Human History of Energy #1

Human history can be seen as a _________ ____ _________ and ____________ over the ___________ and __________ of energy. ______ ______ prehistoric times, humans ______ ______ unable to _________ without the _________ of external energy. Homo sapiens have exceptionally large brains, _____ ___ consumes 20 to 25 percent of all metabolic energy, compared to around 10 percent in other ________ and just 3-5 percent in other _________. In order to maintain such a huge __________ of energy, ______ ____ ___ be a reduction of energy consumption in other _______. The solution was to __________ the energy of _____; _________, cooking. By heating up food, it becomes easier to ______, digest, and _______ calories and ___________. Wild chimpanzees spend six hours or more each day just chewing their food, ______ humans spend only about an hour a day. The high energy need of the brain was ______ ________ by a reduced energy need in digestive systems. In other words, our huge brain was possible by externalizing the energy __________ for food digestion. Biologically speaking, a human body cannot be maintained _________ _________ energy consumption. Beginning _______ ____ _____ of fire, how has humanity discovered various ways to ________, store, and utilize energy outside our own bodies more ___________ and ___________?

Human history can be seen as a series of struggle and development over the acquisition and utilization of energy. Even from prehistoric times, humans have been unable to survive without the addition of external energy. Homo sapiens have exceptionally large brains, and it consumes 20 to 25 percent of all metabolic energy, compared to around 10 percent in other primates and just 3-5 percent in other mammals. In order to maintain such a huge expenditure of energy, there had to be a reduction of energy consumption in other organs. The solution was to harness the energy of fire; namely, cooking. By heating up food, it becomes easier to chew, digest, and absorb calories and nutrients. Wild chimpanzees spend six hours or more each day just chewing their food, while humans spend only about an hour a day. The high energy need of the brain was partly offset by a reduced energy need in digestive systems. In other words, our huge brain was possible by externalizing the energy required for food digestion. Biologically speaking, a human body cannot be maintained without external energy consumption. Beginning from the use of fire, how has humanity discovered various ways to collect, store, and utilize energy outside our own bodies more abundantly and efficiently?

struggle	苦闘する、もがく		harness	動力化する、利用する
acquisition	獲得		namely	すなわち、正確には
utilization	利用、活用		offset	相殺する、帳消しする
prehistoric	有史以前の		externalize	外部化する
external	外部の、外側の		abundantly	豊富に
metabolic	代謝の			

Human History of Energy #2

The second __________ breakthrough in the history of energy is agriculture. __________ history, the sun has been the ________ or _________ source of almost all human activities. Only about 0.05 percent of __________ solar energy is transformed by ____________ into chemical energy in plants, __________ the essential foundation for all animals, including humankind. _________ agriculture, all people _____ ______ ________ as hunter-gatherers. Our ancestors made their living by walking through woods to collect mushrooms and running across plains to hunt animals. Whether in rainforests or _________, only a ________ of the _______ biomass is _______ for us, ____ _______ _____ ____ __________ limitation ____ ____ _________ ____ accessible calories. From 10,000 B.C. _________, farming began ____________ around the world, which dramatically transformed human societies. In terms of the history of energy acquisition, agriculture means the ___________ use of solar energy in a _________ ______ ____ ____. We ______ _____ all wild animals and plants from the land, cultivate a single species, and __________ ______ weeds and _______. The result was remarkable. First, agricultural societies could _________ far higher population densities than hunter-gatherer societies. Second, farming began creating an energy _________ ______ ________ some members of society to _________ ____ a range of activities other than producing food. The denser population and energy surplus __________ ______ ____ ____ to highly complex and __________ ____________ societies. By the end of the 19th Century, however, _______ approached a limit since the yearly amount of energy that photosynthesis can _______ from the sun is _______. For example, the population in Japan reached 30 million in the _______ of the 18th Century, and almost _________ _____ _______ the rest of the Edo period (-1868), which suggests that, _________ ________ on the efficient utilization of solar energy, this is the maximum population capacity that the Japanese ___________ _____ ________.

The second significant breakthrough in the history of energy is agriculture. Throughout history, the sun has been the direct or indirect source of almost all human activities. Only about 0.05 percent of incoming solar energy is transformed by photosynthesis into chemical energy in plants, providing the essential foundation for all animals, including humankind. Before agriculture, all people had been living as hunter-gatherers. Our ancestors made their living by walking through woods to collect mushrooms and running across plains to hunt animals. Whether in rainforests or savannah, only a fraction of the entire biomass is edible for us, so there was an inherent limitation in the amount of accessible calories. From 10,000 B.C. onwards, farming began sporadically around the world, which dramatically transformed human societies. In terms of the history of energy acquisition, agriculture means the exclusive use of solar energy in a specific piece of land. We drive away all wild animals and plants from the land, cultivate a single species, and constantly expel weeds and vermin. The result was remarkable. First, agricultural societies could support far higher population densities than hunter-gatherer societies. Second, farming began creating an energy surplus that allowed some members of society to engage in a range of activities other than producing food. The denser population and energy surplus eventually paved the way to highly complex and advanced hierarchical societies. By the end of the 19th Century, however, yields approached a limit since the yearly amount of energy that photosynthesis can capture from the sun is finite. For example, the population in Japan reached 30 million in the middle of the 18th Century, and almost leveled off during the rest of the Edo period (-1868), which suggests that, relying solely on the efficient utilization of solar energy, this is the maximum population capacity that the Japanese Archipelago can sustain.

photosynthesis	光合成		vermin	害獣、害虫
hunter-gatherer	狩猟採集民		density	密度
fraction	一部、断片		surplus	余剰、黒字
biomass	生物量		pave	舗装する、道を敷く
edible	食用可能な		hierarchical	階層的な、階級制度の
inherent	内在する、固有の		yield	収穫高、産出量
sporadically	散発的に		finite	有限の
exclusive	独占的な、排他的な		level off	安定する、横ばいになる
expel	追い出す		archipelago	列島

Human History of Energy #3

Agriculture enabled humankind to __________ the solar energy raining on the land. But utilizing the sun's radiation _________ ____ _____ _____ ________ was not _________ to _________ the extraordinary population and industrial productivity of the modern times. It was the use of fossil fuels that broke through the __________ limitation of agriculture. Fossil fuels, in a ________ sense, are dead _________ of ancient plants and animals. They ________ solar energy as chemical energy _________ photosynthesis. After they died and _______ under the ground, _______ pressure and geothermal heat gradually transformed them into substances with high energy densities. In other words, fossil fuels are a storage of solar radiation energy that fell on Earth for hundreds of millions of years. Today, we are _________ ______ these ancient _________ of solar power to _______ the expanding population by producing chemical __________, travel around the world with jet planes, and ________ huge shopping _______. We don't pay the _________ price for any of these. They are __________ by ancient sunlight. Today, the ________ person in Japan consumes energy ____ ____ ______ ____ _______ 4500 Watts, and more than 80 percent of that comes ________ burning ______, oil, and gas. _____ ____ _____ to generate the ______ _______ of energy by employing laborers pedaling exercise bicycles, you _______ ______ 270 slaves working eight-hour shifts each. By analogy, we can also understand the historical ____________ on forest resources in pre-modern civilizations. For example, a 40-year-old tree can be _________ ____ a mass of solar energy ___________ over the past 40 years _____ _____ _____. Technological development, cultural advancement, and education systems are only possible in societies with ____________ energy surplus. Forest resources have given us a ___________ energy surplus _______ they are all cut down. Throughout history, progress of human society has been _________ by nature's __________ of past solar energy.

Agriculture enabled humankind to monopolize the solar energy raining on the land. But utilizing the sun's radiation falling at this very moment was not enough to achieve the extraordinary population and industrial productivity of the modern times. It was the use of fossil fuels that broke through the inherent limitation of agriculture. Fossil fuels, in a literal sense, are dead remains of ancient plants and animals. They stored solar energy as chemical energy through photosynthesis. After they died and buried under the ground, earth pressure and geothermal heat gradually transformed them into substances with high energy densities. In other words, fossil fuels are a storage of solar radiation energy that fell on Earth for hundreds of millions of years. Today, we are tapping into these ancient reserves of solar power to feed the expanding population by producing chemical fertilizer, travel around the world with jet planes, and operate huge shopping malls. We don't pay the whole price for any of these. They are subsidized by ancient sunlight. Today, the average person in Japan consumes energy at the rate of about 4500 Watts, and more than 80 percent of that comes from burning coal, oil, and gas. If you were to generate the same amount of energy by employing laborers pedaling exercise bicycles, you would need 270 slaves working eight-hour shifts each. By analogy, we can also understand the historical dependence on forest resources in pre-modern civilizations. For example, a 40-year-old tree can be viewed as a mass of solar energy accumulated over the past 40 years on that spot. Technological development, cultural advancement, and education systems are only possible in societies with sufficient energy surplus. Forest resources have given us a temporary energy surplus until they are all cut down. Throughout history, progress of human society has been invested by nature's reservoir of past solar energy.

monopolize	独占する、占有する		mass	かたまり
tap into	引き出す、活用する		sufficient	十分な
fertilizer	肥料		temporary	一時的な、当面の
subsidize	補助金を出す		reservoir	貯水池、宝庫

Human History of Energy #4

Whether it is building a pyramid, cultivating farmland, or _________ ______, there has to be an input of kinetic energy. Until a ________ ______ in history, humans had only one machine capable of converting solar energy into kinetic energy: the body. First, ______ and ______ ____ the sun's radiation energy as chemical energy through photosynthesis. Then, in the process of __________, the bodies of animals, including Homo sapiens, _____ ________ _______ ______, which we call food, and convert the chemical energy into the movement of muscles. ______ _____ _______ the only way to ________ kinetic energy _____ ______ forms of energy, _______ the discovery of steam engines in the 18th Century. A steam engine burns some kind of fuel, such as coal, and use the resulting heat to boil water, producing steam. As the steam ________, it pushes a piston. The piston moves, and anything that is connected to the piston moves as well. The point is ______ ___ _____ successfully converted thermal energy into kinetic energy. ____ _______, the Industrial Revolution has been a revolution in energy conversion. Previously, humans could ________ energy only in the same form ____ ____ _____ extracted. For example, pre-modern societies used water _______ to ________ the flow of rivers to grind grain, and burned _________ to ______ _____. In ________ case, there is no conversion of energy form. The ________ turns kinetic energy of water into kinetic energy of millstones, and the ________ uses thermal energy in the form of thermal energy _____ ____ ____. Steam engines ________ humanity that any type of energy can be transformed into a useful form, ____ _____ _____ ______ _______ the right machine. In particular, fossil fuels __________ became valuable as we have discovered a way to _______ useful energy from thermal energy.

Whether it is building a pyramid, cultivating farmland, or <u>weaving</u> <u>cloth</u>, there has to be an input of kinetic energy. Until a <u>certain</u> <u>point</u> in history, humans had only one machine capable of converting solar energy into kinetic energy: the body. First, <u>grain</u> and <u>grass</u> <u>fix</u> the sun's radiation energy as chemical energy through photosynthesis. Then, in the process of <u>metabolism</u>, the bodies of animals, including Homo sapiens, <u>burn</u> <u>these</u> <u>organic</u> <u>fuels</u>, which we call food, and convert the chemical energy into the movement of muscles. <u>This</u> <u>had</u> <u>been</u> the only way to <u>generate</u> kinetic energy <u>from</u> <u>other</u> forms of energy, <u>until</u> the discovery of steam engines in the 18th Century. A steam engine burns some kind of fuel, such as coal, and use the resulting heat to boil water, producing steam. As the steam <u>expands</u>, it pushes a piston. The piston moves, and anything that is connected to the piston moves as well. The point is <u>that</u> <u>it</u> <u>has</u> successfully converted thermal energy into kinetic energy. <u>At</u> <u>heart</u>, the Industrial Revolution has been a revolution in energy conversion. Previously, humans could <u>harness</u> energy only in the same form <u>as</u> <u>it</u> <u>was</u> extracted. For example, pre-modern societies used water <u>wheels</u> to <u>capture</u> the flow of rivers to grind grain, and burned <u>firewood</u> to <u>smelt</u> <u>iron</u>. In <u>either</u> case, there is no conversion of energy form. The <u>former</u> turns kinetic energy of water into kinetic energy of millstones, and the <u>latter</u> uses thermal energy in the form of thermal energy <u>as</u> <u>it</u> <u>is</u>. Steam engines <u>taught</u> humanity that any type of energy can be transformed into a useful form, <u>if</u> <u>we</u> <u>could</u> <u>just</u> <u>invent</u> the right machine. In particular, fossil fuels <u>suddenly</u> became valuable as we have discovered a way to <u>extract</u> useful energy from thermal energy.

weave	織る		grind	挽く、粉砕する
kinetic energy	運動エネルギー		smelt	精錬する、溶解する
convert	転換する、変換する		millstone	石臼
steam engine	蒸気機関		thermal	熱の
extract	取り出す、抽出する		grind	挽く、粉砕する

Human History of Energy #5

The last breakthrough in the history of energy is the ___________ of electricity. ______ the _____ 18th Century to the end of the 19th Century, humanity _____ one and a half centuries discovering and developing a ______ ____ technologies necessary to _____ electric energy ___________ ______. Electricity was revolutionary in the following two aspects. First, ____ _____ ___________ increased the flexibility of energy conversion. _________ water ________ could not ______ the kinetic energy of water into thermal energy to warm their house. Steam engines could turn thermal energy into kinetic energy, but they couldn't use the kinetic energy to _______ their room. Electric energy can be the _________ of _______ ________ of energy. Today, we can generate electric energy at a __________ power station, and it can be turned into thermal energy to ______ _____ room. Electricity from a steam turbine can eventually be transformed into light energy by your LED. Electricity is the __________ __________, so to speak. Any source of energy, _____ it's __________ _____ electric energy, can be harnessed as a useful form of energy. Second, electric power has enabled the _____-_________ transmission of energy. Before electricity, energy could only be __________ ____ ____ ______ ______ ____ ____ ________. For example, millstones to ________ wheat powered by a water wheel _____ ____ ____ ______ next to rivers. Today, in contrast, energy produced by hydro turbines at the Kurobe Dam __________ the night in Osaka, 300 kilometers away in power transmission _________. Human history can be seen as the ________ for more ________ energy in more useful and __________ forms more _________ at lower costs. ______ the discovery of electricity, _____ ______ _________ the freedom of conversion and transmission of energy, which _________ a ______ completion in the history of energy. However, there are still _________ challenges such as the _________ of fossil fuels and climate change. How will the ______ for energy ________ in the 21st Century?

The last breakthrough in the history of energy is the implementation of electricity. From the mid 18th Century to the end of the 19th Century, humanity spent one and a half centuries discovering and developing a series of technologies necessary to make electric energy commercially viable. Electricity was revolutionary in the following two aspects. First, it has dramatically increased the flexibility of energy conversion. Medieval water wheels could not turn the kinetic energy of water into thermal energy to warm their house. Steam engines could turn thermal energy into kinetic energy, but they couldn't use the kinetic energy to light their room. Electric energy can be the medium of various forms of energy. Today, we can generate electric energy at a hydroelectric power station, and it can be turned into thermal energy to heat your room. Electricity from a steam turbine can eventually be transformed into light energy by your LED. Electricity is the universal currency, so to speak. Any source of energy, once it's converted into electric energy, can be harnessed as a useful form of energy. Second, electric power has enabled the long-distance transmission of energy. Before electricity, energy could only be consumed at the very place it was extracted. For example, millstones to grain wheat powered by a water wheel had to be right next to rivers. Today, in contrast, energy produced by hydro turbines at the Kurobe Dam illuminates the night in Osaka, 300 kilometers away in power transmission distance. Human history can be seen as the quest for more abundant energy in more useful and versatile forms more efficiently at lower costs. With the discovery of electricity, we have achieved the freedom of conversion and transmission of energy, which marked a certain completion in the history of energy. However, there are still ongoing challenges such as the depletion of fossil fuels and climate change. How will the quest for energy unfold in the 21st Century?

implementation	実行、実装		illuminate	照らす、明るくする
viable	実現可能な、生存可能な		versatile	汎用的な、多才な
medieval	中世の		ongoing	継続中の
medium	媒体、媒介		depletion	枯渇、消耗
hydroelectric power station	水力発電所		unfold	広がる、展開する
transmission	送信、伝達			