

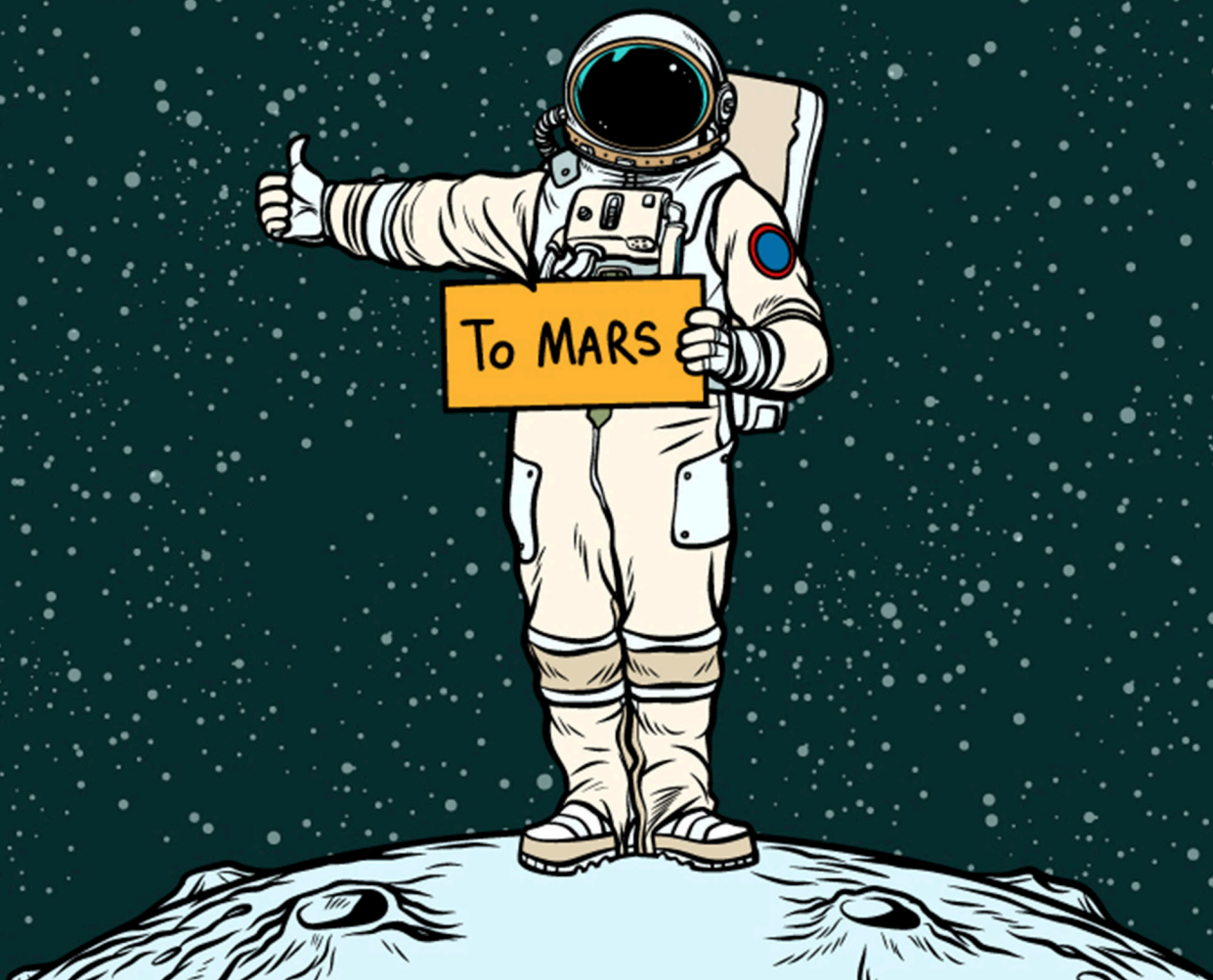
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**Resveratrol Can Protect Body
Muscle in Mars' Partial Gravity**

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Anorexia is Linked with Metabolism: Genome Analysis Reveals

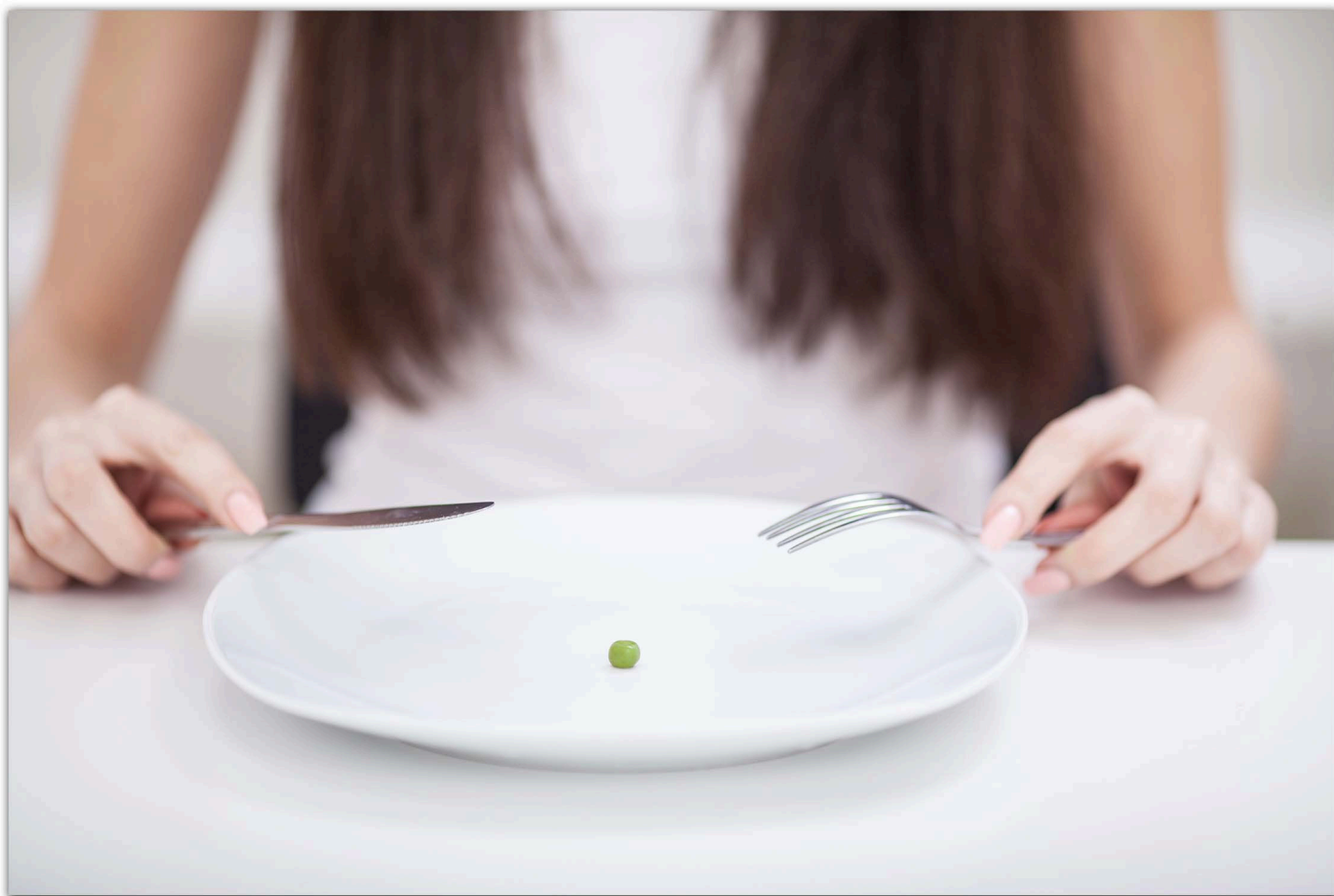
Anorexia nervosa is an extreme eating disorder characterized with significant weight loss. Study on genetic origins of anorexia nervosa has revealed that metabolic differences play an equally important role along with psychological effects in the development of this disease. The new understanding can help to develop novel treatments for anorexia.

Anorexia nervosa is a severe eating disorder and a life-threatening illness. The disorder is characterized by low body mass index (BMI), fear of weight gain and distorted body image. It affects 0.9 to 4 percent women and around 0.3 percent men. Patients of anorexia either starve themselves so that they don't gain any weight, or they heavily exercise and burn extra calories. Anorexia generally causes high mortality rates as it leads to suicides. The treatment of anorexia involves combining psychological interventions and normalizing body weight. These treatments sometimes do not meet with success.

A study published on July 15 in *Nature Genetics* has revealed that anorexia nervosa is partly a metabolic disorder i.e. it is driven by problems in metabolism. Around 100 researchers worldwide collaborated to conduct a large-scale genome-wide study to identify eight genetic

variants linked to anorexia nervosa. The data from Anorexia Nervosa Genetic Initiatives (ANGI), Eating Disorders Working Group of the Psychiatric Genomics Consortium (PGC-ED) and UK Biobank was combined for this study. The total 33 datasets included 16,992 anorexia nervosa cases and around 55,000 controls of European ancestry from 17 countries.

Researchers compared the DNA of the dataset and identified eight important genes which increased risk of the disease. Some of these were linked to psychiatric disorders like anxiety, depression and OCD. Others were associated with metabolic (glycemic), fats (lipids) and body measurement (anthropometric) traits. These overlaps are in addition to the genetic effects which influence body mass index (BMI). Genetic factors also have an effect on one's levels of physical activity. The results suggest that genetic origins of anorexia nervosa disorder are both



metabolic and psychiatric. Metabolism genes appeared to be healthy, but when combined with genes which are associated with psychiatric problems, it increases risk of anorexia.

The current study expands our understanding of genetic origins of anorexia nervosa and reveals that metabolic differences contribute to development of this disorder and thus play an equally important role along with psychiatric or psychological effects. Anorexia nervosa should be classified as a metabo-psychiatric disorder and both metabolic and physiological risk factors need to be explored by doctors to more effectively treat eating disorders and prevent relapse.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source

Hunna J. Watson et al. 2019. Genome-wide association study identifies eight risk loci and implicates metabo-psychiatric origins for anorexia nervosa. Nature Genetics.
<http://dx.doi.org/10.1038/s41588-019-0439-2> ■

Green Designs *to Manage Urban* Heat

Temperatures in big cities are rising due to 'urban heat island effect' and this is increasing the intensity and frequency of heat events. Study uses computational modeling to assess characteristics associated with increased temperatures across land-uses in cities to provide nature-based heat-mitigating solutions for different land-uses.

As more and more people move to big cities due to study and work opportunities, more constructions are coming up leading to a dramatic shift in city landscapes. Almost 54 percent of the global population now resides in urban areas. Big cities are becoming congested and dense. Due to more buildings and pavements in the cities, temperatures are high and continually rising due to a phenomenon called urban heat island effect. With rising temperatures, the frequency and intensity of severe long-lasting heat events is increasing as the summers are getting hotter. Urban heat not just raises temperatures but also causes pollution and detrimental health outcomes especially for the vulnerable population. Urban

heat is becoming an environmental concern for all major cities of the world. Nature-based design solutions for land-uses are needed to be adopted to build sustainable neighborhood for managing urban heat in cities.

In a study published on May 21 in *Atmosphere*, researchers examined the effects of using green infrastructure (vegetation and building material) on ambient air temperatures in various land-uses in Portland city, USA. They used a computational modeling program called ENVI-met microclimate modelling - the first dynamic model which can analyze thermal regime at finer resolutions and can model surface-plant-air-interactions in urban dwellings. Researchers used ENVI-met to first

which environmental characteristics are to be more likely associated with higher temperatures. Second, they analyzed how different green designs could reduce temperatures for these land-uses. In their analysis they explored different green infrastructure changes which were modelled using various land-use types.

Results that design-changes including planting trees and vegetation, installment of green roofs,

heightened roads and roofs, decreasing paved surfaces and using materials on roofs and on sidewalks which can reflect heat can have a good result. Also, material asphalt is highly associated with increase in ambient temperature. Maximum differences in temperature can be achieved by planting trees and using reflective building materials. Green roofs when installed, provided localized cooling and environmental effects like soaking rain water, controlling pollution and





providing a natural habitat to birds. Results showed that combination of different mitigation solutions would give relief from heat.

The current study shows the differences in temperature by incorporating changes in different land-uses in an urban neighborhood. The study provides heat-mitigating nature-based solutions for various city landscapes through an efficient platform for city planners to achieve climate goals.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source

Makido, Y et al. 2019. Nature-Based Designs to Mitigate Urban Heat: The Efficacy of Green Infrastructure Treatments in Portland, Oregon. Atmosphere. 10(5).
<http://dx.doi.org/10.3390/atmos10050282> ■

Enhancing Agricultural Productivity Through Establishing Plant Fungal Symbiosis

Study describes a new mechanism which mediates the symbiont associations between plants and fungi. This opens up avenues to increase agricultural productivity in the future by growing better resilient crops that require less water, land and lesser use of chemical fertilizers.

Plants have a complex symbiotic relationship with mycorrhizal fungi. These fungi form a sheath around plant roots providing multiple benefits under a symbiont relationship. The relationship allows for increased water and nutrient uptake by the plant especially phosphorus and in return, the plant provides carbon to the fungi to feed on and grow. The fungi extend quite long at the plant roots and thus larger volume of soils is now accessible. Almost 80 percent of all land plant species have a mycorrhizal fungus associated with roots. This relationship is the most ubiquitous and relevant plant-microbial interaction of which the underlying mechanisms are still being explored.

In a study published on July 8 in *Nature Plants*,

researchers used genomic sequencing, quantitative genetics, high performance computing and experimental biology to find genetic triggers to enable symbiont relationship between plant and fungi. They chose *Arabidopsis*, a plant which naturally does not interact with ectomycorrhizal fungus *L. bicolor*. They identified a specific gene which is most likely to control the symbiotic relationship between this plant and fungi in the soil. Subsequently, they genetically engineered this plant into a new version which now expresses a protein called G-type lectin receptor-like kinase PtLecRLK1 protein. The plant was now inoculated with the fungus.

G-type lectin receptor-like kinase PtLecRLK1 protein is seen to mediate a symbiotic interaction between *Populus* - *L. bicolor* as well as the



transgenic Arabidopsis - L bicolor systems as the fungus envelops plant root tips and forms a fungal sheath indicating a symbiotic formation. With modification of a single gene, a non-host Arabidopsis was converted into a host for this symbiont.

The current study describes an important molecular step on how symbiotic plant-fungi association is established. Better understanding this relationship by finding genetic triggers can help to use this symbiont relationship to be able to grow plants in adverse conditions like draught, or increasing nutrition and nitrogen uptake, dealing with pathogens etc. The study opens up avenues to engineer beneficial

plant-mycorrhizal relationships. It can help us grow crops which will need less water, lesser agricultural land, less chemical fertilizers, resist pests and pathogens and produce more yield per acre.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

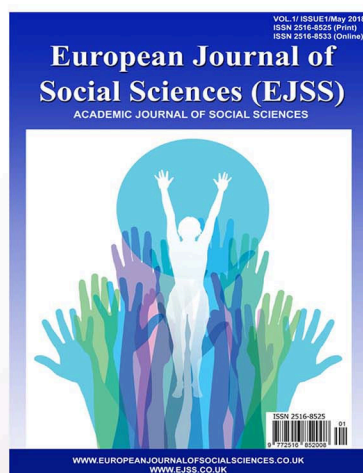
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Labbé, J et al. 2019. Mediation of plant-mycorrhizal interaction by a lectin receptor-like kinase. Nature Plants. 5 (7): 676.

<http://dx.doi.org/10.1038/s41477-019-0469-x> ■

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Complete Connectivity *Diagram of the Nervous* System: An Update

Success in mapping the complete neural network of male and female worms is an important progress towards understanding function of the nervous system.

Our nervous system is an intricate connection of nerves and special cells called neurons which transmit signals to different parts of the body. Human brain has billions of neurons which communicate via a large network of synaptic connections. Understanding the 'electrical wiring' of connections in the nervous system is important to understand its delivery of cohesive function(s) and to model organism behavior.

In a study published on July 3 in *Nature*, researchers have described the first complete connectivity diagram of the nervous system of both sexes of the animal – nematode *C. elegans*. This tiny 1mm long adult roundworm has only about 1000 cells and thus its nervous system is very simple with only around 300-400 neurons. *C. elegans* has been used as a model system in neuroscience because of similarities with humans. It is considered a good model to eventually understand complex human

brain consisting of more than 100 billion neurons. An earlier study, conducted more than three decades ago, had mapped the connections of the nervous system in female roundworm (nematode) *C. elegans* albeit in less detail.

In the current study, researchers analyzed already available and also new electron micrographs of adult male and female worms and pieced them using a specialized software to create complete wiring diagrams of both sexes. This diagram is like a 'neuronal map' and is being called the 'connectome'. The matrices



diagrams contained all (a) connections between individual neurons, (b) connections between neurons to muscles and other tissues and (c) synapses between muscle cells of the entire animal. The synaptic pathways are very similar in male and female worms, though number of synapses differ in their strength and thus are responsible for characteristics sex-specific male and female behaviors at multiple levels. The detailed mapping from sensory input to end-organ output helps to deduce how these animals react to their external surrounding and which nerve connections are responsible for which particular behavior.

The 'structure' of the worm's nervous system is an important step towards quantitatively mapping different neural connections inside the brain, its region and the nervous system to decipher worm behavior. How these animals behave could help specify neural connections which can falter and cause a disease. Many molecules in the roundworms nervous system are similar to human nervous system. This study can assist us in eventually understanding connections in human nervous system and their relationship with health and disease. Since many neurological and psychiatric disorders are known to be caused by some problem in this

'wiring', understanding connections can help us develop therapies for different mental illnesses.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source(s)

1. Cook, SJ et al. 2019. Whole-animal connectomes of both *Caenorhabditis elegans* sexes. *Nature*. 571 (7763).

<https://doi.org/10.1038/s41586-019-1352-7>

2. White JG et al. 1986. The structure of the nervous system of the nematode *Caenorhabditis elegans*. *Philos Trans R Soc Lond B Biol Sci*. 314(1165).

<https://doi.org/10.1098/rstb.1986.0056> ■

Fresh plea for *responsible use of 999* over Christmas period




Monday 16 December 2019: THE Welsh Ambulance Service has issued a fresh plea for the public to use 999 responsibly as Christmas draws near.

While the Christmas and New Year period is generally one of the busiest, new figures have

revealed that last Christmas Day was actually the quietest day in December, prompting the Trust to suggest that people behave differently on December 25th from other days of the year when it comes to calling an ambulance.

The service took 1,374 calls via 999 last Christmas Day; almost 500 calls fewer than on its



busiest day, December 1st, when it had 1,847 calls.

Jason Killens, Chief Executive of the Welsh Ambulance Service, said: “This suggests to us that those people who would normally be tempted to call us inappropriately are busy opening presents and eating lunch which means suddenly their ‘emergency’ can wait.

“By Boxing Day, the calls have gone up. Sometimes this is because people are genuinely unwell, but often it’s a result of overindulgence the previous day.

“People who are genuinely ill don’t choose when they are unwell and, of course, we are there for those patients 24/7, 365 days of the year.

“However, those people who use ambulance services as a substitute for a GP appointment or because they have a long-standing minor illness or injury seem to make different choices on Christmas Day.

“It is these people we are asking to be sensible and to make those same choices every other day of the year.

“Every day should be Christmas Day when you think about how to use 999; it really is that special.”

Most GP surgeries will close on Bank Holidays – including Christmas Day, Boxing Day and New Year’s Day – so the Trust is urging people to take steps now to ensure they are prepared.

Lee Brooks, Director of Operations, added: “Calls to our ambulance service are triaged in order of priority, so if you’re not seriously ill or injured, you will wait longer for our help.

“You also won’t be seen any quicker in emergency departments if you arrive by ambulance as all patients are seen in order of clinical priority, not

according to how or when they arrived in the department.

“Before you dial 999, think about where else you might be able to access the help you need, quicker.

“Nurses employed by the Welsh Ambulance Service are on hand 24/7, including on Christmas Day, to give you advice and information – call them on 0845 46 47, or on 111 if it’s available in your area.

“You can also visit www.nhsdirect.wales.nhs.uk to take one of 20+ symptom checkers, including for cold and flu, dental and stomach pain, to receive immediate online advice about what to do next.

“Don’t forget about your pharmacist, optician and your local minor injuries unit, where there is no need for an appointment.

“If you rely on medicines, make sure you have a big enough supply to see you through, and stocking up on simple remedies is a good idea too, including for indigestion, headache and toothache.”

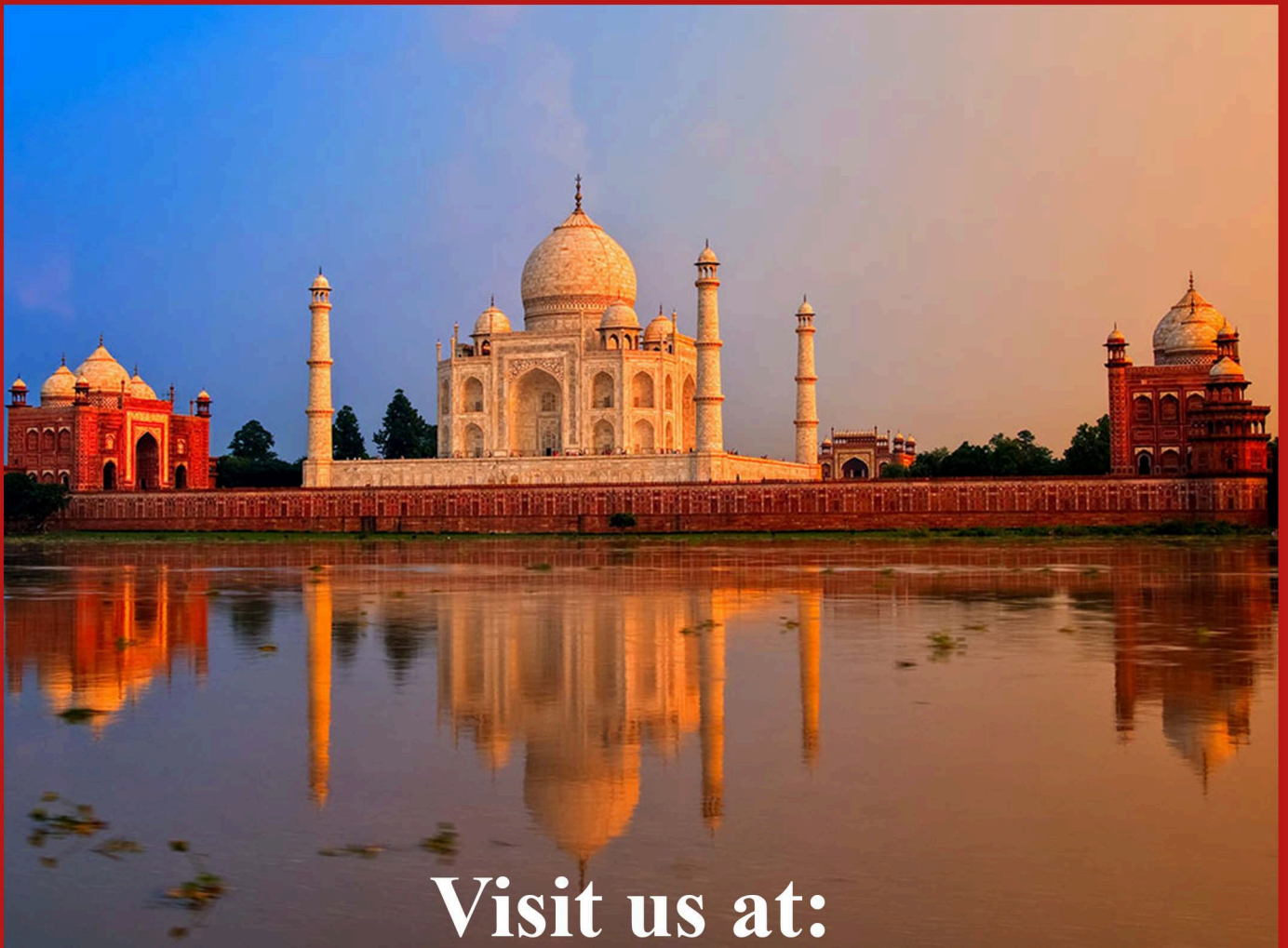
The Welsh Ambulance Service is calling on the public to use its services appropriately as part of its new Be Wise Save Lives campaign.

Follow the campaign on social media using the hashtag #BeWiseSaveLives

Based on press release issued by Welsh Ambulance Services NHS Trust. ■

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Extra-Terrestrial: *Search for Signatures* of Life

Astrobiology suggest that life is abundant in the universe and the primitive microbial life forms (beyond earth) could be found earlier than intelligent forms. The search for the extra-terrestrial life involves looking for biological signatures in the vicinity of solar system and looking for radio signals or technical signatures in far away deeper space. There is case for renewed emphasis on searching technosignatures of life in the universe.

If there is life beyond this planet ? This question has always intrigued people and there has been lot of sensationalism and media attention on extra-terrestrial life forms. But where does science stands? Now we have a full-fledged interdisciplinary area of astrobiology dedicated to the study of the origin, evolution, and distribution of life in the universe.

To the question *If there is life beyond earth*, there is optimism about the possibility of extraterrestrial life (Billings L., 2018). NASA Kepler telescope has shown that the habitable worlds are abundant in the universe. So are building blocks of life hence it seems reasonable to deduce that the life should be abundant in the universe.

Is it really possible to find extra-terrestrial intelligence? Yes, there is increasing possibility due to technological advancements (Hirabayashi H. 2019). Therefore there certainly is a case for

search of life on other planets; the extra-terrestrial life form could be primitive or complex and intelligent. Estimates suggests that there is relative likelihood of success in the searches for primitive life form than intelligent one (Lingam and Loeb, 2019). The dominant thinking in astrobiology is that the “first contact” with extra-terrestrial life may be with microbial life elsewhere (Billings L., 2018).

How do we search them? The search for life in the universe currently involves two approaches - search for biosignatures (signatures of biology) in and around solar system and radio search for technosignatures (signatures of advanced life forms and technology) emitted from sources far away from solar system in the galaxy and beyond. Projects like Mars and Europa landers, James Webb Space Telescope are aimed at search for

signatures of biology in nearby solar system while NASA's SETI (Search for Extra Terrestrial Intelligence) program and the Breakthrough Listen (BL) project are examples of search for technical signatures in far deeper space.

Both approaches offer benefits but the search for technosignatures seems to complement

search for biology but also expands search from solar neighbourhood to deeper in universe into galaxies.

The search for the technosignatures involving orientation, recording and analysis of radio signals or bursts emanating from deep space comes at relatively much lower cost (vis a vis search for biosignatures), for example, the annual budget of NASA's SETI program was about \$10 million. Much of the space can be targeted and searched for radio signals with strong information content, robust detection and interpretations. Further, radio search has a established scientific background and context.

The case for search of technosignature is also made for the fact that search volume sampled so far is very low. The search volume could be expanded in near future. This would require enhanced access to radio telescopes, resources, rebuilding research ecosystem and keeping up with hardware and software advances (Margot et al 2019).

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source(s)



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2. Billings L., 2018. From Earth to the Universe: Life, Intelligence, and Evolution. Biological Theory. 13(2). <https://doi.org/10.1007/s13752-017-0266-6>
3. Hirabayashi H. 2019. SETI (Search for Extraterrestrial Intelligence). Astrobiology. https://doi.org/10.1007/978-981-13-3639-3_30
4. Lingam M and Loeb A 2019. Relative Likelihood of Success in the Search for Primitive versus Intelligent Extraterrestrial Life. Astrobiology. 19(1). <https://doi.org/10.1089/ast.2018.1936>

Editor's Note: Dr Jean-Luc Margot from UCLA has suggested 'NASA does not have a SETI program. It has not had a SETI program in over 25 years. Please consider a correction.'. We would like to add that NASA's SETI program got cancelled in 1993. At that time SETI program's annual budget was about \$10 million. ■

Menstrual Cups:

A Reliable Eco-friendly Alternative

Women need safe, effective and comfortable sanitary products for menstrual management. New study summarizes that menstrual cups are safe, reliable, acceptable yet low-cost and environment-friendly alternative to existing sanitary products like tampons. Enabling menstruating girls and women to make informed choices on sanitary products can help them lead good and healthy lives.

Menstruation is a normal body function in a healthy girl or woman. Around 1.9 billion women worldwide are of menstruating age and every woman spends up to 2 months in a year in handling menstrual blood flow. Various sanitary products are available like sanitary pads and tampons which absorb blood, and a menstrual cup which usually collects blood and will need to be emptied between 4-12 hours as this depends upon blood flow and type of cup used. Two types of such cups are available – bell-shaped vaginal cup and a cervical cup which is placed around cervix similar to a diaphragm. These cups are made up of medically-used silicon, rubber or latex. They are reusable and can last up to a decade, though some single use options are also available. All women require reliable, safe and comfortable menstrual products as poor quality products result in leakage and chaffing and their usage directly affects health.

A very limited number of studies have compared existing sanitary products. A new study published on July 16 in *The Lancet Public Health* aimed to evaluate the safety, practicality, availability, acceptability and cost factors of using a menstrual cup. Menstrual cups have been around since 1930s but awareness about them is very low even in high-income countries. In their study, researchers compiled and reviewed 43 academic studies involving 3,300 women and girls who self-reported their experience of menstrual cup usage. Researchers also collected information from manufacturer and user experience database for events on menstrual cup usage. Examining menstrual blood leakage when using a cup was primary. Also, safety issues and adverse events were evaluated. Costs, availability and environmental savings were estimated. Information was assessed for low, middle-



income and high-income countries.

Analysis showed that menstrual cups are a safe and effective option for menstrual management just like other sanitary products and that lack of familiarity is the biggest hurdle in menstrual cup usage. This product is never mentioned on any educational websites which discuss puberty in girls. Leakage in menstrual cups was similar or less compared to other sanitary products and rates of infection are similar or lower for menstrual cups. Preference for menstrual cups was seen to be high in different countries and even in low income countries, resource constrained setting was not a deterrent.

Different brands are available in 99 countries costing between 72 cents to USD 50. Using reusable menstrual cups also has major environmental and cost benefits as plastic waste can be drastically reduced.

The current study summarizes information on leakage, safety, acceptability of menstrual cups in

comparison with available sanitary products. The study emphasizes that menstrual cups are a safe, reliable and acceptable option in low, middle-income and high-income countries. Enabling women to make informed choices about sanitary products for menstrual management can help them to live a healthy and productive lives.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source

Anna Maria van Eijk et al. 2019. Menstrual cup use, leakage, acceptability, safety, and availability: a systematic review and meta-analysis. The Lancet Public Health. [https://doi.org/10.1016/S2468-2667\(19\)30111-2](https://doi.org/10.1016/S2468-2667(19)30111-2) ■

Resveratrol Can Protect Body Muscle in Mars' Partial Gravity

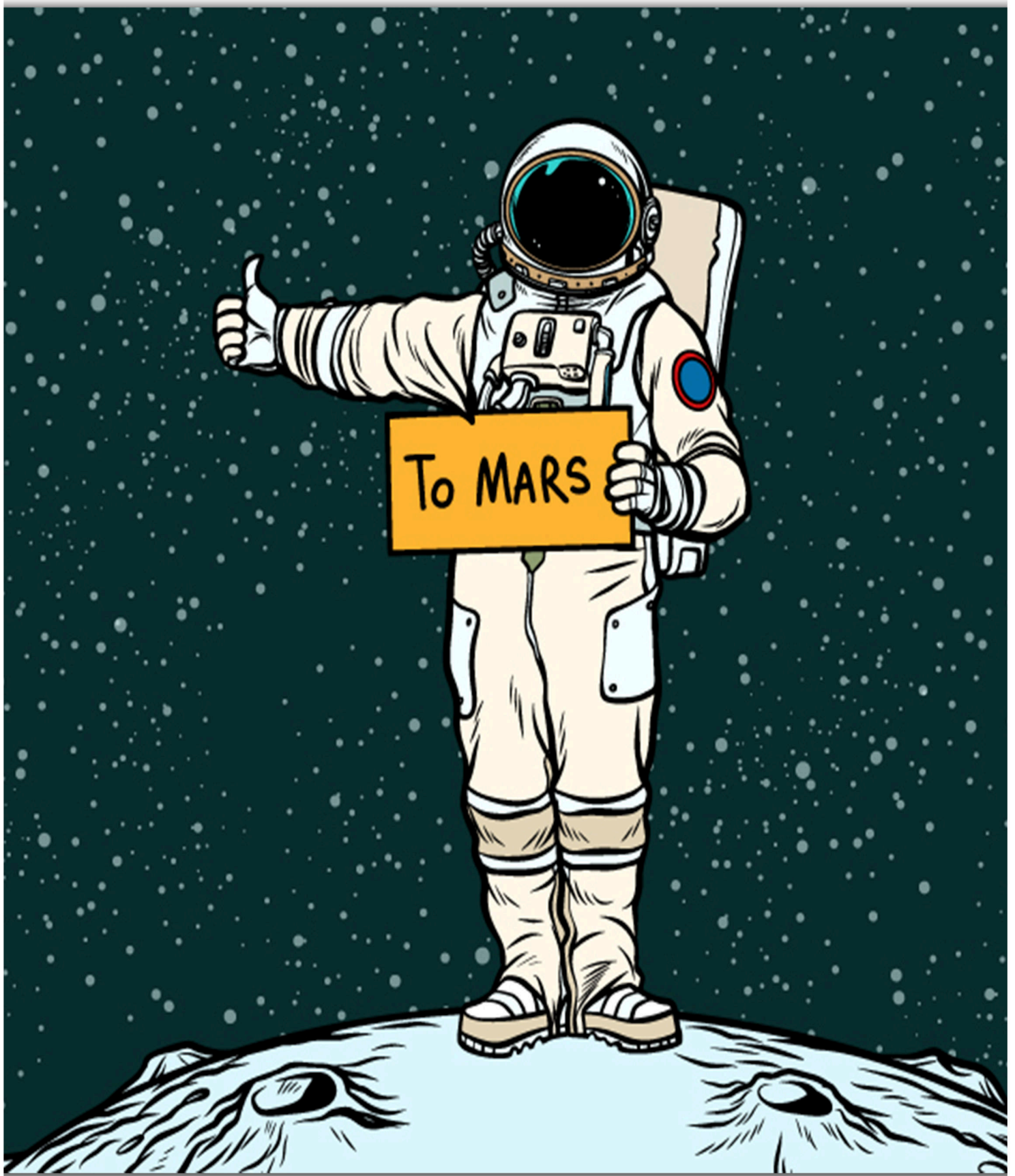
The effects of partial gravity (example on Mars) on our muscular system is still partly understood. Study in rats shows that resveratrol, a compound found in grape skin and red wine, can mitigate muscle impairment in a Mars partial gravity model. This can be beneficial to sustain long-term Mars missions.

The National Aeronautics and Space Administration (NASA) of USA is planning to send astronauts to Moon and Mars. Microgravity is known to affect our body's muscular system as muscles and bones start to become weak. First, weight-bearing muscles like soleus, located in the calf are affected and then slow-twitch muscle fibers are lost. Mars's gravitational pull is only 40 percent of Earth's thus it has a lower gravity of 0.38g. It is still not completely understood how such partial gravity can affect our body. No partial weight-bearing model has been tested until now which can mimic Martian partial gravity. More understanding in this area is critical in order to plan long space missions to Mars and safe return of astronauts to Earth.

A new study published on July 18 in *Frontiers of Physiology* has used recently developed partial weight-bearing animal models of simulated Mars partial gravity to understand how muscle

deconditioning could be addressed on long Mars space missions. To simulate gravity of Mars, rats were fitted with full-body harness and were suspended from their cage ceiling. Divided into two groups, rats were exposed to normal loading (of Earth's) or 40 percent loading of Mars for 2 weeks. Half the number of rats in each group received either resveratrol (RSV) - a safe polyphenol commonly found in grape skin, red wine and blueberries - in water or only water. The animals fed freely on chow diets.

In Mars condition, rats' grip weakened and their calf circumference, muscle weight and slow-twitch fiber content got shrunk. Calf circumference and front and rear paw grip force were measured weekly while calf muscles were analyzed after 2 weeks. Results showed that a moderate daily dose (150 mg/kg/day) of resveratrol was seen to preserve muscle mass and strength in animals exposed to the effects of



a simulated Mars gravity. RSV helped restore front and rear paw grips and protected muscle mass in Mars rat while having no effect on diet or body weight. RSV is known to have anti-inflammatory, anti-oxidative and anti-diabetic effects. It has been shown to promote muscle growth in diabetic animals by increasing insulin sensitivity and glucose uptake in muscle fibers. Astronauts are thought of developing reduced insulin sensitivity during space missions.

Resveratrol is seen to have a muscle-protective effect as it preserves bone and muscle mass. The current study suggests that resveratrol can help to mitigate muscle impairment in a Mars partial

gravity analog which mimics Mars environment. It could be used as a nutritional supplement to reduce muscle and skeletal deconditioning and deterioration on long-term Mars missions.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source

Mortreux, M. 2019. A Moderate Daily Dose of Resveratrol Mitigates Muscle Deconditioning in a Martian Gravity Analog. *Front. Physiol.*
<https://doi.org/10.3389/fphys.2019.00899> ■

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Low EROI of Fossil Fuels: *Case for Developing Renewable Sources*

Study has calculated energy-return-on-investment (EROI) ratios for fossil fuels from first extraction stage till the last stage when the usable fuel is ready. It is concluded that fossil fuels EROI ratios are low, declining and are similar to renewable sources of energy. Development of cost and environment friendly renewable sources is needed to meet our energy demands.

Fossil fuels like oil, coal and gas are dominating the energy production around the globe. Fossil fuels are believed to provide high energy-return-on-investment (EROI). This is the ratio of how much energy is needed to extract a fossil fuel source like coal or oil and how much usable energy this source will eventually produce. Fossil fuels like oil, gas and coal have high EROI ratio of 1:30 meaning one barrel of oil extracted can produce 30 barrels of usable energy. Since the EROI ratio of fossil fuels are usually measured during the extraction process from ground (the primary stage), ratios calculated so far fail to take into account the energy which is required to convert these 'crude' or

forms into usable fuels like petrol, diesel or electric power.

On the other hand, renewable sources of energy like wind and solar have been estimated to have EROI ratios below 10:1 which is far lower mainly because they require initial infrastructure like windmills, solar panels etc which comes at a considerable cost. However, fossil fuels are limited in supply as one day our planet will run out of them. Fossil fuels also heavily pollute the environment. Alternative renewable sources of energy are urgently needed.

A study published on July 11 in Nature Energy has investigated the global energy-return-on-



investment of fossil fuels over a total duration of 16 years at the primary stage (extraction) and at the last finished stage. While EROI ratios at primary stage were approximately 30:1 and agreeable with previous calculations, researchers found that EROI ratios at the finished stage are 6:1. This number is also consistently decreasing and is similar to renewable sources of energy.

However, fossil fuel EROI ratios have declined by almost 23 percent in 16 years, therefore, it becomes imperative to remove our dependency on fossil fuels and opt for more renewable sources of energy considering cost and environmental factors.



The cost of extracting fossil fuels is rapidly increasing which could soon deplete the 'net energy' for finished usable fuels because of the additional energy required to process raw fossil fuels. Also, fossil fuels aren't easily accessible anymore thus requiring higher energies to be extracted thereby escalating the energy cost.

The current study shows that EROI ratios of fossil fuels are now becoming closer to renewable sources of energy. Renewable sources of energy require initial infrastructure like windmills, solar panels etc and thus are not considered as having good EROI.

{You may read the original research paper by clicking the DOI link given below in the list of cited source(s)}

Source(s)

Brockway, P. et al. 2019. Estimation of global final stage energy-return-on-investment for fossil fuels with comparison to renewable energy sources. Nature Energy.

<http://dx.doi.org/10.1038/s41560-019-0425-z> ■



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