Haziran 2021

KOÇ SCIENCE COPE

VKV Koç Özel İlkokulu, Ortaokulu ve Lisesi
Öğrenci Dergisi

Logo Tasarımı:
Can Yılgör / Koç 2020

KOÇ SCIENCE COPE

Kapak Tasarımı:
Su Kaftancıoğlu / Koç 2021

VKV Koç Özel İlkokulu,
Ortaokulu ve Lisesi Öğrenci E-Dergisi
Haziran 2021

E-Dergi Yayımlayan:
VKV Koç Özel İlkokulu,
Ortaokulu ve Lisesi
Tepeören - Tuzla - İstanbul

İmtiyaz Sahibi:
Prof. Dr. Murat Günel

Sorumlu Yazı İşleri Müdürü:
Zeynep Kurmuş Hürbaş

Kurumsal İletişim:
Ceylan Çetinbağ

Dergi Tasarım ve Uygulama:
Dilek Seferoğlu

İçindekiler

Koc School's Incredible Success in "the Academic Marathon"	2
Covid-19 Hakkında Doğru Bilinen Yanlışlar	3
Covid-19 için Çıkarılan Aşıların Karşılastırması	4-5
Fonksiyonel Tıp	6-7
Test	8
A New "Short Sleeper" Gene Has Been Discovered	9-10
The NASA Twins Study	11-12
Yaşamın Kodunu Yeniden Yazma	13-14
Life in Pandemic Fotoğraf Karikatür Sergisi	15-17
Chemistry Club	18
Fake or Not?	19-20
Conrad Challenge & The Project "Energency"	21-22
Carbon Footprint	23-25
What is "snow pollution"? Why does it happen?	26-27
The Chemistry of Eternal Youth: Key Chemicals for Anti-Aging	28-30
A High-Precision Atomic Clock	31-32
Another Sun	33-34
Force	35-36
The Mysterious Reality	37-38
Nuclear Physics and Its Usages	39-41
The Controversy of the Hubble Constant	42-43
The Life and Discovery of Cecilia Payne-Gaposchki	44-47
The Mystery of the Order in the Universe	48-49
Heat Engines and Thermodynamic Cycles	50-53

Koç Science Cope Dergisi Sorumlu Öğretmenleri:
Pınar Şen, Filiz Turfan, Dr. Yeter Erol

Koç Science Cope Dergisi Sorumlu Öğrencileri:
Fizik Editörü: Mehmet Efe Çığ / 11
Kimya Editörü: Mina Taşan / 10
Biyoloji Editörleri: Alara Koç / 11, Yağmur Oğuz / 11, Ada Turgut / 11

Koc School's Incredible Success in "the Academic Marathon"

"Academic Marathon" is a new initiative that discovers students' potential through an immersing and challenging event. Academic Marathon is not only about the championship but also about extending students' limits in academic learning and exploring their own potentials.

The Academic Marathon International Final for the year of 2020 was concluded on January 31st, 2021 online. Competitors won both individual and team awards at the AM 2020. This year, 26 different countries participated in the online competition with 601 competitors in 17 different subjects.

The whole competition was conducted online. The competitors took the material-based objective test for the final round in two hours (specially formatted for online) on January 31st to answer the 100 multiple-choice questions, which test their abilities to learn and understand new knowledge of advanced academic theories. Through the tests, students showed their comprehending and learning abilities as well as harvest new knowledge through the event itself.

Some of the incredible rankings of Koc students:

Team Awards

- 1st place in Chemithon
- 1st place in Psychothon

Individual Awards

- 2nd place in Chemiton - Yalçın Tür
- 4th place in Chemiton - Kerem Dilmen
- 6th place in Chemiton - Cansu Özdemir
- 7th place in Chemiton - Azra Naz Akıncı
- 10th place in Chemiton - Elis Aksu
- 10th place in Chemiton - Emir Bay
- 15th place in Chemiton - Yağmur Yetkin

- 3rd place in Biothon - Mine Metin
- 6th place in Biothon - Aslı Tavaslı

- 3rd place in Physithon - Asya Ülger
- 7th place in Physithon - Zeynep Karahasan
- 0th place in Physithon - Aslı Cihangir
- 12th place in Physithon - Mehmet Efe Çığ
- 12th place in Physithon - Şeniz Ayça Fırtına
- 20th place in Physithon - Beste Baban

- 1st place in Psychothon - Defne Ece Yavuz
- 1st place in Psychothon - Mina Bengi Aral
- 4th place in Psychothon - Duru Kaya
- 11th place in Psychothon - Su Yeşildere
- 13th place in Psychothon - Sıla Sözeri

Source:
Marathon descriptions are taken from Academic Marathon's own sources https://mainbucket.learningfirst.cn/am/AM%20Results.pdf

Covid-19 Hakkında Doğru Bilinen Yanlışlar

Yanlış: Evcil hayvanlardan koronavirüs bulaşır.

Doğru: Evcil hayvanlarımızın ya da sokak hayvanlarının insandan insana bulaşma kabiliyetini kazanmış bu koronavirüsü bulaştırmada herhangi bir rolü yoktur.

Yanlış: Çocuklar hasta olmazlar.

Doğru: Çocuklar da Covid 19 geçirebilir. Üstelik semptomları bulunmayan çocuklar taşıyıcı olup hastalığı yetişkinlere de taşıyabilir.

Yanlış: Ek vitamin kullanımı Covid 19'a karşı korur.

Doğru: Vitamin ilaçlarının, çeşitli besin takviyelerinin ve bitkisel ürünlerin immün sistemi kuvvetlendirdiği bilgisi tamamen yanlıştır. Normal fizyolojik durumumuzda bu sistem tam dengede durur, hiçbir ilaç veya maddenin bağışıklık kuvvetlendirici etkisi yoktur.

Yanlış: Kullanılan maskeler mikrodalga fırınlarda dezenfekte edebilir.

Doğru: N95 maskeler içinde metal parçalar zarar görebilir. Bazı kumaş maskeler yıkanabilir. Yıkanamıyorsa dezenfekte edilerek güneş gören temiz bir yerde birkaç gün havalandırarak tekrar kullanılabilir.

Yanlış: Sebze ve meyveler sabunlu suyla yıkanmalı.

Doğru: Yiyeceklerle koronavirüs bulaşmaz çünkü midemizdeki asit korona virüsün ölmesine yol açar. Dolayısıyla sebze ve meyveleri bu şekilde temizlenmesi çok fazla önerilmiyor. Sadece suyla surterek yıkamak yeterlidir.

Yanlış: Antikor testi pozitif olan bir kişi enfeksiyon geçirdiği için bir daha geçirmez.

Doğru: Antikor testinin pozitif olması sadece hastalığı geçirmiş olduğumuzu gösterir. Ancak yeniden hasta olmaktan koruduğunu gösteren yeterli bir kanıt henüz bulunmamaktadır.

Yanlış: Açık alanda sadece ben maske taksam çevremdekiler takmasa da olur.

Doğru: Fiziksel mesafeye dikkat edilmediğinde ve karşılıklı iki kişiden birinin maske takmaması durumunda bulaşma olasılığı yüzde 5 iken, her iki kişinin maske takması ve fiziksel mesafeye uyması durumunda bulaş riski olmayacaktır. Virüsün damlacık yoluyla ve yakın temasla bulaştığı gerçeğinden yola çıkarak her bireyin maske kullanması ve fiziksel mesafeye dikkat etmesi ve uyum göstermesi bulaşın yayılımının önüne geçecektir.

Yanlış: Sarımsaklı su, alkol, tuzlu su, çeşitli antiseptik gargaralar gibi sıvıların boğaz ya da burun mukozasına uygulanması koruyucudur.

Doğru: Kesinlikle koruyucu değildir. Bu uygulamalar, mukoza bütünlüğünü bozarak virüslerin bu bölgelerdeki hücrelere tutunmasını kolaylaştırabilir.

Yanlış: Sıcak uygulama, sauna, nem ya da soğuk uygulama virüsleri yok eder.

Doğru: Virüsler 56 derecede ölür ama bu sıcaklıkta kendi hücrelerimizin içindeki proteinler de denatüre olarak hücrelerimizin ölümüne yol açar.

Yanlış: Virüslerin canlı olarak kalabilmesi için mutlaka canlı hücrelere ihtiyaç yoktur.

Doğru: İhtiyaçları vardır. Kargo yolu ile veya uzaktan satın alınan çeşitli ürünlerle bulaşma olasılığı çok zayıf, hatta olanaksızdır.

Naz Yörük

COVID-19 İÇİN ÇIKARILAN AŞILARIN KARŞILAŞTIRMASI

Covid-19 virüsünde etkili aşılar 4 ana kategoriye ayrılmaktadır:

• RNA temelli aşılarda virüsün tamamı yerine, genetik bilgisini taşıyan RNA zincirinden kritik bir kısım, "spike proteini" vücuda enjekte ediliyor.

• Viral vektör aşılarında da yine gen teknolojisi kullanılarak, virüsün taşıdığı genetik materyalin bir kısmı, başka bir virüs içine yerleştiriliyor ve vücuda enjekte ediliyor.

• Etkisiz hale getirilmiş veya zayıflatılmış bir virüs formunu kullanan aşılarda, hastalığa neden olmamakla birlikte yine de bir bağışıklık tepkisi oluşturan zayıflatılmış virüsler vücuda enjekte ediliyor.

• Protein parçalarını ve kabuklarını kullanan aşılar da hem Covid-19 virüsünü taklit eden hem de güvenli bir şekilde bağışıklık tepkisi oluşturacak genelleikle modifiye proteinleri insana enjekte ediyor.

Moderna ve Pfizer Aşıları:

Rna temelli aşılar

Pfizer-BioNTech ve Moderna aşısı virüsün "spike proteini" oluşturmak için genetik talimatına dayanıyor. Aşı, hücrelerimizin protein yapmak için okuduğu genetik materyal olan haberci RNA'yı kullanır. Kısaca mRNA olarak adlandırılan molekül kırılgandır ve doğrudan vücuda enjekte edilirse doğal enzimlerimiz tarafından parçalara ayrılır. Aşıyı korumak için Moderna, mRNA'yı lipit nanopartiküllerinden oluşan yağlı kabarcıklara sarar. Kliniklerde gerçekleştirilen deneylere göre Moderna %94.1, Pfizer %95 oranında etki göstermiştir.

Johnson & Johnson Aşısı:

Viral vektör aşısı

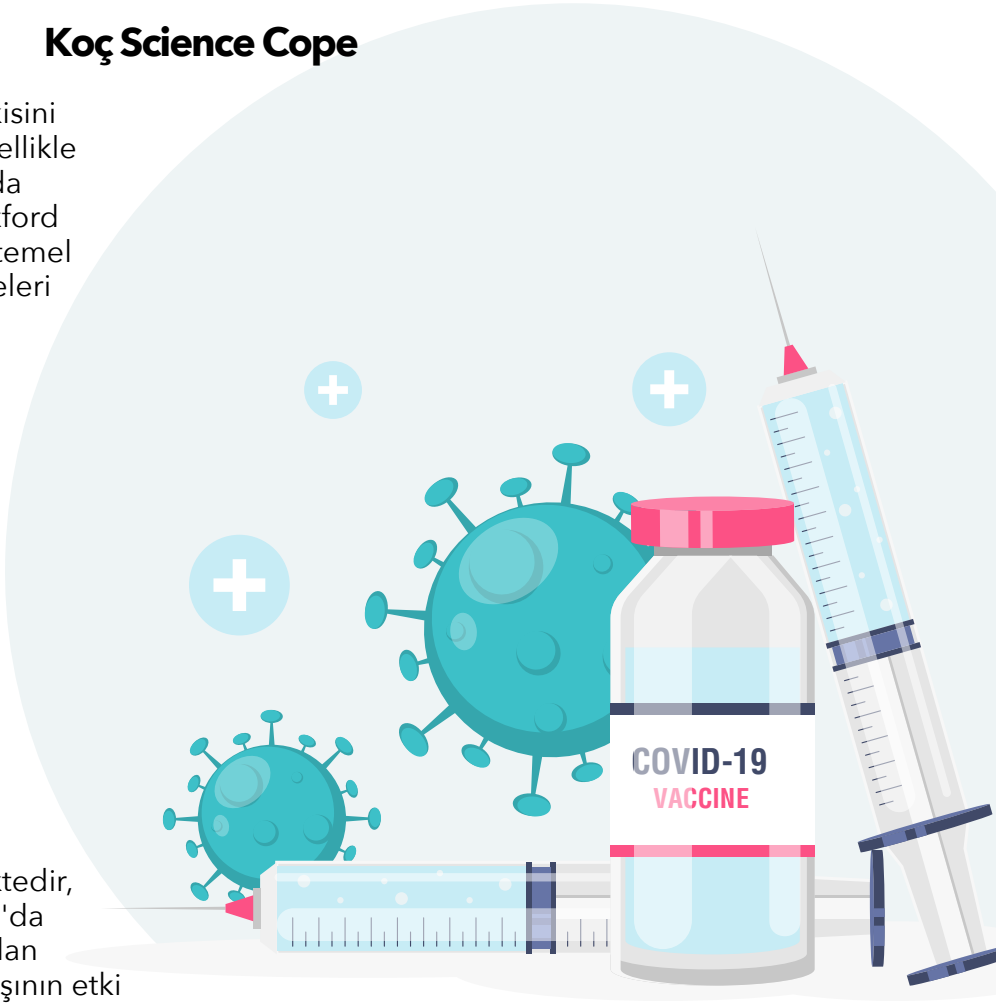
Johnson & Johnson aşısı, Pfizer ve Moderna aşısı ile aynı temellere sahiptir. Ancak, proteindeki bilgiyi tek sarmallı RNA'da depolayan Pfizer ve Moderna aşılarının aksine, çift sarmallı DNA kullanır. Ayrıca bu aşıda, koronavirüste bulunan "spike proteinini" Adenovirus 26 adlı başka bir virüse eklenmiştir. Aşıda, hücrelere girebilen ancak içlerinde çoğalamayan veya hastalığa neden olmayan değiştirilmiş bir adenovirüs kullanılmıştır. Araştırmalara göre Johnson & Johnson aşısı %74 oranında bir etki göstermiştir

Sputnik V ile Oxford Aşıları:

Viral vektör aşılar

Viral vektör bazlı aşılar, aslında antijen içermemesi, bunun yerine bunları üretmek için vücudun kendi hücrelerini kullanmaları bakımından geleneksel aşıların çoğundan farklıdır. Bunu, virüs yüzeyinde bulunan COVID-19 "spike proteinini" insan hücrelerinde antijen üretilmesi için genetik kodu iletmek üzere değiştirilmiş bir virüs (vektör) kullanarak yaparlar. Aşı, hücreleri enfekte ederek ve onlara büyük miktarlarda antijen üretmeleri talimatını

verir, daha sonra bir bağışıklık tepkisini tetikleyerek, belirli patojenlerle, özellikle virüslerle doğal enfeksiyon sırasında olanları taklit eder. Sputnik V ve Oxford Astrazeneca aşıları da bu yöntemi temel alınarak üretilmiştir ve başarı seviyeleri sırayla %92 ve %70 şeklindedir.



CoronaVac Aşısı:

Zayıflatılmış virüs aşısı

CoronaVac, kuduz gibi birçok iyi bilinen aşıda başarıyla kullanılan daha geleneksel bir aşı yöntemidir. Ciddi bir hastalık tepkisi riski olmadan vücudun bağışıklık sistemini virüse maruz bırakmak için öldürülmüş veya zayıflatılmış virüsü aşı halinde kullanarak çalışır. Ancak, aşının dünyanın farklı yerlerindeki etki seviyesi değişmektedir, Türkiye'de %91.25 iken Endonezya'da %65.3 şeklindedir. Brezilya'da yapılan araştırmalar sonucunda ilk olarak aşının etki seviyesi %78 olarak belirlenmiş olsa da 2021 yılının başındaki bir araştırma bu değerin aslında %50,4 olduğunu kanıtlamıştır.

Novavax Aşısı:

Protein bazlı aşı

Novavax şirketi, NVX-CoV2373 adlı protein bazlı bir koronavirüs aşısı geliştirdi. Novavax aşısı, bağışıklık sistemine "spike proteinlere" karşı antikorlar yapmayı öğreterek çalışır. Aşı, modifiye edilmiş bir "spike" genini bakulovirüs adı verilen farklı bir virüse eklendikten sonra insana enjekte edilmesiyle tamamlanır. Enfekte hücreler, koronavirüs yüzeyinde yaptıkları gibi, kendiliğinden bir araya gelerek sivri uçlar oluşturan "spike proteinler" üretti. Aşının etkisi %96.6 olarak başlasa da virüsün mutasyon geçirmesiyle bu değer %86.3 olarak değişmiştir.

Ada Uçar / 10

Kaynakça:
- https://ourworldindata.org/covid-vaccinations
- https://www.nytimes.com/interactive/2020/health/moderna-covid-19-vaccine.html
- https://www.gavi.org/vaccineswork/what-are-protein-subunit-vaccines-and-how-could-they-be-used-against-covid-19
- https://www.nytimes.com/interactive/2020/health/johnson-johnson-covid-19-vaccine.html
- https://www.bbc.com/turkce/haberler-dunya-55092070
- https://www.nytimes.com/interactive/2020/health/novavax-covid-19-vaccine.html

FONKSİYONEL TIP

Fonksiyonel Tıp, hastalığın nasıl ve neden ortaya çıktığını belirler ve her birey için hastalığın temel nedenlerini ele alarak sağlığı iyileştirir.

Hastalık Dedektifleri: Fonksiyonel tıp; optimal sağlığa ulaştırmayı hedefleyen, bireysel, hasta merkezli, bilim, temel alan bir yaklaşımdır. Her hastanın yaşam tarzı, genetik ve biyokimyasal bilgileriyle ilgili verileri dikkatlice toplayarak hastaya özel tedavi planı

yapar. Amaç hastanın şikayetlerine sebep olan kök nedene ulaşarak hastalığı tedavi etmektir. Fonksiyonel tıp, günümüzde ön planda olan geleneksel tıbbın geleceğidir. Vücudu, sistemlere ayırıp bağımsız organlar topluluğu olarak değil, bir bütün olarak görür. Hasta merkezli olarak kurulmuş bir dal olsa da hastaların şikayetleri tedavide asıl amaç değildir.

Hedeflenen çözüm, hastanın şikayetini kaynaklandıran tüm sistemi tedavi etmek ve bu vesileyle de gelecekte bu şikayetin ya da benzerlerinin yeniden doğmasını önlemektir. Yani yalnızca semptomları tedavi etmek yerine, sorunun kaynağına odaklanır. Fonksiyonel tıp uzmanı vücudun kendini iyileştirme gücünü açığa çıkarmak için gereken yol haritasını çizmek, gelecek desteği planlamak ve yönetmeyi hedeflemektedir.

Tedavi yöntemlerine örnekler:

Akupunktur:

Akupunktur, ilaç kullanımı gerekmeksizin, vücudun belirli bölgelerine özel iğnelerin uygulanmasıyla organların fonksiyonlarını düzenlemede kullanılan bir fonksiyonel tıp uygulamasıdır.

Ozonterapi:

Ozon terapisi üç adet oksijenden oluşan ozon gazının kullanımı ile hayata geçirilen bir tedavi yöntemidir. bağışıklı sistemini regüle ettiği, vücudun oksijen kapasitesini arttırdığı ve dolaşım sistemini desteklediği için diyabet, dolaşım bozuklukları ve nörovejetatif hastaları tarafından kullanılabilir

Otoimmün hastalıklara farklı yaklaşımlar:

Günümüzde geleneksel tıp otoimün hastalıkların sebebine bir cevap bulamamıştır ancak fonksiyonel tıp bu probleme farklı bir bakış açısı ile baktığından belirli sebepler sunulabilmektedir. Öne sürülen birkaç sebep: sızdıran veya geçirgen bağırsak, kronik stres ve enfeksiyonlar, toksinlere maruz kalıp detoksine edememe ve besin hassasiyeti şeklindedir.

Bağırsak geçirgenliğinin açıklaması:

İnce bağırsağımız bağ, kas ve epitel doku olarak üç farklı katmandan oluşmaktadır. Çeşitli nedenlerle ve uzun zamanda bağırsaklarımızın bu yapısında bozukluklar oluşabilmektedir. Bu bozukluklar, bağırsaklarımızın besinleri doğru şekilde emilimini engellemekte, sindirimi tamamlanmamış besinlerin, toksik atıkların ve

bakterilerin bağırsak duvarını geçerek damara ulaşmasına neden olmaktadır. Bunun sonucunda, bağışıklık sistemimiz yabancı olarak tanımladığı bu maddelere karşı mücadeleye başlayarak, tüm vücudumuzda kalıcı inflamasyona sebep olur. Başka bir anlatımla, vücuda giren ve damarda olmaması gereken, aslında zararlı olmayan besin parçaları olsa bile, her türlü yabancı maddelerle otomatik olarak mücadele başlatılır.

Fonksiyonel tıp bakış açısıyla, bu sorunun besin alerjileri, migren, astım, kronik yorgunluk, artrit, egzama gibi çok çeşitli hastalıklara neden olabileceği düşünülmektedir. Bazı durumlarda vücudun kendi hücrelerine saldırması ile sonuçlanan bu durum (tiroid hastalıkları), giderek kötüleşen bir süreci başlatabilmektedir. Bağışıklık sistemini sürekli baskı altında ve bir bakıma kendi hücreleri ile savaş halinde olduğu için de, pek çok hastalıkta bağışıklık sistemini baskılayan ilaçlar kullanılması gerekmektedir. Fonksiyonel tıp bakış açısı, temel sorun olarak bulduğu aksaklığı gidererek vücudun kendi dengesine gelmesini sağlamaya çalışmaktadır ve bu amaçla tıp biliminin tüm bilgilerini kullanmayı hedeflemektedir. Temel bakış açısı, oluşan hastalığın semptomlarının giderilmesi için ilaç kullanılması değil, kök nedene ulaşarak problemin tamamen ortadan kaldırılmasıdır.

Beynin vücutla çok sıkı bir bağlantısının olduğu ve birbirlerini derinlemesine şekillendirdikleri günümüzde biliniyor. Vücut sistemlerinden birinin başı dertte ise bu durum beyni de etkiliyor. Bu yüzden fonksiyonel tıp kullanılarak sistemdeki bozuklukları gidermenin vücudumuzla beraber beyne de yardımcı olduğuna inanılıyor.

Fonksiyonel Tıbbın en ünlü doktorlarından olan Dr. Mark Hyman, Fonksiyonel Tıp doktorunun yaptıklarını şu şekilde özetler:

"Yaptığım şey aslında çok basittir. İlk adım kötü şeyleri dışarı atmaktır. Dengesizliğe neden olan şeyler, besin değeri fakir ve işlenmiş gıdalar, toksinler, alerjenler, enfeksiyon ve stres. Sizi rahatsız eden şeyleri ortadan kaldırmaktır. Ayağınıza 10 adet çivi batmışsa, birini çıkarıp bir aspirin çakıp, kendinizi iyi hissedeceğinizi umut edemezsiniz. Tüm çivileri çıkarmanız gerekmektedir, ve sadece birini çıkartmak sizi daha iyi yapmaz."

Ada Uçar /10, Belis Yener / 10

Kaynakça:
• https://www.mind.org.uk/information-support/drugs-and-treatments/complementary-and-alternative-therapies/list-of-complementary-alternative-therapies/
• https://www.huffpost.com/entry/healing-autoimmune-conditions-with-functional-medicine_b_58dd5a6ae4b0fa4c09598738#:~:text=Functional%20medicine%20healthcare%20providers%20treats,reversing%20the%20process%20of%20autoimmunity.

1 **Her gün insan bedeninden ortalama kaç ölü deri hücresi düşer?**

A- 300 milyon
B- 400 milyon
C- 500 milyon

2 **Gökteki en parlak yıldızın adı nedir?**

A- Sirius
B- Polaris
C- Arcturus

3 **Hangi hayvanın kulakları dizinde bulunur?**

A- Kelebek
B- Cekirge
C- Hamam bocegi

4 **Mıknatıs yapımında hangi nadir toprak elementi kullanılır?**

A- Neodimyum
B- Prometyum
C- Itriyum

5 **Yağmur damlaları yere ortalama saatte kaç km hızında düşer?**

A- 11
B- 44
C- 77

6 **İnsan vücudunda bulunan bakteri hücrelerinin insan hücrelerine oranı ortalama kaçtır?**

A- 8:1
B- 10:1
C- 12:1

7 **Gaz halinde renksiz olan oksijenin sıvı halindeki rengi nedir?**

A- beyaz
B- yesil
C- mavi

8 **Işığın Güneş'ten Dünya'ya ulaşması ortalama ne kadar zaman alır?**

A- 8 salise
B- 8 saniye
C- 8 dakika

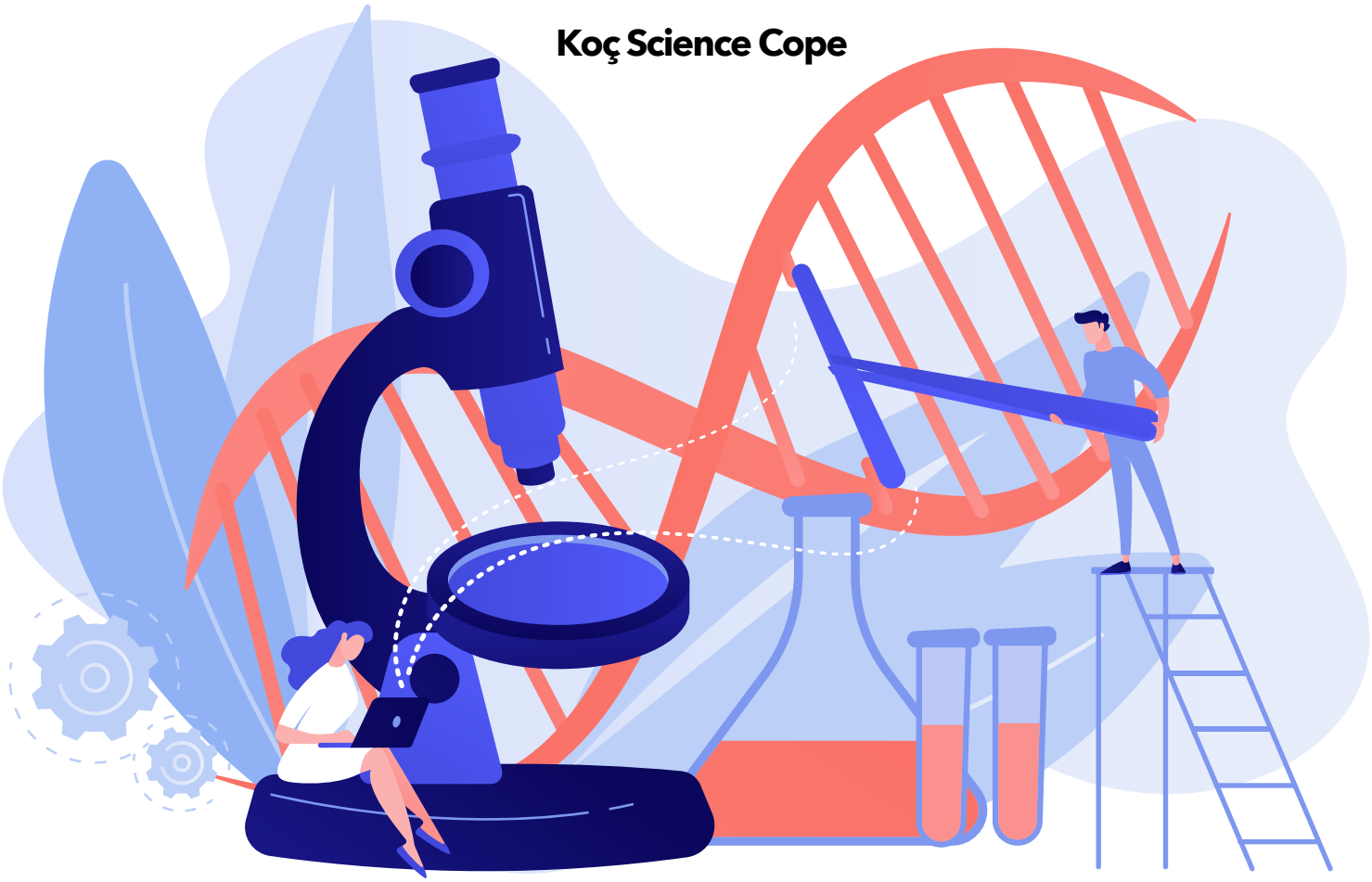
9 **Gram başı en çok kaloriye sahip olan makro besin hangisidir?**

A- lipid
B- protein
C- karbonhidrat

10 **Sakız gibi çiğnenebilen elementin adı nedir?**

A- Toryum
B- Indiyum
C- Molibden

Cevap Anahtarı: C, A, B, A, A, B, C, C, A, B



A New "Short Sleeper" Gene Has Been Discovered

Sleep is a complicated concept, lots of branches of science are still trying to discover this concept. There is a saying that "You should sleep at least 8 hours" but according to a research made back in 2009 by neurology professor Ying-Hui Fu it is discovered that gene mutation can affect your sleep duration. The mutation in DEC2 seems to work by releasing the breaks on orexin production. This gene controls orexin level, which is the hormone that maintains wakefulness. Fu said "These are not people who've trained themselves to wake up early. They're born this way." The people who have this mutation in their gene can fully function with an average of 6.25 hours.

After 10 years of research, scientists have discovered a second "short sleep" gene. In this new study, it is discovered that a family included three successive generations of natural short sleepers, none of them having the DEC2 mutation. Researchers used a technique called linkage analysis, which is to pinpoint the exact chromosomal location of the mutation. They identified a single-letter mutation in a gene known as ADRB1 which is similar to the mutation in DEC2, both of the mutations are linked to natural short sleepers. After research and experiments, scientists have discovered

that the protein encoded by the ADRB1 gene has played a role in a variety of essential biological processes. Lab-grown cells and mice had been genetically engineered with an identical mutation in ADRB1. Then it was found that the ADRB1 gene was found at a high rate in the brainstem region responsible for sleep control. They think that genes with mutation function differently because it has been seen that the mutant version is deteriorating quicker than the non-mutant version.

This hypothesis was confirmed, the researchers used a technique that involves modifying cells called "optogenetics" so that they can be activated by light. When the light is concentrated on neurons, the pons is alerted and had ADRB1 expression. It was observed that when these neurons were triggered, the mouse woke up instantly. When the mouse was experiencing non-REM sleep, normally in the non-REM phase neurons are not normally activated, it was seen that these neurons supported wakefulness, and also they have discovered that the genes with the mutation were more easily activated than the non-mutant version.

As a result, it was seen that in the mice that have a mutation in their ADRB1 gene, the ratio of wakefulness-promoting to sleep-promoting neurons really alters than the generation that has no mutation. After these experiments, the researchers have found that mutation in ADRB1 helps to make it easier to awaken and stay awake longer.

Fu said "Today, most people are chronically sleep-deprived. If you need eight to nine hours, but only sleep seven, you're sleep-deprived" These natural short sleepers do not suffer from any kind of sleep deprivation or any health issues associated with sleep deprivation. Short sleepers are more likely to be more optimistic, more energetic, and better multitaskers. Also, they have higher pain tolerance, they do not suffer from jet lag and researchers have thought that natural short sleepers may live longer. Fu said, "By studying them, we hope to learn what makes for a good night's sleep so that all of us can be better sleepers leading happier, healthier lives."

Nida Yalınbaş / 10

Resources:
• https://www.ucsf.edu/news/2018/03/410051/scientists-discover-how-gene-mutation-reduces-need-sleep
• https://www.ucsf.edu/news/2019/08/415261/after-10-year-search-scientists-find-second-short-sleep-gene

The NASA Twins Study

Is it possible to age faster than your identical twin? Most people would directly oppose this idea. After all, how could two people with the exact same genetic structure age differently?

The NASA Twins Study conducted in March 2015 suggested that this is in fact possible. In this experiment astronaut, Scott Kelly spent 340 days in space while his identical twin brother, Mark Kelly, remained on Earth. This study was a very unique opportunity for NASA. Since identical twins have a very similar genetic makeup, they also have very similar physical appearances. By observing the changes in the twins' bodies caused by their surrounding environments, scientists gained a better understanding of the effects of long-term space travel on the human body. (NASA, 2019)

The main goal of this experiment was to investigate the physical, cognitive and molecular changes that can happen to an astronaut's body after spending time in space. NASA had 10 teams focusing on 10 different areas. However, there were 3 main findings brought to us by this research that has had and will continue to have a major effect on the future of science. These 3 areas are telomeres, immunome (immune system), and gene expression.

Before talking about the first major finding, it's important to know what telomeres are. Telomeres are special features found at the ends of each strand of DNA (also known as deoxyribonucleic acid; a nucleic acid found in the cell's chromosomes that contains the cell's coded genetic instructions). Our chromosomes are protected by telomeres, just like jump ropes are protected by plastic handles. They protect our chromosomes from damage or fusing with nearby chromosomes. (Healthline, 2018) Telomere lengths normally shorten as the person ages. However, they can also shorten depending on other factors such as stress, lifestyle changes and environmental exposure.

One of the most eye-catching revelations of this experiment was the length of Scott's telomeres. During his stay in space, Scott's telomeres appeared to lengthen, presumably due to his healthy diet and regular exercise. But once he came back to Earth, his telomeres shortened and returned to base-line length merely within hours from his arrival. The findings are expected to contribute to a better understanding of the effects of spaceflight on the aging process, as well as better countermeasures to protect crew health. They can also help in minimizing the effects of disease and ageing on humans on Earth.

The second finding is about the immune system or "immunome". During the experiment Scott received three flu shots, each of them one year apart. He got the first one on Earth, the second in space and the third back on Earth. The findings showed that Scott's reaction to the vaccine was appropriate, even to the one he got in space. This finding is very significant since it showed that the immune system reacted properly in space. Meaning that if a vaccine was ever to be needed in a long-duration space mission, it would have a proper effect on the person. These results are expected to give us a better understanding of how humans adapt to spaceflight and they may be useful in the development of new treatments. (NASA, 2019)

The last major finding is about gene expression. Gene expression is a fundamental process of life that connects the information that is encoded inside the gene to the final function of the gene product. (ScienceDirect, 2014) The samples that were taken from Scott before, during and after his stay in space showed some changes in gene expression. Although Mark also experienced some changes in his gene expression, they were relatively normal and much different than Scott's. Upon his return to Earth, 93.1% of these changes turned back to normal while a small subset lingered. The damage in his DNA was associated with exposure to radiation.

These results express the way that the human body can react to hostile environments like space and help researchers better understand how environmental stressors impact gene function, resulting in a better understanding of physiological processes in space. Chemical changes in DNA and RNA caused by spaceflight can alter the role of genes involved in biological processes such as metabolism and immune system functions. This study compares shifts in DNA and RNA methylation (the biological process in which methyl groups are added into RNA/ DNA) in one astronaut over the course of a one-year space trip to his twin brother on Earth. The findings are expected to reveal patterns of gene expression in astronauts, improvements in their regulation in space, and other genetic changes brought on by space travel. An improved understanding of the effect of stressors on RNA and DNA methylation can increase the duration of space-travel for future missions. It could also be beneficial in the creation of new therapies and preventative measures for health conditions on Earth.

The revelations from the Twins Study have contributed to human health both on Earth and in space and it will continue to shine a light on similar studies in the future. It broadened our understanding of long-term space travel and opened up new opportunities for astronauts alike. This study that NASA conducted with Scott and Mark Kelly was an invaluable first, but it definitely won't be the last of its kind.

Lal Tütüncüoğlu / 9

References:
• "Gene Expression." Gene Expression - an Overview | ScienceDirect Topics, 2014, www.sciencedirect.com/topics/medicine-and-dentistry/gene-expression.
• Telomeres: The Role of Shortening in Cancer ... - Healthline. 2018, www.healthline.com/health/telomeres.
• Perez, Jason. "NASA's Twins Study Results Published in Science Journal." NASA, NASA, 11 Apr. 2019, www.nasa.gov/feature/nasa-s-twins-study-results-published-in-science.

Yaşamın Kodunu Yeniden Yazma

1) Genetik Makas CRISPR-Cas9

DNA'mızda yani bütün bilgilerimizi barındıran molekülde değişiklik yapılabildiğini düşünün. Genetik hastalıkları tedavi etme imkanı

sağlayabileceği gibi yenilikçi kanser tedavilerine de katkısı olurdu. Emmanuelle Charpentier ve Jennifer Doudna'nin geliştirdiği, 2020 Kimya Nobel Ödülü'nü alan "genetik makas" bu hayali gerçeğe dönüştürüyor. Yaşayan hücrelerin DNA'sında belirli ve hassas değişiklikler yapmaya izin veren bu araç, önceden belirlenmiş bir bölgedeki herhangi bir DNA molekülünü kesebilecek şekilde kontrol edilebiliyor. Şimdiden kalıtsal göz hastalıkları ve orak hücre anemisi, beta talasemi gibi kan hastalıklarının tedavisinde CRISPR/Cas9 kullanmak için klinik denemeler yapılıyor. Bunların yanında bitki genomlarında değişiklik yapma imkanı sunduğundan küf, haşere ve kuraklığa dayanıklı ürünlerin de geliştirilmesini sağladı. Ancak bu buluşun farklı amaçlar için de kullanılabilecek olması, örneğin genetik olarak değiştirilmiş embriyo oluşturmak, etik açıdan kaygılara yol açıyor. Kesin olan ise bu buluşun herkesi etkileyecek olması.

https://www.nobelprize.org/prizes/chemistry/2020/press-release/
https://www.bbc.com/turkce/haberler-dunya-54447208

2) AI ile kanser hücrelerinin tanımlanması

Sağlıklı hücre ile kanser hücresi mikroskopta benzer gözükebildiğinden ayırt etmek her zaman kolay değildir. Ancak hücrelerin içindeki pH seviyesi ayırt edici bir özelliktir. Kanser hücrelerinin pH seviyesi genellikle sağlıklı hücrelerden daha fazla olmaktadır. Bu özelliği kullanan araştırmacılar hücrenin asitlik seviyesini analiz ederek kanser olup olmadığını belirleyen bir teknik geliştirdi. Yapay zeka kullanılarak %95'in üzerinde doğruluk oranı olan bu test, yaklaşık yarım saatte tamamlanıyor. Yöntem, pH'a duyarlı bir boya olan bromtimol mavisinin canlı hücrelere uygulanmasına dayanıyor. Her hücre boyaya farklı tepki verdiğinden yapay zeka tabanlı bir algoritmayı kullanarak hücre özellikleri çıkarılıp analiz edilebiliyor. Tüm bunlar hücreleri canlı tutarken gerçekleştirilebiliyor.

https://www.news-medical.net/news/20210317/AI-based-technique-determines-cancer-cells-by-their-acidity.aspx

3) Havadan içme suyuna: Skysource Wedew

Küresel ısınmadan ve çevre kirliliğinden su her zamankinden daha değerli olmuş durumda. Dünyada yaklaşık 1 milyar insan su kıtlığı çekmekte. Bu soruna çözüm için geliştirilen makine, etraftaki sıcak havayı toplayıp bunu soğutma tankında soğutarak yoğuşma işlemini gerçekleştiriyor. İşlem sonrası toplanan hava suya dönerken çeşitli filtrelerden geçerek içilebilir hale getiriliyor. Biyokütle enerjisiyle çalışan makine; çevredeki odunları, hindistan cevizi kabuklarını ve diğer organik atıkları enerji kaynağı olarak kullanıyor. Çevrede organik atık bulunmuyorsa güneş

panelleri ve yerleşik bir batarya ile de çalışabiliyor. Wedew ile hava durumuna bağlı olarak günde 113 litre ile bin 135 litre arasında su üretmek mümkün oluyor.

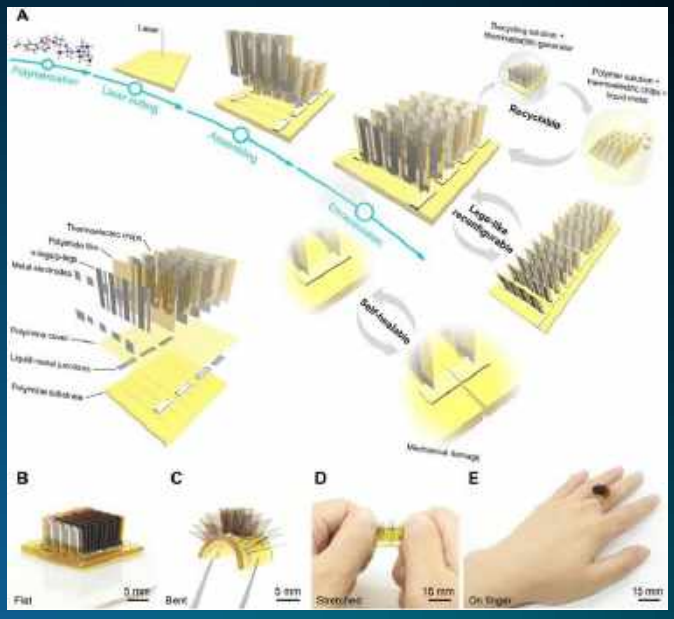
https://www.skysource.org/

4) Yeni nesil güneş enerjisi panelleri

Sürdürülebilir enerji kaynaklarının önemi her gün artıyor. Güneş panelleri de en yaygın yöntemler arasında. Bu nedenle yeni üretilen sekizgen şeklinde aynalı güneş panelleri, yılın en iyi buluşlarından. Buluşu yapan firmanın kurucusu, yeni teknolojilerini şöyle özetliyor: "Sekizgen şeklindeki panellerin üzerinde içerisinde 100 bin adet motorlu ve bilgisayar kontrollü ayna bulunuyor. Bu aynalar güneş ışığını yaklaşık 40 metre yükseklikteki bir kulenin tepesinde bulunan dev büyütece yönlendiriyor. Bu kulede, onlarca güneş panelinden yansıyan ışınlar yoğunlaşıyor ve yaklaşık 2000 fahrenhayt (34.44 bin derece) ısı elde ediliyor."

https://www.solarpaces.org/helioheat-commercializes-the-dlr-1000c-solar-receiver-centrec

5) Vücut ısısından elektrik üreten yüzük



Yüzüklerin Efendisi'nden çıkmışa benzeyen bu yüzük, vücut ısısı ve ortamdaki havanın ısı farkını kullanan termoelektrik jeneratörler sayesinde elektrik elde edebiliyor. Her santimetrakaresi yaklaşık 1 volt enerji üreten cihaz, hasar gördüğünde kendini de onarabiliyor. Bu özelliği, yapısındaki gümüş nanoparçacıklara katılan polimin adı verilen özel bir polimer sayesinde oluyor. Polimin, yırtıldığında kendini düzeltebiliyor. Cihazın tüm parçalarının geri dönüştürülebilir olması da başka bir güzel özelliği. Vücudu bataryaya dönüştüren yüzük, dijital saatlere güç vermeye yetecek kadar enerji üretiyor.

https://advances.sciencemag.org/content/7/7/eabe0586

Belis Yener / 10

LIFE IN PANDEMIC
FOTOĞRAF KARİKATÜR SERGİSİ

Geçtiğimiz yıl sürecinde global pandemi dolayısıyla herkes evlere kapanmak zorunda kaldı ve normalleşme süreci kapsamında dışarı çıkabilmenin insanlar için ne kadar da önemli olduğu anlaşılmış oldu. Maske gibi gereklilikler pandeminin sembolü haline geldi ve hayatımızın büyük bir parçası oldu. Bu zorlu dönemde sosyal hayat da olumsuz etkilendi ve normal kavramının tanımı değişti.

Bütün bu olayların etkisi altında herkesin kreatif dışa dönümleri oldu. Bundan hareketle, derginin bu bölümünde yer verdiğimiz "Life in Pandemic" adlı fotoğraf ve karikatür sergisinde okulumuzdaki sanatseverlerin çalışmalarını bir araya getirmiş olduk.

Naz Yörük / 11

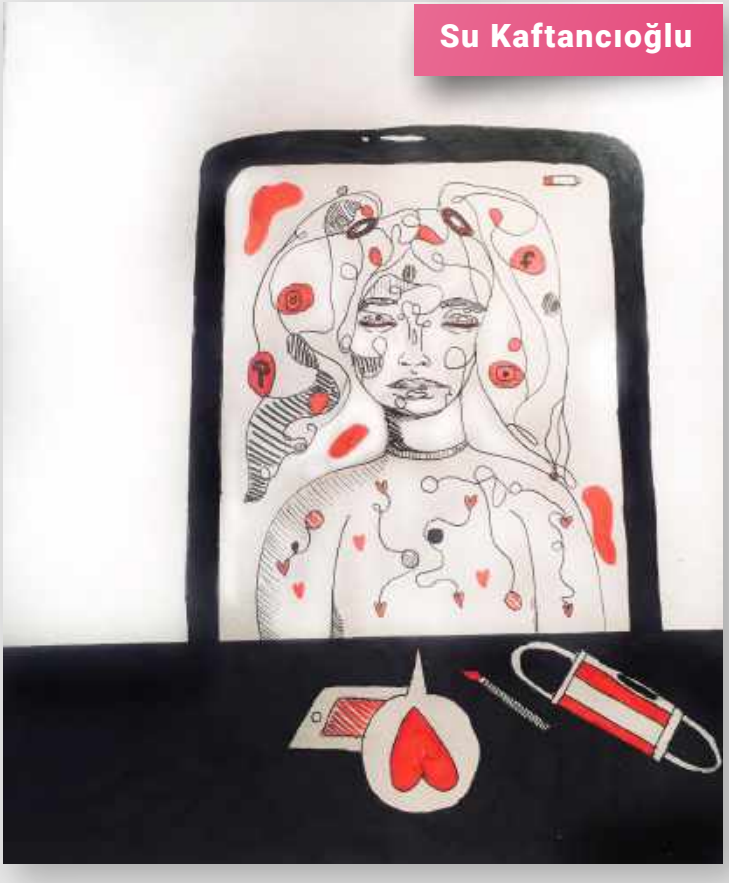
Naz Yörük

Naz Yörük

Su Kaftancıoğlu

Naz Yörük

Selin Toker



Su Kaftancıoğlu

Selin Toker

Sarp Gürel

Baldan Dolu

İdil Sena Keskin

CHEMISTRY CLUB

The main purposes of the Chemistry Club are to learn the chemistry behind show experiments and to teach others. We believe experiments are one of the biggest reasons people's interest in science. Therefore, we aim to encourage people to enjoy science through these show experiments. In the 2019-2020 academic year, we conducted the Elephant Toothpaste Experiment, the Blue Bottle Experiment, the Pharaoh's Serpent Experiment, the Burning Money Experiment, and many more. Furthermore, we designed posters explaining the chemistry and mechanism behind the experiments.

At the same time, we prepared posters and informative articles about significant days for the chemistry world, such as the Mole Day, and shared them with our school. In the 2019-2020 academic year, we were planning to carry out these demonstration experiments in the pyramid of our school and share the scientific explanations of the experiment with our friends, but we had to postpone this event due to the pandemic.

We want to bring this idea to life when face-to-face activities restart. When face-to-face meetings were canceled in the 2020-2021 academic year due to pandemic conditions, we decided to create a website called Oganesson in order to adapt to the changing conditions. We shared the videos of the demonstration part of the experiments that we carried out on this site, the materials, the procedure, and the scientific explanation of the experiments. Our aim is to inform a wider audience by explaining and visually demonstrating these experiments.

Derin Ak / 12

FAKE OR NOT?

Have you ever wondered how we can today tell whether a painting was really painted by an artist; Picasso, for instance, is thought to have painted an estimate of 13.500 paintings in his lifetime. Can that really be possible? Or are there multiple Picassos?

As science has progressed over the years, chemists have developed techniques that can help identify if a painting is a fake or an original. Although even these modern-day techniques cannot tell if a painting was, for a 100% certainty, painted by someone in particular, it can follow the traces of clues to draw a strong conclusion.

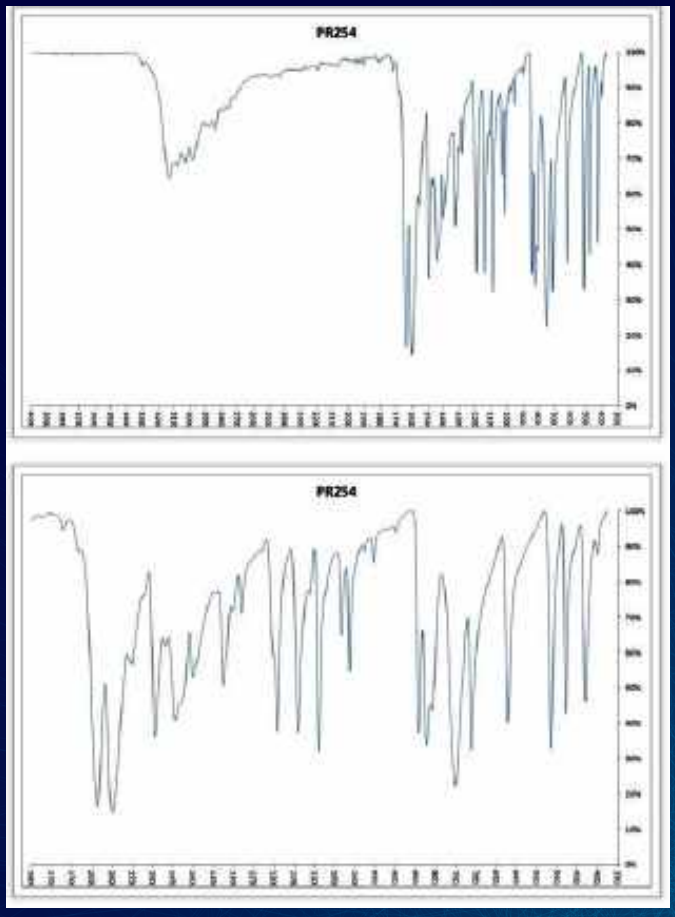
There are three versions of the painting titled "Bedroom in Arles" by the infamous painter Van Gogh; one of the paintings is in the Van Gogh Museum in Amsterdam, one is in the Art Institute of Chicago, and the last one is in Musée d'Orsay in Paris. Interestingly, from the letters that he wrote to his brother Leo, it was understood that Van Gogh himself painted all three. Even though there was no forgery mystery about these paintings, many people before have tried, (and failed) to take advantage of an artist who has a unique style. Forgeries of pieces are oftentimes of those who can be distinguished to be correspondent to the style of a well- known artist.

One example of these types of forgeries is the Otto Wacker case. Not with the previously mentioned paintings, but with others, a German art dealer named Otto Wacker became famous for selling and commissioning the paintings of Van Gogh. With his forgeries, he even managed to convince the greatest Van Gogh experts that the paintings he was selling were genuine and the experts even supplied certificates of authenticity to document that. He had claimed that a Russian had bought the paintings, transferred them to Switzerland illegally, and commissioned an illegal agent to sell them. The experts believed the need for the initial buyer in Russa's wish to remain anonymous given the fact that he would have been living in the Soviet Union at the time. Some respectful galleries bought these paintings, believing the story that Wacker made up. Even after Wacker's fraud was discovered, experts couldn't actually distinguish the fake ones from the originals. Controversy was resolved when two siblings named Monica and Michael Jong inherited one of these paintings in question. In the year 2000, they took this painting to a Canadian scientist named Marie-Claude Corbeil, and she used a technique called as the X-ray technique on the canvas and the mystery was once and for all solved… it was a fake!

The X-rays are a form of electromagnetic radiation that is invisible to our eyes. Just as doctors use the X-rays, when focused on a canvas it could determine the structure of the canvas beneath the paint. The lighter areas of the X-ray image indicate where the X-ray was absorbed and the dark areas are where it passes through. The bones in our body absorb the X-rays, thus appearing white. The case with the canvas is no different. The canvas is composed of threads that are perpendicular to each other. The scientist Marie-Claude saw exactly that when she X-rayed the painting in question: an ordinary canvas. Though from the letters that Van Gogh sent his brother, it was discovered that Van Gogh, in reality, used what is called an "asymmetrical canvas". A canvas, which contains a different number of horizontal and vertical threads. So, in conclusion, the X-ray method unfortunately proved that the painting that Monica and Michael Jong owned couldn't have been an original Van Gogh.

Another very famous fraud case is the Pollock Case. After Jackson Pollock, an expressionist artist from the United States in the 50's passed away, many paintings that were claimed to be his surfaced. He was even named as one of the most faked artists ever in history. Especially, when the Upper East Side gallery Knoedler & Co. was accused of selling over 80-million-dollar worth of fake Abstract Expressionist paintings, the case became one of the biggest scandals in the history of the art market. Alex Matter found 32 paintings that were claimed to be the works of Jackson Pollock. He got help from an expert named James Martin in order to establish the authenticity of the paintings. Carefully, by using a surgeon's scalpel Martin removed paint chips that were as thin as a strand of hair. With the samples he obtained from the paintings, he utilized a technique called Fourier Transform Infrared, FTIR in short.

The radiation used in the FTIR technique is infrared light, and when infrared light is absorbed by compounds they vibrate. With the amount of this vibration, by the FTIR method, which bonds are present in the compound can be determined. The FTIR spectrum is recorded between the electromagnetic radiation range of 400–4000cm-1. When it is passed through a sample, a printout of the spectrum which shows the frequencies that were absorbed is created. The troughs in the printout represent wavenumbers at which radiation is absorbed.



The segment of the spectrum below 1500 cm-1 is called the 'fingerprint region' and it is characteristic of the molecule as a whole. The fingerprint region, as its name also suggests, is unique for all compounds, so the comparison of this region with infrared spectra in databases can be used to identify unknown molecules.

Martin solved this mystery by comparing the fingerprint region. When he compared the spectra of samples from the 32 paintings, he found that a pigment that was used in the paintings couldn't have been used by Pollock.

10 of the paintings in question had pigments that matched the color that is commonly known as the "Ferrari red" for which FTIR spectrum is given above. The Ferrari red was patented in the early 1980's. Jackson Pollock died in 1956… so the paintings were discovered to be frauds.

Chemistry can be a part of our lives in the most unexpected ways. These methods, named as the X-ray method and the Fourier Transform Infrared method involving chemistry, for example, were used to authenticate some paintings. The fact that these interesting discoveries were made in the light of chemistry is proof alone that there is so much more to discover when it comes to science.

Cansu Özdemir / 11

References:
MutualArt, M. (2018, January 09). The Most Faked Artists in History. Retrieved April 13, 2021, from https://www.mutualart.com/Article/The-Most-Faked-Artists-in-History/ADD1DF7752FEBC5D
Nelson, M. (2011, April). Authentic or Not. Retrieved April 13, 2021, from https://www.acs.org/content/dam/acsorg/education/resources/highschool/chemmatters/videos/chemmatters-april2011-authentic-or-not.pdf
NHS, N. (Ed.). (2018, July 13). X-Ray. Retrieved April 13, 2021, from https://www.nhs.uk/conditions/x-ray/
Owen, S. (2011). Chemistry for the IB diploma coursebook (2nd ed.). Cambridge: Cambridge University Press.

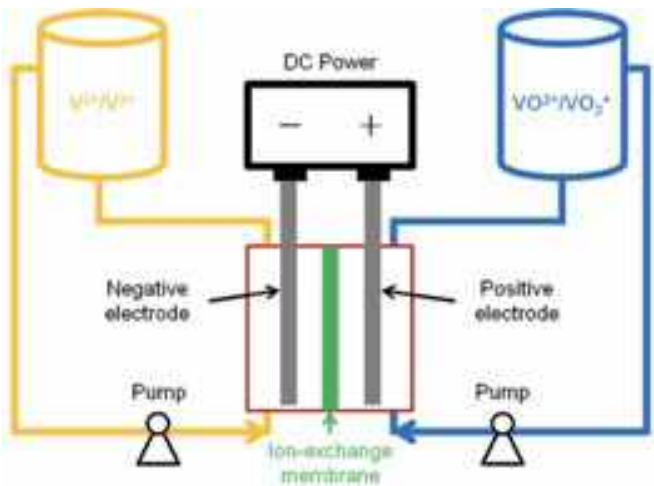
Conrad Challenge & the Project "Energency"

The Conrad Challenge is an US based annual, multi-phase innovation and entrepreneurship competition that encourages young adults to participate in designing the future through purpose-driven education. Each year, teams of 2-5 students, ages 13-18, from around the world create products and/or services to address some of the most pressing global and local challenges. They become entrepreneurial problem-solvers, addressing challenging social, scientific and societal issues through utilizing their creativity and critical-thinking skills.

This year we, as a team of five, participated in the challenge with a project aiming to provide emergency electricity supply for disaster areas and immigrant camps. Our project "Energency" benefited the flow battery technology to build the durable, scalable and quick-deployed that is much needed in crisis situations.

Energency creates value in the energy industry in specific to fast and portable energy supply to emergency sites such as refugee camps and natural disaster areas. The industry practice for similar situations is usually the pursuit of establishing power infrastructure, which is delayed and thus ineffective in implementing such emergencies. Temporary solutions are limited and only include solutions such as the usage of liquified petroleum gas, which is both dangerous and insufficient in terms of the energy it provides. Energency, on the other hand, becomes a fast, effective and sustainable tool by integrating the innovative technology of flow-batteries and solar panels to the solution. For the aforementioned crucial usages, Energency would aspire as a business by contracts with governments, non-governmental organizations (NGOs) and intergovernmental organizations (IGOs). Furthermore, our product would be highly convenient for recreational use as in events like festivals, concerts, campsites etc. and in any other organization away from electrical infrastructure requiring sufficient power supply for a short period of time.

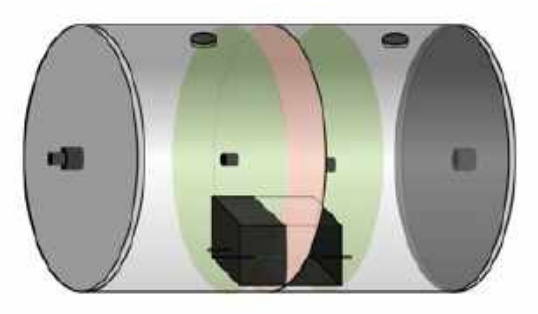
Our product, Energency, relies on the basic principles of a redox flow battery (RFB). The final product is a combination of 3 main components: the cells, the hive and a solar panel system. Both the hive and the cells will be transported to the target area in case of an emergent energy requirement. The Cells are rechargeable unit flow-battery, which will be distributed among people and the Hive is a tanker containing the required electrolytes for recharging the flow batteries and recharges the discharged liquids via the solar panels at the top. Energency Hive is integrated with a photovoltaic solar panel array to provide off-grid charging solutions. We have limited space on top of the hive. Therefore, we had to use the space we got in the most efficient manner. Due to our space constraints, we have decided on using monocrystalline solar panels for their high efficiency.



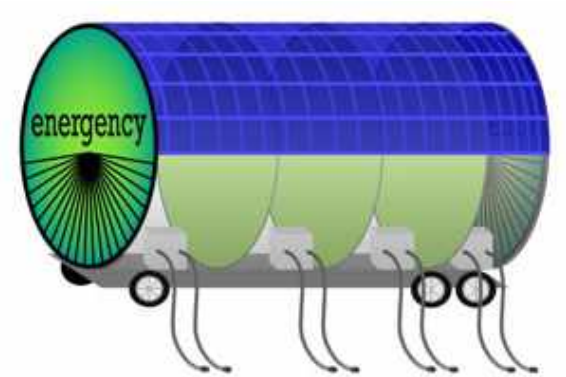
The basic concept of the cell is a redox flow battery consisting of two storage parts, an ion-exchange membrane in between those parts, a direct current converter, and one positive, one negative, in total two electrolytes:

the basic components of a flow battery. Two storage parts separate the positively and negatively charged electrolytes and the selective ion exchange membrane in between maintains the charge neutrality condition for each half-cell. The anode and cathode compartments are separated and a specific amount of that solutions interact via ion exchange membrane. There, redox reactions occur and a direct current converter makes use of the electronegativity difference between the negative and positive electrolyte solutions to generate electricity.

Model of the "Cell"



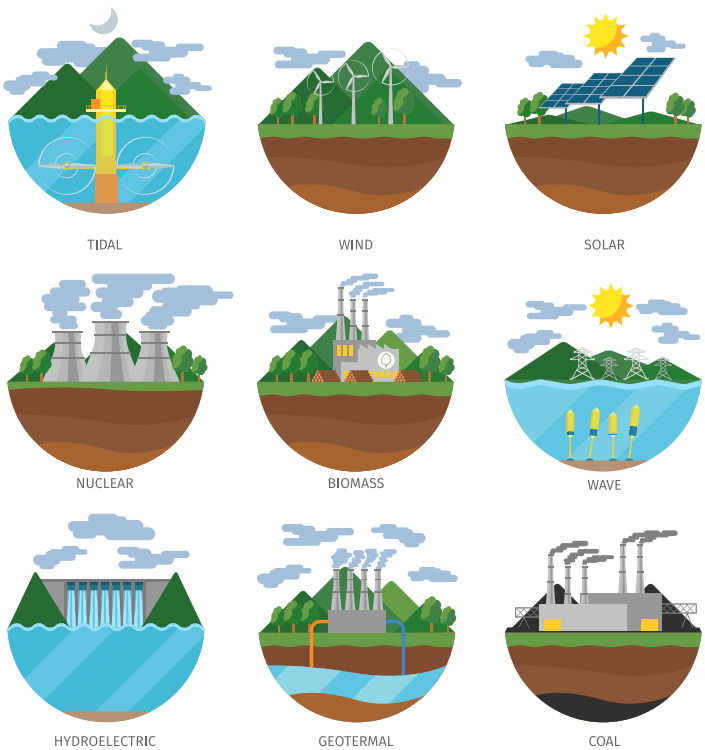
3D Model of the "Hive"



Redox (reduction-oxidation) is a type of chemical reaction which causes atoms to alter their oxidation states. The reduction is the gain of electrons, whereas oxidation is the loss of electrons. Reduction and oxidation occur simultaneously, causing the redox reaction. In Energency, the flow batteries which make use of redox reactions are used. Flow batteries use similar principles when compared to other conventional chemical batteries such as lithium-ion and lead-acid batteries. These batteries all have electrolytes which consist of chemical potential energy converted into electrical energy via ion exchange. These electrolytes in flow batteries are not stationary unlike conventional batteries. Moreover, the scalability of energy of the flow batteries enables us to tailor the need for our business.

Yalçın Tür / 11
Ahmet Emre Güçer / 11

Bibliography
Jia, Chuankun, et al. "High-Energy Density Nonaqueous All Redox Flow Lithium Battery Enabled with a Polymeric Membrane." Science Advances, American Association for the Advancement of Science, 1 Nov. 2015, advances.sciencemag.org/content/1/10/e1500886.
The Challenge." Conrad Challenge, www.conradchallenge.org/conrad-challenge.
Rychcik, M., and M. Skyllas-Kazacos. "Characteristics of a New All-Vanadium Redox Flow Battery." Journal of Power Sources, Elsevier, 20 Aug. 2001, www.sciencedirect.com/science/article/abs/pii/0378775388800053.
Yuan, Zhizhang, et al. "Advanced Materials for Zinc-Based Flow Battery: Development and Challenge." Wiley Online Library, John Wiley & Sons, Ltd, 2 Sept. 2019, onlinelibrary.wiley.com/doi/abs/10.1002/adma.201902025.



CARBON FOOTPRINT

The term "carbon footprint" has become popular over the past years. People started to become aware of the environmental danger we are facing due to the greenhouse gas (GHGs) emissions. As this notion became more prominent, people become interested in learning the definition and the effects of carbon footprint. GHGs emission is a real problem for the environment and the eco-system. The humans are the most prominent contributor to the problem, and have the responsibility to fix it. Thus, it is important for everyone to understand the GHGs and know what to do in order to decrease GHGs emission.

WHAT IS CARBON FOOTPRINT?

Carbon footprint commonly defined as a certain amount of gaseous emission that is associated with human activities and relevant to climate change (Carolyn C. Pertsova, 2007). However, there is no consensus on how to measure or quantify carbon footprint. Even though carbon dioxide (CO_2) makes up the vast majority of greenhouse gas emissions, it is important to understand other GHGs as well. GHGs include carbon dioxide, methane (CH_2), nitrous oxide (N_2O) and fluorinated gases. These gases are released during combustion of fossil fuels and natural gas. The methane and nitrous oxide in the atmosphere are able to trap the heat up to 114 years thereby causing global warming and contribute to the climate change (US Environmental Protection Agency). Accumulation of these GHGs can also lead to the suffocation of living creatures that depend on oxygen. Furthermore, fluorinated gases, gases that are solely caused by human activities, can stay in the atmosphere longer than other GHGs, lasting for thousands of years in some cases (EPA, 2020). Fluorinated gases are solely human-made and caused by human activities.

CALCULATION OF CARBON FOOTPRINT

Another important factor is how the carbon footprint is measured and quantified. The basic and well-known way to measure the carbon footprint is by undertaking the GHGs emission and life-cycle assessments. As for the individuals there are multiple online platforms that help to calculate the carbon footprint. Biggest issue with calculation of carbon footprint is that this calculation usually accounts only for direct emissions and exclude the indirect ones (Carolyn C. Pertsova, 2007). Nowadays the way the companies calculate their carbon footprint is by only calculating the direct emission and emission from purchased energy with less focus on supply chain and indirect emissions. The known average data for direct emission is only the 14% of the total supply chain carbon emissions and when the input from the purchased energy is added it will be up to 26% of the total supply chain carbon emissions (Matthews et al., 2008). This data shows that the calculations we have for the carbon footprints might not always be accurate after all.

CAUSES OF GHGS EMISSION

GHGs are the fundamental elements of the carbon footprint. First of all, even though some causes of certain greenhouse gases are naturally occurring, human activities, especially since the Industrial Revolution, have had a very significant role in the production of these gases. The biggest human made factors in the production of these gases are power plants, residential building and road transportations as well as energy industry processes and losses, iron and steel manufacturing, coal mining, chemical and petrochemical industries (Liu, Guo, & Xiao 2019). Deforestation, forest degradation, land usage, livestocks, agricultural soils, etc. by affecting the environment to change also contributes to GHGs emissions.

Another prominent cause is the burning of fossil fuels. Surveys and observations have been made to detect the rise in greenhouse gas over time and the main drivers of the

GHGs emission. As of 2017, the CO_2 levels were equivalent to 142%, Methane levels were up to 253% and Nitrous oxide was 121% of what they were in pre-Industrial Revolution. In the last 25 years there has been an increase of 33% in the emission caused mainly by energy driven consumption of human activities (such as burning fossil fuels and destroying the carbon absorbing forests) which increases GHGs emission and lead to global warming (Liu, Guo, & Xiao 2019). As for the main drivers of this emission, the resultants were separated into four sub-effects at both country and industry level. One the most effective drivers of them all was the rapid global economic growth. However, there could be a significant amount of reduction by the help of the technological innovations and the improvement of the electric efficiency. Secondly, it was found that the causes may vary based on country-level. While the effects of the investments were overwhelming to developing countries than to developed countries, net export effects were much greater in developed countries.

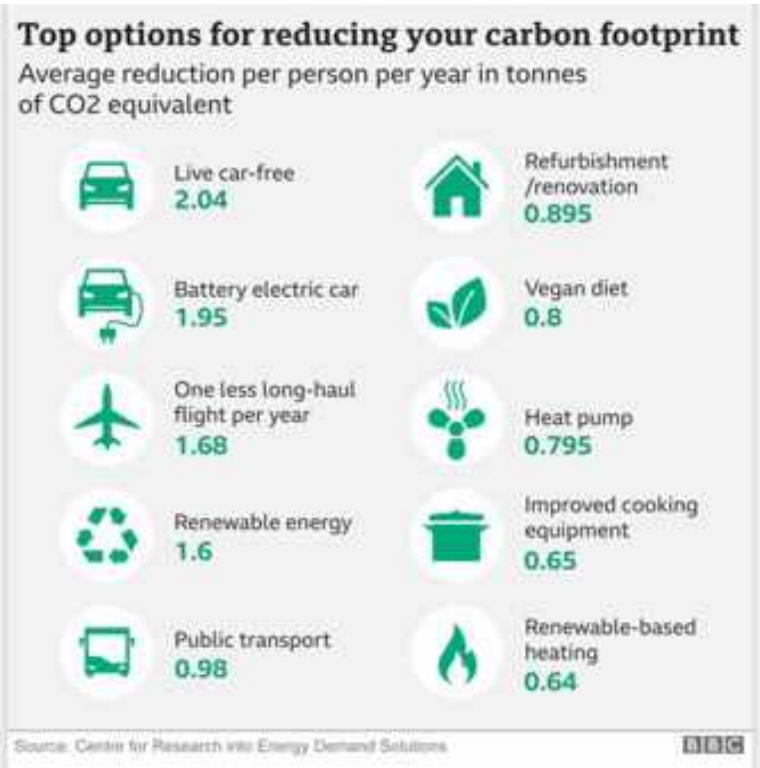
This suggests the vast amount of the pollution in developing countries. Moreover, China and India are the countries that take the lead in the production of CO_2 and CH_4, however the change in N_2O is still positive in some countries due to agriculture. Lastly, cluster analysis shows the relation between gross domestic product and the growth in GHGs emission between different countries (Liu, Guo, & Xiao 2019). As to elaborate the main drivers for each building block of GHGs, the excessive amount of CO_2 in the atmosphere is mainly caused by burning fossil fuels, deforestation and cement production. It should be noted that CO_2 is a naturally occurring gas and it is essential to life because it is the output of cellular respiration and used in photosynthesis. Methane is mainly released in oil, coal and natural gas industries.

People started to use natural gas for the reason it contains less CO_2, it should be taken into notice that methane is more hazardous to the environment since it can trap the heat better than CO_2. Nitrous oxide is mainly produced by fuel combustion. As for the fluorinated gases, being used as refrigerants, aerosol propellants, foam blowing agents, solvents, and fire retardants are some of the fundamental causes. Unfortunately, even though it is known that these substances are ozone-depleting, they are still being used widely across the globe. They are also used in industry (perfluorocarbons are used as byproducts of aluminum production and used in manufacturing of semiconductors), and transmission and distribution of electricity (EPA, 2020).

HOW TO REDUCE CARBON FOOTPRINT

There are so many ways for one to reduce their footprint with doing so much to little work. Of course, in order to achieve this reduction, we have to make some sacrifices from our comfort for the good of the environment. Before starting to reduce your carbon footprint, one should find out their initial footprint. Here are some things you might want to know before calculating your carbon footprint: approximately how many hours you take in transportation by vehicles or plane, the average energy usage at home, the amount of money spent in shopping and the composition of your diet. (The New York Times, How to reduce your carbon footprint Livia Albeck-Ripka)

As for how to reduce the carbon footprint there are multiple things one can do. You can start eating less meat (the reason why experts say that cutting of red meat is more environmentally healthy is because in production lots of feed, water and lands are used), start driving less and cycling/walking more, if possible, fly less, waste less. In your home you might also want to be more cautious with heat, lights and appliances, learn and start recycling, be energy efficient, dress/shop sustainably. After doing all these, you might also want to contribute to this reduction by knowing your facts about the topic, join climate action groups for if we want to change something we must do it as a whole, as a society, always inform the others and never hold back from speaking up about this topic. (The New York Times, How to reduce your carbon footprint Livia Albeck-Ripka)



We should really start taking this matter into our hands. GHGs emission is a serious problem for the environment and living species, and the real reason why this has become such an important problem is because of humans. We need to solve this problem that we have created. There variety of things one can do to contribute and to help our planet. The key is to understand the carbon footprint before the point of no return. We should start changing our actions. Little changes, such as eating less meat or driving less may need some sacrifices from our comfort, but we should be more than willing to make these sacrifices to protect the environment, the world; our home. We should also inform other people about this because this matter is such a big issue, that we cannot deal with it if we don't do it together. Even though the term has become almost a buzzword in the media across all over the world and people have finally started becoming more aware of the situation, there are still people who don't really know the reality and some who don't take part in it to solve this problem. As sad as this is, we have to accept that this is a real problem and we have to do as much as we can to solve it. GHGs emission may have become a huge problem, but it still is not too late to turn back from it if we start to take this matter into our hands.

Zeynep Naz Öksüz / 9

References:
• Pertsova, C. C. (2007). Introduction. In Ecological economics research trends. New York: Nova Science.
• Overview of greenhouse gases. (2020, September 08). Retrieved April 03, 2021, from https://www.epa.gov/ghgemissions/overview-greenhouse-gases#f-gases
• Overview of greenhouse gases. (2020, September 08). Retrieved April 03, 2021, from https://www.epa.gov/ghgemissions/overview-greenhouse-gases#f-gases
• Liu, D., Guo, X., & Xiao, B. (2019, January 16). What causes growth of global greenhouse gas Emissions? Evidence from 40 countries. Retrieved April 03, 2021, from https://www.sciencedirect.com/science/article/abs/pii/S0048969719302165
• The importance of carbon footprint estimation boundaries. (n.d.). Retrieved April 03, 2021, from https://pubs.acs.org/doi/abs/10.1021/es703112w
• How to reduce your carbon footprint. (n.d.). Retrieved April 03, 2021, from https://www.nytimes.com/guides/year-of-living-better/how-to-reduce-your-carbon-footprint
• Images: www.ecomatcher.com
www.co2living.com

WHAT IS "SNOW POLLUTION"? WHY DOES IT HAPPEN?

Snow is white, beautiful, and because of its high absorbance of sound, it is mostly associated with a pure, peaceful environment. However, research shows that unfortunately, sound is not the only thing snow absorbs, and it is almost like a sponge when it comes to sucking up dangerous pollutants from the air. It turns out snow might not be as pure as initially thought.

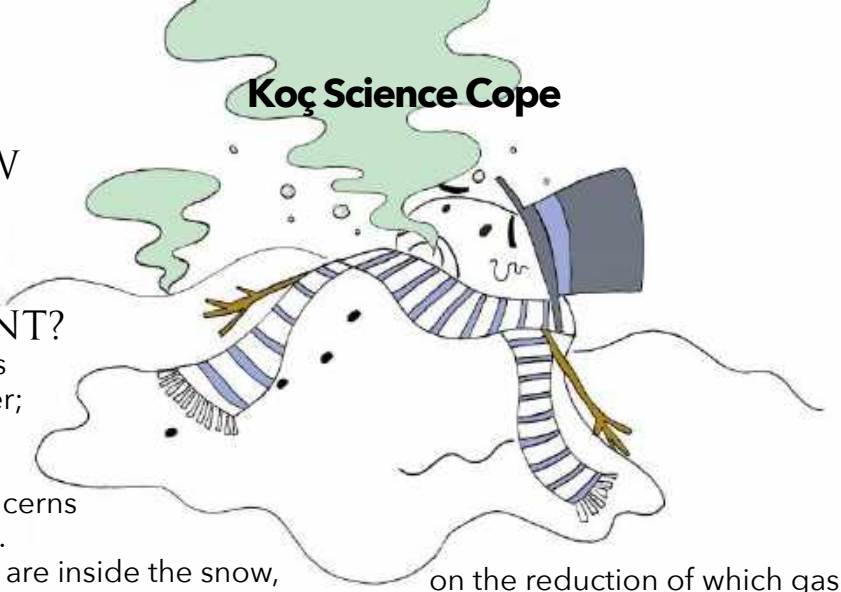
Snow pollution happens when snow absorbs toxic chemicals from the air while first falling and later on the surface. Most of the gases that snow absorbs come from car exhausts and other fossil fuels, meaning that snow particles become a tightly packed ball of poison. Scientists and researchers from McGill University tested how snow reacts with pollutants by exposing it to a car exhaust in a frozen glass sphere built in the lab. It was concluded that although diverse types of gases are affected differently by varying levels of cold, it is certain that snow is highly absorbent to chemicals. Other studies also found out that snow alters nanoparticles from airborne particulate matter, which are associated with numerous health problems such as lung inflammation and heart diseases. Colder temperatures, especially temperatures below zero increase the density of nanoparticles in polluted air, and they also increase the risk of said conditions if snow in those areas is consumed.

One other concern when it comes to air pollution during winter is the cold and dry air combined with more than usual use of fuels. During summer, warm air rises and carries most pollutants with it, but during winter cold air sinks while bringing all the toxic gases with it and creating a layer of toxic smog. This is called winter inversion, and it is a threat in areas with high concentrations of toxic gases.

Furthermore, due to the lack of moisture in chilly weather, the chances of pollutants being washed away decreases as well. Dry air has fewer cleansing properties than moisturized air, which means with the combination of already elevated levels of air pollution, there is a higher chance of seeing irritation and breathing difficulties. Although snow might absorb considerable amounts of pollutants, it still isn't enough to say the air is clean during winter as more fossil fuels are consumed to keep our houses warm, making both the air and the snow more polluted.

Snow pollution and air pollution during winter might be dangerous, but that doesn't mean that it is impossible to enjoy snowfall. As long as there isn't a noticeable smog and snow isn't directly consumed, most areas are safe to enjoy winter.

WHY IS SNOW POLLUTION DANGEROUS FOR THE ENVIRONMENT?



Enjoying the snow is mostly okay in winter; however, that being said, snow pollution still poses many concerns for the environment. Once the pollutants are inside the snow, they may go through chemical transformations to create additional gases with varying levels of toxicity. Research shows that even after just one hour the concentration of chemicals such as benzene (C_6H_6), toluene (C_7H_8), ethylbenzene (C_8H_{10}), and xylenes (C_8H_{10}) increase significantly while several hazardous compounds also become noticeable. Some of these newly formed chemicals might also get released back to air or water once the snow melts, posing serious health issues and environmental concerns. These gases are also known as the BTEX gases, and they are known for their easily contaminating chemical properties, for example, they can easily mix into groundwater and air. The dangers of even a little exposure to those gases include skin irritation, nervous system problems such as tiredness, dizziness, and headache, and respiratory problems. Long-time exposure is a much more critical concern as it can affect the liver, kidney, and blood systems. That is why even though enjoying snow is possible during winter, it is still best to be cautious of the potential dangers that may come afterwards and prevent snow pollution from happening.

How to prevent snow pollution?

Almost like any type of pollution, preventing snow pollution boils down to decreasing the usage of harmful gases and fossil fuels. Since snow pollution is specifically tied to the number of nanoparticles and concentration of car exhaust gases in the air, it might also help to study how each toxin reacts with snow under different conditions. That way, it would be possible to identify the most harmful ones for the environment, and which areas should focus on the reduction of which gases. It is also important to optimize engines; moreover, even if fossil fuels are going to be used, creating new formulations that do not react as strongly with snow might help prevent the dangers of snow pollution.

Elif Maviş / 10

Photo source:

• Wickremasignhe, Sihara. “The Dark Secret behind Snow Pollution.” The McGill Tribune, 13 Mar. 2016, www.mcgilltribune.com/sci-tech/dark-secret-behind-snow-pollution-643215/.

• Caleb. “WHY FOG HATES THE SNOW.” Sunrise's Swansong, 2 Feb. 2013, sunriseswansong.wordpress.com/2013/02/02/why-fog-hates-the-snow/.

References:

• Howard, Jacqueline. “Snow Soaks Up Toxic Pollutants In The Air, Study Shows.” HuffPost, HuffPost, 19 Jan. 2016, www.huffpost.com/entry/snow-polluted_n_569d33e2e4b0778f46fa4aa1.

• “Melting Snow Contains a Toxic Cocktail of Pollutants.” ScienceDaily, ScienceDaily, 4 Apr. 2017, www.sciencedaily.com/releases/2017/04/170404160052.htm.

• Mitra, Srijata, and Pranab Roy. “BTEX : A Serious Ground-Water Contaminant.” Science Alert, 30 Dec. 2010, scialert.net/fulltext/?doi=rjes.2011.394.398#t1.

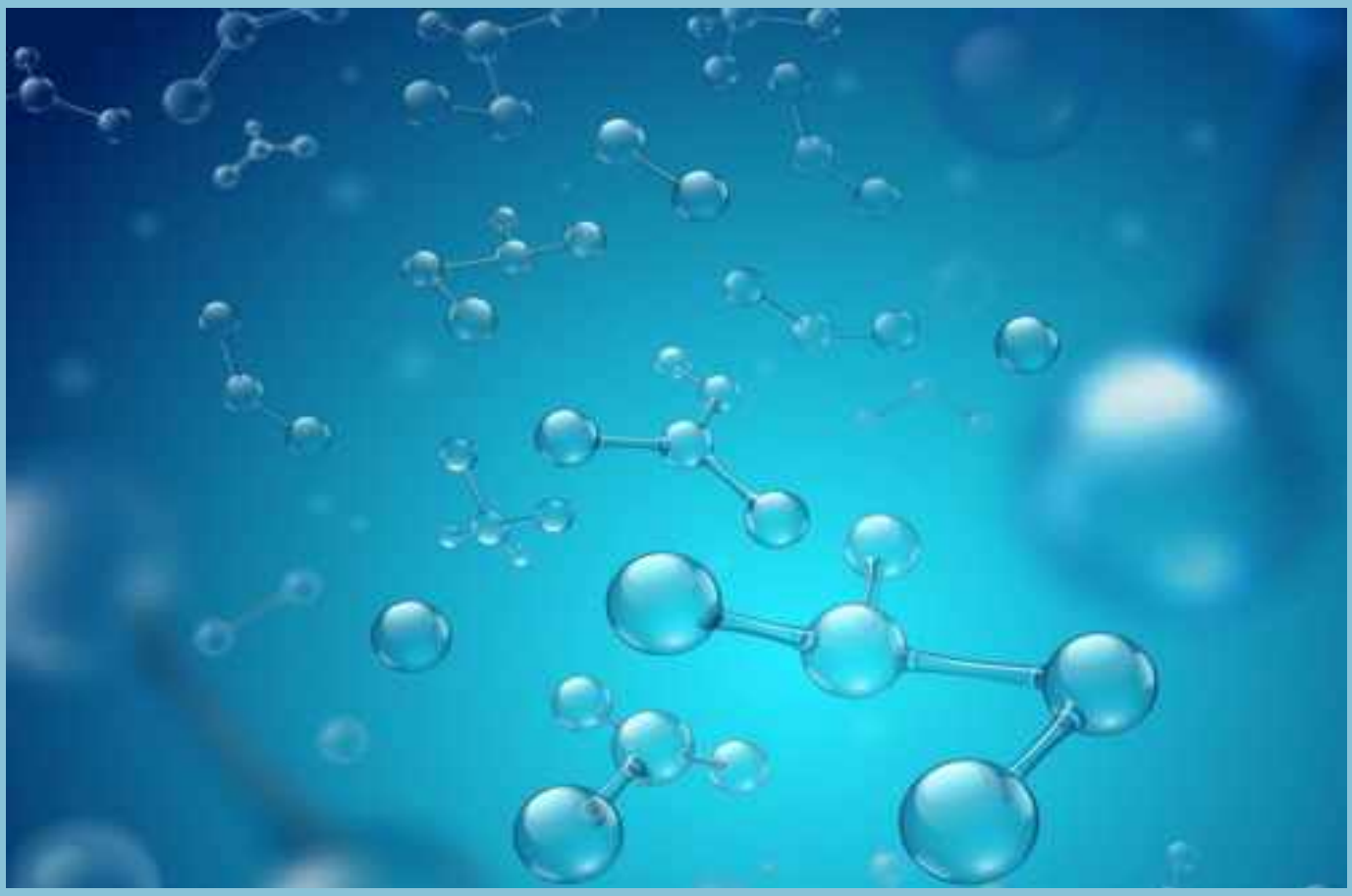
• “Public Health.” Public Health - European Commission, 23 Mar. 2020, ec.europa.eu/health/scientific_committees/opinions_layman/en/nanotechnologies/l-2/6-health-effects-nanoparticles.htm#:~:text=Materials%20which%20by%20themselves%20are,lung%20inflammation%20and%20heart%20problems.

• Staff, AccuWeather. “Why Air Pollution Is Worse in Winter.” AccuWeather, 25 Feb. 2020, 9:59 PM TRT, www.accuweather.com/en/health-wellness/why-air-pollution-is-worse-in-winter/689434.

• Team, TWC. “Why Do Pollution Levels Skyrocket During Winter?.”

• The Weather Channel, 17 Oct. 2020, weather.com/en-IN/india/science/news/2018-10-30-why-do-pollution-levels-skyrocket-during-winter.

• Wickremasignhe, Sihara. “The Dark Secret behind Snow Pollution.” The McGill Tribune, 13 Mar. 2016, www.mcgilltribune.com/sci-tech/dark-secret-behind-snow-pollution-643215/.

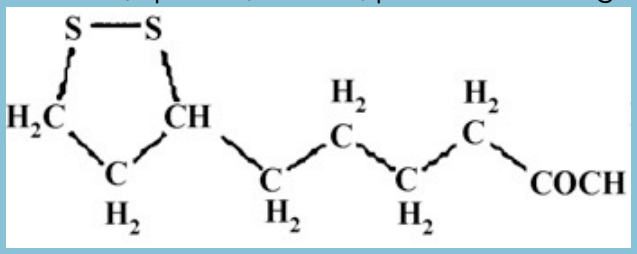


The Chemistry of Eternal Youth: Key Chemicals for Anti-Aging

Have you ever wondered how time passes so quickly? It is definitely a fact that time waits for no one, it goes by so rapidly and without any consent. One can easily feel disappointed and concerned about the changes their body goes through as they get older, therefore scientists started working on reducing the physical changes as much as possible by searching the **chemistry behind preserving our youth.** Whether it is the "youth vaccine", "anti-aging creams" (usually the preference) or taking supplements, people's biggest wish nowadays is to discover how to achieve the young, elastic and hydrated skin which helps the skincare industry maintain their position as one of the highest earning businesses in the world. The studies done by the University of California San Francisco, show that genetic nuances only affect 10% of the skin's overall youthful appearance, so it is all up to the person itself to defy old skin and preserve their healthy self. Here are a few of the chemicals that will give the help needed **as the guide to look ageless** and their structural and physicochemical properties.

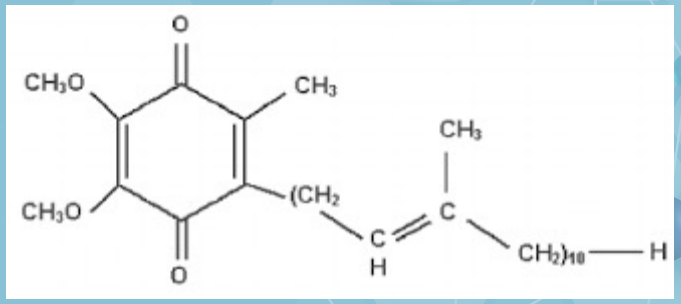
Alpha-Lipoic Acid ($C_8H_{14}O_2S_2$) is classified as an organosulfur compound that has been synthesized in various microorganisms, plants, animals and humans. Most importantly, it is one of the main cofactors of multi-enzyme complexes in mitochondria. It boosts the cellular energy, prevents aging and moisturizes skin. It also helps to activate crucial antioxidants and provides skin with Coenzyme Q10 ($C_{59}H_{90}O_4$), which is one of the most important antioxidants that reduce deteriorating. It has various well-known

enantiomers (molecules that have the mirror images of each other) such as S-Lipoic Acid and R-Lipoic Acid. It is found in vegetables like broccoli, spinach, tomato, peas and cabbage.



The structure of alpha-lipoic acid) ($C_8H_{14}O_2S_2$)

Coenzyme Q10 ($C_{59}H_{90}O_4$) is a lipid-soluble biomolecule that is present in the mitochondria of many animals and within some bacteria. The 10 time repetition of isoprenyl (CH_2=C(CH_3)–CH=CH–) in the formula detects the number 10 in the name. It shows differences between species, the common version is the Coenzyme Q10 for humans however rats have shown properties to have Coenzyme Q9 in their bodies. The isoprenyl group that repeats ten times helps the mobility, interaction with membrane proteins. Without containing sufficient amounts of Coenzyme Q10, the body loses its ability to produce decent amounts of collagen ($C_{65}H_{102}N_{18}O_{21}$) and elastin ($C_{27}H_{48}N_6O_6$) which are two of the most important chemicals for retaining the moisture of skin. It is usually present in every cell of the body, however, the amount is scarce without consuming it from elsewhere. It is present in fishes like sardine and mackerel and also in vegetables such as broccoli, mushrooms, spinach and soya beans.



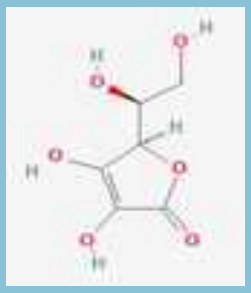
(The structure of Coenzyme Q10) ($C_{59}H_{90}O_4$)

Hyaluronic Acid [($C_{14}H_{21}NO_{11}$)n]: Hyaluronic acid is one of the most well-known chemicals that aid anti-aging, therefore manufacturers from all over the world spend months on creating the best HA solutions in the market. It is known for moisturizing the skin, while also preserving supple and hydrated. Its well-known property comes from its being a non-sulfated glycosaminoglycan (GAG), which gives the molecule the unique ability to bind with H_2O molecules. The [($C_{14}H_{21}NO_{11}$)n] molecule is known to be composed of repeating polymeric disaccharides of D-Glucuronic Acid and N-acetyl D-glucosamine linked by glycosidic bonds. The glucose-based structure of the molecule creates its tendency to bind with water and to form strong hydrogen bonds with it which keeps the moisture inside the skin. Despite the simplicity of the chemical structure of the molecule, it has been observed that it has various physicochemical properties, its polymers appear in many configurations and shapes according to their size, salt concentration and pH value. Board-certified dermatologist Dr. Fayne Frey states that "Compared to other polymers, hyaluronic has the greatest ability to hold water," which is why it is an important factor in keeping hydration.

(The chemical structure of hyaluronic acid) ($C_{14}H_{21}NO_{11}$)n

Niacinamide ($C_6H_6N_{20}$): It is the active form of Vitamin B3 and is the component of nicotinamide adenine dinucleotide (NAD) which is found in all living cells. It is also referred as Nicotinamide and it is a pyridine carboxamide which means that it is a pyridine (colorless liquid) but one of its hydrogens are swapped with a carboxamide group. Niacinamide appears to be a white powder

and it has a role of being an anti-inflammatory agent, an antioxidant and a cofactor. It aids the body in cell signaling, DNA signaling and the conversion of carbohydrates into protein and lipids. Niacinamide is a very crucial vitamin for the functioning of the body, as well as blocking melanin from coming to the surface of skin and brightening the dark spots.



(The chemical structure of Niacinamide) ($C_6H_6N_2O$)

Vitamin C ($C_6H_8O_6$). Also known as Ascorbic Acid, Vitamin C is a water-soluble vitamin. It is an antioxidant that prevents environmental pollutants and UV rays from affecting the skin and it is also contributing to the formation of collagen ($C_{65}H_{102}N_{18}O_{21}$) in skin, teeth, bones and capillaries. These UV rays, pollutants and lacking the activation of important chemicals like collagen, are the most predominant reasons why the skin shows age quicker than it should and why it deteriorates unexpectedly. Ascorbic acid additionally helps fight bacterial infections, detoxifying reactions and Dr. Eric Bravermen from PATH Medical Center further explains the benefits of Vitamin C, by revealing that "Vitamin C increases skin's collagen, making it appear plumper while reducing signs of wrinkles and fine lines." It could be taken from eating citrus fruits or many vegetables. Vitamin C cannot be produced within the human body so it has to be provided within the diet.

(The chemical structure of Vitamin C) ($C_6H_8O_6$)

Overall, the chemical properties of the given 5 molecules provide the ability to preserve the health of skin and help activate the skin cells to give its visually pleasing appearance. If all are being consumed regularly, its long-term effects will be visual to the human eye as the skin cells get older.

Mina Taşan / 10

References:
• "Hyaluronic Acid: A Key Molecule in Skin Aging." Taylor & Francis, www.tandfonline.com/doi/full/10.4161/derm.21923.
• Szeląg, Małgorzata, et al. "Quantum-Chemical Investigation of the Structure and the Antioxidant Properties of α-Lipoic Acid and Its Metabolites." Journal of Molecular Modeling, 30 Nov. 2011, https://link.springer.com/article/10.1007/s00894-011-1306-y
• "Effect of Coenzyme Q10 Supplementation" PubMed Central (PMC), 1 Dec. 2018, www.ncbi.nlm.nih.gov/pmc/articles/PMC6316376. (just for the chemical property part in the beginning for coenzyme Q10)
• "Skin Aging: Genetic Nuances." Dermatology Times, www.dermatologytimes.com/view/skin-aging-genetic-nuances .
• PubChem. "Ascorbic Acid." PubChem, https://pubchem.ncbi.nlm.nih.gov/compound/54670067 .
• "Nicotinamide." PubChem, https://pubchem.ncbi.nlm.nih.gov/compound/936.

source: (newsasiatoday.com)

A High-Precision Atomic Clock

Is it possible to go faster than the light? Have you ever run so fast that you just couldn't follow the objects around you? Or saw someone running across the street and had to step aside to not hit him. Maybe he missed the school bus. Maybe he was late to work. Maybe he just needed to use the gentle's. One thing for sure is that he was fast.

Then, what is the max speed someone can get? At the 2009 World Athletics Championships final in Berlin, Usain Bolt broke the record for 100 meters dash by finishing in just 9.58 seconds[1]. Now that's fast. He is now holding the title of the world's fastest person of all time. But what if we could go faster than him. Faster, the fastest. Light is currently the fastest thing in the universe with a speed of 299,792,458 meters per second[2]. The Sun is 150 million kilometers away from the Earth and light takes just eight minutes and 20 seconds to travel that far[3]. That is nowhere near Usain Bolt's record. Can you imagine going that fast? We could go anywhere anytime. Everyone would be like Flash from the DC universe. But the question is, can we go faster than that?

When we think about it, it seems impossible. Einstein also thought the same in his theory of relativity. Just like he predicted, time ran slower for the moving clocks. So, the faster something travels, the more massive it gets, and the more time slows, until you finally reach the speed of light, at which point time stops altogether. And if time stops, well so does speed.

In Einstein's famous equation $e=mc^2$ where "e" is energy, "m" is mass and "c" is the speed of light, the light speed is constant which means mass and energy are directly proportional. This is also why time slows down for faster and

bigger objects. Since the speed of light is so high, it will require an unimaginable amount of mass to reach the speed of light. According to this logic, nothing can travel faster than the speed of light[4].

However, scientists of course denied this theory and made some experiments for that. In September 2011, physicists Antonio Ereditato and Dario Autero shocked the world with the OPERA (oscillation project with emulsion-tracking apparatus) project. The experiment timed neutrinos, subatomic particles which have no particular charge and have a mass near-zero[5], produced at CERN, as they arrived 730 kilometres away at OPERA's underground detector at the Gran Sasso National Laboratory in Italy. High-precision atomic clocks stationed at each end of the beam were synchronized using the Global Positioning System (GPS). The team reported in September 2011 that neutrinos arrived at Gran Sasso 60 nanoseconds faster than a light beam would do[6]. Unfortunately, it turned out the OPERA result was wrong. A timing problem had been caused by a poorly connected cable that should have been transmitting accurate signals from GPS satellites.

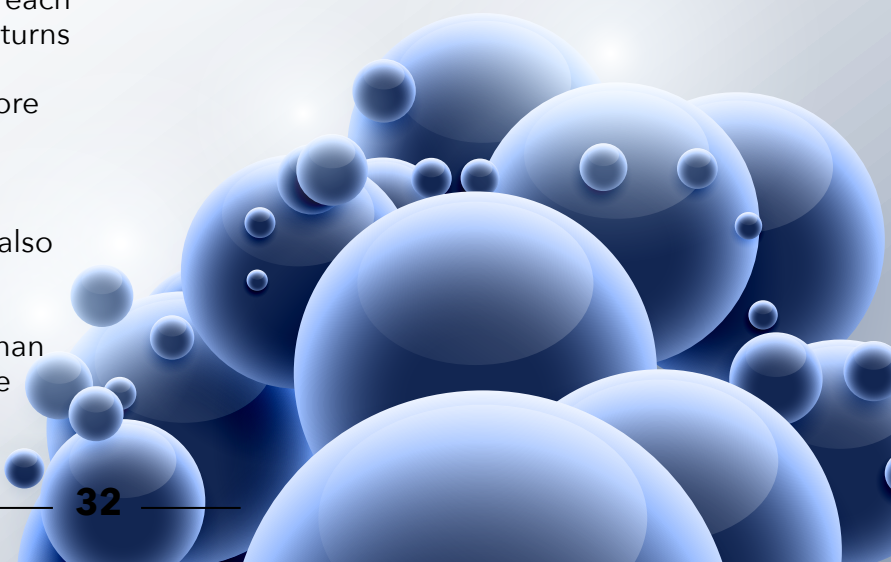
Another attempt was made by William Bertozzi at the Massachusetts Institute of Technology (MIT), early 1960s. He experimented with accelerating electrons at greater and greater velocities. Because the electrons have a negative charge, it is possible to propel, or rather repel them by applying the same negative charge to a material. The more energy applied, the faster the electrons will be accelerated. It is possible to imagine that we could just increase the energy, applied to reach the required speed of 300,000km/s, but it turns out that electrons can't move that fast. Bertozzi's experiments found that using more energy didn't simply cause a directly proportional increase in electron speed[7].

Theories about going faster than light are also made for quantum level. Tachyons, as an example, are hypothetical particles with imaginary masses which can travel faster than light speed. They presumptively exhibit the unusual property of increasing in speed as their energy decreases and require infinite energy to slow down to the speed of light. However, there is no experimental evidence about the existence of tachyons. Because a tachyon would always travel faster than light, it would not be possible to see it approaching. After a tachyon has passed nearby, an observer would be able to see two images of it, appearing and departing in opposite directions. These properties of tachyons are inconsistent with the known laws of physics, making most physicists believe that faster-than-light particles cannot exist[8].

In the end, it is safe to say we cannot go faster than light with today's technology. Maybe one day, with something that has infinite mass and energy, it would be possible to exceed the speed of light. But until someone disproves, keep running.

Berzah Ozan Bal / 10

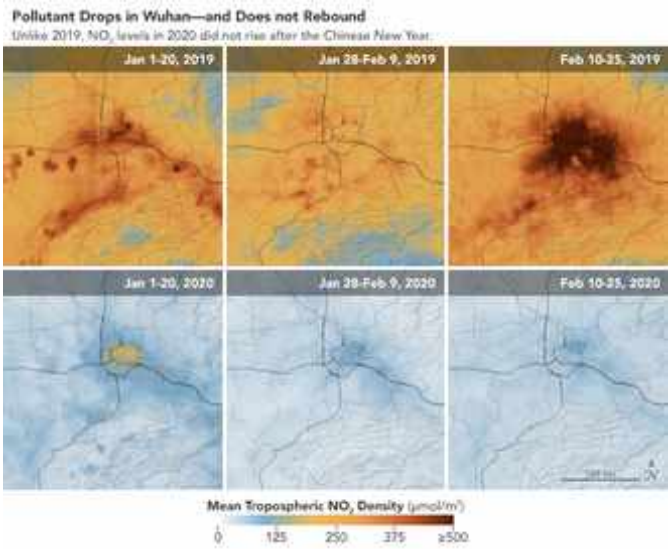
References:
[1]https://en.m.wikipedia.org/wiki/100_metres
[2]What is the Speed of Light? - Universe Today
[3]http://www.bbc.com/earth/story/20150728-travel-from-the-sun-to-jupiter
[4]Why can't anything travel faster than light? - Cosmos Magazine
[5]What is a neutrino? - Scientific American
[6]Embattled neutrino project leaders step down : Nature News & Comment
[7]http://www.bbc.com/earth/story/20160429-the-real-reasons-nothing-can-ever-go-faster-than-light
[8] Tachyon - Wikipedia



ANOTHER SUN

The Necessity of Fusion Energy

The use of fossil fuels has been a great debate for a long time, but in terms of resolution there haven't been any significant steps taken. However, when the whole world got locked down due to the Covid-19 pandemic and there was no need for energy as much as in normal times, the world recognized how the environment has altered for the good. The center of the virus Wuhan has had an approximate decrease of 360μmol/m² of NO_2 density—which is a dramatic decrease—in the



The change in NO_2 density in Wuhan in a year

Chinese New Year in 2020. In the industrial giant China, the overall carbon emissions have declined 25 percent and nitrogen dioxide emissions were reduced approximately 50 percent due to several reasons such as the closure of factories and less usage of vehicles among the country. Therefore, the 2015 Paris Agreement has become extremely crucial. More than 110 countries have signed the agreement such as developed countries like Finland and Austria have promised to go carbon-zero until 2035 and 2040 respectively. The majority of other countries have agreed to go carbon-zero until 2050, but only the industrial giant China has promised to go carbon-zero until 2060. Even though the world has promised to give up its most productive energy source, the energy will still be an issue. To resolve this problem, countries are developing new ways to generate a great amount of electricity from energy conversions. Depending on the statistics of a global demographic website, the estimated population of the world will be about 10.1 billion in 2060. Which energy source will satisfy the necessity of energy when fossil fuels are out of the game? The answer for that question is fusion energy.

What Is Fusion Energy and Its Benefits

Fusion power is a type of power generation derived from two over-heated atoms. These light atoms are heated up to 150 million Celsius degrees and gain great velocities. Due to that high velocity, the atoms collide with each other, thus forming a heavier nucleus and releasing a greater amount of energy during the process. This nuclear process is called fusion reaction and the machines that make this reaction possible and harness the energy are called fusion reactors.

There are a variety of benefits for this new sustainable energy source. For instance, the most intriguing benefit is that the fusion reactors don't have greenhouse gas emission such as CO_2 and NO_2—but only helium. It occupies less land than other energy facilities including both renewable and non-renewable sources, thus increasing free space and reducing visual pollution. Another beneficial aspect of fusion energy is that it is safer. Compared to nuclear power plants, the fusion reactors have no risk of meltdown at all. Japan has experienced the detrimental consequences of a core meltdown in Fukushima power plant in 2011, but with fusion reactors, there is no such risk. Moreover, in fusion facilities there isn't any long-lived radioactive waste as a byproduct of the reaction. This is a great benefit since it lowers the potential of harming the environment and decreasing the odds of an undesirable mutation in the organisms. Furthermore, there is an abundant source of fusion fuel on planet Earth. The main energy source is deuterium and tritium-isotopes which are found in sea water-and are able to be derived from lithium.

Therefore, there is enough fusion fuel for approximately the next 100 million years. Fusion reactions release nearly 4 million times as much as the chemical reactions occurring with coal, gas, or natural gas and 4 times more energy than nuclear fission reactions, thereby having the opportunity to generate much more energy than usual energy sources. By generating greater amounts of energy, there will be a greater amount of generated electricity between 1 and 1.7 gigawatt-nearly powering up 300.000-370.000 houses-the cost for electricity and technology would drop down and people would have more access to technology as well as electricity. The last benefit of the fusion energy is that it can produce on-demand energy, meaning that since it is safer, it could be built close to where the electricity is needed.

Artificial Suns

Due to the countless benefits of the fusion energy some countries such as China and Korea have decided to build their fusion reactors and since they are extremely hot, they are named as "artificial sun". China has been building their artificial sun since 2006 and they managed to turn it on in 2020 for the first time. The HL-2M Tokamak is a nuclear fusion reactor that heats up to 150 million degrees—which is nearly 10 times hotter than the sun's core— ; however, the super-magnetic cooling mechanism keeps it running. The reactor applies powerful magnetic fields to the contained loop of hot plasma that heats up the isotopes inside and their velocity increases, thereby generating energy from their movement. With this high velocity, the fusion -fusing two nuclei of two atoms- occurs and generates huge amounts of energy without generating large amounts of nuclear waste.

HL-2M TOKAMAK

The reactor is built under the International Thermonuclear Experimental Reactors(ITER), a coalition of countries that have nuclear power plants, and the successful activation of this fusion reactor has encouraged other nations to try the artificial sun. Korea has built and tested their artificial sun that heats up to 100 million degrees. The Korean Superconducting Tokamak Advanced Research (KSTAR) was tested in November 2020 and it gave successful results. The feature that distinguishes the KSTAR from HL-2M is that it is capable of keeping the hottest and most unstable state of the isotope, the plasma state, for 20 seconds giving it a longer time to harness the energy. After these successful attempts of using the first artificial suns in the east, ITER also decided to shine up the west. They have decided to build the next artificial sun in France which is expected to be completed in 2025.

Fusion energy is a great source for humanity in many ways. Countries are trying to use this safe and clean energy source for humanity that will save the environment from detrimental effects as well protecting them with this safer solution. The artificial suns are the reactors that harness that energy and are humanity's newest and brightest solution for the future.

Furkan Baylav / 10

Sources:
• https://en.wikipedia.org/wiki/Impact_of_the_COVID-19_pandemic_on_the_environment
• https://www.worldometers.info/world-population/world-population-projections/
https://en.wikipedia.org/wiki/Fusion_power
• https://generalfusion.com/what-are-the-benefits-of-fusion-energy/
• https://www.iter.org/sci/Fusion
• https://globalnews.ca/news/7505850/china-artificial-sun/
• https://phys.org/news/2020-12-korean-artificial-sun-world-sec-long.html

FORCE ?

We have all seen Newton's Law *F=ma*. When seen such a statement, one wonders, fine, force is equal to mass times acceleration; however, what exactly is force? Surely, we are measuring *something* when we hang objects on dynamometers. Of course, this question can easily be answered by saying, well, we measure the object's mass times its acceleration. What this implies is that Force is "ma" and nothing else, that force has no other meaning than being something equal to "ma". This suggests that the statement *F=ma* is a definition, not a relation. It does not say that Force as an independent entity is equal to mass times acceleration, rather states that force is mass times acceleration. This was what I had found comfort in thinking, that *F=ma* was a statement that defined force – notice that the word choice is not actually important, if force really does not have an independent meaning, then another word such as gibblygobbly could as well have been used

But this was not the case either. Because the word "force" means something, and "gibblygobbly" does not. It is not an arbitrary thing that is the subject of this equation, and the term "force" does actually have a meaning. Apart from ma, we use other intuitive descriptions of force. A quick search through google and you can come across this definition:

"any action that tends to maintain or alter the motion of a body or to distort it" (force | Definition & Formula, 2009)

And of course, there is the famous "push or a pull"

Now, this is entirely different from saying *F=ma* is a mere definition. Because when we say that Force is the mass times the object's acceleration, and accept it as a definition, we presume that Force is nothing else. But this sentence suggests that it also has a physical meaning, *an interaction*, and interactions are elements of the physical world, thus force should have a physical origin. And this does not fit with the "definition" that is *F=ma*, which is a mathematical statement.

To understand this better, one can look at acceleration. The equation could be rearranged to the form *a=F/m*. In this case, are we *defining* acceleration to be force divided by mass? No, we are not. Acceleration has its own definition that is unrelated to the equation *a=F/m*, the rate of change of velocity. Therefore the value this law holds in terms of acceleration is not a definition, but a relation. So does force have its own separate definition?

Richard Feynman's commentary on this matter suggests:

"The real content of Newton's laws is this: that the force is supposed to have some independent properties, in addition to the law *F=ma* but the specific independent properties that the force has were not completely described by Newton or by anybody else, and therefore the physical law *F=ma* is an incomplete law." (Feynman, Leighton, and Sands, 2015)

So what do these previous paragraphs actually mean?

F=ma is not actually a definition, and Force is not just ma, but what force is, apart from ma, we don't actually know. And that is unsettling because force is what we all learn in basic physics classes and it is in essence what we base our understanding of physics on. The fact that there lies some ambiguity in such an essential concept seems rather odd, to which

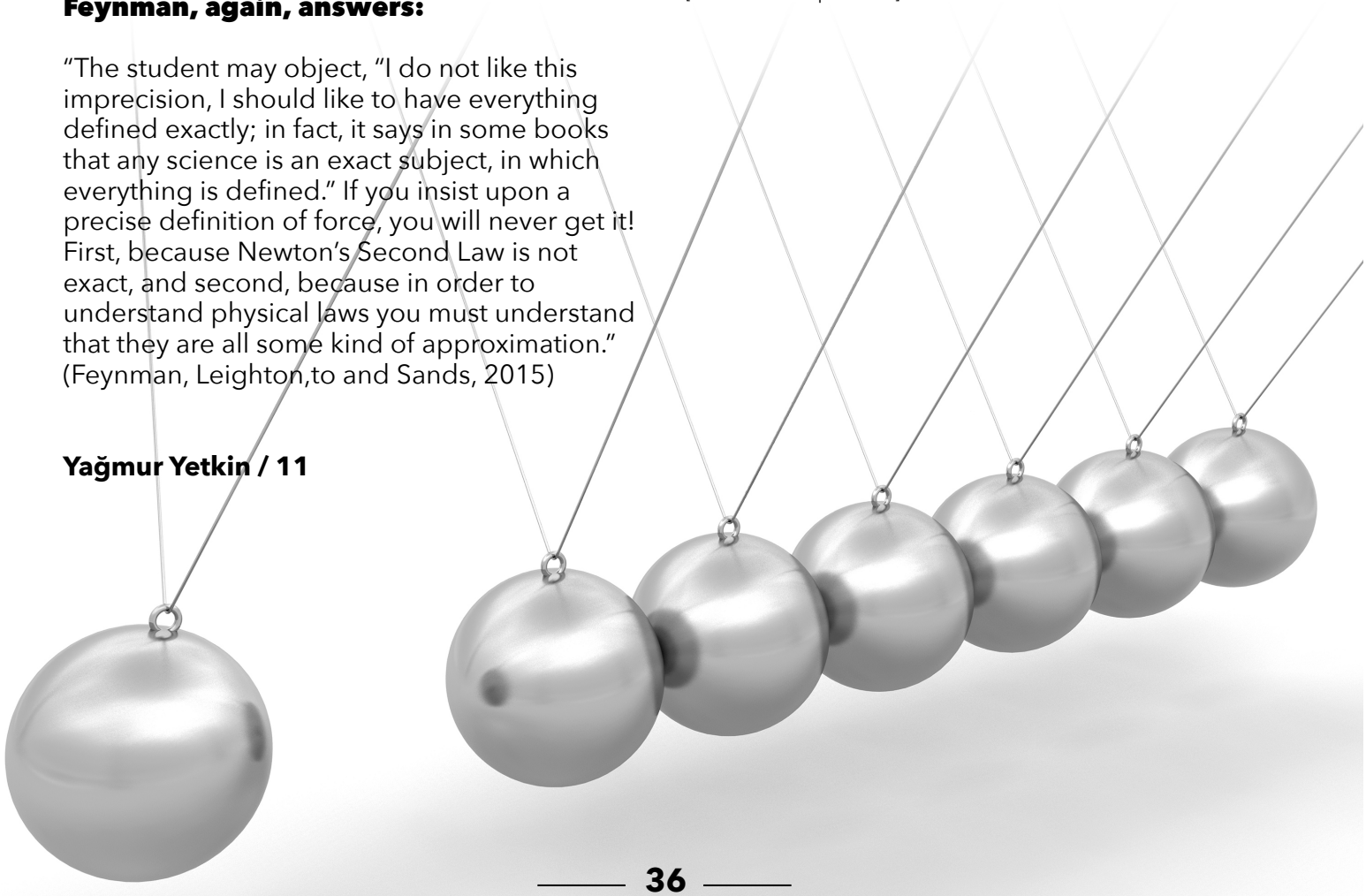
Feynman, again, answers:

"The student may object, "I do not like this imprecision, I should like to have everything defined exactly; in fact, it says in some books that any science is an exact subject, in which everything is defined." If you insist upon a precise definition of force, you will never get it! First, because Newton's Second Law is not exact, and second, because in order to understand physical laws you must understand that they are all some kind of approximation." (Feynman, Leighton,to and Sands, 2015)

Yağmur Yetkin / 11

References:
Feynman, R., Leighton, R. and Sands, M., 2015. Feynman lectures on physics. New York: Basic Books.

Encyclopedia Britannica. 2009. force | Definition & Formula. [online] Available at: <https://www.britannica.com/science/force-physics> [Accessed 10 April 2021].



the mysterious reality

What lies beyond the clouds? What lies beyond the blue atmosphere that has fascinated the human mind all these years? What makes space so enchanting and mysterious at the same time?

Since long before humanity can remember, humankind worked on space. Predicted, inferred, put out theories… Although nowadays most of them cannot be considered efficient, it is known that the knowledge they gathered build up to our fascinating research and theories about this magnificent reality. It is estimated that 2,400 years ago, the Babylonians originated their horoscopes from space. Since then research about space has never stopped. Human kind, as an outcome of their feeling of curiosity, studied the idea of astrology or attempted to find the God that they believed was hidden beyond their vision.

They looked up to the sky and questioned. For example, Galileo Galilei, a scientist who highly promoted the scientific revolution in the 17th century, endorsed the "Copernican Theory", stating that the sun is located in the center while other planets, including our own, revolve around it. This forms the basis of our so-called knowledge of the Milky Way. Unfortunately, he was sentenced to lifetime imprisonment in 1633. Consecutive to Galileo, Descartes is an honorable mention with his own work in philosophy and astronomy which repeatedly supported the scientific revolution in the 17th century. He stated that space is Euclidean in structure, infinite, flat, and not empty. However, none of these people could do what Isaac Newton did as he created the fundamental laws of physics and gravity which laid the foundation of research until the 20th century. He established his first law in 1687 through his book, Philosophiae Naturalis Principia. These and many more scientists of the 17th century all had a very significant impact on the scientific riot. With this background knowledge, let's move on to what makes it so mind-blowing.

As it is pretty obvious, something about space enchanted the human mind and caused many people to be interested in finding out more about it, but what more is there to even find out about? We have the Sun, the Earth, even the Milky Way. What do we need more? It is known for a fact that only 4 percent of the visible universe is discovered. Imagine what lies beyond our knowledge. It is so mysterious, astonishing, and horrifying if you think about it. Let me put out some interesting facts:

1. The Sun makes up 99 percent of our solar system's mass. Imagine how small the Earth is in comparison to the mass of the solar system, perhaps how insignificant us, humans, are in regarding the formation of the mass of the solar system.

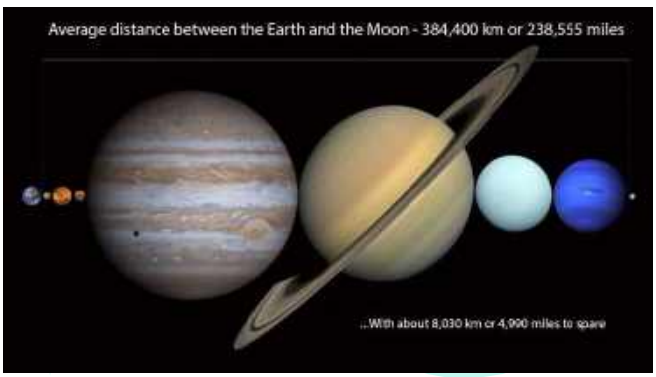
2. One Venus day is longer than one Venus year. This is about its significant rotation and size. Planet day refers to the time it takes for a planet to revolve around its own axis which is, for Venus, 243 days. Planet year refers to the time it takes for the planet to revolve around the Sun which is almost 225 days. Hence, a year is not always bigger in quantity than a day if you think about it. Not if you are on Venus.

3. In Saturn and Jupiter, it might be raining millions of pounds of diamonds every year. The atmosphere has such high heat and pressure that it might squeeze carbon to form diamonds. What a lovely planet that would be…

4. Venus orbits in the opposite direction than all the other planets in our Solar System. Its axis

is estimated to be flipped by the Sun's gravitational pull.

5. It is possible to fit all the planets in the Solar System between the Moon and the Earth. The average distance from the Moon to the Earth is 4,392 km. In addition, all the planets put side by side will result in a 380,008 km long shape, leaving us with an extra of 4,392 km.



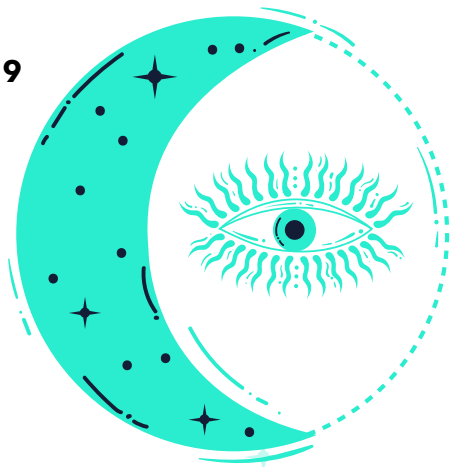
6. A perilous crash is going to occur in 4 billion years between the Milky Way and the Andromeda Galaxy. Fortunately, the Earth is not going to be destroyed. In fact, the galaxy product of this collusion has been named as Milkomeda/Milkdromeda. What a relief…

I agree that these facts are unpredictable but still don't explain why humankind is so attracted to space. Why humankind studied space is directly related to their curiosity, which is an intrinsic quality that makes humans so unique. One way we, humans, differ from any other species is our so-called feeling of curiosity. We get curious about something, then we do research and then come to a conclusion. However, when it comes to space, it is not so trivial. When you are studying space there is no way for you to come to a significant conclusion. Space is a concept, you can't touch, feel or look at unless you put on a spacesuit or launch a shuttle to understand its most detailed equations and that takes a lot of courage. Looking at the first five shuttle launches, there is a one in five odds for the shuttle to be destroyed and for the astronaut to die in it.

Hence, it must be very interesting to wonder if one is going to be floating gloriously in space or dead at the end of the day the space shuttle launches. A very selfless sacrifice is what astronauts are doing for the whole of mankind. Why people are willing to take that risk is a question I can't answer though Chris Hadfield did in his TED talks. He delivered a speech about an astronaut floating through space without his ability to see because of an accident (fortunately, he was able to recover after he completed the spacewalk). I advise you to listen to that because he talked about how real danger and fear contradict, meaning you actually can overcome any risk by showing determination and courage. Another reason for humans' interest in space might be their survival instinct. Currently NASA, the most well-known company studying the space, is attempting to find another planet where humans can colonize as there is a very high probability for the Earth to deplete its resources very soon. "Is there a way for us to solve this?" is a question NASA is working on. Hopefully, there is.

To conclude, space is so terrifying due to its mysterious side but enchanting at the same time that caused the human mind to be interested in it all these years. Even though studying in space takes a lot of courage some people are still willing to take the risk. Still, why space has attracted so many human minds revolve as a mystery; but it is clear that curiosity and survival instinct make a really big part of it. "The Earth is the cradle of humanity, but mankind cannot stay in the cradle forever.", Konstantin Tsiolkovsky. Maybe life is more than just being on Earth…

Dilara Doğa Talu / 9



https://www.youtube.com/watch?v=JipLCxRBHaQ
https://mashable.com/article/sun-stars-space-facts/

Nuclear Physics and Its Usages

What is exactly nuclear physics?

To put it simply, nuclear physics is a field of science that studies atomic nuclei and their constituents and interactions. Nuclear physics also shouldn't be mistaken for atomic physics, which studies the atom as a whole, including its electrons.But before diving deeper into the world of fission, fusion, nuclei, and radiation, we need to understand the basics of the subject.

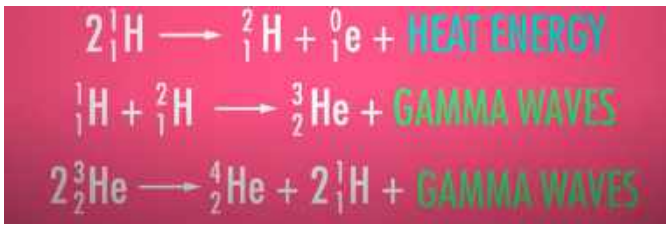
What's the history behind it? Which scientists played an important role in the creation of nuclear physics?

The history of nuclear physics as a discipline distinct from atomic physics starts with the discovery of the electron by J.J Thomson in 1897, therefore proving that the atom had an internal structure. In the years that followed, Marie Curie, Pierre Curie, Ernest Rutherford, and many others took great strides in expanding the knowledge about the subject. Around the 1920s, Arthur Eddington anticipated the discovery and mechanism of nuclear fusion processes in stars, in his research paper. Up until that point, the source of stellar energy, which can be defined as the energy radiating from a star, was a complete mystery; Eddington correctly speculated that the source was the fusion of hydrogen into helium, liberating enormous amounts of energy.

In conclusion, our exponential development in nuclear physics was a result of brilliant scientists, assumptions and predictions. Now that we have gotten the basics out of the way, we can look deeper into the topic and the series of processes behind how the smallest particles in the universe interact with each other.

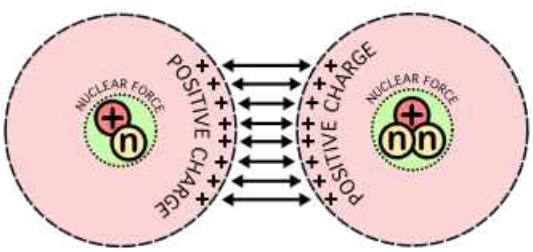
Nuclear Fusion

Perhaps one of the most astonishing natural events that take place in the universe is the birth of stars. Away out there in space there are huge clouds of dust and gas, and if one of those clusters of dust and gas is massive enough, it collapses under its gravity. After a million years later, the center of the cluster gets denser and hotter, and eventually, the particles of gas and the dust start to stick together instead of repelling each other due to the extreme temperature and pressure in a process we now call nuclear fusion.



To summarize, nuclear fusion is a reaction in which two or more atomic nuclei are combined to form one or more different atomic nuclei and subatomic particles. The reason why stars are able to generate massive amounts of energy is due to the fusion of lighter elements such as hydrogen to heavier elements, such as helium.

However, a substantial energy barrier of electrostatic forces must be overcome before fusion can occur. At large distances, the naked nuclei repel each other because of the repulsive electrostatic force between positively charged protons. If two nuclei can be brought close together, fusion can occur with the effect of quantum tunneling. To put it simply, quantum tunneling is a phenomenon in physics where particles and wave functions are able to pass through barriers. In other words, particles can travel through walls, if they're thin enough.

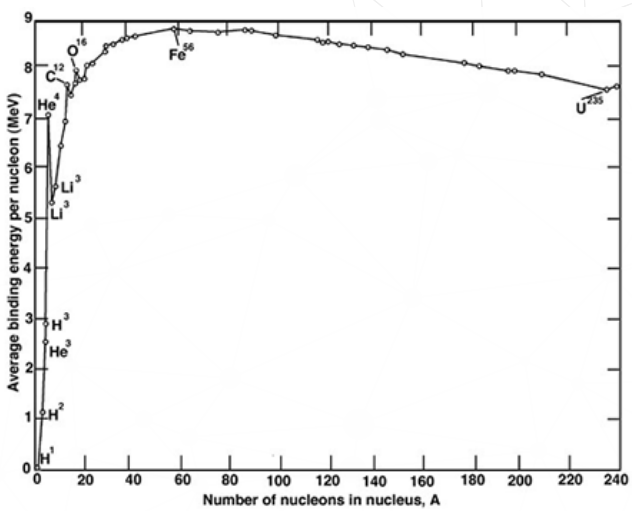


Fission

Nuclear fission is a process in which a heavy nucleus, when bombarded with neutrons, splits into two nuclei of nearly equal mass with the release of enormous amounts of energy. So while fusion reactions make heavier elements, fission reactions split these heavy elements into lighter ones.

The graph shows the average binding energy, which exemplifies the minimum energy that would be required to disassemble the nucleus of an atom per nucleon (nucleon means protons and neutrons). As you can see, the higher the number of nucleons in an element are, the higher the binding energy needed (up to Fe). Consequently, this means that elements such as hydrogen and helium are easily fusible since they need less energy to bind together. On the other hand, iron is the most tightly bound, and stable. The reason why the binding energy slowly decreases for elements heavier than iron is that they become less stable and more available for nuclear fission.

If we were to look at the graph below, we would be able to see that uranium, particularly uranium-235 is able to yield the most amount of energy from its own fission which is why we use uranium in our nuclear reactors as well as nuclear weapons.



Applications of Nuclear Physics:

Nuclear Weapons

Perhaps the most famous application of nuclear physics is the creation of nuclear weapons or otherwise known as weapons of mass destruction. In fission weapons a mass of fissile material is forced into supercriticality (when an element is subject to tremendous amounts of temperature and pressure), allowing an exponential growth of chain reactions, bursting out tremendous amounts of energy. The other basic type of nuclear weapon produces its energy by the means of fusion. These types of bombs, more commonly referred to as Hydrogen Bombs, are much more destructive than warheads that utilize fission.

Nuclear Power Plants

Nuclear power is the use of nuclear reactions that release nuclear energy to generate heat, which most frequently is then used in steam turbines to produce electricity. Presently, the vast majority of electricity from nuclear power is produced by the fission of uranium and plutonium although scientists all around the world are actively researching how fusion reactions can be used to generate electricity. Around 10% of the global energy supply comes from nuclear power plants.

Medical Applications

Nuclear medicine and radiology are the whole of medical techniques that involve radiation or radioactivity to diagnose, treat and prevent disease. While radiology has been used for close to a century, “nuclear medicine” began approximately 50 years ago. Today, about one-third of all procedures used in modern hospitals involve radiation or radioactivity. These procedures are among the best and most effective life-saving tools available, they are safe and painless and don’t require anesthesia, and they are helpful to a broad span of medical specialties, from pediatrics to cardiology to psychiatry. X-Rays, MRI scanners, CAT scans each utilize nuclear technology.

Gediz Doganca / 9

References:
• https://www.eia.gov/energyexplained/nuclear/nuclear-power-plants.php
• https://en.wikipedia.org/wiki/Quantum_tunnelling
• https://www.youtube.com/watch?v=mZsaaturR6E
• https://www.jstor.org/stable/24987405?casa_token=xBHPTY6QxsYAAAAA%3AaQmwoPKGHBs9NweHNTfLL2KnZU3FEGLjBCquA795a5rw9YTZ8-kYB-vJQoHwjLIarNDOAo3MusTWlQLwNPwVPmQDu3Kz4DGpgLlYzc82pNZBPo5altk&seq=1#metadata_info_tab_contents
• https://www.energy.gov/ne/articles/nuclear-101-how-does-nuclear-reactor-work
• https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-power-reactors/nuclear-power-reactors.aspx
• https://www.britannica.com/science/physics-science/Nuclear-physics
• http://nuclearconnect.org/know-nuclear/applications/medical-uses
• 2014 × 1500

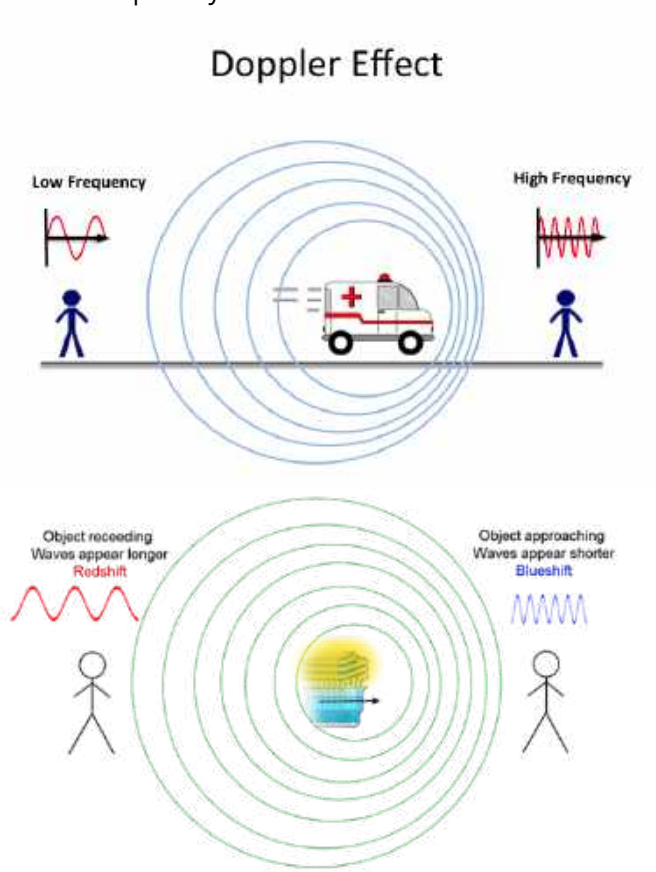
The Controversy of the Hubble Constant

Thanks to legendary astronomer Edwin Hubble's work in 1925 we know that the universe is expanding. However, even after almost 100 years astronomers still can't precisely measure the rate of its expansion (also known as the Hubble constant). Especially for the last 20 years scientists have argued over methods of measurements and the astronomical community was fiercely divided around this single issue.

Before getting into the controversy surrounding the Hubble constant we first have to understand the expansion of the universe and what exactly the Hubble constant is.

Even before Hubble's works there was lots of evidence pointing at an expanding universe. Firstly, after Einstein released his general theory of relativity some scientists went on to apply the theory for the whole universe and saw that it resulted in not a static but a dynamic cosmos, which means that the universe should be in some way changing shape. At the time many, including Einstein, thought that this was indeed a mistake in general relativity and there was no way the universe would be expanding. After it was confirmed that the universe was really expanding Einstein called his speculation his biggest mistake, since he could have maybe won another nobel prize for proving the expansion of the universe through his equations.

Besides general relativity, the most important evidence pointing at an expanding universe is the fact that galaxies are moving away from us. But how do we know this? Well, there is a phenomenon in physics called the doppler shift. The general idea is that, if the source of a wave is moving the waves in front of the moving object compress and have higher frequencies while the waves behind the object are farther apart from each other which lowers their frequency. A perfect example for the doppler effect is a moving ambulance. If an ambulance ever passes next to you with its alarm on you'll notice that when it is moving towards you the sound waves compress and you hear a higher frequency sound, but when it is moving away from you the sound becomes a lower frequency.



This concept is one of the most useful tools in astronomy, as it enables us to calculate the speed at which astronomical objects are moving towards or away from us. Even though we used sound waves in our example the doppler shift also applies to electromagnetic waves. If a sun that has an original colour of yellow moves towards us it will appear with a color that is closer to blue end of the emw spectrum since blue has a higher frequency, but if it moves away from us it will appear as a color closer to red end of the emw spectrum since red has a lower frequency. This is the reason why we call astronomical objects moving away from us as "redshifting" and those moving towards us as "blueshifting". However,

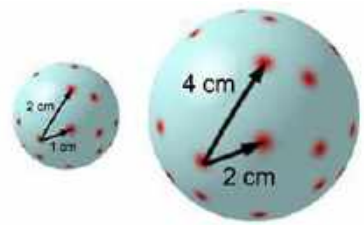
$$z = \sqrt{\frac{c+v}{c-v}} - 1$$

$z = redshift$
$v = recessional\ velocity$
$c = speed\ of\ light$

please do not try throwing objects towards yourself or away from yourself to observe this effect since you can hurt yourself and others and in order to observe doppler shifts for electromagnetic waves the object must be traveling at velocities close to 5200 km/s.

When Hubble looked at the sky he noticed one crucial thing. Almost every galaxy he saw was redshifting, meaning they were moving away from the milky way. The most straightforward explanation for such a thing would be that our galaxy has some sort of special repelling force that is pushing other galaxies away. However, Hubble noticed another crucial detail. Galaxies that were farther away from us were moving even faster than those near us. These two observations lead Hubble to conclude that the universe is not static but in a state of expansion. Let us summarize these ideas through a clever analogy.

Imagine the universe being a balloon. Therefore, we can imagine the expansion of our universe as the expansion of the balloon.



Let's draw a point on the balloon and assume that as the milky way. We can also draw two other points that are respectively 1 and 2 cm away from our initial point and imagine that those are two other galaxies. Finally, let's blow inside the balloon and expand our universe. After doing this you'll notice that the other two galaxies moved away from us, but more importantly while the closer one only moved 1 cm the other one moved a total of 2 cm.

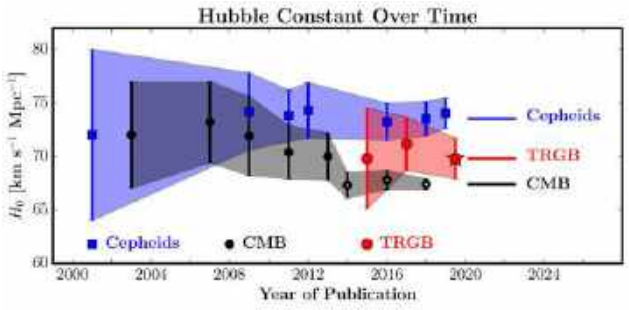
As you can see, our galaxy doesn't have some kind of special magical force that repels other galaxies, it is actually the universe itself that is expanding.

$$v = H_0 d$$

$v = recessional\ velocity\ of\ galaxy$
$H_0 = Hubble\ constant$
$d = distance\ to\ galaxy$

After this discovery Hubble went on to publish his famous law.

Which relates the distance of a galaxy from us, to its recessional velocity. The equation is fairly simple with one important component, the Hubble Constant or in other words the expansion rate of the universe.



During his research Hubble calculated the constant to be 500 km/s/Mpc, which was an extremely bad estimation. However, through years of research we were able to shrink down the uncertainty and find an accurate and precise answer. Well, to tell the truth we found two different precise answers.

The graph above shows how scientists were able to pinpoint the Hubble constant over the years. The blue region shows how the Cepheid star technique has become more precise over the years and the Black region shows how the cosmic microwave background method has become more precise over the years. Our technology has enabled us to make more and more precise measurements as time went on. However, the bad news is that different types of measurements (represented by different colours on the graph) gave different values for the Hubble constant. Obviously, teams from each method of measurement claim that their method is more accurate, which has divided the astronomical community and left scientists with no clear and true answer.

Overall, the Hubble constant is a great and exciting example of science. It was a great breakthrough many years ago and it is still an exciting mystery waiting to be discovered.

Eli Morhayim / 11

Works Cited:
https://www.britannica.com/science/Hubbles-constant
https://www.livescience.com/hubble-constant.html
https://www.scientificamerican.com/article/how-a-dispute-over-a-single-number-became-a-cosmological-crisis/
https://skyandtelescope.org/astronomy-news/tension-continues-hubble-constant/

The Life and Discovery of Cecilia Payne-Gaposchkin

Cecilia Payne-Gasposchkin was a British born, American astronomer and astrophysicist who suggested that the real composition of stars was mostly made of hydrogen and helium. Throughout her life, she has faced various challenges, mostly because of her gender, but she still managed to overcome those challenges and carry her discovery to the future. She was persistent, passionate about science and research, and followed her dreams against all odds. She is one of the greatest astronomers in history and her story is a very inspiring one.

Figure 1:
https://www.harvardmagazine.com/2020/05/feature-vita-cecila-payne-gaposchkin

Early Life and Education

Cecilia was born in Wendover, England as Cecilia Helena Payne in 1900. Cecilia's father died when she was four years old and her mother was forced to raise the family on her own. Her mother decided to move to London with Cecilia, when Cecilia was 12. She continued her education, which she had begun in her hometown Wendover, in London. Although her interest was in science, Cecilia Payne was also a talented musician like her father Edward John Payne. While she was attending St Paul's Girls' School, she was urged by Gustav Holst, who taught music at the school, to pursue a career in music, but she continued to focus on science.

Her brilliance and passion for science earned her a scholarship for college education. In 1919, she started her studies at the Newnham College which was one of just two colleges for women at the Cambridge University. She started her studies in botany but she was also very much interested in other sciences. A lecture by Arthur Eddington which she attended ignited her interest in astronomy. Later, she was able to meet Professor Eddington on an open night for the public held by the Cambridge Observatory. She told Professor Eddington about her interest in astronomy and that in fact she wanted to become an astronomer. Professor Eddington saw her potential, encouraged her ambition and invited her to use the Observatory's library, with access to all the latest astronomical journals. This was a turning point for Cecilia Payne and opened the world of astronomical research to her. However, astronomy was still seen as a branch of mathematics at that time and she was unable to change her major field of study to astronomy but she was done with botany. She changed her major to physics, with all the astronomy classes she could take on the side.

Unfortunately, being a woman was a major disadvantage in the academic world back then. Realizing that her only real career option in the United Kingdom was to become a teacher and there were more opportunities for a woman to work in astronomy in the United States than in Britain, Cecilia started looking for opportunities that would enable her to move to the United States. This is how she met Harlow Shapley, the new director of the Harvard College Observatory, who offered her a graduate fellowship where he had just established a

graduate program in astronomy. She became the second student to receive this fellowship. In 1923, she left England for the United States, where she made her discovery and lived for the rest of her life.

"The Most Brilliant PhD Thesis Ever Written in Astronomy"

So, what was her discovery? Cecilia discovered that the true composition of the Sun and all stars were similar and were mostly made of hydrogen and helium which was against the common scientific belief at the time. She owed her discovery to the science of spectroscopy, which is the study of spectra (light).

In order to understand how Cecilia made the discovery, we first have to talk about Electromagnetic radiation. Electromagnetic radiation is a form of energy that can travel in space and is present everywhere around us. It can take many forms such as radio waves, microwave, infrared light, visible light, ultraviolet, x-ray and gamma rays all of which are ordered according to their wavelengths in the Electromagnetic spectrum. The type of electromagnetic radiation that has the highest wavelength, will have the lowest energy; as the higher the frequency of the wavelength is, the more energy it will carry. Visible light, which is the spectrum of light that the naked human eye can see, is only a small part of the electromagnetic spectrum and astronomers generally use nanometers as the unit for measuring wavelength.

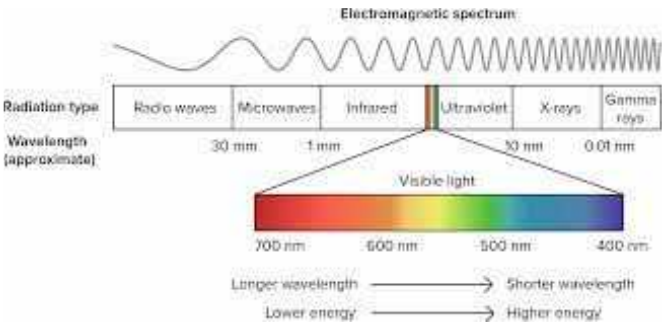


Figure 2:
https://www.pngkey.com/maxpic/u2t4r5w7r5w7t4r5/

The light (electromagnetic radiation) coming from a star, such as the Sun, can be used in order to learn about the elements forming that star. Throughout centuries, scientists have discovered various methods to examine these lights in order to better-understand the composition of the stars. The works of many scientists related to this field, such as the works of Kirchhof and Bunsen, has made it possible to identify the different elements by comparing their wavelengths to samples we have present on Earth. Thus, making it possible to analyze wavelengths of light (spectral lines) coming from stars and learn about their composition with the study of spectroscopy.

Moreover, the way these scientists were able to analyze the composition of stars was by looking at the absorption lines in their light spectrum. These absorption lines are the result of various elements, present in the composition of stars, that absorb different wavelengths of light. By comparing these lines, present in some wavelengths, to the lines that different elements caused, which was observed in a laboratory setting, scientists were able to make accurate guesses about the composition of stars. At the time, these studies revealed that the elements found in the composition of a star were the same as or similar to the elements that make up the Earth's crust, with similar percentages. Hence, scientists assumed that most stars were made up of heavy elements such as iron.

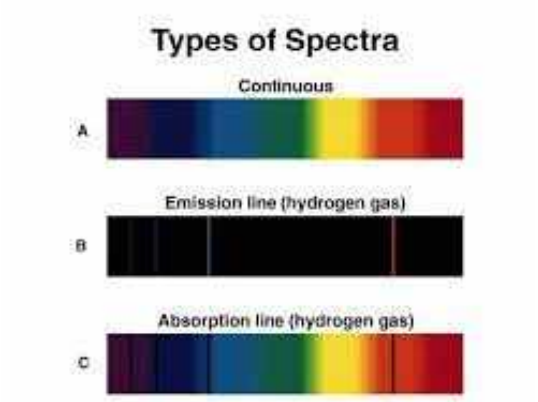


Figure 3:
https://slidetodoc.com/chapter-4-spectroscopy-kirchhoffs-first-law-t-hot/

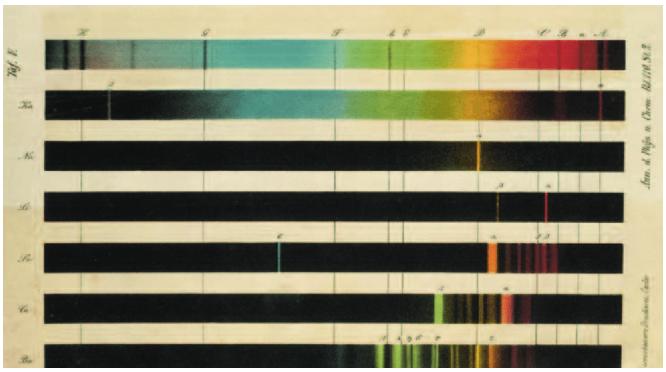


Figure 4:
https://www.researchgate.net/figure/color-plate-from-Bunsen-Kirchhoff-1860-p-of-a-limited-selection-of-characteristic_fig2_283149401

Harvard College had a relatively long history of working on stellar spectra and by the time Cecilia Payne arrived for her studies, they most probably had the World's largest archive on this topic. The stars were classified into seven types according to their spectra: O, B, A, F, G, K and M; with O being the hottest and M being the coolest. Here, Cecilia Payne immediately began working on her Ph. D. thesis about stellar spectra, for which she used the work of an Indian astrophysicist Meghnad Saha. Meghnad Saha had developed an equation, called the Saha equation, that could be used in order to calculate the ionization levels of the elements forming a star and Saha's work helped Cecilia develop a different understanding about stars.

Cecilia came up with the idea that the variation in stellar spectra was not due to different amounts of the elements, but it was rather due to the different ionization levels of the atoms in a star and also the different surface temperatures of the stars. According to her calculations, the composition of elements in different kinds of stars were nearly the same and they were abundant in hydrogen and helium rather than heavy metals. Thus, as most of the mass of the universe consisted of stars, the majority of the mass of the universe consisted of these two lightest elements, hydrogen and helium; and other elements only took up a small portion of the total mass.

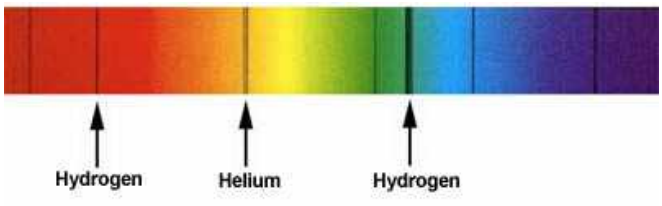


Figure 5:
https://www.saburchill.com/HOS/astronomy/028.html

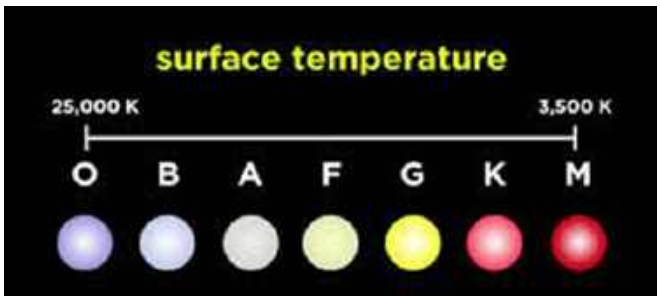


Figure 6:
https://www.youtube.com/watch?v=Y5VU3Mp6abI

However, sadly, Payne's calculations and conclusion were shocking to the scientific community at that time, since it was still commonly believed that the composition of the stars were similar to Earth, consisting of heavier elements. Professor Henry Norris Russell at Princeton who was a leading academician of the field, claimed that Cecilia's results were "clearly impossible.". Unfortunately, Cecilia, who needed to protect her career especially as a woman in academic life, was forced to insert a statement in her thesis that said her calculations were "almost certainly not real."

On the other hand, even though these various challenges, Cecilia was able to receive her Ph.D. But as Harvard did not grant doctoral degrees to women, Payne received her first Ph.D. in astronomy from Radcliffe College for her thesis, "Stellar Atmospheres: A contribution to the observational study of high temperature in the reversing layers of stars". Later on, her thesis would be defined by many scientists as ***"The Most Brilliant PhD Thesis Ever Written in Astronomy".*** In the following years she published her thesis as a book "Stellar Atmospheres" and within a few years it was understood that her calculations and conclusion were correct. Professor Russell also reached the same results in 1929.

The Passion for Research

Unfortunately, although Payne worked as a professor, meaning she had undertaken all the duties of one like lecturing, conducting research and advising students, she was not appointed as one. Harlow Shapley also thought that she deserved to be appointed as a professor but the University did not give academic positions to women and they were very strict about that policy. Thus, Cecilia was working as a technical assistant to the director of the observatory and was paid a low salary.

On the other hand, Cecilia was not a person who would easily give up. With great passion and persistence, she continued her studies facing all kinds of challenges. She wrote and published several books and in 1938, she was appointed as the Philips Astronomer, an officer of Harvard. Whereas, Harlow Shapley had to convince the University administration that her appointment as the Philips Astronomer would not make her a member of the college faculty. Although she was named a lecturer in astronomy and taught courses, those courses were not listed in the Harvard catalog for many years. Finally, in 1956 Cecilia Payne became a full professor and first woman Chair of the Department of Astronomy, where she continued to publish and wrote several other books.

In 1976, the American Astronomical Society awarded her the prestigious Henry Norris Russell Prize. In her acceptance speech, she spoke of her lifelong passion for research and said; "The reward of the young scientist is the emotional thrill of being the first person in the history of the world to see something or understand something. Nothing can compare with that experience."

Arda Deniz Altınok / 9

Resources and References:

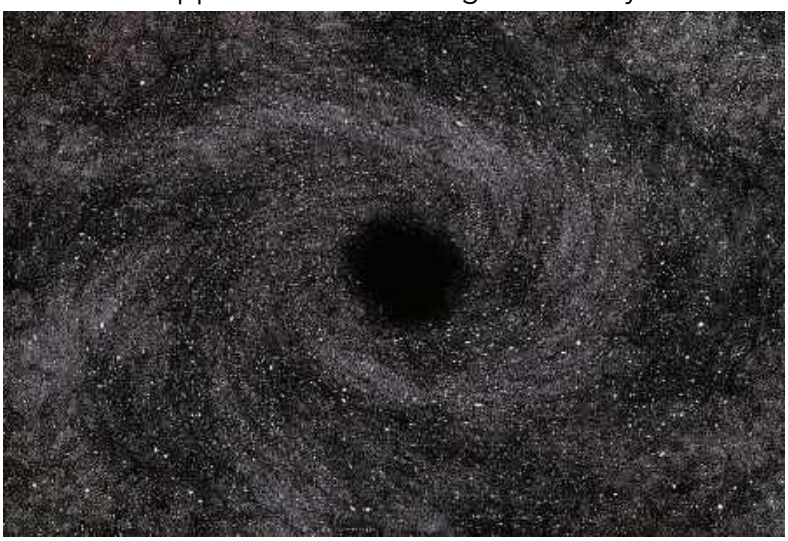
• "Cecilia Payne-Gaposchkin". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Cecilia_Payne-Gaposchkin. https://en.wikipedia.org/wiki/Cecilia_Payne-Gaposchkin
• "Edward John Payne". En.Wikipedia.Org, 2020, https://en.wikipedia.org/wiki/Edward_John_Payne. https://en.wikipedia.org/wiki/Edward_John_Payne
• Gregersen, Erik. "Cecilia Payne-Gaposchkin". Encyclopedia Britannica, 3 Dec. 2020, https://www.britannica.com/biography/Cecilia-Payne-Gaposchkin. Accessed 3 March 2021. https://www.britannica.com/biography/Cecilia-Payne-Gaposchkin
• Soter, Steven, and Neil deGrasse Tyson. "Cecilia Payne: Discoverer Of The Chemical Makeup Of Stars | AMNH". American Museum Of Natural History, https://www.amnh.org/learn-teach/curriculum-collections/cosmic-horizons-book/cecilia-payne-profile. https://www.amnh.org/learn-teach/curriculum-collections/cosmic-horizons-book/cecilia-payne-profile
• Observatory, Goodsell. "Cecilia Payne-Gaposchkin - Carleton College". Carleton.Edu, 2020, https://www.carleton.edu/goodsell/research/student-research/women/payne/. https://www.carleton.edu/goodsell/research/student-research/women/payne/
• Davy, Amy. "Cecilia Payne: 'A Rebel Against The Feminine Role' - Science Museum Blog". Science Museum Blog, 2018, https://blog.sciencemuseum.org.uk/cecilia-payne-a-rebel-against-the-feminine-role/. https://blog.sciencemuseum.org.uk/cecilia-payne-a-rebel-against-the-feminine-role/
• Moore, Donovan. "Cecilia Payne-Gaposchkin: The First To Describe What Stars Are Made Of". BBC Science Focus Magazine, 2020, https://www.sciencefocus.com/space/cecilia-payne-gaposchkin-the-first-to-describe-what-stars-are-made-of/. https://www.sciencefocus.com/space/cecilia-payne-gaposchkin-the-first-to-describe-what-stars-are-made-of/
• Williams, Richard. "This Month In Physics History". Aps.Org, 2015, https://www.aps.org/publications/apsnews/201501/physicshistory.cfm. https://www.aps.org/publications/apsnews/201501/physicshistory.cfm
• "Payne-Gaposchkin, Cecilia (1900-1980) | Harvard Square Library". Harvardsquarelibrary.Org, https://www.harvardsquarelibrary.org/biographies/cecilia-payne-gaposchkin-3/. https://www.harvardsquarelibrary.org/biographies/cecilia-payne-gaposchkin-3/
• "Stellar Classification". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Stellar_classification. https://en.wikipedia.org/wiki/Stellar_classification
• "Astronomical Spectroscopy". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Astronomical_spectroscopy#stellar_spectrum. https://en.wikipedia.org/wiki/Astronomical_spectroscopy#stellar_spectrum
• "Fraunhofer Lines". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Fraunhofer_lines. https://en.wikipedia.org/wiki/Fraunhofer_lines
• "Spectral Line". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Spectral_line. https://en.wikipedia.org/wiki/Spectral_line
• "Meghnad Saha". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Meghnad_Saha. https://en.wikipedia.org/wiki/Meghnad_Saha
• "Ionization". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Ionization. https://en.wikipedia.org/wiki/Ionization
• Nagaraja, Mamta Patel. "Introduction To The Electromagnetic Spectrum | Science Mission Directorate". Science.Nasa.Gov, 2021, https://science.nasa.gov/ems/01_intro. https://science.nasa.gov/ems/01_intro
• Mattson, Barbara, and Phil Newman. "Electromagnetic Spectrum - Introduction". Imagine.Gsfc.Nasa.Gov, 2014, https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html. https://imagine.gsfc.nasa.gov/science/toolbox/emspectrum1.html
• Lucas, Jim. "What Is Electromagnetic Radiation? | Live Science". Livescience.Com, 2015, https://www.livescience.com/38169-electromagnetism.html. https://www.livescience.com/38169-electromagnetism.html
• Britannica, The Editors of Encyclopaedia. "Spectrum". Encyclopedia Britannica, 20 Jul. 1998, https://www.britannica.com/science/spectrum. Accessed 4 March 2021. https://www.britannica.com/science/spectrum
• "Spectroscopy". En.Wikipedia.Org, 2021, https://en.wikipedia.org/wiki/Spectroscopy. https://en.wikipedia.org/wiki/Spectroscopy

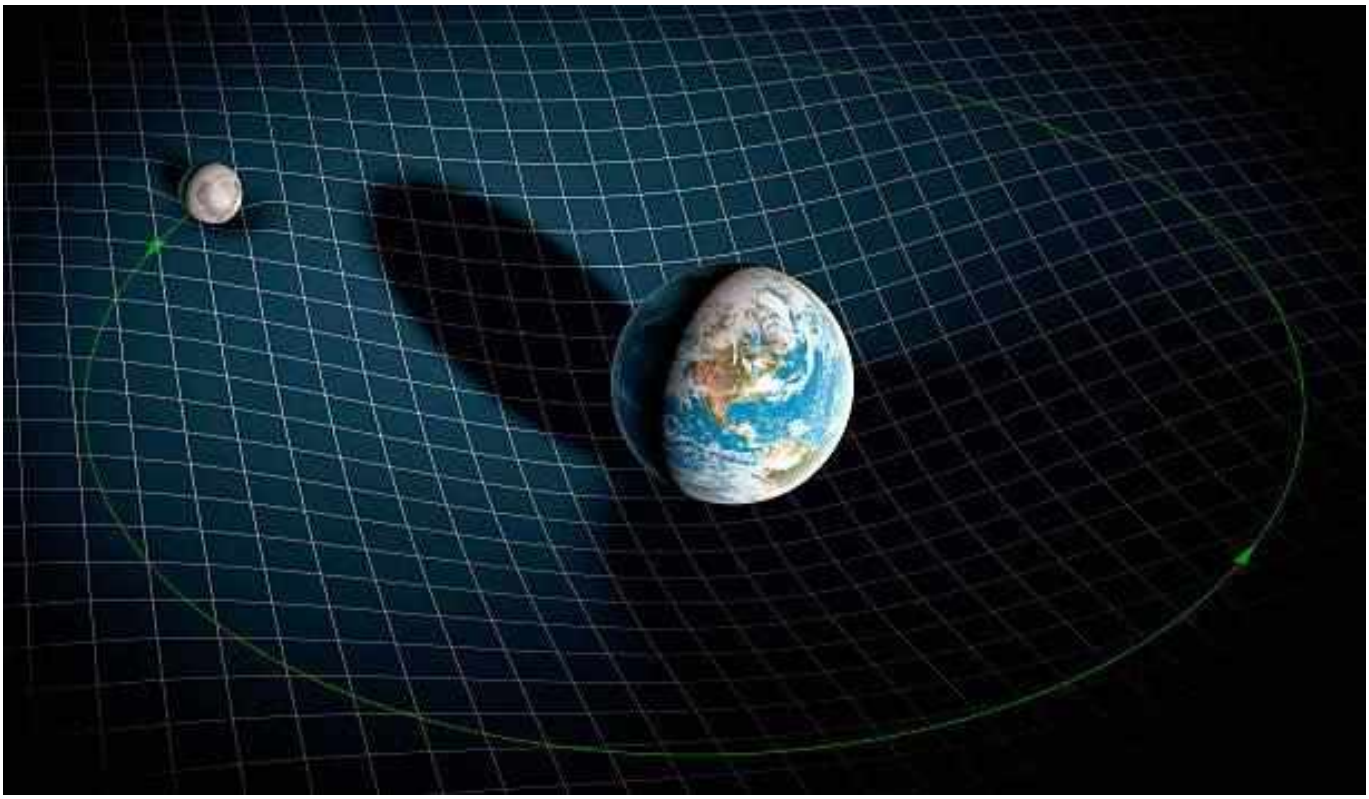
The Mystery of the Order in the Universe

Have you ever looked upon the sky on a cloudless night and wondered how all stars and planets stay on the very spot, away from Earth? Or have you ever thought about the logic beyond the term "gravitation", that we all are familiar with from our schools? All of these questions, this mystery can be answered by a single term that Newton came up with under an apple tree: "gravity".

There is an order in the universe, everything goes according to this order. Galaxies consist of millions of planets, meteoroids, and stars all around the universe. Each one of them has its path. In other words, the universe is a marathon that has millions of participants who are in continuous motion. At this point, everything seems crystal clear however mankind could not resist the charm of questioning and discovered the reason for this continuous motion; gravity. As for lexical meaning, gravity is "the force that attracts a body towards the centre of the earth, or towards any other physical body having mass." In other words, everything that possesses a mass experiences a potential gravitational force. For example, there is a gravity force between me and the computer that I am currently using. There is also a gravity force between planets which explains the logic behind galaxies. As you all can reckon, most of the galaxies have a central star or Supermassive blackhole that all objects revolve around. In our Solar System, it is the Sun for example. All planets, Earth, Mars, revolve around the Sun continuously. That is a consequence of gravitational force between the Sun and other planets. But why cannot Earth or other planets be the center instead of the Sun? Why does the Sun take hold of all planets? At this exact point, Newton's gravitational law steps in.

Newton's gravitational law is a revolution for physics. It states that every particle in the universe attracts every other particle with a force. This force is directly proportional to the multiple of their masses and inversely proportional to the square of the distance between their centers. It is denoted as $F= G \times \frac{m1 \times m2}{r^2}$, where G symbolizes the gravitational constant, the universal constant used while calculating the attraction between two masses. In other words, as the masses of the particles increase, gravitational force increases, and as the distance between them increases gravitational force decreases. To observe this change, this force needs to be high. For example, we are not able to observe the force between us and a pencil since the masses are too low for a visible change. Considering the constant value of G, which is 6.67×10^{-11}, it can be concluded that the mass of at least one object needs to be too high in order to observe a change by bare eyes. To exemplify, we can observe the force between a pencil and the earth when the pencil is dropped from a desk. It goes directly to the





floor and we call this the effect of gravitation. You cannot observe this change in space because the force in space is much less compared to this one since the distance between the pencil and a great mass in space is too much. Thus, we can conclude that the force on pencil and earth are the same but Earth does not move because of its inertia.

Now, there is a question that I haven't answered up to that point: Which factor decides the direction of this force? The answer is simple as it is typed: mass. The higher mass object establishes supremacy over another one which ends up as the less mass object rotating around the other. The main reason that the higher mass object stays still can be explained by the formula F=ma, which shows the inverse proportion between mass and acceleration. Thus, higher mass causes lower acceleration. This explains the reason for the Sun being the center of our galaxy.

In conclusion, gravity has a crucial role in the order of this endless mystery. There may be lots of things that we have not discovered in the universe but thanks to Newton, we know one thing for sure; gravitational force constitutes the base of the universe

Ardıl ÖRÇEN / 10

References:
• https://tr.wikipedia.org/wiki/K%C3%BCtle%C3%A7ekim
• https://tr.wikipedia.org/wiki/Newton%27un_evrensel_k%C3%BCtle%C3%A7ekim_yasas%C4%B1
• https://evrimagaci.org/kutlecekimi-nedir-cisimler-birbirlerini-nasil-cekiyor-9642
• https://i.dailymail.co.uk/i/pix/2015/11/06/15/2DEA777D00000578-3306656-A_new_study_challenges_the_Nice_Model_according_to_which_the_Sol-a-7_1446822659335.jpg
https://media.gettyimages.com/illustrations/earthmoon-system-in-spacetime-illustration-id685024439?k=6&m=685024439&s=612x612&w=0&h=KPIz6JGFminsFes3hmSJUEC2WHN4Z8D1LW5mRRhpeUI=
• https://media.gettyimages.com/photos/black-hole-digital-illustration-picture-id520217044?k=6&m=520217044&s=612x612&w=0&h=dZQn6MD1OnCG1BkhMugxwX6rirhkNlpIYn5KpzvY1eg=

Heat Engines and Thermodynamic Cycles

To understand the process under our cars' hood or inside mega turbines we should be looking at heat engine concepts such as Carnot Heat Engine. Before that let's begin with some primary knowledge.

Thermodynamics is a branch of physics that is concerned with the relationship between heat, work, temperature, and energy. First trials to understand the relationship between these terms began with the work of Robert Boyle and Robert Hooke about pressure-volume correlation in 1656. Works of other scientists like Gay-Lussac have continued and accelerated with the invention of the thermometer in the 17th century. During the 18th century, different engines such as the Newcomen engine and Watt engine were used. Affected by those engine designs, Sadi Carnot, who is regarded as the founding father of thermodynamics, published his book "Reflections on the Motive Power of Fire" in 1824, marking the beginning of thermodynamics as a modern discipline.

Laws of Thermodynamics

The First Law of Thermodynamics explains the change in internal energy (temperature) and work done by the system. (positive work)

The first law is based on the conservation of energy in heat and thermodynamics. Conservation of energy states that the energy in a system remains constant. For example, a powerplant burning coal to produce electricity uses this law while converting heat into electric energy and conserving the total energy.

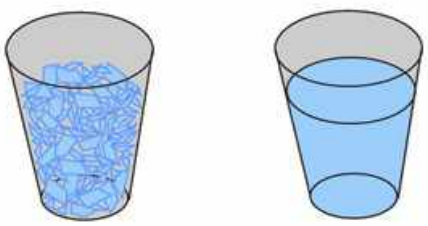
The change in internal energy of a system is equal to the heat added to the system minus the work done by the system.

$$\Delta U = Q - W$$

Change in internal energy — Heat added to the system — Work done by the system

The Second Law of Thermodynamics is about the direction of spontaneous processes, the entropy of the system. In nature, entropy tends to remain the same or increase. The change in entropy ΔSis equal to the heat transfer ΔQdivided by the temperature T. While in reversible processes final entropy is equal to initial entropy, in irreversible processes final entropy is bigger than initial. Moreover, it defines the maximum amount of efficiency in an engine.

The universe tends to create chaos with entropy. For example, as you know a glass of water is more disordered than a glass of ice cubes since a liquid is more disordered compared to a solid. A glass of ice tends to melt and become a liquid in nature. This can be thought of as an example of an entropy increase in nature.

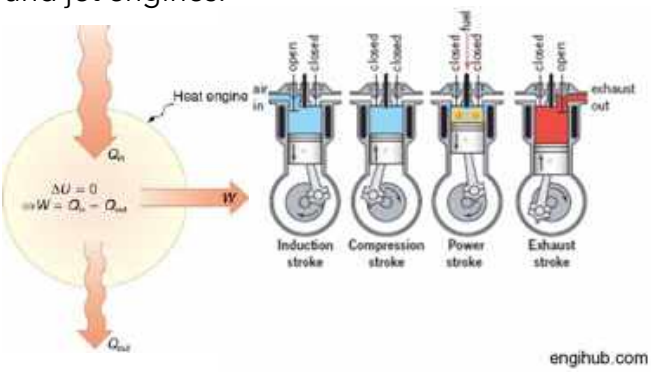


WHICH IS MORE DISORDERED?
THE GLASS OF ICE CHIPS OR
THE GLASS OF WATER

Definition of Heat Engine and PV Diagrams

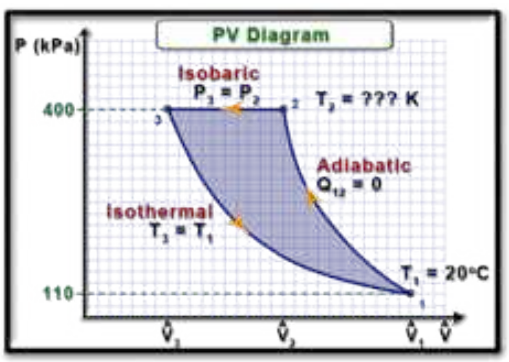
Heat engines are machines that use heat to do work according to the laws of thermodynamics. So, heat engines convert thermal energy to mechanical energy. These engines are now

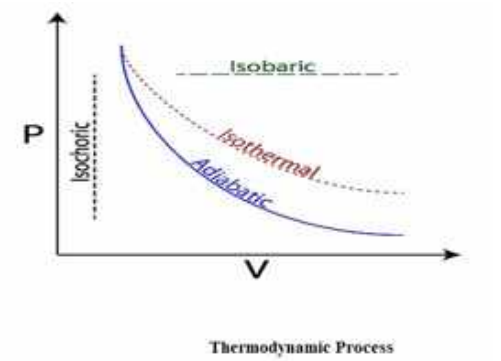
used in a variety of applications such as gasoline and diesel engines, steam turbines, and jet engines.



Heat engines are usually illustrated on a PV diagram. These diagrams include various engine cycles that made up the process of work done in the engine. It is important to know the concept behind the P-V diagrams since they visualize the thermodynamic cycles in an engine while it is working.

These diagrams can include four processes: isothermal, isobaric, isochoric, adiabatic.
Isothermal: Constant Temperature, Q is used for W
Isobaric: Constant Pressure W=P×ΔV
Isochoric: Constant Volume W=0
Adiabatic: No Heat Transfer Q=0, rapid reaction





Thermodynamic Process

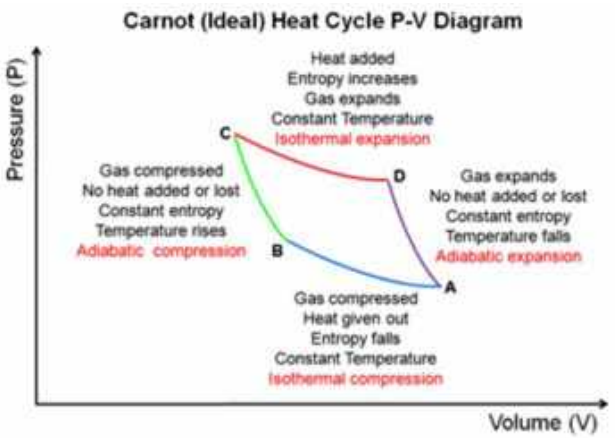
For example, the most efficient engine, the Carnot heat engine, includes isothermal and isentropic (reversible adiabatic) cycles. The P-V diagrams are close loops. The area inside the loop represents the amount of work done.

Carnot Heat Engine

Idealized by Sadi Carnot, Carnot Heat Engine is the most efficient engine. In order to approach the Carnot efficiency, the processes involved in the heat engine cycle must be reversible and involve no change in entropy. This means that the Carnot cycle is an idealization since no real engine processes are reversible and all real physical processes involve some increase in entropy.

For example, the most efficient four-stroke diesel engine, Wartsila-Sulzer RTA 96-C, has an efficiency of over 50%. Moreover, gas turbines are also efficient engines with efficiency up to 61% by General Electric. In contrast, most piston engines have a range of 20% to 30% efficiency.

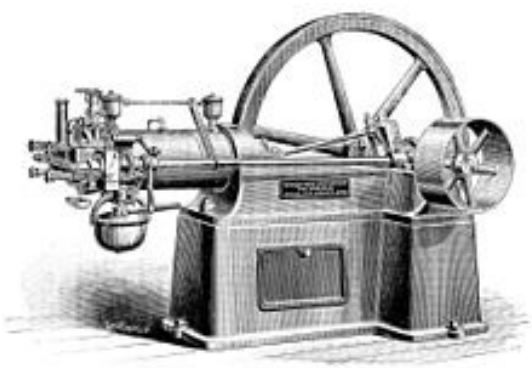
Carnot Engine is composed of two isothermal and two adiabatic processes. In the first process, isothermal expansion of gas takes place. The gas does work on the surrounding while the temperature is kept constant. Then, in a reversible adiabatic process thermal insulation is present, avoiding any heat transfer from outside. The gas expands by doing work on surroundings, while cooling. After the adiabatic process, another isothermal process happens. In this case, the surroundings do work on gas. The gas is further compressed in the last process of adiabatic.



Other Examples of Heat Engines

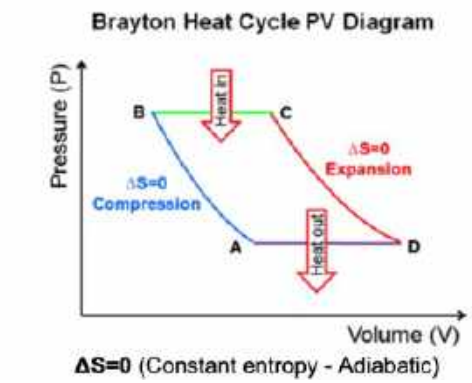
Otto Cycle

Otto Cycle is a cycle used in four-stroke engines which run our cars. The first person to build a working four-stroke engine, a stationary engine using a coal gas-air mixture for fuel, was German engineer Nicolaus Otto. Today the four-stroke principle is commonly known as the Otto cycle and four-stroke engines using spark plugs often are called Otto engines.
It is related to the ideal gas law that is PV=nkT, where P is pressure, V is volume, n is a number of moles of gas, k is Boltzman constant and T is temperature. In a car engine, the fuel enters the cylinder, and then it is adiabatically compressed. Adiabatic compression results in the volume decrease while the pressure and temperature increase. When compression is complete, the spark plugs ignite the fuel, which then increases the temperature and pressure at a constant volume. Power stroke, which makes the gas expand adiabatically, results in a sudden drop in the pressure and temperature. This reaction is the source of power that runs our cars. Finally, exhaust fumes are released, decreasing the pressure and starting the cycle with new fuel.



Brayton Cycle

Brayton Cycle is named after American engineer George Brayton. Although it was first used in Brayton Piston Engine, now it is used in the explanation of gas turbine cycles. Gas turbine engines create power from burning fuel in a combustion chamber and using the fast-flowing combustion gases to drive a turbine-like the high-pressure steam drives a steam turbine. Brayton Cycle begins with adiabatic compression. In adiabatic compression, the air is drawn into the turbine and compressed in the compressor stage. Secondly, isobaric ignition takes place in which fuel is mixed with the high-pressure air and burned at constant pressure. In adiabatic expansion hot gases expand in the turbine stages. In isobaric exhaust, hot gases are ejected into the environment.



Stirling Engine

The Stirling engine was invented in 1816 by Robert Stirling who sought to create an alternative to the steam engines due to the fact that boilers of steam engines often exploded due to the high steam pressures used. It was a closed-cycle external combustion engine just like the Carnot Engine. The working principle of the Stirling Engine was based on Charles' Law which states the relationship between volume and temperature.

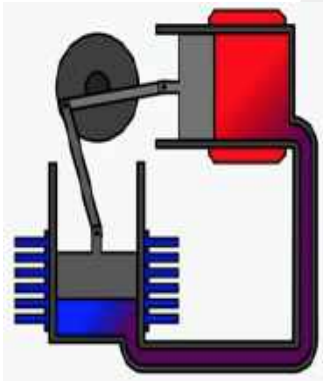
Heat Engine Processes Summary

Combustion Type	Cycle/Process	Compression	Heat Addition	Expansion	Heat Rejection
External Combustion (Closed Cycle)	Carnot	isentropic	isothermal	isentropic	isothermal
	Stirling	isothermal	isometric	isothermal	isometric
	Ericsson	isothermal	isobaric	isothermal	isobaric
	Rankine (Steam)	adiabatic	isobaric	adiabatic	isobaric
	Stoddard	adiabatic	isobaric	adiabatic	isobaric
Internal Combustion (Open Cycle)	Lenoir	none	isometric	isentropic	isobaric
	Otto (Petrol)	adiabatic	isometric	adiabatic	isometric
	Atkinson	adiabatic	isometric	adiabatic	isometric
	Miller	adiabatic	isometric	adiabatic	isometric
	Diesel	adiabatic	isobaric	adiabatic	isometric
	Brayton (Jet)	adiabatic	isobaric	adiabatic	isobaric

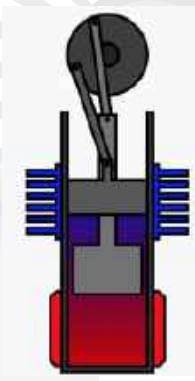
There are 3 major configurations of Stirling Engine: Alpha, Beta, Gamma. In general, the working principle of the Stirling Engine is based on the volume increase and decrease of the gas, which is held in a variable volume container and constructed from a movable piston in a cylinder closed at one end. This fluctuation in volume will cause the piston to move out and in. Repeated heating and cooling will cause a reciprocating movement of the piston. This movement can be converted to rotary motion using a conventional connecting rod and a crankshaft.

Emir Erman / 11

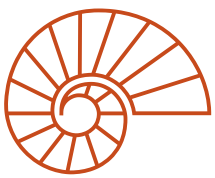
Alpha



Beta



References:
• Engineering Insider, https://engineeringinsider.org/otto-cycle-processes/
• Florida Tech News, https://news.fit.edu/archive/thermodynamics-scenes/
• Mpoweruk, https://www.mpoweruk.com/heat_engines.htm
• Wikipedia
• Hyperphysics, http://hyperphysics.phy-astr.gsu.edu/hbase/heacon.html#heacon
• Nasa, https://www.grc.nasa.gov/www/k-12/airplane/thermo2.html
• LibreTexts Chemistry, https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_
• Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Thermodynamics/Thermodynamic_Cycles/Carnot_Cycle
• Texas Gateway, https://www.texasgateway.org/resource/152-first-law-thermodynamics-and-some-simple-processes



KOÇ OKULU
İLK · ORTA · LİSE

VKV Koç Özel İlkokulu, Ortaokulu ve Lisesi
Tepeören Mahallesi Eski Ankara Asfaltı Caddesi
No: 60 Tuzla 34941 İstanbul, Türkiye
www.koc.k12.tr

Vehbi Koç Vakfı