THE NOBEL PRIZE

Speaker's manuscript – Chemistry Prize 2019
Developing the world's most powerful battery

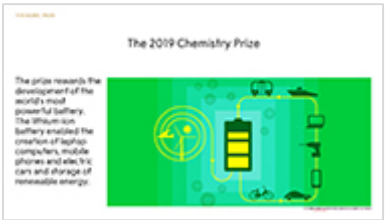
The Nobel Prize in Chemistry

- The Nobel Prize in Chemistry is one of the five prizes founded by Alfred Nobel and awarded on 10 December every year.
- Before Alfred Nobel died on 10 December 1896, he wrote in his will that the largest part of his fortune should be placed in a fund. The yearly interest on this fund would pay for a prize given to "those who, during the preceding year, shall have conferred the greatest benefit to humankind."
- The interest would be divided into five equal parts, with one part awarded "to the person who shall have made the most important chemical discovery or improvement".

Who is rewarded with the Chemistry Prize?

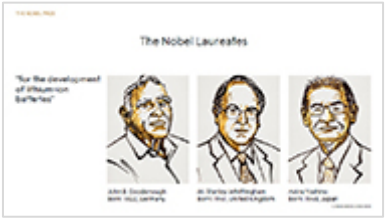
- The Nobel Prize in Chemistry is thus awarded to people who have made discoveries or improvements that have given us knowledge about the structure of various substances and how they are created and changed – how and why they react with each other, and even how we can create new molecules.
- This is Ada Yonath, who was awarded the 2009 Nobel Prize in Chemistry for her pioneering contributions to studies of the ribosome.

Chemistry Prize 2019



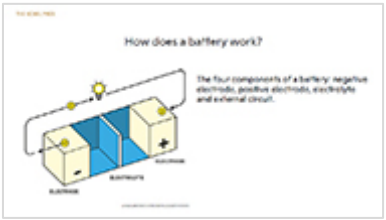
- The 2019 Chemistry Prize is about the development of the lithium-ion battery: a technological revolution.
- The 2019 Laureates developed a rechargeable, lightweight battery powerful enough to be used in many different fields, for example mobile phones, pacemakers and electric cars.
- The potential for storing energy from renewable sources – such as solar and wind power – in batteries opens the way for sustainable energy use. To achieve this, the Laureates needed to overcome difficult challenges – especially in taming the highly reactive lithium atom.

The Nobel Laureates



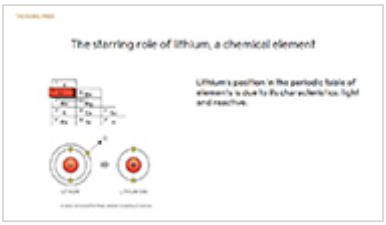
- The 2019 Laureates in Chemistry – M. Stanley Whittingham, John B. Goodenough and Akira Yoshino – contributed in different ways to the development of the lithium-ion battery.
- They did not work together, but their research was based on making improvements in each other's discoveries.
- Intensive research on lithium-ion batteries began early in the 1970s and continued well into the 1980s. In 1991 a Japanese electronics company began selling the first commercial lithium-ion batteries.

How does a battery work?



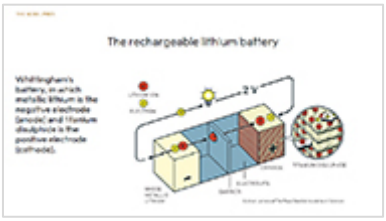
- A battery consists of four different components: a negative and a positive electrode, an electrolyte and an external circuit.
- The negative electrode is a substance that is oxidised (emits an electron), and the positive electrode is a substance that is reduced (gains an electron).
- Between these two electrodes is an electrolyte (ionic solution) that can transport charged particles (ions).
- Finally, to start the battery (create a closed circuit) we need an external circuit, for example flowing through a lamp or an electric device.
- Research aimed at finding new technology and developing an efficient new rechargeable battery that could store energy began in earnest during the mid-20th century, when there was a threat that oil would run out.

The starring role of lithium, a chemical element



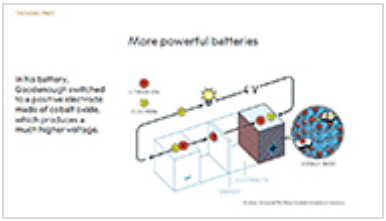
- Metallic lithium is the lightest solid chemical element. It has only one valence electron and is highly reactive – this is lithium's weakness, but also its strength.
- When a lithium atom gives up its valence electron it forms a positively charged lithium ion, which is more stable.

The rechargeable lithium battery



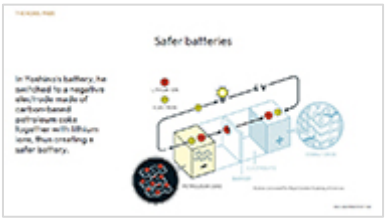
- M. Stanley Whittingham's contribution to the development of a rechargeable battery was the discovery that titanium disulphide can be used as the positive electrode.
- Titanium disulphide is a substance whose atoms are arranged in many layers, with empty spaces between them. Here many lithium ions can be stored, and no chemical reaction occurs during storage.
- When batteries are then charged, the lithium ions flow back through the electrolyte to the negative electrode.
- For the negative electrode in his battery, Whittington took advantage of lithium's enormous power to release electrons.

More powerful batteries



- John B. Goodenough was familiar with Whittingham's battery. Based on his knowledge of materials he improved it by using a different substance, cobalt oxide, as the positive electrode.
- Cobalt oxide also has layers of atoms with spaces in between, where lithium ions can be stored.
- The use of cobalt oxide doubled the power of the battery from two volts to four volts without increasing its volume or weight.
- This was a crucial step in the development of portable electronic devices, which required lightweight, rechargeable batteries.
- Yet safety was still a problem when using highly reactive metallic lithium.

Safer batteries



- As oil again became cheaper, Western countries became less interested in battery development.
- But in Japan, there was a growing interest in batteries because of the portable electronics boom. Electronics companies wanted lightweight, rechargeable batteries for their new portable devices.
- Akira Yoshino improved on the lithium battery by instead using lithium ions together with a carbon-based material, petroleum coke, in the negative electrode. Because the battery now only contained lithium ions instead of pure metallic lithium, this made it safer – which was Yoshino's major contribution.
- To test the safety of the battery, Yoshino performed two experiments. First he dropped a large piece of iron on his new battery containing only lithium ions, and nothing happened. When he repeated his experiment with a battery containing pure lithium, the result was a violent explosion.
- By switching from lithium to lithium-ion batteries, lightweight rechargeable batteries – with high capacity and voltage – had now also become safer and more stable.

The benefits

- Lithium-ion batteries made possible the development of today's electronic devices – including mobile phones, pacemakers, laptop computers and electric cars.
- Because lithium is a small, light chemical element it can store a lot of energy per unit of weight and volume. As a result, electronic devices have become more portable and do not need to be charged as often.
- By storing renewable energy such as solar, wind and hydro power, lithium-ion batteries can replace fossil fuels and enable us to reduce emissions of carbon dioxide and other greenhouse gases.
- Lithium-ion batteries thus contribute to more sustainable energy use.

Quote, Olof Ramström, member of the Nobel Committee

- Olof Ramström, member of the Nobel Committee, on the huge, everyday impact of the development of lithium-ion batteries.