

The rise of X-ray crystallography

Synchrotrons and free-electron lasers are shaping the next century of crystallography.

1611 Kepler notes six-fold symmetry and structure of snowflakes

1723 Capaler publishes his introduction to crystallography

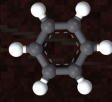
1815 Haüy introduces translational symmetry

1895 Röntgen discovers X-rays **Nobel, 1901**



1913 William Lawrence and William Henry Bragg solve structure of salt and diamond **Nobel, 1915**

1922 Davisson and Thomson discover diffraction of electrons by crystals **Nobel, 1937**



1929 Lonsdale proves planar structure of benzene

1924 Bernal solves the structure of graphite

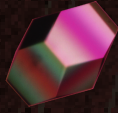
1916 Debye and Scherrer invent powder analysis

1912 William Lawrence Bragg finds formula linking diffraction pattern to crystal structure (also 1913)

1912 Max von Laue shows X-rays diffracted, proving their wave-like nature **Nobel, 1914**



1965 Structure of lysozyme solved



1946 Summer receives **Nobel** for showing that enzymes can be crystallised

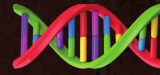
1946 Hodgkin solves penicillin, one of several biochemicals solved during her career **Nobel, 1964**

1952 First synchrotron beamline, Cornell



1972 Antinsen, Moore and Stein win **Nobel** for protein folding

1957 First protein structures solved by Kendrew (myoglobin) and Perutz (haemoglobin) **Nobel, 1962**

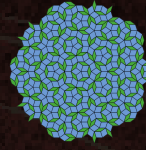


1953 Crick, Watson and Wilkins decipher structure of DNA **Nobel, 1962**

1947 First observation of synchrotron radiation (General Electric)

1981 SRS in the UK becomes first dedicated X-ray storage ring

1984 Drenth, Huber and Michel solve 3D structure of membrane protein **Nobel, 1988**



1982 Shechtman discovers quasicrystals **Nobel, 2011**

1994 ESRF, the first third-generation synchrotron, enters operation

1994 Brockhouse and Shull share **Nobel** for neutron diffraction

2014 Protein Data Bank nears 100,000 deposits



2012 NASA's Curiosity rover uses X-ray diffraction to analyse Martian soil

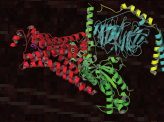
2005 First soft-X-ray free electron laser, FLASH, enters operation

2009 Yonath, Steitz and Ramakrishnan win **Nobel** for ribosome structure using synchrotron X-rays

2009 First hard-X-ray free-electron laser enters operation at SLAC

1998 Mackinnon solves structure and function of ion channels **Nobel, 2003**

1997 Boyer and Walker receive **Nobel** for ATP structure using synchrotron light



2011 Kobayashi et al. solve G-protein coupled receptor using synchrotrons **Nobel, 2012**

2016 European XFEL enters operation
>2020 Synchrotrons strive towards X-ray diffraction limit