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Chemical Education

ICE-9: Nobel Prizes in 2020

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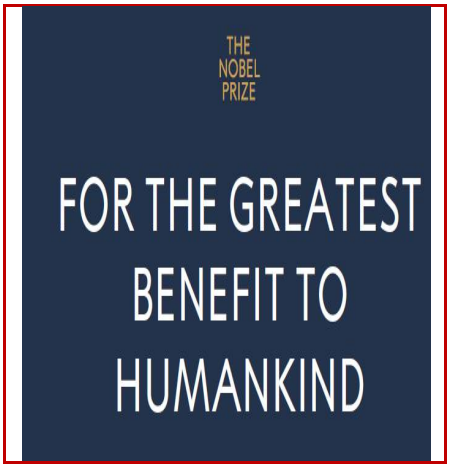
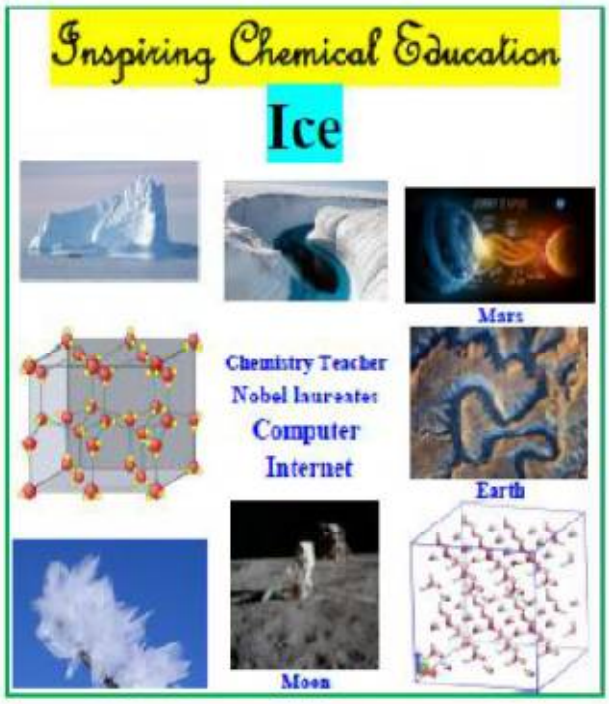


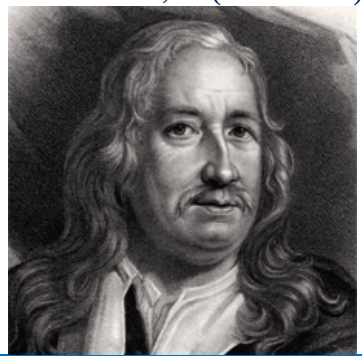


Alfred (Bernhard) Nobel was born on October 21, 1833 in Stockholm, Sweden. His father, Immanuel Nobel was an inventor/engineer and his mother Carolina Andriette (Ahlsell) Nobel (1805-1889) was a homemaker. During though time (1938-1942) (when Immanuel was trying to start a new life in Finland and Russia after bankruptcy) she earned modest amounts for herself and children by running a milk and vegetable shop. Andriette was very close to her son Alfred and was very supportive of her husband.

In seventeenth century, Sweden was a great power in northern Europe. Alfred's family descended from Olof Rudbeck, the best-known technical genius in Sweden.

Dr. Nobel was a chemist, engineer, scientist, technocrat, entrepreneur and philanthropist of nineteenth century. He was fluent in several languages; wrote poetry and drama. Nobel was also very much interested in social and peace-related issues. Some of his views were considered radical at that time.

Dr. Nobel invented powerful explosives including dynamite and bagged around 350 patents of different countries. Alfred Nobel signed his last will in Paris on November 27, 1895, instituting prizes to honor men and women from all over the world. He set apart 31 million SEK (about $250 million dollars, adjusted to inflation in 2020) from his personal resources for the awards.

Olof Rudbeck, Sr (1630–1702)	Olof Rudbeck d.y. (1660–1740)
	
Ancestors	
Carolina Andriette (Ahlsell)	Immanuel Nobel
	
Mother	Father

Alfred Nobel at a young age in the 1850s

- Contentment is the only real wealth
- Home is where I work and I work everywhere
- Hope is nature's veil for hiding truth's nakedness

Nobel Awards for Human achievement (Ha!): The awards introduced by Alfred Nobel are known as 'Nobel prizes' and the person received the prize is called a 'Nobel Laureate' from then onwards. Three Nobel awards are in basic sciences viz. Physics, Chemistry and Physiology or Medicine. Fourth and fifth prizes are for Literature and peace. These five awards have been given since 1901 to individuals or organizations for contributions for 'Greatest benefit to Humankind'. The institutions responsible for modes operandi of the prizes are: The Royal Swedish Academy of Sciences for the Nobel Prize in Physics and Chemistry, Karolinska Institute for the Nobel Prize in Physiology or Medicine, the Swedish Academy for the Nobel Prize in Literature.

And a Committee of five persons elected by the Norwegian Parliament looks after the Nobel Peace Prize.

Nobel Prize in Economics: In 1968, Nobel Prize in Economic Sciences, in Memory of Alfred Nobel, was established by a donation from Sweden's central bank Sveriges Riksbank. The donation was in commemoration of the 300th anniversary of the bank. Nobel Foundation itself undertakes all chores of administration and refereeing process. Laureates had been receiving the awards since 1969 at the same ceremony.

One award is conferred annually in each of the said disciplines to one person or shared among not more than three living recipients or organization (WFP, OPCW, Grameen Bank, Red Cross, UNICEF...) for the contributions which led to benefit humankind. The prize carries a Gold medal, diploma and monetary award (10,000,000 SEK, or US$ 1,145,000). The celebration of event, in December of every year, comprises of Nobel lecture, banquet party organized by Swedish academy (Sweden) in presence of Prince of the country. The award continues to be the most coveted, prestigious and honorable. They are indicators of recognition for achievements (and subsequent applications) of single-minded/dedicated individuals' sustained efforts with perseverance in seeking truth or nature of nature leaving aside all aspirations for spontaneous/short-term targets. It is the cumulative outcome of group members/ collaborators spanning many calendar years.

2020 Nobel Prizes: In 2020, eight scientists, two social scientists (seven men and three women), one organization and one linguist (woman) won Nobel Prizes under the six categories. The awards are in commemoration with their contributions that led to the greatest benefit to humankind. The core topics which won Nobel prizes this year are Einstein's theory of relativity and black holes, presence of super massive black hole at the center of our milky way (galaxy), CRISPER/cas9 genetic scissors in genetic editing/engineering, discovery of Hepatitis C virus cause of cirrhosis/liver cancer in humans, eradicating hunger from world in poor population, poetic voice with austere beauty, and new formats/theories in auctions benefitting seller, buyer and tax payers.

Tables 1 to 6 incorporate the focal theme of awardees' contribution, country/year of birth of Nobel laureates, affiliation to institute/employer at the time of announcement of award and share of award. The recorded first responses of recipients of Noble prize when informed of the award are in Supplementary information (SI-1). It is extracted from achieve records of the telephonic conversation of Adam Smith (Chief Scientific Officer of Nobel Media, Sweden) with the Laureates. SI-2 incorporates Noble words of Noble Laureates of the year 2020. SI.3 describes black holes and SI.4 show portraits of Einstein.

Nobel Prizes in Physics 2020

Roger Penrose was awarded one-half-of-2020-Nobel Prize in Physics for the theoretical proof of formation of black holes. It is established as a consequence of Einstein's general theory of relativity. The other-half of the noble prize is shared by Reinhard Genzel and Andrea Ghez for their decadal pursuit of high-end-experiments with state-of-art-telescopes in discovering invisible and extremely heavy object (supermassive black hole) at the centre of our galaxy (milky way) which governs the orbits of stars. Andrea Ghez is the fourth woman to win a Nobel Prize Physics and 38th MIT graduate becoming a Nobel Laureate.

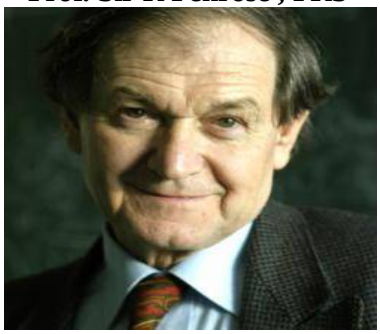
Einstein era: The general theory of relativity of Einstein propounded November 1915 is a landmark contribution in modern physics.

+ Provided an entirely new foundation for understanding gravity
+ It upended all the previous concepts of space and time
+ This theory has provided the basis for all studies of the universe
+ Has a practical use in one of our most common navigation tools, the GPS

Einstein thought that black holes could not actually exist. He was also under the impression that even gravitational waves may not be detected experimentally due to their weak nature of signal

Supermassive black hole says "listen to Albert."
Inner shadow has reaffirmed Einstein's theory of gravity; (Image: © EHT Collaboration)

Table 1.1 Focal theme (a) of Nobel Prize for Physics in 2020	
Discovery	o Black hole formation is a robust prediction of the general theory of relativity
Discipline	Relativistic Physics; Cosmology; Astronomy

Affiliation	Nobel Laureate (Physics) Photo, Date & place of birth	Share
University of Oxford, Oxford, United Kingdom	**Prof. Sir R Penrose , FRS**  1931 Colchester, United Kingdom	1/2

Roger Penrose era: In nineteen sixties, Roger Penrose, British mathematician and theorist, brought forth ingenious mathematical methods to probe into Albert Einstein's general theory of relativity (GTR). Penrose proved theoretically that black holes are a consequence of this GTR or in other words, GTR leads to mysterious black holes. He proposed the concept of a trapped surface to describe a black hole.

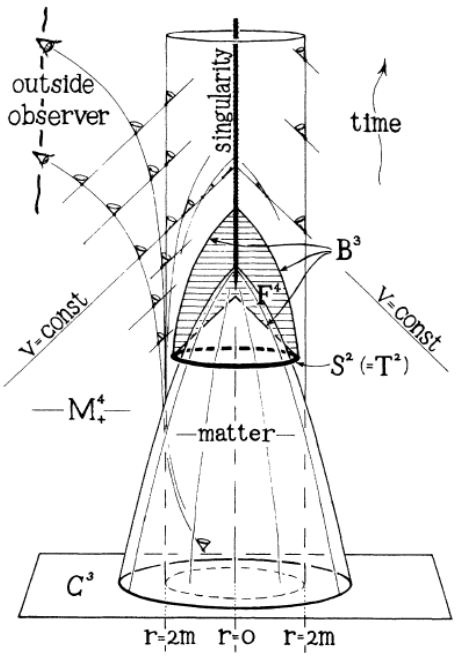
Penrose's ground-breaking article was published in January 1965 and is still regarded as the most important contribution to the general theory of relativity since Einstein.

Sparkle for proposal of trapped surface by Roger Penrose

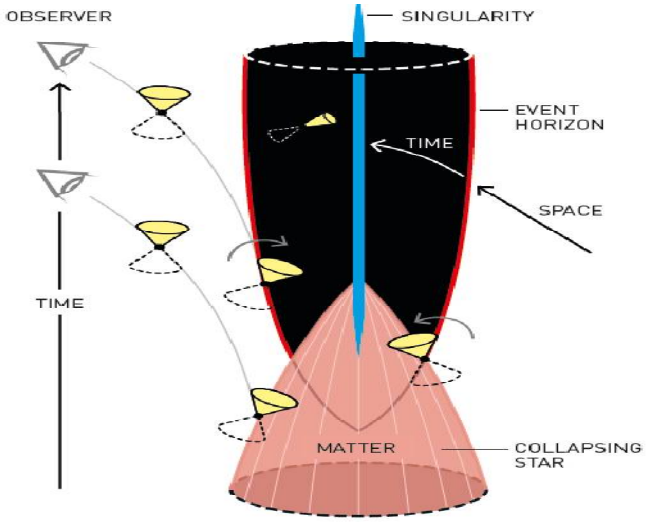
This idea sparkled to Penrose when was walking with his colleague on a day way back from college in the autumn of 1964. His friend was talkative and was continuously speaking to him. But, when they were crossing road, suddenly his friend stopped talking and then went away to a side street to reach his abode. Something flashed in the brain of Penrose and that after noon he went to his office and searched for it in his memory. This idea, he called trapped surface and used in mathematical tool (jargon) of black holes. He felt that it was what he was unconsciously looking for in a concrete usable format.

Astrophysics back ground: By 1960s, it was established that Sagittarius A* is at the centre of the Milky Way, our galaxy. All stars in the galaxy orbit around it. More deep and intense investigations started in 1990s when larger telescopes, advanced instrumentation and modern communication technology were accessible to elite scientists. The orbits of the brightest stars closest to the middle of the Milky Way have been mapped with increasing precision.

Theoretical conceptualisation of black holes



Spherically symmetrical collapse



- The light cone shows the paths of the light rays forward and backward in time
- When matter collapses and forms a black hole, the light cones that cross the black hole's event horizon will turn inward, toward the singularity.
- An outside observer will never really see the light rays reach the event horizon, they just nudge it
- No one can see further

Roger Penrose,
Gravitational Collapse And Space- Time Singularities
Physical Review Letters,14(4)(1965) 57-59

Table 1.2 Focal theme (b) of Nobel Prize for Physics in 2020		
Discovery	! Supermassive compact object at the center of our galaxy	☞ Reinhard Genzel ☞ Andrea Ghez
Object_ achieved	! Most convincing evidence of Supermassive object ! Revealing stars in the center of our galaxy orbiting a black hole are too small to see with a telescope	

Affiliation	Nobel Laureate (Phys) Photo Date & place of birth	Share
🕮 University of California, Berkeley, CA, USA, 🕮 Max Planck Institute for Extraterrestrial Physics, Garching, Germany	Reinhard Genzel  24 March 1952, Bad Homburg vor der Höhe, Germany.	1/4
🕮 University of California, Los Angeles, CA, USA	Andrea Ghez  1965, New York, NY, USA	1/4

Reinhard Genzel and Andrea Ghez era: Reinhard Genzel (German astronomer) and Andrea Ghez (USA) each lead a group of astronomers since 1990s. Their research focus is on a region at the centre of the Milky Way which is shaped like a flat disc about 100,000 light years across. It consists of gas

and dust and a few hundred billion stars; one of these stars being our Sun. They continuously developed/refined the protocol of goals, technology, telescopes with more sensitive digital light sensors and better adaptive optics. The target was to attempt to see the heart of the Milky Way obscured by the dust clouds. Finally, they were able to more precisely determine the positions of the stars. This created a new window to follow them night by night and resolution of images improved thousandfold.

Objectives: To explore/characterize the extremely dynamic region at the galaxy's centre.

Stars to monitor: Almost for thirty years, these researchers tracked some thirty of the brightest stars in the multitude. The stars move most rapidly within a radius of one light-month from the centre, inside which they perform a busy dance like that of a swarm of bees.

One star, called S2 or S-O2, labelled as S2 by Genzel's group (called S02 by the team led by Ghez), has a very short orbiting period under 16 years around Sgr A*. These astronomers monitored and mapped its entire orbit.

State-of art instruments and inferencing tools

Telescopes: Reinhard Genzel and his group used Very Large Telescope (VLT) facility on Paranal mountain (also in Chile) in their perseverance research. Four giant telescopes in combination (each with a monolithic mirror of diameter of more than 8 meters) were the probes in this cosmological investigation. Andrea Ghez and her team of researchers employed telescopes containing mirrors that are almost 10 meters in diameter. Each mirror is like a honeycomb, consisting of 36 hexagonal segments which can be controlled separately. This enables one to better focus the starlight. This facility is in the Keck Observatory, located on the Hawaiian mountain of Mauna Kea.

Hexagonal-segmented 10-metre primary mirror of the Keck I telescope.

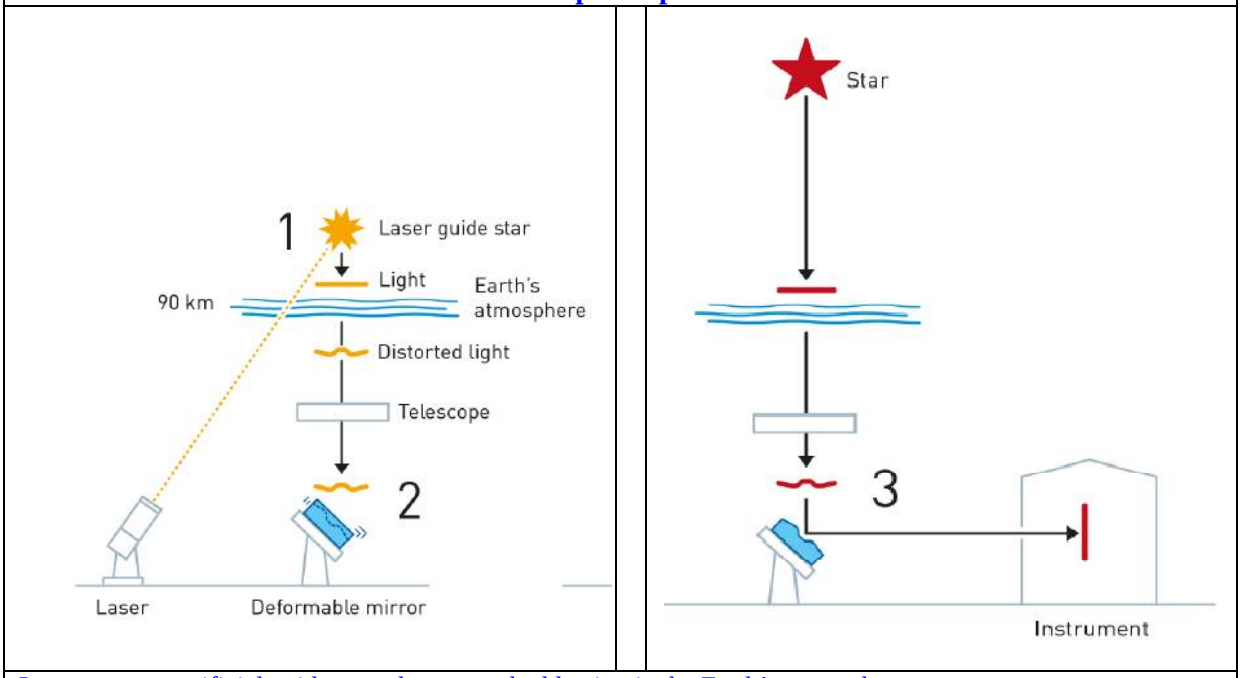
Aerial view of the Keck Observatory's twin domes; telescopes inside

NASA/JPL

- Mauna Kea Observatory, Mauna Kea, Hawaii, U.S.
- Bottom: Keck Observatory;
- Centre left: NASA Infrared Telescope Facility
- Top, from left to right: Canada-France-Hawaii Telescope, Gemini North telescope, University of Hawaii 2.2-metre telescope United Kingdom Infrared Telescope.

Adaptive optics: These researchers' improved/developed tools to perceive the processes around centre of the Milky Way obscured/distorted/blurred by the huge clouds of interstellar gas and dust. Bubbles of air which are colder or hotter than surroundings in the atmosphere function like lenses and thus refract light reaching telescope on surface of earth (land). With innovative/ingenuous methods, stretching the limits of technology, they realised procedures/ modules which compensate for distortions due to Earth's atmosphere. In this context, the advent of adaptive optics was a land mark in measurements nearer to true values, indispensable to their long-term high-end-research commitments. The telescopes are now equipped with a thin extra mirror that compensates for the air's turbulence and corrects the distorted image.

Adaptive optics



Laser system: artificial guide stars that sense the blurring in the Earth's atmosphere.

The images of the bright spots generated by the laser → used in a feedback loop

→ To introduce fast deformations of a secondary mirror →

Effectively correct for the atmospheric turbulence in the science images

Information: The independent measurements of these two groups agree excellently. The data ((swing of stars with such astonishing speeds) is analysed in the light of GTR.

Inference: The stars' orbit data unequivocally provide the most convincing evidence for the presence of a supermassive black hole at the heart of the Milky Way.

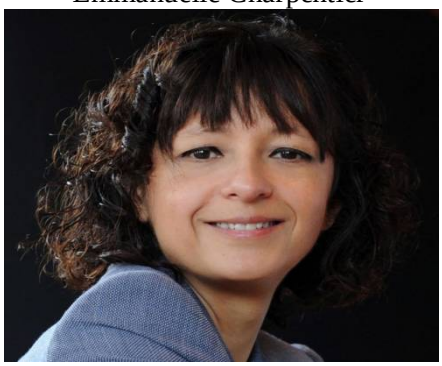
Nobel Prizes in Chemistry 2020

Earlier Landmarks: The molecular structure of DNA was reported in 1953 by J.D. Watson and F.H.C. Crick. In 1962, these scientists won Nobel Prize in Physiology or Medicine and since then interest in in-depth study of genetic material grew steadfast. The emerged science and technology were in the direction of genetic engineering for the benefit to mankind and also eco-balance.

Gene editing methods: The earlier producers for gene editing viz. Zinc-finger nucleases (ZFNs) and transcription activator-like effector nucleases (TALENs) are slower and laborious

Table 2.1 Focal theme of Nobel Prize for Chemistry in 2020				
Obj_achieved	! Method for genome editing		☞ Emmanuelle Charpentier ☞ Jennifer A. Doudna	

Necessity			**Benefit**	

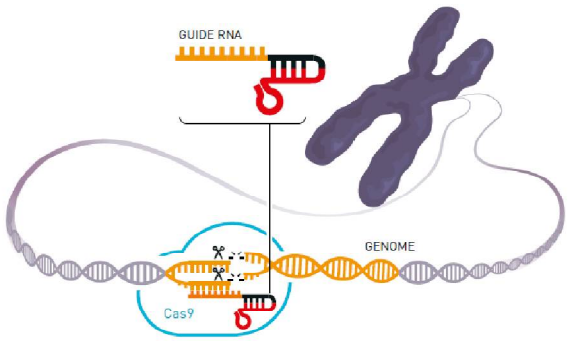
Affiliation	Nobel Laureate (Chem) Photo, Date & place of birth	Share
Max Planck Unit for the Science of Pathogens, Berlin, Germany 	Emmanuelle Charpentier  11 December 1968, Juvisy-sur-Orge, France	1/2

Affiliation	Nobel Laureate (Chem) Photo, Date & place of birth	Share
University of California, Berkeley, CA, USA	Jennifer A. Doudna  19 February 1964, Washington, DC, USA	1/2

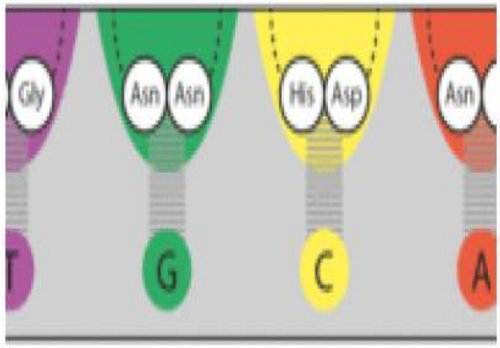
Accidental Discovery genetic scissors (CRISPR-Cas9): Streptococcus pyogenes (belonging to one of the classes of flesh-eating bacteria) cause the most harm to humanity. Emmanuelle Charpentier discovered a previously unknown molecule, tracer-RNA and published results in 2011. The tracrRNA is part of bacteria's ancient immune system. A mysterious enzyme Cas9, associated with CRISPR (CRISPR/Cas) disarms viruses by cleaving their DNA.

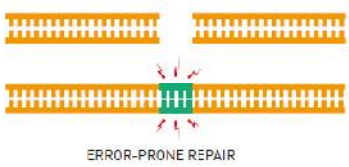
Collaboration of Emmanuelle Charpentier and Jennifer Doudna: Emmanuelle Charpentier is a French microbiologist/geneticist and Jennifer Doudna, an experienced biochemist, has vast knowledge of RNA. They met in Puerto Rico in an American Society Microbiology conference. Their research collaboration resulted in understanding the details and also in re-engineering some bacterial defence system in the laboratory. The outcome was in recreating the bacteria's genetic scissors in a test tube.

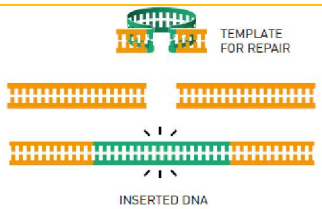
Discovery of CRISPR-Cas9 system: Further, simplification of the scissors' molecular components emerged (in the year 2012) in a tool (CRISPR/Cas9 genetic scissors). It edits genes in all kinds of cells from different organisms This is an astounding innovation. Subsequently, within a short period of time, they demonstrated that this was possible in test tubes using a jellyfish gene (called green fluorescent protein).



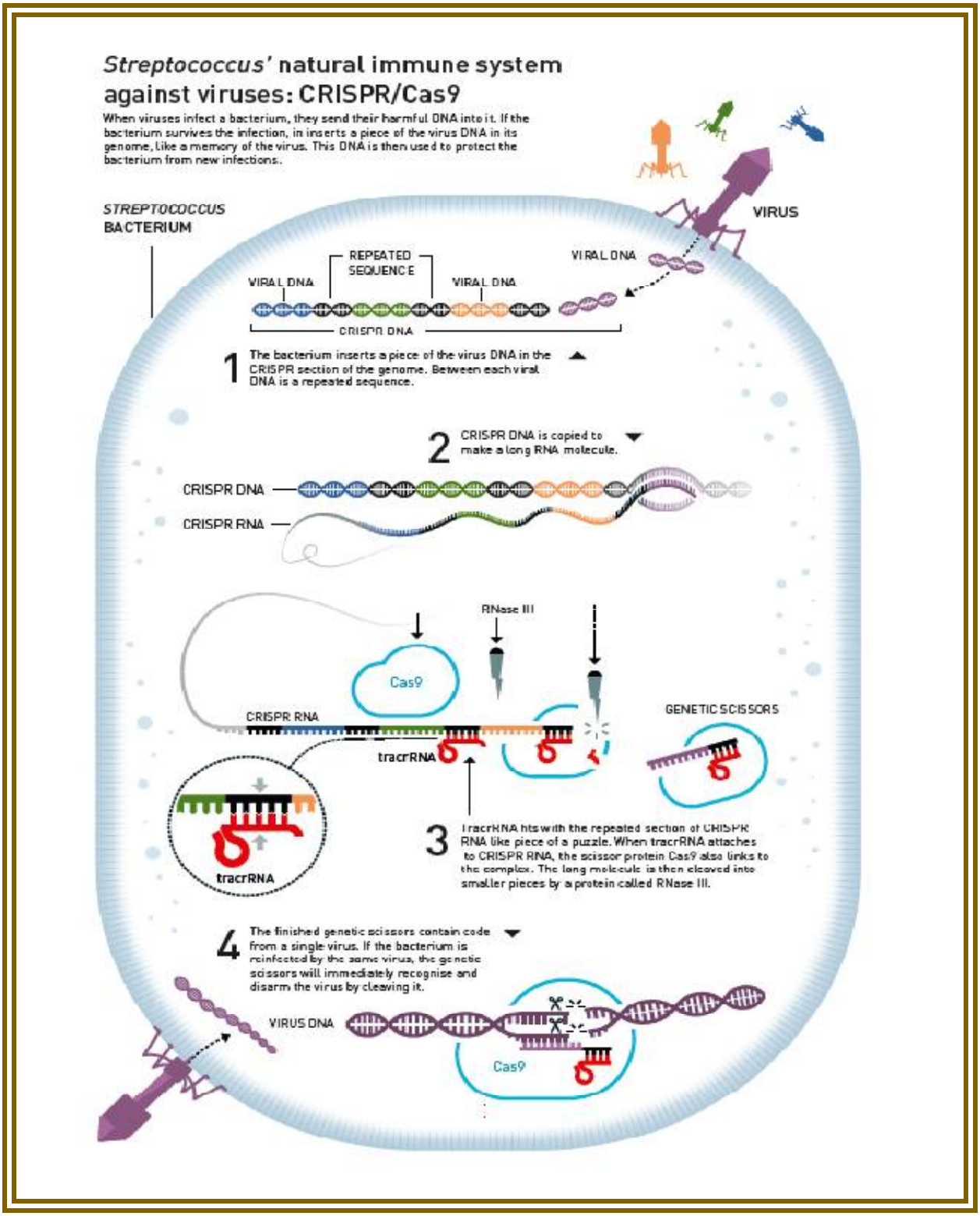
CRISPR/Cas9 genetic scissors



If	Researchers can allow the cell itself to repair the cut in the DNA
	leads to the gene's function being turned off in most cases
Then	

If	Researchers want to insert, repair or edit a gene
	They can specially design a small DNA template for this. The cell will use the template when it repairs the cut in the genome, so the code in the genome is changed
Then	

Immune system in bacteria: In yesteryears, scientists opined that bacteria only had a rudimentary immune system. This proof that a bacterium also has (human-style) immune system is a breakthrough in the annals of biology. CRISPR systems preserve genetic material of invaded virus (which infected the bacteria) and incorporate it into surveillance complexes to achieve adaptive immunity to curb a future attack by the same virus. In the natural form itself, bacteria have the detection (scissors to recognise DNA from viruses) and auto attack systems.



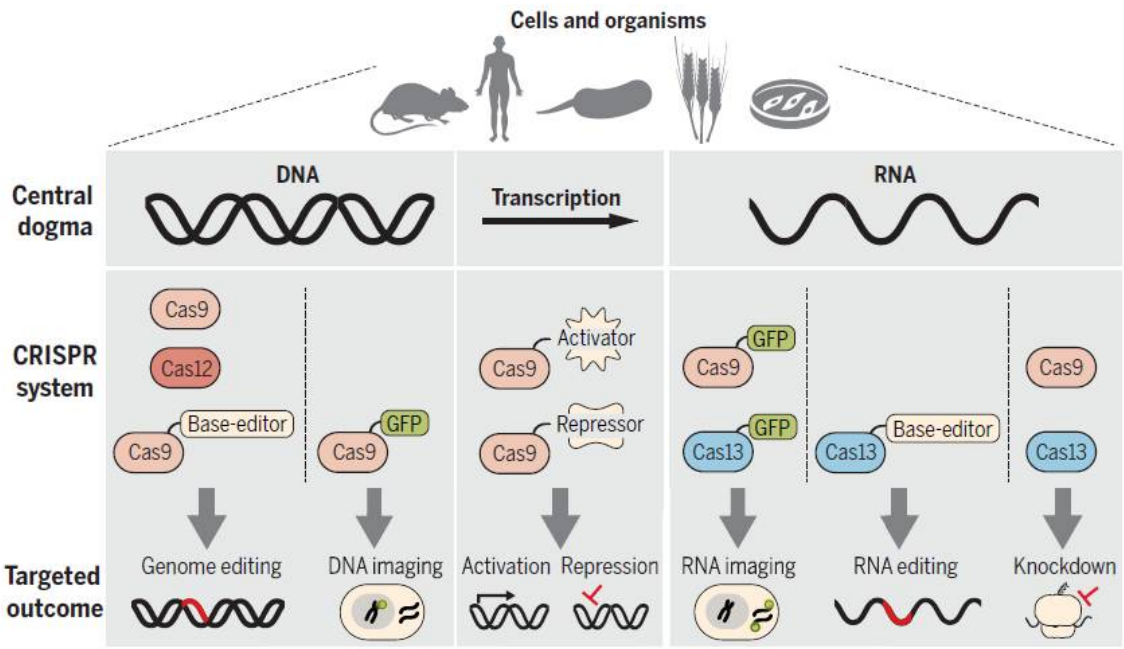
Charpentier and Doudna created a tool in the laboratory which could be controlled to cut any DNA molecule at a predetermined site. This has a fantastic opening to rewrite the code of life in principle, leaving aside pragmatic feasibility in toto.

CRISPR-Cas9 gene editing

Genetic scissors,

- ✓ Researchers can edit the genome of practically all living things.

Check three times, cut once



- CRISPR-Cas systems allow genetic manipulation across the central dogma
- CRISPR-Cas guides the future of genetic engineering

Gavin J. Knott1 and Jennifer A. Doudna, Science 361, 866–869 (2018)

Advantages. CRISPR-Cas9

+ More precise
+ Easy to engineer
+ Less laborious and much faster compared to Zinc-finger nucleases (zfns), transcription activator-like effector nucleases (talens)
+ Inexpensive. (150 times cheaper than zfns)
+ Genetically modified mice, an animal model
  + engineering a mouse with a single mutation
    + With CRISPR-Cas9 one month
    + Other methods: nearly two years
  + To study genetics and disease pathways

Applications. CRISPER-Cas9: Now, CRISPER-Cas9, genetic editing (engineering) tool spread its wings in pure basic sciences, biotechnology, plant genetics, future therapeutics etc. The modifications, editing of DNA sequences in cells (of any organism i.e. any/(all life forms) opened new era of life processes. This is, of course, within the framework of ethics keeping in view of prosperity (physical/mental health, comfort) of future generations. Although, genomic manipulations are not an experimental bottleneck now, simultaneous editing of multiple genes in a species is not in a matured stage of operation.

Applications. CRISPER-Cas9

- Plant Kingdom
  - + Innovative crops
    - + Withstanding moulds, pests, drought
- Animal Kingdom
  - To change the DNA of animals

Applications. CRISPER-Cas9 Human domain

- Cancer therapies
  - Clinical trials (on going) of new cancer therapies
  - Genetic manipulation on the basis of simpler RNA-guided DNA recognition
- Opportunities for curing genetic diseases
- Point-of-care diagnostics

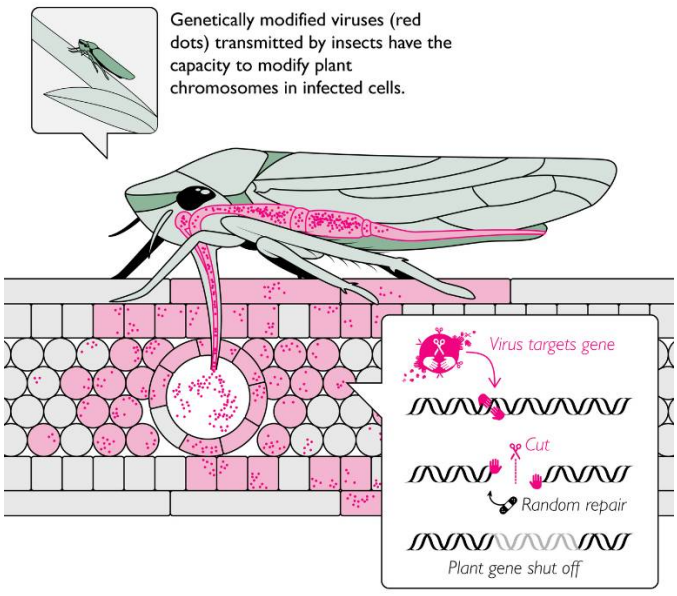
- (Near/Not far) future
- Curing inherited diseases (now a Dream)

- (Distant) future
  - To engineer desirable genetic traits
  - Functional genomic screens
- New approaches to live-cell imaging

! **To create so-called "designer babies***

Insect Ally-Program – Insects as allies or as weapons?

Genetically engineered rice with
genetic scissors,

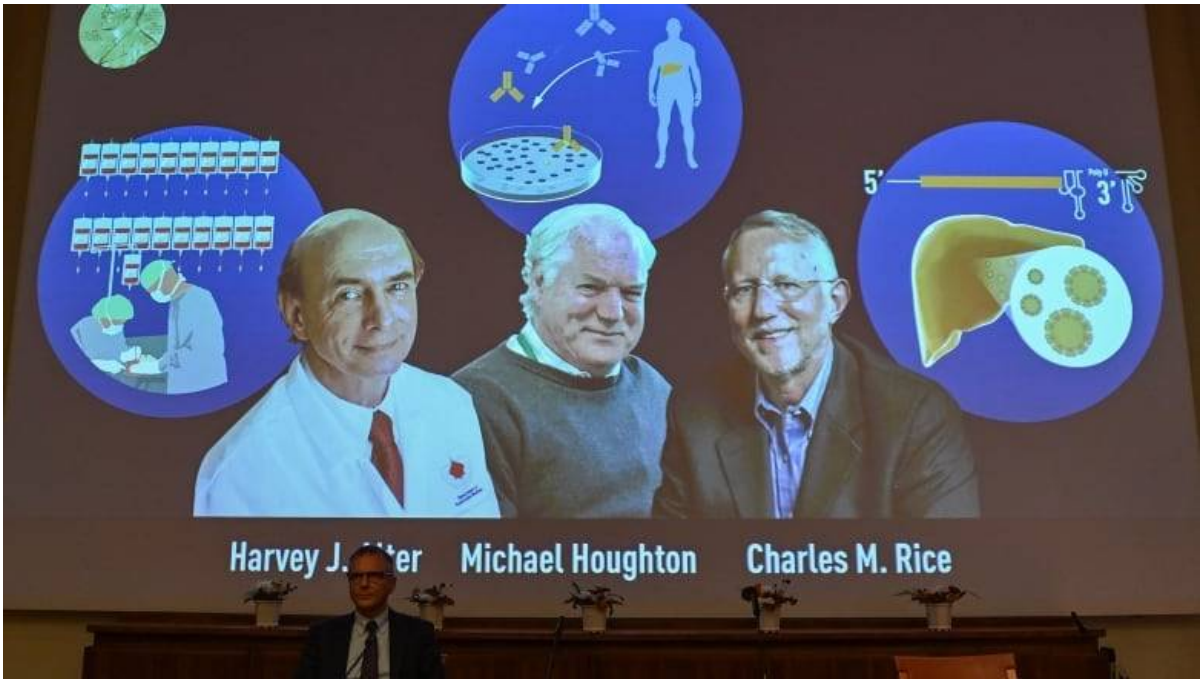


+ Rice that do not absorb poisonous heavy metals from the soil

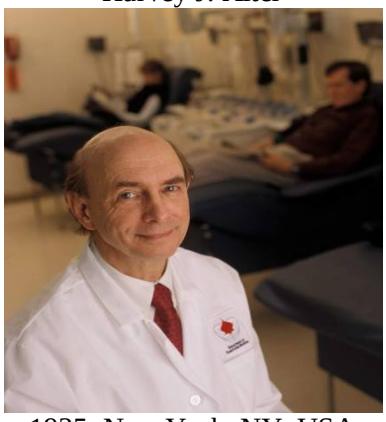
Nobel Prizes in Physiology or Medicine 2020

Table 3.1 Focal theme of Nobel Prize for Physiology or Medicine in 2020

! **Discovery** **Hepatitis C virus**	☞ Harvey J. Alter	🕮 Demonstrated that an unknown virus was a common cause of chronic hepatitis
	☞ Michael Houghton	🕮 Used an untested strategy to isolate the genome of the new virus that was named Hepatitis C virus
	☞ Charles M. Rice	🕮 Provided the final evidence showing that Hepatitis C virus alone could cause hepatitis



Nobel Awards for Scientific Achievements (NASA): Harvey J. Alter, Michael Houghton and Charles M. Rice won Nobel Prize in Physiology or Medicine of 2020 for their seminal contributions in the identification of Hepatitis C virus (HCV, which is an RNA type virus) belonging to Flavivirus family. This discovery of HCV shed light on the root causes of chronic hepatitis leading to more than a million deaths per year all over the world. The follow up research and development resulted in highly sensitive blood tests for the virus (to prune blood samples for eliminating post-transfusion hepatitis), antiviral drugs and vaccines enable medical professionals (practitioners) to cure the disease. This has the consequence of saving millions of lives from suffering and premature deaths. WHO has a hope of eradicating Hepatitis C virus infection by 2030 from the world population. This is one piece of scientific achievement for benefit of humankind in the physical health dimension allowing one live a full life span.

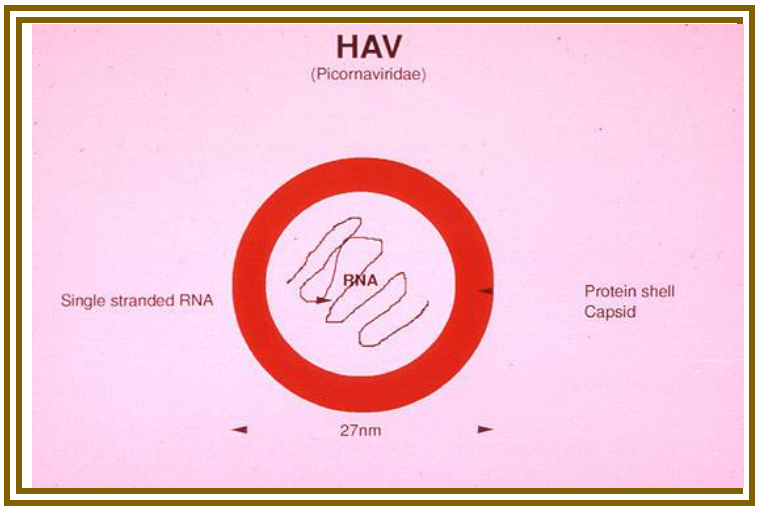
Affiliation	Nobel Laureate (Med) Photo Date & place of birth	Share
National Institutes of Health, Bethesda, MD, USA 	Harvey J. Alter  1935, New York, NY, USA	1/3

Viral diseases: The significant morbidity and mortality toll on the globe is due to Zika, yellow fever, dengue, West Nile virus, chikungunya, hepatitis and coronavirus (SARS, MERS, and latest SARS-CoV-2). The World Health Organization (WHO) estimates there are over 70 million cases of hepatitis C worldwide and 400,000 deaths from it each year. John Hopkins University data shows that within 10 months 543 lakhs of people are infected with SARS-CoV-2, of whom 13 lakhs of patients died globally (as on 16th Sep 2020). The human infection and transmission of this deadly disease (Covid-19) has its origin in Wuhan, China in 2019 Dec, becoming a pandemic.

"Infectious or epidemic hepatitis		Family
Hepatitis A	HAV	Picornaviridae
Hepatitis D	HDV	Deltaviridae
Serum hepatitis		
Hepatitis B	HBV	Hepadnaviridae DNA virus
Hepatitis E	HEV	Hepeviridae
Hepatitis C virus,	HCV	Flaviviridae

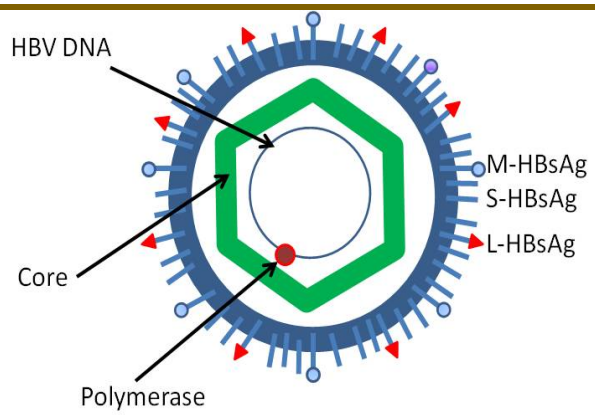
Hepatitis: The Greek physician Hippocrates, respected as the father of western medicine, described the disease hepatitis during 400 B.C approximately. Infectious hepatitis is caused by five different types of RNA or DNA viruses.

Hepatitis A: In 1940's, two main types of infectious hepatitis were suspected. The first one was named hepatitis A which is primarily transmitted through contaminated food and water. It has a short incubation period and manifests as an acute illness for a short period. It is followed by life-long immunity. The second one was called Hepatitis B.

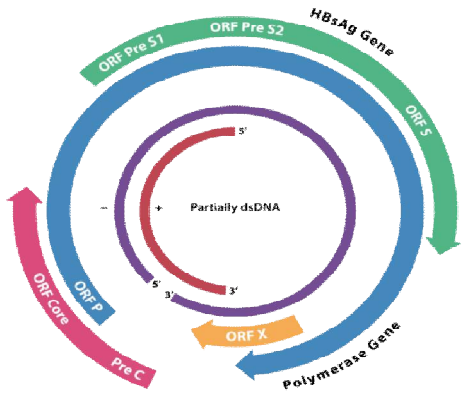


Hepatitis B: Hepatitis B is an insidious disease; Even, individuals infected (Otherwise healthy) do not show any symptoms for many years before reaching the chronic condition,

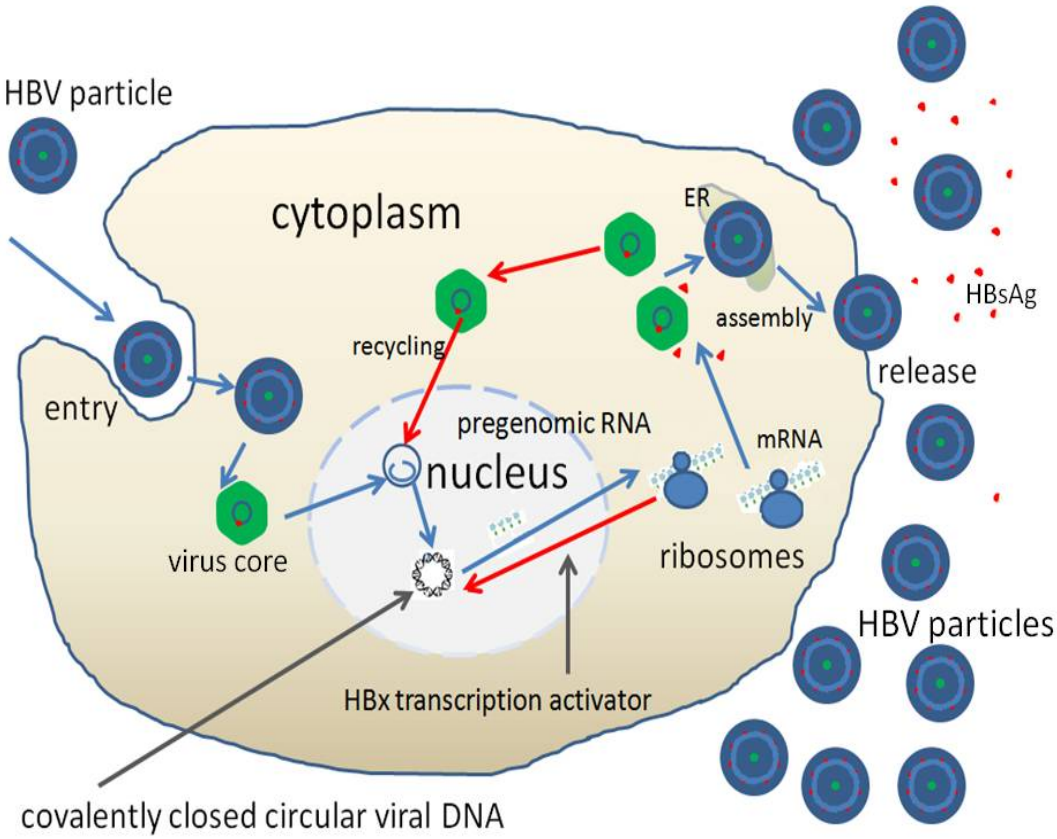
with the development of cirrhosis or liver cancer and many times requiring liver transplantation. It is transmitted through blood and bodily fluids. In the year 1967, Baruch Blumberg discovered this virus and won the Nobel Prize in 1976 for Physiology or Medicine. It led to the development of diagnostic tests of blood samples (for transfusion) and also an effective vaccine. The revised blood purity protocols had the advantage of curtailing human to human transmission during surgical procedures.



Structure of Hepatitis B virus



Genome organisation of HBV. The genes overlap



Hepatitis B virus replication

Stigma: Even after the discovery of the Hepatitis A and B viruses and implementation of strictures on the purity procedures of blood for transfusion, there were significant liver disease cases. So, a majority of hepatitis cases remained unexplained. This led to think there was still at least one other virus (Hepatitis Not A not B) or more that were causing liver damage.

Hepatitis C virus. Discovery

Harvey J. Alter: At the US National Institutes of Health, Harvey J. Alter was an intramural researcher and was probing into causes of hepatitis disease in patients who had received blood transfusions. With the development of tests for detection of hepatitis A in blood samples, it was clear that neither hepatitis A nor B is the source of infection, interfering an unknown virus/infectious agent was playing the drama. It is known that chimpanzees are the only susceptible host of hepatitis virus besides humans.

Animal Studies: Further, his group showed that blood from these hepatitis patients transmitted the disease to chimpanzees, inferring that an in-depth search for "non-A, non-B" hepatitis disease is mandatory

Affiliation	**Nobel Laureate (Med)** **Photo** **Date & place of birth**	
University of Alberta, Edmonton, Canada 	Michael Houghton, PhD, DSc Hon  United Kingdom	1/3

Michael Houghton: In 1982, Michael Houghton, a researcher at Chiron Corporation, initiated a search for NANBH virus employing a screening program of DNA fragments. As, only genetic material from

the host was identified in the first phase, his group screened patiently one million bacterial colonies. They found one colony that does not contain either chimpanzee or human DNA sequences showing the signal for virus of interest in hepatitis. This sequence is a RNA with 10,000 nucleotides and encoded a large open reading frame (ORF). It is related to a distant homology with the genomes of known RNA viruses. It has a positive strand RNA genome and they named it as Hepatitis C virus (HCV), a new member in Flaviridae family.

Affiliation	**Nobel Laureate (Med)** **Photo** **Date & place of birth**	
Rockefeller University, New York, NY, USA 	Charles M. Rice  1952, Sacramento, CA, USA	1/3

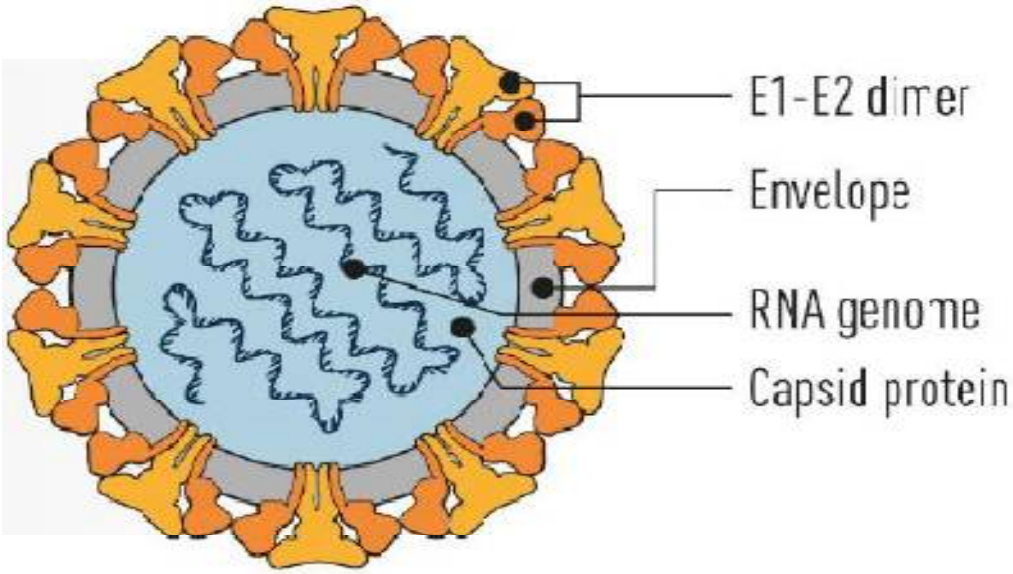
Charles Rice: Rice from Washington University in St Louis, found a conserved, non-coding region at the 3' end of the HCV RNA genome. The group thought that it plays an important role in virus replication.

Animal experiments:

Failure: Rice constructed viral RNA genomes containing the conserved 3' region and injected them into the liver of chimpanzees. They failed to detect newly produced virus in the blood, an evidence for HCV replication.

Success: Many RNA viral replications are error prone and also viral sequences have inactivating mutations. Rice engineered a set of RNA genomes and injected into the liver of chimpanzees. clinical signs of hepatitis were detected in these species. Further, infectious virus was found in their blood for several months

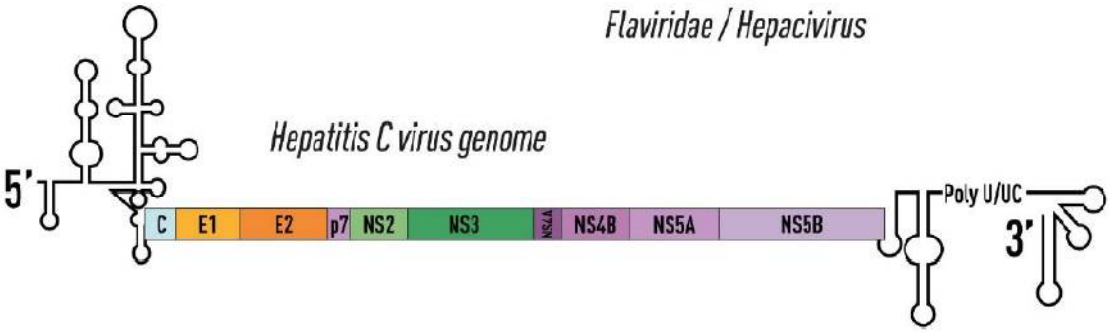
Hepatitis C virus (HCV). Structure



Flaviridae / Hepacivirus

RNA Virus

- E1 and E2: exposed on the surface
- Viral envelope : glycoproteins

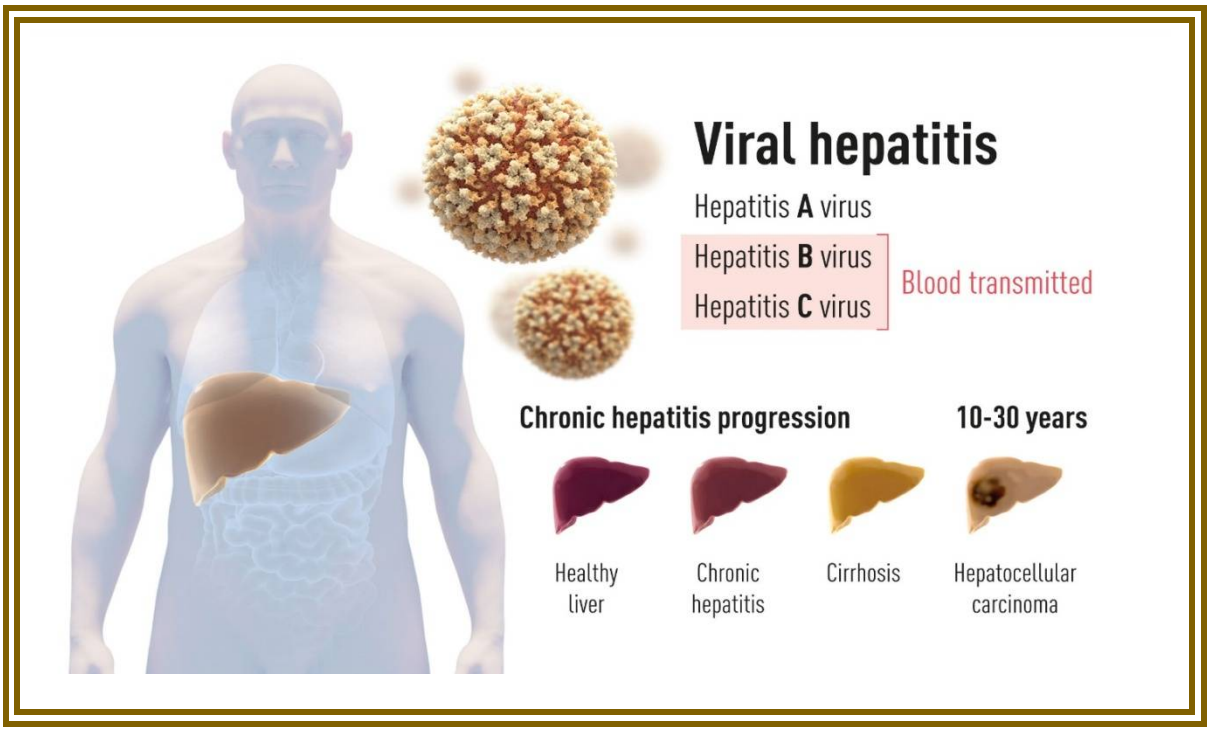


- Viral genome encoding a large polyprotein that is cleaved into multiple structural and non-structural proteins with 5' and 3' terminal untranslated regions

This is conclusive evidence that Hepatitis C virus (HCV) alone causes hepatitis, persists long-term and stimulates a specific antibody response. All these features are of the human infection.

Recent research in Rice's lab
Studies to understand o Virus replication o Innate immune responses that limit infection
Developing new in vitro culture

☞ Established the first immunocompetent mouse model of HCV infection ☞ Paving way towards vaccine development
☞ Studies of HCV-associated liver cancer
☞ Applying the human liver mice, as well as new in vitro culture methods ☞ To study HBV, which is often refractory to curative treatment due to the virus's highly stable covalently closed circular DNA genome (cccDNA)



Medical treatment of Hepatitis C: Hepatitis (induced by HCV/HXV) is curable by a short-term treatment with anti-viral drugs in more than 95% of cases. Directly acting antivirals (i.e. combination of drugs that target critical viral functions), proved to be highly effective and diminished the risk of selecting drug resistant variants of the virus. The wider spread of this dreaded disease is under control due to implementation of elimination protocols of contaminated blood and blood products.

Hurdles for complete eradication of viral hepatitis

- Lack of broad screening campaigns
- Inadequate diagnosis of patients with hepatitis (HBV or HCV)
- High cost of adequate (state-of-art) treatment protocols
- Most patients are financially poor
- Distribution of drugs to needy people
- Contaminated
  - Blood supply
  - Medical equipment
  - Procedures
- Life style
  - Stigmatized populations viz. drug users

2020 Nobel Prize in Literature

: .

Table 4 Focal theme of Nobel Prize Literature in 2020	
Objective	o Unmistakable poetic voice that with austere beauty makes individual existence universal

Residence at the time of the award	Nobel Laureate (Literature) Photo, Date & place of birth	Share
	Louise Glück  **22 April 1943** **New York,NY, United States**	1/1

Nobel Prize in Peace 2020

Table 5 Focal theme(a) of Nobel Prize for Peace in 2020	
Objective	▪ Efforts to combat hunger, for its contribution to bettering conditions for peace in conflict-affected areas and ▪ For acting as a driving force in efforts to prevent the use of hunger as a weapon of war and conflict

	Nobel Prize (Peace)	Share
	**World Food Programme (WFP)**  End hunger –a global goal	1/1

2020 Nobel Prizes in Economics

Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel

Four Nobel Laureates – Research Director and his three former Ph.D. students: It a perfect combination of events that three Ph.D. students of Bob Wilson won Nobel prizes in Economics; Alvin Roth in 2012, Bengt Holmström in 2016 and Paul R. Milgrom in 2020. Another sparkle is Bob Wilson himself was awarded Nobel prize in 2020 and that too he shared with his Ph.D. student Milgrom.
Bob calls it his "trifecta".
AS: In cricketing terms we'd call it a hattrick.
Bob: Ah, a hattrick, ah, very good.
Well, I've been more of a speculative thinker, and Paul is very precise

.Table 6. Focal theme of Nobel Prize for Economics in 2020

Theory_ improvement	Improvements to auction theory and inventions of new auction formats	
Benefit_to_ mankind	New ways to use auctions that benefit sellers, buyers and taxpayers around the world.	

Affiliation	Nobel Laureate (Economics) Photo Date & place of birth	Share
Stanford University, Stanford, CA, USA	Paul R. Milgrom  20 April 1948, Detroit, MI, USA	1/2

Affiliation	Nobel Laureate(Economics) Photo, Date & place of birth	Share
Stanford University, Stanford, CA, USA	Robert B. Wilson  1937, May 16, Geneva, Nebraska. USA	1/2

Supplementary Information (SI)

SI-0: Themes for Nobel Awards	
Physics	! Should have made the most important discovery or invention within the field of physics
Chemistry	! Person who made the most important chemical discovery or improvement

Medicine or Physiology	! People who have either made a discovery about how organisms work or have helped find a cure for a disease
Literature	! The person who produced in the field of literature the most outstanding work in an ideal direction
Peace	! The person who has done the most or best to advance fellowship among nations, the abolition or reduction of standing armies, and the establishment and promotion of peace congresses
Economics	! Outstanding contributions in Economics or Social Sciences
Those who brought the greatest benefit to humankind	

SI.1: First Response of Noble Prize Winners of 2020

Nobel Laureate (2020)	First Response	Discipline
Andrea Ghez 	! So, thrilled! I still can't quite believe it ! I heard the news with a phone call at two in the morning, so I was fast asleep. And I think for the first few minutes thought I was dreaming	Phys
Reinhard Genzel 	! It was completely unexpected and ! I'm … wow … I'm on cloud 17 ! I never would have thought I ever get, which is 'this is Stockholm calling'	Phys
Emmanuelle Charpentier	! Charpentier tells Adam Smith of her surprise at receiving the call from Stockholm ! I have to say that when he called I was totally… I could not believe it, I mean I was really… I mean I'm still emotional, because you don't… I mean, again…	Chem

	🕮 And I also think of my colleagues for sure, of all my former members of my team, [unclear] and Krzysztof Chylinski, who really also made this happen	
Jennifer A. Doudna 	! It's truly astounding. It's extraordinary. Yeah, it's just been amazing ! She was woken by a call from Nature journalist (Heidi Ledford): "I assumed she was calling me to ask me to comment on somebody else winning the Nobel Prize!	Chem
Michael Houghton 	! It's a great honour of course, and ! I'm very, very, very pleased. Thank you. ! it was a big surprise and I was very sleepy. And yes, it was wonderful 🕮 So, yes, I work with some great people, without whom I would not have had this success	Med
Harvey J. Alter 	! I'm not shocked because I got a morning phone call, which put me into shock. You're the aftershock AS: I'm proud to be the aftershock, that's a nice idea o Yes, I was, yeah, it was 4:45 I think on the east coast here. The phone rang… and who the heck is calling? And I didn't answer it. And then about 5 minutes later it rang again and still, still didn't answer it, and the o third time I got up angrily to answer it. o It was Stockholm. It was a weird, weird experience. o AS: I imagine your anger subsided fairly fast. o HA: [Laughs]. It did, yes, it went away in about a second. o It was replaced by the shock. AS: What was the first thing you did after hearing the news?	Med

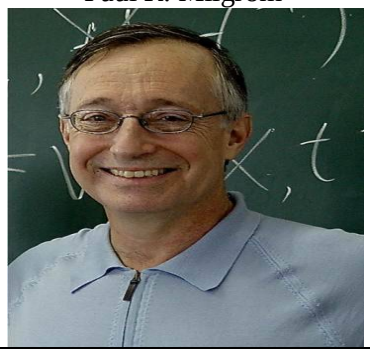
	▪ HA: I told my wife. I woke her up. ! It's just… you know, it's so kind of other-worldly. ! It's something that you don't think will ever happen, and ! Sometimes don't think you deserve it to happen. ! ➢ And then it happens in this crazy COVID year, ➢ Just where everything is turned upside down. ➢ This is another, nice upside down for me	
	! I am overwhelmed at the moment, ! But so pleased that 🕮 This originally obscure virus has proven to have such a large global impact	
	o I can only thank NIH, itself, for creating the permissive and collaborative environment that supported these studies over the course of decades (more than 50 years) o I don't believe my contributions could have occurred anywhere else o There are so many persons at NIH who advanced my research	
Charles M. Rice 	! Well, I am absolutely stunned ! I guess when you get it… when you get a call like this and ! you're not expecting it, ! you pretty much don't know what to say. ! But this is really a big surprise, o not the fact that Hepatitis C is being you know sort of recognised o I feel as though I'm just kind of a representative of the sort of molecular virologist community that contributed something to this fight against this disease. ▶ I heard just a short time ago that Harvey Altern and Mike Haughton were also co-laureates for this Prize, and, you know, they really deserve an incredible amount of credit	Med

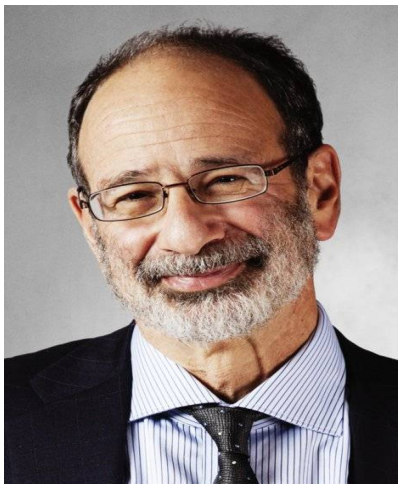
	Happening -- Expectation	
Emmanuelle Charpentier 	☞ Despite considerable speculation that surely CRISPR would be awarded ☞ That in this regard most likely my name will be… will be mentioned ☞ And I think it's maybe	
	Conferring award ☞ I have to say, the fact that you hear it and that, as I said, you connect to it, but you still believe it's another person or it's surreal, it's not… and ☞ when it happens, now it's real and ☞ Now I have to deal with it.	

Academic profile of **Emmanuelle Charpentier**		
1986-1992	Biology, microbiology, biochemistry genetics	University Pierre Marie Curie (UPMC), Paris
1992-1995	Graduate student	Institut Pasteur, Paris
1993-1995	University Teaching Assistant	UPMC, Paris
1995-1996	Post-Doc	Institut Pasteur, Paris
1996-1997	Post-Doc	Rockefeller University, New York).
1997-1999	Asst. Research Scientist	New York University Medical Center, New York
1999	Research Associate	St. Jude Children's Research Hospital, Memphis
1999-2002	Research Associate	Skirball Institute of Biomolecular Medicine, New York

Employment. of Emmanuelle Charpentier		
2002-2004	Lab Head Guest Professor	Institute of Microbiology Genetics, University of Vienna, Vienna
2004-2006	Lab Head, Assistant Professor	Department of Microbiology, Immunobiology & Genetics, University of Vienna, Vienna
2006	Private Docent	Microbiology, Habilitation, Centre of Molecular Biology, University of Vienna, Vienna
2006-2009	Lab Head Associate Professor	Max F. Perutz Laboratories, University of Vienna, Vienna
2009-2013	Lab Head, Associate Professor	Laboratory for Molecular Infection Medicine Sweden (MIMS), Umeå University, Umeå
2013	Docent	Medical Microbiology, Umeå University, Umeå

2013-2015	Department Head	Helmholtz Centre for Infection Research, Braunschweig W3 Professor Hannover Medical School, Hannover
2014-2017	Lab Head Visiting Professor	Laboratory for Molecular Infection Medicine Sweden (MIMS), Umeå University, Umeå
2015-2018	Director	Max Planck Institute for Infection Biology, Berlin
since 2014-	Professor	Alexer von Humboldt Professor
since 2015-	Scientific member	Max Planck Society
since 2016-	Honorary Professor	Humboldt University, Berlin
since 2018-	Founding Scientific Managing Director	Max Planck Unit for the Science of Pathogens, Berlin

Economics : Four Nobel Prize awardees from one research School		
2020	Paul R. Milgrom 	o I mean, I think we're both a little bit o … we're both nerds in, you know, in a certain way. o We … I don't really know what to say about the magic between us. We haven't done that many joint projects.
2016	Bengt Holmström  With my advisor Bob Wilson at the Nobel ceremonies	☞ At the GSB Bob Wilson was a towering figure. Not yet 40 years old – and looking ten years younger – Bob's influence extended well beyond the Decision Sciences group ☞ As an advisor, Bob was extremely generous with his time. He liked to put his students on a regular schedule: discipline was essential for good work (something that regrettably hasn't stuck with me). In the beginning I met Bob weekly ☞ Just as importantly, his vision of where the field was headed and what role incentive and information theories would play in economics were an inspiration for his students. ☞ It's no exaggeration to say that the use of modern game theory would not be what it is today without the foresight and insight that Bob provided for a several generations of young scholars around the world

2012	Alvin Roth 	☞ Bob Wilson agreed to be my advisor and rescued me from having what looked to be a very short academic career after I failed one of my Ph.D. qualifying exams
		☞ He was on sabbatical that year, but met with me regularly once a week for an hour. In memory, our meetings followed a kind of script: I would spend a while explaining to him why I hadn't made progress that week, and then he would spend a while telling me not to be discouraged. Then I would describe some roadblock to further progress, and he would, as we finished our meeting, recommend a paper for me to read ☞ Because his recommendations had always been very much on target, I would go straight from his office to the library and start to read the paper. As I did, I would think, this time Bob made a mistake, this paper has nothing to do with my problem. But then, somewhere in the middle of the paper would be a lemma or remark that helped me get around that roadblock

SI.2: Noble words of Noble Laureates

Nobel Laureate (2020)	Verdict	Discipline
Emmanuelle Charpentier 	☞ Evaluated through a potential number of publications and H-index factors, this does not… it's nice, ☞ Progress does not come through impact factors, ☞ Progress comes through solid work, yes ☞ You need time to do the work in a proper way, in a deep way and… and ☞ ☞ I want to mention this because I would not like to see science having lost this sense	Chem

Jennifer A. Doudna (Chemist)

Inspiration for pure science pursuit	🕮 Attractions of science o It is unpredictable ☞ You can never know in advance where an idea or a question may lead ☞ Sometimes a curious mind will meet a dead end ☞ Sometimes it will encounter a thorny labyrinth that takes years to navigate ! But, now and again, ! She realises she is the first person ever to gaze upon a horizon of untold possibility
Key to success	Doudna comments that much of it was down to o Her luck in having good mentors early on in her career and o Having had the freedom to build up her laboratory team with people ☞ With whom she shares a personal chemistry and the same scientific vision and drive
Wide extension of CRISPR-Cas9 tool	🕮 Yeah, thinking back about how it really started with just a curiosity driven project ! It still amazes me every day to see the extraordinary work that's going on now globally with this technology, and …
Woman & recognition	"there's a sense that no matter what a woman do, their work will not be recognised in the way it would be if they were a man
	AS:what you can learn from bacteria? JD: Exactly, and how much more they, I'm sure, still have to teach us
	🕮 In some ways it makes you look a little bit differently at nature to know that there are all these secrets hidden in what one would call 'lesser' species. ! I've heard many people say that to me, you know, when I would give talks about this work, ! Many people have said almost exactly that, sort of surprised in a way, and saying 'wow, bacteria are actually really cool

Academic profile of **Jennifer A. Doudna**

1989	Ph.D.	Harvard Medical School, Boston, USA Biochemistry (RNA)	Supervisor: Jack Szostak, a geneticist who won a Nobel Prize in 2009.
	Post Doctoral	Spent some time working with Szostak	

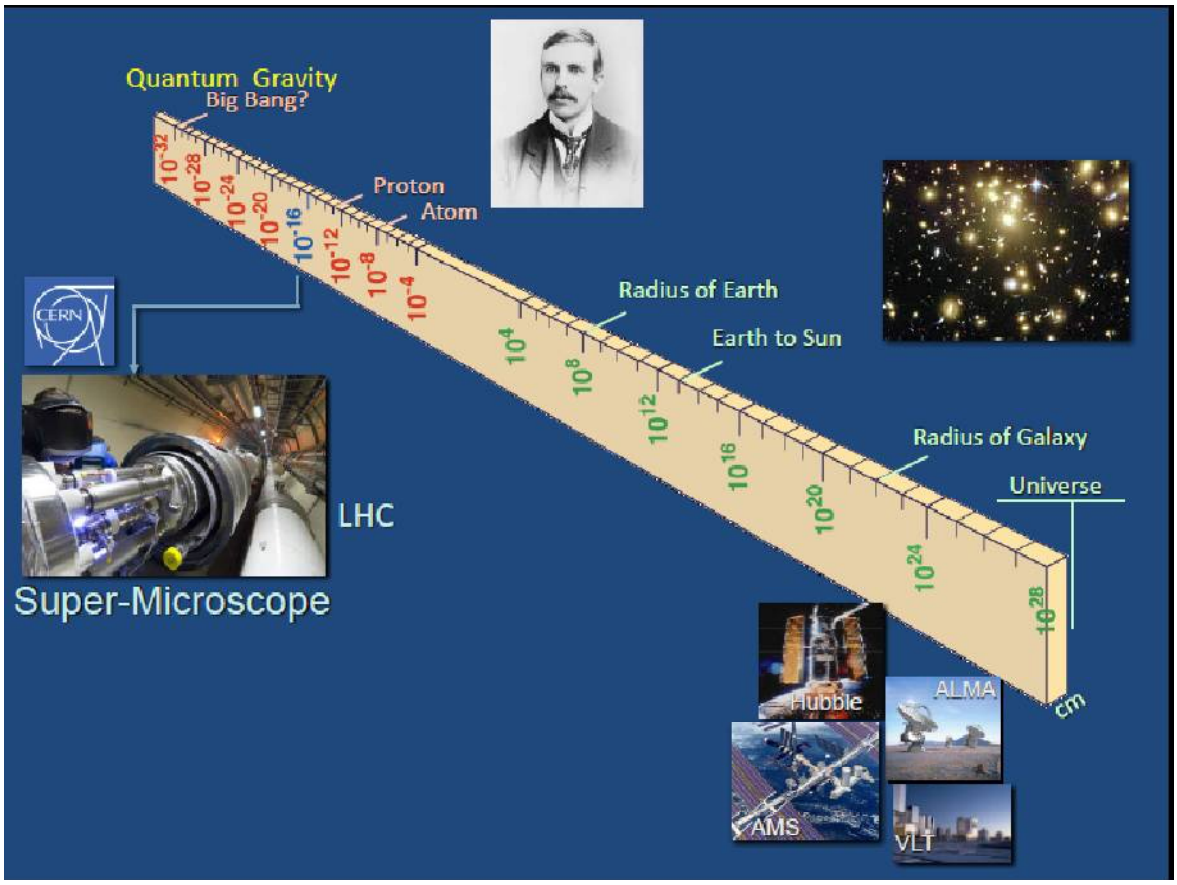
1989-1994	Postgraduate fellowship	Laboratory of Thomas Cech at the University of Colorado in Boulder	Nobel Prize, in 1989, for discovering the catalytic properties of RNA.(Marino) He also had the equipment to carry out X-ray diffraction which would help her decipher the three-dimensional atomic structure of RNA.

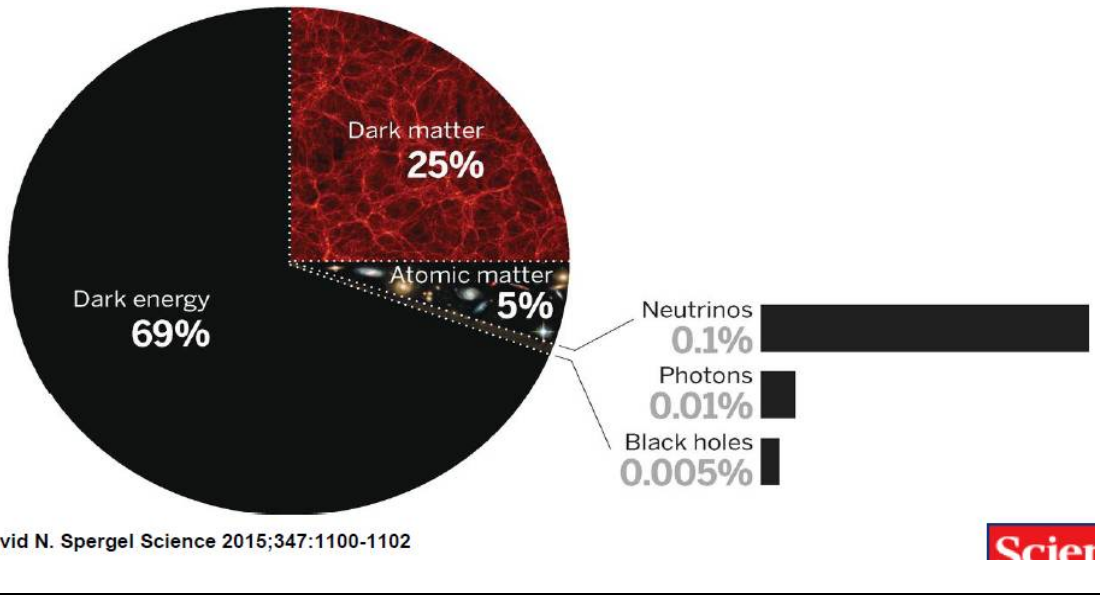
		Employment. of Jennifer A. Doudna
Assistant professor	1994-2000	☞ Yale University
Henry Ford II Professor	2000	☞ Molecular Biophysics and Biochemistry Yale University
Professor	2002	☞ Biochemistry and Molecular Biology University of California, Berkeley
Investigator		☞ Howard Hughes Medical Institute
		☞ J.A.D. is an investigator of the HHMI and ☞ executive director of the Innovative Genomics Institute at the University of California, Berkeley, and the University of California, San Francisco. ☞ J.A.D. is a cofounder of Editas Medicine, Intellia Therapeutics, Caribou Biosciences, Scribe Therapeutics, and Mammoth Biosciences. ☞ J.A.D. is a scientific adviser to Caribou Biosciences, Intellia Therapeutics, eFFECTOR Therapeutics, Scribe Therapeutics, Sythego, Metagenomi, and Inari ☞ Member of the Board of Directors of Driver and Johnson & Johnson

Achievements (breakthroughs)Jennifer A. Doudna

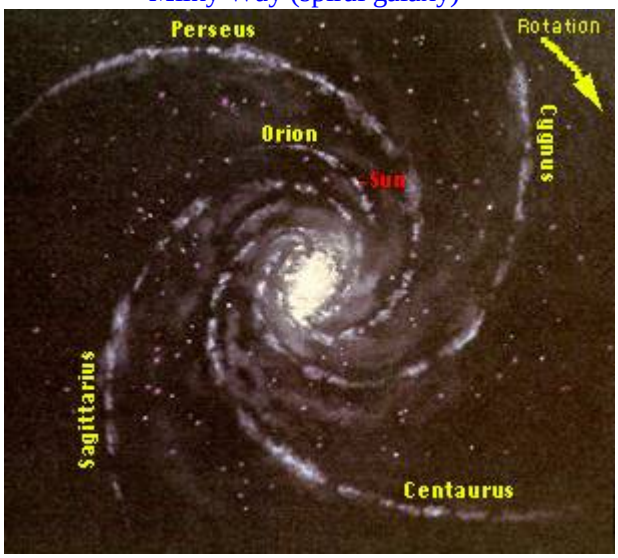
- ☞ Doctoral student in Szostak's laboratory. She helped to demonstrate that RNA not merely carries instructions from DNA for synthesising proteins but also helps to catalyse the process.
- ☞ Seven years later Doudna announced, together with Cech, the three-dimensional structure of the P4-P6 domain of the Tetrahymena thermophila group I intron ribozyme, a particular type of RNA. It was a major achievement because prior to this only one other single RNA structure had been unravelled, transfer RNA (tRNA), and it was much smaller and simpler than the ribozyme.
- ☞ Working with Cech and others, including Cate - her future husband, Doudna helped demonstrate that the ribozyme had a defined shape and an organised structure similar to proteins.(Cate et al; Marino)
- ☞ By 1998, Doudna and her team had determined the crystal structure of their first viral RNA - the hepatitis delta virus (HDV), a human pathogen linked to hepatitis B.

SI.Phys (SI.3)


Quantum Gravity
Big Bang?
Proton
Atom
Radius of Earth
Earth to Sun
Radius of Galaxy
Universe
LHC
Super-Microscope
Hubble
ALMA
AMS
VLT
cm


Dark matter
25%
Atomic matter
5%
Dark energy
69%
Neutrinos
0.1%
Photons
0.01%
Black holes
0.005%
David N. Spergel Science 2015;347:1100-1102

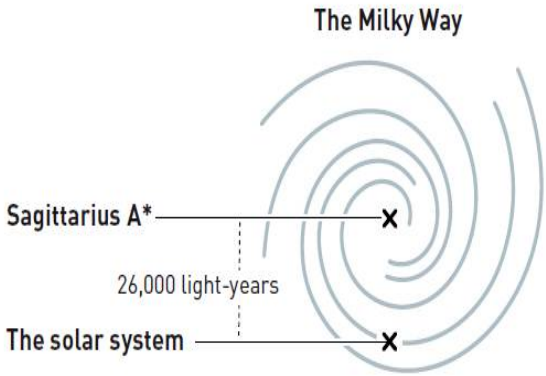
Milky Way (spiral galaxy)



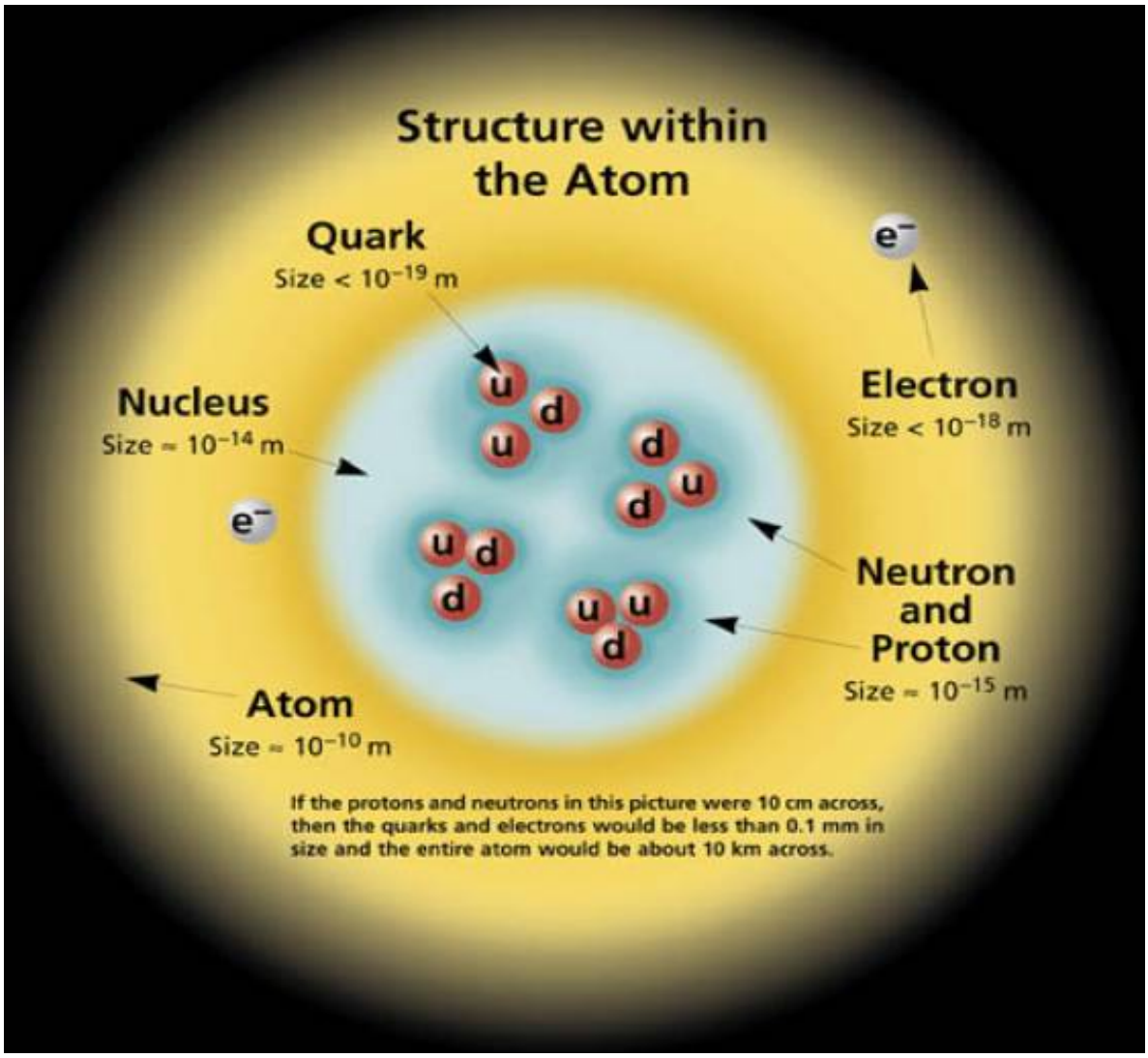
- Spiral galaxy: simple spherical bulge of gas and stars at its center
- Diameter of the Milky Way: 100,000 light-years
- Major arms: Perseus; Sagittarius; ….
- Location of Sun (and, rest of our solar system) : near the Orion arm
- Sun is located about 28,000 light-years from the Galactic Centre
- Sun orbits around the centre of the Milky Way Galaxy moving at an average velocity of 828,000 km/hr
- Time for complete orbit for Sun around the Milky Way: about 230 million years

Milky Way (barred spiral galaxy)

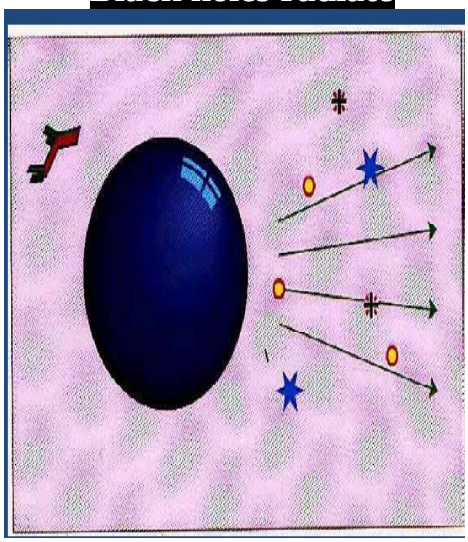
- Model: based on recent observations
- Barred spiral galaxy: a "bar of stars" crossing the central bulge
- Still Solar system rotates around the center just the same

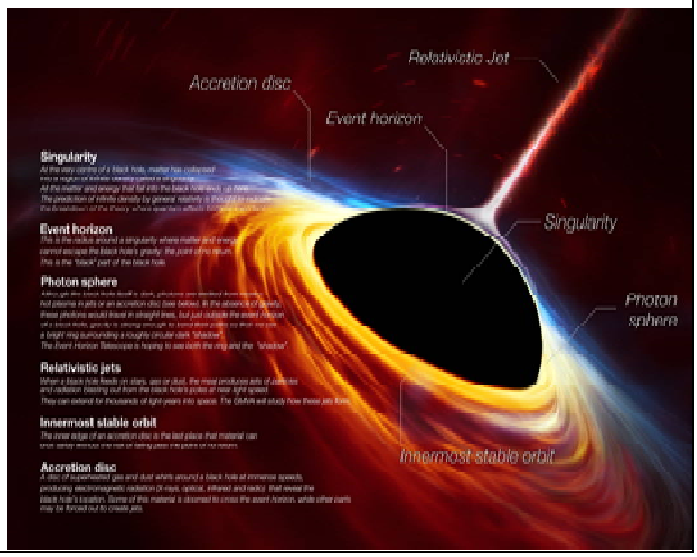


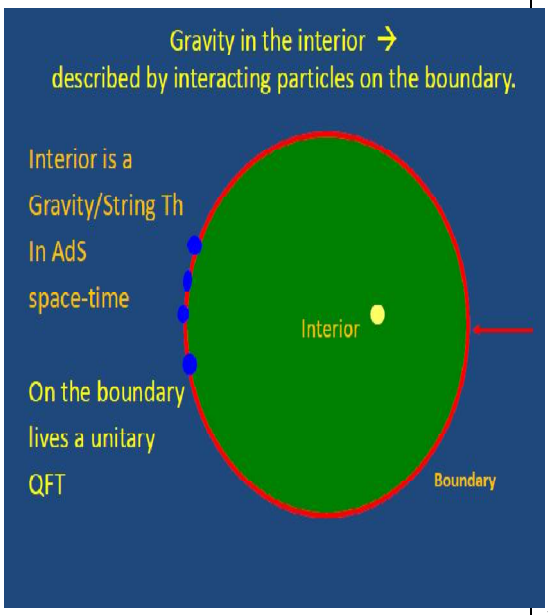
- Seen from above: shaped like a flat disc

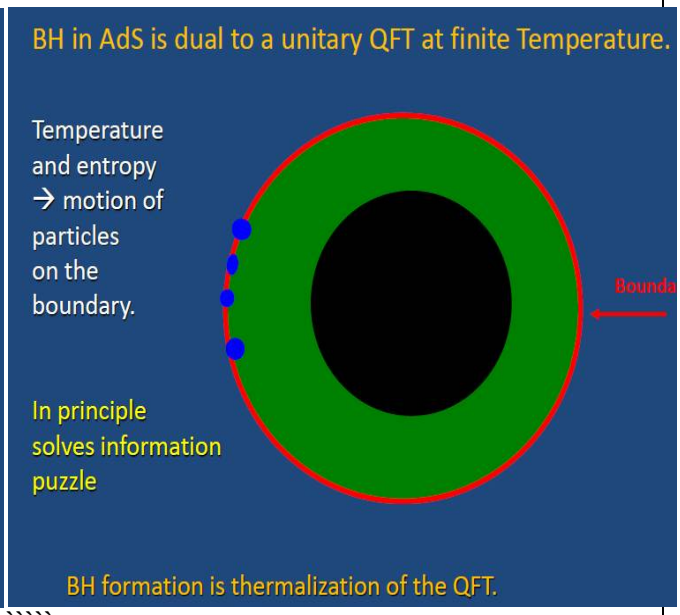


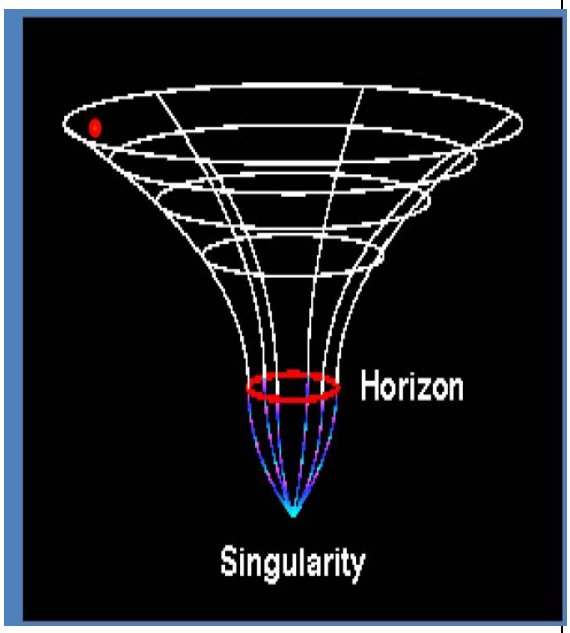
Black holes radiate

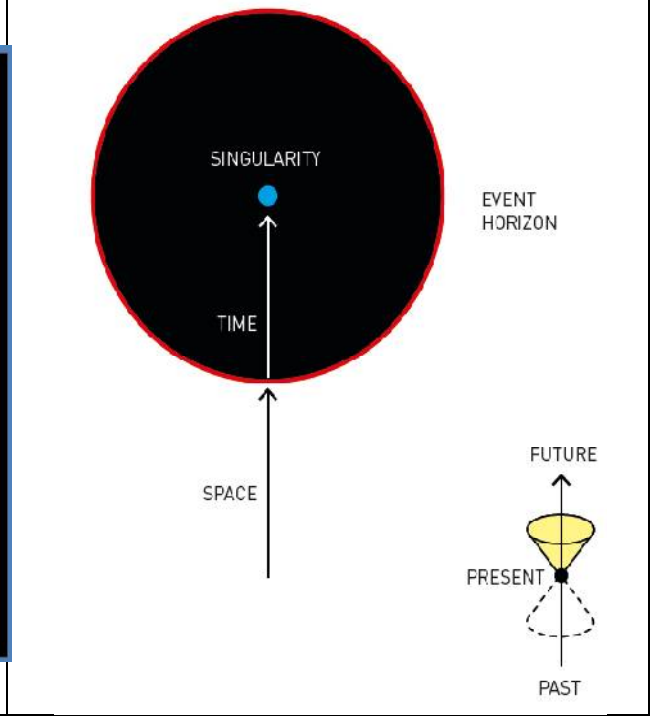





Gravity in the interior →
described by interacting particles on the boundary.
Interior is a
Gravity/String Th
In AdS
space-time
On the boundary
lives a unitary
QFT
Interior
Boundary


BH in AdS is dual to a unitary QFT at finite Temperature.
Temperature
and entropy
→ motion of
particles
on the
boundary.
In principle
solves information
puzzle
Bounda
BH formation is thermalization of the QFT.


Horizon
Singularity


SINGULARITY
EVENT
HORIZON
TIME
SPACE
FUTURE
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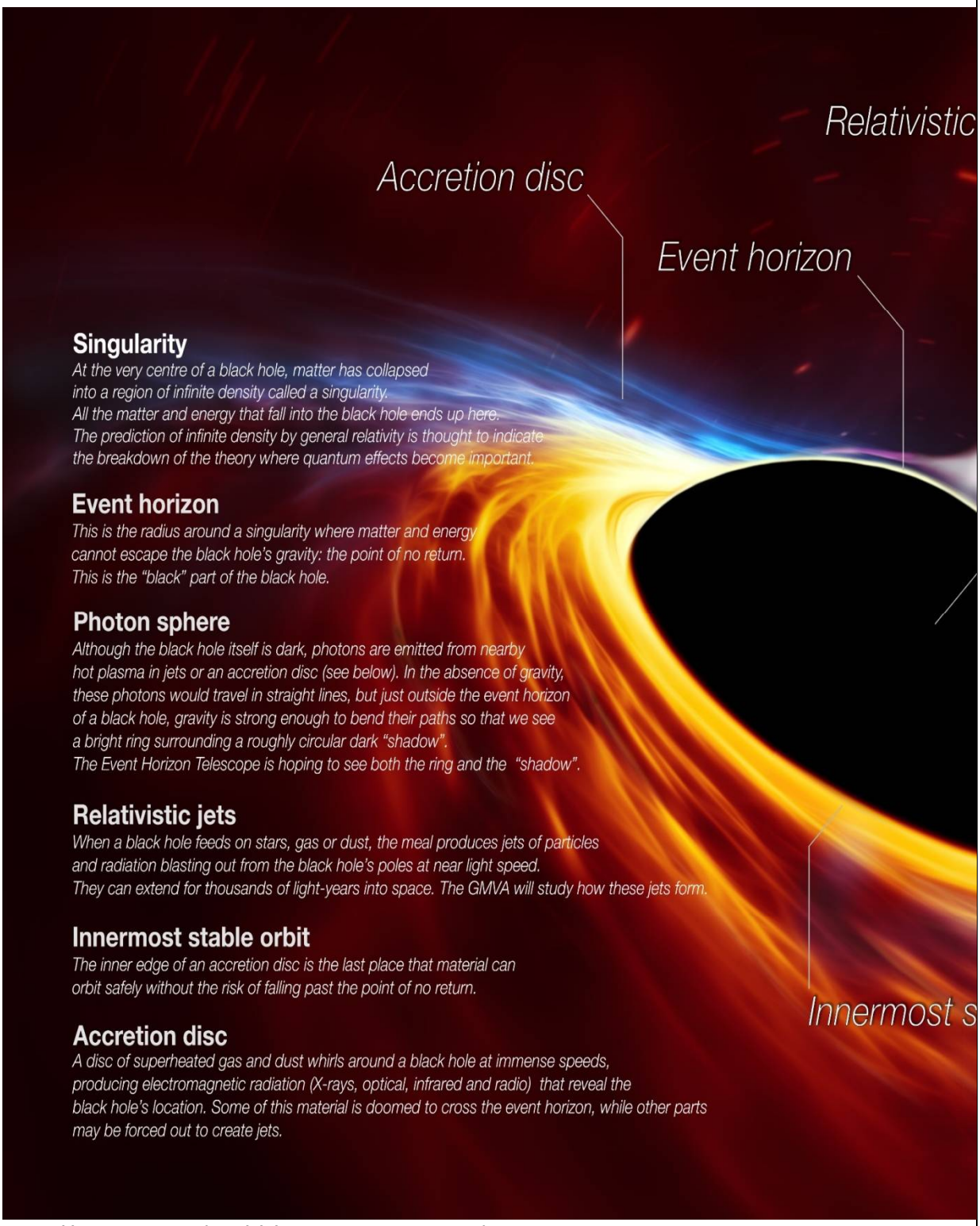
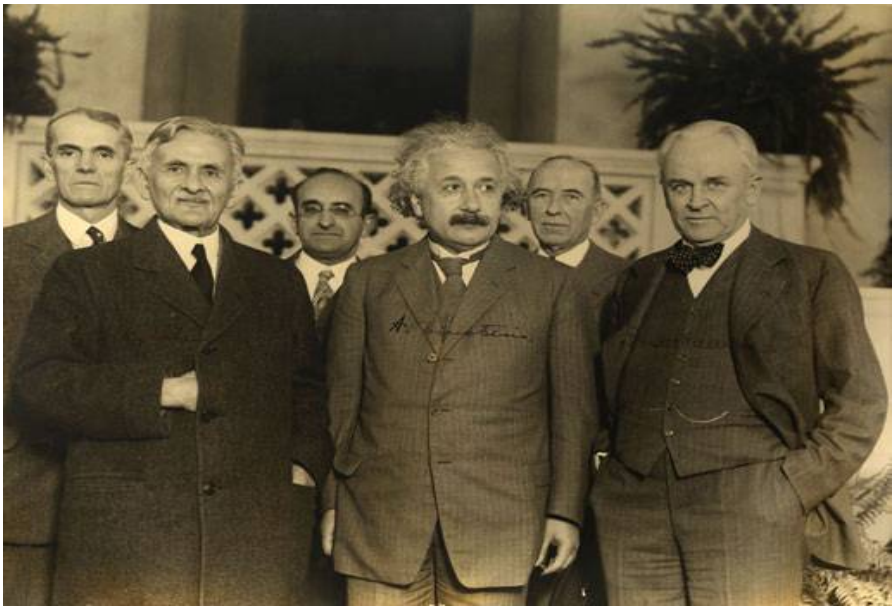


Credit: ESO, ESA/Hubble, M. Kornmesser/N. Bartmann

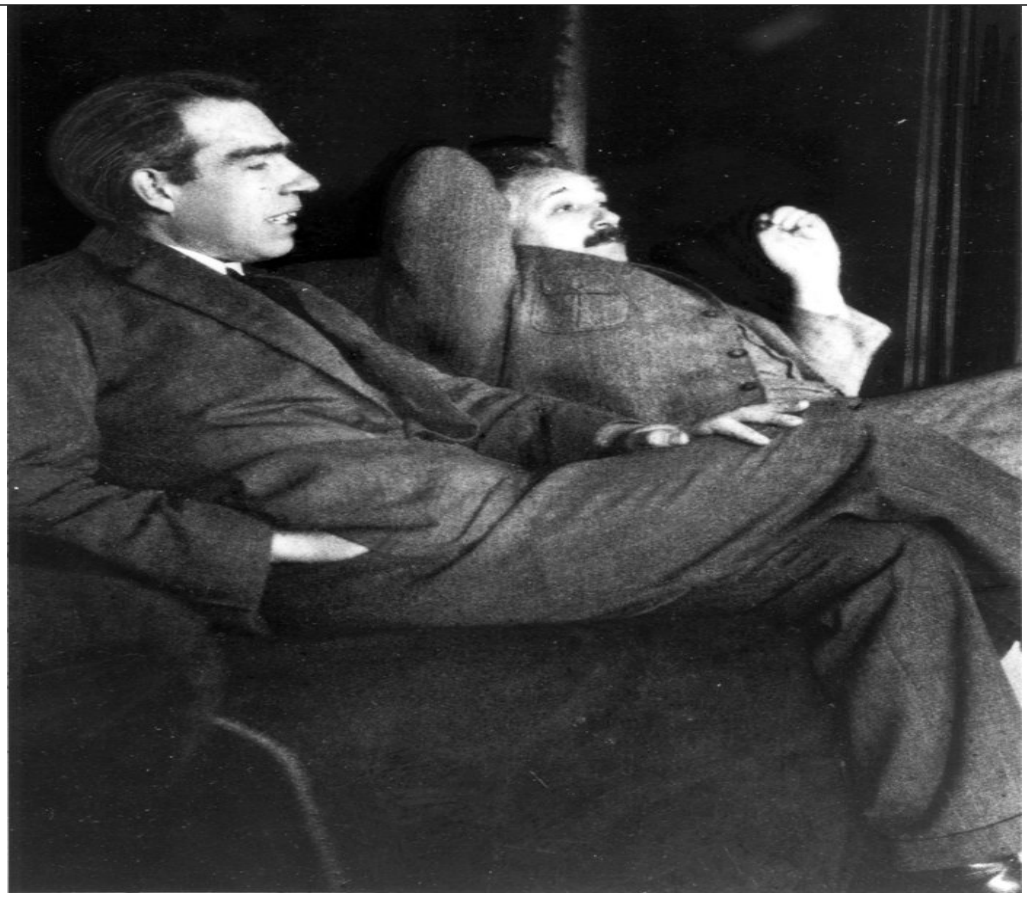
SI.4. Albert Einstein

From left to right: Nobel Laureates Walther Nernst, Albert Einstein, Max Planck, Robert A. Millikan and Max von Laue at a dinner given by Professor von Laue in Berlin, 11 November 1931.
Source: Nationaal Archief Photographer unknown Public domain via Wikimedia Commons



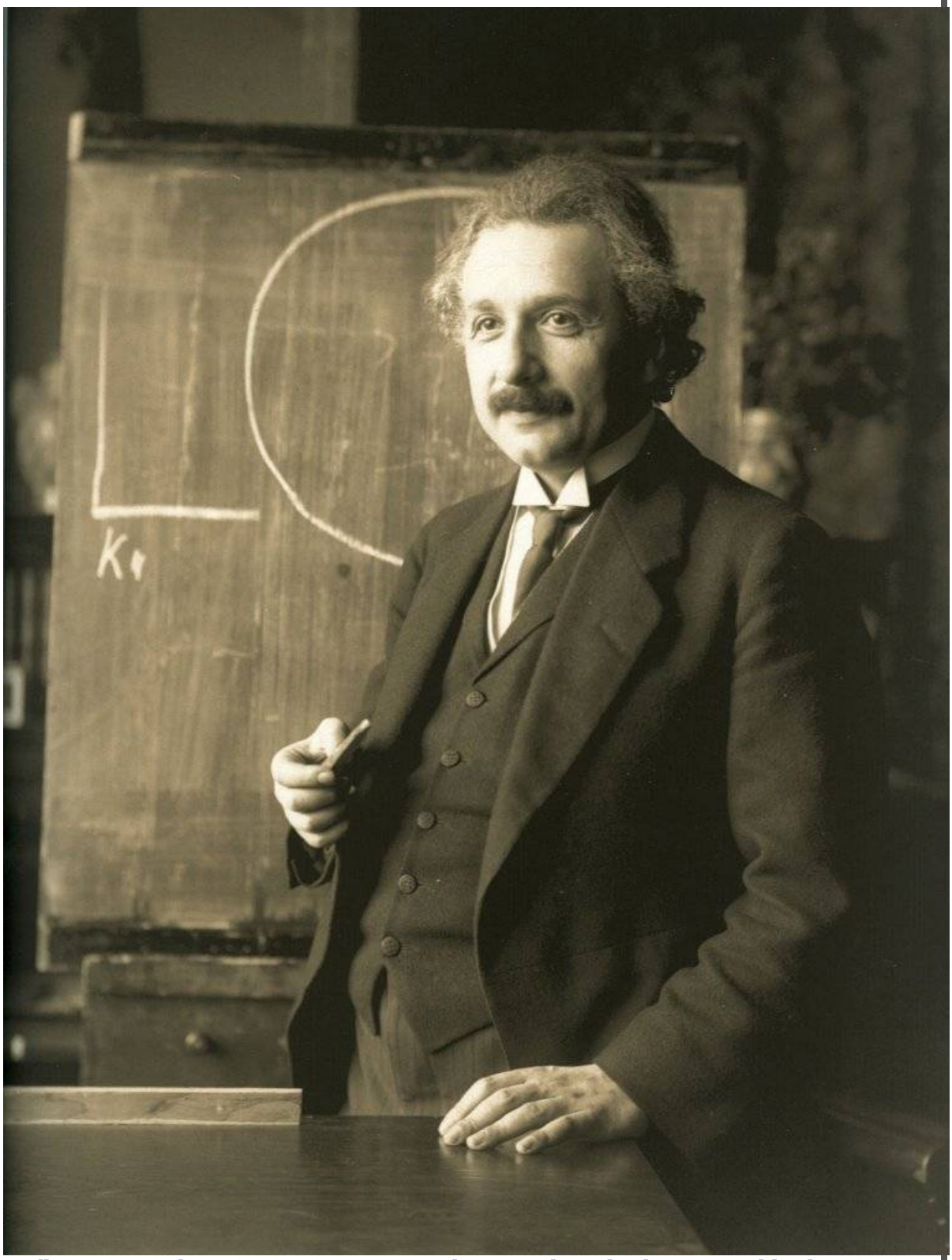
Three Nobel Laureates in Physics standing in front of the Athenaeum at California Institute of Technology (Caltech), 1931.
Front row from left: Albert A. Michelson, Albert Einstein and Robert A. Millikan.
Source: Smithsonian Institution Libraries Photographer unknown Public domain via Wikimedia Commons

Nobel Laureates in Physics Albert Einstein (left) and Niels Bohr (right) walking.
Photo taken at the 1930 Solvay Conference in Brussels. Source: Danish Film Institute Photo: Paul Ehrenfest



Niels Bohr (left) and Albert Einstein (right).
The picture was taken at physicist Paul Ehrenfest's home in Leiden, December 11, 1925.
Source: Wikimedia Commons

Albert Einstein in his office at the University of Berlin, 1920. Source: "The Solar Eclipse of May 29, 1919, and the Einstein Effect, in The Scientific Monthly 10:4 (1920), 418-422, p. 418 Photographer unknown



Albert Einstein lecturing in Vienna, 1921. Photo: Ferdinand Schmutzer Public domain via Wikimedia Commons

Nobel Prize winners
NIH Intramural Research Program

Harvey J. Alter*	2020	Hepatitis C virus
Alfred Gilman and Martin Rodbell*	1994	G-proteins and the role of these proteins in signal transduction in cells
Baruch S. Blumberg and D. Carleton Gajdusek*	1976	Concerning new mechanisms for the origin and dissemination of infectious diseases
Christian B. Anfinsen*	1972	Ribonuclease, especially concerning the connection between the amino acid sequence and the biologically active conformation.
Julius Axelrod*	1970	Concerning the humoral transmitters in the nerve terminals and the mechanism for their storage, release and inactivation
Marshall W. Nirenberg*	1968	Interpretation of the genetic code and its function in protein synthesis

Mother Nature (Universe) has

Many secrets, messages, expressions ….

It is for the human mind to discover through Science

https://www.nobelprize.org/prizes ACS.org ; sciencedirect.com	*Information Source*

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