs of one of those components, the other remaining components can be affected and compromised. Thus, it is timely to know about the pressing effects of species being extinct and that of our ecosystem being imbalanced.

Biodiversity and Ecosystem

Biodiversity is defined as the vast variety of life forms in the entire Earth. It encompasses all kinds of life forms, from the single-celled organisms to the largest multi-celled organisms. Its definition is in the structural and functional perspective and not as individual species.

Another definition of biodiversity is "the variability among living organisms from all sources, including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems. Biodiversity is the source of the essential goods and ecological services that constitute the source of life for all and it has direct consumptive value in food, agriculture, medicine, and in industry." (Villaggio Globale, 2009)

Understanding biodiversity within the concept of ecosystem needs a thorough study on the relationship of the biotic, the living organisms and the abiotic, nonliving organisms. Interdisciplinary approach is needed to study the ecosystem. Biodiversity plays a major role in this natural dynamics. For example, a large number of golden snails in a certain area of a rice field can help predict a low production of rice harvest, since eggs of the golden snails are considered pest for rice plant. On a positive view, the larger number of different species in a certain area can be a predictor of sustainable life in that area. Sustainability of the ecosystem ensures a better survival rate against any natural disaster. Therefore, we, as human inhabitants of the ecosystem, must preserve and conserve the biodiversity of all creatures.

In simpler terms, it is true that people will always depend on biodiversity on the wholeness of our being and in our everyday lives. More so, our health will ultimately depend upon the products and services that we acquire from the ecosystem. Somehow, there are ways and processes in the ecosystem that are not apparent nor appreciated by us, human beings. Think about the need to drink clean and fresh water, the need to eat healthy vegetables and food, or the need of man to transport which makes him rely on fuel. All of these are human needs that are answered and provided by our ecosystem. Thus, if we fail to keep the process of taking care of the ecosystem, it is us who are actually putting our lives at risk. Significant decline in biodiversity has direct human impact when ecosystem in its insufficiency can no longer provide the physical as well as social needs of human beings. Indirectly, changes in the ecosystem affect livelihood, income, and on occasion, may even cause political conflict (WHO, n.d.).

Changes in Biodiversity

Alteration in any system could bring varied effects. A change in biodiversity could have erratic effects not only in wildlife or marine life but also in human beings. For example, humans inhabiting the forest would disturb the natural order of life. Trees and plants would be affected in the land- clearing operations where the houses would be built. The animals, insects, and all types of life forms in the cleared area would either be displaced or most likely be killed. The loss of these life forms could affect the entire ecosystem governing that environment. The food chain might be damaged. From this, we can clearly infer that when our ecosystem is not well taken care of, biodiversity encounters changes that may impact human health on such different levels.

Threats to Biodiversity

There are major threats to biodiversity that were identified by the United Nations' Environment Programme (WHO, n.d.). These are the following:

1. *Habitat loss and destruction.* Major contributing factor is the inhabitation of human beings and the use of land for economic gains.

2. *Alterations in ecosystem composition.* Alterations and sudden changes, either within species groups or within the environment, could begin to change entire ecosystems. Alterations in ecosystems are a critical factor contributing to species and habitat loss.
3. *Over-exploitation.* Over-hunting, overfishing, or over-collecting of species can quickly lead to its decline. Changing consumption patterns of humans is often cited as the key reason for this unsustainable exploitation of natural resources.
4. *Pollution and contamination.* Biological systems respond slowly to changes in their surrounding environment. Pollution and contamination cause irreversible damage to species and varieties.
5. *Global climate change.* Both climate variability and climate change cause biodiversity loss. Species and populations may be lost permanently if they are not provided with enough time to adapt to changing climatic conditions.

Consequences of Biodiversity Loss

Even with the improvement of technology and science at present, we still have a lot to learn about biodiversity, more so about the consequences of biodiversity loss. However, the basic concept about biodiversity loss was from Charles Darwin and Alfred Russel Wallace.

Intact ecosystems function best since the organisms composing them are specialized to function in that ecosystem to capture, transfer, utilize and, ultimately, lose both energy and nutrients. The particular species making up an ecosystem determine its productivity, affect nutrient cycles and soil contents, and influence environmental conditions such as water cycles, weather patterns, climate, and other nonbiotic aspects. The loss of biodiversity has many consequences that we understand, and many that we do not. It is apparent that humankind is willing to sustain a great deal of biodiversity loss if there are concomitant benefits to society; we hope they are net benefits. In many cases, the benefits seem to accrue to a few individuals only, with net societal loss. However, it is extremely difficult to estimate the future costs of losses in biodiversity or of environmental damage (Rainforest Conservation Fund, 2017).

As stated by Tilman, "The Earth will retain its most striking feature, its biodiversity, only ii humans have the prescience to do so. This will occur, it seems, only if we realize the extent to which we use biodiversity (Rainforest Consevation Fund, 2017)."

Nutritional Impact of Biodiversity

According to the World Health Organization, biodiversity is a vital element of a human being's nutrition because of its influence to food production. Biodiversity is a major factor that contributes to sustainable food production for human beings. A society or a population must have access to a sufficient variety of nutritious food as it is a determinant of their health as human beings.

Nutrition and biodiversity are linked at many levels: the ecosystem, with food production as an ecosystem service; the species in the ecosystem; and the genetic diversity within species. Nutritional composition between foods and among varieties/cultivars/breeds of the same food can differ dramatically, affecting micronutrient availability in the diet. Healthy local diets, with adequate average levels of nutrients intake, necessitates maintenance of high biodiversity levels. Intensified and enhanced food production through irrigation, use of fertilizer, plant protection (pesticides), or the introduction of crop varieties and cropping patterns affect biodiversity and thus impact global nutritional status and human health. Habitat simplification, species loss, and species succession often enhance communities, vulnerabilities as a function of environmental receptivity to ill health (WHO, 2007).

Health, Biology, and Biodiversity

Almost all living organisms are dependent to their environment to live and reproduce. Basic needs of living organisms such as air, water, food, and habitat are provided by its environment. The evolution of human beings was due to the improved access to these basic needs. Advances in agriculture, sanitation, water treatment, and hygiene have had a far greater impact on human health than medical technology.

Although the environment sustains human life, it can also cause diseases. Lack of basic necessities is a significant cause of human mortality.

Environmental hazards increase the risk of cancer, heart disease, asthma, and many other illnesses. These hazards can be physical, such as pollution, toxic chemicals, and food contaminants, or they can be social, such as dangerous work, poor housing conditions, urban sprawl, and poverty. Unsafe drinking water and poor sanitation and hygiene are responsible for a variety of infectious diseases, such as schistosomiasis, diarrhea, cholera, meningitis, and gastritis. In 2015, approximately 350,000 children under the age of five (mostly in the developing world) died from diarrheal diseases related to unsafe drinking water, and approximately 1.8 billion people used drinking water contaminated with feces. More than two billion people lacked access to basic sanitation.

The interrelation between human health and biological diversity is considerable and complex. With the current biodiversity loss at unprecedented rates, the delicate balance between human health and biological diversity is at risk.

Environment-Related Illnesses

Some human illnesses that are found to be related with its environment include Parkinson's disease, heart disease, cancer, chronic obstructive pulmonary disease, asthma, diabetes, obesity, occupational injuries, dysentery, arthritis, malaria, and depression.

By contrast, activities that promote health and extend human life could have adverse environmental effects. For example, food production causes environmental damage from pesticides and fertilizers, soil salinization, waste produced by livestock, carbon emissions from food manufacturing and transportation, deforestation, and overfishing. Health care facilities also have adverse environmental impacts. Hospitals use large quantities of electricity and fossil fuels and produce medical wastes. To prevent some diseases, it may be necessary to alter the environment. For example, malaria was eradicated in the United States and other developed nations in the 1940s and 50s as a result of draining wetlands and spraying DDT to kill mosquitoes. A reduction in mortality from starvation or disease can lead to overpopulation, which stresses the environment in many different ways—increasing use of fossil fuels, clearing of land, generating pollution and waste, and so on (Rensik & Portier, 2017).

Interestingly, according to experts, climate change could also have a serious impact on human health and could deteriorate farming systems and reduce nutrients in some foods. In this case, biodiversity increases resilience, thus helping adjust to new environmental conditions. Safeguarding of coral reefs, for instance, is essential to reduce the risk of floods, as this extraordinary ecosystem can reduce wave energy by 97%, thus protecting over 100 million people all over the world.

Relationships between human health and the environment raise many ethical, social, and legal dilemmas by forcing people to choose among competing values. Many of the issues at the intersection of health and the environment have to do with managing benefits and risks. For example, pesticides play an important role in increasing crop yields, but they can also pose hazards to human health and the environment. Alternatives to pesticide use create trade-offs in health. The extreme action of stopping all pesticide uses could significantly reduce agricultural productivity, leading to food shortages and increased food prices which would, in turn, increase starvation in some parts of the world. Public health authorities have opted to regulate the use of pesticides to enhance food production while minimizing damage to the environment and human health. Energy production and use help sustain human life, but it can also pose hazards to human health and the environment, such as air and water pollution, oil spills, and destruction of habitats (Rensik & Portier, 2017).

No issue demands greater care in balancing benefits and risks than global warming. A significant percentage of global climate change is due to the human production of greenhouse gases. Climate change is likely to cause tremendous harm to the environment and human health, but taking steps to drastically reduce greenhouse gases could have adverse consequences for global, national, and local economies. For example, greatly increasing taxes on fossil fuels would encourage greater fuel efficiency and lower carbon dioxide emissions, but it would also increase the price of transportation, which would lead to widespread inflation and reduced consumer spending power. Managing benefits and risks also raises social justice concerns. In general, people with lower socio-economic status have greater exposure to certain harmful environmental conditions in their homes or at work, such as lead, mercury, pesticides, toxic chemicals, or air and water pollution. Communities and nations should wisely choose a site for a factory, a power plant, or waste dump, or regulating safety in

the workplace to minimize impact to the society. The decision-making process should be fair, open, and democratic, so that people who will be affected by environmental risks have a voice in these deliberations and can make their concerns known (Rensik & Portier, 2017).

When drafting and implementing environmental health regulations, it is important to consider vulnerable subpopulations. A vulnerable subpopulation is a group with an increased susceptibility to the adverse effects of an environmental risk factor, due to their age, genetics, health status, or some other condition. If an environmental regulation is designed to protect average members of the population, it may fail to adequately protect vulnerable subpopulations. Justice demands that we take care of people who are vulnerable. However, almost everyone in the population has an above-average susceptibility to at least one environmental risk factor. Since providing additional protection to everyone would be costly and impractical, protections must be meted out carefully and the populations who are vulnerable to a particular environmental risk factor must be defined clearly (Rensik & Portier, 2017).

In addition to this, various public health strategies pit the rights of individuals against the good of society, such as mandatory treatment, vaccination, or diagnostic testing; isolation and quarantine; and disease surveillance. The owner of a coal-burning power plant must deal with many laws concerning the operation of the plant, workplace safety, and carbon emissions. A developer who plans to build 150 new homes with land he has purchased may also have to deal with laws concerning storm drainage, water and sewage lines, gas lines, sidewalks, and so on. Restrictions on property rights are justified to protect human health and the environment. However, opponents of these restrictions argue that they are often excessive or not adequately supported by scientific evidence (Rensik & Portier, 2017).

Human rights issues also come up with research on environmental health that involves human subjects. For such research to be ethical, human subjects must give consent, and great care must be taken to ensure that they understand that they can opt out of the research project. Since the late 1990s, some pesticide companies have tested their products on human subjects to gather data to submit to the government for regulatory purposes. Some commentators charge that these experiments are unethical because they place people at unacceptably high risk without a clear benefit to society. Others have argued that the experiments, if properly designed and implemented, could produce important benefits to society by providing useful knowledge about the effects of pesticides that lead to stronger regulations (Rensik & Portier, 2017).

With these in mind, a mitigating plan and a workable plan of action should be studied in order to not compromise biodiversity, while at the same time, promote good health among the society.

SUMMARY

Most of the time, it may seem impossible to really value species singly or in a detailed manner. But we have to consider the entire Earth as a single unit. A loss of single-celled species or a family of wild grass can have adverse effects in the entire biosphere. Biodiversity seen in macro level seems to be still vast and rich, yet if we look at it in micro-level, per species, we have lost too much. Eventually, in the near future, this biodiversity loss will have a great negative effect especially to us humans. "The value of biodiversity is the value of everything" (Rainforest Conservation Fund, n.d.).

We must recognize the value of the organisms with which we share the planet. As Costanza et al. (1997) put it, "We must begin to give the natural capital stock that produces these services adequate weight in the decision-making process, otherwise, current and continued future human welfare may drastically suffer... many ecosystem services are literally irreplaceable." We do not, and probably cannot, ever evaluate such services adequately, but we can value the ecosystems of the world appropriately (Rainforest Conservation Fund, n.d.).

THINK ABOUT THESE QUESTIONS

1. How would you reconcile the emerging needs of human beings regarding their health and the need to protect the growth of biodiversity?
2. Do you think that Earth can exist without human beings taking care of it? Or biodiversity also needs human beings for it to be in a continuous growing process?
3. What are small ways that you think would promote safekeeping our biodiversity? What do you think are the common human activities that can harm biodiversity? What would be the consequences if these human activities might be stopped and prohibited?

ACTIVITIES

1. **Advocacy writing.** In groups of five, brainstorm and come up with an advocacy that you think is timely, knowing that in our emerging needs to endure in this world, biodiversity collapses and suffers just to provide our necessities for survival.
2. **Concept mapping.** List down several concepts that the society or human beings benefit from biodiversity. On the other circle, enumerate the different challenges and disadvantages that biodiversity suffers as we work our way to acquire the benefits. On the space where the two circles meet, list down possible ways and strategies on how we could acquire these benefits and needs without compromising the growth process of biodiversity.

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LESSON 3

GENETICALLY MODIFIED ORGANISMS: SCIENCE, HEALTH, AND POLITICS

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- identify issues on genetically modified organisms (GMOs);
- discuss different implications and impact of GMOs; and
- create a research paper on the impact of GMOs in the Philippine context.

INTRODUCTION

In 2001, Rosalie Ellasus, a former overseas Filipino worker in Singapore turned farmer, attended the Integrated Pest Management – Farmers Field School and was introduced to Bt Corn, a genetically modified corn that is resistant to the destructive Asian corn borer. Ms. Ellasus volunteered for demo-testing in her field. Bt Corn yielded 7.2 tons per acre as compared to a regular yield of 4.2 tons per hectare. No insecticide spraying was needed. This is one of the success stories of genetically modified organisms (GMOs) (Ongkiko, 2016).

Genetic engineering has been with the human society since selective breeding was introduced to humankind and when animals were domesticated. Yet, the process of genetic alterations is all but natural.

It was in 1951 that the term *genetic engineering* was coined by Jack Williamson, author of the science fiction novel *Dragon's Island* (Stableford 2004). This was years before actual research findings on the DNA's role in heredity and its structure, the double-helix of Watson and Crick, were published. Through continuous search for development, genetic engineering no longer stayed in science fiction novel. It became a reality in science laboratories. The general process of genetic engineering is the deliberate manipulation of the organism's genes, where it may involve transfer of genes from other organism.

An antibiotic-resistant E. coli bacteria was created in 1973. To date, there are ongoing researches on GMOs such as using genetically modified male mosquitoes as pest control over female mosquito carriers of Zika virus.

However, despite the many possibilities of creating solutions for problems and opening doors for innovations, genetic engineering faces much opposition. Opponents raise ethical, social, and environmental issues related to genetic engineering and its GMOs.

This lesson will present the existence of genetic engineering, specifically GMOs in the different areas of life, the impact to humankind, and the controversies that surround them.

Genetically Modified Organism

Genetically modified organism (GMO) is the term used for an organism created through genetic engineering. The World Health Organization (WHO, 2014) defines GMO as an "organism, either plant, animal, or microorganism, in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating or natural recombination." Below is a diagram of how bacterial gene is introduced through genetic engineering to plant cells and tissues to develop and breed a genetically modified plant.

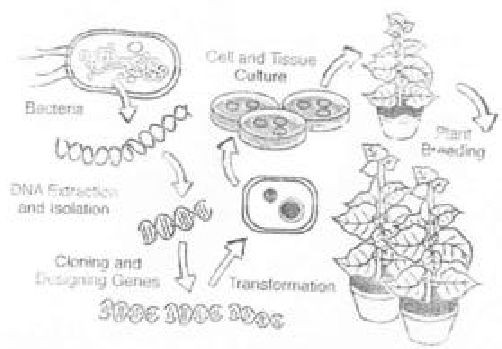


Figure 8. The Genetic Engineering Process on a Plant

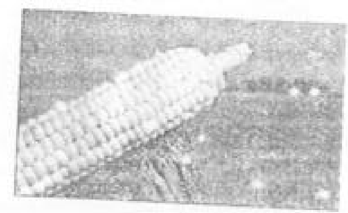
The development of GMOs was perceived to help in the advancement of technology for the benefit of humans in different industries like agriculture and medicine.

GMOs in Food and Agricultural Industries

The Center for Ecogenetics and Environmental Health (CEEH, 2013) identified the following roles of GMOs in the food and agricultural industries:

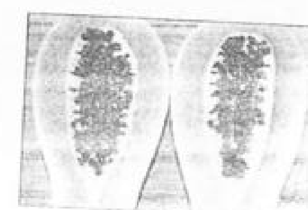
1. Pest resistance – genetically modified plants to resist certain pests.

   An example is Bt Corn. The DNA (genome) of the Bt Corn has been modified with the gene of *Bacillus thuringiensis*, a soil bacterium that produces proteins which is toxic to corn borers (worms).



2. Virus resistance – genetically modified plants to resist certain viruses.

   An example is GM papaya or rainbow papaya. The papaya ringspot virus (PRSV) is known to be detrimental to papaya plants. The protein of PRSV was introduced to the papaya plant through plant tissue which turned out to be resistant to the virus itself. The effect was like the vaccines humans have against measles or influenza virus.



3. Herbicide tolerance – genetically modified plants to tolerate herbicide.

   An example is Roundup Ready soybean. Glyphosate, an herbicide for weeds, was introduced to soybeans making it tolerant to the herbicide itself. Farmers then can spray the herbicide killing the weeds but not the soybeans.

4. Fortification – genetically modified plants fortified with certain minerals.

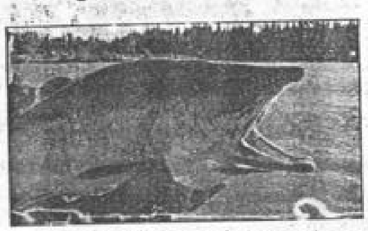
   An example is Golden Rice. Beta-carotene, a precursor of vitamin A, was introduced through biosynthesis genes to the rice, making the rice grains fortified with vitamin A.

5. Cosmetic preservation – genetically modified plants resist natural discoloration.

   An example is Arctic Apple. The apple variety was genetically modified to suppress the browning of apple due to superficial damage.

6. Increase growth rate – a genetically modified organism that has higher yield in growth than normal species.

   An example is AquAdvantage salmon. A gene from an ocean pout, an eel-like fish was introduced to Pacific Chinook salmon, making the salmon grow faster than its normal rate.



GMOs in Non-Food Crops and Microorganisms

Genetically modified organisms (GMOs) in non-food crops and some microorganisms involve the following:

1. Flower production – GMOs in flower production are seen in modified color and extended vase life of flowers.

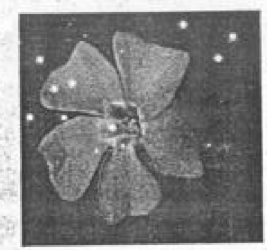
   Examples are Blue Roses. The so-called "blue" roses, which are, in reality, lilac or purple, contained cyanidin 3,5-diglucoside, together with large amounts of flavonols. The introduction of the flavonoid 3l, 5l-hydroxylase gene into pelargonidin- or cyanidin-producing rose cultivars diverts the anthocyanin biosynthetic pathway toward the production of delphinidin glucosides and the flower color to blue (Elomaa & Holton, 1994).

2. Paper production – modified characteristics of trees for higher yield of paper production.

   Examples are poplar trees. Lignin is a complex polymer in trees that is removed from wood to make paper through kraft process, through inserting genes that code for ferulic acid in young poplar trees, the lignin structure is modified, making lignin easier to breakdown (Veniza, 2014).

3. Pharmaceutical productions – modified plants to produce pharmaceutical products.

   Examples are periwinkle plants. Bacterial genes were added to the periwinkle plant to enhance the production of vinblastine, an alkaloid usually added to drugs for cancer treatments like Hodgkin's lymphoma (Runguphan, 2010).



4. Bioremediation – use of modified plants that can assist in the bioremediation of polluted sites.

   An example is shrub tobacco. *Nicotiana glauca*, or shrub tobacco genetically modified with phytochelatin TaPCSI1, is used for bioremediation. It shows high level accumulation of zinc, lead, cadmium, nickel, and boron and produces high biomass.

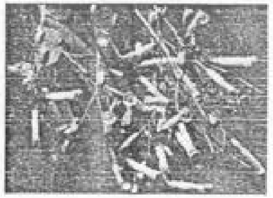


Figure 9. *Nicotiana glauca*

5. Enzyme and drug production – use of modified microorganisms that can produce enzymes for food processing and medicines.

One example of this is CGTase. Cyclomaltodextrin glycosyltransferase (CGTase), an enzyme used for food flavor enhancer, is produced in higher quantity by bacterium Bacillus which was genetically modified with the gene of a thermophilic anaerobe, Thermoanaerobacter, carrying CGTase (Pedersen & Jorgensen, 1995).

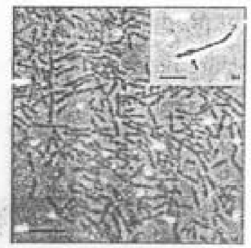


Figure 10. Thermoanaerobacter

Another example is artemesin. Artemesinic acid is a compound used for anti-malarial drug extracted from sweet wordwood plant. Through genetic engineering, it can be synthetically produced by yeast and bacteria with sweet wordwood plant gene (Zimmer, 2006).

6. GMOs in the medical field – genetic engineering is playing a significant role from diagnosis to treatment of human-dreaded diseases. It helps in the production of drugs, gene therapy, and laboratory researches.

One classic example is Humulin, the genetically engineered insulin used by Type 1 diabetes patients who are insulin-dependent. In the past, insulin is extracted from the pancreases

of pigs and cows that have caused allergic reactions to some diabetics using it. In 1978, researchers from the City of Hope National Medical Center and Genentech Biotechnology Company were able to produce human insulin. The gene for insulin was inserted to bacterial DNA that was able to produce almost exactly the same human insulin. This was a breakthrough in the mass production of human insulin. In 1996, modified human insulin was approved, called the *Humalog*.

Figure 11. Humulin, a sample of genetically engineered insulin.

Benefits of GMOs

Studies show some of the potential benefits of GMOs:

- Higher efficiency in farming – with the use of pesticide-resistant/herbicide-tolerant GMO crops, there will be less use for herbicides/pesticides, and lower cost for labor and cultivation.
- Increase in harvest – GMO crops resistant to pests and diseases means increase in potential growth and harvest.
- Control in fertility – controlling the purity of the hybrid seeds (GMO seeds) ensures higher yields.
- Increase in food processing – altered characteristics of GMO crops help ease food processing.
- Improvement of desirable characteristics – GMOs offer longer shelf life, enhanced color and taste, enhanced production or reduction of enzymes, and other modified characteristics of plants, animals, and microorganisms.

- Nutritional and pharmaceutical enhancement – GMO crops like maize fortified with lysine and Golden Rice fortified with vitamin A and iron. There are now edible vaccines for viral and diarrheal diseases.
- Reduce the use of fertilizer and pesticides

There are over 400 million acres of GMO farmlands all over the world. The top five countries that operate GMO farmlands are the United States, Brazil, Argentina, India, and Canada. Some of the GMO agricultural crops that have been approved for public consumption and are already in the market include: alfalfa, corn, papaya, soya bean, sugar beets, and squash. Most of these GMO crops were made to be resistant to pests. Some examples of common food with GMOs are Kellogg's Corn Flakes, Quaker Chewy Granola Bars, Ultra Slim Fast, Quaker Yellow Corn Meal, and Alpo Dry Pet Food.

In the animal industries, there are ongoing researches like studies on Pacific salmon that grows twice faster than the native salmon and chicken resistant to H5N1 bird flu viruses. However, these GMO animals are all in research laboratory and not yet approved for public consumption.

Potential Risks of GMOs

Despite the promising claims of GMOs, the opponents of GMOs claim otherwise. For example, there are studies that show a link in the adaption of pesticide-resistant GMO crops to the significant growth of super weeds that became pesticide-resistant, too. This caused additional problem to more than 12 million acres of farms in the United States.

Opponents of GMOs have the following major concerns:

1. Since genetic engineering is still a young branch of science, there are inadequate studies on the effects of GMOs to humans and the environment.
2. Genetic engineering promotes mutation in organisms which the long term effect is still unknown.

3. Human consumption of GMOs might have the following effects:
    - More allergic reactions – GMO food may trigger more allergic reactions, more so create new ones, as side effect of the gene alteration.
    - Gene mutation – GMO food may develop abnormalities and mutation, more than the desired product of the gene alteration.
    - Antibiotic resistance – GMO food contains antibiotic-resistant genes; this may cause disease-causing bacteria likely to be more antibiotic-resistant too, increasing the possibility of widespread of the disease.
    - Nutritional value – GMO food may have change in their nutritional value.

Potential Environmental Risks Caused By GMOs

Karki (2006) summarized the perceived potential environmental risks caused by GMOs. The identified major risks are the following:

1. Risk in gene flow – there is a potential risk of the modified gene to be transferred from the GMO crop to its wild relative or organism in the soil and human intestine (when ingested). For example, a decaying GMO plant could possibly transfer the modified genes to the bacteria and fungi in the soil. Bacteria and fungi are capable of using a genetic material from their surroundings. There are no studies yet on the effects of the absorbed modified gene to the other organisms.
2. Emergence of new forms of resistance and secondary pests and weed problems – GMO crops resistant to certain pesticides may trigger new form of pest resistance while GMO herbicide-tolerant crops may lead to the over use of the herbicides which may trigger new form of weed resistance.
3. Recombination of Virus and Bacteria to Produce New Pathogens – the modified gene can be transferred and integrated in the viral or bacterial genes which may lead to

viral or bacterial gene modification or mutation. This living modified virus and bacteria may then cause new disease that may affect other organisms including human beings.

Other direct and indirect environmental risks caused by GMOs (Molfino & Zucco, 2008):

1. Direct environmental risks are:
   - introduction of the GMOs in the natural environment may cause disruption of the natural communities through competition or interference;
   - the possibility of unexpected behavior of the GMOs in the environment if it escapes its intended use and may post threats or become pest;
   - may cause harmful effects to ecosystem processes if GMOs interfere with the natural biochemical cycles; and
   - the persistence of GMO genes after its harvest which may cause negative impacts to the consumer of GMO products.
2. Indirect environmental risks are:
   - alteration of agricultural practices like managing negative impacts of GMOs to the environment such as evolution of insects, pests, and weeds that became resistant to GMO crops;
   - may have impacts to biodiversity caused by the alteration in agricultural practices; and
   - may have varied environmental impacts due to GMOs interaction and release in the natural environment.

Potential Human Health Risks caused by GMOs

A major concern in the use and consumption of GMOs is its effect on human beings, primarily on human health. Some potential human health risks are identified (Akhter, 2001), such as:

- consumption of GMOs may have adverse effects since it is not naturally or organically produced;
- consumption of GMOs may alter the balance of existing microorganisms in the human digestive system;
- production of toxins may be detrimental to human health; and
- production of allergens may have adverse effects on humans.

Worldwide, there are many groups that campaign against GMO food consumption. They encourage people to boycott GMO products and to be vigilant in checking if the food they buy has GMO ingredients. In the Philippines, the Supreme Court has ruled against the use of Bt eggplant, another genetically modified crop (Ongkiko, 2016).

Other potential risks that raise major concern are:

- Human Genome Project (HGP) – Mapping of human genes to provide framework for research and studies in the field of medicine. It was feared that the ability to produce human genetic information would create biases and give much power to people holding the information and to the disadvantage of those who do not have the genetic information.
- Mutation of genetically engineered microorganisms – Genetically modified bacteria and viruses may mutate to become more resistant or virulent that may cause more dreadful diseases for human beings.
- Cloning – The asexual reproduction of an organism using parent cell through genetic engineering. In February 24, 1997, the first mammal, Dolly, a sheep from Scotland, was born through cloning. With its celebrated success came the fear of human cloning. It emerged the ethical issue of man "playing God."

Scientists and medical practitioners would definitely continue to search for ways to preserve lives. Genetic engineering is perceived to be one of the keys to this venture. Gene therapy and gene alteration are promising ways to improve human health conditions.

On the other hand, great fears loom in the process of this quest. There are many things to be considered before a certain medical process using genetic engineering be accepted.

These concerns were affirmed by the reports, of the World Health Organization. WHO reported three major issues on GMOs that are in international public debates. These are the potential risks of allergic reactions, gene transfer/flow, and outcrossing (WHO, 2014).

The primary issue on GMOs presented in public debate is its unnatural production or what is termed to be a violation of nature. The creation of new organisms, like GMOs, posts moral issues on defiance to natural laws. Another concern is the potential risks to the environment and human health, to which so much is unknown yet.

Biosafety on GMOs

There are initiatives for the protection of the general human population regarding the issues and concerns about GMOs. International organizations developed principles and treaties that somehow ensure biosafety on GMOs. Some of these initiatives are as follows:

- *The Codex Alimentarius Commission* (Codex). The Food and Agricultural Organization (FAO) together with the World Health Organization (WHO) created The Codex Alimentarius Commission (Codex). Codex is an intergovernmental body that develops the Codex Alimentarius, know us the International Food Code. Codex is responsible for the development of standards, codes of practices, guidelines, and recommendations on food safety. With the pressing issues and concerns on GMOs, in 2003, Codex has developed principles for the human health risk analysis of genetically modified (GM) food products. The principles include pre-market assessments of GM food products and its evaluation of direct and indirect effects. However, the Codex principles has no binding effect on national legislation but through the sanitary and phytosanitary measures of the World Trade Organization, national legislators are encouraged to complement their national standards with the Codex Principles (WHO, 2014).

- *Cartagena Protocol on Biosafety*. Established in 2003, Cartagena Protocol is an international environmental treaty that regulates the transboundary movements of Living Modified Organisms (LMOs). The Cartagena Protocol requires exporters to seek consent from the importers before its first shipment of LMOs (WHO, 2014).
- *International Trade Agreement on labeling of GM food and food products*. The agreement requires exporters of GM food and food products to label their products and give rights to importing parties to reject or accept the GM products. The premise of this policy is that consumers have the right to know and the freedom to choose GM or non-GM products (Whitman, 2000).

The World Health Organization (WHO, 2014) claims that all GM products that are available in the international market have passed safety assessment by national authorities. The safety assessments basically look at the environmental and health risk factors and food safety usually follows the Codex Food Code.

GMOs in Philippine Context

Introduction of GMOs in our country created issues and controversies similar to other countries with GMOs. There are, of course, proponents and opponents of these issues.

The GMO concern started in the 1990s with the creation of the National Committee on Biosafety of the Philippines (NCBP) through Executive Order No. 430 of 1990. The NCBP developed the guidelines on the planned release of genetically manipulated organisms (GMOs) and potentially harmful exotic species in 1998. In 2002, the Department of Agriculture released Administrative Order No. 8, the guideline for the importation and release into the environment of GM plants and plant products. On that same year, the entry of GMO importation started (Baumuller, 2003). The Philippines was marked to be the first country in Asia to approved commercial cultivation of GMOs when GM corn planting was approved in 2002 (Serapio & Dela Cruz, 2016).

From December 2002 to present, there are 70 GMO applications approved by the Department of Agriculture for the release to the environment, 62 GMOs of which are approved for food feed and processing and the remaining 8 were approved for propagation (Aruelo, 2016).

In 2004, the Philippines was classified by International Service for acquisition of agri-biotech applications as one of the fourteen biotech-mega countries which grow 50,000 hectares or more of GMO crops annually (James, 2004). In that same year, Senator Juan Flavier authored a bill on the mandatory labeling of food and food products with GMOs. The Senate did not pass the bill.

In 2006, the Philippines became part of the Cartagena Protocol on Biosafety. In the same year, Executive Order No. 514 was issued to address the biosafety requirements of the Cartagena Protocol and the establishment of the National Biosafety Framework (NBF).

In 2010, the Organic Agriculture Act was issued, encouraging organic agriculture than GMO-related agriculture. Prior to this act, there are several provinces like Negros Occidental and Negros Oriental which agreed to support organic agriculture. There was the establishment of the Negros Organic Island through a memorandum of agreement (MOA) between the two provinces in 2005. With this MOA, the two provinces were able to ban the entry of GMOs and living GMOs to their provinces through provincial ordinance. Similar to this case, Davao City passed the Organic Agriculture Ordinance in 2010 This city ordinance helps the prevention of field testing of GM Bt eggplant in the UP Mindanao Campus (Aruelo, 2016).

In 2012, Representative Teddy Casiño, together with other congressmen, filed a bill pushing for the mandatory labeling of GM food and food products. To date, there is no Philippine biosafety law, only biosafety regulations formed under NBF.

A study on the biosafety regulations of the Philippines concluded that the existing regulation is weak, which can be fixed through legislation such as a republic act (Richmond, 2006).

In December 2015, the Supreme Court ordered to put an end to the field testing of GMO Bt eggplant and declared Administrative Order No. 8, series of 2002 of the Department of Agriculture as null and void. This means that any actions or procedures related to GMO importations and propagation is temporarily put to stop until a new administrative order is issued in accordance with the law.

In March 7, 2016, five government agencies namely, the Department of Science and Technology, Department of Agriculture, Department of Environment and Natural Resources, Department of Health, and Department of the Interior and Local Government, passed a Joint Department Circular No. 1, series of 2016 on rules and regulations for the research and development, handling and use, transboundary movement, release in the environment, and management of the genetically modified plant and plant products derived from the use of modern biotechnology. This joint department circular paves way to issuance of new permits for planting and importing GM crops in the country.

SUMMARY

Genetic engineering is an emerging field of science. Its quests are to preserve and prolong life. In more than four decades since the first genetically modified bacteria was produced, thousands of genetically modified organisms have been created and propagated. Some are approved by experts and government authorities for human use and consumption while others are kept in institutional research laboratories subject for more experiments.

There are advantages and disadvantages in using genetic engineering in both fields of medicine and food and agriculture, there are controversies that are still debatable up to the present. The major concern of the opponents is the long-term effect of GMOs to humans while the proponents' flagship is the success stories of the GMO recipients.

There is still a long way to go for GMOs to prove itself, as humans seek answers to life's predicaments or as humans play like God.

THINK ABOUT THESE QUESTIONS

1. How would you reconcile the advantages and disadvantages that GMOs bring to humans?
2. When do you think should the pursuit of GMOs research stop?
3. Is genetic engineering a pure scientific process or it is indeed an act of humans playing like God?

ACTIVITIES

1. **Agree or Disagree.** Discuss the topics below according to your opinions. Group yourselves based on your opinions (If you agree or disagree). Within your group, prepare pointers for your discussion. After which, face the other group and start a debate.

   Topics:

   a. Use of genetically modified milk from animals for human baby consumption
   b. Economic concerns over moral issues on GM food and food products

2. **Research Work.** Write an individual research paper on the impacts of GMOs on one of the following topics:

   a. Golden Rice of the International Rice Research Institute
   b. Genetically modified organism produced by Philippine researchers
   c. Issues on Philippine biosafety policies

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LESSON

4

THE NANO WORLD

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- define nanotechnology;
- characterize nanoscale;
- describe the various uses of nanotechnology;
- discuss concerns on the use of nanotechnology; and
- explain the status of the use of nanotechnology in the Philippines.

INTRODUCTION

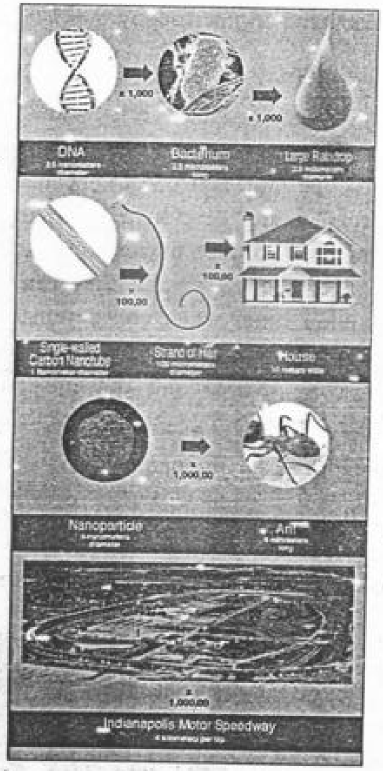
Scientific researchers have developed new technological tools that greatly improve different aspects of our lives. The use of nanoscale is one important interdisciplinary area generated by advancement in science and technology. Scientists and engineers were able to build materials with innovative properties as they manipulate nanomaterials. Indeed, research and application of knowledge on nanomaterials will continue to bring widespread implications in various areas of the society, especially health care, environment, energy, food, water, and agriculture.

Nanotechnology refers to the science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers (NNI, 2017). Nanoscience and nanotechnology employs the study and application of exceptionally small things in other areas of science including materials science, engineering, physics, biology, and chemistry (NNI, 2017).

The concepts of nanotechnology and nanoscience started in December 29, 1959 when Physicist Richard Feynman discussed a method in which scientists can direct and control individual atoms and molecules in his talk "There's Plenty of Room at the Bottom" during the American Physical Society meeting at the California Institute of Technology. The term "nanotechnology" was coined by Professor Norio Taniguchi a decade after the dawn of the use of ultraprecision machining (NNI, 2017).

How Small is a Nanoscale?

A nanometer is a billionth of a meter, or 10^{-9} of a meter. The illustration below shows how small nanoscale is compared to other particles or materials.



Manipulation of nanomaterials needs an adept understanding of their types and dimensions. The various types of nanomaterials are classified according to their individual shapes and sizes. They may be particles, tubes, wires, films, flakes, or shells that have one or more nanometer-sized dimensions. One should be able to view and manipulate them so that we can take advantage of their exceptional characteristics.

How to View Nanomaterials

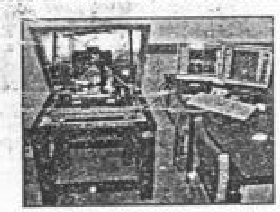
Scientists use special types of microscopes to view minute nanomaterials. During the early 1930s, scientists used electron microscopes and field microscopes to look at the nanoscale. The scanning tunneling microscope and atomic force microscope are just among the modern and remarkable advancements in microscopy.

1. Electron microscope

   German engineers Ernst Ruska and Max Knoll built the first electron microscope during the 1930s. This type of microscope utilizes a particle beam of electrons to light up a specimen and develop a well-magnified image. Electron microscopes produce higher and better resolution than older light microscopes because they can magnify objects up to a million times while conventional light microscopes can magnify objects up to 1,500 times only. Scanning electron microscope (SEM) and transmission electron microscope (TEM) are the two general types of electron microscope.

2. Atomic force microscope (AFM)

   It was first developed by Gerd Binig, Calvin Quate, and Christoph Gerber in 1986. It makes use of a mechanical probe that gathers information from the surface of a material.



3. Scanning tunneling microscope

   This special type of microscope enables scientists to view and manipulate nanoscale particles, atoms, and small molecules. In 1986, Gerd Binig and Heinrich Rohrer won the Nobel Prize in Physics because of this invention.

Nanomanufacturing

It refers to scaled-up, reliable, and cost-effective manufacturing of nanoscale materials, structures, devices, and systems. It also involves research, improvement, and incorporation of processes for the construction of materials. Therefore, nanomanufacturing leads to the development of new products and improved materials. There are two fundamental approaches to nanomanufacturing, either bottom-up or top-down (NNI, 2017):

1. Bottom-up fabrication

   It manufactures products by building them up from atomic- and molecular-scale components. However, this method can be time-consuming. Scientists and engineers are still in search for effective ways of putting up together molecular components that self-assemble and from the bottom-up to organized structures.

2. Top-down fabrication

   It trims down large pieces of materials into nanoscale. This process needs larger amounts of materials and discards excess raw materials.

There are new approaches to the assembly of nanomaterials based from the application of principles in top-down and bottom-up fabrication. These include:

- Dip pen lithography

  It is a method in which the tip of an atomic force microscope is "dipped" into a chemical fluid and then utilized to "write" on a surface, like an old-fashioned ink pen onto paper.

- Self-assembly

  It depicts an approach wherein a set of components join together to mold an organized structure in the absence of an outside direction.

- Chemical vapor deposition

  It is a procedure wherein chemicals act in response to form very pure, high-performance films.

- Nanoimprint lithography

  It is a method of generating nanoscale attributes by "stamping" or "printing" them onto a surface.

- Molecular beam epitaxy

  It is one manner for depositing extremely controlled thin films.

- Roll-to-roll processing

  It is a high-volume practice for constructing nanoscale devices on a roll of ultrathin plastic or metal.

- Atomic layer epitaxy

  It is a means for laying down one-atom-thick layers on a surface.

With the use of these techniques, nanomaterials are made more durable, stronger, lighter, water-repellent, ultraviolet- or infrared-resistant, scratch-resistant, electrically conductive, antireflective, antifog, antimicrobial, self-cleaning, among others. The abovementioned characteristics lead to the manufacture of the present variety of nanotechnology-enabled products such as tennis rackets and baseball bats to catalysts for purifying crude oil and ultrasensitive recognition and classification of biological and chemical toxins.

It is not impossible that in the near future, computers that are better, more efficient, with larger storage of memory, faster, and energy-saving will be developed. Soon, the entire memory of a computer will be saved in a single tiny chip. Moreover, nanotechnology has the potential to construct high-efficiency, low-cost batteries and solar cells.

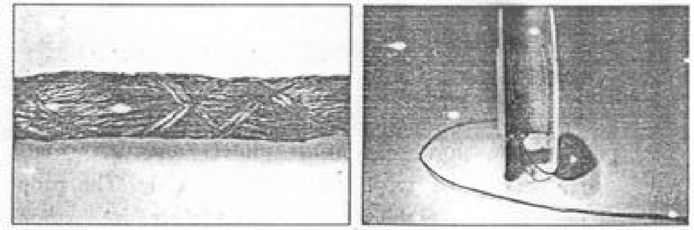


Figure 12. A product of nanomanufacturing: A 16 gauge wire, approximately 1.3 millimeters in diameter, made from carbon nanotubes that were spun into thread and the same wire on a 150 ply spool. (Source: Nanocomp).

Distinct Features of Nanoscale

Nanotechnology involves operating at a very small dimension and it allows scientists to make use of the exceptional optical, chemical, physical, mechanical, and biological qualities of materials of that small scale (NNI, 2017). The following are distinct features of nanoscale:

1. Scale at which much biology occurs.

   Various activities of the cells take place at the nanoscale. The deoxyribonucleic acid (DNA) serves as the genetic material of the cell and is only about 2 nanometers in diameter. Furthermore, the hemoglobin that transports oxygen to the tissues throughout the body is 5.5 nanometers in diameter.

   A good number of modern researches focus on advancing procedures, therapies, tools, and treatments that are more accurate and custom-made than traditional methods and cause no adverse effects on the body.

   An example of this is the bio-barcode assay, which is a fairly inexpensive approach for identification of specific disease markers in the blood despite their small number in a particular specimen.

2. Scale at which quantum effects dominate properties of materials.

Particles with dimensions of 1-100 nanometers have properties that are significantly discrete from particles of bigger dimensions. Quantum effects direct the behavior and properties of particles in this size scale. The properties of materials are highly dependent on their size. Among the essential properties of nanoscale that change as a function of size include chemical reactivity, fluorescence, magnetic permeability, melting point, and electrical conductivity.

One example is the nanoscale gold, which is not only the yellow-colored element we are used to seeing but it can also appear red or purple. Gold's electrons display restricted motion in the nanoscale. Practically, nanoscale gold particles selectively build up in tumors, where they permit both precise imaging and targeted laser destruction of the tumor while avoiding damage on healthy cells.

3. Nanoscale materials have far larger surface areas than similar masses of larger-scale materials.

As we increase the surface area per mass of a particular material, a greater amount of the material comes in contact with another material and can affect its reactivity.

If 1 cubic centimeter is filled with micrometer-sized cubes—a trillion (1012) of them, each with a surface area of 6 square micrometers—the total surface area amounts to 6 square meters, or about the area of the main bathroom in an average house. When that single cubic centimeter of volume is filled with 1-nanometer-sized cubes—1021 of them, each with an area of 6 square nanometers—their total surface area comes to 6,000 square meters.

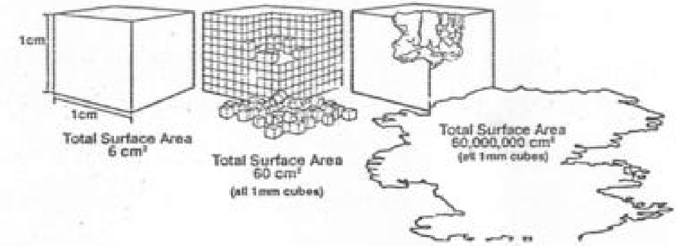


Figure 13. The Effect of the Increased Surface Area Provided by Nanostructured Materials

Government Funding for Nanotechnology in Different Countries (Dayrit, 2005)

1. U.S. National Nanotechnology Initiative
   - The best-known and most-funded program is the National Nanotechnology Initiative of the United States. The NNI was established in 2001 to coordinate U.S. federal nanotechnology R&D. The NNI budget in 2008 and 2009 were $1.4 billion and $1.5 billion, respectively.
2. European Commission
   - In February 2008, the EC officially launched the European Nanoelectronics Initiative Advisory Council (ENIAC).
3. Japan (Nanotechnology Research Institute, under the National Institute for Advanced Industrial Science and Technology, AIST)
4. Taiwan (Taiwan National Science and Technology Program for Nanoscience and Nanotechnology)
5. India (Nanotechnology Research and Education Foundation)
6. China (National Center for Nanoscience and Technology)
7. Israel (Israel National Nanotechnology Initiative)

8. Australia (Australian Office of Nanotechnology)
9. Canada (National Institute for Nanotechnology or NINT)
10. South Korea (Korea National Nanotechnology Initiative)
11. Thailand (National Nanotechnology Center or NANOTEC)
12. Malaysia (National [Malaysia] Nanotechnology Initiatives or NNI)

Possible Applications of Nanotechnology in the Philippines (Dayrit, 2005)

1. ICT and semiconductors
2. Health and medicine
3. Energy
4. Food and agriculture
5. Environment

Nanotech Roadmap for the Philippines (funded by PCAS-TRD-DOST)

1. ICT and semiconductors
2. Health and biomedical
3. Energy
4. Environment
5. Agriculture and food
6. Health and environmental risk
7. Nano-metrology
8. Education and public awareness

Benefits and Concerns of Using Nanotechnology

Nanotechnology has various applications in different sectors of the society and environment. Salamanca-Buentello et al. (2005) proposed an initiative called "Addressing Global Challenges Using Nanotechnology" to accelerate the use of nanotechnology to address critical sustainable development challenges. They suggested a model that could help figure out the possible contributions of the community in overcoming global challenges that pose risk on health and other aspects of peoples' lives. However, there are concerns that need to be addressed before using and promoting materials derived from nanotechnology (Dayrit, 2005).

1. Nanotechnology is not a single technology; it may become pervasive.
2. Nanotechnology seeks to develop new materials with specific properties.
3. Nanotechnology may introduce new efficiencies and paradigms which may make some natural resources and current practices uncompetitive or obsolete.
4. It may be complicated to detect its presence unless one has the specialist tools of nanotechnology.

Table 2. Benefits and Concerns of the Application of Nanotechnology in Different Areas

Example of Areas Affected by Nanotechnology	Possible Benefits	Concerns
Environment	• Improved detection and removal of contaminants • Development of benign industrial processes and materials	• High reactivity and toxicity • Pervasive distribution in the environment • No nano-specific EPA regulation

Health	• Improved medicine	• Ability to cross cell membranes and translocate in the body • No FDA approval needed for cosmetics or supplements
Economy	• Better products • New jobs	• Redistribution of wealth • Potential cost of cleanups and healthcare • Accessibility to all income levels

(Source: University of Washington, n.d.)

Social and Ethical Considerations in Conducting Research on Nanotechnology

1. Who will benefit from it? On the other hand, who won't?
2. For whom and what are your objectives for developing your product?
3. How will it affect social, economic, and political relationships?
4. What problem is your "product" trying to solve?
5. Who will have access to it? Who will be excluded?
6. Are there dangers involved with its development (e.g., safety, health, pollution)? How can you minimize them?
7. Who will own it? How can you assure access to it?

(Source: University of Washington, n.d.)

SUMMARY

Nanotechnology is an advanced interdisciplinary field that encompasses science and technology that manufactures materials of great help to the improvement of various areas of society especially health care, environment, energy, food, water, and agriculture. It is a field that

needs to be explored, not only by known experts but also neophytes, in order to advance our knowledge of science and technology, and more importantly, to help improve our quality of life. But, before we engage in nanotechnology, we need to take into account the social, ethical, and environmental concerns of using such nanomaterials.

THINK ABOUT THESE QUESTIONS

1. What are nanomaterials and how are they made?
2. What are the factors that need to be considered before manufacturing materials through nanotechnology?
3. What are the contributions of nanotechnology for the improvement and sustainability of our environment?

ACTIVITIES

1. **Creative Work.** Illustrate or design a product or output that is made up of nanomaterials you want to create. Explain the raw materials that make up your product, the steps involved for developing your product, and the specific use of the final product. What is the significance of your output for the society?
2. **Philosophical discussion.** Form groups made up of five to eight members and discuss the impact of nanotechnology in various aspects (health, environment, economy, ethics, etc.) of the society. Share your own ideas and principles in relation to the topic. Encourage everyone to participate.
3. **Portfolio.** Conduct a research on the recent innovations or advancements in nanotechnology in different countries. Cut out pictures and provide descriptions. Show and discuss your output in class.

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LESSON

5 THE ASPECTS OF GENE THERAPY

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- describe gene therapy and its various forms; and
- assess the issue's potential benefits and detriments to global health.

INTRODUCTION

Medical science has detected many human diseases related to defective genes. These types of diseases are not curable by traditional methods like taking readily available medicines. Gene therapy is a potential method to either treat or cure genetic-related human illnesses.

In 2015, a team of researchers at the Harvard Medical School and the Boston Children's Hospital stated that they were able to restore basic hearing in genetically deaf mice using gene therapy. The Boston Children's Hospital research team also reported that they have restored a higher level of hearing—down to 25 decibels which is actually equivalent to a whisper. They used an improved gene therapy vector developed at the Massachusetts Eye and Ear that was identified as "Anc80" which enables the transfer of genes to the inaccessible outer hair cells when introduced into the cochlea (Fliesler, 2017).

Human gene therapy was actually first realized in 1971 when the first recombinant DNA experiments were planned. It can be simply viewed as insertion foreign DNA into a patient's tissue that hope to successfully eradicate the targeted disease. It was actually inspired by the success of recombinant DNA technology which occurred over the last 20 years. Without a doubt, gene therapy is the most promising yet possibly unfavorable medical field being studied.

The Basic Process

There are several approaches to gene therapy. These are the following (Fliesler, 2017):

- Replacement of mutated gene that causes disease with a healthy copy of the gene
- Inactivation of a mutated gene that is functioning improperly
- Introducing a new gene into the body to help fight a disease

In general, a gene cannot be directly inserted into a human gene or cell. A gene is inserted into another gene using a carrier or vector. At present, the most common type of vectors are viruses that have been genetically changed to carry normal human DNA. Viruses have evolved a way of encapsulating and transporting their genes to human cells in a pathogenic manner (Science Daily, 2017).

Two Types of Gene Therapy

The idea of gene therapy is based on correcting a disease at its root; fixing the abnormal genes that appear to lead to certain diseases.

There are essentially two forms of gene therapy. One of which is called somatic gene therapy. Somatic gene therapy involves the manipulation of genes in cells that will be helpful to the patient but not inherited to the next generation (Nimsergern, 1988).

The other form of gene therapy is called germ-line gene therapy which involves the genetic modification of germ cells or the origin cells that will pass the change on to the next generation (Your Genome, 2017).

Stem Cell Gene Therapy

Stem cells are mother cells that have the potential to become any type of cell in the body. One of the main characteristics of stem cells is their ability to self-renew or multiply while maintaining the potential to develop into other types of cells. Stem cells can become cells of the blood, heart, bones, skin, muscles, brain, among others. There are different sources of stem cells but all types of stem cells have the same capacity to develop into multiple types of cells.

Stem cells are derived from different sources. Two of which are embryonic and somatic stem cells.

The embryonic stem cells are derived from a four- or five-day-old human embryo that is in the blastocyst phase of development. The embryos are usually extras that have been created in IVF (in vitro fertilization) clinics where several eggs are fertilized in a test tube then implanted into a woman (Crosta, 2013).

The somatic stem cells are cells that exist throughout the body after embryonic development and are found inside of different types of tissue. These stem cells have been found in tissues such as the brain, bone marrow, blood, blood vessels, skeletal muscles, skin, and the liver. They remain in a non-dividing state for years until activated by disease or tissue injury. These stem cells can divide or self-renew indefinitely, enabling them to generate a range of cell types from the originating organ or even regenerate the entire original organ. It is generally thought that adult or somatic stem cells are limited in their ability to differentiate based on their tissue of origin, but there is some evidence to suggest that they can differentiate to become other cell types (Crosta, 2013).

The Bioethics of Gene Therapy

There are ethical issues involved in gene therapy. Some of the inquiries cited are (Genetics Home Reference, 2017):

1. How can "good" and "bad" uses of gene therapy be distinguished?
2. Who decides which traits are normal and which constitute a disability or disorder?

3. Will the high costs of gene therapy make it available only to the wealthy?

4. Could the widespread use of gene therapy make society less accepting of people who are different?

5. Should people be allowed to use gene therapy to enhance basic human traits such as height, intelligence, or athletic ability?

Another controversy involves the germline therapy. As discussed, germline therapy is genetic modification of germ cells that will pass the change on to the next generation. There are a lot of questions on the effects of the gene alteration to the unborn child and the next generation, since the alteration can be passed on. In the United States, the government does not fund researches on human germline gene therapy.

SUMMARY

Gene therapy is a method that may treat or cure genetic-related human illnesses. There are two forms of gene therapy. One is somatic gene therapy which involves the manipulation of genes in cells that will be helpful to the patient but not inherited to the next generation. The other is germline gene therapy which involves the genetic modification of germ cells or the origin cells that will pass the change to the next generation.

There are many ethical issues on gene therapy. Some of these issues are about questions on whose authority or power to decide which human traits should be altered; other concerns are on the discriminatory effects of those who may not or cannot avail gene therapy.

THINK ABOUT THESE QUESTIONS

1. Would you subject yourself for gene therapy without its 100% assurance of effectiveness or future negative side effects?
2. Should gene therapy be limited to medical concerns only or could it be used for aesthetic purposes?

ACTIVITIES

1. **Flow chart.** Make a flow chart of the basic process of gene therapy. Explain each part of the process. You may use references for your guide.
2. **Concept mapping.** Using a Venn diagram, differentiate the two forms of gene therapy.
3. **Debate.** Have a debate on the bioethical issues on gene therapy.

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LESSON

6 CLIMATE CHANGE

LESSON OBJECTIVES

At the end of this lesson, the students should be able to:

- identify the causes of climate change;
- understand the effects of climate change on the society; and
- illustrate how the community helps in mitigating the hazards caused by climate change.

INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC), a United Nations body that evaluates climate change science, released its report on global climate change. The report's important conclusions were the following: world's climate has changed significantly over the past century; the significant change has human influence; using climate models and if the trend continues, the global mean surface temperature will increase between 1°C and 3.5°C by 2100.

Why should a few degrees of warming be a cause for a concern? According to experts, global climate change could have a greater potential to change life in our planet than anything else except a nuclear war. These changes will also lead to a number of potentially serious consequences.

But first, what is climate change? Climate change refers to the statistically significant changes in climate for continuous period of time. Factors that contribute to climate change can be natural internal process,

external forces, and persistent anthropogenic changes in the composition of the atmosphere or in land use. It can also be due to natural occurrences or contributed by acts of human beings.

This lesson will present the causes of climate change and its effects on the society.

Causes of Climate Change

The causes of climate change could be natural or by human activities.

Natural Causes

Volcanic Eruptions

Volcanic eruptions are one of the natural causes of climate change. When volcanoes erupt, it emits different natural aerosols like carbon dioxide, sulfur dioxides, salt crystals, volcanic ashes or dust, and even microorganisms like bacteria and viruses. The volcanic eruption can cause a cooling effect to the lithosphere because its emitted aerosol can block a certain percentage of solar radiation. This cooling effect can last for one to two years.

What happens in violent volcanic eruptions is the release of ash particles in the stratosphere. The volcanic ashes which have sulfur dioxide combine with water vapor. It then forms to sulfuric acid and sulfurous aerosols. The sulfurous aerosols then are transported by easterly or westerly winds. Volcanoes located near the equator are more likely to cause global cooling because of the wind pattern. Volcanoes located near to north or south poles are less likely to cause cooling because of pole wind pattern, the sulfurous aerosols are confined in pole area.

There are several recorded major volcanic eruptions that cause climate change. Mount Tambora of Indonesia erupted in 1816. It was considered as the largest known eruption in human history. The eruption caused snowfall in the northeastern United States and Canada. It affected their agricultural lands, losing crops that caused food shortage and increased human mortality. The eruptions of Mount Krakatau of Indonesia in 1883 and Mount Pinatubo of the Philippines in 1991 contributed, too, to the cold years of planet Earth.

Orbital Changes

Earth's orbit can also cause climate change. This was proposed by the Milankovitch theory. The Milankovitch theory states "that as the Earth travels through space around the Sun, cyclical variations in three elements of Earth-Sun geometry combine to produce variations in the amount of solar energy that reaches Earth (Academic Emporia, 2017).

The three elements that have cyclic variations are eccentricity, obliquity, and precession.

Eccentricity is a term used to describe the shape of Earth's orbit around the Sun. The impact of the variation is a change in the amount of solar energy from perihelion (around January 3) to aphelion (around July 4). The time frame for the cycle is approximately 98,000 years (Academic Emporia, 2017). Currently Earth's eccentricity is 0.016 and there is about a 6.4% increase in insolation from July to January (Academic Emporia, 2017). Academic Emporia (2017) states, "The eccentricity influences seasonal differences: when Earth is closest to the Sun, it gets more solar radiation. If the perihelion occurs during the winter, the winter is less severe. If a hemisphere has its summer while closest to the Sun, summers are relatively warm."

Obliquity is the variation of the tilt of Earth's axis away from the orbital plane. As this tilt changes, the seasons become more exaggerated. The obliquity changes on a cycle taking approximately 40,000 years. Academic Emporia (2017) states "the more tilt means more severe seasons—warmer summers and colder winters; less tilt means less severe seasons—cooler summers and milder winters."

Precession is the change in orientation of Earth's rotational axis. The precession cycle takes about 19,000 to 23,000 years. Precession is caused by two factors: a wobble of Earth's axis and a turning around of the elliptical orbit of Earth itself (Academic Emporia, 2017). Obliquity affected the tilt of Earth's axis, precession affects the direction of Earth's axis. The change in the axis location changes the dates of perihelion (closest distance from Sun) and aphelion (farthest distance from Sun), and this increases the seasonal contrast in one hemisphere while decreasing it in the other hemisphere (Academic Emporia, 2017). Currently, Earth is closest to the Sun in the Northern Hemisphere winter, which makes the winters there less severe (Academic Emporia, 2017). Another consequence

of precession is a shift in the celestial poles. Five thousand years ago, the North Star was Thuban in the constellation Draco. Currently, the North Star is Polaris in the constellation Ursa Minor.

During the 1940s and 1950s, the theory fell into disrepute due to radiocarbon dating, indicating a lag in cooling versus insolation and to a scale problem with high frequency glacial advances (Academic Emporia, 2017). The theory was revived several times throughout the late 1960s to the present (Academic Emporia, 2017).

The Carbon Dioxide Theory

Carbon dioxide (CO_2) is added when power and heat are produced by burning coal, oil, and other fossil fuels. Carbon dioxide is transparent to sunshine but not invisible to infrared (heat) radiation leaving the ground. Carbon dioxide absorbs part of the infrared radiation in the air and returns it to the ground keeping the air near the surface warmer than it would be if the carbon dioxide did not act like a blanket. Doubling the carbon dioxide raises the temperature to 2°C to 3°C.

Human Activities

Human activities contribute to climate change. The largest known contribution comes from the burning of fossil fuels, which releases carbon dioxide gas to the atmosphere. Greenhouse gases and aerosols affect climate by altering incoming solar radiation and outgoing infrared (thermal) radiation that are part of Earth's energy balance. Changing the atmospheric abundance or properties of these gases and particles can lead to a warming or cooling of the climate system. Since the start of the industrial era (about 1750), the overall effect of human activities on climate has been a warming influence. The human impact on climate during this era greatly exceeds that due to known changes in natural processes, such as solar changes and volcanic eruptions. Human activities result in emissions of four principal greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and the halocarbons (a group of gases containing fluorine, chlorine, and bromine). These gases accumulate in the atmosphere, causing concentrations to increase with time (www.c02now.org).

The greenhouse gases mentioned are natural gases. However, the high level of these gases in the atmosphere contributes to the greenhouse effect. The increasing amount of these gases is due to human activities. High level of carbon dioxide comes from fossil fuel use in transportation; and the building, heating, cooling, and manufacture of cement and other goods. Deforestation releases carbon dioxide and reduces its uptake by plants. High methane emission is related to agriculture, natural gas distribution, and landfills. High nitrous oxide is also emitted by human activities such as fertilizer use and fossil fuel burning. Halocarbon gas concentrations have increased primarily due to human activities. Principal halocarbons include the chlorofluorocarbons (e.g., CFC-11 and CFC-12) which were used extensively as refrigeration agents and in other industrial processes before their presence in the atmosphere was found to cause stratospheric ozone depletion. The abundance of chlorofluorocarbon gases is decreasing as a result of international regulations designed to protect the ozone layer (The Encyclopedia of Earth, 2016).

Ozone is another greenhouse gas that is continually produced and destroyed in the atmosphere by chemical reactions. In the troposphere, human activities have increased ozone through the release of gases such as carbon monoxide, hydrocarbons and nitrogen oxide, which chemically react to produce ozone.

Halocarbons released by human activities destroy ozone in the stratosphere and have caused the ozone hole over Antarctica. While water vapor is the most abundant and important greenhouse gas in the atmosphere, human activities have only a small direct influence on the amount of atmospheric water vapor. Indirectly, humans have the potential to affect water vapor substantially by changing climate. For example, a warmer atmosphere contains more water vapor. Human activities also influence water vapor through CH_4 emissions, because CH_4 undergoes chemical destruction in the stratosphere, producing a small amount of water vapor, and aerosols, the small particles present in the atmosphere with widely varying size, concentration, and chemical composition. Some aerosols are emitted directly into the atmosphere while others are formed from emitted compounds. Aerosols contain both naturally occurring compounds and those emitted as a result of human activities. Fossil fuel and biomass burning have increased aerosols containing sulphur compounds, organic compounds, and black carbon (soot). Human activities such as surface mining and industrial processes have increased dust in the atmosphere

(IPCC, 2007). On September 16, 1986, an international treaty was adapted. It is called the Montreal Protocol. The treaty aimed to regulate the production and use of chemicals that contribute to Ozone layer depletion (Britannica, 2017).

Effects of Climate Change on Society

Climate change could cause severe affects to all life forms around our planet. It direct affects the basic elements of people's lives like water, food, health, use of land, and the environment.

With the average global temperature which is predicted to rise by 2 to 3°C within the next fifty years, glaciers will continue to melt faster. Melting glaciers will increase flood risks during the wet season and strongly reduce dry-season water supplies to one-sixth of the world's population, predominantly in the Indian subcontinent, parts of China, and the Andes in South America. Declining crop yields due to drought, especially in Africa, are likely to leave hundreds of millions without the ability to produce or purchase sufficient food. At mid to high latitudes, crop yields may increase for moderate temperature rises (2 to 3°C), but then decline with greater amounts of warming. Ocean edification, a direct result of rising carbon dioxide levels, will have major effects on marine ecosystems, with possible adverse consequences on fish stocks (Stern, 2007).

Climate change will increase worldwide deaths from malnutrition and heat stress. Vector-borne diseases such as malaria and dengue fever could become more widespread if effective control measures are not in place. Rising sea levels may result in more flooded areas each year with a warming of 3 or 4°C. There will be serious risks and increasing pressures for coastal protection (Stern, 2007).

Ecosystems will be particularly vulnerable to climate change, with one study estimating that around 15–40% of species face extinction with 2°C of warming. The consequences of climate change will become disproportionately more damaging with increased warming. Higher temperatures will increase the chance of triggering abrupt and large-scale changes that lead to regional disruption, migration, and conflict. Warming may induce sudden shifts in regional weather patterns like the monsoons or the El Niño. Such changes would have severe consequences for water availability and flooding in tropical regions and threaten the livelihood of billions. Melting or collapse of ice sheets would raise sea levels and eventually threaten at least 4 million km^2 of land, which today is home to 5% of the world's population (Stern, 2007).

SUMMARY

Climate change is a worldwide issue that we have to face. Climate change is referred as statistically significant climate variation persisting for an extended period of time. The continuous climate change could bring drastic effects to living and nonliving forms on Earth.

Climate change is brought by several factors like natural processes and persistent human activities. Global warming is one of the major effects of climate change. Global warming threatens all life forms on Earth. It has drastic effects on water availability, food source, health issues, land use, and ecosystem.

THINK ABOUT THESE QUESTIONS

1. What significant contribution can individuals make in response to climate change?
2. Is climate change preventable?
3. What should be the significant contribution of the society as well as the government in mitigating the hazards caused by climate change?

ACTIVITIES

1. **Group Work.** Each group will create an infomercial showing how the community can help mitigate the hazards caused by climate change.
2. **Individual Work.** Create an advocacy campaign by making a poster via social media that tells about how the community will help mitigate the hazards caused by climate change.

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