Stewardship of the Biosphere

An Interactive Qualifying Project

Submitted to the Faculty of the

WORCESTER POLYTECHNIC INSTITUTE

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Degree of Bachelor of Science

By

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Abstract

We are part of Earth's biosphere, the thin and fragile living layer whose beauty inspires us and whose resources succor us. The environment of the biosphere consists of the lithosphere, hydrosphere and atmosphere, in simple words the land, sea and sky. What physical conditions of this cosmic cocoon enable life to develop and flourish? As exploiters of Earth's resources, what is our impact on these conditions? How might we manage our industry and consumption to promote a healthy, robust biosphere? In this IQP students will research and explore answers to these and other questions. Team members will employ perspectives spanning the sciences from physics to biology to global affairs, to understand the foundational physical conditions and the relationships between these "parameters of life" and our ubiquitous conduct. Students will also develop a website, videos and animations illuminating their findings and advancing "Stewardship of the Biosphere".

Website: https://sites.google.com/site/stewardsofthebiosphere/

Acknowledgements

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1 Introduction

This section will cover the history of the Biosphere, its evolution, the Biosphere today, and the questions to be answered throughout this paper!

1.1 What is the Biosphere?

The Earth is one feat of nature that has puzzled the minds of its inhabitants to this day. Through science, we have been able to uncover the secrets of the Earth, but most of it is yet to be observed or understood. The universe is 13.73 ± 0.12 billion years old (Plait, 2013) while the Earth is only 4.54 billion years old (CAIN, 2013), thus the Biosphere has been evolving and incessantly changing and adapting for approximately 4 billion years.

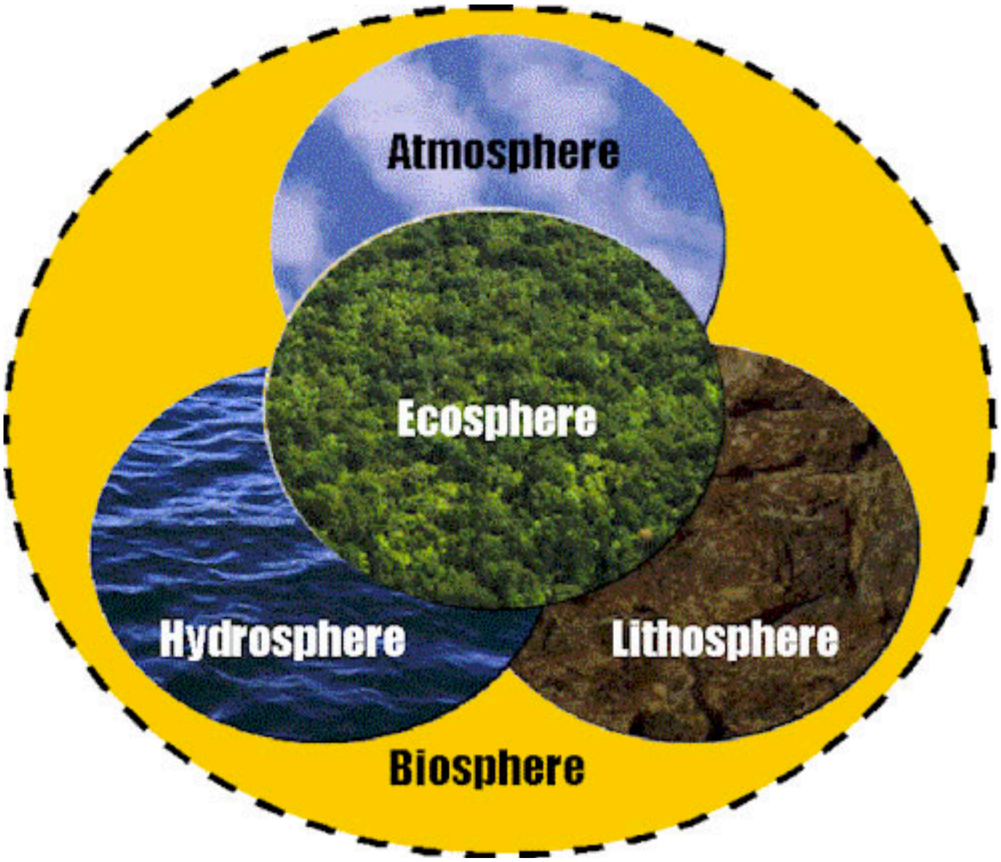

Figure 1: The biosphere is composed of three regions, the Atmosphere, the Lithosphere, and the Hydrosphere.

The biosphere is a core concept within Biology and Ecology, where it serves as the highest level of biological organization. The Biosphere is a layer of the planet Earth where life is in existence and also sustained. It can also be defined as a closed and self-regulating system where all life can be found on Earth (NASA, 2012). The total surface area of the Biosphere is about 197,000,000 square miles. Approximately 75% of this is covered in water. The other 25% is divided primarily into seven major landmasses or continents. On each of these continents exists the various necessities of life, including air, water, soil, and food. However, the ecosystems that are able to survive and produce on each continent vary widely (Zoky, 2010).

The Biosphere has evolved since the first single-celled organisms originated about 3.5 billion years ago. These early organisms survived under atmospheric conditions resembling those of our neighboring planets Mars and Venus, which have atmospheres composed primarily of carbon dioxide. Billions of years of primary production by plants released oxygen from this carbon dioxide and deposited the carbon in sediments, eventually producing the oxygen-rich atmosphere we know today. Free oxygen, both for breathing (O_2, respiration) and in the stratospheric ozone (O_3) that protects us from harmful UV radiation, has made possible life as we know it while transforming the chemistry of earth systems forever (Mesquita, 2013).

There are three main physical parts of the Biosphere, the atmosphere, the lithosphere, and the hydrosphere. The three sections of the Biosphere are essential to the existence of the Biosphere; without one of the sections, the Biosphere would be very different or even nonexistent. The atmosphere, the lithosphere, and the hydrosphere all contain the essential necessities of the Biosphere: most organisms can be found living comfortably in the boundaries of the three sections of the Biosphere, with the exception of most aquatic organisms.

The Atmosphere

The Atmosphere is the smallest region of the Biosphere. The Earth is massive enough for its gravity to retain a pretty sizable atmosphere, which is just a layer of gasses surrounding the planet. The atmosphere has a mass of about 5 x 10^{18} kg but there is no defined boundary between itself and outer space; however, about ¾ of its mass is about 11 x 10^{3} meters from the lithosphere (Mesquita, 2013). The further you head from the lithosphere headed towards space, the atmosphere gets thinner and thinner; thus its ability to support life is limited to the proximity between it and both the lithosphere and the hydrosphere.

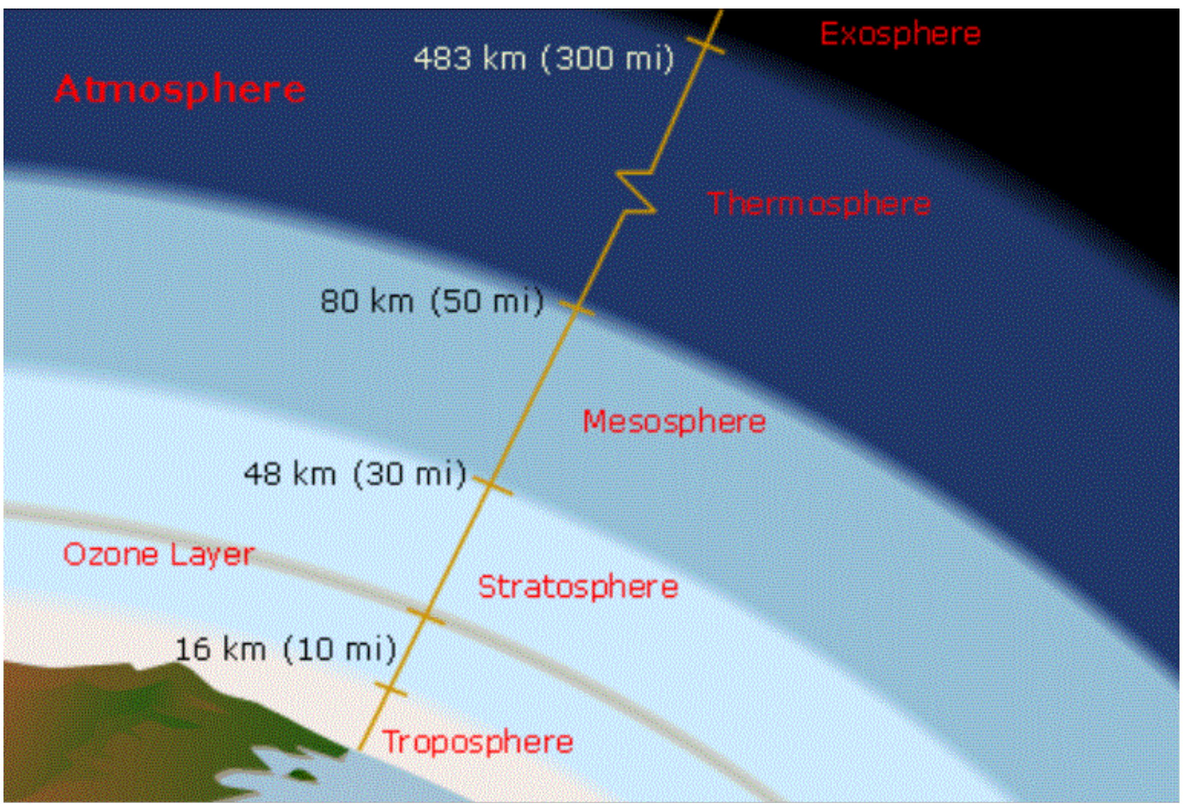

Figure 2: This illustration shows several layers that are part of the Atmosphere. The approximate thickness of the layers is shown but it's not the same worldwide (Pacific Island Travel, 2012).

The common name given to the atmospheric gases used in breathing and photosynthesis is air. The atmosphere contains about 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. Water vapor is also mixed in with the other prominent gases in the atmosphere, on average around 1%.

The atmosphere is more essential to the Biosphere than the other regions due to its location with respect to the other spheres. Cyanophyta is a phylum of bacteria that can be found in almost all terrestrial and aquatic habitats; they obtain their energy through photosynthetic processes. These photosynthetic bacteria evolved the ability to produce oxygen as a gas, a byproduct of photosynthesis. Through photosynthetic processes, the atmosphere changed dramatically from a reducing one to an oxidizing one, which lead to the near extinction of the Oxygen-intolerant organisms. According to the endosymbiotic theory, the chloroplasts found in plants and eukaryotic algae evolved from cyanobacteria ancestors via endosymbiosis. The creation of the modern Biosphere as can be observed today is due to the reactions that occurred and are still ongoing primarily in the atmosphere.

The Lithosphere

Through years of studies, there is a theory that has emerged that claims that 250 million years ago; all of the Earth's landmasses were connected in one large plate called Pangea (CDE, 2009). The lithosphere can be divided into two subsections, the oceanic lithosphere, and the continental lithosphere. The oceanic crust is characterized with the oceanic crust and is located primarily in the oceans basins. The continental lithosphere is associated with the continental crust and is found primarily on the boundary between the lithosphere and the atmosphere. The oceanic lithosphere is typically 50,000– 100,000 meters thick, while the continental lithosphere is 40,000 – 200,000 meters thick (Geological Society, 2009).

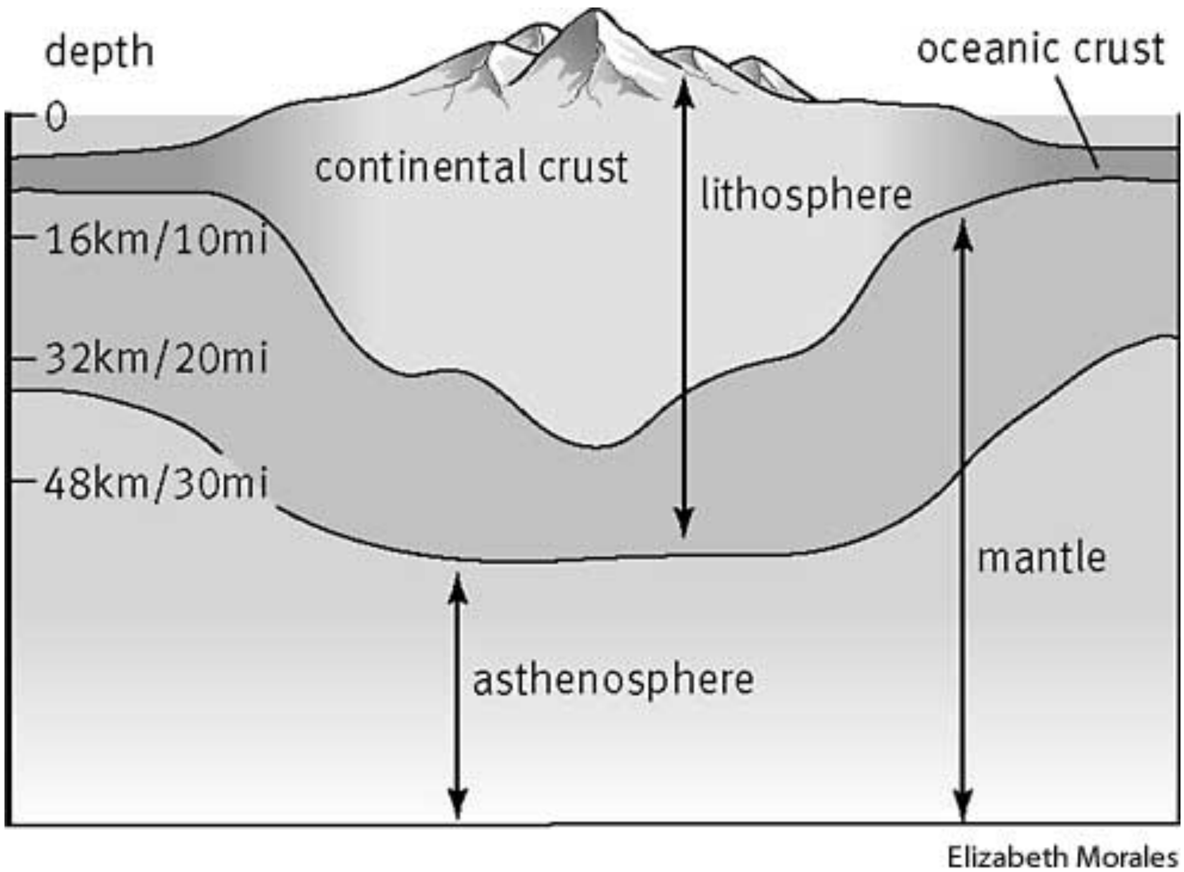

Figure 3: The lithosphere is an essential part of the Biosphere (Morales).

The lithosphere as a sphere of the Biosphere is not self sufficient in supporting the organisms that inhabit it, but in conjunction with both the atmosphere and the hydrosphere, the Biosphere becomes complete. Organisms on the lithosphere rely on the air from the atmosphere or the dissolved air and food in the water from the hydrosphere. The lithosphere is also an essential region of the Biosphere due to its invaluable resources that promote life cycles that drive the closed and self-regulating life system on Earth. Some of these life cycles include the carbon cycle and the nitrogen circle, which are very essential for plant, animal and microorganism life on Earth.

The carbon cycle is a continuous series of events in the Biosphere that traces the usage and production of carbon in the environment. Carbon is a part of rocks, air and even the ocean. The carbon journey starts with plants whereby they take carbon and energy from the sun and other nutrients in order to produce their own food and grow. The carbon then decomposes upon the plants death, or is consumed by animals for nutrients. The carbon that ended up in the soil as it decomposes serves as nutrients for other plants, or as fossil fuels. The carbon that was consumed by animals will eventually end up as fossil fuel. The animals always produce carbon dioxide through respiration. The fossil fuels will be used to power factories and move cars and carbon monoxide will be a byproduct of the process. Thus, through respiration and the use of fossil fuels, the carbon is forced into the atmosphere where plants can continue the indefinite cycle (The University Corporation For Atmospheric Research, 2013).

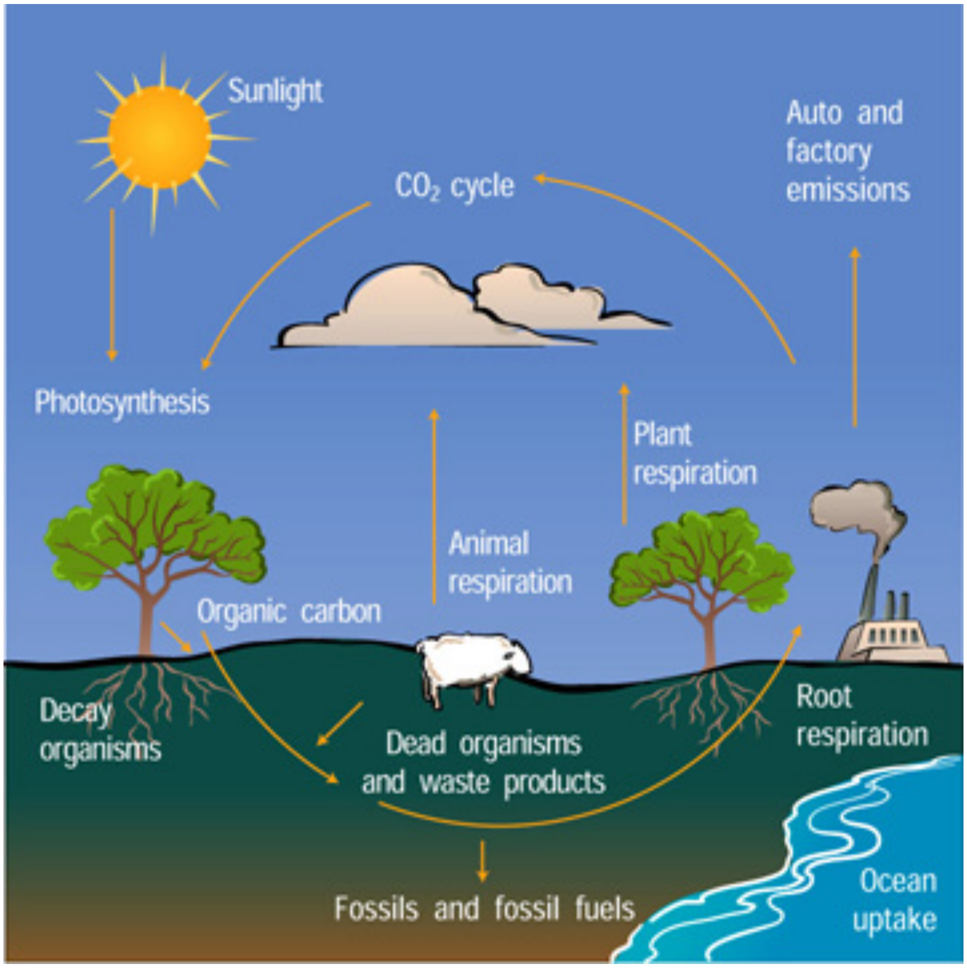

Figure 4: The carbon Cycle (The University Corporation For Atmospheric Research, 2013).

The nitrogen cycle is also an important cycle in the Biosphere. Nitrogen is about 80% of the air that animals breathe but the nitrogen inhaled is not used in that form. Most of the animal's body nitrogen needs are met through the food that it consumes. The nitrogen cycle begins with nitrogen fixing bacteria. These bacteria could also coexist symbiotically with plants such as bean plants and other legumes. All of these bacteria fix nitrogen, either in the form of nitrate or in the form of ammonia. Most plants can take up nitrate and convert it to amino acids. Animals acquire all of their amino acids when they eat plants or other animals that feed on plants. When plants or animals die or release waste, the nitrogen is returned to the soil. The usual form of nitrogen returned to the soil in animal wastes or in the output of the decomposers, is ammonia. There are nitrite bacteria in the soil and in the water, which take up ammonia and convert it to nitrite. Nitrite is somewhat toxic, but another type of bacteria, nitrate bacteria, will take nitrite and convert it to nitrate, which can be taken up by plants to continue the cycle. There are denitrifying bacteria, which take the nitrate and combine the nitrogen back into nitrogen gas where the cycle started.

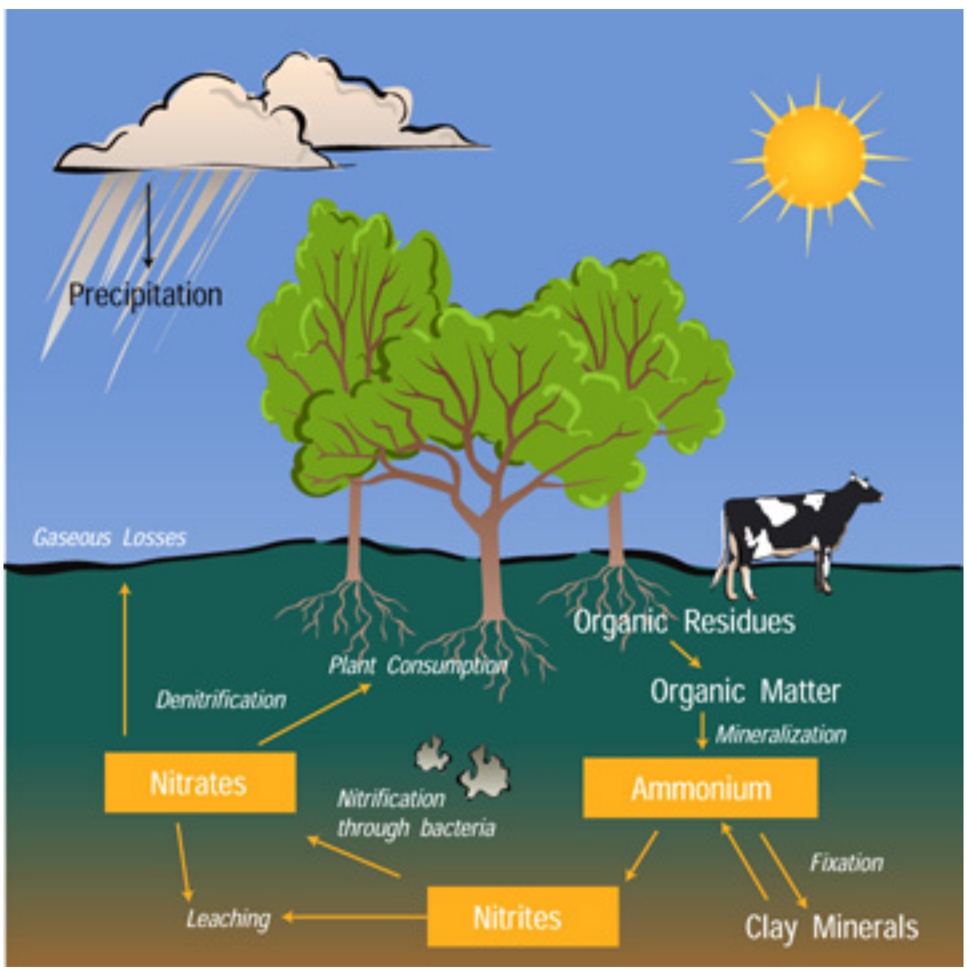

Figure 5: The Nitrogen Cycle (The University Corporation For Atmospheric Research, 2013).

The Hydrosphere

The hydrosphere is the liquid portion of the Biosphere that includes the oceans, seas, lakes, ponds, rivers, streams, glaciers, and more. The hydrosphere is key to the beginning and survival of the Biosphere since all life cycles begun in the hydrosphere. The total mass of the Earth's hydrosphere is about 1.4×10^{18} tonnes, which is about 0.023% of the Earth's total mass (United States Geological Survey, 2011). The hydrosphere, like the atmosphere, is always in motion. The motion of rivers and streams can be easily seen, while the motion of the water within lakes and ponds is less obvious. Some of the motion of the oceans and seas can be easily seen while the large scale motions that move water great distances such as between the tropics and poles or between continents are more difficult to see. These types of motions are in the form of currents that move the warm waters in the tropics toward the poles, and colder water from the Polar Regions toward the tropics. These currents are called trans-continental currents and they exist on the surface of the ocean and at great depths in the ocean, up to about 4000 meters.

The hydrosphere shares a boundary with both the atmosphere and the lithosphere, which affects the way the hydrosphere is changing. The motion of the atmosphere, wind, affects the oceans currents above it. The energy in the wind gets transferred to the ocean at the ocean surface affecting the motion of the water there. The effect of wind is largest at the ocean surface. The ocean serves two main purposes in the Earth's climate system. First, it is a large reservoir of chemicals that can contribute to the greenhouse effect in the atmosphere and energy absorbing about 90% of the solar radiation, which hits the surface. This reservoir changes very slowly limiting how fast the climate can change. Second, it works with the atmosphere to redistribute the energy received from the sun such that the heat in the topics, where a lot of energy is received from the sun, is transferred toward the poles, where heat is generally lost to space.

Figure 6: This image shows the boundary between all three regions of the Biosphere. The Hydrosphere covers about 70% of the total Earth's surface (University of Indiana, 2009).

1.2 Concerning the Biosphere!!

The Earth's Biosphere is a very diverse and unique place in the Universe. This is the only known and confirmed location in the observable Universe that has life of assorted natures. Knowing this, the first thought that should be of concern is the preservation of this miracle of science. But as it has been observed through the history of the Earth, the health of the Biosphere has passed the period of maximum robustness and it is on a decline in its effectiveness to provide for the living system it provides for. The Biosphere was introduced as a closed and self-regulating system, but once nature cannot regulate itself, there is bound to be trouble.

During the period of the evolution of the living beings that inhabit the Earth, there have been an impact on the environment, but one organism seems to be the most destructive. Humans have evolved for a long time and in the past millennia, the biosphere has been changed dramatically. There have been reports of whole savannahs in North Africa that have become deserts due to over grazing and climate change, big mountains have been curved, ecological systems have been separated and even killed in order to make our lives better. Humans are not the only cause of the Earth's environmental deterioration, but their actions have sped up the process to a whole new level!

This report will strive to answer very basic questions about the human impact on the environment, and offer viable solutions that would help rectify the damage done to the Biosphere!

2 Pollution in the Biosphere

Pollution is the presence in or introduction into the environment of a substance or thing that has harmful or poisonous effects (Pineda, 2013). There are three main types of pollution in the Biosphere; those are air, water, and land pollution.

Air Pollution

Air pollution is a type of pollution that is observable in real time. Most people are familiar with the dramatic changes that came about at the beginning of the industrial revolution in the early 1800s. During this time, a lot of manufacturing plants sprung up and the burning of fossil fuels for energy created tons of carbon dioxide as a waste product. Carbon dioxide is one of the greenhouse gasses. The amount of carbon dioxide and other green house gasses in the atmosphere increased dramatically. Greenhouse gasses are very efficient at trapping heat from the environment and also from the sun, thus the biosphere will become warmer. There are warnings from scientists that study the affects of the warming of the planet and it's alarming. If the Earth as a whole gets a little warmer, on average, some plants and animals will no longer be able to grow or survive and that will be a real disaster (Natural Resources Defence Council, 2012).

There are also some types of pollution that go unnoticed. Farming is a great feat for humans and it has become necessary for survival. However, there have been studies that have been conducted in Europe about over farming or rather having too many livestock at one location or region. Livestock are like most animals on Earth, they excrete waste that is rich in methane. Methane just happens to be one of the greenhouse gasses, thus leading to global warming.

Global warming is another effect of pollution that has had dramatic consequences over the last decade to half century. Most of the water present on Earth is either frozen or in the ocean. As once can imagine, global warming warms the planet and thus melting some of the water that has been stored in glaciers and ice caps at an un-natural and alarming rate. This leads to rising water levels, the disturbance in the gulf streams, change in the marine life, and ultimately change in the seasons and even weather.

Gulf streams are the ocean currents that travel along the longitude lines. The Gulf Stream primarily takes the warm water from the equator and takes it to both the North Pole and the South Pole and in the same instance; it takes the cold water from the North and South Pole and takes them towards the equator. This water cycle helps maintain the equilibrium regional temperatures around the globe and create monsoon winds in conjunction with solar energy.

Water Pollution

Water pollution is also a prominent type of pollution. In the absence of laws and regulations that could control the pollution of the waters as we have today in majority of the countries in the world, the industrial revolution saw the beginning of large scale pollution (Natural Resources Defence Council, 2012). As factories and plants generated finished products ready for suppliers and consumers, they also ended up with a lot of byproduct. The only logical way, at the time, to get rid of the waste was to dump it into a river and let the current take it to the ocean, where it really wouldn't matter. Most of these byproducts were full of chemicals and nutrients that promoted bacteria growth, and thus most bodies of water they emptied out to became polluted with rapid and innumerable algae growth.

Figure 7: A river filled with green algae (Wikipedia).

Technological Pollution

There are inestimable ways that humans continue to pollute the Biosphere even after finding out about their impact on it. Humans have come to rely on technology and that needs energy, thus in an effort to provide for this indirect need, the Biosphere has seen its share of abuse through pollution. The lithosphere has been exploited for fossil fuels in the form of coal and oil. The mining of oil and coal has left the lithosphere very damaged and the ecosystems have been destroyed.

Technological advances in our modern society mean that the society can do more than our capability in the past. It also means that society have a great responsibility to make sure that its errors are do not lead to the deterioration of the environment. It can also be said that the better the technology, the worst the pollution. In the past half-century, there have been multiple oil spills and nuclear meltdowns. These are not just regular pollutions of the Biosphere; they affect a very large portion of the environment. The BP Oil spill of 2010 had a huge impact that it also affected humans directly like no other pollution has done. There were wildlife dying, migrations interrupted, and food sources that were shut off. Thus technology of the future has a huge price for progress!!

Figure 8: The BP Oil Spill of 2010 (Cocuzza, 2013).

3 Viable Solutions to the Human Energy Dependence

This section of this report will strive to provide energy sources that will aid the endeavor to save the Biosphere. The main goal is to start leaning towards clean and safe sources of energy.

3.1 Solar Energy

The sun is and has always been the most versatile source of energy for the Planet. Solar radiation warms our atmosphere, provides energy for photosynthetic plant and bacterial life, and it the central basis of our life on Earth. Harnessing the energy of the sun has been very inefficient in the past due to inefficient technology, but as technology evolves we become more and more efficient. New solar cells as well as solar thermal plants will allow for lighter, cheaper, and more efficient collection and storing of the sun's energy.

The human population in the Biosphere consumes about 15 – 18 Terawatts of power per year while the sun transmits about 101,000 terawatts of power onto the earth every year (Transportation and Energy, 2013). In a recent study, they came to the conclusion that the Earth absorbs more energy in one hour than the population could use in a whole year. There are a variety of ways to harvest solar energy form the sun such as solar fields/ plants in the deserts and in the oceans, and also individual usage. The world's desert area is about 90,000 square kilometers and given that about 90 percent of the human population lives next to a desert, this is a sustainable solution. In theory, it would require less than 1 percent of the available land area in Africa and the Middle East to supply the entire world with clean power (Solar Renewable Energy, 2003). Currently, an average person consumes about 300 -500 watt hours per year of energy through transportation, heating and other daily activities. By using an efficient individual plan, just 20 square meters of solar power plant could provide enough power for the individual for an entire year (Solar Renewable Energy, 2003).

Applications of the solar technology are endless to say the least. There are many modalities of solar technology with many being discovered and researched today. With the advancement of solar technology, our houses could be covered with solar cells such that we wouldn't require an external source of power ever, assuming the sun keeps on shining!! The current solar technology markets are looking to improve the solar cells efficiency such that many of the energy from the sun would not be lost to heating or reflection. As an incentive, the United States Department of Energy awarded Dow Solar $12.8 Million in 2011 to develop the next generation breakthrough building integrated solar cells.

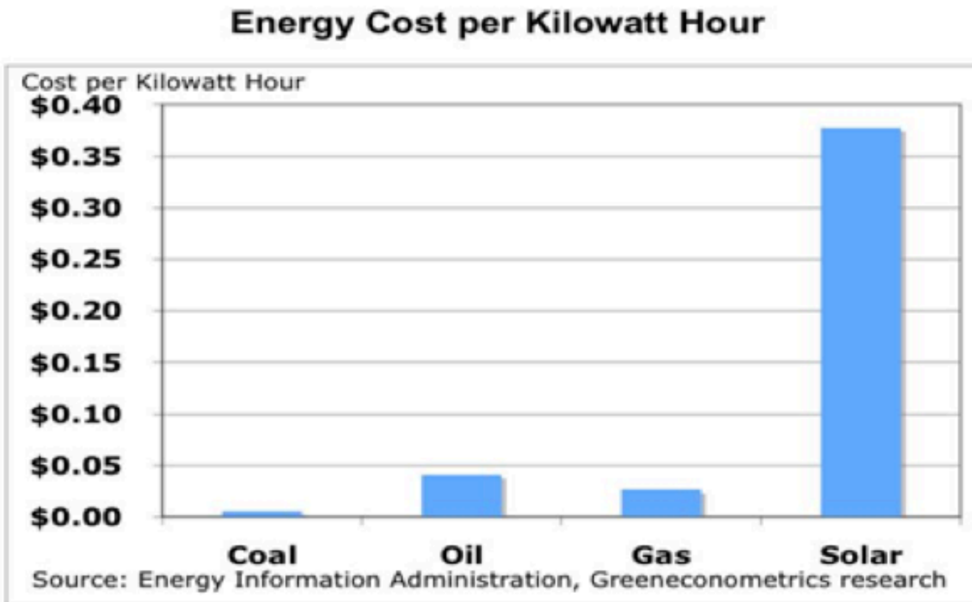

Figure 9: This chart demonstrates how cheap solar energy is as compared to the leading energy sources at the moment (Papundits World Press).

This technology can also be advanced from homes to vehicles, phones and much more.

Figure 10: Solar power plant (Papundits World Press).

3.2 Nuclear Energy

Nuclear energy has received a negative attitude from most who know of the current arms race between the current World's Powers since they are familiar with nuclear warheads that are used as weapons. But the topic is broader than that. Nuclear power is both dangerous and essential in the universe. Nuclear fission occurs every single second in the most prominent objects in the night sky, the stars (Physics of the Stars, 2002). Our sun has billions of nuclear fission going on within it in so that it can continue to shine bright. Nuclear energy is also a sustainable source of power but it does have high risks with its implementation. The current worldwide nuclear power production makes up about 6% of the global power generation and about 13% of the global electricity production. Most of these nuclear facilities are centered on 3 countries, the United States, France, and Japan. As of August 2011, there were 432 reactors and 65 more under construction and their total production amounts to about 428,699 Mega Watts (Nuclear Power Plants Worldwide, 2012). The projected reduction of nuclear power plants after 2015 assumes more decommissioning and termination of active reactors than construction of new ones (World Nuclear Association, 2011).

In fact, a properly functioning nuclear power plant actually releases fewer radioactive byproducts into the atmosphere than a coal-fired power plant. According to the Nuclear Energy Institute, the power produced by all of the world's nuclear plants would normally be 2 billion metric tons of CO_2 per year if they solely depended on fossil fuels. All of this comes with a light fuel requirement. Nuclear fission produces roughly a million times more energy per unit weight than fossil fuel alternatives.

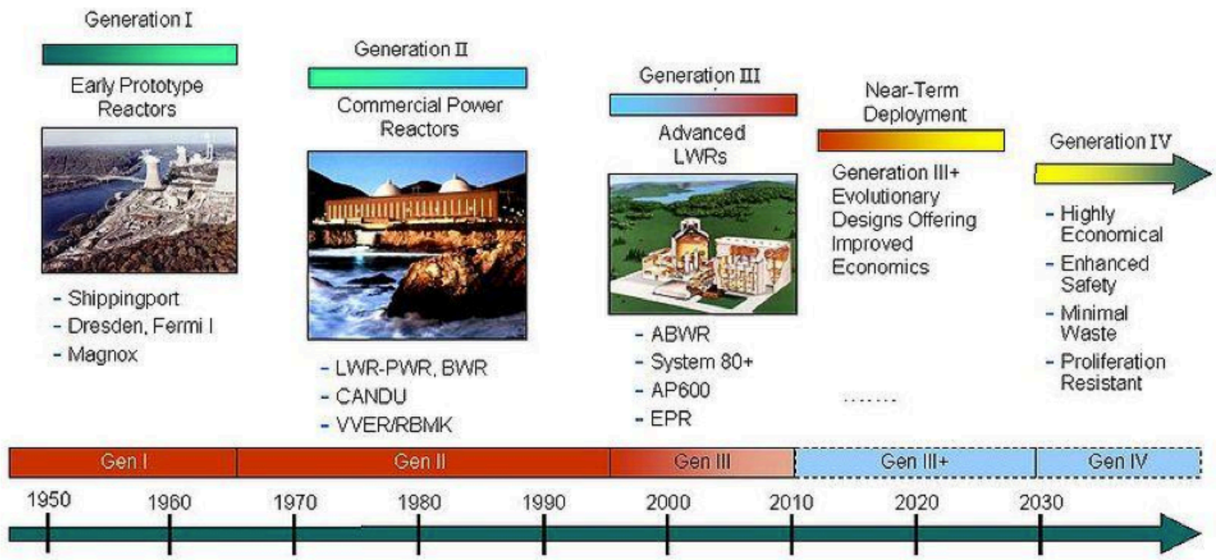

Figure 11: Nuclear fission reactors have been categorized by their main features into 4 generations, starting from the earliest models in the 1950s to the current reactors and future models (Jan Leen Kloosterman, TU-Delft, 2012).

The limiting problems that arise with the use of nuclear reactors are the management of both the raw materials and the byproducts. The operation of the nuclear reactor requires products that are naturally radioactive, which is harmful and a prolonged exposure can be lethal. Nuclear power plants also produce a great deal of low-level radioactive waste in the form of radiated parts and equipment. Over time, spent nuclear fuel decays to safe radioactive levels, but this process takes tens of thousands of years. Even low-level radioactive waste requires centuries to reach acceptable levels. Currently, the nuclear industry lets waste cool for years before mixing it with glass and storing it in massive cooled, concrete structures. This waste has to be maintained, monitored and guarded to prevent the materials from falling into the wrong hands. All of these services and added materials cost money, on top of the high costs required in building a plant.

With the government's intervention to make sure that all rules and regulations are adhered to, Nuclear energy could be used cleanly and cost effectively.

3.3 Wind Energy

Wind energy is another modality of indirect solar energy since the sun heats the planet, the heat in one location diffuses into other locations in an effort to obtain equilibrium, and thus the wind is created. Wind energy is not reliable if observed instantaneously compared to other forms of obtaining energy but on average it is very reliable and it competes with some of the top energy production methods.

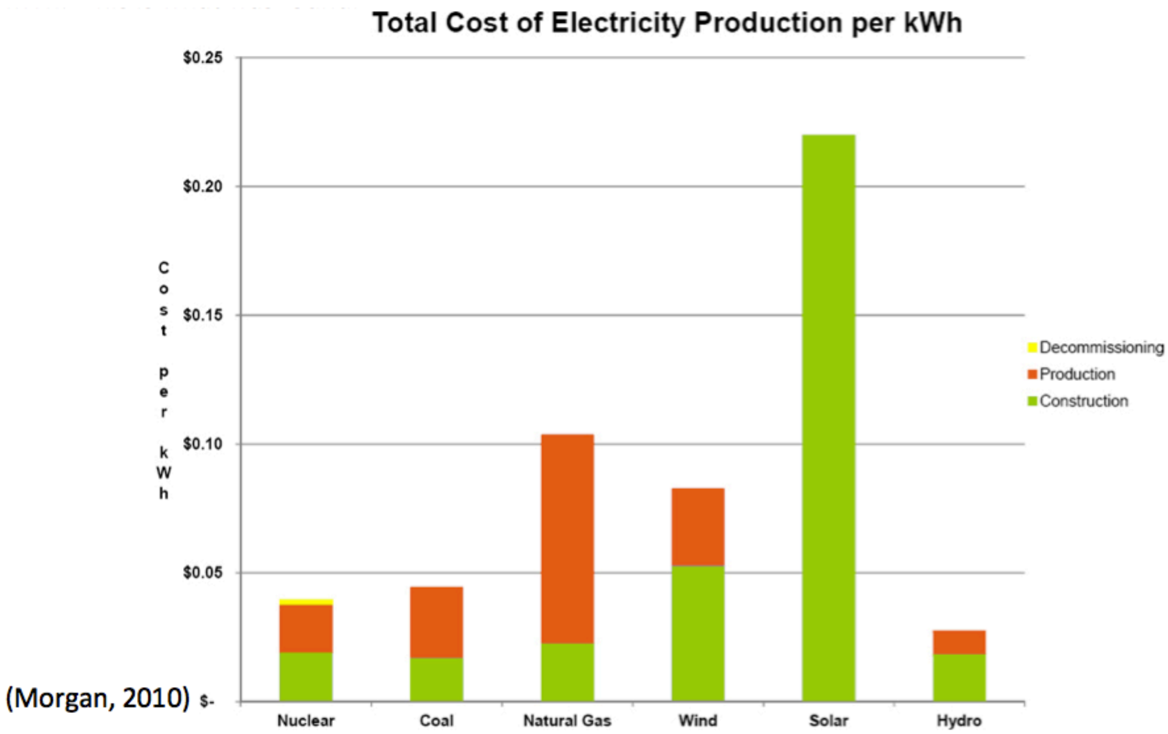

Figure 12: Wind energy is relatively cost efficient compared to some of the top methods of obtaining energy (Morgan, 2010).

Scientists and engineers are working on creating far more efficient blades in order to capture the maximum amount of energy for a given breeze. It makes sense that the more wind blowing by a turbine, the more energy it will produce, so for maximum efficiency, a good location to set up the turbine is required. Wind energy is very clean and there are no unknown hazards associated with its implementation.

There have been complaints that there is noise pollution in the proximity of the turbines but that seems to be false as shown below:

Jet engine at takeoff	140 decibels
Ambulance siren	120 dB
Chainsaw	110 dB
Power Hand Drill	98 dB
Tractor	96 dB
Hair Dryer / Power Lawn Mower	90 dB
Normal conversation	60 dB
Wind turbine	50 dB
Whisper in ear	30 dB

As shown, the wind turbine's noise pollution is between a whisper in the ear and a normal conversation, thus it is not much of pollution. The researchers have also pointed out that the noise is almost always diluted by the noise created by the wind.

3.2 Other Types of Energy

Geothermal Energy

Geothermal energy is a clean form of energy that produces a good amount of energy in its lifetime. Geothermal energy comes from the heat that is stored in the Earth's crust that is released by drilling a vent and capturing the steam energy to turn turbines and make energy. The availability and feasibility of drilling geothermal wells makes it difficult to rely on them for long-term usage.

Hydroelectric Energy

Hydroelectric energy is one the most widely used forms of energy production in the globe. The cost of this form of energy generation is relatively low, making it a competitive source of renewable electricity. This form of Energy generation relies on dams to trap water and upon their release, to turn turbines that produce electricity. This form of energy generation is widely used globally and also accepted socially, thus there is no need to overly promote it here.

4 The Future of the Project

This Interactive Qualifying Project has a lot of future applications that would greatly benefit the Stewardship of the Biosphere. I was able to provide a written report of my findings and a website showcasing the Biosphere during the given time. I developed an animation showing the water cycle on the earth but due to lack of knowledge, it stands unfinished and in need of furnishing. There is still more to be done in order to alert humans the dangers of not taking care of the Biosphere.

Some ideas on what can be done include, posters to put around the campus and in the Libraries, some short presentations at colleges and the local libraries, more animation development, more video development, building a three dimensional stand that could perform simple tasks and show how the biosphere works, and more.

5 The project Experience!

This was one of the first major Projects that I had the opportunity to do at Worcester Polytechnic Institute (WPI). I was very happy at the beginning of the project since I knew that at the end of the IQP, I would be able to add this to my resume that I had worked on a project at WPI. The project started on the A-term of my junior year and we had a total of three people working on this project, titled "The Stewards of the Biosphere." During our weekly meetings, we would present a minimum of 10 slides that were focused on facts and ongoing research of the Biosphere. The Biosphere is a very big place, thus we never ran out of anything to write or present. Before the meeting, I personally would watch YouTube videos on the biosphere and environmental topics, read some journals from the New York Times and other notable sources. After watching and reading, I would make a list of topics to research online and then during the week research a topic and make a slide for it in preparation for the upcoming Meeting Presentation.

At first we gave good ideas of what this project would entail for us, what was attainable and what wasn't. We thought of creating a robot that would showcase the processes in the Biosphere while a presenter or a recorded voice would explain what was happening; but this turned out to be too advanced since none of the current team members had any experience in the mechanical machining or the robotics area. From this point the focus became presenting the idea to on campus students, a public presentation at places such as the Museum of Science, and a local town's public library. We were each tasked with obtaining contacts and permission to present as these locations but it was hard to get an approval to do something that was not a finished product; most of the times, the contact would ask for references, sample of work, and an abstract of what we had in mind but we had to tell them that it was in the making, thus they would advice us to get a finished product first then contact them. For the first two terms, we did research and archived our research.

There were some complications with some of the group members. The leader of the group was never really reliable and would sometime show up to the meeting without any research done or anything to present and that proved to be frustrating when it happened. At the end of A-term, I gave a write up to the leader for her to integrate her work since we had worked on different sections of the paper. At the beginning of B-Term, I was alerted by our IQP advisor, Professor Frank Dick, that nothing had been submitted and that we had failed the first term of the IQP. This was very infuriating but we still persevered since there was time to catch up. In B-Term I did the same thing; I gave the leader my section and told her that she must submit it and if not I would do it myself. I was then surprised to find out that the group leader had dropped the IQP and that she would be working on a different project. To make it worse, the leader never submitted my paper for which I followed up on early C-Tem by submitting it but it was too late and I failed B-Term too.

The next couple of days I was very infuriated; I contemplated finding another IQP out of anger but I caught myself with the help of out advisor I decided that I could manage it myself. I wrote a proposal of what I planned to do for both A and B Term and we continued to hold meetings and presentations in his office. Since it was now going to be mostly me working on the project, the focus changed dramatically and we chose to go with making a website which would include applets, animations and information about the Biosphere. Web design is really complicated so Professor Dick procured the services of IT representative from the Library, James Monaco and he coached us through the web design project. He was able to show us the basics of using Adobe Photoshop and Adobe Premier in order to create an animation. The more defined the animation got, the more complicated it became to make it.

In both C and D Term, I spent some times with James Monaco and some grad students who were willing to help me out in the Library. Learning Adobe Photoshop and Premier was fun but I needed results thus I spent most of the time learning and using it than actually doing research. As a "Steward of the Biosphere," it is our duty to advertise the Biosphere and making the animation seemed to be the best way to go about it. In D Term, I was also late on my paper and thus I required an extra Term to complete the IQP. In the last term of this IQP, I focused more on writing a decent paper, and making the website much better. I also managed to recruit one student, Diego Adrianzen: class of 2014, Management Engineering, who in D-Term went to Puerto Rico to work on a Water Shed, a very important part of the Biosphere. He volunteered to have me interview him and put it in the Website.

The Website can be found at the following link:

https://sites.google.com/site/stewardsofthebiosphere/

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