The Science of Energy #1

Energy is everywhere ____ ____ _______. ____ you are listening to this on your phone in an air-conditioned room and working your brain to understand the essence of energy, what _________ your phone, air conditioners, and your brain is nothing _____ but energy.
Then what is energy? This might be the most difficult question you ______ ____ _____. Surprisingly, even Nobel Prize winners have great ______ ________ a ___________ answer to that _________ simple question. In Physics today, ______ ____ no _______ __________ of what energy is. __________ we have no _________ and ____________ ________ of energy, we _____ ____ _____ ______ to understanding the essence by _________ ____ ______ _____ __________ perspectives. Energy is ____ ____ ______ of challenges that humanity is facing now, _____ ____ ____ _____ the key to understanding the ________ of human society ____ ____ this day. Science ________ about energy _________ ____ a _______ knowledge for _________ our insights into the world and working __________ a ________ future. So, ______ ________ is energy?

Energy is everywhere in our lives. If you are listening to this on your phone in an air-conditioned room and working your brain to understand the essence of energy, what powers your phone, air conditioners, and your brain is nothing else but energy. Then what is energy? This might be the most difficult question you could ever ask. Surprisingly, even Nobel Prize winners have great trouble providing a satisfactory answer to that seemingly simple question. In Physics today, there is no clear knowledge of what energy is. Though we have no ultimate and comprehensive definition of energy, we still can get closer to understanding the essence by breaking it down into different perspectives. Energy is at the core of challenges that humanity is facing now, and it is also the key to understanding the journey of human society up to this day. Science literacy about energy serves as a vital knowledge for deepening our insights into the world and working towards a brighter future. So, what exactly is energy?

power (v)	動かす、動力供給する		seemingly	外見上は、見たところ
satisfactory	満足のいく		comprehensive	包括的な、網羅的な

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The Science of Energy #2

The ______ “energy” _______ _______ an ancient Greek word “energeia.” An Ancient Greek philosopher Aristotle has given an ________ definition to this concept; _______ capable of doing work. ____ _____ ________ __________ and elusive, ____ ____ ______ ____ ______ _______ the essence of energy. Today, energy is _______ understood as something that ______ ____ the source of physical or chemical changes ____ ____ object. In other words, energy is not about a specific substance or phenomenon. Rather, ____ ____ a concept ______ ________ anything that can cause physical or chemical _________ in objects. For example, workers constructing a huge Pyramid carried massive stones by using their muscles to ______ _________ to them, which we call ______ energy. ______ ____ ______ in a _____ is boiling and undergoing a physical transition _____ ______ to gas, that change is being caused by thermal energy. ______ _______ ____ a bicycle on a hilltop that is just about to gain acceleration and go down the hill, we ________ the bicycle to _________ gravitational potential energy. _______ a ______ scientific _______ ____ ______, thermal energy and gravitational potential energy are ___________ phenomena; the ________ is ____________ the kinetic energy of __________ molecules or _______ in a substance, and the ______ is _______ ______ _______ the earth's gravitational _____. But we can find _______ _______ _____ ______ they are sources capable of doing work, and one can be ________ _____ another. As Aristotle suggested, energy is a concept, _____ ____ _____ take a variety of forms.

The term “energy” derives from an ancient Greek word “energeia.” An Ancient Greek philosopher Aristotle has given an abstract definition to this concept; force capable of doing work. It may appear ambiguous and elusive, but he seemed to have grasped the essence of energy. Today, energy is commonly understood as something that serves as the source of physical or chemical changes in an object. In other words, energy is not about a specific substance or phenomenon. Rather, it is a concept that includes anything that can cause physical or chemical alteration in objects. For example, workers constructing a huge Pyramid carried massive stones by using their muscles to apply acceleration to them, which we call kinetic energy. When the water in a kettle is boiling and undergoing a physical transition from liquid to gas, that change is being caused by thermal energy. When there is a bicycle on a hilltop that is just about to gain acceleration and go down the hill, we consider the bicycle to possess gravitational potential energy. From a pure scientific point of view, thermal energy and gravitational potential energy are different phenomena; the former is generally the kinetic energy of vibrating molecules or atoms in a substance, and the latter is what comes from the earth's gravitational pull. But we can find common ground in that they are sources capable of doing work, and one can be converted into another. As Aristotle suggested, energy is a concept, and it can take a variety of forms.

derive	派生する、由来する		thermal energy	熱エネルギー
abstract	抽象的な		undergo	経験する、経る
ambiguous	あいまいな		liquid	液体
elusive	とらえどころのない		gas	気体
substance	物質		gravitational	重力の、重力による
alteration	変化、変更		molecule	分子
acceleration	加速、加速度		atom	原子
kinetic energy	運動エネルギー		convert	変換する

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The Science of Energy #3

From a human perspective, energy can be defined as force capable of doing useful work for us, _______ ____ ____ _____ various forms. _____ ____ ______ the flow of energy that is __________ lighting the light bulb in your room _______ ____ ____ source. Originally, it was chemical energy _________ ____ fossil fuel, which turned into thermal energy __________ ___________ reactions. The thermal energy _______ water, _____ _____ ____ was transformed into the ________ energy of a steam turbine, creating electric energy. ____ ______ _______ power lines to your home, and the electric energy is converted into light energy by the filament, lighting your room. However, not all energy in ___________ is turned into light energy; the conversion __________ is about 10%. According to the _____ ____ _____ _____________ of energy, every form of energy can be ______ into another form, and no energy is ever lost in any of these conversions. Then, ______ _____ ____ _____ _____ 90% go? _____ _____ _____ of conversion, some ___________ of energy is transformed into ____________ _____ and ________ _______. For example, some of the thermal energy within the turbine ___________ by heating the surrounding air and the cooling water. ______ electrical energy is transformed into light energy, a ___________ _____ _____ is turned into thermal energy _____ ____ the ____________ of the filament in the light bulb. No energy is ever lost in any of these conversions, but the _________ of energy has ___________ in the process.

From a human perspective, energy can be defined as force capable of doing useful work for us, and it can take various forms. Let us trace the flow of energy that is currently lighting the light bulb in your room back to its source. Originally, it was chemical energy embedded in fossil fuel, which turned into thermal energy through combustion reactions. The thermal energy boils water, and then it was transformed into the kinetic energy of a steam turbine, creating electric energy. It travels along power lines to your home, and the electric energy is converted into light energy by the filament, lighting your room. However, not all energy in petroleum is turned into light energy; the conversion efficiency is about 10%. According to the law of the conservation of energy, every form of energy can be turned into another form, and no energy is ever lost in any of these conversions. Then, where did the rest of 90% go? At each step of conversion, some proportion of energy is transformed into unintended form and scatters away. For example, some of the thermal energy within the turbine dissipates by heating the surrounding air and the cooling water. When electrical energy is transformed into light energy, a fraction of it is turned into thermal energy due to the resistance of the filament in the light bulb. No energy is ever lost in any of these conversions, but the utility of energy has diminished in the process.

tracce	たどる、遡る		conservation	保存、不変
embed	埋め込む		proportion	割合、部分
combustion	燃焼		scatter	撒き散らす
power line	送電線		dissipate	消散する
filament	フィラメント、繊維		fraction	部分、かけら
petroleum	石油		diminish	減る、減らす

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The Science of Energy #4

In Japanese mythology, the __________ god Amaterasu is also the _________ of the sun. Similarly, there are __________ ________ around the world that serve as both the highest god and the symbol of the sun, such as Quetzalcoatl in Maya and _______, and Ra in _______. _________ people might have somehow realized that all energy on earth is _________ ______ the sun's radiation. The energy in the earth's _________ ______ __________ ______ a single source: plants. By the process of _____________, they __________ solar energy and _______ ___ _____ _______ ________. ___________ eat plants to gain solar energy __________, and __________ eat __________ to do _________. Homo sapiens has never been the _________. We maintain our _______ functions by ___________ plants and animals, and stay warm and _______ metals by cutting down trees and using them ____ ______. Modern industrial society has also been _________ ___________ on the sun. Fossil fuels are the __________ ___________ of past solar energy, since they were ___________ the remains of __________ plants and animals ______ _____ _____ slowly transformed ______ pressure and geothermal heat. Wind and water powers are also indirect use of solar energy. Wind is the phenomenon in which air ________ ______ high-pressure ______ to low-pressure ______, and the differences in ____________ pressure ______ ______ the differential heating of Earth's ___________ by the sun. Water power ___________ the gravitational potential energy of water that is ______ ______ the ocean onto land _____ ___________. With some exceptions such as nuclear power and geothermal power generation, all sources of energy ____________ _____ ____ in the sun. From eating rice to burning firewood, sailing ships to building pyramids, everything we have done ____________ history has been some form of ________ or _________ use of solar energy.

In Japanese mythology, the supreme god Amaterasu is also the goddess of the sun. Similarly, there are numerous deities around the world that serve as both the highest god and the symbol of the sun, such as Quetzalcoatl in Maya and Aztec, and Ra in Egypt. Ancient people might have somehow realized that all energy on earth is derived from the sun's radiation. The energy in the earth's ecosystem comes ultimately from a single source: plants. By the process of photosynthesis, they captured solar energy and packed it into organic compounds. Herbivores eat plants to gain solar energy indirectly, and carnivores eat herbivores to do likewise. Homo sapiens has never been the exception. We maintain our bodily functions by consuming plants and animals, and stay warm and smelt metals by cutting down trees and using them as fuel. Modern industrial society has also been largely dependent on the sun. Fossil fuels are the compressed preservation of past solar energy, since they were originally the remains of ancient plants and animals which have been slowly transformed under pressure and geothermal heat. Wind and water powers are also indirect use of solar energy. Wind is the phenomenon in which air flows from high-pressure areas to low-pressure areas, and the differences in atmospheric pressure arise from the differential heating of Earth's surfaces by the sun. Water power harnesses the gravitational potential energy of water that is lifted from the ocean onto land by evaporation. With some exceptions such as nuclear power and geothermal power generation, all sources of energy eventually end up in the sun. From eating rice to burning firewood, sailing ships to building pyramids, everything we have done throughout history has been some form of direct or indirect use of solar energy.

numerous	多数の		carnivore	肉食動物
deity	神、女神		smelt	精錬する
radiation	放射能、放射線		compress	圧縮する
photosynthesis	光合成		harness	動力化する、活用する
compound	化合物		evaporation	蒸発
herbivore	草食動物		geothermal	地熱の

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The Science of Energy #1

If almost all the energy on earth ________ ______ the sun's radiation, then what is the source of the solar energy ____ ____ ______ ________? Within the sun, hydrogen fusion reactions are ____________ ________ ______, transforming hydrogen into helium. ___________ this nuclear _________ reaction, there is a __________ in the total mass, and this decrease in mass is _________ as energy. In other words, the loss of ___________ becomes energy. ____ _____ _____ counterintuitive, but this is part of what Einstein __________ in the __________ of relativity. We often confuse mass with ________, but they are two _________ _______. Mass is actually a _______ form of energy that __________ the 'inertia' of an object, or in other words, an object's __________ to ______ _______. All matter is energy ____ ______. As Einstein discovered, mass is ___________ to energy and they are ____________. Every loss of mass results in the release of energy ____________ to the ________ of the speed of light. This principle ________ the foundation of nuclear power generation. The _________ of _________ _____ _________-235 ________ a chain reaction of nuclear fission. Before and after these fission reactions, ________, the mass reduces ____ _______, and the reduced mass is released as thermal energy. The rest is the same to thermal power generation; the thermal energy _________ the _______ __________ to generate electricity. Thus, we can understand energy ___________ from various ________. ____ ______ ____ human life and society, energy can be defined as any force capable of doing useful work for us. Speaking scientifically but __________ _______ the _________ ___________, energy is about the transformation or ____________ of solar ___________. ___________, on a ________ scale, ______ that make up our bodies and things around us are ____________ masses of energy. But the ______ _______ _____ _________ __________. Physicists around the world are still in the ______ of a ___________ _________ of the essence of energy.

If almost all the energy on earth derives from the sun's radiation, then what is the source of the solar energy in the first place? Within the sun, hydrogen fusion reactions are constantly taking place, transforming hydrogen into helium. Throughout this nuclear fusion reaction, there is a reduction in the total mass, and this decrease in mass is released as energy. In other words, the loss of quantity becomes energy. It must sound counterintuitive, but this is part of what Einstein unveiled in the Theory of relativity. We often confuse mass with weight, but they are two separate things. Mass is actually a static form of energy that represents the 'inertia' of an object, or in other words, an object's resistance to being moved. All matter is energy at rest. As Einstein discovered, mass is equivalent to energy and they are interchangeable. Every loss of mass results in the release of energy proportional to the square of the speed of light. This principle forms the foundation of nuclear power generation. The collision of neutrons with uranium-235 triggers a chain reaction of nuclear fission. Before and after these fission reactions, again, the mass reduces in total, and the reduced mass is released as thermal energy. The rest is the same to thermal power generation; the thermal energy rotates the steam turbine to generate electricity. Thus, we can understand energy differently from various aspects. In terms of human life and society, energy can be defined as any force capable of doing useful work for us. Speaking scientifically but limitedly within the Earth's atmosphere, energy is about the transformation or preservation of solar radiation. Ultimately, on a cosmic scale, atoms that make up our bodies and things around us are essentially masses of energy. But the exact details still remain unsolved. Physicists around the world are still in the midst of a relentless pursuit of the essence of energy.

hydrogen	水素		equivalent	等しい、等価な
fusion	融合		interchangeable	交換可能な
helium	ヘリウム		proportional	比例した、釣り合った
mass	質量、かたまり		collision	衝突
counterintuitive	直感に反した		neutron	中性子
unveil	明らかにする		uranium	ウラン
Relativity	相対性（理論）		fission	分裂、核分裂
static	静止した、静的な		relentless	絶え間ない、容赦ない
inertia	慣性			

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The Science of Energy #5

If almost all the energy on earth ________ ______ the sun’s radiation, then what is the source of the solar energy ____ ____ ______ ________? Within the sun, hydrogen fusion reactions are ____________ ________ ______, transforming hydrogen into helium. ___________ this nuclear _________ reaction, there is a __________ in the total mass, and this decrease in mass is _________ as energy. In other words, the loss of ___________ becomes energy. ____ _____ _____ counterintuitive, but this is part of what Einstein __________ in the __________ of relativity. We often confuse mass with ________, but they are two _________ _______. Mass is actually a _______ form of energy that __________ the 'inertia' of an object, or in other words, an object's __________ to ______ _______. All matter is energy ____ ______. As Einstein discovered, mass is ___________ to energy and they are ____________. Every loss of mass results in the release of energy ____________ to the ________ of the speed of light. This principle ________ the foundation of nuclear power generation. The _________ of _________ _____ _________-235 ________ a chain reaction of nuclear fission. Before and after these fission reactions, ________, the mass reduces ____ _______, and the reduced mass is released as thermal energy. The rest is the same to thermal power generation; the thermal energy _________ the _______ __________ to generate electricity. Thus, we can understand energy ___________ from various ________. ____ ______ ____ human life and society, energy can be defined as any force capable of doing useful work for us. Speaking scientifically but __________ _______ the _________ ___________, energy is about the transformation or ____________ of solar ___________. ___________, on a ________ scale, ______ that make up our bodies and things around us are ____________ masses of energy. But the ______ _______ _____ _________ __________. Physicists around the world are still in the ______ of a ___________ _________ of the essence of energy.

If almost all the energy on earth derives from the sun’s radiation, then what is the source of the solar energy in the first place? Within the sun, hydrogen fusion reactions are constantly taking place, transforming hydrogen into helium. Throughout this nuclear fusion reaction, there is a reduction in the total mass, and this decrease in mass is released as energy. In other words, the loss of quantity becomes energy. It must sound counterintuitive, but this is part of what Einstein unveiled in the Theory of relativity. We often confuse mass with weight, but they are two separate things. Mass is actually a static form of energy that represents the 'inertia' of an object, or in other words, an object's resistance to being moved. All matter is energy at rest. As Einstein discovered, mass is equivalent to energy and they are interchangeable. Every loss of mass results in the release of energy proportional to the square of the speed of light. This principle forms the foundation of nuclear power generation. The collision of neutrons with uranium-235 triggers a chain reaction of nuclear fission. Before and after these fission reactions, again, the mass reduces in total, and the reduced mass is released as thermal energy. The rest is the same to thermal power generation; the thermal energy rotates the steam turbine to generate electricity. Thus, we can understand energy differently from various aspects. In terms of human life and society, energy can be defined as any force capable of doing useful work for us. Speaking scientifically but limitedly within the Earth's atmosphere, energy is about the transformation or preservation of solar radiation. Ultimately, on a cosmic scale, atoms that make up our bodies and things around us are essentially masses of energy. But the exact details still remain unsolved. Physicists around the world are still in the midst of a relentless pursuit of the essence of energy.

hydrogen	水素		equivalent	等しい、等価な
fusion	融合		interchangeable	交換可能な
helium	ヘリウム		proportional	比例した、釣り合った
mass	質量、かたまり		collision	衝突
counterintuitive	直感に反した		neutron	中性子
unveil	明らかにする		uranium	ウラン
Relativity	相対性（理論）		fission	分裂、核分裂
static	静止した、静的な		relentless	絶え間ない、容赦ない
inertia	慣性			

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