

Energy Flow in the Earth's Systems



“No opposite can be known without its opposite.” -Rumi

Presence and lack. Form and formlessness. Abundance and poverty. Knowledge and doubt. The world's design is built around the existence of dualities. The Earth's multiple systems are no exception to this rule- they are designed to be dependent on the presence or absence of energy.

In this chapter, we will explore the different forms of energy and their multiple uses.

First Dimension : Analytical Thinking

SCIENTIFIC UNDERSTANDING

The Earth's living and non-living systems are all connected in one way or another. All living things have likely shared the same carbon, nitrogen, and oxygen atoms at some point in time. All organisms, no matter how large or tiny, use a form of energy and recycle matter.

Most types of energy found on our planet are RENEWABLE. These forms of energy can be used again and again and are continuously replaced. Examples of renewable resources are solar energy, wind energy and water energy.

Some types of energy are known as NON-RENEWABLE. These resources are those that cannot be replenished in the foreseeable future. Fossil fuels such as coal, oil, and natural gas fall into this category. Millions of years ago, carbon-containing organisms died, sank to the bottom of oceans, and were converted into coal, oil, and natural gas. Coal is the product of terrestrial plants that decom-



posed 300 million years ago. This black substance is used to fuel power plants and industrial factories. Oil and natural gas are the products of decomposing microscopic sea plankton. These resources are used to make petroleum products.

Reserves of non-renewable resources are dwindling. It is strange how human civilisation has opted for the most limited resources to power most industries although other forms of renewable energy are much more abundant.

There are many forms of energy available on our magnificent planet. We will explore six of these energy sources below. The first of these- Solar Energy- is the most abundant. Solar energy is energy from the sun that is produced through the fusion of hydrogen nuclei. Solar energy is a type of renewable energy- by design, it is unlimited.



The second type of energy is Wind Energy. Wind Energy is produced when air that is heated by solar energy expands, resulting in a drop of pressure and the formation of a low-pressure region. Wind is the motion of air towards this low-pressure region from other higher-pressure sites. Wind Energy is a renewable form of energy.

The third type of energy is Hydroelectric Energy. Hydroelectric energy is the potential energy of water at higher elevations. This energy is commonly used in the world to generate electricity at hydroelectric power plants. Another form of energy associated with water is wave energy. This vast resource is used to generate electricity, but it is not commonly utilized since it is not economical. All forms of energy that are associated with water are considered renewable resources.

The difference between a renewable and non-renewable information



<https://youtu.be/nKgeTvQWZaI>

The fourth type of energy – Biomass Energy- is the energy produced millions of years ago by the bodies of decomposing organisms. It comes in the form of fossil fuels such as coal, oil, or natural gas. Remember, this type of energy is labeled as non-renewable- meaning its sources are limited.

The fifth type of energy is Nuclear Energy. Nuclear energy is the energy in the nucleus, or the core of an atom. The nuclear energy produced by the fission of uranium atoms is enormous and is utilised by nuclear power plants to produce electricity. This form of energy is non-renewable.

Another type of renewable energy is Geothermal Energy. In the last chapter, we discovered how the hot lava in a volcano can be utilised as a source of geothermal energy to fuel power stations. Geothermal energy is produced when radioactive elements in the Earth's core slowly decay. Since this type of decay never stops, geothermal energy can be considered renewable.

The Law of Conservation

The Law of Conservation states that energy cannot be created or destroyed. Energy can only be changed from one form to another. Your physical form is an example of this. When you bite into a juicy apple, the energy stored in that apple is transferred to your cells, where it is used for energy or to make other macromolecules.

All living organisms are connected to each other and to non-living matter. An ecosystem is a group of interdependent living and non-living matter.

Ecosystems and the Law of Conservation

The Law of Conservation is most evident when exploring ecosystems. The energy that enters an ecosystem travel through it and is changed to other forms of energy. For example, light energy from the sun is converted to chemical energy in plants in the process of photosynthesis which is then transferred to birds that eat the plants.

“The nuclear energy produced by the fission of uranium atoms is enormous and is utilised by nuclear power plants to produce electricity.”

What is nuclear energy?



<https://youtu.be/Ta3z3pGK0vU>

Birds store some of the chemical energy they consume in their bodies (potential chemical energy), use some of it for movement (kinetic energy) and making sounds (sound energy) and release some of it as heat (heat energy). Energy is never lost- it simply converted from one form to another.

It is important to note that when one organism feeds off another organism, there is ALWAYS heat energy lost in the process.

Food chains and food webs

Energy is transferred from one organism to another in an ecosystem in paths called trophic levels. Look at the figure below. You can see that the first trophic level of any food chain is called the Producer. The second is the Primary Consumer, the third is the Secondary Consumer and the third trophic level is called the Tertiary Consumer.

Remember, since heat energy is always lost in the movement of energy from one form to another, the organisms at each trophic level are **never** 100% efficient at energy transfer. With each ascending level, more energy is lost as heat, and through respiration and movement. This is the reason why our food chains cannot be longer than four or five levels in length.



Producers (Autotrophs)

These are organisms that are designed to utilise the Sun's energy and use it to make chemical energy. They include all plants and photosynthetic prokaryotic organisms.



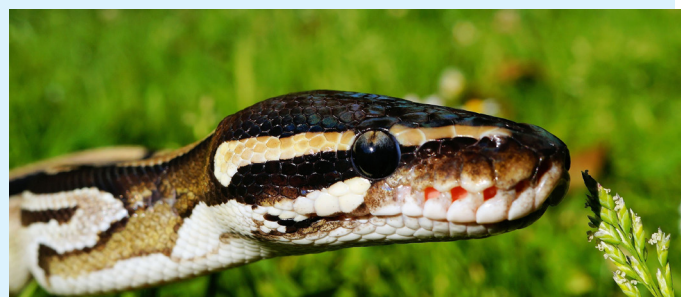
Primary Consumers

These organisms are **herbivores**- organisms that feed exclusively on plants or photosynthetic prokaryotic organisms.



Secondary Consumers

These organisms are those that feed on Primary Consumers and are called carnivores.



Tertiary Consumers

These organisms are those that feed on Secondary Consumers and are also **carnivores**.

Amazing Scientific Facts

-Energy Flow in the Earth's Systems-

1.

Did you know that bubble gum is manufactured using a petroleum product obtained from the crude oil refining process?

2.

Did you know that the world's largest wind turbine is in Hawaii? It is 20 stories high and has spinning blades that are as long as a football field!

3.

Did you know that installing a small wind turbine in your garden can provide enough electricity to power your home entirely?

4.

Did you know that it takes only one gallon of oil to pollute one million gallons of water? Oil spills can have a disastrous effect on marine life.

Second Dimension : Analogical Thinking

Humans have attempted to produce what they have named 'clean energy' for the future by mimicking the process of photosynthesis. As we have learned in Chapter 8, photosynthesis is the process by which plants are designed to convert solar energy to chemical energy.

The aim of Artificial Photosynthesis (AP) is to split water into its components- oxygen and hydrogen- and use the hydrogen as a fuel. Whereas the process of photosynthesis in plants generates oxygen and glucose, AP produces hydrogen and oxygen. The hydrogen that is produced can then be used to fill the fuel cells of electric cars. Solar energy is stored in the chemical bonds between the hydrogen molecules.

The main advantage of using hydrogen as a fuel is that it is lighter than other chemical batteries.

Although AP has not been developed for large-scale use, if scientists manage to

make an artificial leaf capable of artificially photosynthesising on a large scale, then this process can potentially replace fossil fuels and the harmful environmental effects associated with their combustion.

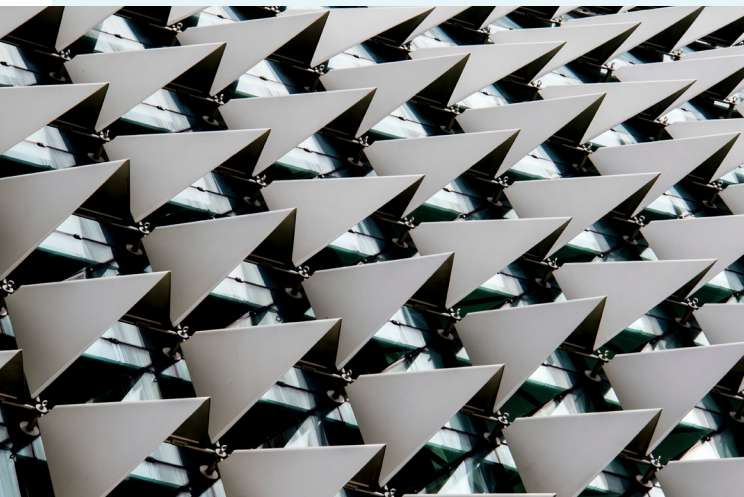
Artificial Photosynthesis can also be used in other industries such as pharmaceuticals and in the production of plastic.

Artificial photosynthesis, like many other man-made inventions, is a form of **biomimicry**.

Learning from leaves: Going green with artificial photosynthesis



<https://youtu.be/VK-dULEK-rc?t=2>



Bio-mimicry is a term used to describe any method that attempts to solve a human problem by copying or adapting methods from nature. Other examples of biomimicry include wind turbines modeled after the fins of humpback whales and self-cleaning solar panels modeled after the lotus flower.

An interesting form of biomimicry called Grid Swarm Technology (GST) was developed by a clean energy company called Encycle. This innovation was inspired by observing the social behaviour of bees that are, by design, experts at communication and coordination.

Normally, electrical equipment in commercial and residential buildings is designed to function individually. Electrical devices in buildings are usually set on different thermostats (or timers) and are not linked with one another in any shape or form. The concept underlying GST relies on creating a wireless network among electrical appliances within a building to allow them

to assess and coordinate their energy consumption. Individuals who install this technology on their properties are potentially able to save 5 to 10 per cent of their energy expenses per annum.

Another form of biomimicry relates to the flying behaviour of geese. Copying the V-formation of migrating geese, planes can increase their fuel efficiency. This concept is based on the reduction in wind resistance that occurs when planes follow a lead plane in a V formation. This is called wake surfing and has helped companies like Boeing and NASA cut down on their engine fuel costs.

“ Copying the V-formation of migrating geese, planes can increase their fuel efficiency.”



<https://vaeec.org/biomimicry-and-energy-efficiency/>



Third Dimension : Critical Thinking

We have just learned about the Earth's energy systems and can now see that the living and non-living systems are inexorably linked. We have also learned that energy has been designed to be converted from one form to another and discovered how the law of conservation has been programmed to make sure energy levels remain in check.

The Earth's inbuilt recycling systems such as the Nitrogen, Carbon and Water Cycles have been designed to be dependent on the Earth's energy systems. It is difficult to consider the trillions of atoms within the Nitrogen, Carbon and Water Cycles without considering the fact that they are drawn to the ground by the actions of the gravitational pull. Similarly, it is impossible to consider the Rock Cycle without linking its individual components to all

the other systems that recycle various atoms and molecules throughout the Earth such as carbon, nitrogen and water.

If we ponder on the law of conservation that states that energy cannot be created or destroyed, we can see that the energy is continuously being recycled on the micro and macro level.

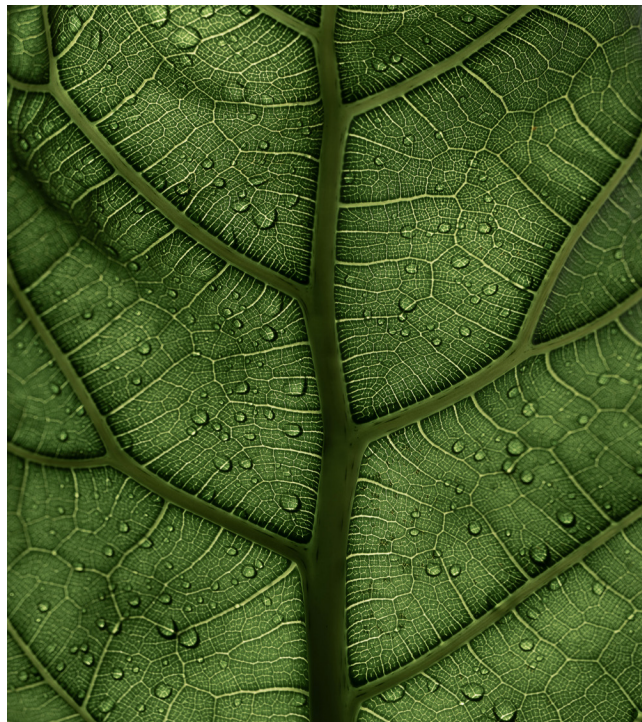
The law of conservation applies to physical matter as well as energy. As impossible as it may seem, it is quite likely that the atoms that made up the body of an Asian woman in the 1920s can be found in the body of a person living in America a century later today. In fact, we occupy multiple physical bodies in our lifetime. Our physical selves change multiple times as we age over the years when our cells die and are replaced by new ones.

Comparing Photosynthesis to Artificial Photosynthesis (AP)

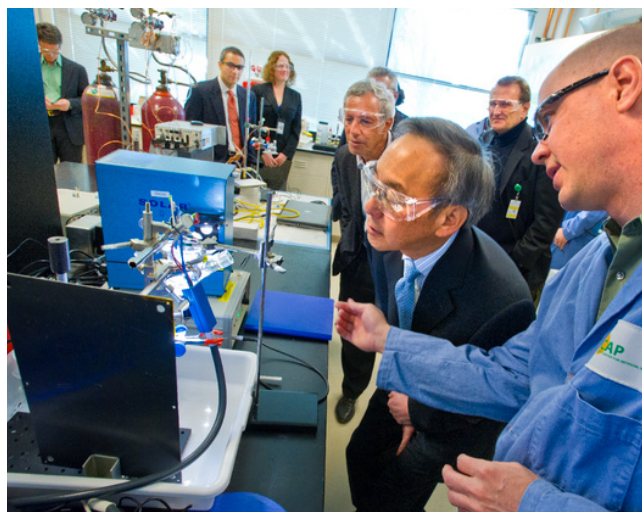
Let us see now see how energy production in artificial photosynthesis compares to photosynthesis in nature.

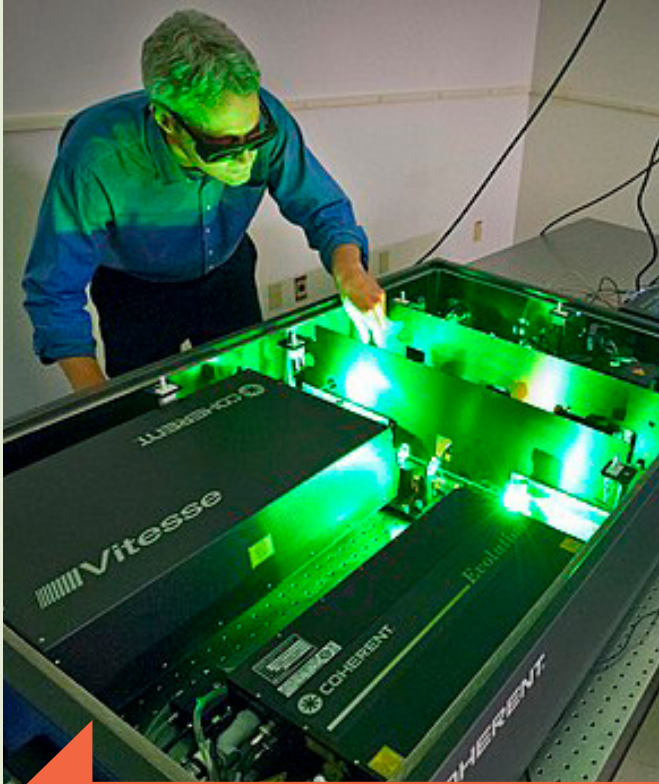
In nature, a plant's leaves absorb carbon dioxide from the air while its roots absorb water from the soil. Light energy from the sun then triggers the process of photosynthesis. This involves a number of different organelles in the plants' cells like chloroplasts and enzymes. At the end of this process, water is split into its oxygen, hydrogen, and free electrons. The electrons and hydrogen are combined with the carbon dioxide molecules to make a sugar -glucose- and the glucose is used for energy consumption by the plant. The oxygen is released back into the environment where is it taken up by other living organisms and recycled in many different ways through the Earth's multiple cycling systems. Remember, oxygen is an essential component of molecules involved in the Nitrogen cycle, Water cycle and the Carbon Cycle.

To mimic photosynthesis in the lab, scientists need to know how much energy is required to split a water molecule. It has been found that 2.5 Volts are needed to be exact. To create an artificial leaf, scientists need to use a catalyst to combine with light energy- such as light-sensitive cobalt oxide or manganese.



“Let us see now see how energy production in artificial photosynthesis compares to photosynthesis in nature.”





Artificial Photosynthesis

In AP, scientists have to use a combination of structural lead, nanowires and two different catalysts to create an artificial photosynthesising leaf. The surface of the man-made leaf contains nanowires to capture carbon dioxide, water, and light energy. First, light energy is used to stimulate the electrons found in a catalyst, triggering a reaction that divides the water molecules into protons and oxygen atoms. The oxygen is released into the air while the protons are moved through another membrane along with carbon dioxide. With the aid of another catalyst, carbon dioxide is then combined with the protons to yield the prized product—hydrogen fuel.

It is now clear that human innovation is almost always inspired by existing phenomena. Human beings have turned to the apparent acts of nature to look for answers to their problems. They constantly attempt to mimic existing worldly systems but always seem to fall short of producing outcomes with the same level of quality, cost-efficiency, and function. The biological and physical systems that human beings have mimicked have been designed with perfection and have been operating flawlessly for centuries without fail or interruption.

So why then does man believe he can outsmart the design of the planet that has been created for him to live and breathe in?

Artificial Leaves Replicate Photosynthesis? | Horizons | BBC



<https://youtu.be/J556uXwrjII>

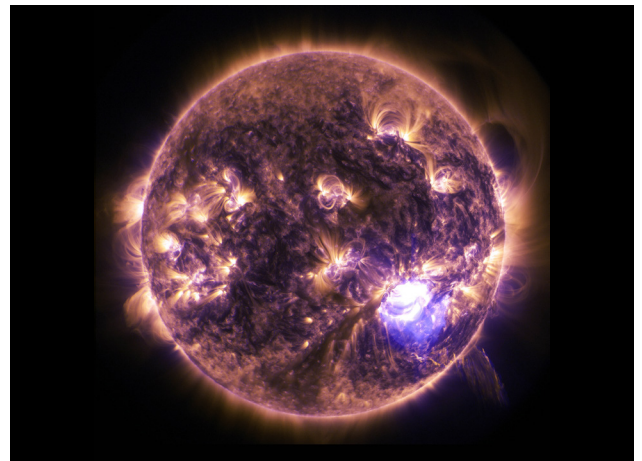


Fourth Dimension : Meditative Thinking

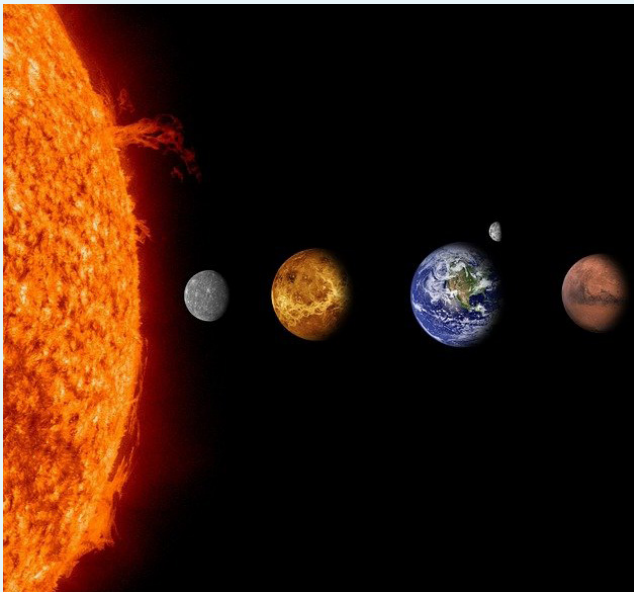
How can we know the Maker of the Earth's energy systems? How can we be sure about our knowledge of its Creator? We believe the answer lies in observing the very nature of energy.

Knowing that the Earth's primary source of energy is a star- our sun- if it were to burn out like other stars, what would happen?

Consider the lifespan of a star. In the burning of a star, such as our sun, the hydrogen atoms within the star collide in a process called nuclear fusion, producing incredible amounts of heat and light in the form of high-energy particles. This process of burning is the phase in which stars are visible in the sky. Scientists estimate that the Sun has enough fuel to burn for 5 billion years. However, there are no guarantees for this. What if the Sun's fuel suddenly ran out? What prevents all the hydrogen atoms



from colliding at the same time, causing the Sun to explode? Scientists say this is because the nuclei of hydrogen atoms only fuse in the core of the Sun, where pressure and heat levels are highest. However, this explanation appears to be a mere description of the phenomenon based on observation and analysis- it is not an explanation of why this phenomenon occurs.



Could we summon another star in the universe to enter our Solar System and replace the Sun's role? Are we in control of the Sun in our Solar System? Do we command the Earth to spin on its axis, resulting in wind and ocean currents? What about the pull of gravity? It is clear that we have no control over any aspect of the Earth, Sun or Solar System in our universe or on the energy systems that sustain them.

The energy systems on our planet are designed to sustain us. The unrelenting masses of electromagnetic energy that arrive on Earth every second of every day are far beyond our needs. The amount of energy used by human civilisation in one year is less than the amount of solar energy the Earth receives through the Sun every hour. The annual energy consumption of human beings around the globe is 410 quintillion Joules. In comparison, the sun is designed to provide 430 quintillion Joules of energy every hour!

<https://www.businessinsider.com/this-is-the-potential-of-solar-power-2015-9>

When we look closely at the Earth's energy systems, we can see the signs of their Creator within them. We can thus see that causes and nature are not the source of the Earth's energy since they are not intelligent, conscious, or powerful self-sustaining beings. As we look closely at the way energy flows through Earth, we should see that it takes infinite knowledge and power to create such a flawless system. Therefore it is impossible to create or maintain a source of energy for our planet such as solar energy no matter how much we try. As human beings, we have limited knowledge, power and will.



"Did you know that the amount of energy used by human civilisation in one year is less than the amount of solar energy the Earth receives through the Sun every hour."

The Creator of the planet's energy is the Maker of the star through which it is produced. The Creator of the Sun's light is the Creator the Earth that receives it, and the Creator of its recipients- the plants- that combine it with carbon dioxide and water to make glucose- the fuel of living cells. The Creator must be the one who equips the chlorophyll pigments within the plants' leaves with the tools to convert the carbon dioxide from the air and the water from the soil into glucose and oxygen. He must be the One who teaches the other organisms to use the plants as a source of nutrition. He must be the one who allows the plants to absorb the water through their roots and the carbon dioxide through the tiny pores in their leaves. He must also be the Creator of the mechanism through which plants sustain their own energy systems and those of the other organisms on the planet that depend on them for survival.



To claim ownership over the planet's energy systems, one would need to have the knowledge and power to create the Earth's primary source of energy -the Sun. To do this, we should first consider what the Sun is made of. Can we re-create even one of the trillions of simple hydrogen atoms within the Sun? Do we even know how to combine two hydrogen atoms whose nuclei would normally repel one another, in the process of nuclear fusion? Scientists attribute the occurrence of nuclear fusion to the "hidden hand of gravity" caused by the incredible mass of the Sun, that comprises 99.8% of all the mass in our solar system. What is the true hidden hand of the force of gravity?

Do we even understand why hydrogen atoms, protons or electrons behave as they do? Despite the incredible knowledge some scientists have attained of the universe, they still cannot understand why subatomic particles act as they do.



He must also be the Creator of the mechanism through which plants sustain their own energy systems

Solar Energy - Nuclear Fusion in the Sun - Simplified Version



<https://youtu.be/pusKlK1L5To>

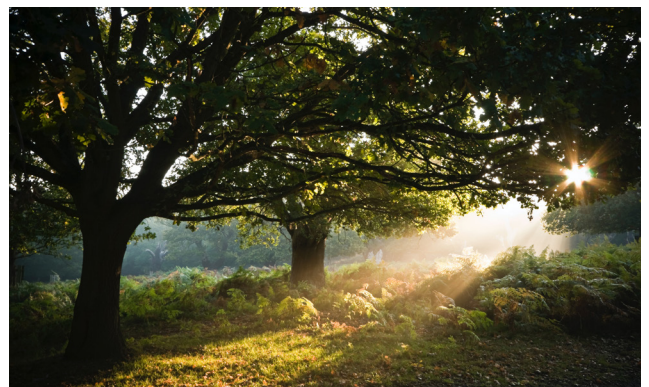
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Why do positively charged nuclei repel one another in the first place? Why do electrons move the way they do? Just as we cannot create or even control the microscopic universe, we cannot possibly believe we can control the macroscopic universe.

It is clear that the Creator of energy is the Creator of the Earth and all of its inhabitants. This is because our Creator knows the needs of the inhabitants of this planet for energy. The Creator of energy must also be the Creator of the star, Solar System and galaxy from which it originated.

By reflecting on the how the Earth's energy cycles remain in balance and are associated with multiple beneficial outcomes, we should reach the conclusion that there must be an All-Encompassing Power who controls

the balance between the release of light energy from the sun in our Solar System and its uptake by photosynthesising organisms on our planet. The Creator of light and heat must know of the energy needs of all the living beings on our planet. He must know the amount of light that needs to be delivered to plants to sustain all the other trophic levels on Earth and the exact amount of heat needed to keep our planet warm enough for life to exist.



Fifth Dimension : Moral Thinking

RESPONDING WITH BETTER CHARACTER

“And still, after all this time, the sun has never said to the Earth, ‘You Owe Me’. Look what happens with love like that, it lights up the sky.” - Rumi

There are several virtues we can learn by simply being conscious of the incredible abundance of energy we receive at every moment.

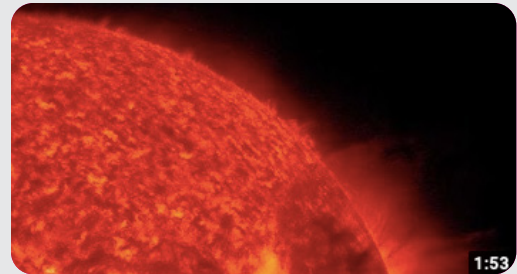
The first virtue is unconditional love.

The important role our sun has been assigned to by our Creator as the primary facilitator of energy for our planet is often taken for granted. The Sun's brightness is tightly regulated to meet the needs of human civilisation. Even a small increase in brightness would mean the end of civilisation as all water sources would immediately dry up and the surface of the planet would become too hot to sustain any form of life. By observing how the Sun continuously shines its light on us every day by the order of our Creator, we can learn to shine our own light onto others without expecting anything in return. This is the true meaning of unconditional love.

Would you trade the abundant sources of energy provided to us by our Creator for anything else? Do you pay for the sunlight that brightens your world, or the warmth you receive on your skin? Would you be willing to give it away at any cost?

For the continuous provision of energy in the form of light and heat, we are grateful.

**Here's what will happen
when our sun dies**



<https://youtu.be/p24SQlhJVZo>

“Do you pay for the sunlight that brightens your world, or the warmth you receive on your skin? ”



The second virtue is thus gratitude.

Common courtesy dictates that when we receive a gift, we appreciate the generosity of the giver. At the very least, we give thanks in return. Gratitude is being thankful to the Creator for bestowing us with energy systems that are designed to provide fuel for our everyday lives, so that we can live and work comfortably and productively. Being grateful means paying it forward by showing the same generosity to others that we have been bestowed by our Creator.

The third virtue is reflection.

By observing how the sun's rays are reflected from one surface to another, we are reminded of the moral obligation of reflection.

From the minute we are born into this world, we are surrounded by signs and symbols

on which to reflect. Our daily lives consist of a plethora of signs in the form of experiences which we can analyse, reflect, and deliberate on. If we consider that everything that happens to us is an opportunity for reflection, our lives become instantly more purposeful. We are thus driven to find meaning in everything.

Reflection also means being conscious of and reflecting on the responsibility we have towards our planet and to those less fortunate who have been denied the abundance of resources by the inconsiderate actions of others.

What do you believe The True Bestower of Bounties wants in return for the precious gift of the Earth's energy systems? Although He does not need anything from us, The Most-Generous asks us for three things: one is remembrance, another is reflection and the third is gratitude.



“Our daily lives consist of a plethora of signs in the form of experiences which we can analyse, reflect, and deliberate on.”

1

Remembrance is realizing that there is a Creator of the Earth’s energy systems.

2

Reflection is thinking of the priceless, miraculous energy systems as gifts of our Creator’s mercy.

3

Gratitude is being thankful to the Creator for bestowing us with energy systems that are designed to provide fuel for our everyday lives, so that we can live, survive and thrive on this Earth.

The ‘Wood Wide Web’ and Energy Exchange

Did you know that deep down beneath the forest floor lies a network of fungal organisms that communicate via long thin threads called mycelia? These mycelia actually connect fungi to each other by linking the roots of plants together.

Interestingly, information about the availability of nutrients in the soil is shared by the fungal network using mycelia. Via the ‘wood wide web’, fungi can also work together to spread toxins to kill off plants which they deem unwelcome.

Scientists use the phrase **mycorrhizal associations** to describe the relationship between plants and the fungi that live in their roots. In this type of relationship, a plant acts as a source of carbohydrates for the fungi. In return, the fungi help by absorbing the water from the surrounding soil and supplying nutrients such as phosphorus and nitrogen to the plant.

This exchange of energy between living organisms is an example of a mutually beneficial relationship.

We can learn a lot from mycorrhizal associations- by working together with others, we can help each other survive and thrive in challenging situations.

<http://www.bbc.com/earth/story/20141111-plants-have-a-hidden-internet>

TEST YOUR KNOWLEDGE

I. UNDERSTANDING SCIENCE TERMS

Complete the following sentences with a word or words from the Science Terms that will make the sentence correct.

Renewable Non Renewable Coal Oil Natural Gas Nuclear Energy Carnivore Autotroph Herbivor

1. _____ is the product of terrestrial plants that decomposed 300 million years ago.
2. _____ and _____ are the products of decomposing microscopic sea plankton.
3. A _____ is an organism that feeds on plants and a _____ is an organism that feeds on animals.
4. Resources that cannot be replenished in the foreseeable future are called _____ resources.
5. A _____ is an organism that is designed to utilize the Sun's energy in the process of photosynthesis.
6. _____ forms of energy can be used again and again and are continuously being replaced.

Label the following diagram:

Primary consumer, Teriary consumer, Secondary consumer, Autotroph



II. CHECKING FACTS

Determine whether each of the following is true or false.

1. Wind Energy is produced when air that is heated by solar energy expands, resulting in an increase of pressure and the formation of a high pressure region. _____
2. Secondary Consumers are all carnivores. _____
3. The organisms at each trophic level are always 100% efficient at energy transfer. _____
4. It takes only one gallon of oil to pollute one million gallons of water. _____
5. Hydrogen can be used as a fuel. _____
6. Nuclear energy is renewable. _____

III. UNDERSTANDING CONCEPTS

Write a short answer for each question or statement.

1. What is the Law of Conservation?

2. What is the main difference between a renewable and non-renewable resource?

3. What is the Sun made of?

4. How do you know that there is a Hidden Hand behind the design of the Earth's energy systems?

5. List two hidden messages found in the Sun from its Maker.

6. Why is it an offense to deny the presence of the Creator of the Earth's energy systems?



V.APPLYING CONCEPTS

Write a paragraph to answer each question.

1. How is photosynthesis in an artificial leaf different from the process by which a real leaf photosynthesizes?

2. Describe how your life would be impacted if the Sun's brightness were to increase slightly.

3. Why do you think the hydrogen atoms that collide within the Sun to produce heat and light energy could not have created the Sun?

4. The One who creates the Earth's energy systems has to be the Creator of the Earth. Why?

5. Why do you think the Earth's energy resources are valuable gifts? Describe two things that make you appreciate the value of these resources.



6. How can you show your gratitude to the One who granted you with the Earth's multiple sources of energy?

V. THINK-THANK GAME

In this “think-thank” game, we want you to think about the water cycle and give thanks to their Maker. We also call it the “play to praise” game. The goal of this game is to think of at least five things about the water cycle that you are thankful for.

Number of players: At least two

Directions:

Player 1 repeats an appreciation phrase loudly and quickly. Player 2 responds, without pausing, with something to be thankful for. This is repeated five times.

To win:

Player 2 needs to respond five times (without pausing) with different things about the Water Cycle to be thankful for in order to win the game.

Here is an example of two rounds of this game:

1. Player 1 repeats the appreciation phrase loudly and quickly. For example: “Thanks to the Maker of the Water Cycle!”
2. Player 2 responds, without pausing, with something about the Water Cycle to be thankful for. For example: “creating an efficient system to cycle water without wasting a single drop”
3. Player 1 repeats the appreciation phrase again loudly and quickly. For example: “Thanks to the Maker of the Water Cycle!”
4. Player 2 responds, without pausing, with another thing about the Water Cycle to be thankful for. For example: “For transporting water through clouds without causing noise pollution!”

This should be continued for another three rounds until Player 2 wins or loses.