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Chemical Education

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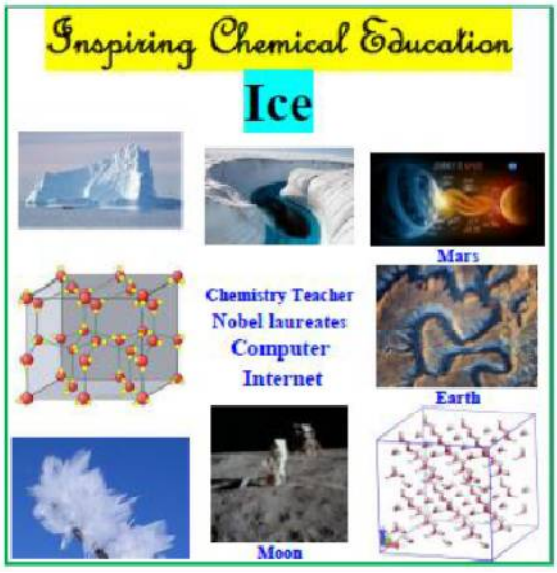


ICE-8: Nobel Prizes in 2019

Nobel prizes were instituted by Dr. Nobel, an engineer and entrepreneur. This venture was started with his personal property. The researchers whose contributions result in "greatest benefit to humankind" are given a Gold medal, diploma and cash in the annual event every year. The functions is organized by Swedish academy (Sweden) in presence of Prince and the awardees from then onwards are called Nobel Laureates. Since inception in 1901, hundreds of scientists were bestowed with Nobel Prizes in three pure science disciplines viz. Physics, Chemistry and Physiology/Medicine. Dr. Nobel, himself being a poet and peace monger, two other disciplines under Nobel prize list are Literature and Peace. In 1969, the sixth prize was introduced for Economics. The Nobel Prize continues to be the most prestigious and honorable recognition/award for intellectual achievement in the world.

The focal theme of research, objects achieved, county/year of birth, institute at the time of announcement of 2019 Nobel Laureates are given in **Tables 1-6**.The spontaneous brain wave of these experts when they came to know of the award are described in Supplementary information **(SI-1).**This information is an exert from the telephonic conversation of Adam Smith(Chief Scientific Officer of Nobel Media, Sweden) with the Laureates.SI-2 incorporate Noble words of Noble Laureates of this year.

Nobel Prizes in Physics 2019

The focus of Physics Nobel Prize is around discoveries in the origin/ dynamics of universe, properties of energy in the form of radiation and interactions between materials or radiation with material(s). Physics brings out extrinsic relationship i.e. the way physical systems feel inside.

One half of this Year (2019) Nobel Prize in physics goes to James Peebles for seminal contribution in cosmic background radiation and theories about evolution of universe. The analytical and numerical models revealed fundamental properties and components of universe. This resulted in a unified model of universe explaining dynamic since a fraction of second after Big Bang until present time. It also projects into distant feature.

Table 1.1 Focal theme (a) of Nobel Prize for Physics in 2019

Obj_achieved	o Understanding the evolution of universe
	o Earth's place in the cosmos
Discipline	Theoretical discoveries in physical cosmology

Affiliation	Nobel Laureate (Physics) Photo, Date & place of birth	Share
Princeton University, Princeton, NJ, USA  James Peebles, lecturing at Princeton Univ., 2016	James Peebles  1935, Winnipeg, Canada	1/2

The noteworthy postulate (thesis) of Peebles about universe was published in 1965. The abstracts of the paper stars as "a critical factor in the formation of galaxies may be the presence of a black body radiation content of the universe". This analytical search and results of YakovZeldovich, a Russian scientist were the point of time for the start of physical cosmology. Earlier Cosmology, more or less, contained unconfirmed speculations, very little data and thus enjoyed only empirical status. The

results of accurate measurements-temperature anisotropies-in CMB and the precise sky surveys turned classical cosmology into an exact science with ever increasing accuracy or precision (KB 1.1). Physics hiding in the nature will be unveiled resulting in better comprehensive knowledge.

Kbits 1.1: Phys.Cosmology

Physical (precision) cosmology	Knowledge validated (high precision)
+ Explains evolution of dynamic structure of universe + Tool to discover hidden physics	🕮 Age of universe: 13.8 billion years with better than 1% accuracy 🕮 Boson confirmation at six sigma level 🕮 Statistical evidence of dark matter at 100 standard deviations
Possible but to be confirmed	**Un explained**
? New particle ? Super symmetric patterns of known particle ? Axions hypothetical ? Enable to explain strong nuclear forces	- Physics of cosmological constant - Nature of dark matter - 69% dark energy - Dark matter has weight but cannot have any other effect

The second half of the prize in physics is shared between Michel Mayor and Didier Queloz for the discovery of first planet "51 Pegasi b" orbiting around sun like star in "pegasus constellation". In 1995, these scientists reported their findings of first exoplanet and by now more than 4000 exoplanets are discovered. This activity is a deep level research pursuit requiring highly precise measurements of small variations in the color of the star (KB 1.2,1.3).

KB 1.2:.K Bits of about first exoplanet (51 Pegasi b)

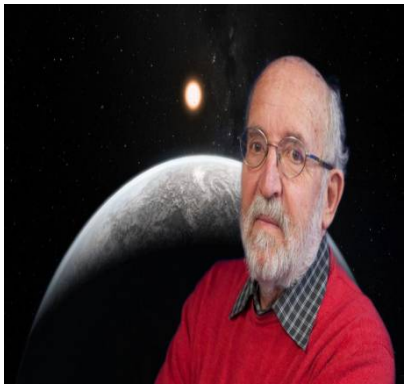
- Distance from Earth: 50 light years
- Time required to go around the star : Four days
- Proximity: it is very close to the star
- Temperature: 1000°C
- Guess: No chance to support (normal) life similar to that on earth

KB 1.3.Basis of exploring exoplanet research Doppler Effect

If	An object moves away from a point
Then	It appears reddish
If	Object approaches towards point
Then	It appears bluer
If	There are wobbling moments in stars
Then	There is a planet moving around the star

Table 1.2 Focal theme (b)of Nobel Prize for Physics in 2019

Discovery	Exoplanet orbiting a solar-type star

Affiliation	Nobel Laureate (Phys) Photo Date & place of birth	Share
University of Geneva, Geneva, Switzerland 	Michel Mayor  1942, Lausanne, Switzerland	1/4

Affiliation	Nobel Laureate (Phys) Photo Date & place of birth	Share
University of Geneva, Geneva, Switzerland, University of Cambridge, Cambridge, United Kingdom 	Didier Queloz  23 February 1966, Geneva, Switzerland.	¼

Life on earth: The human perception of life on earth refers to species with digestion (energy for sustenance) and reproduction (continuity). The basic difference between plant and animal kingdoms is in additional characteristics of locomotion in members of latter category. The number of neurons, nerves system, brain etc has limited function in many life forms. The more evolved human beings have higher brain activity including speech, leaning and ultimate bliss of consciousness. The latter is still a open puzzle with different attributes popular among specialists in Artificial intelligence and Neuro biology. The accumulated wisdom points out necessary conditions for existence of life are temperature, atmosphere, water, oxygen and carbon dioxide.

Life on other planets: With evolution of life on our mother earth (a planet in the solar system), it is curious to explore life on any other planet in the universe. Although it has been addressed continuously with state-of- art instrumentation and knowledge, the task remains to be a big challenge in the science pursuit. The preliminary results on the exoplanet show life is negligible because of 1000^{O}K temperature on it. The intense explorations with MARS rover 2020 in future will be also towards probing into life on MARS. Now another facet is, if life were there on another planet, it may not be of the form now human mind is aware of. It may have different characteristics, composition, characteristics and functions. However, it is still a far-off target to realise.

Nobel Prizes in Chemistry 2019

The 2019 Laureates in Chemistry – M. Stanley Whittingham, John B. Goodenough and Akira Yoshino – contributed in different ways to the development of the lithium-ion batteries.They did not work together, but their research was based on making improvements sequentially. The progress in the realization of lithium_ion_batteries is briefly described in the three phases (vide infra).

Table 2.1 Focal theme (a) of Nobel Prize for Chemistry in 2019

Obj_achieved	Lithium-ion batteries

Affiliation	Nobel Laureate (Chem) Photo, Date & place of birth	Share
Binghamton University, State University of New York, New York, NY, USA	M. Stanley Whittingham  22 December 1941, United Kingdom	1/3

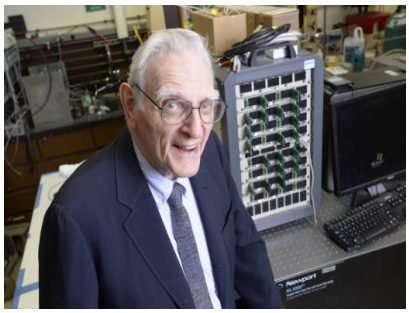
Phase-I

M. Stanley Whittingham found Titanium disulphide suitable for anode. The atoms in TiS2 are in many layers with empty spaces between them. Li+ can be stored here without any subsequent chemical reaction. Li metal was used as cathode and it's high tendency to release electron was advantageously used. During charging Li+ flows back through the electrolyte to cathode
limitations.

Research experience at Exxon: Exxon practiced special research culture and use to remain on the top in the energy sector. The groups of scientists were asked to do great research, publish the results but not with the inaudible chemicals. Whittingham and others started probing into batteries and may other tasks. The support of basic/applied the research was also like drilling an oil well. It will be funded and continued if at least there are 10% positive results with a firm hope of success at the end. During that period may American investors (IBM, GE, BELL, Dupont, AT&T) supported basic research for a long period to maintain unperturbed firm knowledge base to address any issue in the product line. But later, there is a change in focus towards stock market of value added finished products.

Table 2.2 Focal theme (b) of Nobel Prize for Chemistry in 2019

Obj_achieved	Lithium-ion batteries	**Benefit**	Benign environment High energy
Necessity	Fossil fuel-free society		

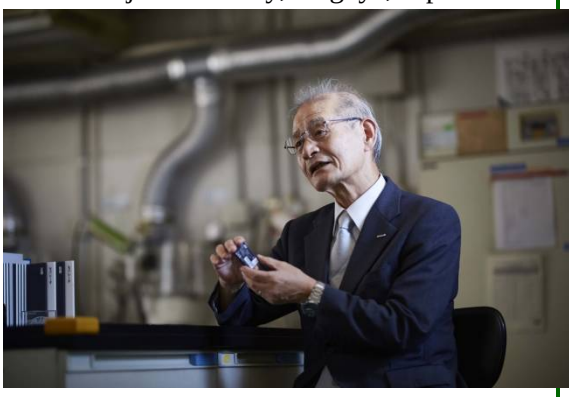
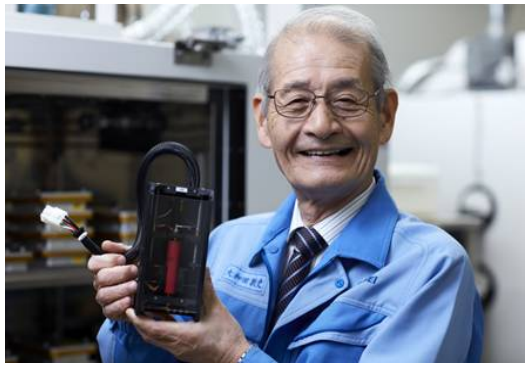
Affiliation	Nobel Laureate (Chem) Photo Date & place of birth	Share
University of Texas, Austin, TX, USA	John B. Goodenough  25 July 1922, Jena, Germany	1/3  Young J B Goodenough

Phase-II

The research outcome of Whittingham's battery was familiar to J.D. Goodenough. He tried cobalt oxide as cathode which also has a layered structure and Li+ can safely fit in the voids. But miraculously, the voltage of battery jumped to 4.0 eV (from 2.0 eV in previous batteries) without any increase in weight or volume. This high energy property is a crucial parameter in portable electronic devices. But safety remained as a hurdle due to high reaction nature of lithium metal.

Table 2.3 Focal theme (c) of Nobel Prize for Chemistry in 2019

Obj_achieved	Lithium-ion batteries	**Benefit**	Benign environment High energy
Necessity	Fossil fuel-free society		

Affiliation	Nobel Laureate (Chem) Photo, Date & place of birth	Share
Asahi Kasei Corporation, Tokyo, Japan, Meijo University, Nagoya, Japan 	Akira Yoshino  30 January 1948, Suita, Japan	1/3

Phase-III

Akira Yoshino employed Lithium ion with petroleum coke in the negative electrode. The undisputed safety from explosion is due to employment of Li+ instead of metallic lithium. The realization of this lithium ion device by Akira surmounting all safety hurdles is bliss for public use. It is just like a drug without any toxic effect of any kind in health care.

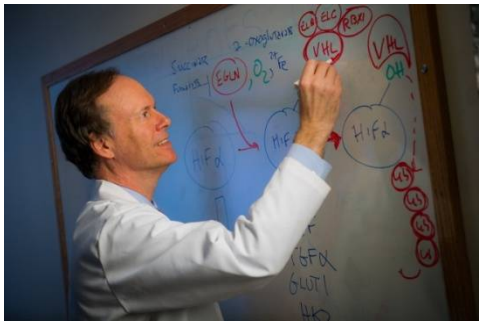
Yoshino's experiment for testing safety Li ion battery was a land mark. In 1986, Yoshino borrowed facility used for testing explosives. An Iron lump was dropped first on metallic lithium battery and it resulted in a violent explosion. But, with lithium ion battery not even ignition took place. The success of test endorsed the commercial viability of the product at industrial level. Had Li+ battery failed in this test, all the attempts should have been only academic exercise and should have been dropped from commercialization like non aqueous secondary batteries earlier.

Nobel Prizes in Physiology or Medicine 2019

This year award is for understanding the basic science in sensing and adaptation of cells for oxygen. This venture has the motive "as knowledge grows more and more, the human life is enriched". Dr (NL) Peter believes that researchers/sponsors neither need to know nor dream for benefits while pursuing basic search dealing with either fundamental particles (molecules) or Universe/exoplanets. The natural consequence is that researchers with application pursuit bring out new products and refinement of existing ones. This job is pursued by process designers and technologists. The analogy is that management and marketing specialists play their strategies if and only if (iff) products are available. The knowledge of gold is basic in zillion varieties of armaments. To name a few, knowledge contributes to nutritious food, comforts, pollution free environment, morbidity free long life, reduced pain/ less discomfort even in end-of-life diseases, serine mentality, compromised comfort and ease in physically/mentally challenged lives, monitoring/controlling avalanches and natural calamities, harnessing energy from natural sources (Sun, Wind) and knowing beyond yesteryears reachable miracles in space (Mars).

Table 3.1 Focal theme (a)of Nobel Prize for Physiology or Medicine in 2019

Obj_achieved	How cells sense and adapt to low oxygen availability	**Necessity**	Hypoxia--chemical biology

Affiliation	**Nobel Laureate (Med)** **Photo** **Date & place of birth**	**Share**
Harvard Medical School, Boston, MA, USA, Howard Hughes Medical Institute, Chevy Chase, MD, USA 	William G. KaelinJr.  1957, New York, NY, USA	1/3

Background: Oxygen, a simple diatomic molecule, is essential for sustenance of life processes. It is the byproduct of photosynthesis in the plant kingdom. Mitochondria present in all animal cells uses O_2 to convert food into useful energy. For the details of this enzymatic process, Otto Warburg was awarded Nobel prize in 1931. Natural Evolution brought out the ways and means of supply of oxygen to tissues and cells in adequate quantities. Corneille Heymans won 1938 Nobel prize in Physiology/medicine for blood oxygen level sensing. The respiratory level is controlled by carotid body with direct communication with the brain.

In humans, the red blood cells of blood flowing through lungs absorb oxygen and distributes to all cells in the entire body. The reaction of O_2 with glucose is the source of energy and is called cellular (or internal) respiration. At high altitudes, the oxygen content in the air is low. Even in a healthy individual, more oxygen is used during intense exercise as the muscle movement consumes higher amount. When one has a wound, the blood cannot reach all the cells around it and leads to depletion of oxygen. This low amount of oxygen in the body leads to hypoxia. But metabolism adopts to this condition and restores to normalcy. Here, two steps viz. sensing oxygen and corrective mechanism operate. This phenomenon of oxygen in life sustenance of animals and humans was understood/known for centuries to medical science professionals and scientists. But, molecular mechanism of how cells of biological life adapt to low or high levels of oxygen remained to be a black box.

Discovery: Research results of William G. Kaelin Jr., Sir Peter J. Ratcliffe and Gregg L. Semenza unveiled molecular processes of how cells sense oxygen and also adapt to changing levels (KB.2.1,SI.3.1) They identified the molecular machinery doing the job meticulously.

KB.2.1 Molecular mechanism of hypoxia

If	Levels of oxygen are normal
Then	Hydroxyl groups added to HIF-1α at specific positions
→	Controls rapid degradation of HIF-1α
If	cells receive reduced amount of O_2
Then	More HIF-1α is required
If	O_2 in cells is high
Then	HIF-1α amount is reduced
If	Hypoxia
Then	There is increase in level of hormone erythropoietin (EPO)
→	Increased production of red blood cells (Erythropoiesis)

Role (consequences) of sensing of O_2

- Fine tuning of immune system function & physiological processes
- Critical in the formation of normal blood vessels and placenta during fetal development
- Chronic renal failure leads to severe anemia

Consequence: The knowledge of mechanism for one of life's most essential adaptive processes (viz. how hypoxia condition is tackled by the physiological metabolism) is clear now. The new knowledge is about chemical reactions with biomolecules taking place in cells and components involved.

Benefits to human health: The beneficial bliss of new knowledge of hypoxia to humankind is creation of a new window for the medical world in bringing forth new strategies to develop medicines in treating anemia, cancer, myocardial infarction etc.

Affiliation	Nobel Laureate (Med) Photo Date & place of birth	Share
University of Oxford, Oxford, United Kingdom, Francis Crick Institute, London, United Kingdom 	Sir Peter J. Ratcliffe  1954, Lancashire, United Kingdom	1/3

Affiliation	Nobel Laureate (Med) Photo Date & place of birth	Share
Johns Hopkins University, Baltimore, MD, USA All / Since 2014 Citations: 1, 39,968 / 56, 457 h-index: 171 / 118 692 Publications / 1984-2019	Gregg L. Semenza  1956, New York, NY, USA	1/3

2018 Nobel Prize inLiterature awarded in 2019

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Table 4.1 Focal theme(a) of Nobel Prize Literature in 2018	
Obj_achieved	o Narrative imagination with encyclopedic passion o Represents crossing of boundaries as a form of life

Residence at the time of the award	Nobel Laureate (Literature) Photo, Date & place of birth	Share
Wroclaw, Poland 	**Olga Tokarczuk**  29 January 1962, Sulechów, Poland	1/1

2019 Nobel Prize in Literature

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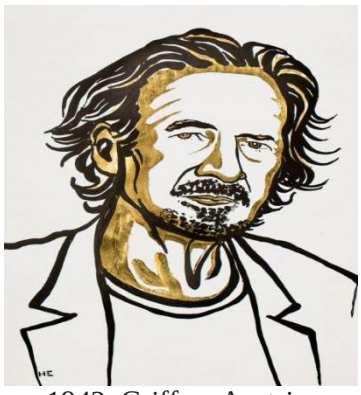
Table 4.2Focal theme(a) of Nobel Prize Literature in 2019	
Obj_achieved	▪ Periphery and the specificity of human experience

Residence at the time of the award	Nobel Laureate (Literature) Photo, Date & place of birth	Share
Chaville, France	**Peter Handke**  1942, Griffen, Austria	1/1

Nobel Prize in Peace 2019

Table 5.1 Focal theme(a) of Nobel Prize for Peace in 2019	
Obj_achieved	▪ Peace and international cooperation ▪ Decisive initiative to resolve the border conflict with neighboring Eritrea

Role	Nobel Laureate (Peace) Photo, Date & place of birth	Share
Prime Minister of the Federal Democratic Republic of Ethiopia 	**Abiy Ahmed Ali**  15 August 1976, Beshasha, Ethiopia	1/1

2019 Nobel Prizes in Economics

Table 6.1 Focal theme of Nobel Prize for Economics in 2019	
Obj_achieved	Alleviating global poverty through experimental approach

Affiliation	Nobel Laureate (Economics) Photo Date & place of birth	Share
Massachusetts Institute of Technology (MIT), Cambridge, MA, USA SverigesRiksbank Prize in Economic Sciences in Memory of Alfred Nobel 2019 	Abhijit Banerjee  21 February 1961, Mumbai, India	1/3

Table 6.2 Focal theme of Nobel Prize for Economics in 2019	
Obj_achieved	Alleviating global poverty through experimental approach

Affiliation	Nobel Laureate(Economics) Photo, Date & place of birth	Share
Massachusetts Institute of Technology (MIT), Cambridge, MA, USA The SverigesRiksbank Prize in Economic Sciences in Memory of Alfred Nobel 2019 	Esther Duflo  1972, Paris, France	1/3

Table 6.3 Focal theme of Nobel Prize for Economics in 2019	
Obj_achieved	Alleviating global poverty through experimental approach

Affiliation	Nobel Laureate(Economics) Photo, Date & place of birth	Share
Harvard University, Cambridge, MA, USA The SverigesRiksbank Prize in Economic Sciences in Memory of Alfred Nobel 2019 	Michael Kremer  1964	1/3

Supplementary Information (SI)

SI-1: First Response of Noble prize winners

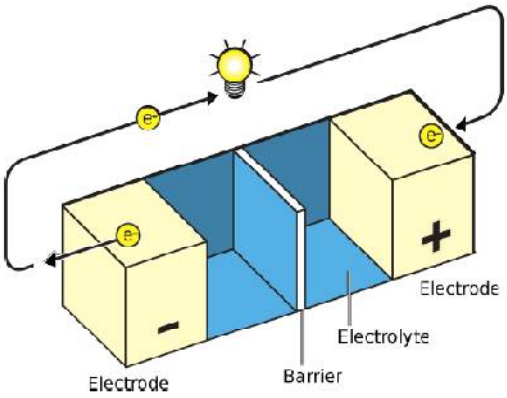
Nobel Laureate (2019)	First Response	Discipline
Michel Mayor	Very nice surprise!	Phys
Didier Queloz	I was in the middle of a scientific meeting with colleagues, and then I stopped breathing … [Laughs] Well I'm still shaking a lot, I must say I'm so glad, I mean I'm so glad the Nobel Prize committee for this. It's just amazing	Phys
William G. Kaelin Jr.	I was… again I'm in a state of shock, it's… obviously it's absolutely wonderful news, but my heart's still racing and I think it's all just sinking in	Med
Sir Peter J. Ratcliffe	It's a very happy event, obviously very satisfying and a reward for me. I'm happy about it. Yes, I think it's a … and comfortable with talking to people such as yourself. Um … I'm not ecstatic about the possibility of being a public figure, if that's what one is. I'll do my duty I hope. … I'm not a tiger for publicity	Med
Peter Handke	I think it was not my freedom, it was another freedom, of outside, I don't know. Completely… freedom in an absurd way.	Literature

	AS: It sounds as if the effect will take a long time to sink in. PH: Yes, you are right, ja. Ja.	
Abiy Ahmed Ali	I was so humbled and thrilled when I just heard the news	Peace

SI-2: Noble words of Noble Laureates

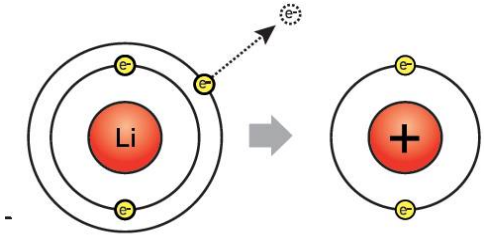
Nobel Laureate (2019)	Verdict	Discipline
Michel Mayor	Quality of the work and the creativity, I mean it's not related to the age of the people.	Phys
Didier Queloz	In my mind, I still feel like a PhD student when I'm doing research. So I'm fine with that.	Phys
Yoshino	Keep thinking every day	Chem
Goodenough	Don't retire too early, live long	Chem

SI.Chem.Li ion Battery



Uses of Lithium ion batteries

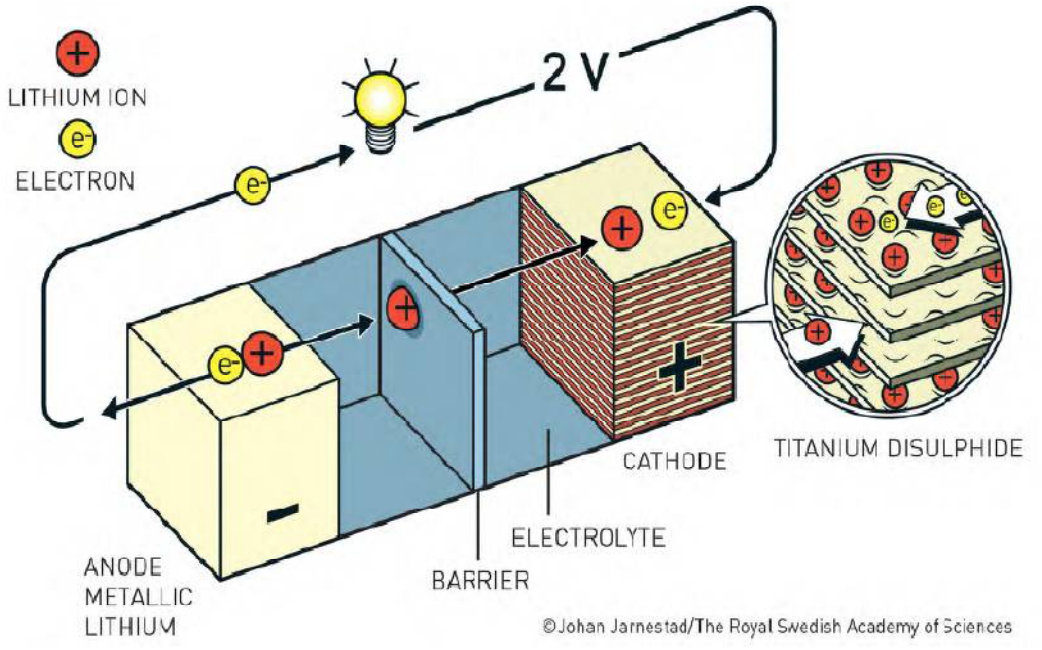
- For sustainable energy
- Portable electronic devices : [mobile phones, pacemakers]
- Laptop computers
- Long-range electric cars.
- Power storage:
  [renewable [solar, wind]energy; hydro power]
  + lithium-ion batteries can replace fossil fuels
    →Reduces emission of greenhouse gases



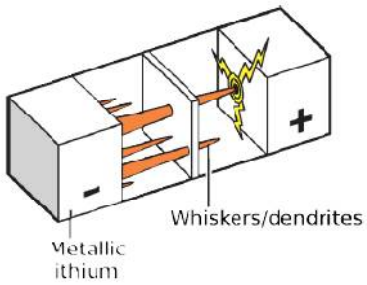
Properties. Lithium. Batteries

- Light metal
- Stores a large mount energy per unit of weight and volume
- Rechargeable

Whittingham's battery

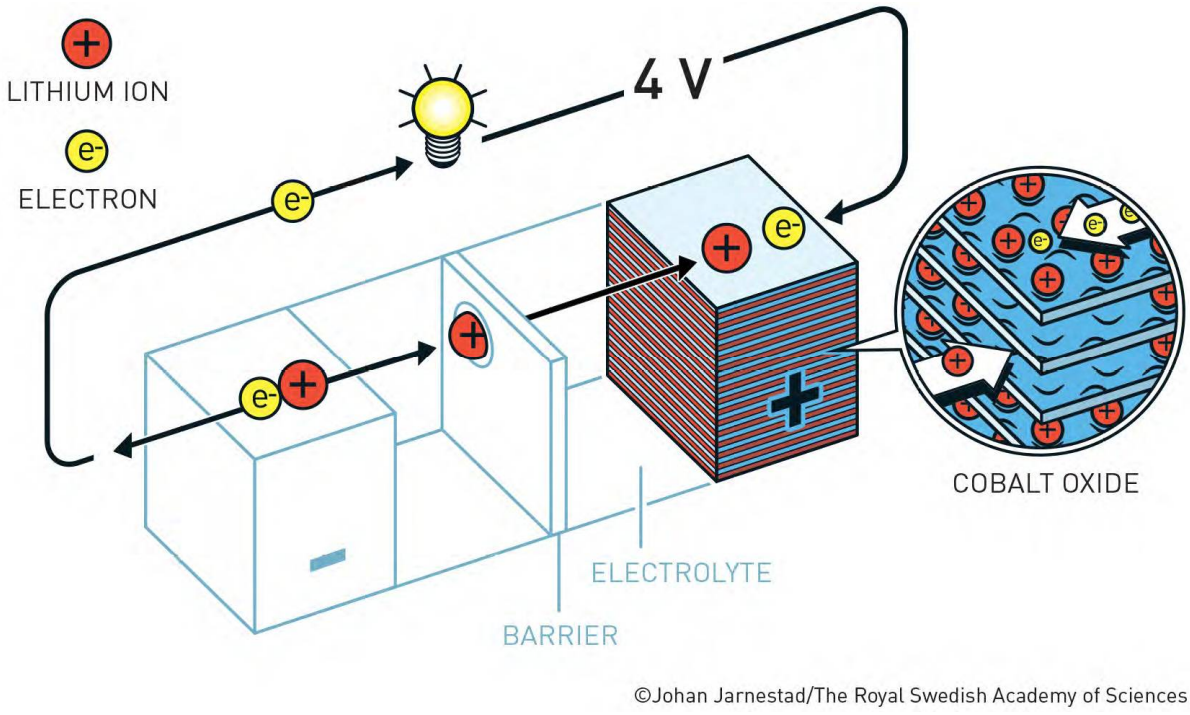


Negative electrode (Anode)	Positive electrode (Cathode)	Battery	Volts
Metallic lithium	Titanium disulphide	Whittingham	2



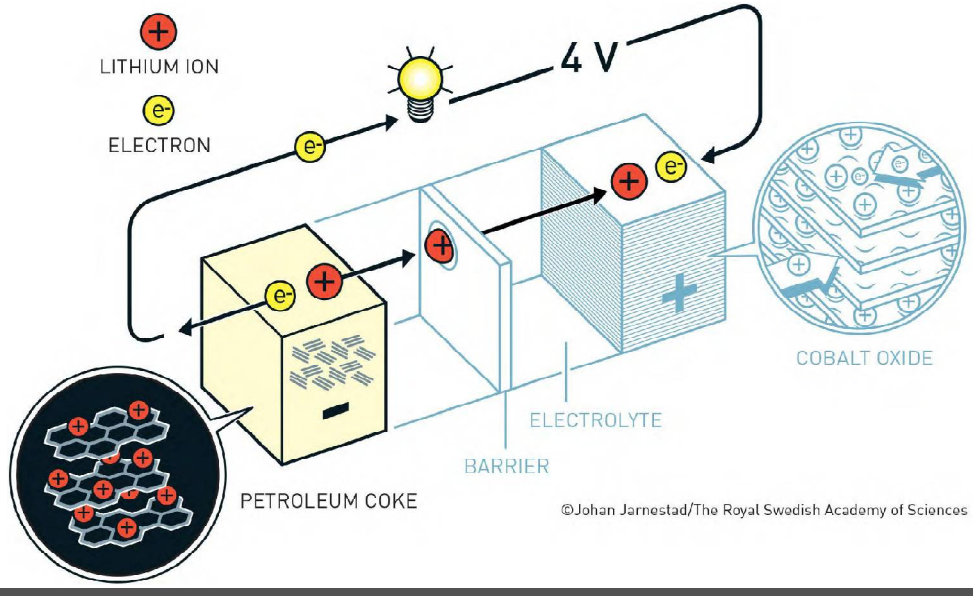
lithium whiskers/dendrites →short-circuit

Goodenough 's battery



Negative electrode (Anode)	Positive electrode (Cathode)	Battery	Volts
Lithium metal	Cobalt oxide	Goodenough	4

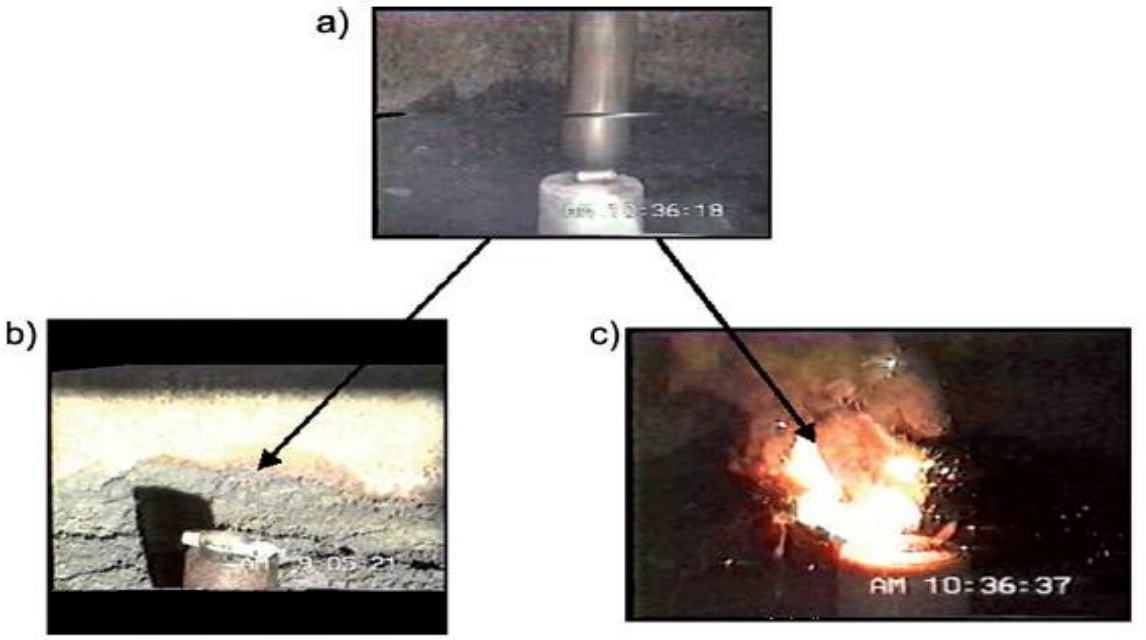
Yoshino 's battery



Negative electrode (Anode)	Positive electrode (Cathode)	Battery	Volts	
Lithium ion in Petroleum coke	Cobalt oxide	Yoshino	4	**Safety**

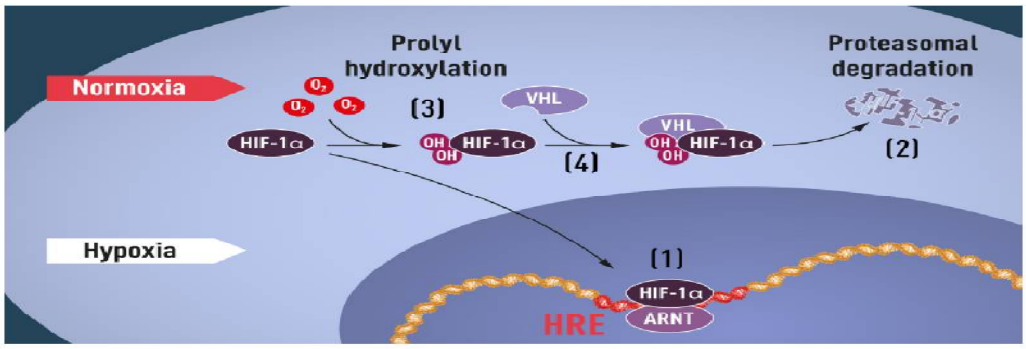
Akira Yoshino,Angew. Chem. Int. Ed. 2012, 51, 5798 – 5800
The Birth of the Lithium-Ion Battery,

Safety test of Lithium atom and lithium ion batteries



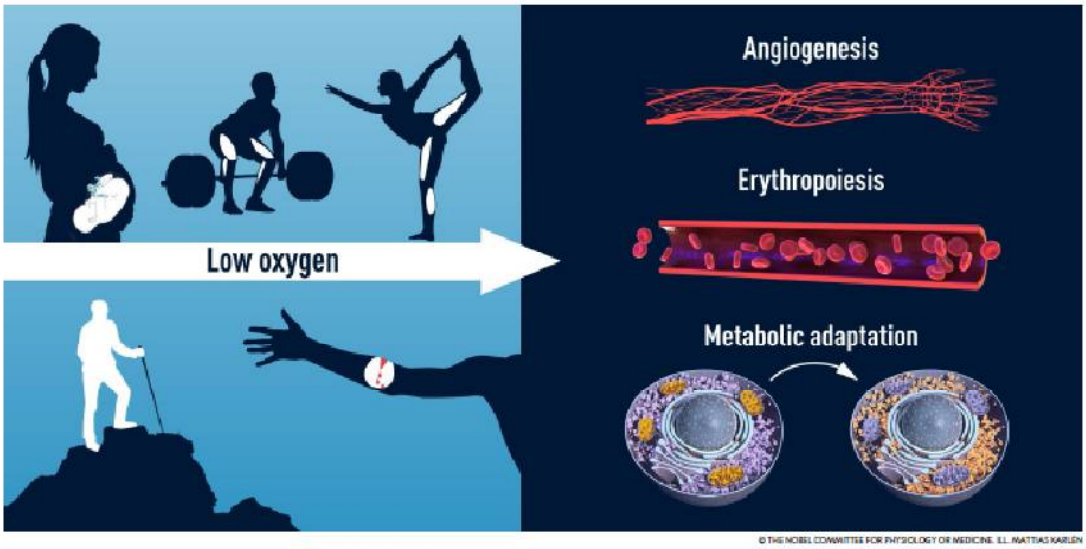
(a) Iron lump(b) Iron lump colliding with Li ion battery
(c) Iron lump colliding with Li atom battery

SI.Med(SI.3.1)



(1)Adaptation to low oxygen
(2) Under high oxygen conditions, HIF-1α is targeted for destruction by the proteasome
(3) Hydroxylated in an oxygen-dependent manner
(4) Hydroxylation allows the HIF-1α protein to be recognized by the VHL complex

HYPOXIA	A cell in the body suffering from a shortage of oxygen (1–5% $O_{2)}$)
Normoxia	Normal levels of oxygen (oxygen tensions between 10–21%)
hyperoxia	oxygen> 21%.
VHL	von Hippel-Lindau tumor suppressor gene



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